Public Sector Pension Policies and Capital Accumulation in an Emerging Economy: The Case of Brazil*

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Abstract

In many emerging economies such as Brazil pension programs of public sector workers are more generous than pension programs of private sector workers. 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 this paper, we develop a two-sector dynamic general equilibrium framework to quantify these opportunity cost effects. We find that the efficiency and welfare gains of reallocating government resources from non-productive public sector pensions to productive public education and infrastructure investments are larger than the welfare effects created by classic public pension reforms that simply reduce savings and tax distortions by making pensions less generous. Calculating transitions to the post-reform steady state, we find that welfare losses

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for the generation born before the reform are offset by welfare gains by the generations born after the reform.

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1 Introduction

Pension programs for civil servants are on average more generous than pension programs for private sector workers as pension replacement rates for public sector workers tend to be considerable larger than replacement rates in the private sector (see Table 2 in Palacios and Whitehouse (2006)). 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. According to a recent OECD report on Brazil, for instance, public spending on pensions accounts for over 10 percent of GDP, a much higher share than the OECD average, despite Brazil's younger population (OECD (2005)). Therefore, in Brazil almost one half of all pension payments go to public sector retirees who constitute only 6 percent of the retired population (Souza et al. (2004)).

There is very little justification for simultaneously running a more generous separate public pension scheme for civil servants. 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 many emerging economies. There is evidence for emerging economies 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), Panizza and Qiang (2005), and Worldbank (2009)). If on top of that public pension programs are more generous than private pension programs, equity issues will be magnified resulting in a very high income concentration. In the presence of population aging overly generous public sector pension plans seem problematic since they become a heavy burden on the budget of an 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. 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. This is true in general and for developing and emerging economies in particular.

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. 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), Auerbach and Kotlikoff (1987), and many others). 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 (2009) show that these adverse effects are substantial but they concentrate their analysis on early retirement issues and do not consider alternative uses of funds such as public education.

In this paper we focus on exploring the effects of the third channel, alternative investments, while also taking capital accumulation effects into account. We argue that the previous literature has understated the possible efficiency gains and welfare improvements from public policy reform by ignoring the alternative usage of the freed up resources for investments into infrastructure and public education.

To capture all dimensions of the economic effects of generous public sector pensions, we develop a dynamic general equilibrium model with public and private sectors. In our model, the government has multiple functions. First, it hires civil servants to work in two sectors, public education and public provision of infrastructure. Second, the government finances public expenditures on education and invests in a public capital to provide services to firms. In addition the government runs two separate public pension schemes, one for public sector retirees and one for private sector retirees. This rich 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.

Our main focus 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 obtain quantitative results we calibrate the model to Brazil where the public pension system is unusually generous. We then conduct several policy experiments.

First, we investigate the effects on the intertemporal consumption-savings decision and then on capital accumulation as a whole while cutting the generosity of the public sector pension system and letting government consumption adjust to clear the government budget constraint. With this policy experiment we can isolate the pure crowding out effect of public pension programs

on private savings when keeping distortive taxes unchanged. In the next step we let taxes adjust to clear the government budget constraint 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 first 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 surprisingly large. The intuition is that increases in civil servants's savings increase the capital stock. The additional income from higher output levels induces private sector workers to save more. Thus, this general equilibrium income effect passes the savings effects of the reform on to private sector agents. Second, we find that the effects of the pension reforms can be much larger, when the pension reform is used to reduce the income tax. 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 results in even larger effects. 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. 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. The sensitivity analysis is conducted in section 5. Section 6 concludes. The appendix contains all tables and figures.[1]

[1]We present the model solution method in a technical appendix that is available on the authors' website at:
http://pages.towson.edu/jjung/Brazil1TecApp.pdf

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. We therefore get

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

We distinguish two groups among civil servants. A fraction θ of civil servants is working in the public education sector $N^{ge} = \theta N^g$, the others $N^{gi} = (1-\theta) N^g$ are working in the public infrastructure sector. 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 benefit payments.

Agents in both sectors value consumption when young and consumption when old, so that the preferences of generation t in sector j can be expressed as

$$U\left(c^j_{y,t}, c^j_{o,t+1}\right) = u\left(c^j_{y,t}\right) + \pi\beta u\left(c^j_{o,t+1}\right),$$

where $c^j_{y,t}$ and $c^j_{o,t+1}$ are consumption levels when young in period t and when old in period $t+1$, π is an exogenous survival probability, β is the time discount factor.

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^p_t according to the production function

$$Y_t = F\left(G_t, K_t, H^p_t\right).$$

Capital K depreciates at rate δ each period. The service flow G from the public good is provided for free by the government. We think of this as services derived from roads, highways or other elements of core infrastructure which is made available to firms at a zero price.[2] Firms only hire capital and labor.

[2] In an alternative specification we allow the public good to enter consumer preferences as well. None of our qualitative results are affected by this modeling choice and only welfare

Human capital is produced according to

$$h_{t+1} = \mathcal{H}\left(H_t^{ge}, E_t, h_t\right), \tag{1}$$

where H_t^{ge} is public educational human capital (teachers), E_t is public education expenditure, and h_t is the parental human capital.

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 $H_t^{gi} = H_t N_t^{gi} = H_t\left(1-\theta\right) N_t^g$ and public capital K_t^G (e.g. roads, highways, etc.) to produce the flow of services G of a public good according to

$$G_t = \mathcal{G}\left(K_t^G, H_t^{gi}\right). \tag{2}$$

Public capital evolves according to

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

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 parameter Ψ^g measures the generosity of the public sector pension system. 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 surviving public sector retirees (the public employees of the previous period N_{t-1}^g multiplied by the survival rate π) and by the generosity factor Ψ^g.

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results are altered slightly quantitatively (but not qualitatively).

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. payments of public debt

$$\left(1 + r_t^b\right) B_t = \left(1 + r_t^b\right) \Delta_{B,t} Y_t,$$

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

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

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 $B_t = \Delta_{B,t} Y_t$. The government collects all accidental bequests from the deceased households. The government

budget constraint can be written as

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

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, $\Delta_{B,t}$ is the fraction of GDP in public debt, 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

$$\max_{\left\{c_t^j, c_{t+1}^j, i_{t+1}^j\right\}} u\left(c_{y,t}^j\right)+\pi\beta u\left(c_{o,t+1}^j\right) \tag{9}$$

$$s.t.$$

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

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/N_t^j is the

per capita government transfer received when old.[3] 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 G_t, τ_t^{sspf}, w_t^p, and q_t.

2.4 Definition of Equilibrium

Given the government policy

$$\left\{\tau_{Lt}^p, \tau_{Lt}^g, \tau_{Lt}^{ssp}, \tau_{Lt}^{ssg}, \tau_{Lt}^{sspf}, \tau_{Kt}, \Delta_{E,t}, \Delta_{G,t}, \Delta_{C_g,t}, \Delta_{T,t}, \Delta_{B,t}, w_t^g, N_t^g, \Psi^g, \Psi^p\right\}_{t=0}^{\infty},$$

a competitive equilibrium is a collection of sequences of decisions of privately employed households $\left\{c_{y,t}^p, c_{o,t+1}^p, i_t^p\right\}_{t=0}^{\infty}$, sequences of decisions of publicly employed households $\left\{c_{y,t}^g, c_{o,t+1}^g, i_t^g\right\}_{t=0}^{\infty}$, 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 $\left\{K_t^G, H_t^g\right\}_{t=0}^{\infty}$, and sequences of factor prices $\left\{w_t^p, q_t, r_t^b\right\}_{t=0}^{\infty}$ such that

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

[3] The wage of an agent of sector j is $w_t^j h_t$. We assume that human capital itself is not sector specific so that aggregate human capital H_t can simply be split into a fraction employed by the private sector $H_t N_t^p$ and a fraction $H_t N_t^g$ employed by the public sector.

(ii) factor prices are determined by

$$\begin{aligned} q_t &= F_K\left(G_t, K_t, H_t^p\right), \quad (11) \\ w_t^p &= F_{H^P}\left(G_t, K_t, H_t^p\right), \quad (12) \\ R_t &= \left(1 + r_t^b\right) = \left(1 - \tau_t^k\right) q_t + 1 - \delta, \end{aligned}$$

(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

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

(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 a civil servant. The provision of "Parity" indexes pensions to nominal wages paid to all civil servants in the same pay class.

According to Bonturi (2002) and Souza et al. (2004) the public sector pension system in Brazil accounts for almost 50 percent of all retirement payments, whereas public sector retirees only account for 6 percent of all retirees.[4] The average contribution rate of civil servants towards their pension fund is 11 percent. In the private sector the contribution rates are much higher, roughly 27 percent (7.6 percent employees contribution and 20 percent employer contribution) in the manufacturing and service sector. In the agricultural (rural) sector contribution rates are somewhat lower and range around 16 percent. Souza et al. (2004) report a deficit of the pension system of roughly 4.5 percent of

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

GDP, 3.5 percent is caused by the public sector, the remaining 1 percent comes from the private sector. The generosity of the public sector pension system has led to concerns about its sustainability.[5]

3.1 Preferences and Technology

Table 1 reports all preference and technology parameters. We use the following utility function to express preferences over two periods

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

where σ is the inverse of the intertemporal elasticity of substitution. The discount factor is a standard one year estimate but since one period is roughly 30 years long, we scale the discount factor accordingly. We choose this together with parameter σ to match the equilibrium interest rate and the capital output ratio in the steady state.

The consumption good is produced according to a standard Cobb-Douglas function

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

where $\alpha_i \in (0,1)$ for $i = 1,2,3$, $\alpha_2 + \alpha_3 = 1$, and $A > 0$. The condition $\alpha_2 + \alpha_3 = 1$ 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. Note also that capital's share of $\alpha_2 = 0.4$ is large relative to the estimates reported in Gollin (2002), but this relatively large parameter value is consistent with estimates for Brazil in Ferreira and do Nascimento (2005) and with values used by Barro and Sala-i-Martin (2004). The value for the elasticity of output with respect to infrastructure capital, $\alpha_1 = 0.1$ lies between estimates by Holtz-Eakin (1994), Ai and Cassou (1995) and Ferreira and do Nascimento (2005).

[5] 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.

The government produces the public good according to

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

where $Z > 0$, $\chi_2 > 0$, and $\eta_2 \leq 1$. For parameter η_2 we use a value of 0 (Cobb-Douglas production function) as the benchmark

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

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

Human capital is produced according to

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

where $D > 0$, $\eta_1 \leq 1$, $\chi_1 > 0$, $(\gamma_1, \gamma_2) \in (0,1)$, and $\gamma_1 + \gamma_2 \leq 1$. We use a value of $\gamma_1 = 0.1$ for the learning elasticity with respect to public expenditure. Fernandez and Rogerson (1998) use the Card and Krueger (1992) estimates to infer that the earnings elasticity of earnings with respect to educational expenditures (quality) is around 0.18. In order to remain on the conservative side and to help ensure that our results do not rely on overly large estimates of opportunity costs we use the value of this elasticity to be 0.1.

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.

3.2 Government

Table 2 reports the specific public policy parameters we use for the calibration exercise. The top panel 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 sector labor force.

We set public expenditures on education exclusive of teacher salaries equal

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

According to Calderon, Easterly and Serven (2003), investment in infrastructure is about $\Delta_G = 1$ percent of GDP. Wages to current civil servants amount to about 5.1 percent 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 percent of GDP, while public sector pensions amount to about 5 percent of GDP (see Souza et al. (2004)).

In our model public sector wages are higher than private sector wages by a factor ξ. According to Foguel et al. (2000) the public-private wage gap is between 30 to 60 percent. Since public pension payments are indexed to public wages this parameter is important in determining the distortionary effects of the public pension policy on aggregates and welfare. We conduct our analysis with a conservative value of $\xi = 1.35$ in order to not overestimate the effects of our pension reform experiments. Our model then produces a public sector wage bill of 4.7 percent of GDP, which is slightly below the public wage bill of 5.1 percent of GDP in the data.

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 percent of GDP. As $\Psi^g > 1$ the pensions paid are actually higher than current average wages.[6] 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 percent of GDP (see Souza et al. (2004)) accounting for the fact that private sector retirees comprise roughly 94 percent of all retirees.

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

[6] 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 earned at higher ages, "average wage" replacement rates of $\Psi^g > 1$ shall not surprise the reader.

fund.[7] The labor income tax rate for both types of employees net of social security contributions is $\tau_L = 11$ percent and the capital tax rate is $\tau_K = 15.5$ percent resulting in tax revenues of 35 percent of GDP excluding social security contribution rates.

There are about 5.2 million civil servants in Brazil which is $N^g = 6$ percent of the total labor force of about 85 million.[8] According to the Global Education Database, there are approximately 2.17 million teachers in Brazil. Thus we set $\theta = 42$ percent.

4 Policy Experiments and Results

Here we introduce several hypothetical pension reforms. 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 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. The policy reform is unanticipated. Current civil servants are grandfathered.

4.1 Public Pensions and Savings

In the first experiment, 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. This is our benchmark experiment. We present steady state results in figures 1 and 2. We also include the benchmark experiment in each graph for easy comparison with the other policy reforms.

[7] 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).

[8] These numbers are from a report by the Social Security Ministry of Brazil in 2002.

We can confirm and quantify 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 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. 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 $\Psi^g = 1$, the steady state output increases by up to 4 percent of GDP as can be seen in the top-left panels of figures 1 and 2 respectively. This change in generosity decreases the size of the public sector pension program from 5.6 percent of GDP to 3.8 percent of GDP.[9]

The mechanism that drives this effect is: Cutting the pension of civil servants induces them to increase savings which in turn lowers the interest rate. The decline in interest rates decreases incomes of old public and private sector agents. 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"). On the other hand, increases in public sector savings will augment the capital stock. This will lead to increases in income of private sector agents and it will allow them 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.

4.2 Public Pensions vs. Taxation

We next investigate the effects from reducing the distortionary effects of taxes used to finance generous public sector pension plans. 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 a large public pension program anymore, taxes can be reduced. As a consequence the

[9] Reductions in the public sector pension deficit due to the Lula reform are likely to be smaller at about 0.5 percent of GDP (see Pinheiro (2004)).

labor tax or the capital tax rate can be cut by up to 5 percentage 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 percent. 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 total output change. Second, since taxes adjust to clear the government budget constraint a second effect, the "tax effect", becomes active. 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. We find that these two effects together cause the large increase of steady state output of close to 15 percent of GDP when the replacement rate is reduced all the way down to $\Psi^g = 1$.

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 percent 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 capital taxes play only a minor role, whereas tax distortions from labor taxes have large effects.

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 do not decrease anymore (as in the case with labor taxes adjusting). In fact, the after tax interest rate increases slightly (see red line in panel 5 of figure 1). Increases in the net interest rates induce agents to save less because the income effect dominates the substitution effect. The extra income when old entices agents to save less (income effect) and the price effect from higher returns on savings is not able to compensate for this. As a result capital accumulation slows down. This channel of effects is absent when labor taxes adjust. As a results, efficiency gains are 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. Alternatively, 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 percent when using the extra funds for public infrastructure. We provide the following intuition. 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 percent.

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 $\Psi^g = 1$ in the following way.

We first record the present value life time welfare levels of the benchmark economy for each cohort over the transition period $U\left(c^j_{y,0}, c^j_{o,0}\right)$ where $c^j_{y,0}$ and $c^j_{o,0}$ are pre-reform steady state consumption levels in sector j. We then record consumption levels for each cohort when the government administers a change in the pension scheme of civil servants $\left\{c^j_{y,t}, c^j_{o,t+1}\right\}_{t=1}^{T-1}$ and adjust these consumption levels with a multiplicative factor ϕ so that the present value life time welfare under the new policy regime is equal to the welfare in the old regime

$$U\left(c^j_{y,0}, c^j_{o,0}\right) = U\left(c^j_{y,t}\left(1+\phi^j_t\right),\ c^j_{o,t+1}\left(1+\phi^j_t\right)\right),\ \text{for } t = 1, ..., T,$$

where $c^j_{y,t}$ and $c^j_{o,t+1}$ are post-reform consumption levels in sector j in transition period t and factor ϕ^j_t is the compensating consumption of generation t in sector j expressed as percentage of per period consumption levels. We then calculate the average per period compensating consumption for each generation (a weighted average over both sectors) as $\phi_t = N_p \times \phi^p_t + N_g \times \phi^g_t$.

Figures 3 to 6 report compensating consumption levels for the four policy experiments that we concentrate on, that is (i) labor taxes adjust, (ii) capital taxes adjust, (iii) public capital investments adjust, and (iv) investments into public education adjust. In all four figures we illustrate the average percentage of current value compensating consumption over current value consumption for each age cohort. We distinguish between private ϕ^p_t (circles), public ϕ^g_t (triangles) and aggregate ϕ_t (x's) welfare levels.

In addition we report a summary measure of discounted compensating consumption levels over the transitions as fraction of benchmark GDP $\Delta C/Y_0$ where

$$\Delta C = \sum\nolimits_{t=1}^{T-1}\left(\prod\nolimits_{i=0}^{t}\frac{1}{\left(1+r^b_{t+i}\right)}\right)\left(\begin{array}{c} N^g\left(\pi\phi^g_{t-1}c^g_{o,t} + \phi^g_t c^g_{y,t}\right) \\ +N^p\left(\pi\phi^p_{t-1}c^p_{o,t} + \phi^p_t c^p_{y,t}\right)\end{array}\right), \qquad (13)$$

and r^b_t is the period interest rate over 30 years. We chose the length of the transition period T so that the economy fully transitions to the new steady state and ΔC only changes by negligible amounts with increases in T.

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

to 6). 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 and since pensions are indexed to current wages, the pension income of private sector retirees increases. However, 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 whereas all future public sector generations will lose from the reform. Overall the economy gains 3.94, 0.127, 0.42, or 0.25 percent of benchmark GDP in terms of discounted compensating consumption when either labor taxes, capital taxes, spending in public capital, or spending in public education adjust to clear the government budget in the new policy regime with lower public pensions.

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.

Conesa and Krueger (1999) identify a status quo bias in pension reform that is stronger when the income heterogeneity among agents is large. Since our agents are identical within each age cohort (except for the private/public split) our model understates the status quo bias. In addition we do not model the asymmetric political influence of civil servants who are hardest hit by the pension reform. It is therefore likely that the political reform is harder to implement than our welfare analysis suggests.

4.5 The Optimal Usage of Released Public Funds

In the previous experiments we have analyzed the efficiency effects and the welfare effects of reallocating government funds from non-productive public pensions into tax cuts or investments into either productive public education or productive investments into public capital. In these experiments we restricted the government to change only one policy variable at a time so that we could

separate "opportunity cost effects" from the "tax effects". We next allow the government to change more than one policy variable simultaneously and analyze whether there is an optimal rule of how to invest the freed up resources from the pension reform. We again use the sum of the discounted compensating consumption streams over the transitions ΔC as our welfare measure and postulate that the government wants to maximize welfare according to this measure.

We first consider the case in which the government assumes labor taxes are fixed. Freed up resources can then only be "spent" by (i) decreasing the capital income tax rate τ_K, (ii) increasing the fraction of GDP spent on public education Δ_E and (iii) increasing the fraction of GDP spent on public investment Δ_G. Analytically these options translate into the following inequalities:

$$\Delta_{E,t} \geq \Delta_{E,0},\ \Delta_{G,t} \geq \Delta_{G,0} \text{ and } \tau_{K,t} \leq \tau_{K,0}, \tag{14}$$

where $\Delta_{E,0}$, $\Delta_{G,0}$ and $\tau_{K,0}$ are the policy parameters of the benchmark steady state before the pension reform. We reformulate the government budget constraint slightly and collect the policy parameters that the government can change on the left hand side so that

$$\left(\Delta_{E,t} + \Delta_{G,t} - \tau_{K,t}\alpha_2\right) Y_t = \left\{ \begin{array}{c} \left(B_{t+1} - \left(1 + r_t^b\right) B_t\right) + \left(\tau_{L,t}^{ssg} + \tau_{L,t}^{g}\right) w_t^g H_t N_t^g \\ + \left(\tau_{L,t}^{ssp} + \tau_{L,t}^{sspf} + \tau_{L,t}^{p}\right) w_t^p H_t N_t^p + (1-\pi) R_t K_t \\ - \left(\begin{array}{c} \Delta_{C_g,t} Y_t + \pi \Psi^p w_t^p H_t N_{t-1}^p \\ + w_t^g H_t N_t^g + \pi \Psi^g w_t^g H_t N_{t-1}^g \end{array} \right). \end{array} \right. \tag{15}$$

The government problem is then to solve

$$\max_{\left\{\Delta_{E,t}, \Delta_{G,t}, \tau_{K,t}\right\}_{t=1}^{T}} \left\{ W(T) \text{ s.t. } (14) \text{ and } (15) \text{ for all } t = 1, ..., T \right\},$$

where $W(T)$ is a measure for aggregate welfare over the consumption period T.[10] Let $\frac{\partial W(T)}{\partial \Delta_{E,t}}$, $\frac{\partial W(T)}{\partial \Delta_{G,t}}$, $\frac{\partial W(T)}{\partial \tau_{K,t}}$ be the marginal welfare effects of investments in public education, investments in public capital and the capital income tax in each transition period $t = 1, ..., T$. Without the policy restriction (14) the government can adjust all policy parameters until the marginal effects of the policies on social welfare are identical across the policy parameter space, i.e. $\frac{\partial W(T)}{\partial \Delta_{E,t}} = \frac{\partial W(T)}{\partial \Delta_{G,t}} = \frac{\partial W(T)}{\partial \tau_{K,t}}$, which is the "first best" policy. However, in our case

[10] As described above we use the sum of the discounted compensatin consumption streams over the entire transition period.

the government faces the policy restriction (14). The optimal mix of allocation rules now depends on the ranking of the magnitudes of the marginal welfare effects. The government first allocates funds to the activity that has the largest positive effect on marginal welfare.

Since the government problem is fairly complex we are unable to obtain closed form solutions to identify the welfare function derivatives. We therefore conduct a numerical analysis. The government first fixes the labor tax rate at the initial steady state value so that $\tau_{L,t} = \tau_{L,0} = 15.362$ percent for all $t = 1, ..., T$. The government then decreases public pension payments and can use the freed up resources to either finance a decrease in capital taxes $\tau_{K,t}$, an increase in public education spending $\Delta_{E,t}$ or an increase in investments into public capital $\Delta_{G,t}$. Since we want to present all possible combinations in a table, we combine the spending fractions $\Delta_{E,t}$ and $\Delta_{G,t}$ by introducing a variable a_t that measures the fraction of total spending $\Delta_{E,t} + \Delta_{G,t}$ into public education, that is

$$\begin{aligned} \Delta_{E,t} &= a_t \times (\Delta_{E,t} + \Delta_{G,t}), \text{ so that} \\ \Delta_{G,t} &= (1 - a_t) \times (\Delta_{E,t} + \Delta_{G,t}). \end{aligned}$$

If $a_t = 0$, then the government's additional investments go only to public capital, whereas if $a_t = 1$ the government's additional investments go exclusively to public education. In table 4 we plot this fraction against the capital tax rate and report the resulting measures for aggregate discounted welfare of the various combinations of a_t and $\tau_{K,t}$. When calculating this table we hold the ratio of $\Delta E_t / \Delta G_t = a_t / (1 - a_t)$ and the capital tax rate $\tau_{K,t}$ fixed over the entire transition period.

We find that if the government does not lower the capital tax rate so that $\tau_{K,t} = \tau_{K,0} = 15.5$ and also leaves the fraction of public education spending unchanged at its original steady state value $a_t = a_0 = 0.714$ for all $t = 1, .., T$, then the resulting welfare gain in the new steady state is 3.323 percent of benchmark GDP, measured in terms of the sum of discounted compensating consumption streams.[11] It should be understood that the levels of $\Delta_{E,t}$ and $\Delta_{G,t}$ do adjust in reaction to the lower public pension payments that create

[11] Note again that our welfare measure is $\Delta C / Y_0$ where ΔC is the sum of the discounted stream of compensating consumption streams. If this value is -3.323 it means that the households could give up discounted consumption streams worth 3.323 percent of benchmark GDP in order to become indifferent between the reform and the status quo over the transition periods. A negative number therefore indicates a welfare gain.

leftover funds that can be spent otherwise. The deviation of the optimal policy ($a_t = 0.7$) to the current policy ($a_0 = 0.714$) is small. The latter means that additional welfare gains can be achieved by investing relatively more funds in public education as opposed to investments into a public capital. Similarly the government could decrease the capital tax rate $\tau_{K,t}$ which would trigger smaller increases in the endogenously adjusting variables $\Delta_{E,t}$ and $\Delta_{G,t}$ (in reaction to the decrease in public pensions). In this case, fewer of the freed up resources would go towards public education and public capital as some of it is given back to households via the lower capital tax. From table 4 we see that decreasing the capital tax rate from 15 to 12 percent can still produce welfare gains. However, these gains are smaller as the reduction in capital tax distortions produces smaller welfare gains than investments into education and public capital. In this sense it is always better to invest freed up resources than to allow for tax cuts.

We also conduct a similar analysis fixing the capital tax rate $\tau_{K,t} = \tau_{K,0}$ for all $t = 1, .., T$ and allowing the government to adjust

$$\Delta_{E,t} \geq \Delta_{E,0},\ \Delta_{G,t} \geq \Delta_{G,0} \text{ and } \tau_{L,t} \leq \tau_{L,0}.$$

We report the results of this analysis in table 5. We find similar results that suggest that distortions from labor taxes are smaller than gains from investments into public education and public capital.

5 Sensitivity Analysis

In this section we investigate 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 6. We normalize output of the model with $\Psi^g = 1.5$ to one hundred to facilitate the comparison of the post reform steady states with the benchmark economy. As we decrease the generosity of public pensions from $\Psi^g = 1.5$ to $\Psi^g = 1$ steady state output increases by 10 percent in the benchmark case. If parameter γ_1 is increased to 0.15 then the output effect is even larger (15 percent of

GDP) since now the freed up resources are invested in public education which becomes more and more productive as γ_1 increases.

The effect of changes in γ_2 are reported in table 7. We find that larger values for γ_2 result in larger output effects as investments into public capital adjust to clear the government budget constraint.

In addition, we investigate the sensitivity of our analysis with respect to changes in χ_1, the relative productivity of public education (infrastructure) spending vs. human capital employed in the public education sector. We find that increases in χ_1 results in increases of the effects of the reform as one would suspect in this case.

Little is known in the empirical literature on education production functions of developing countries and about the elasticity of substitution between teachers and material education inputs, parameter η_1. In table 8 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 8 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 percent 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 percent to 4 percent of GDP.

Final goods and services production function. In table 10 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 percent and 15 percent. 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 11 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. In addition we investigate how the public capital depends on changes in χ_2 in table 12. We find that when the productivity of human capital is lower (say from $\chi_2 = 1$ to $\chi_2 = 0.8$) relative to public sector capital, then the reform that adjusts investments into the public capital has larger effects by about 1 percent of GDP as output increases from 110.7 to 111.6 (see second column in table 12).

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 analysis. We found that (*i*) the direct effects of pension reform through savings of civil servants are relatively small but the total savings effects are large at up to 4 percent of GDP, (*ii*) the effects from reducing tax distortions are large at up to 15 percent of GDP, and (*iii*) the indirect effects from reinvesting freed up resources into public education or infrastructure are also substantial at up to 10 percent 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 for the current generation of private sector retirees. These workers will experience 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. Since many other developing and emerging economies have similar generous pension systems (e.g. Palacios and Whitehouse (2006) and Gupta et al. (2009)) we expect our results to hold beyond the case of Brazil. This result should also hold if population growth and aging of the

population is taken into consideration.

In this paper we have concentrated on the influence of public sector pension reform on capital accumulation and the allocation of government resources to different productive sectors. The public pension reform may also have important effects on the employment sector choice of workers and the allocation of human capital across sectors. We leave the exploration of these channels for future research.

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
	$\alpha_1 = 0.1$	Ferreira and do Nascimento (2005)
	$\alpha_2 = 0.4$	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 the size of the 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	$\theta = 42\%$	

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

	τ_K	0.12	0.13	0.14	0.15	0.155
	0.200	6.899	3.284	2.588	2.061	1.848
	0.300	1.986	1.061	0.366	-0.162	-0.376
	0.400	0.585	-0.336	-1.029	-1.558	-1.773
	0.500	-0.317	-1.235	-1.928	-2.457	-2.673
a	0.600	-0.836	-1.753	-2.445	-2.975	-3.191
	0.700	-0.985	-1.900	-2.592	-3.121	-3.337
	0.710	-0.977	-1.892	-2.584	-3.113	-3.329
	0.714	-0.962	-1.887	-2.579	-3.108	-3.323
	0.720	-0.954	-1.869	-2.560	-3.089	-3.305
	0.730	-0.938	-1.852	-2.543	-3.072	-3.288
	0.740	-0.916	-1.831	-2.522	-3.051	-3.263

Table 4: **The Optimal Usage of Released Public Funds.** Aggregate welfare is measured in terms of discounted compensating consumption streams over the transition period as fraction of GDP in the initial period. We fix $\tau_L = 15.36$. Negative numbers indicate welfare gains. The maximum welfare gain possible is additional consumption in the amount of 3.337 percent of GDP.

	τ_L	0.12	0.13	0.14	0.15	0.1535
	0.200	11.268	5.897	3.915	2.346	1.848
	0.300	6.191	3.562	1.641	0.107	-0.376
	0.400	4.664	2.093	0.208	-1.299	-1.773
	0.500	3.683	1.148	-0.715	-2.204	-2.673
a	0.600	3.120	0.605	-1.245	-2.725	-3.191
	0.700	2.961	0.451	-1.394	-2.872	-3.337
	0.710	2.974	0.460	-1.386	-2.853	-3.329
	0.714	2.979	0.468	-1.381	-2.847	-3.323
	0.720	2.988	0.476	-1.374	-2.840	-3.305
	0.730	3.006	0.494	-1.353	-2.823	-3.288
	0.740	3.031	0.517	-1.331	-2.798	-3.263

Table 5: **The Optimal Usage of Released Public Funds**. Aggregate welfare is measured in terms of discounted compensating consumption streams over the transition period as fraction of GDP in the initial period. We fix $\tau_K = 15.5$. Negative numbers indicate welfare gains. The maximum welfare gain possible is additional consumption in the amount of 3.337 percent of GDP.

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

	Ψ	1	1.25	1.5	1.6
	0.300	108.014	104.523	100.000	97.169
	0.400	108.916	105.082	100.000	96.747
γ_2	0.500	110.288	105.927	100.000	96.114
	0.600	112.624	107.357	100.000	95.065
	0.700	117.481	110.299	100.000	92.986

Table 7: 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 8: Change in Output with Δ_E adjusting

	Ψ	1	1.25	1.5	1.6
	0.100	107.201	104.019	100.000	97.555
	0.150	108.798	105.008	100.000	96.802
χ_1	0.200	110.288	105.927	100.000	96.114
	0.250	111.682	106.782	100.000	95.484
	0.300	112.988	107.580	100.000	94.905

Table 9: Change in Output with Δ_E adjusting ($\eta_2 = 0.5$)

	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 10: 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 11: Change in Output with Δ_G adjusting

	Ψ	1	1.25	1.5	1.6
	0.800	111.575	106.246	100.000	97.027
	0.900	111.092	105.979	100.000	97.158
χ_2	1.000	110.663	105.743	100.000	97.275
	1.100	110.280	105.531	100.000	97.380
	1.200	109.936	105.340	100.000	97.475

Table 12: Change in Output with Δ_G adjusting

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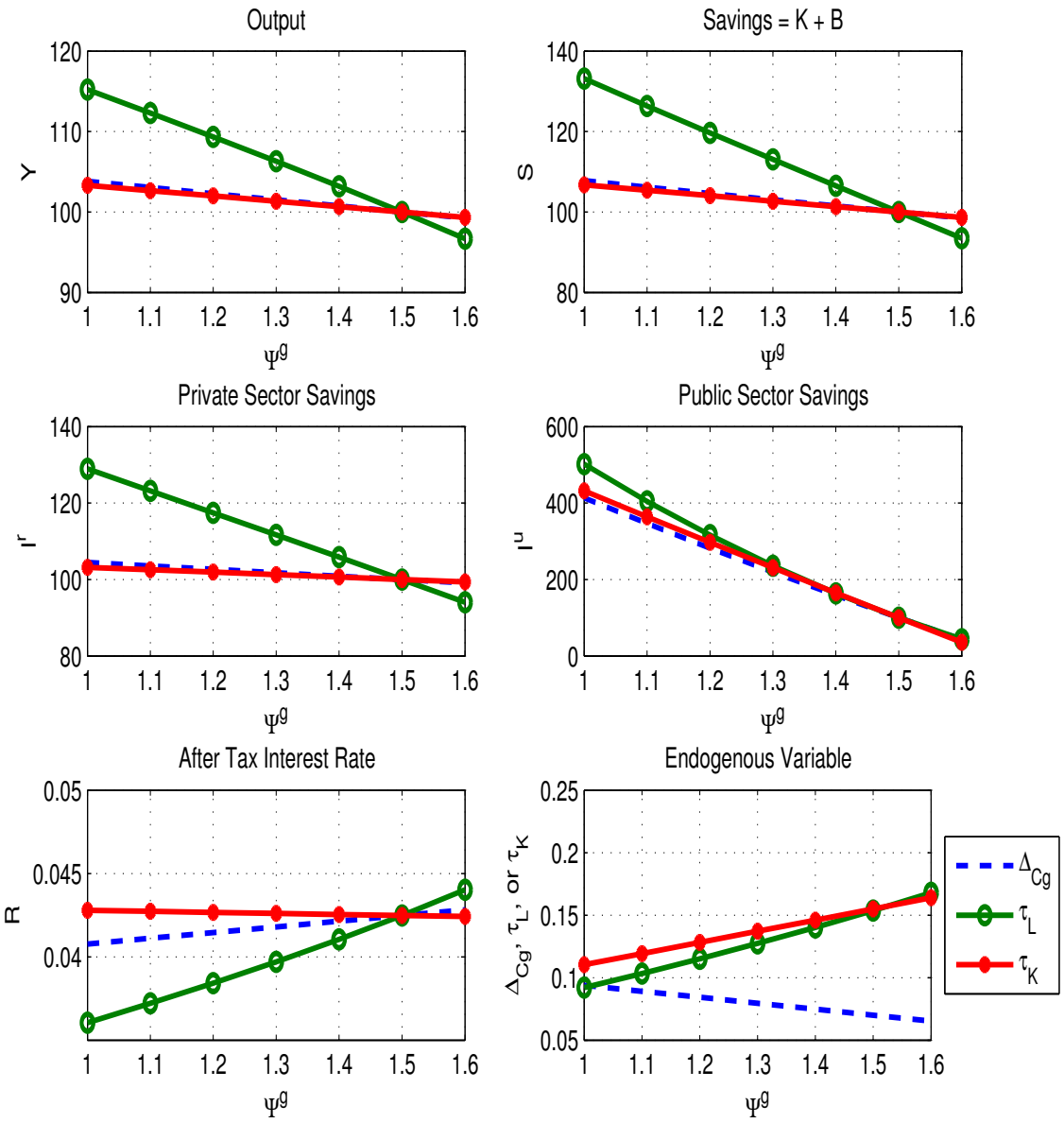

Figure 1: Effect of decreasing public sector pensions Ψ^g and decreasing labor taxes τ_L or capital taxes τ_K

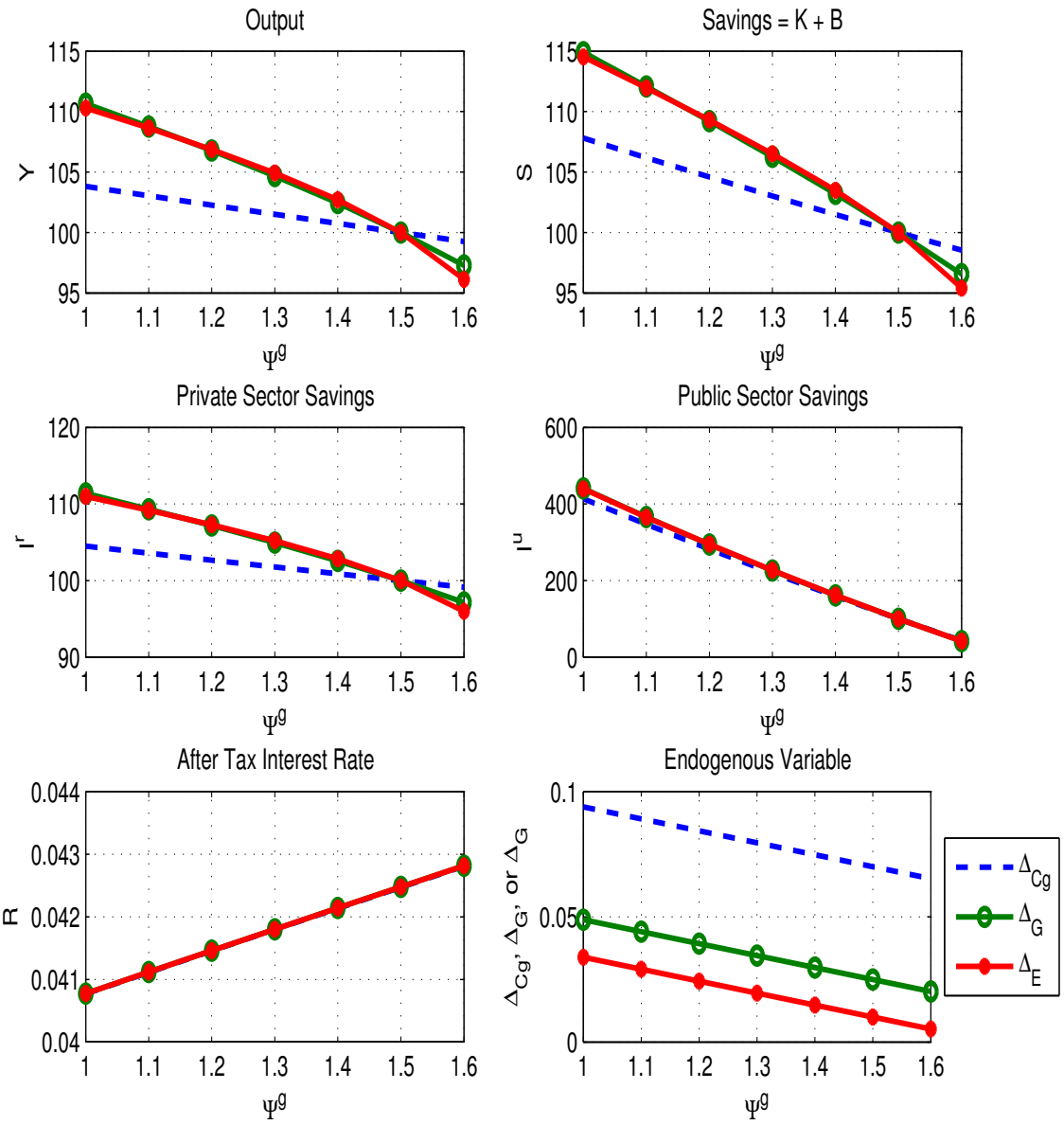

Figure 2: Effect of decreasing public sector pensions Ψ^g and increasing public investment Δ_G or public education Δ_E

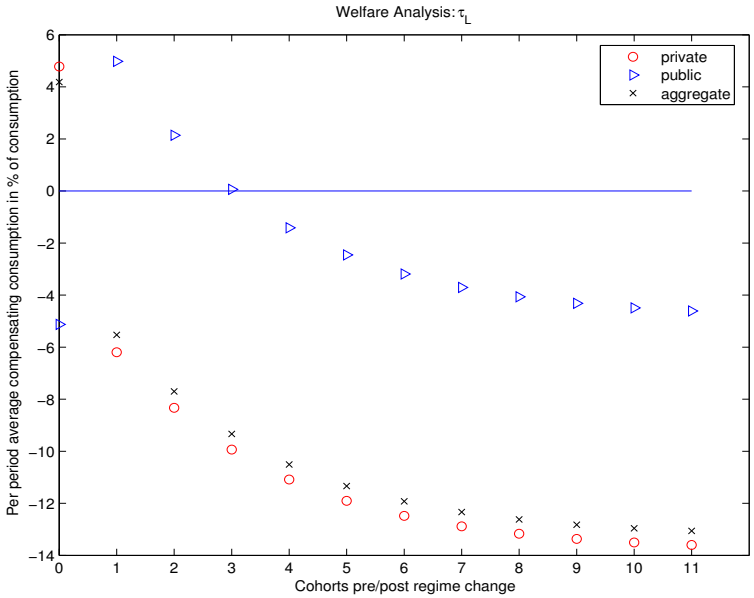

Figure 3: Compensating consumption given to individuals to offset the policy change that reduces the generosity of public pension replacement rate $\Psi^g = 1.5$ to $\Psi^g = 1.0$ letting capital tax τ_L adjust to clear the government budget constraint. Compensating consumption is expressed as the average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

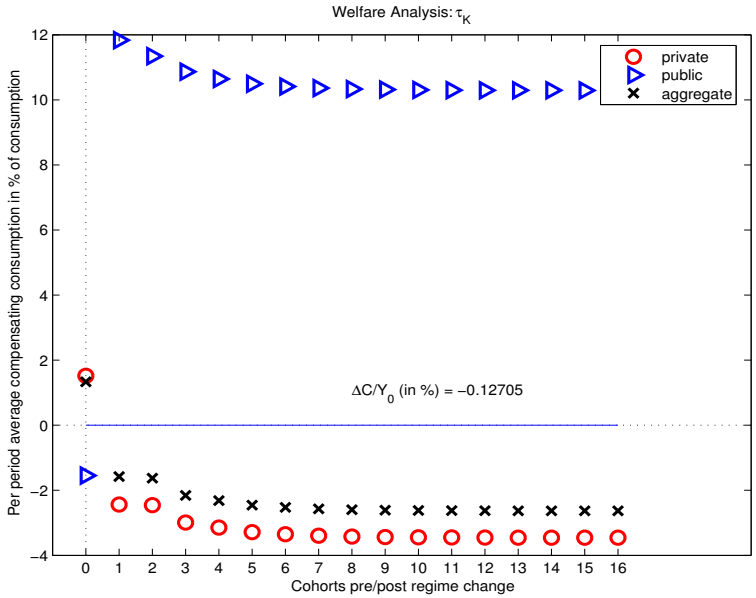

Figure 4: Compensating consumption given to individuals to offset the policy change that reduces the generosity of public pension replacement rate $\Psi^g = 1.5$ to $\Psi^g = 1.0$ letting capital tax τ_K adjust to clear the government budget constraint. Compensating consumption is expressed as the average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

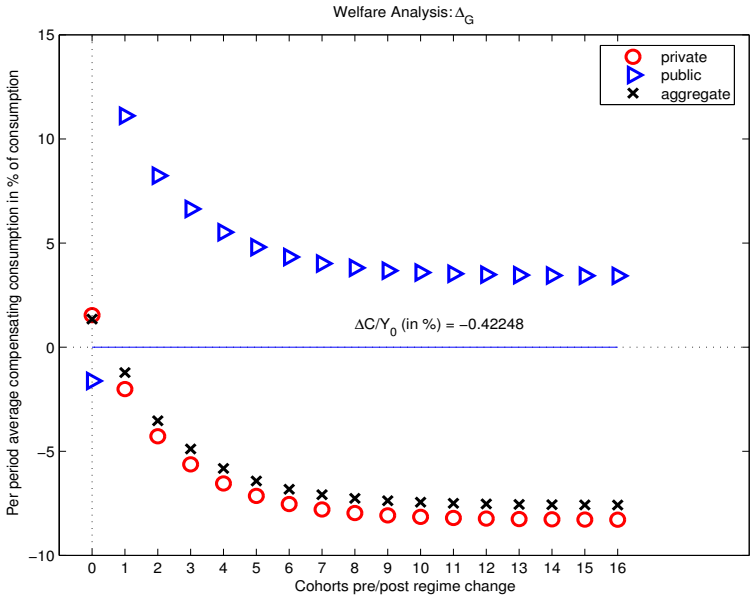

Figure 5: Compensating consumption given to individuals to offset the policy change that reduces the generosity of public pension replacement rate $\Psi^g = 1.5$ to $\Psi^g = 1.0$ letting investments into public capital Δ_G adjust to clear the government budget constraint. Compensating consumption is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

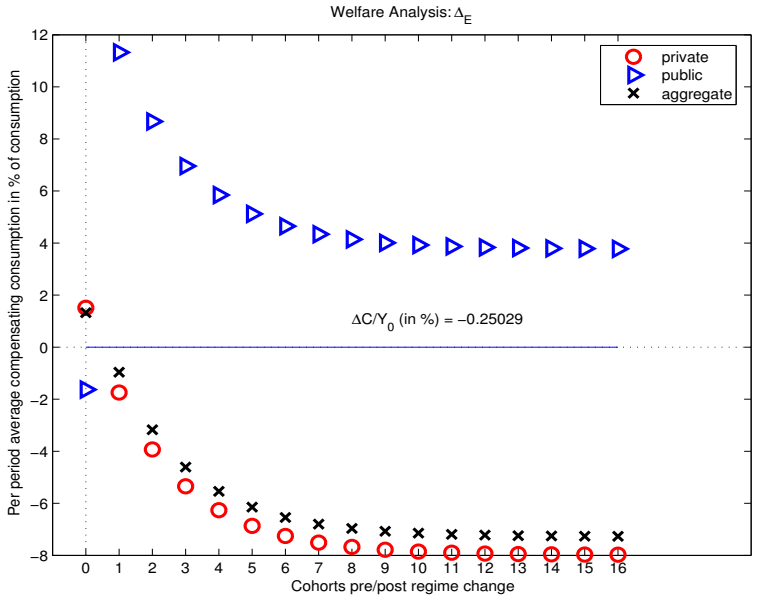

Figure 6: Compensating consumption given to individuals to offset the policy change that reduces the generosity of public pension replacement rate $\Psi^g = 1.5$ to $\Psi^g = 1.0$ letting public education expenditures Δ_E adjust to clear the government budget constraint. Compensating consumption is expressed as the average percentage of current value per period compensating consumption over current value consumption.

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