Macroeconomic Implications of Early Retirement in the Public Sector: The Case of Brazil

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28th September 2006

Abstract

In Brazil generous public sector pensions have induced civil servants to retire on average at age 55. In this paper we use an OLG model to assess the effects of such policy induced early retirement on capital accumulation and long-run income levels. We calibrate the model to data from Brazil and then conduct policy experiments changing the generosity of (early) public sector pensions. We find that the current generosity of public sector pensions which induces civil servants to retire 10 years prematurely (at age 55 rather than at age 65) is often associated with decreases in steady state output (GDP) of over 2 percent and welfare losses in the private sector of more than 1 percent of consumption.

JEL Classification: H55

Keywords: Early Retirement, Pension reform, Capital accumulation.

*We would like to thank participants at the Midwest Macroeconomics Meetings at Washington University in St. Louis, the EEA-ESEM 06 Conference in Vienna, the 62nd Congress of the International Institute of Public Finance in Paphos-Cyprus, the PET 06 Conference in Hanoi, and Stephen Parente 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

1 Introduction

"Early" retirement has become common in the industrialized economies. As is evident from table 1 from Blöndal and Scarpetta (1998a), effective retirement age in the European Union for men has dropped from about 66 in 1960 to about 61 in 1995, even though life expectancy has increased by about 7 years in this period. The retirement age for women has experienced a similar drop. In some instances the drop in labor force participation among mature males has been spectacular. In France labor force participation of males between the ages of 60 and 64 dropped from over 84% in 1960 to below 20% in 2000. In the Netherlands the corresponding numbers are over 68% in 1960 and less than 18% in 2000. Such early retirement provisions can be very costly. Table 2, which is taken from Herbertsson and Orszag (2003), illustrates that such costs can be larger than 10% of GDP.

Explanations for the drastic increase in early retirement can be found in Gruber and Wise (1998, 1999), Blöndal and Scarpetta (1998a), Visco (2000), Herbertsson (2001), Blundell, Meghir and Smith (2002), Herbertsson and Orszag (2003), Conde-Ruiz, Galasso and Profeta (2005) and Wise (2005). These papers establish a credible empirical link between the design of pension systems and early retirement decisions. Michel and Pestieau (1999), Ahituv and Zeira (2000), Cremer and Pestieau (2003) and Fehr, Sterkeby and Thogersen (2003) among others, use overlapping generations models to study how social security policies influence retirement decisions. Rust and Phelan (1997) and Jimenez-Martin and Sanchez (2003) estimate life cycle models with social security programs to assess the impact of these programs on retirement behavior. Kopecky (2005) argues that early retirement among males in the US can be explained by an increase in the real wage and a decrease in the price of leisure goods.

The literature on early retirement for the most part has focused on the industrialized world and ignored developing countries. While this emphasis is justified to some degree, generous pension schemes and early retirement issues are not wholly absent in developing countries.

In Brazil for example, civil servants retired on average at the age of 54 in 2002 (it was 49 in 1988). Figure 1 illustrates the retirement age distribution of civil servants of the federal government.[1] The public pension system in Brazil ranks among the most generous in the world. Public sector pensioners account for about 5% of all pensioners, yet receive about 50% of the value of all pension payments. The average contribution rate to public section pensions, 11%, is far lower than the 27% contribution rate in the urban private sector. According to Souza et al. (2004) the deficit of the public sector pension system amounts to 3.5% of private sector output. "Integrality" ensures that pensions received equal the highest (last) income of the public sector employee. This level of generosity was even surpassed in the military and police force, where the first pension payment matched the highest salary one pay grade higher. Phantom promotions just before retirement may contribute even more to the generosity of public sector pensions. "Parity" ensures that pension payments are indexed to wages of current civil servants. After retiring from the civil service, workers are allowed to accept jobs in the private sector and also receive public sector pensions.

There is a relatively small literature studying the macroeconomic effect of pension reform in developing countries generally or in Brazil specifically. Ferreira (2004) studies social security reform in Brazil in the context of a small open economy. He finds large welfare gains from social security reform. Ferreira (2005) studies the redistributional effect of social security reform along the transition in Brazil. Glomm et al. (2005) study the macroeconomic effects of generous public sector pensions, concentrating on opportunity costs of foregone public education expenditure and infrastructure investment. They abstract from early retirement effects. In this paper we focus only on the early retirement effects of generous pensions to civil servants. We only consider one channel: Generosity of public sector pensions causes early retirement which is costly and has to be financed by taxes, which in turn influence capital accumulation and long-run (steady state) income.

We use an overlapping generations model where a period is five years and where individuals become economically active at age 20 and die for sure at age 80. The government hires civil servants and invests in a public capital that together produce a productive public good. Retirement among civil servants may occur endogenously at ages $50, 55, 60$ or 65 depending on the design

[1] In 1998, a minimum retirement age for civil servants was established at age 53 for men and age 48 for women.

of the pension system. Upon early retirement civil servants are free to pursue employment in the private sector. All government expenditures are financed by taxes on labor and on capital income. The government budget is assumed to be balanced in each period. We calibrate the model to data from Brazil. We calculate steady state equilibria as well as transition paths between pre- and post reform steady states.

In the calibrated model we calculate public pensions levels which leave civil servants exactly indifferent between the aforementioned retirement ages. We find that decreasing generosity of public sector pensions from levels where all civil servants retire at age 55 to levels where they retire at age 65 increases steady state private sector output by about 2% when capital tax rates adjust to clear the government budget and early retirees worked 40% of their time on average in the private sector. Effects of similar magnitude are obtained when the government adjusts the labor tax to clear the government budget. We find that the quantitative effects are fairly robust to changes in the parameters. Apart from a grand-fathering effect, transitions indicate a smooth monotone progression between steady state output levels.

The paper is organized as follows. The next section describes the model. Section 3 contains the definition of competitive equilibrium. In section 4 we solve the model. In section 5 we calibrate the model to Brazil and in section 6 we conduct policy experiments. We conduct extensive sensitivity analysis for these policy reform experiments. Section 7 concludes. The appendix contains all tables and figures.

2 The Model

There is a large number of individuals who live for 12 periods in an OLG set-up. Each period accounts for 5 years, with working life beginning at age 20 and life ending for sure at age 80. There are two types of agents, public sector workers (or civil servants) and private sector workers. For workers in the private sector retirement is assumed to occur only after period $J_1 = 9$, which corresponds to age 65. Agents retire for $J_2 = 3$ periods, so that

$$J_1 + J_2 = 12.$$

While all workers in the private sector retire at period 9 (age 65), civil servants can retire early, that is before period 9 (age 65).

All civil servants face the same wage scheme and pension scheme. The wage scheme for civil servants is set by the government, and thus differs from the market-determined wage scheme for private sector workers. The pension scheme for civil servants differs from the scheme for private sector workers in contribution rates, in benefit payments, as well as the possibility of participating in an early retirement program. For them the number of periods worked $(J_1 - J_e)$ and the number of periods in retirement $(J_2 + J_e)$ are endogenous. The length of early retirement is denoted J_e where we allow for $J_e = 0, 1, 2, 3$ early retirement periods. The number of early retirement periods is chosen endogenously by public sector workers. Thus the starting period of early retirement is $J_1 - J_e + 1$ and the final period of early retirement is J_1. Standard retirement of public sector workers starts at age $J_1 + 1$ and lasts until $J_1 + J_2 = 12$. In this period all workers, public and private are retired and not allowed to work anymore.

It is not uncommon in Brazil for public sector early retirees to take a job in the private sector. The possibility of receiving pension payments while working elsewhere constitutes a strong incentive for early retirement. According to Bonturi (2002) public sector early retirees were even able to draw pension payments while working at a different public sector job. We account for this by letting public sector early retirees work in the private sector for a fraction $(1 - L)$ of their time. This choice is discrete: the public sector retiree either works $(1 - L)$ of the time in the private sector or not at all.

Human capital over the life-cycle evolves according to

$$h^{\nu}_{j,t+j-1} = e^{\beta^{\nu}_0 + \beta^{\nu}_1 j + \beta^{\nu}_2 j^2},\ \nu = \{p, g\}\,,$$

where $\beta^{\nu}_0, \beta^{\nu}_2 < 0$ and $\beta^{\nu}_1 > 0$. This functional specification allows for a hump-shaped income-age profile as shown in figure (2) . Here and in the rest of the paper the superscripts p and g denote private sector workers and government workers (civil servants), respectively. Once agents retire, their human capital stays constant by assumption. We assume that for all cohorts at all time periods and all ages public sector wages exceed those in the private sector in order to mimic the more generous public sector compensation scheme, but we maintain the assumption that all workers of a given age are equally productive regardless of whether they work in the public or private sector.[2]

In each period there is an exogenous survival probability of cohort i which we denote π_i. The worker dies for sure after J periods and leaves an accidental bequest that is taxed and redistributed to the newborn cohort by the government.[3] Population grows exogenously at net rate n. We assume stable demographic patterns so that similar to Huggett (1996) age i agents make up a constant fraction μ_i of the entire population at any point in time.

In addition, we assume that at time t there is a newborn generation whose size is normalized to $\frac{1}{J}$ with initial human capital level h_{1t}. Since agents face the probability of dying $(1 - \pi_1)$ before age 20, the human capital "supplied" by this generation is $\frac{1}{J} h_{1t} \pi_1$. At time $t + 1$ the newborn cohort supplies $(1 + n) \frac{1}{J} h_{1t+1} \pi_1$ etc. If every cohort is born with the same human capital level, so that $h_{1t} = h_{1t+1}$ (i.e., the shift factor $\Theta = 1$) then aggregate human capital follows

$$H_{t+1} = (1 + n) H_t.$$

To simplify the notation we will from now on drop the time subscripts for individual human capital. If we detrend human capital by $(1 + n)$ we see that the share of human capital of each cohort i as fraction of aggregate human capital, denoted as μ_{it}, stays constant. The fraction μ_i is recursively defined as

$$\mu_i = \frac{\pi_i}{(1 + n)} \mu_{i-1}.$$

Since the population grows exogenously at rate n, we know that human capital, physical capital and output all grow at rate n as well. The fraction dying each period (conditional on survival up

[2]This assumption greatly simplifies the analysis of the model. Tran (2006) contains a more realistic model of the choice between employment in the public or private sector.

[3]An alternative redistribution method is to divide the after tax bequests equally among all individuals alive as in Huggett (1996). It turns out that the results are not affected by the way the government redistributes bequests.

to the previous period) can be defined similarly as

$$\upsilon_i = \frac{1 - \pi_i}{(1 + n)} \mu_{i-1}.$$

We assume that the government hires a constant fraction of each age cohort so that the total number N^g of workers in the civil service is constant. With early retirement the fraction of each cohort employed by the public sector has to increase in order to maintain the absolute number N^g of workers in the public sector. We define n^g as the fraction of public sector workers, whereas n^p is the corresponding fraction of private sector workers. Formally, this implies

$$n^g = \frac{N^g}{\sum_{i=1}^{J_1 - Je} \mu_i} \text{ and } n^p = (1 - n^g).$$

Agents value a single consumption good and during the early retirement phase they also value leisure. The utility function of a member of generation t is

$$V = \sum_{j=1}^{12} \beta^{j-1} \left(\prod_{i=1}^{j} \pi_i \right) \left[\frac{(c_{j,t+j-1})^{1-\sigma}}{1 - \sigma} \right] + \sum_{k=J_1 - J_e}^{J_1} \beta^{k-1} \left(\prod_{i=1}^{k} \pi_i \right) \theta L_{k,t+k-1}, \tag{1}$$

where $c_{j,t+j-1}$ is consumption of the private good of an agent with age j at calendar time $t+j-1$.

The variable $L_{k,t+k-1}$ is the fraction of time consumed as leisure during the periods of early retirement. It represents the average public sector retirees' participation rate in the private sector and is exogenous in the model. In this specification of preferences, leisure is introduced only as a vehicle that generates endogenous retirement decisions among civil servants in the relevant age range. At $J_1 + 1$ the agent transitions into "normal" retirement and hence we drop the variable for leisure in the utility functions, since all agents, private and public, will be fully retired at that time, for J_2 periods in total. We assume $0 < \theta$.

The privately supplied good is produced from three inputs, the public good 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 depreciates at rate δ_p each period. The public good in the production function can be thought of as the stock of public infrastructure such as toll free roads. This public good is made available to all firms at a zero price. Specifications of the technology similar to this one have been used by Barro (1990) and Turnovsky (1999), for example.

The government uses effective labor (human capital) of civil servants and public capital K_t^G to produce infrastructure capital according to

$$G_t = Z\left[\left(K_t^G\right)^\eta + \chi\left(\omega_h H_t^g\right)^\eta\right]^{1/\eta}, \tag{2}$$

where $Z, \chi > 0$ and $\eta \leq 1$. The fraction of civil servants contributing to the production of the public good is denoted $\omega_h \in (0,1)$. 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. Public capital evolves according to

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

where public investment I_t^G is financed through taxes on labor and capital income.

The government finances investment in public capital $I_{G,t} = \Delta_{G,t} Y_t$, where $\Delta_{G,t}$ is the fraction of private sector output allocated to public investments. The governmental wage bill for its currently employed civil servants is

$$n^g \sum_{j=1}^{J_1-J_e} w_t^g h_j^g \mu_j.$$

In addition to the wage bill the government finances three kinds of transfers to the old. The first type of transfer payment is pension payments to private sector workers. These private sector pensions are functions of current private sector wages and the payment received by each private retiree is given by

$$T_{j,t+j-1}^p\left(w_{t+j-1}^p, h_{J_1}^p\right) = \Psi^p w_{t+j-1}^p h_{J_1}^p.$$

Transfer payments to each public sector worker who retires early depend upon the retirement age. In the early retirement period from $J_1 - J_e + 1$ to period J_1 the transfer is given by

$$T^g_{1,j,t+j-1}\left(w^g_{t+j-1}, h^g_{J_1-J_e}\right) = \Psi^g_1 w^g_{t+j-1} h^g_{J_1-J_e},$$

and thereafter it is given by

$$T^g_{2,j,t+j-1}\left(w^g_{t+j-1}, h^g_{J_1-J_e}\right) = \Psi^g_2 w^g_{t+j-1} h^g_{J_1-J_e}.$$

The government sets the pension replacement rates for the private sector Ψ^p as well as the replacement rates for the public sector in the early retirement phase Ψ^g_1 and the standard retirement phase Ψ^g_2. The replacement rates are defined as a fixed fraction of the last wage payment received by the worker. The parameter values of Ψ^g_1 and Ψ^g_2 will be chosen to capture the principle of "integrality" in the public sector.

The government collects labor income taxes in the private and public sector at the rates $\tau^p_{L,t}$ and $\tau^g_{L,t}$, pension income is taxed at rate $\tau_{R,t}$ and accidental bequests are taxed at $\tau_{B,t}$. The government also taxes capital income $q_t K_t$ at the rate $\tau_{K,t}$, where q_t is the capital rental rate. We can thus express government revenues as

$$\tau^g_{L,t} n^g \sum\nolimits_{j=1}^{J_1-J_e} w^g_t h^g_j \mu_j + \overbrace{\tau^r_{L,t} n^g \sum\nolimits_{j=J_1-J_e+1}^{J_1} w^p_t h^p_j \mu_j}^{\text{early retirees working in private sector}} + \tau^p_{L,t} n^p \sum\nolimits_{j=1}^{J_1} w^p_t h^p_j \mu_j$$

$$+\tau_{K,t} q_t K_t + \tau_{R,t} n^p \sum\nolimits_{j=J_1+1}^{12} \Psi^p w^p_t h^p_{J_1} \mu_j + \tau_{R,t} n^g \sum\nolimits_{j=J_1-J_e+1}^{J_1} \Psi^g_1 w^g_t h^g_{J_1-J_e} \mu_j$$

$$+\tau_{R,t} n^g \sum\nolimits_{j=J_1+1}^{12} \Psi^g_2 w^g_t h^g_{J_1-J_e} \mu_j + \tau_{B,t} \sum\nolimits_{j=J_1+1}^{12} \left[n^g s^g_j v_j + n^p s^p_j v_j\right]. \tag{4}$$

Finally, we summarize the residual government expenditure as $C_{G,t}$, in the amount $\Delta_{C_{G,t}} Y_t$, where $\Delta_{C_{G,t}}$ is the fraction of private sector output allocated to residual spending in period t. Residual spending includes parts of government consumption (e.g. military expenditure) and is needed to match government policy parameters. Government consumption is thrown into the ocean. The government budget constraint is given by

$$\begin{aligned}
&\Delta_{C_G,t}Y_t + \Delta_{G,t}Y_t + \overbrace{n^g \sum\nolimits_{j=1}^{J_1-J_e} w_t^g h_j^g \mu_j}^{\text{public wages}} + \overbrace{n^p \sum\nolimits_{j=J_1+1}^{12} (1-\tau_{R,t})\, \Psi^p w_t^p h_{J_1}^p \mu_j}^{\text{private pensions}} \\
&\overbrace{+n^g \sum\nolimits_{j=J_1-J_e+1}^{J_1} (1-\tau_{R,t})\, \Psi_1^g w_t^g h_{J_1-J_e}^g \mu_j}^{\text{public pension during early retirement}} + \overbrace{n^g \sum\nolimits_{j=J_1+1}^{12} (1-\tau_{R,t})\, \Psi_2^g w_t^g h_{J_1-J_e}^g \mu_j}^{\text{public pension during standard retirement}} \\
= \;& \tau_{L,t}^g n^g \sum\nolimits_{j=1}^{J_1-J_e} w_t^g h_j^g \mu_j + \tau_{L,t}^p n^p \sum\nolimits_{j=1}^{J_1} w_t^p h_j^p \mu_j + \tau_{K,t} q_t K_t \\
&\underbrace{+\tau_{L,t}^g n^g \sum\nolimits_{j=J_1-J_e+1}^{J_1} w_t^p h_j^p \mu_j}_{\text{retirees working in private sector}} + \underbrace{\tau_{B,t} \sum\nolimits_{j=1}^{12} \left[n^g s_j^g \upsilon_j + n^p s_j^p \upsilon_j \right]}_{\text{accidental bequests}}. \qquad (5)
\end{aligned}$$

When civil servants retire at J_1, the case with standard retirement, the terms $\left(n^g \sum\nolimits_{j=J_1-J_e+1}^{J_1} (1-\tau_{R,t})\, \Psi_1^g w_t^g h_{J_1-J_e}^g \mu_j\right)$ and $\left(\tau_{L,t}^g n^g \sum\nolimits_{j=J_1-J_e+1}^{J_1} w_t^p h_j^p \mu_j\right)$ drop out of the government budget constraint.

3 Equilibrium

3.1 Household Problem

We have two types of households whose utility maximization problems are not identical. The private households cannot retire early so retirement age is not a choice variable. The private household's problem is to maximize utility from expression (1) by choosing the consumption stream $\left\{c_{j,t+j-1}^{p}\right\}_{j=1}^{12}$ subject to the lifetime budget constraint:

$$\sum_{j=1}^{12}\left(\prod_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)c_{j,t+j-1}^{p}=\underbrace{\left[\begin{array}{c}\left(1-\tau_{B,t}\right)T_{B,1}+\sum_{j=1}^{J_1}\left(\prod_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)\left(1-\tau_{L,t+j-1}^{p}\right)w_{t+j-1}^{p}h_{t}^{p}\\+\sum_{j=J_1+1}^{12}\left(\prod_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)\left(1-\tau_{R,t+j-1}\right)\Psi^{p}w_{t+j-1}^{p}h_{J_1}^{p}\end{array}\right]}_{\mathcal{I}_t^p}, \tag{6}$$

where

$$T_{B,1}=\left(\sum_{j=J_1+1}^{12}\left[n^{g}s_{j}^{g}v_{j}+n^{p}s_{j}^{p}v_{j}\right]\right)/\mu_{1} \tag{7}$$

are transfers of accidental bequests to the newborn individual. Private households do not enjoy leisure so that

$$L_{k,t+k-1}^{p}=0,\ \text{for } k=\left\{J_1-J_e,...,J_1\right\}.$$

The optimal savings stream $\left\{s_{j,t+j-1}^{p}\right\}_{j=1}^{12}$ is then calculated as residual from the period budget constraints.

Public households have the possibility to retire early and the option to work a fraction $(1-L)$ of their time in the private sector during early retirement. Their lifetime budget constraint is:

$$\sum_{j=1}^{12}\left(\prod_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)c_{j,t+j-1}^{g}=\underbrace{\left[\begin{array}{c}\left(1-\tau_{B,t}\right)T_{B,1}+\sum_{j=1}^{J_1-J_e}\left(\prod_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)\left(1-\tau_{L,t+j-1}^{p}\right)w_{t+j-1}^{g}h_{j}^{g}\\+\sum_{j=J_1-J_e+1}^{J_1}\left(\prod_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)\left(1-\tau_{R,t+j-1}\right)\Psi_{1}^{g}w_{t+j-1}^{g}h_{J_1-J_e}^{g}\\+\sum_{j=J_1+1}^{12}\left(\prod_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)\left(1-\tau_{R,t+j-1}\right)\Psi_{2}^{g}w_{t+j-1}^{g}h_{J_1-J_e}^{g}\\+\sum_{j=J_1-J_e+1}^{J_1}\left(\prod_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)\left(1-L_{j,t}^{g}\right)\left(1-\tau_{L,t}^{g}\right)w_{t}^{p}h_{j}^{p}\end{array}\right]}_{\mathcal{I}_t^g}. \tag{8}$$

Households working in the public sector enjoy leisure in the potential early retirement periods so that

$$L_{k,t+k-1}^{g}\in(0,1),\ \text{for } k=\left\{J_1-J_e,...,J_1\right\}.$$

The public household's problem is defined as choosing retirement age J^{e} and consumption

$\left\{c^{g}_{j,t+j-1}\right\}_{j=1}^{12}$ to maximize utility from expression (1) subject to the budget constraint (8).

3.2 Firm Problem

The firm's problem is standard. Given the level of public capital it chooses to hire physical capital and human capital to maximize profits. Thus the firm's problem is

$$\begin{array}{l} \max\limits_{\left(H_t^p, K_t\right)} F\left(G_t, K_t, H_t^p\right) - w_t^p H_t^p - q_t K_t, \\ \text{given } \left(w_t^p, q_t, G_t\right). \end{array}$$

3.3 Definition of Equilibrium

Given the government policy $\left\{\tau^{p}_{L,t}, \tau^{g}_{L,t}, \tau^{p}_{B,t}, \tau^{g}_{B,t}, \tau_{K,t}, \tau_{R,t}, \Delta_{G,t}, \Delta_{C_G,t}, w^{g}_{t}, N^{g}, \Psi^{p}, \Psi^{g}_{1}, \Psi^{g}_{2}\right\}_{t=0}^{\infty}$, a competitive equilibrium with standard retirement is a collection of sequences of decisions of privately employed households $\left\{c^{p}_{j,t}, s^{p}_{j,t}\right\}_{t=0}^{\infty}$ and sequences of decisions of publicly employed households of early retirement period $\left\{J_{e,j,t}\right\}_{t=0}^{\infty}$ and of consumption and saving $\left\{c^{g}_{j,t}, s^{g}_{j,t}\right\}_{t=0}^{\infty}$ where $j = \{1, ..., 12\}$, sequences of aggregate stocks of private physical capital and private human capital $\left\{K_t, H^{p}_{t}\right\}_{t=0}^{\infty}$, sequences of aggregate stocks of public physical capital and public human capital $\left\{K^{G}_{t}, H^{g}_{t}\right\}_{t=0}^{\infty}$, sequences of factor prices $\left\{w^{p}_{t}, q_t\right\}_{t=0}^{\infty}$ such that

(i) the sequence $\left\{c^{p}_{j,t}, s^{p}_{j,t}\right\}_{t=0}^{\infty}$ solves the maximization problem of the privately employed household which is maximize (1) subject to (6), and the sequences $\left\{J_{e,j,t}\right\}_{t=0}^{\infty}$ and $\left\{c^{g}_{j,t}, s^{g}_{j,t}\right\}_{t=0}^{\infty}$ solves the maximization problem of the publicly employed household which is maximize (1) subject to (8),

(ii) factor prices are determined by

$$\begin{aligned} q_t &= \alpha \frac{Y_t}{K_t}, \\ w^{p}_{t} &= (1-\alpha)\frac{Y_t}{H^{p}_{t}}, \\ R_t &= (1-\tau_{K,t})\, q_t + 1 - \delta_p, \end{aligned}$$

(iii) capital markets clear[4]

$$K_{t+1} \quad = \quad S_t = n^p \sum\nolimits_{j=1}^{12} \mu_j s_{j,t}^p + n^g \sum\nolimits_{j=1}^{12} \mu_j s_{j,t}^g, \tag{9}$$

$$H_t^p \quad = \quad n^p \sum\nolimits_{j=1}^{J_1} \mu_j h_j^p + \overbrace{n^g \sum\nolimits_{j=J_1-J_e+1}^{J_1} \mu_j h_j^p}^{\substack{\text{public sector early retirees} \\ \text{working in private sector}}},$$

$$H_t^g \quad = \quad n^g \sum\nolimits_{j=1}^{J_1-J_e} \mu_j h_j^p,$$

(iv) commodity markets clear[5]

$$\sum\nolimits_{j=1}^{12} C_{j,t}^p + C_{j,t}^g + S_t + I_{G,t} + C_{G,t} = Y_t,$$

(v) bequests are returned to new born cohorts

$$T_{B,1,t} = \frac{n^p \sum\nolimits_{j=1}^{12} \upsilon_j s_{j,t}^p + n^g \sum\nolimits_{j=1}^{12} \upsilon_j s_{j,t}^g}{\mu_1},$$

(vi) and the government budget constraint (5) holds.

4 Solving the Model

4.1 Household's Optimal Choice

Optimal Consumption and Saving

[4]Since private and public sector workers are equally productive, we use vector h^p for both private and public sector workers in the accumulation of producing human capital.

[5]Since the public good G is an input into private sector production of Y, the public sector wage bill is already contained in the measure of Y. For simplicity we do not take net exports into account when expressing policy parameters as percentage of GDP. Since according to Bank (2006) net exports in Brazil are only approximately 1.5% of GDP we think this is an acceptable compromise.

Private and public sector workers have differing income streams over their life-cycle. Due to the generosity of the public sector compensation scheme, lifetime income of public sector workers is higher than that for private sector workers.[6] Therefore, the government can directly set the number of public sector workers N^g it wants to employ. The first order conditions for the households problem with respect to consumption are

$$c^{\nu}_{j,t+j-1} : \beta^{j-1}\pi_j \left(c^{\nu}_{j,t+j-1}\right)^{-\sigma} = \left(\prod\nolimits_{k=1}^{j} \frac{1}{R_{t+k-1}}\right)\lambda^{\nu} \text{ for } j = \{1,...,12\} \text{ and } \nu = \{p,g\},$$

where λ^{υ} is the Lagrange multiplier from each household's maximization problem. Substituting consumption into the respective lifetime budget constraint we can solve for λ^{υ} and get

$$\lambda^{\nu} = \left[\frac{\sum_{j=1}^{12}\left[\left(\beta^{j-1}\pi_j\right)^{\frac{1}{\sigma}}\left(\prod\nolimits_{k=1}^{j} R_{t+k-1}\right)^{\frac{1-\sigma}{\sigma}}\right]}{\mathcal{I}^{\nu}_t}\right]^{\sigma}, \text{for } \nu = \{p,g\}, \tag{10}$$

so that consumption can be expressed as

$$c^{\nu}_{j,t+j-1} = \left[\frac{1}{\beta^{j-1}\pi_j}\left(\prod\nolimits_{k=1}^{j}\frac{1}{R_{t+k-1}}\right)\lambda^{\nu}\right]^{\frac{1}{-\sigma}}. \tag{11}$$

Once we know the optimal consumption plans we use the period budget constraints of households to get savings. The optimal savings of public sector workers can be expressed as

$$s^p_{1,t} = \left(1-\tau^p_{L,t}\right) w_t h^p_1 + \left(1-\tau^p_{B,t}\right) T_{B,1,t} - c^p_{1t}, \tag{12}$$

$$s^p_{j,t+j-1} = \left(1-\tau^p_{L,t}\right) w_{t+j-1} h^p_j + R_{t+j} s^p_{j-1,t+j-2} - c^p_{j,t+j-1} \text{ for } j = \{2, J_1\} \text{ and}$$

$$s^p_{j,t+j-1} = \left(1-\tau_{R,t}\right)\Psi^p w_{t+j-1} h^p_{J_1} + R_{t+j} s^p_{j-1,t+j-2} - c^p_{j,t+j-1} \text{ for } j = \{J_1+1, 12-1\}.$$

[6] Compare Terrell (1993), Assaad (1997), Glinskaya and Lokshin (2005) and Hyder and Reilly (2005) for some accounts of generous public sector pay.

Public sector workers save according to

$$
s_{1,t}^{g} = \left(1-\tau_{L,t}^{g}\right) w_{t}^{g} h_{1}^{g} + \left(1-\tau_{B,t}^{g}\right) T_{B,1,t} - c_{1t}^{g}, \tag{13}
$$

$$
s_{j,t+j-1}^{g} = \left(1-\tau_{L,t}^{g}\right) w_{t+j-1}^{g} h_{j}^{g} + R_{t+j} s_{j-1,t+j-2}^{g} - c_{j,t+j-1}^{g} \text{ for } j = \{2, J_1 - J_e\},
$$

$$
\begin{aligned}
s_{j,t+j-1}^{g} &= (1-\tau_{R,t}) \Psi_{1}^{g} w_{t+j-1}^{g} h_{J_1-J_e}^{g} + R_{t+j} s_{j-1,t+j-2}^{g} - c_{j,t+j-1}^{g} + \left(1-\tau_{L,t}^{p}\right) w_{t+j-1}^{p} h_{j}^{p} \\
\text{for } j &= \{J_1 - J_e + 1, J_1\},
\end{aligned}
$$

$$
s_{j,t+j-1}^{g} = (1-\tau_{R,t}) \Psi_{2}^{g} w_{t+j-1}^{g} h_{J_1-J_e}^{g} + R_{t+j} s_{j-1,t+j-2}^{g} - c_{j,t+j-1}^{g} \text{ for } j = \{J_1 + 1, J - 1\}.
$$

Optimal retirement age of public sector workers

The optimal retirement age or early retirement period of public sector workers can be obtained by comparing their lifetime-utility conditioning on retirement age. This is a discrete choice. The public sector workers choose early retirement period J_e according to:

$$
\max_{J_e} V(J_e) = \sum_{j=1}^{12} \beta^{j-1} \left(\prod_{i=1}^{j} \pi_i\right) \frac{\left(c_{j,t+j-1}^{g}\right)^{1-\sigma}}{1-\sigma} + \sum_{k=J_1-J_e}^{J_1} \beta^{k-1} \left(\prod_{i=1}^{k} \pi_i\right) \theta L_{k,t+k-1}, \tag{14}
$$

given Ψ_1^g and Ψ_2^g and given all prices.

4.2 The Government

The government satisfies the budget constraint (5) each period. There is a number of ways to achieve this. We assume that there is no labor tax discrimination between public and private sector workers so that the labor tax rate is given by $\tau_{L,t}^{g} = \tau_{L,t}^{p} = \tau_{L,t}$. We assume that the government satisfies the budget constraint by adjusting either the capital tax rate $\tau_{K,t}$ or the labor tax rate $\tau_{L,t}$ when civil servants' retirement behavior changes. Government consumption and government investment in the public good are expressed as a fraction of GDP. Then the endogenous tax rate $\tau_{K,t}$ ($\tau_{L,t}$ or $\Delta_{G,t}$) is a function of exogenous government policy variables and technology parameters only and it adjusts to satisfy the budget constraint each period.

4.3 The Steady State Solutions and Transitions

The complexity of the model prevents us from obtaining any analytical solution. Therefore, we calibrate the model to obtain some numerical results. First, we solve for steady state equilibrium. The steady state solution is numerically obtained according to the following algorithm based on Auerbach and Kotlikoff (1987).

Algorithm 1 *1. Guess an initial output Y and early retirement period for public servants J_e.*

2. Solve for G, K, w^p and q given the exogenous human capital level in the private sector H^p, using

$$\begin{aligned}
K^G &= \frac{\Delta_G Y}{\delta_g}, \\
G &= Z\left[\left(K^G\right)^\eta + \chi\left(\omega_h H^g\right)^\eta\right]^{1/\eta}, \\
K &= \left[\frac{Y}{AG^{\alpha_1}\left(H^p\right)^{\alpha_3}}\right]^{\frac{1}{\alpha_2}}, \\
w^p &= (1-\alpha)\frac{Y}{H^p}, \\
q &= \alpha\frac{Y}{K}.
\end{aligned}$$

3. Use the government budget constraint to solve for capital tax τ_K or labor tax τ_L. Then use $R = (1-\tau_K)\frac{Y}{K} + 1 - \delta_p$ to solve for interest rate.

4. Household

(a) Using the household lifetime budget constraint to solve for lifetime incomes in the two sectors: $\mathcal{I}^p$ and $\mathcal{I}^g$.

(b) Solve for shadow prices λ^p and λ^g according to (10).

(c) *Solve for consumption* c_j^p *and* c_j^g *for* $j = \{1, J\}$ *according to* (11).

(d) *Solve for savings* s_j^p *and* s_j^g *for* $J = \{1, J-1\}$ *according to* (12).

(e) *Solve for early retirement period* J_e^{new} *for public sector workers according* (14).

5. *Use* (9) *to get aggregate steady state savings* S *and set* $K^{new} = S$.

6. *Calculate accidental bequests:* $T_{B,1,t}$ *according to* (7)

7. *Calculate* $Y^{new} = AG^{\alpha_1} (K^{new})^{\alpha_2} (H^p)^{\alpha_3}$.

8. *Update* Y *using the convex combination:* $Y = \lambda Y^{new} + (1-\lambda) Y$, $\lambda \in (0,1)$ *and* $J_e = J_e^{new}$

9. *Repeat until* Y *and* J_e *converge.*

Next, we solve for transition. The approach to solve for the equilibrium transition path is similar to that used to solve for steady state. However, it becomes more complicated because we now have to solve for many different maximization problems simultaneously in all transition periods[7].

5 Calibration

We calibrate a 12 period OLG model to Brazilian data. In the model one period corresponds to five years and agents become economically active at age 20 and die for sure at age 80. The survival probabilities are calculated from Brazilian life-tables for the year 2001.[8] The population growth is equal to $n = 7.73\%$ per period which corresponds to an annual growth rate of 1.5%.[9] In the calibration, retirement of workers in the public sector occurs after period 7 at age 55 (this matches Brazilian data) and retirement of private sector workers occurs after period 9 at age 65.

[7]The algorithm is available upon request from the authors.

[8]The lifetables are available at the following WHO website: http://www3.who.int/whosis/life/life_tables

[9]See the OECD Factbook 2006 - Economic, Environmental and Social Statistics that also contains the annual growth rates for Brazil for the years 1981-2004 at http://titania.sourceoecd.org/vl=3134242/cl=11/nw=1/rpsv/factbook/01-01-01-g02.htm

Workers who work in the public sector but do not have the status of a civil servant are counted as private sector workers.

We use the economic parameters reported in table 3 for this calibration. The discount factor β takes a standard value. Estimates for the inverse of the intertemporal elasticity of substitution σ for Brazil range from 1 to 5 (see Issler and Piqueira (2000) and Soriano and Nakane (2003)). We pick pick $\sigma = 1.5$ and perform sensitivity analysis. The preference parameter θ is chosen to get the correct retirement age for the public sector which is 55 years at relatively high replacement ratios which match the Brazilian experience.

The fraction $1 - L$ that early retirees work in the private sector is set to 0.4. There is no data available on the amount of work of early retirees. We therefore exogenously set parameter L and conduct sensitivity analysis. Larger values of L will understate the effects of the reform. In order to not overstate our results we therefore conduct sensitivity analysis of larger L values.

Total factor productivity A is normalized so that output is equal to 100 in the benchmark case. Standard estimates of capital's share of GDP are around 0.3 (see Gollin (2002)). Estimates for Brazil tend to be higher. Ferreira and do Nascimento (2005) use a value of 0.4 for capital's share of GDP in Brazil. We use the same value. This parameter specification allows us to match the capital output ratio of Brazil which is around 3 (e.g. Bresser-Pereira (1990) and Souza-Sobrinho (2004)).[10] The estimates for α_1 for the US cluster around 0 when panel data techniques are used (e.g. Hulten and Schwab (1991) and Holtz-Eakin (1994)) and they cluster around 0.2 when GMM is used to estimate Euler equations (e.g. Lynde and Richmond (1993) and Ai and Cassou (1995)). For a cross-section of low income countries including Latin American countries Hulten (1996) obtains an estimate for α_1 of 0.1. This is the value we use. The depreciation rate of capital δ_p is set to match the capital output ratio and the interest rate.

We have little information on the parameters of the production technology for the public good. We view the choice of $Z = 1$, $\chi = 1$, $\eta = 0.5$ and $\omega_h = 0.2$ as our benchmark and we perform sensitivity analysis on these parameters. We find that our results are fairly robust to the

[10]Capital K is a stock variable, whereas output Y is a flow variable over the five year period. In order to calculate the capital output ratio we have to adjust for the number of years per period, so that $\frac{K}{Y/5}$ is the capital output ratio that we report.

changes in Z, η, χ and ω_h. Ferreira (2005) provides an estimation of the wage-age profile wh_j, where

$$h_j = \exp(-.2314 + .0529j - .0093j^2),$$

and $j = 1, 2, ...55$ which is illustrated by the dashed line in figure 2. We use Ferreira's estimates directly for our private sector wage-age profile and we use it to construct the public sector wage-age profile for our calibration. The public sector wage-age profile is higher than in the private sector reflecting the relative generosity of public sector compensation. Furthermore, we assume that until retirement public sector wages are rising with age.

The markup for public wages is $\xi = 1.15$ which captures the reality in Brazil that public sector wages are higher than private sector wages. Foguel et al. (2000) report that even if one accounts for the large share of low wage informal employment in the private sector there is still a considerable markup left in public sector wages vs. formal private sector wages. The parameters Ψ^p and Ψ_i^g, $i = 1, 2$ can be thought of as gross replacement rates of pension payments. They capture the relatively low replacement rates of private sector pensions and the high replacement rates ensured by integrality and parity in the public sector [11]. The gross replacement rate for private sector workers is about 50% of the wage payment in the last working period. For civil servants who retire early the gross replacement ratio is about 94% of the wage payment in the last working period for the early retirement years and then rises to 110% as age reaches 65 years. These high replacement rates together with private sector income generates the bough in the income-age profile illustrated by the red dashed line in figure 2. For civil servants who retire at age 65 the steep section of the income-age profile captures "phantom promotions". After retirement at age 65 income is flat over the rest of the life-cycle. Retired civil servants also have to pay income tax. We assume that this tax is equal to the labor tax of active workers.

[11] Bonturi (2002) reports that a private sector worker that actively contributed to the pension system will receive roughly 80% of her highest wage or salary as pension payment. If the worker did not contribute to the system during her worklife she is still entitled to get a minimum pension that is equal to the minimum wage level after reaching retirement age. This is an anti poverty measure and concerns mostly rural sector workers who are roughly 30% of private sector retirees. Only half of the private sector labor force contributes to the pension system. Almost all workers in the informal sector, like rural workers and domestic employees, do not contribute. In 1999, there were close to 18 million recipients of social security transfers and roughly one-third of them got the minimum wage level transfer. In our model, we index retirement benefits.of private sector workers to the last wage income (the highest one). In order to match the data we need to choose a very small value Ψ^r.

The public policy parameters used for our calibration are contained in table 4. In our model public investment is 2.5% of private sector output. This is close to a value reported by Calderon and Serven (2003). In our model government residual expenditures, net of the wage bill for civil servants, constitute 20% of private sector output. The labor and capital tax rates used here are the same as those used by Ferreira and do Nascimento (2005). The fraction of civil servants (without early retirement) is fixed exogenously at 7%.

Table 5 contains Brazilian data that our model output matches. The public sector wage bill is 5.1% of private sector output. Pensions for civil servants are 2.9% of private sector output and private pensions are 6.3% of private sector output. These numbers are close to the numbers reported in Souza et al. (2004). Government size is 36.8%, measured as tax revenue in percent of private sector output and the capital output ratio is close to 3 as reported above. The fraction of civil servants per age cohort is 8.36% with two early retirement periods.

6 Policy Experiments, Sensitivity Analysis and Welfare Analysis

In this section we report the results of policy reforms. We begin with an economy in its steady state under the policy parameters from table 4. We then introduce a permanent and unexpected change in the generosity parameter Ψ_1^g and calculate the transitional path and the new steady state. We describe two scenarios. In the first the government used capital taxes to clear the government budget constraint, in the second labor taxes are used to adjust the budget constraint.

We find that decreasing the generosity of civil servants' pensions increases output in all cases we consider. There are three effects causing this result. They all work in the same direction. First, decreasing civil servants' retirement pay induces them to retire later, which in turn increases human capital in both private and public sectors, which ultimately raises private sector output. Second, cutting civil servants' retirement pay increases their incentive to save, which in turn increases the stock of physical capital and hence output. Third, decreasing civil servants' retirement pay allows for smaller tax distortions which also increases output.

6.1 Capital Tax Adjusts to Clear the Government Budget Constraint

In figure 4 we report the public agents' retirement decision in the steady state as a function of the generosity parameter of early retirement pension payments Ψ_1^g when capital taxes adjust to clear the government budget constraint. Of course these decisions depend upon leisure L. Since we do not have data on L we conduct extensive sensitivity analysis on this parameter as reported in table 6 and table 7. When Ψ_1^g is small public sector workers do not want to retire early since their welfare of working up to age 65 exceeds their welfare from early retirement. If Ψ_1^g is below 0.886, public sector pensions are not generous enough so that public sector workers prefer to work up to their standard retirement age of 65. As the generosity of early retirement benefits increases beyond 0.886 agents prefer to retire one period early, that is at age 60. If Ψ_1^g increases further and exceeds 0.938 public sector workers would like to retire two periods early at age 55 and finally if Ψ_1^g exceeds 0.984 all public sector workers would prefer to retire three periods early at age 50. Of course these outcomes depend crucially on the weight θ individuals attach to leisure in the utility function. We choose θ so that in accordance with actual policy in Brazil early retirement pay is close to full retirement pay and civil servants retire at age 55 (2 periods early).

Table 6 contains the replacement rates which leave civil servants just indifferent between the possible early retirement ages. If the early retirement replacement ratio Ψ_1^g drops below 0.938 for example in row 1, then civil servants retire at age 60 instead of at age 55. Table 6 also shows how sensitive these critical replacement ratios are to changes in the economic parameters.

The first main result is reported in table 7. There the benchmark case we consider is highlighted in bold. In the calibration steady state output for the benchmark case is normalized to 100 by choosing the appropriate total factor productivity A. When we conduct sensitivity analysis we do not change the total factor productivity, however, we use the entries in the third column (the 2 early retirement period case) to normalize output over all retirement periods for a given parameter setting. It is then easy to compare respective steady state output rates for various early retirement periods.

In the policy reforms considered in table 7 the capital tax rate adjusts to satisfy the government budget constraint. We see from table 7 that a permanent and unexpected decline in the early retirement replacement ratio increases steady state output by over 2%. This result is relatively robust to changes in the intertemporal elasticity of substitution σ and the elasticity of substitution in public production η. Notice that an increase in leisure L magnifies the effects of this reform: When $L = 1$, output rises by 3.5% when public sector pensions become less generous. If the productivity of infrastructure capital α_1 is higher the effect of this policy reform is larger as well.

In figure 5 we report the transitions caused by a policy change in the generosity of early retirement payments. Our benchmark case is early retirement at age 55, that is 2 periods early, at generosity $\Psi_1^g = 0.938$. We next change Ψ_1^g from 0.938 down to 0.82 so that all public agents would like to continue working until age 65. The line marked x describes this transition for the capital tax rate in panel 1, output in panel 2, capital in panel 3. Decreasing the generosity and enticing agents to not retire early increases steady state output by 2.130% after a transition period of 15 periods (75 years). See also table 7 top row for this result.

We then conduct the same experiment by changing the generosity again down to $\Psi_1^g = 0.886$ so that all civil servants want to retire one period early at age 60. The line marked with triangles reports the transitions. Steady state output now increases by 1.182%.

Finally, we make public pensions more generous by raising Ψ_1^g to 0.984 so that public sector workers retire three periods early at age 50. This policy generates retirement ages that match the data from the late 1980s. The resulting trajectory is illustrated by the diamond line. Output decreases from 100 to 98.469 over the transition period.

In figure 6 we illustrate the effects of these reforms on public sector pensions, on private sector pensions and on public sector wages. We show both absolute changes and changes in these variables as fraction of private sector output (GDP). Note in the top panel of figure 6 that public sector pensions decrease sharply from almost 3% of private sector output to 1.5% of private sector output but only after seven periods. This delay is due to grandfathering of current civil servants.

Private pensions rise gradually. Immediately after the policy reform private sector wages increase and since pensions are indexed to private wages, private pension payments rise. The increase in private pensions in absolute terms becomes more drastic after grandfathering has disappeared after 7 periods. Notice that initially private pensions as a fraction of output falls since private sector output rises faster. After 50 years (10 periods) private sector pensions become larger even as a fraction of GDP.

Public sector wages fall at first and rise after seven periods both in absolute terms and as a fraction of private sector output. The initial decline in the public sector wage bill is due simply to an accounting identity. Since civil servants now (after the reform) work for 9 periods rather than 7 periods, fewer civil servants will be hired from each generation to keep the total public sector employment constant in the long run. This decline again lasts for seven periods. After seven periods, the public sector wage bill rises and reaches a level higher than the pre-reform level. This rise to a higher level is due to larger tenure of civil servants and human capital rising with tenure.

Figures 7 and 8 illustrate the case where early retirees are not allowed to work in the private sector. These results correspond to row 3 in table 6 and table 7 when leisure $L = 1$. Reducing the early retirement replacement rates for civil servants from 0.938 to some value below 0.886 results in civil servants retiring at age 65. This in turn triggers a 3.5% increase in GDP.

6.2 Labor Taxes Adjust to Clear the Government Budget Constraint

Tables 8 and 9 illustrate the effects of the policy reform when the labor tax adjusts instead of the capital tax to satisfy the government budget constraint. As is evident from table 9, the effects of changing the generosity of public sector pensions are smaller when these changes are financed by a change in a labor tax. In the benchmark case inducing civil servants to retire at age 65 instead of age 55 increases steady state output by roughly 1.6%.

Figure 4 illustrates the public agents' retirement decision in the steady state as a function of the generosity parameter of early retirement pension payments Ψ_1^g when labor taxes adjust to clear the government budget constraint. Figures 10 and 11 illustrate the transitions to the new steady state when the change in the generosity of civil servants' pensions is accompanied by a change in the labor tax. The qualitative effects of this particular policy reform are very similar to the previous result. Note however that the effects on output are smaller. Furthermore, when the labor tax adjusts to satisfy the government budget, the effects on the real wage rate are non-monotonic. At first the real wage drops, but then after about 35 years (7 periods) the real wage rate starts to increase to its new and higher steady state level.

6.3 Welfare Analysis

Figure 12 reports compensating consumption levels per age cohort to make agents indifferent between the benchmark case and the regime without early retirement of civil servants. We first record the present value welfare levels of each cohort over the transition period for the case without a policy change, that is civil servants retire at age 55 throughout the 'transition' period. Second, we record welfare levels for each cohort when the government administers a change in the pension compensation scheme of civil servants that induces them to retire at age 65. We then calculate the average per period compensating consumption for each generation that equalizes their respective lifetime welfare. In figure 12 we illustrate the average percentage of current value compensating consumption over current value consumption for each age cohort. We distinguish between private (red circles), public (blue triangles) and aggregate (black x's) welfare levels. We see that civil servant generations that are born before the policy change benefit from it because of grandfathering. Private sector workers also benefit because of higher GDP. In the long run these welfare gains are approximately 1% of private sector workers. Civil servants that are born after the policy shock loose because of the lower compensation scheme, the longer working time and the slow adjustments during the transitions. In the aggregate the economy is better off in the new policy regime.

7 Conclusion

In this paper we have studied the effects of generous early retirement provision for civil servants on capital accumulation and long-run level of income. We have used an OLG economy calibrated to Brazil for this purpose. We found that decreasing early retirement benefits so that average retirement age among civil servants rises from the current 55 years to 65 years raises steady state income by over 2%. The transition lasts about 25 periods or 125 years. Decreasing generosity of early retirement benefits more moderately so that civil servants retire at age 60 raises long-run income by about 1.2%. When civil servants who retire early are not allowed to work in the private sector during early retirement the income gains from reducing generosity of early retirement are larger at about 3.5%.

For the purpose of this analysis we have required the government budget to be balanced each period and we have not allowed the government to run a deficit. We also abstracted from the potentially important issue of population ageing and from any distributional issues of public sector pension reform. Finally, we did not consider elastic labor supply of the working age population in order to keep the model simple. We leave these extensions for future work.

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	Men				Women			
	Life expectancy 1960-65	95-2000	Retirement age 1960	1995	Life expectancy 1960-65	95-2000	Retirement age 1960	1995
Belgium	67.9	73.8	63.3	57.6	73.9	80.6	60.8	54.1
France	67.6	74.2	64.5	59.2	74.5	82.0	65.8	58.3
Germany	67.4	73.9	65.2	60.5	72.9	80.2	62.3	56.1
Ireland	68.4	73.6	68.1	63.4	72.3	79.2	70.8	60.1
Italy	67.4	75.0	64.5	60.6	72.6	81.2	62.0	57.2
Spain	67.9	74.5	67.9	61.4	72.7	81.5	68.0	58.9
Sweden	71.6	76.3	66.0	63.3	75.6	80.8	63.4	62.1
UK	67.9	74.5	66.2	62.7	73.8	79.8	62.7	59.7

Table 1: Longevity and effective retirement age in the European Union (1960-1995) in Blöndal and Scarpetta (1998a) . Original Source: United Nations Population Division, World Population Prospects, 1998.

	1980	1990	2000	2010		1980	1990	2000	2010
Hungary	–	–	16.5	19.4	Ireland	4.6	6.9	6.8	8.9
Belgium	–	15.2	14.1	17.9	Australia	7.5	7.5	8.1	11.1
Luxemburg	–	12.5	12.6	15.1	Canada	5.5	6.7	7.2	10.5
Austria	–	–	14.4	15.9	Sweden	5.9	4.7	5.2	7.5
Germany	7.8	9.5	13.2	12.6	USA	5.6	5.4	5.7	8.1
Greece	–	10.4	10.7	11.2	New Zealand	–	7.9	7.8	11.6
Czech Republic	–	–	11.1	15.2	Turkey	–	5.0	4.0	5.1
France	6.2	11.2	10.3	15.1	Japan	2.8	4.3	5.4	7.5
Netherlands	8.1	10.5	11.1	15.9	Norway	5.0	4.9	5.2	8.1
Poland	–	–	7.7	11.1	Switzerland	–	2.9	6.7	9.3
Finland	8.2	9.6	10.6	15.8	Korea	–	2.2	3.7	5.0
Spain	4.8	9.7	9.3	11.1	Mexico	–	2.1	2.8	3.7
Portugal	6.0	9.1	8.6	9.4	Ireland	–	0.5	1.6	2.2
Denmark	–	6.9	8.2	11.3					
UK	–	7.5	7.2	10.1	OECD Average	5.3	6.7	7.1	9.1

Table 2: Costs of Early Retirement as fraction of GDP in some OECD countries in Herbertsson and Orszag (2003)

Parameters			Observation/Comment/Source
Preferences			
	Discount factor	$\beta = 0.995^5$ $= 0.9752$	
	Inverse of Intertemporal Elasticity of Substitution	$\sigma = 1.5$	Issler and Piqueira (2000) Soriano and Nakane (2003)
	Leisure	$\theta = 0.01$	To match retirement age
	Fraction of early retirement leisure	$L = 0.6$	We consider this our benchmark case and conduct sensitivity analysis.
Technology			
	Private Production:		
		$A = 18.38$	Normalization, so that $Y = 100$
		$\alpha_1 = 0.1$	Hulten (1996)
		$\alpha_2 = 0.4$	Ferreira and do Nascimento (2005)
		$\alpha_3 = 0.6$	
		$\delta_p = 1 - .94^5$ $= 0.2661$	To match $\frac{K}{Y}$ and R
	Public Production:		
		$Z = 1$	Normalization
		$\chi = 1$	Normalization
		$\eta = 0.5$	
	Fraction of civil servant human capital used for production of public good G :	$\omega_h = 0.2$	
		$\delta_g = 1 - 0.96^5$ $= 0.1846$	
	Human Capital:		
	private wage-age profile parameters	$\beta_0^p = -0.2314$ $\beta_1^p = 0.0529$ $\beta_2^p = -0.00093$	Ferreira (2005)
	public wage-age profile parameters	$\beta_0^g = -0.2314$ $\beta_1^g = 0.042$ $\beta_2^g = -0.00053$	Authors construction from Ferreira (2005)
	population growth rate:	$n = 1.015^5 - 1$ $= 0.0773$	OECD-Factbook 2006

Table 3: Preference and Policy Parameters

	Variables for Benchmark Case $J^e = 2$		Source
Policies:			
Δ_G	Investment in public good (in % of private sector output)	2.5%	Calderon and Serven (2003)
Δ_{Cg}	Government residual expenditure (in % of private sector output)	20%	Social Security Ministry of Brazil (2002) and authors' calculation
Ψ^p	Indexation parameter (generosity of private pensions)	0.5	Based on Bonturi (2002)
ξ	Public wages as a fraction of private wages	1.15	Foguel et al. (2000)
Ψ_2^g	Indexation parameter (generosity of public pensions)	1.1	Integrality
Ψ_1^g	Generosity of early public retirement (benchmark)	0.94	Integrality
Taxes:			
τ_L	Labor tax rate	40%	Ferreira and do Nascimento (2005)
τ_P	Income tax when retired	40%	
τ_B	Tax on bequests	40%	
τ_K	capital tax rate	16.9%	Ferreira and do Nascimento (2005)
Labor Allocation:			
N^g	fraction of civil servants	7%	Social Security Ministry of Brazil (2002)
N^p	private sector employees	93%	

Table 4: Policy Parameters

	Variables for Benchmark Case $J^e = 2$		Source
$\frac{K}{Y}$	Capital output ratio	3	Bresser-Pereira (1990) and Souza-Sobrinho (2004)
Government Size:			
	Tax revenue (in % of private sector output)	36.82%	Immervoll et al. (2006) report 35% of GDP.
n^g	Endogenous fraction of civil servants per cohort with early retirement	8.36%	Souza et al. (2004) report 6%.
Expenditures:			
$n^g \sum_{j=1}^{J_1 - J_e} w_t^g h_j \mu_j$	Wage bill public sector workers (in % of private sector output)	5.1%	Social Security Ministry of Brazil (2002) and authors' calculation
$\frac{T_1^g + T_2^g}{Y}$	Public pensions (in % of private sector output)	2.9%	Souza et al. (2004) report 5% of GDP.
$\frac{T^p}{Y}$	Private pensions (in % of private sector output)	6.3%	Souza et al. (2004) report 6.6% of GDP.

Table 5: Model Outcomes that Match Brazilian Data

J^e:	1 (age 60)	2 (age 55)	3 (age 50)
L:			
0.60	**0.886**	**0.938**	**0.984**
0.80	1.056	1.141	1.219
1	1.226	1.343	1.467
σ:			
0.50	0.847	0.945	1.049
1	0.866	0.938	1.010
1.50	**0.886**	**0.938**	**0.984**
2	0.794	0.847	0.886
α_1:			
0	0.847	0.892	0.932
0.05	0.866	0.912	0.958
0.1	**0.886**	**0.938**	**0.984**
0.15	0.912	0.964	1.017
0.2	0.951	1.004	1.062
η:			
-2	0.879	0.971	1.049
-1	0.879	0.971	1.049
0	0.879	0.958	1.017
0.50	**0.886**	**0.938**	**0.984**
0.80	0.886	0.938	0.977
Z:			
0.5	0.886	0.938	0.984
1	**0.886**	**0.938**	**0.984**
1.5	0.886	0.938	0.984
2	0.886	0.938	0.984
3	0.886	0.938	0.977
χ:			
0.5	0.886	0.938	0.977
1	**0.886**	**0.938**	**0.984**
1.5	0.886	0.938	0.984
2	0.886	0.938	0.984
3	0.886	0.938	0.984
ω_h:			
0.1	0.886	0.938	0.984
0.2	**0.886**	**0.938**	**0.984**
0.3	0.886	0.938	0.984
0.4	0.886	0.938	0.984
0.5	0.886	0.938	0.984

Table 6: Sensitivity Analysis: Replacement rates for early retirees that leave civil servants just indifferent between various retirement ages when capital tax adjusts.

J^e:	0 (age 65)	1 (age 60)	2 (age 55)	3 (age 50)
L:				
0.60	**102.127**	**101.178**	**100.000**	**98.480**
0.80	102.813	101.594	100.000	97.870
1	103.509	102.018	100.000	97.207
σ:				
0.50	102.301	101.314	100.000	98.165
1	102.189	101.229	100.000	98.352
1.50	**102.127**	**101.178**	**100.000**	**98.480**
2	101.889	101.051	100.000	98.649
α_1:				
0	101.694	100.933	100.000	98.800
0.05	101.886	101.039	100.000	98.648
0.1	**102.127**	**101.178**	**100.000**	**98.480**
0.15	102.421	101.339	100.000	98.256
0.2	102.820	101.556	100.000	97.962
η:				
-2	102.252	101.357	100.000	98.070
-1	102.252	101.357	100.000	98.070
0	102.200	101.282	100.000	98.266
0.50	**102.127**	**101.178**	**100.000**	**98.480**
0.80	102.125	101.174	100.000	98.508
Z:				
0.5	102.127	101.178	100.000	98.479
1	**102.127**	**101.178**	**100.000**	**98.480**
1.5	102.127	101.177	100.000	98.480
2	102.127	101.177	100.000	98.481
3	102.127	101.177	100.000	98.501
χ:				
0.5	102.126	101.176	100.000	98.504
1	**102.127**	**101.178**	**100.000**	**98.480**
1.5	102.128	101.179	100.000	98.475
2	102.129	101.181	100.000	98.471
3	102.131	101.185	100.000	98.462
ω_h:				
0.1	102.126	101.176	100.000	98.483
0.2	**102.127**	**101.178**	**100.000**	**98.480**
0.3	102.128	101.178	100.000	98.478
0.4	102.128	101.179	100.000	98.476
0.5	102.128	101.180	100.000	98.475

Table 7: Sensitivity Analysis: Steady state effects of changing generosity of early pension payments when capital tax adjusts.

J^e:	1 (age 60)	2 (age 55)	3 (age 50)
L:			
0.60	**0.978**	**1.020**	**1.048**
0.80	1.176	1.246	1.303
1	1.360	1.459	1.543
σ:			
0.50	0.865	0.949	1.020
1	0.907	0.978	1.020
1.50	**0.978**	**1.020**	**1.048**
2	0.978	1.006	1.020
α_1:			
0	0.949	0.992	1.006
0.05	0.964	1.006	1.034
0.1	**0.978**	**1.020**	**1.048**
0.15	1.006	1.048	1.077
0.2	1.034	1.077	1.105
η:			
-2	0.978	1.077	1.147
-1	0.978	1.077	1.147
0	0.978	1.048	1.105
0.50	**0.978**	**1.020**	**1.048**
0.80	0.978	1.020	1.048
Z:			
0.5	0.978	1.020	1.048
1	**0.978**	**1.020**	**1.048**
1.5	0.978	1.020	1.048
2	0.978	1.020	1.048
3	0.978	1.020	1.048
χ:			
0.5	0.978	1.020	1.048
1	**0.978**	**1.020**	**1.048**
1.5	0.978	1.020	1.048
2	0.978	1.020	1.048
3	0.978	1.020	1.063
ω_h:			
0.1	0.978	1.020	1.048
0.2	**0.978**	**1.020**	**1.048**
0.3	0.978	1.020	1.048
0.4	0.978	1.020	1.048
0.5	0.978	1.020	1.048

Table 8: Sensitivity Analysis: Replacement rates for early retirees that leave civil servants just indifferent between various retirement ages when labor tax adjusts.

J^e:	0 (age 65)	1 (age 60)	2 (age 55)	3 (age 50)
L:				
0.60	**101.612**	**100.878**	**100.000**	**98.921**
0.80	102.154	101.201	100.000	98.466
1	102.685	101.519	100.000	98.013
σ:				
0.50	101.237	100.687	100.000	99.115
1	101.416	100.784	100.000	99.022
1.50	**101.612**	**100.878**	**100.000**	**98.921**
2	101.738	100.939	100.000	98.864
α_1:				
0	101.308	100.712	100.000	99.146
0.05	101.447	100.788	100.000	99.031
0.1	**101.612**	**100.878**	**100.000**	**98.921**
0.15	101.831	100.996	100.000	98.779
0.2	102.103	101.143	100.000	98.605
η:				
-2	101.824	101.106	100.000	98.456
-1	101.824	101.105	100.000	98.457
0	101.725	100.999	100.000	98.661
0.50	**101.612**	**100.878**	**100.000**	**98.921**
0.80	101.607	100.873	100.000	98.931
Z:				
0.5	101.612	100.878	100.000	98.920
1	**101.612**	**100.878**	**100.000**	**98.921**
1.5	101.612	100.878	100.000	98.921
2	101.611	100.877	100.000	98.922
3	101.611	100.877	100.000	98.922
χ:				
0.5	101.609	100.875	100.000	98.927
1	**101.612**	**100.878**	**100.000**	**98.921**
1.5	101.614	100.881	100.000	98.915
2	101.617	100.883	100.000	98.909
3	101.621	100.888	100.000	98.873
ω_h:				
0.1	101.610	100.876	100.000	98.924
0.2	**101.612**	**100.878**	**100.000**	**98.921**
0.3	101.613	100.879	100.000	98.918
0.4	101.614	100.880	100.000	98.916
0.5	101.615	100.881	100.000	98.914

Table 9: Sensitivity Analysis: Steady state effects of changing generosity of early pension payments when labor tax adjusts.

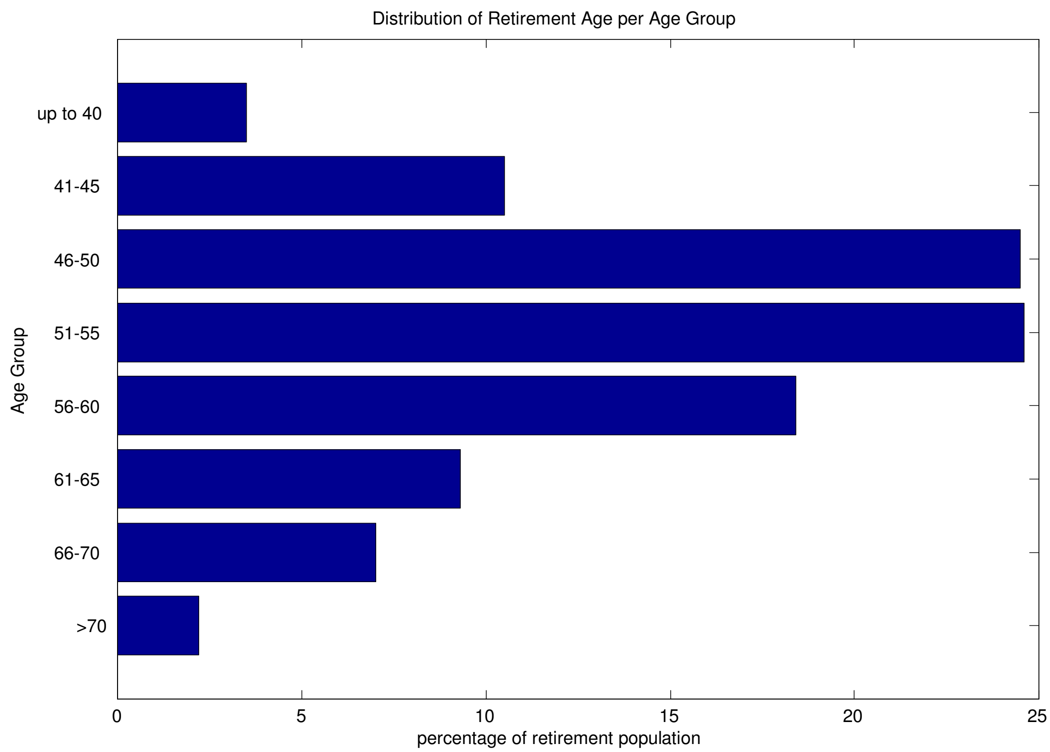

Figure 1: Source: Ministry of the Budget and Administration, 2002. Distribution of early retirement per age group in the public sector.

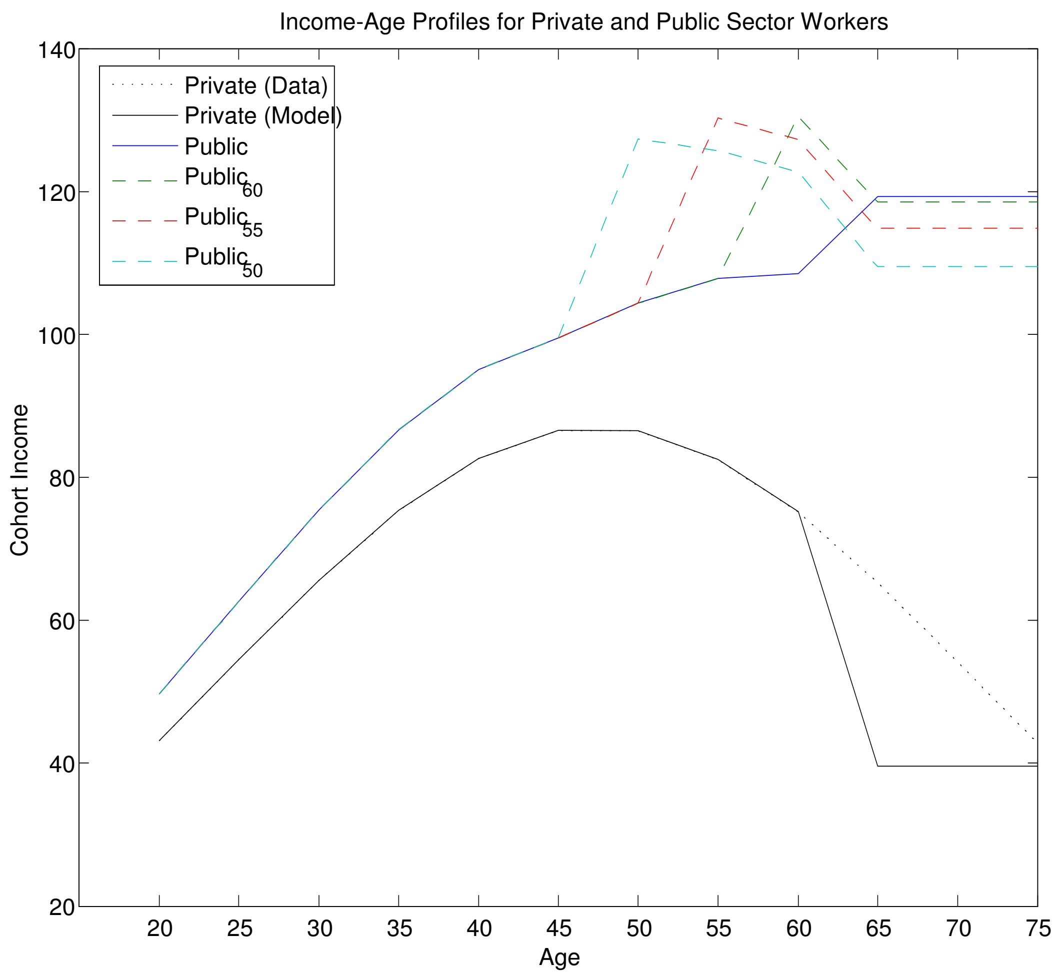

Figure 2: Income-age profiles of private and public sector workers when public sector early retirees are working 40% of their time in the private sector. Source for dashed line: Ferreira (2005)

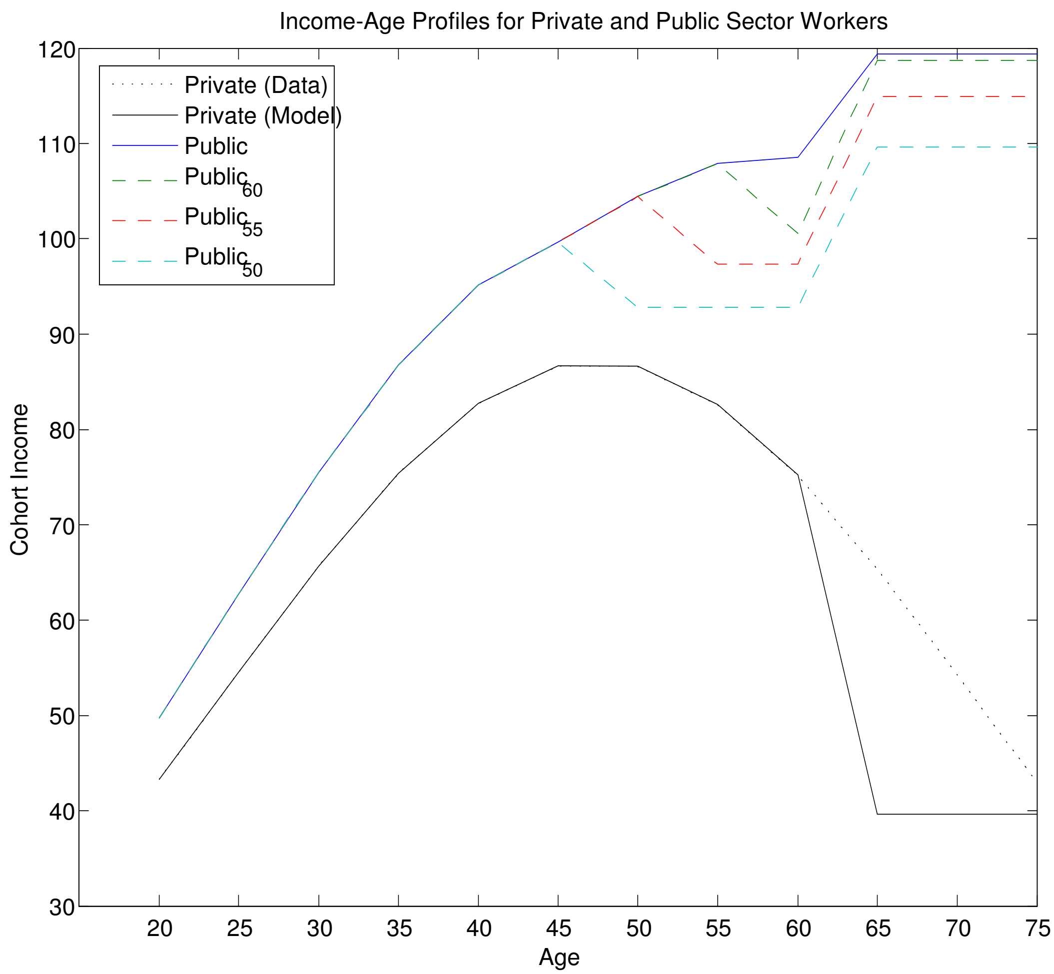

Figure 3: Income-age profiles of private and public sector workers when public sector early retirees are not working in the private sector. Source for dashed line: Ferreira (2005)

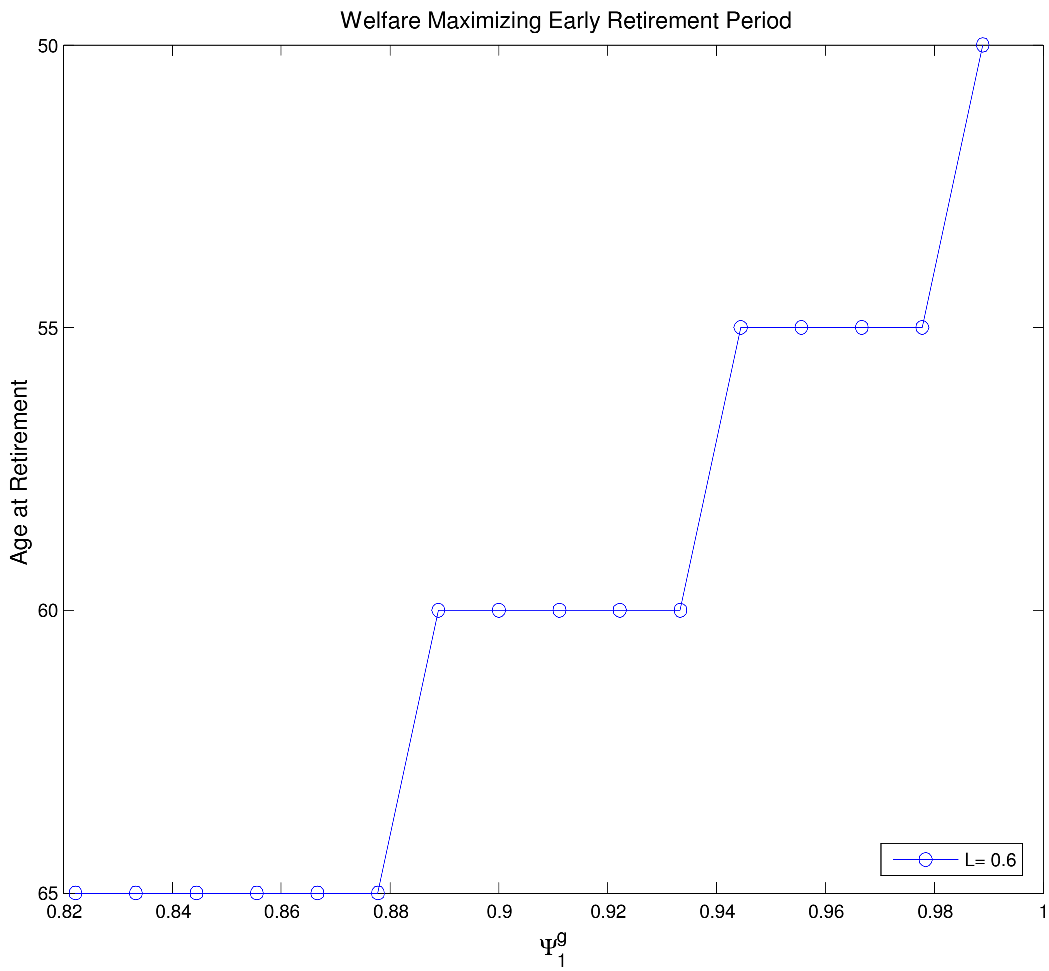

Figure 4: Public agent retirement age as function of public pension generosity Ψ_1^g when capital tax adjusts

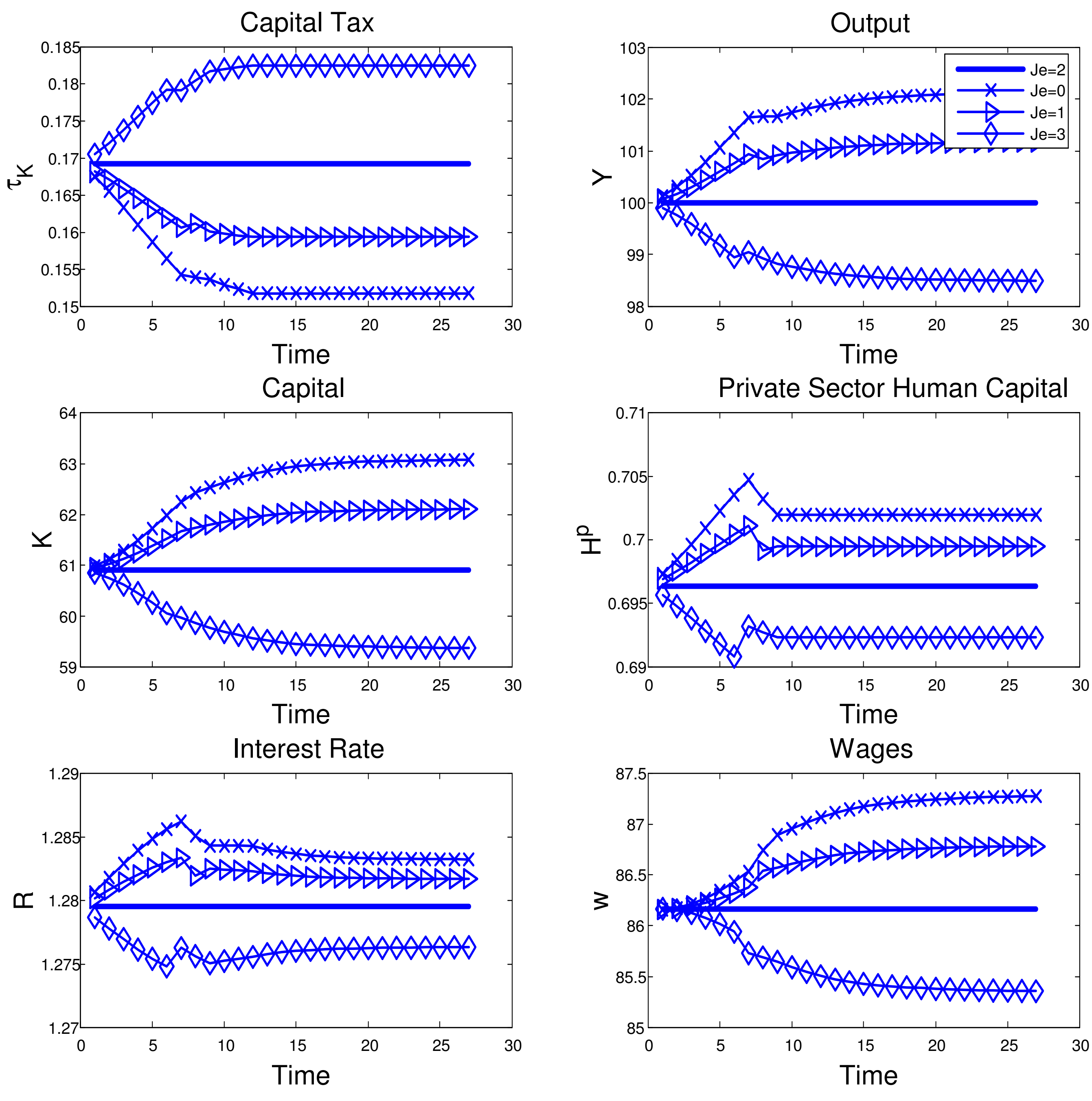

Figure 5: Transition from retiring early at 50, 55 and 60 to 65 with early retirees working on average 40% of their time in the private sector. Capital tax τ_K adjusts to clear the government budget constraint.

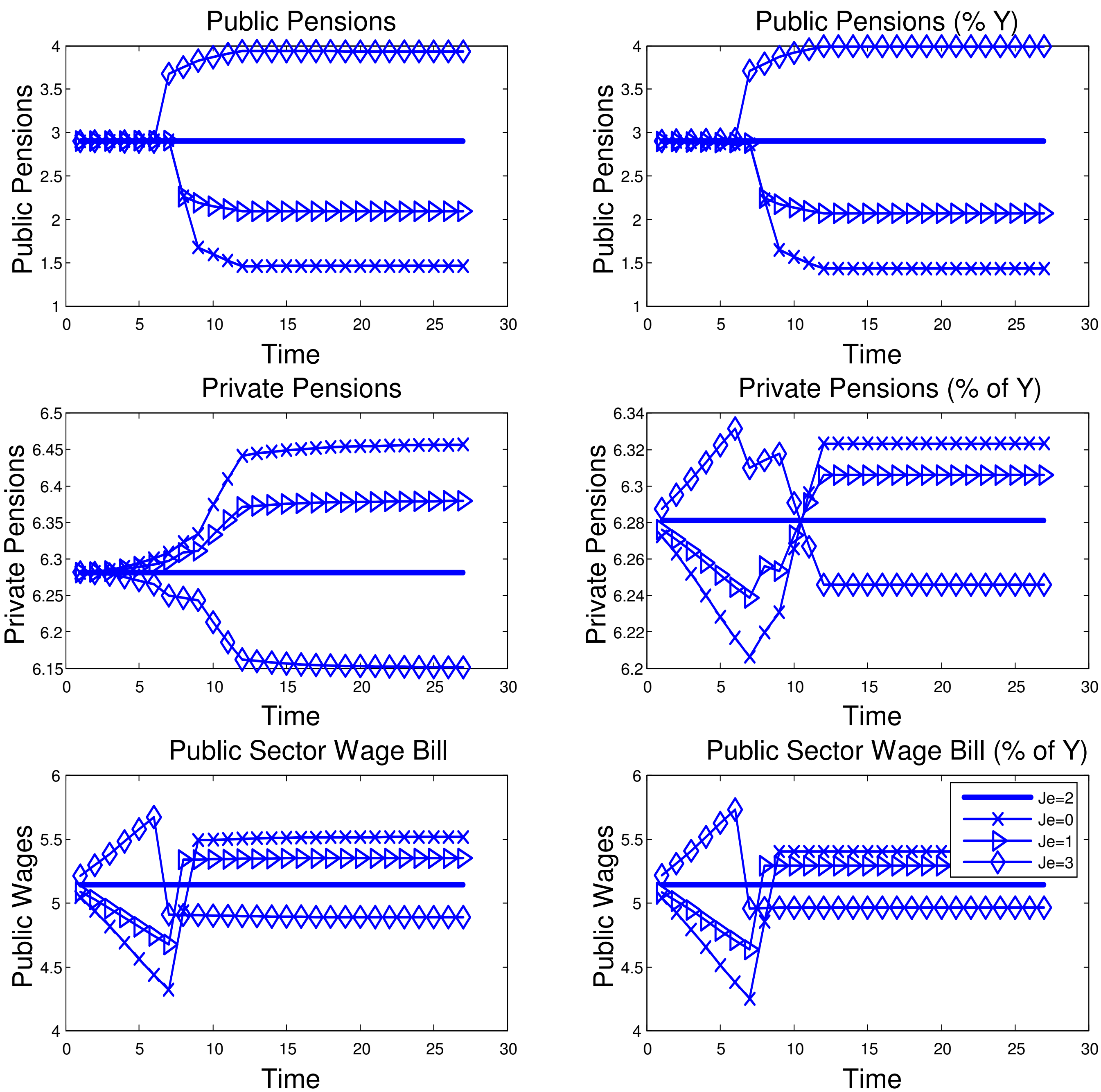

Figure 6: Transition from retiring early at 50, 55 and 60 to 65 with early retirees working on average 40% of their in the private sector. Capital tax τ_K adjusts to clear the government budget constraint.

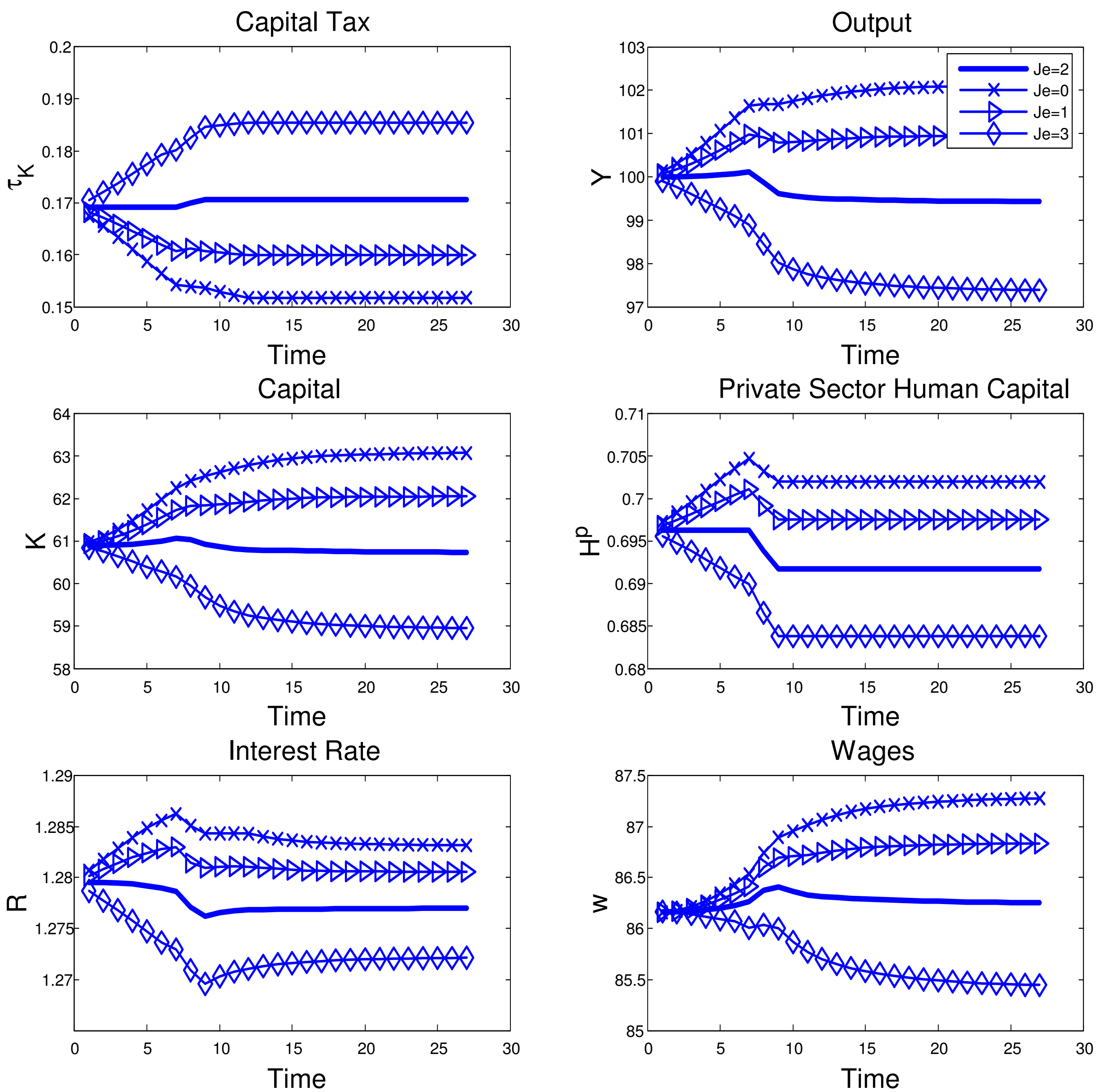

Figure 7: Transition from retiring early at 50, 55 and 60 to 65 with early retirees not working in the private sector. Capital tax τ_K adjusts to clear the government budget constraint.

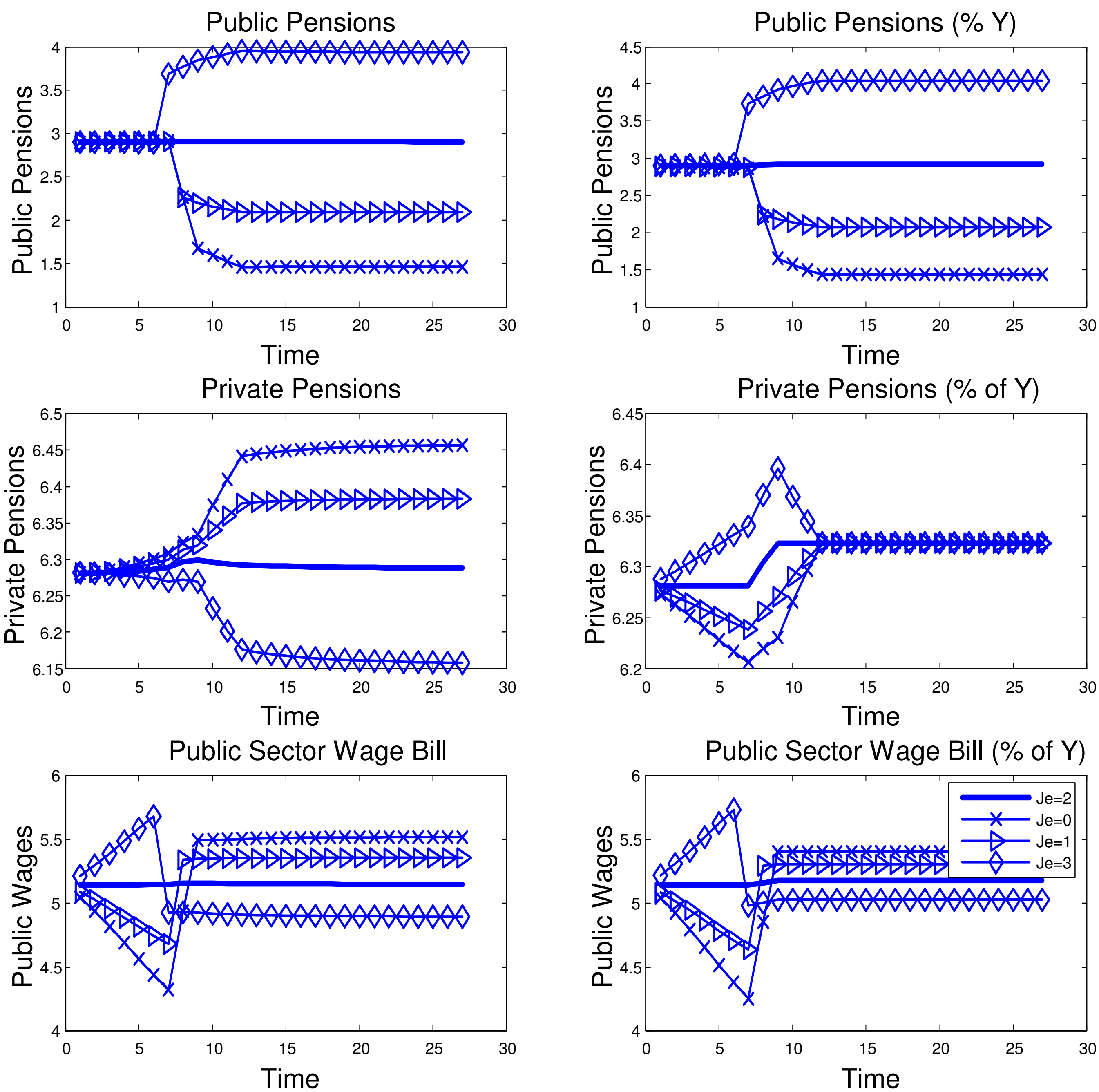

Figure 8: Transition from retiring early at 50, 55 and 60 to 65 with early retirees not working in the private sector. Capital tax τ_K adjusts to clear the government budget constraint.

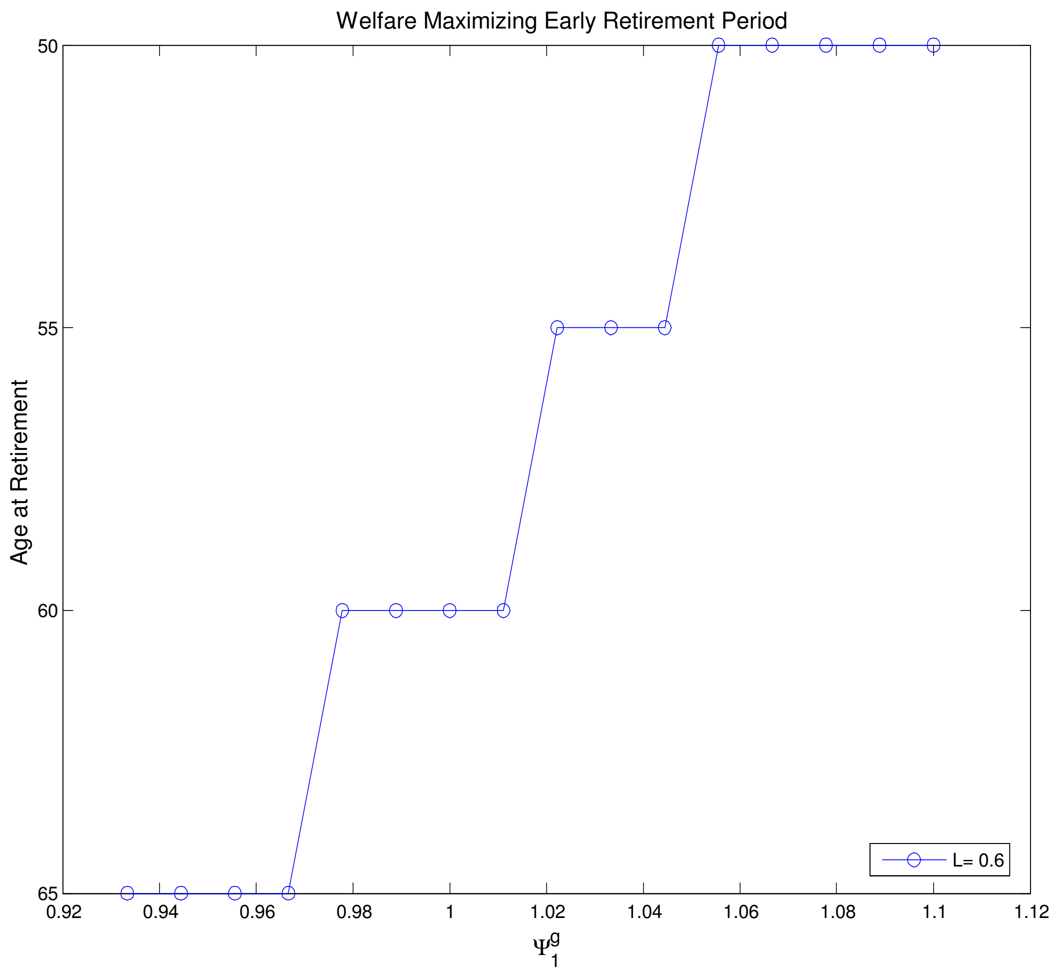

Figure 9: Public agent retirement age as function of public pension generosity Ψ_1^g when labor tax adjusts

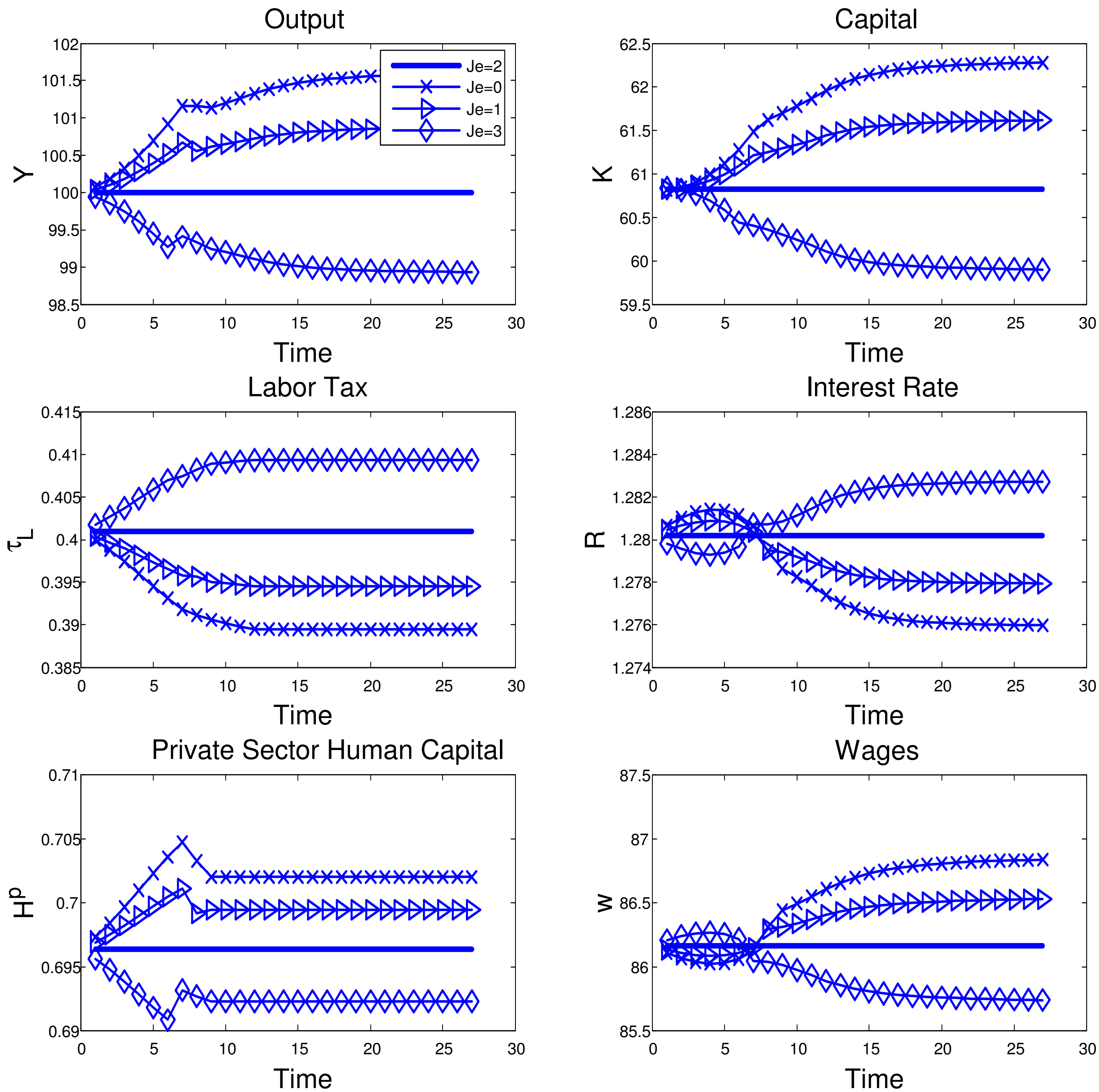

Figure 10: Transition from retiring early at 50, 55 and 60 to 65 with early retirees working on average 40% of their time in the private sector. Labor tax τ_L adjusts to clear the government budget constraint.

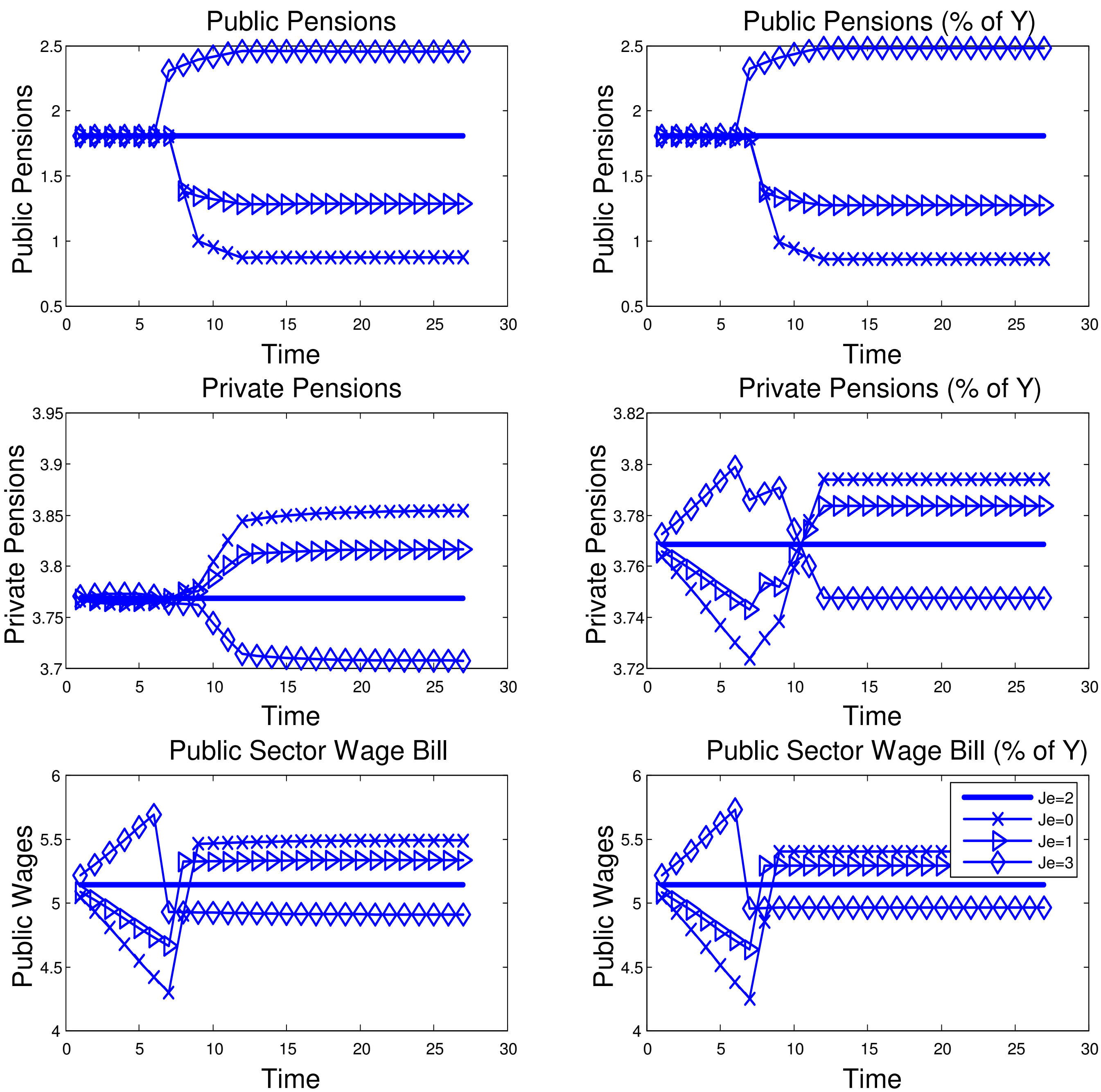

Figure 11: Transition from retiring early at 50, 55 and 60 to 65 with early retirees working on average 40% of their in the private sector. Labor tax τ_L adjusts to clear the government budget constraint.

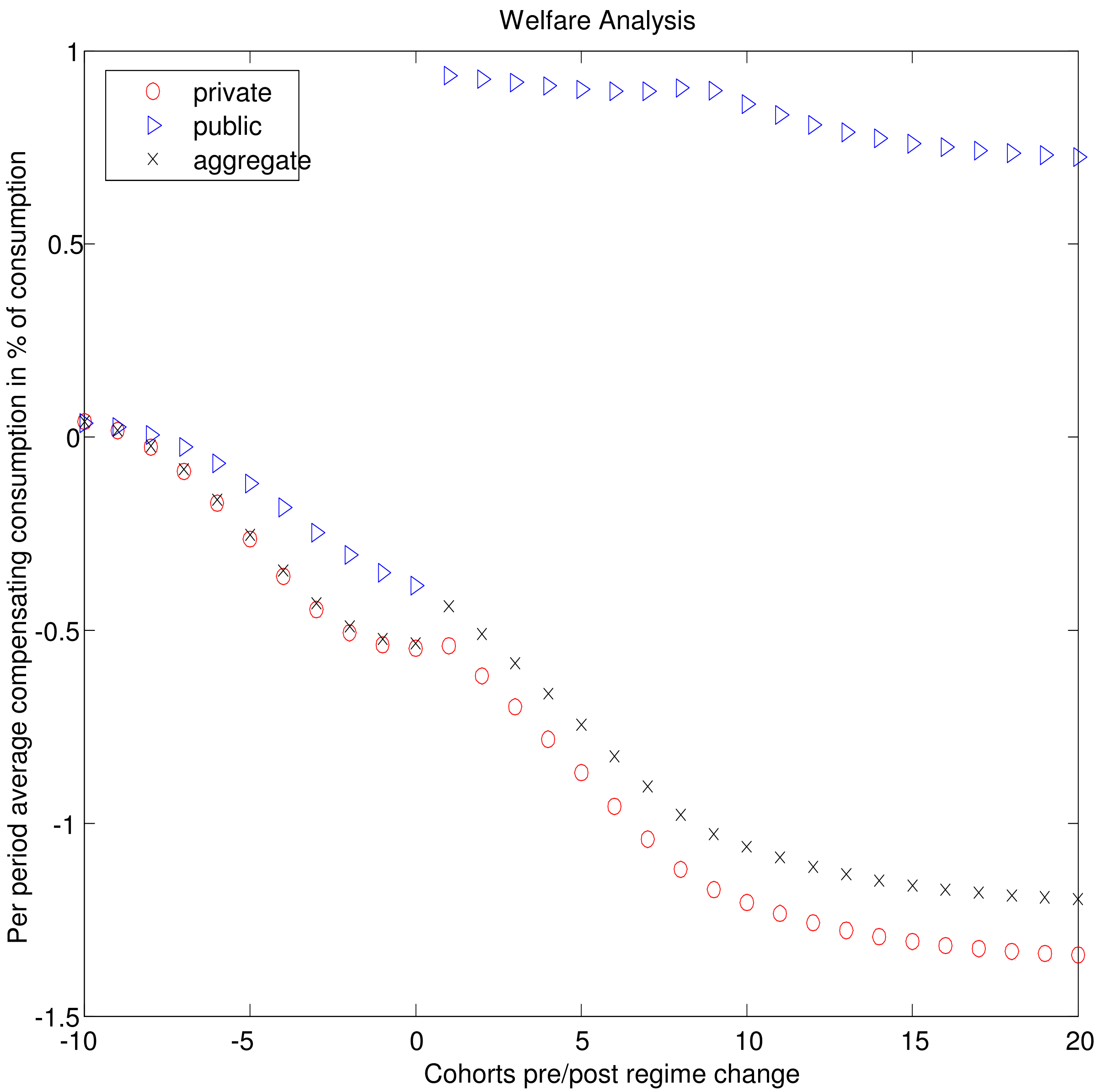

Figure 12: Compensating consumption given to individuals to offset the policy change that induces civil servants to postpone their retirement from age 55 to 65 in terms of life-time welfare per age cohort, expressed as the average percentage of current value per period compensating consumption over current value consumption.