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A Macroeconomic Analysis of the Fiscal System in Egypt

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A Macroeconomic Analysis of the Fiscal System in Egypt*

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Abstract

We construct a dynamic general equilibrium model to analyze the fiscal situation of Egypt. We model Egypt as a small open economy that takes real interest rates and world prices of fuel as given. Since a large component of the government budget consists of pensions payments, we use an overlapping generations structure. The model contains descriptions of the public and private sector, as well as descriptions of the production sectors for a public good such as infrastructure, energy, and a final aggregate consumption good. The model pays special attention to the energy sector. We then calibrate the model to data from Egypt. The following policy reforms are considered: (i) reductions in pensions to public sector workers, (ii) reductions in pensions to private sector workers, (iii) reductions in the public sector pay premiums, (iv) decreases of the energy subsidies, and (v) a decrease of the public sector workforce. In each case we reduce the "expenditure" by 15 percent. For each of the reforms we adjust consumption taxes, labor taxes, "capital taxes", or public investments in infrastructure to satisfy the government budget constraint. We calculate the new steady states, the transition paths to the new steady states, and the size of the welfare gains or losses for all reforms. We find that due to the modest nature of the reforms, the effect of the policy reforms on GDP and consumption are modest. Often these gains are in the neighborhood of 1 percent. We find that welfare gains or losses can be sizeable and that the largest gains from the reforms are attained when the freed up resources are used for infrastructure investments or for lowering the tax on company profits.

JEL Classification: E21, E63, H55, J26, J45

Keywords: fiscal policy reform, public sector reform, energy subsidies, growth

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1 Introduction

At least since the 1990s have formal dynamic general equilibrium models been used to study the influence of fiscal policy on capital accumulation, economic growth, long run levels of income, and welfare. Examples of this literature include Barro (1990), Saint-Paul (1992), Glomm and Ravikumar (1997), Turnovsky (2000), Blankenau and Simpson (2004) and many others. Calibrated versions of these types of models have been used to asses the quantitative effects of particular fiscal policy reforms on economic growth. Most of these calibration exercises are done in the context of the US economy. These papers include Lucas (1990), Glomm and Ravikumar (1998) and many others. In these models a typical result is that the effect of tax reform on growth can be very small as in Lucas (1990), for example, while growth effects of changes in public expenditures on infrastructure and public education, to name just a few, can be larger. See for example Baier and Glomm (2001).

There is now an emerging literature that recognizes the many peculiarities of fiscal policies in developing economies and that explicitly models many of these features. Schmitz (2001) models the large involvement of the government in the production of investment goods and finds that the low level of productivity in government production relative to private production and the large involvement of the government in these activities in the model can be responsible for a large part of the long run income difference between poor and rich countries. In some developing economies such as Brazil transfers as a fraction of GDP are relatively large. Rioja and Glomm (2004) and Glomm et al. (2009) find that the reallocation of transfers, i.e. public pensions to productive expenditures on education or infrastructure can have sizeable growth effects. Glomm, Jung and Tran (2009) focus on the effects of generous pensions to civil servants that induce early retirement in Brazil and find that an alternative public sector pension system that would delay retirement by five years would increase long run GDP by up to 3%.

In this paper we extend the research program outlined above by studying the effects of fiscal policies particular to the Egyptian economy on economic growth, long run levels of income and welfare. At the outset of this enterprise it is useful to take stock of the particular fiscal policy situation in Egypt.

First, the size of the public sector in production in Egypt is large whether measured in terms of output, investment or employment relative to the respective total. Public sector employment is around 25 percent of total employment and public investment has in the past exceeded private investment. This large public involvement is especially pronounced in the petroleum markets where both the public investment and employment shares have reached over 65 percent.

Second, public pension have been relatively generous. Replacement rates of around 80 percent with corresponding contributions of 21 – 24 percent for salaried employees and 14 – 16 percent for workers are high, not only in comparisons to countries with similar average incomes, but more remarkably also in comparison to rich countries.

Third, energy extraction and production play a crucial role in the Egyptian economy. The energy sector accounts for 20 percent of total GDP. Of course this number is subject to considerable fluctuations given the observed large variation in world energy prices. Associated with the energy sector is a large and important system of subsidies. These types of subsidies are not limited to the energy sector but extend also to food and other commodities. Total commodity subsidies account for around 7 percent of GDP, with energy subsidies making up around 77 percent of all commodity subsidies, that is around 5.4 percent of GDP.

In this paper we study the effects of changes in many dimensions of public sector involvement in the economy. More specifically we analyze (*i*) a decrease in the generosity of public sector pensions, (*ii*) a decrease in the generosity of private sector pensions, (*iii*) a reduction of wages in the public sector, (*iv*) a decrease in energy subsidies for households and firms, and (*v*) a decrease in the size of the workforce employed in the public sector

We use a dynamic general equilibrium model with overlapping generations, a public sector, and an energy sector and model the Egyptian economy as a small open economy with physical capital and energy trading at fixed world market prices. We solve for steady states and transitions. The latter allows us to present a complete welfare analysis of the policy reform or policy adjustments triggered by above mentioned events.

Our results are as follows: (*i*) Reducing public sector pensions by 15 percent results in moderate output increases. (*ii*) Reducing private sector pensions by 15 percent increases output more because this policy reform affects more workers. (*iii*) Reductions in public sector wages can result in output increases or decreases depending on which public policy adjusts to accommodate the drop in public sector wages. (*iv*) Decreases in energy subsidies can cause output to decrease. (*iv*) Decreases in the public sector workforce allow for the increase of the private sector workforce which results in growth effects. Many of the policy effects are mitigated by the small open economy assumption that allows capital and energy to be traded internationally at fixed prices.

The paper is organized as follows. The next section describes the model. In section 3 we calibrate the model to Egypt and in section 4 we conduct policy experiments. Section 5 provides a discussion of the results and concludes. The appendix contains all tables and figures. A separate technical appendix, available upon request from the authors, contains the details for all the model solutions and the welfare calculations.

2 The model

2.1 Heterogeneity

There is a large number of individuals who live for J periods in an overlapping generations economy. The economy is open so that many prices (i.e. interest rates and the price of energy) are exogenous. We do not allow for labor migration. Each period accounts for $\frac{70}{J}$ years, with working life beginning at age 20 and life ending for sure at age 90. In each period there is a mortality probability. Workers are born with an innate ability that determines their income. This income type cannot be changed. In addition, workers can either work in the public sector (civil servants etc.) or in the private sector. We denote the income type as variable *income* and the working sector as $sector \in \{Private, Government\}$. The agent is then characterized by age, income type, and working sector. We summarize the income type and working sector in state vector $\theta = \{income, sector\}$. Here and in the rest of the paper the subscripts P and G denote private sector workers and public sector workers respectively. When we need to distinguish between the sectors we fix the sector variable to one of the sectors and use the following state vector notation $\theta_P = \{income, sector = Private\}$ and $\theta_G = \{income, sector = Government\}$. The variable $\mu_j(\theta)$ denotes the mass of age j agents with characteristic θ. We normalize the initial population to equal one in each period so that aggregate variables correspond to per capita values. It then has to hold that $\sum_{j=1}^{J} \sum_{\theta} \mu_{j,t}(\theta) = 1$.

2.2 Demographics

Agents have a random life time. At each age, agents face a mortality shock with a given survival probability π_j. Population grows exogenously at net rate n. We assume stable demographic patterns so that, similar to Huggett (1996), age j agents make up a constant fraction $\mu_{j,t}$ of the entire population at any point in time t. The relative size of each age cohort $\mu_{j,t} = \sum_{\theta} \mu_{j,t}(\theta)$ is recursively defined as

$$\mu_{j,t} = \frac{\pi_j}{(1+n)} \mu_{j-1,t}.$$

Similarly, the cohort size of agents dying each period (conditional on survival up to the previous period) can be defined recursively as

$$\upsilon_{j,t} = \frac{1-\pi_j}{(1+n)} \mu_{j-1,t}.$$

2.3 Human capital

Agents are endowed with one unit of time each period and they provide $(1 - l_{j,t})$ units of time to the labor market with a certain efficiency $e_j(\theta)$. Effective labor (or human capital) at each age is given by $h_{j,t}(\theta) = (1 - l_{j,t})\, e_j(\theta)$. This varies over the life-cycle following the typical hump-shaped pattern.

2.4 Preferences and technology

Within each period of their lives agents value two consumption goods $c_{j,t}(\theta)$ and $m_{c,j,t}(\theta)$ (e.g. energy, fuel) as well as leisure $l_{j,t}(\theta)$ according to the utility function

$$u\left(c_{j,t}(\theta), l_{j,t}(\theta), m_{cj,t}(\theta)\right).$$

This function has the standard properties of monotonicity and quasi-concavity. Utility is discounted at the rate β.

Physical capital depreciates at rate δ each period and can be used in the production of the final consumption good and the production of energy, so that

$$K_t = K_{P,t} + K_{M,t},$$

where $K_{P,t}$ is the physical capital used in the final consumption goods production and $K_{M,t}$ is the physical capital used in the production of energy.

The consumption good is produced from four inputs, a public good G_t, the private physical capital stock $K_{P,t}$, effective labor (human capital) in the private sector $H_{P,t}$, and energy $M_{P,t}$ according to the production function

$$Y_t = F_P\left(G_t, K_{P,t}, H_{P,t}, M_{P,t}\right).$$

This production function is homogenous of degree one in $K_{P,t}$, $H_{P,t}$, and $M_{P,t}$. The public good in the production function can be thought of as the stock of public infrastructure such as 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), Turnovsky (1999) and others. Total factor productivity grows exogenously at rate g.

The intermediate good (energy) is produced using capital K_M and human capital H_M according to

$$M_t = F_M\left(K_{M,t}, H_{M,t}\right).$$

Profits of energy production, if any, are redistributed to the government.

The government uses effective labor (human capital) of civil servants $H_{G,t}$ and public capital $K_{G,t}$ to produce infrastructure capital according to

$$G_t = F_G\left(K_{G,t}, H_{G,t}\right). \tag{1}$$

This production function is characterized by the properties of monotonicity, concavity, and homogeneity of degree one. 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

$$K_{G,t+1} = \frac{1}{(1+n)(1+g)}\left((1-\delta_G)\, K_{G,t} + I_{G,t}\right), \tag{2}$$

where we detrend capital with the exogenous population growth rate and the exogenous technological growth rate. Public capital depreciates at rate δ_G in each period and $I_{G,t}$ is investment in the public capital.

2.5 Labor markets and government

Labor markets. We assume that workers cannot migrate, so that labor markets are closed. At the beginning of their life, workers are assigned employment in either the public or private sector. We assume that for all cohorts in all time periods public sector wages exceed those in the private sector in order to mimic the more generous public sector compensation scheme. Hence all workers prefer public sector jobs to jobs in the private sector. We maintain the assumption that all workers of a given age and type are equally productive regardless of whether they work in the public or private sector. All workers will retire at age J_1 irrespective of the sector they are working in. We think of this as the standard retirement age, i.e. age 60.

Government expenditures. The government finances investment in public capital $I_{G,t} = \Delta_{G,t} \times GDP_t$, where $\Delta_{G,t}$ is the fraction of GDP allocated to public investments.[1] The remainder of government expenditure is government consumption $C_{G,t}$. We let $C_{G,t} = \Delta_{C_{G,t}} Y_t$. Government consumption is assumed to be unproductive.

The government uses public capital and hires labor to produce public goods. The fraction of civil servants is fixed exogenously at N^G as a matter of government policy. The total wage bill of currently employed civil servants is

$$Wage_{G,t} = \sum_{\theta_G} \sum_{j=1}^{J_1} w_{G,t} h_{j,t}(\theta_G)\, \mu_{j,t}(\theta_G)\,.$$

The wages of civil servants are set by the government using a markup $\xi^W > 1$ over private sector wages so that $w_{G,t} = \xi^W \times w_{P,t}$. Private sector wages are determined by the market.

The government runs two separate pension programs, one for public sector workers and one for private sector workers. All workers of both sectors are required to participate in the pension program and consequently have to pay a social security tax $\tau^P_{SS,t}$ and $\tau^G_{SS,t}$. When workers retire they stop paying labor taxes and social security taxes and are eligible to draw pension benefits. We summarize the payout formula to private sector retirees as

$$Pen_{j,t}(\theta_P) = \Psi_P \times \frac{1}{J_1} \sum_{j=1}^{J_1} w_{P,t-J_1+j} \times h_{i,t-J_1+j}(\theta_P, j)\,, \tag{3}$$

[1] *GDP* in the model is defined as the sum of private sector output Y and private consumption of energy $p_M M_C$.

and the payout formula to public sector retirees as

$$Pen_{j,t}(\theta_G) = \Psi_G \times \frac{1}{J_1} \sum_{j=1}^{J_1} w_{G,t-J_1+j} \times h_{i,t-J_1+j}(\theta_G, j). \quad (4)$$

Note that the payout formula is a function of the workers average earnings, where Ψ_P and Ψ_G stands for the pension replacement rate in the private and public sector respectively.

In addition, the pension scheme for public sector workers differs from the scheme for private sector workers in contribution rates and benefit payments. The total pension payouts for private sector retirees and for public sector retirees are given by

$$Pen_{P,t} = \overbrace{\sum_{\theta_P} \sum_{j=J_1+1}^{J} Pen_{j,t}(\theta_P)\mu_{j,t}(\theta_P)}^{\text{total pensions private sector workers}}$$

and

$$Pen_{G,t} = \overbrace{\sum_{\theta_G} \sum_{j=J_1+1}^{J} Pen_{j,t}(\theta_G)\mu_{j,t}(\theta_G)}^{\text{total pensions public sector workers}}.$$

Government income. The government collects labor income taxes from all workers in the private and public sector at the rates $\tau_{L,t}^P$ and $\tau_{L,t}^G$ as well as social security taxes $\tau_{SS,t}^P$ and $\tau_{SS,t}^G$. Accidental bequests are taxed at $\tau_{Beq,t}$. The government also taxes consumption at rate $\tau_{C,t}$, fuel consumed by households at rate $\tau_{Mc,t}$, and fuel used in firm production at rate $\tau_{M_P,t}$. In addition, the government collects a tax on capital $t_{K,t}$.

The total tax revenue is given by

$$
\begin{aligned}
Tax_t = \;& \overbrace{\left(\tau_{L,t} + \tau^{P}_{SS,t}\right) \sum_{\theta_P} \sum_{j=1}^{J_1} w_{P,t} h_{j,t}(\theta_P) \mu_{j,t}(\theta_P)}^{\text{labor and soc. sec. income tax from the private sector}} \\
& + \overbrace{\left(\tau_{L,t} + \tau^{G}_{SS,t}\right) \sum_{\theta_G} \sum_{j=1}^{J_1} w_{G,t} h_{j,t}(\theta_G) \mu_{j,t}(\theta_G)}^{\text{labor and soc. sec. income tax from the public sector}} \\
& + \overbrace{\tau^{Beq,t} \sum_{\theta} \sum_{j=1}^{J} a^{j,t}(\theta) \upsilon^{j,t}(\theta)}^{\text{tax on bequests}} \\
& + \overbrace{\tau_{K,t} (q_t - \delta) K_t}^{\text{capital tax}} + \overbrace{\tau_{K,t} r_t B_t}^{\text{tax on bonds' interest}} \\
& + \overbrace{\tau^{C,t} \sum_{\theta} \sum_{j=1}^{J} c^{j,t}(\theta) \mu^{j,t}(\theta)}^{\text{consumption tax}} \\
& + \overbrace{\tau_{M_c,t} \sum_{\theta} \sum_{j=1}^{J} \bar{p}_{M,t} m_{C,j,t}(\theta) \mu_{j,t}(\theta)}^{\text{fuel tax/subsidy from HH}} \\
& + \overbrace{\tau_{M_P,t} \sum_{\theta} \sum_{j=1}^{J} \bar{p}_{M,t} m_{P,j,t}(\theta) \mu_{j,t}(\theta)}^{\text{fuel tax/subsidy from firms}},
\end{aligned}
$$

where $\bar{p}_{M,t}$ is the world market price of fuel. The government can borrow a fraction $\Delta_{B,t}$ of GDP each period. These bonds are denoted $B_{t+1} = \Delta_{B,t} Y_t$, where $\Delta_{B,t}$ is set exogenously. Newly issued bonds have to be detrended with the exogenous technological growth rate G and the exogenous population growth rate n.[2] The government also collects all profits from the energy sector. The government budget constraint can be expresses as

$$R_t B_t + C_{G,t} + I_{G,t} + I_{E,t} + Wage_{G,t} + Pen_{P,t} + Pen_{G,t} = Tax_t + (1+g)(1+n) B_{t+1} + EnergyProfit_t. \tag{5}$$

2.6 Household problem

In general, households in the private and the government sector have similar maximization problems. Households decide their consumption of final goods and energy as well as leisure $\{c_{j,t}(\theta), l_{j,t}(\theta), m_{c,m,t}(\theta)\}_{j=1}^{J(\theta)}$ as a function of their income type and their sector of employment as summarized in state vector θ. The household problem can be

[2] Fuster, Imrohoroglu and Imrohoroglu (2005) use similar exogenous growth rates.

recursively formulated as

$$V_t(a_{j,t}(\theta),\theta) = \max_{\{a_{j,t}(\theta),c_{j,t}(\theta),m_{c,j,t}(\theta),l_{j,t}(\theta)\}} \{u(c_{j,t}(\theta), l_{j,t}(\theta), m_{c,m,t}(\theta)) + \beta\pi_j V_{t+1}(a_{j+1,t+1}(\theta), \theta)\} \tag{6}$$

s.t.

-
$$\begin{aligned}&(1+\tau_{C,t}) c_{j,t}(\theta) + (1+\tau_{M_c,t})\bar{p}_{M,t} m_{c,j,t}(\theta) + (1+g) a_{j+1,t+1}(\theta)\\ &= R a_{j,t}(\theta) + (1-\tau_{L,t}-\tau_{SS})(1-l_{j,t}(\theta)) e_j(\theta) w_t + (1-\tau_{Beq,t}) T_{Beq,t}\end{aligned} \quad \text{if } j \leq J_1,$$

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$$\begin{aligned}&(1+\tau_{C,t}) c_{j,t}(\theta) + (1+\tau_{M_c,t})\bar{p}_{M,t} m_{c,j,t}(\theta) + (1+g) a_{j+1,t+1}(\theta)\\ &= R a_{j,t}(\theta) + (1-\tau_{Beq,t}) T_{Beq,t} + Pen_{j,t}(\theta)\end{aligned} \quad \text{if } J_1 < j,$$

$$\begin{aligned}0 &\leq a_{j,t}(\theta),\\ 0 &< l_{j,t}(\theta) \leq 1,\end{aligned}$$

where $j = \{1, 2, ..., J\}$, $w_t = \{w_{P,t} \text{ or } w_{G,t}\}$ is the individual wage rate which is sector specific, and T_{Beq} are transfers of accidental bequests that are taxed at rate $\tau_{Beq,t}$. Notice that household assets are required to be non negative, i.e. households are not allowed to borrow.

2.7 Firm problems

Capital and fuel can be bought at world market at prices $\bar{q}_t = \bar{q}_{P,t} = \bar{q}_{M,t}$ and $\bar{p}_{M,t}$ respectively. The final goods producing firm solves the problem

$$\max_{(H_{P,t},K_{P,t},M_{p,t})} \{F_P(G_t, K_{P,t}, H_{P,t}, M_{P,t}) - w_{P,t}H_{P,t} - \bar{q}_{P,t}K_{P,t} - (1+\tau_{M_P})\bar{p}_{M,t}M_{P,t}\},$$

given $(w_{P,t}, \bar{q}_{P,t}, \bar{p}_{M,t}, G_t)$. The fuel producing firm solves the problem

$$\max_{(K_{M,t},H_{M,t})} \{\bar{p}_{M,t}F_M(K_{M,t}, H_{M,t}) - \bar{q}_{M,t}K_{M,t} - w_{M,t}H_{M,t}\},$$

given $(\bar{p}_{M,t}, \bar{q}_{M,t}, w_{M,t})$. We graphically summarize the main features of the model in figure 1.

2.8 Definition of equilibrium

We model all markets as competitive so that all households and firms take all prices as given. Given the government policy

$$\left\{\tau_{L,t}, \tau_{SS}^{P}, \tau_{SS}^{G}, \tau_{B,t}, \tau_{K,t}, \tau_{M_c,t}, \tau_{M_P,t}, \Delta_{B,t}, \Delta_{G,t}, \Delta_{C_G,t}, \xi_t^{W}, \Psi_{P\,t}, \Psi_{G,t}\right\}_{t=0}^{\infty}$$

and the exogenously given prices

$$\{\bar{q}_{P,t}, \bar{q}_{M,t}, \bar{p}_{M,t}\}_{t=0}^{\infty},$$

a competitive equilibrium is a collection of sequences of decisions of privately and publicly employed households $\{l_{j,t}(\theta), c_{j,t}(\theta), m_{c,j,t}(\theta), a_{j+1,t+1}(\theta)\}_{t=0}^{\infty}$, sequences of aggregate stocks of private physical capital and private human capital $\{K_{P,t}, K_{M,t}, H_{P,t}, H_{M,t}\}_{t=0}^{\infty}$, sequences of aggregate stocks of public physical capital and public human capital $\{K_{G,t}, H_{G,t}\}_{t=0}^{\infty}$, sequences of factor prices $\{w_{P,t}, w_{M,t}, w_{G,t}\}_{t=0}^{\infty}$ such that

(i) the sequence $\{c_{j,t}(\theta), l_{j,t}(\theta), m_{c,j,t}(\theta), a_{j+1,t+1}(\theta)\}_{t=0}^{\infty}$ solves the household maximization problem (6),

(ii) domestic capital demand, wages, domestic fuel prices, and the after tax interest rate are determined by

$$\begin{aligned}
\bar{q}_{P,t} &= \frac{\partial F_P(G_t, K_{P,t}, H_{P,t}, M_{P,t})}{\partial K_{P,t}}, \\
w_{P,t} &= \frac{\partial F_P(G_t, K_{P,t}, H_{P,t}, M_{P,t})}{\partial H_{P,t}}, \\
\bar{q}_{M,t} &= \frac{\bar{p}_{M,t}\partial F_M(K_{M,t}, H_{M,t})}{\partial K_{M,t}} \\
w_{M,t} &= \frac{p_{M,t}\partial F_M(K_{M,t} H_{M,t})}{\partial H_{M,t}}, \\
w_{M,t} &= w_{P,t}, \\
w_{G,t} &= \xi^W w_{P,t}, \\
\bar{q} &= \bar{q}_{P,t} = \bar{q}_{M,t}, \\
R_t &= 1 + (1 - \tau_{K,t})(\bar{q}_t - \delta) = 1 + (1 - \tau_{K,t})\bar{r}_t,
\end{aligned}$$

(iii) aggregate variables are given by

$$A_t = \int_\theta \sum_{j=1}^{J} a_{j,t}(\theta)\,\mu_{j,t}(\theta) + \overbrace{\int_\theta \sum_{j=1}^{J} a_{j,t}(\theta)\,\nu_{j,t}(\theta)}^{\text{accidental bequests}},$$

$$\Delta K = \overbrace{(A_t - B_t)}^{\text{domestic capital supply}} - \overbrace{(K_{P,t} + K_{M,t})}^{\text{domestic capital demand}}, \text{ (net exports of capital)}$$

$$\bar{p}_{M,t}\Delta M = \bar{p}_{M,t}\left[\overbrace{F_M(K_{M,t})}^{\text{domestic fuel supply}} - \overbrace{(M_c + M_p)}^{\text{domestic fuel demand}}\right] > 0, \text{ (net exports of fuel)}$$

$$H_t = H_{P,t} + H_{M,t} = \int_{\theta_P} \sum_{j=1}^{J} \overbrace{(1 - l_{j,t}(\theta_P))}^{h_{j,t}(\theta_P)}\, e_{j,t}(\theta_P)\,\mu_{j,t}(\theta_P),$$

$$H_t^G = \int_{\theta_G} \sum_{j=1}^{J_1} \overbrace{(1 - l_{j,t}(\theta_G))}^{h_{j,t}(\theta_G)}\, e_{j,t}(\theta_G)\,\mu_{j,t}(\theta_G),$$

$$S_t = \int_\theta \sum_{j=1}^{J} a_{j+1,t+1}(\theta)\,\mu_{j,t}(\theta),$$

$$C_t = \int_\theta \sum_{j=1}^{J} c_{j,t}(\theta)\,\mu_{j,t}(\theta),$$

$$M_{c,t} = \int_\theta \sum_{j=1}^{J} m_{c,j,t}(\theta)\,\mu_{j,t}(\theta),$$

(iv) commodity markets clear[3]

$$C_t + (1+g)\,S_t + I_{G,t} + C_{G,t} = Y_t + (1-\delta_P)\,K_t + (1+n)(1+g)\,B_t + Beq_t + EnergyProfit_t,$$

(v) taxed accidental bequests are returned in lump sum transfers to surviving agents

$$T_{B,t} = \frac{\int_{\theta_P} \sum_{j=1}^{J} a_{j,t}(\theta_P)\,\upsilon_{j,t}(\theta_P) + \int_{\theta_G} \sum_{j=1}^{J} a_{j,t}(\theta_G)\,\upsilon_{j,t}(\theta_G)}{\int_\theta \sum_{j=1}^{J} \mu_{j,t}(\theta)},$$

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

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[3] 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.

In addition, the aggregate S_t already incorporates the exogenous population growth rates via the population weight μ. We therefore only have to detrend with the exogenous technological growth rate g.

3 Calibration

We solve the model for steady states using a numerical algorithm similar to Auerbach and Kotlikoff (1987). This algorithm solves a complicated set of non-linear equations using an iterative technique commonly referred to as the Gauss-Seidl method. The algorithm starts with a guess of various endogenous variables and treats them as exogenous. Then, after solving all individual household maximization problems and imposing the budget constraints and market clearing conditions, the algorithm solves for a new set of endogenous variables. If the new set of endogenous variables equals the original guesses, a solution to the system has been found and the algorithm stops. Otherwise, we take linear combinations of the guessed variables and the new solutions for the variables and start all over. Once the algorithm converges to a steady state, we compare the model's outcome to moments in the data for Egypt. We use a similar algorithm to solve for transitions between two equilibrium allocations that result from changes in policy variables. We check for uniqueness of equilibrium by trying various starting points for the algorithm.[4]

We first calibrate a closed economy version to get prices for energy and capital. We then fix these prices and adjust the total factor productivity of the energy sector to match energy export and capital import figures from Egypt in 2008. We present the parameter values that are used in the baseline model in table 1. Policy parameters are summarized in table 2 and matched data moments are presented in table 3. We next describe briefly how we calibrated the model.

3.1 Heterogeneity

We calibrate the OLG model with $J = 14$ periods to Egyptian data. Thus, each model period corresponds to 5 years. Agents become economically active at age 20 and die for sure at age 90. We differentiate among two income types (rich and poor) and two sector types (private and public), which is summarized in state vector

$$\theta = \{income = \{1, 2\}, sector = \{Private, Government\}\}.$$

3.2 Demographics

We use population fractions by age group from *African Statistical Yearbook 2005* (2005). The annual population growth rate was $n = 1.8\%$ in 2006 according to the United

[4]There is no formal proof of uniqueness available for this type of Auerbach-Kotlikoff models (see Kotlikoff, Smetters and Walliser (2001)). Laitner (1984) provides a proof of uniqueness for a linearized version of the original Auerbach-Kotlikoff model.

Our solution algorithm is locally stable. That is for changes in initial conditions (guesses of initial prices R and w) the algorithm converges to the same steady state. We have no proof of global convergence. It has been our experience that higher order dynamics in multi period OLG models with bonds can lead to multiple steady states. In such cases we were able to rule out Pareto inferior steady states (e.g. steady states that result in negative interest rates). Compare also Colucci (2003) who shows the existence of at least two steady states in a very simple multi period OLG model.

Nations World Population Prospects.[5] We then choose the survival probabilities so that the model matches size of the different age groups.

3.3 Human capital

Income profiles are calculated using

$$wh_j(\theta) = w \times e_j(\theta) \times (1 - l_j(\theta)) .$$

We distinguish between low and high skilled workers, where we define high skilled workers as workers with a post-secondary degree or a university degree. We pick the profiles $e_j(\theta)$ so that high skilled agents earn wage incomes that are twice as high as wage incomes of low skilled agents. The efficiency profile exhibits the typical hump-shaped pattern over the life cycle.

According to Worldbank (2008) the skill decomposition in the public sector is 70 percent low skilled workers (i.e. highest degree is vocational high school) and 30 percent high skilled workers (i.e. post-secondary and university and above). The skill decomposition in Egypt overall is roughly 50 percent low skilled and 50 percent high skilled according to Worldbank (2009). Given the size of the public sector, the private sector skill decomposition results in 43 percent low skilled and 57 percent high skilled workers.

In addition we assume that public sector workers are 20 percent less productive on average across both skill groups. However, the public sector income-age profile is higher reflecting the more generous compensation (wages and pensions) in the public sector.

3.4 Preferences and technology

Preferences are represented by the following utility function:

$$u(c_{j,t}(\theta), l_{j,t}(\theta), m_{c,j,t}(\theta)) = \frac{\left(\Theta \left(c_{j,t}(\theta)^{\gamma} l_{j,t}(\theta)^{1-\gamma}\right)^{\rho} + (1-\Theta)(m_{c,j,t}(\theta))^{\rho}\right)^{\frac{1-\sigma}{\rho}}}{1-\sigma},$$

where c and l is consumption and leisure respectively and m_c is energy consumed by the household, and $0 < \gamma < 1$, $\sigma > 0$, $0 < \Theta < 1$, and $\rho > 0$. Motivated by the RBC literature (e.g. Kydland and Prescott (1996)) we assume the elasticity between consumption and leisure is one. The parameter γ measures the relative weight of consumption versus leisure. The elasticity of substitution between consumption and energy m_c is $\frac{1}{1-\rho}$. The parameter Θ measures the importance of consumption and leisure relative to energy and σ is the coefficient of relative risk aversion. $\Theta = 0.90$ is chosen the match the household demand for energy.

[5] Awad and Zohry (2005) find that the population growth rate was about 1.9% for the earlier period from 1990 to 2005.

The elasticity of substitution between consumption and energy is $\frac{1}{1-\rho} = 0.8$ so that $\rho = -0.25$. Consumption and energy are therefore complements. The consumption preference parameter $\gamma = 0.27$ is chosen to get labor supply to be around 30 − 35 hours a week for agents in their prime working age from 25 to 55. Both, the time preference parameter $\beta = 1.035$ and the inverse of the intertemporal elasticity of substitution $\sigma = 1.15$ are chosen to match the capital output ratio and the real interest rate.[6] Consequently, in our model the resulting capital output ratio is equal to 3.2 and the after tax real interest rate is $R = 3.4\%$.

The exogenous technological rate of growth is 1 percent (Worldbank communication). The production function for the final good is

$$F_P\left(G_t, K_{P,t}, H_{P,t}, M_{P,t}\right) = A_1 G_t^{\alpha_1} K_{P,t}^{\alpha_2} H_{P,t}^{\alpha_3} M_{P,t}^{\alpha_4},$$

where $\alpha_i \in (0, 1)$ for $i = 1, ..., 4$, $\alpha_2 + \alpha_3 + \alpha_4 = 1$ and $A_1 > 0$. Total factor productivity A is normalized to one. The estimates for α_1, the productivity parameter of the public good in the final goods production function, for the U.S. 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)). Calderon and Serven (2003) estimate this parameter to be around 0.15 and 0.20. For a cross-section of low income countries Hulten (1996) obtains an estimate for α_1 of 0.10. We use $\alpha_1 = 0.09$, which is a conservative estimate in order to not overstate our results.

The capital share of GDP is very high in Egypt so we chose $\alpha_2 = 0.52$. Parameter $\alpha_3 = 0.36$ together with the preference parameter for leisure $(1 - \gamma)$ determines average hours worked. We pick α_4, the share of energy in production to be equal 0.12. We chose this parameter to match the size of the energy sector in Egypt. The size of the energy production sector is jointly determined by parameters α_4 (domestic industry demand for energy), Θ (household demand for energy), and A_2 (energy supply).

The intermediate goods' (energy sector) production function is

$$F_M\left(K_{M,t}, H_{M,t}\right) = A_2 K_{M,t}^{\eta_{21}} H_{M,t}^{\eta_{22}},$$

where $A_2 > 0$ and $\eta_{21}, \eta_{22} \in (0, 1)$ and $\eta_{21} + \eta_{22} \leq 1$. If the production function exhibits constant returns to scale this will result in zero profits. If we have decreasing returns to scale, profits π_M have to be redistributed to the government. We chose $\eta_{21} = 0.78$ and $\eta_{22} = 0.05$ so that firms make a profit of 4 percent of GDP which compares well to the 3 percent reported by the Worldbank (Worldbank communication). All profits from the energy sector are collected by the government. Total factor productivity A_2 is chosen to match the size of the energy sector and also the size of energy exports. In the model, energy exports amount to 6 percent of GDP compared to empirical estimates of

[6] It is clear that in a general equilibrium model every parameter affects all equilibrium variables. Here we associate parameters with those equilibrium variables that they affect the most quantitatively.

5.8 percent of GDP (Worldbank communication).

Finally, since this is a small open economy model where capital and energy can be traded at world market prices, the model also results in capital imports of 5.1 percent of GDP. Worldbank sources report estimates that range between 5.46 to 6.6 percent of GDP on average between 2005 – 2008. Capital depreciates at 20 percent per year.

The production function for the public good is

$$F_G\left(K_{G,t}, H_{G,t}\right) = A_3 K_{G,t}^{\eta_3} \left(\omega_h H_{G,t}\right)^{(1-\eta_3)},$$

where $A_3 > 0$ and $\eta_3 \in (0,1)$. The fraction of civil servants contributing to the production of the public good is denoted $\omega_h \in (0,1)$. The remaining civil servants produce government consumption that is not explicitly modeled. Total factor productivity $A_3 = 0.6$ is chosen to match the size of the public goods sector. We have little information about the parameters of the production technology of the public good. We view the choice of $\eta_3 = 0.4$ and $\omega_h = 0.4$ as our benchmark and we perform sensitivity analysis on these parameters. We find that our qualitative and quantitative results are relatively robust to changes in η_3 and ω_h. Capital K_G depreciates at 15 percent per year.

3.5 Labor markets and government

Labor markets. In the model we assume that all agents retire at age 60, or $J_1 = 8$. The total number of periods in a life is $J = 14$ which corresponds to age 90. The government policy parameters are summarized in table 2.

Government expenditures. Based on Worldbank (2009) public sector employment as fraction of total employment is approximately 25 percent. In addition, public sector workers earn on average up to 30 percent higher wages than private sector workers. Since this number is calculated factoring in income of informal sector workers, we pick a slightly more moderate markup factor of public wages of 20 percent so that $\xi^W = 1.20$ to not overstate wages in the public sector.

According to Gupta et al. (2009), 90 percent of the labor force is covered by the pension program. In order to not overstate the replacement rates in the private sector we decided to match the size of the pension programs (public and private) as percent of GDP as well as the government revenue from payroll taxes paying for pensions.[7] This allows us to not only match the size of pension programs but also their relative deficit/surplus. in 2007 the pension system in Egypt ran a deficit of 0.8 percent of GDP according to Gupta et al. (2009), where the private sector pensions contributed a deficit

[7] Pension replacement rates in the public sector are 80 percent on average. Replacement rates in the private sector are higher. Estimates for replacement rates are as high as 150 percent of average lifetime salary (see Gupta et al. (2009)). These high replacement rates in the private sector are the result of averaging. There are large groups of workers working in the private sector who have very low income and some of these workers are informal sector workers. However, we do not distinguish informal vs. formal sector workers in our model. The private sector replacement rates in our model are therefore much lower and chosen to match aggregate private sector pension payments.

of 0.9 percent of GDP and public sector pension plans ran a surplus of roughly 0.1 percent of GDP. We therefore end up using replacement rates of $\Psi_P = 0.28$ and $\Psi_P = 0.85$ as well as payroll taxes of $\tau_{SS}^{P} = 3\%$ and $\tau_{SS}^{G} = 18\%$.[8]

Government income. In addition the government raises labor taxes, consumption taxes, taxes on bequests, and taxes on profits (in the model this is approximated using capital taxes[9]) to finance public sector workers, government consumption, investments into public capital, and service of its debt. Capital taxes in Egypt are zero. However, tax revenues raised from corporate profits are three times the size of revenues raised from labor income taxes. If one excludes taxes collected from Suez Canal profits, the tax revenue raised on company profits is still twice the size of labor income tax revenue. In our model we use capital taxes as a proxy for taxes on profits and choose the capital tax rate so that revenue streams from taxes on profits are matched.

We set the tax rates so that revenues streams from the various taxes are matched to data from Worldbank (2009). Table 3 presents the details. According to Worldbank (2009) total tax and non-tax revenues as fraction of GDP are about 28 percent, half from personal and corporate income tax, the remainder from sales and excise taxes. This revenue figure includes profits from oil exports and Suez canal fees so that estimates for tax revenue itself are probably between 15 and 20 percent. The model is calibrated to generate tax revenues of 16 percent of GDP.

The size of the energy subsidies is 5.29 percent of GDP according to Worldbank (2009). We choose subsidy rates for households of $\tau_{M_C} = 36$ percent and $\tau_{M_P} = 28$ percent which result in energy subsidies of 5.2 percent in the model.

The government issues new bonds in the amount of $\Delta_B = 26$ percent of GDP in every model period which results in a steady state government debt level of 65 percent of GDP (Worldbank (2009) states 65.percent as well).

We calibrate investments into a public capital that is needed to produce a public good (e.g. roads etc.) to be $\Delta_G = 3$ percent of GDP in order to match the size of the public good production as a share of GDP (27 percent according to Worldbank (2009). In our model the government share in production is 28 percent of GDP, 11 percent from public goods production (produced by a public capital and public sector workers) and 17 percent from energy production (produced by physical capital and human capital employed in the energy sector at competitive wages). Profits from the energy sector are redistributed to the government budget.

[8]The statutory contribution rates are between 21 _ 24 percent for salaried employees and between 14 _ 16 percent for workers (Worldbank (2009)).

[9]Capital taxes in the model are raised on asset returns of households and not on capital stock in the production sector.

4 Policy experiments and results

We run five separate policy events. The first experiment decreases the generosity of public sector pensions by 15 percent. The second experiment decreases the generosity of private sector pensions by 15 percent. The third experiment decreases the wage subsidies in the public sector by 15 percent. In the fourth experiment we decrease the energy price subsidy by 15 percent. In the fifth experiment we decrease the workforce in the public sector by 15 percent. In all experiments we let either consumption taxes (τ_C), labor taxes (τ_L), capital/profit taxes (τ_K), or investments into the public capital (Δ_G) adjust to clear the government budget constraint in reaction to the simulated 15 percent change of the respective status quo variable.

The policy changes are unanticipated by all agents. Decreases in pensions are "grandfathered" meaning that current retirees will keep their pre-reform pension. All other policy experiments have immediate effects on all economic agents. Steady state results of the experiment are summarized in tables 4 to 8. Transitions and welfare analyses for selected experiments are presented in the figures 2 to 7. We next describe the results in more detail.

4.1 Experiment 1: Decrease in public sector pension replacement rates

In this experiment we decrease the public pension replacement rate by 15 percent and let either consumption taxes, labor taxes, capital/profit taxes, or investments in the public capital adjust to clear the government budget constraint. Steady state results are presented in table 4.

Steady state analysis with an adjustment in consumption taxes. The results of this experiment are presented in column two of table 4. Decreasing the generosity of pension payments to the public sector workers decreases their old age non labor income. As is standard in overlapping generations models, such a decrease increases savings of the affected population. This increase in savings by public sector workers in turn increases the steady state capital stock. The increase of 1.67 percent is quantitatively large. Due to complementarities in human and physical capital, increases in the capital stock tend to increase wage rates as well. With an increase in the wage rates savings by private sector workers can increase as well, reinforcing the initial increase in savings and the overall capital stock. If human capital and other productive inputs are not adversely affected by this policy change, output (GDP) will increase as a result of this policy change. The overall increase in output of about 0.18 percent is small, reflecting the relatively modest cut in public sector pensions of15 percent.

In this version of the model economy, unlike the closed economy version, the interest rate does not adjust to changes in the stock of capital. The increase in asset accumulation precipitated by the cut in public sector pensions either increases exports of capital or decreases imports of capital. In this case, capital imports decline by about 20 percent.

The cut in public sector pensions generates a small negative wealth effect which induces public sector workers to increase their labor supply, which in turn increases human capital in the public sector and therefore production of the public good. On the other hand, private sector workers respond to these changes with a decrease of their labor supply. Total (public and private) hours worked increase slightly.

Perhaps most significant is that all of these changes induce an increase in aggregate consumption of around 0.65 percent. This is significant since coupled with an increase in energy consumption and an almost steady consumption of leisure, these effects point toward a potential welfare increase caused by this policy.

Transition dynamics with an adjustment in consumption taxes. In this subsection we solve for the transition dynamics following the policy reform. Results of the transitions are presented in figure 2. The temporary drop in consumption in panel 7 can be explained by the initial rise in savings which is induced by the pension reform. Over time, increases in income generate a sustained increase in consumption as well. We find that after small transitory effects due to grandfathering, the transitions are smooth and monotone. Welfare results are presented in figure 3. There and in the following figures the reform becomes effective at the beginning of the life of generation 0.

First we calculate the compensating consumption measure for each of the four types of individuals. This measure allows us to identify the winners and the losers from this reform. Moreover, this exercise lets us calculate the size of potential welfare gains and/or losses associated with each policy reform. The first panel of figure 3 illustrates that workers born before the reform who are employed in the private sector are almost indifferent between the two policies. This is so, because for them there are only a few small general equilibrium effects that come into play towards the end of their lives. Private sector workers alive or born after the reform are clearly better off. These welfare gains are larger the later the individual is born. Workers who are born before the reform, but are live during the reform will see lower taxes towards the end of their lives and some of the general equilibrium adjustments pointed out above. For workers born after the reform the welfare gains approach about 1 percent of consumption. These welfare gains are larger for poorer workers than for richer workers. In the long run, rich workers gain 1.3 percent of consumption and poor workers gain 1.5 percent of consumption.

There is a similar but opposite pattern for public sector employees. Those retired before the implementation of the reform are unaffected. Those working at the time the reform is implemented experience very small welfare changes. Of course, those agents who start their careers after the reforms are fully implemented are fully affected and they experience welfare losses. For poor public sector workers the welfare losses are around 2.5 percent of consumption and for rich public sector employees they are about 3 percent of consumption.

The third panel of figure 3 illustrates aggregate compensating consumption. This is a measure that allows us to put a price tag in terms of aggregate consumption on these reforms. It is also apparent from this third panel that initial generations bear the cost of this reform, while future generations are the beneficiaries. It is apparent from this panel, that initial aggregate losses are very small, while the benefits to future generations are a modest 0.3 percent of consumption.

Steady state analysis with an adjustment in labor taxes. Table 4 (third column) presents the steady state results of this reform. The results are very similar in magnitude to the results previously discussed. It is noteworthy, however, to point out that capital imports decrease by more than 33 percent which is a direct result of the stronger capital accumulation (2.77 percent growth over the status quo). The latter is a result of complementarities with human capital. Since labor taxes decrease slightly from 2.9 to 2.24 percent, wages increase and more human capital is accumulated than in the earlier experiment. However, as Egypt continuous to import capital, we still do not observe very large positive effects on the final goods production (small increase of 0.23 percent). The economy merely shifts from importing physical capital to producing it.

Steady state analysis with an adjustment in capital taxes. When capital taxes adjust to accommodate the drop in public pensions (fourth column 4) we find that capital taxes decrease by 3.42 percentage points to adjust for cuts in public sector pensions. This drop in the capital tax rate triggers a savings effect that increases the steady state capital stock by 8.6 percent. Egypt decreases its capital imports and ends up using slightly less capital in domestic production so that output drops marginally.

Steady state analysis with an adjustment in investments in public capital. Finally, in the last case of experiment 1 (fifth column in table 4) we let investments into public capital adjust to clear the government budget constraint. We find that the government can increase its investment into public capital from 3 percent to 3.15 percent of GDP. This small increase in public capital triggers and increase of 2.9 percent in the production of the public good G, that in turn increases GDP by 0.63 percent. This is a small increase, but it is still larger than the output increases in the previous two experiments with either consumption or labor tax adjusting.[10]

We can summarize the results from the first round of experiments as follows. The 15 percent cut in public pensions results in moderate output increases regardless of which government policy we let adjust in response to the decrease in public sector pensions. Hence, the government is able to reduce non-productive spending and either lower taxes or increase productive infrastructure investments. The effects are small since policy reform is modest and the increases in domestic savings merely decrease Egypt's dependency

[10] We also solve for a closed economy version of this model and in general find similar results. Decreases in pension payments, free up resources, so that investments into infrastructure can be increased. Compare also the closed economy results in Glomm et al. (2009). Higher levels of public good G result in larger output increases of GDP for this particular experiment. General equilibrium effects (price adjustment effects) amplify the growth effects in the closed economy version of our model. In addition, as capital and energy cannot be sold off or bought for a fixed price at the international market, they fully enter domestic production and amplify positive or negative growth effects.

on capital imports, so that the changes in domestic capital accumulation do not fully enter into domestic production.

4.2 Experiment 2: Decrease in private sector pension replacement rates

In this experiment we decrease the private pension replacement rate by 15 percent and let either consumption tax, labor tax, capital tax, or investments in the public capital adjust to clear the government budget constraint. Steady state results are presented in table 5.

Steady state analysis with an adjustment in consumption taxes. The de- crease in private sector pensions results in higher savings rates as workers in the private sector adjust for the lower pension income when old. The capital stock increases by 0.53 percent which is partly offset by a decrease in capital imports. As more physical capital is used in the final goods production, more human capital is employed as well due to physical-human capital complementarities. This starts an income feedback loop for households which results in a growth of domestic output of 0.52 percent. The consumption tax rate drops from 18 percent to 16.63 percent. The growth effects together with the drop in the sales tax induce households to consume more of the final consumption good which increases welfare in the long run. The effect on GDP and consumption here are about twice as large as in the previous experiment since a much larger fraction of the labor force is affected and since private pensions present a larger distortion on savings and capital accumulation.

Transition dynamics with an adjustment in consumption taxes. We solve the model for transition dynamics from the status quo equilibrium to an equilibrium with less generous pensions in the private sector and present the results of the welfare analysis with consumption taxes adjusting in figure 4. We observe that private and public sector workers born under the old regime are almost indifferent between the reform and the status quo (two top panels in figure 4). Private sector workers born immediately after the reform is implemented lose from the reform. However, poor private sector workers born between 5 to 8 periods after the reform gain from it as growth effects materialize eventually and also benefit private sector workers with less generous pensions. On the other hand, welfare gains for rich workers set in 3 periods, or 15 years, later. Such a policy might thus also have desirable redistributional consequences.

On the other hand, generations of public sector workers born after the implementation of the reform do immediately benefit from the growth effects triggered by the reform and experience welfare gains (they do not lose income because their pensions remain stable). Public sector workers are among the clear winners of this reform as their pensions remain constant and they can benefit from the growth effects triggered by the pension cuts in the private sector. Overall the economy experiences a welfare loss of about 0.1 percent of GDP in compensating consumption units in the short and intermediate run, but in the long run the economy can gain more than 0.4 percent of GDP in compensating consumption every period.

Steady state analysis with an adjustment in labor taxes. Table 5 (third column) presents the results for this case. The labor tax rate decreases from 2.9 to 0.98 percent. Increases in the labor supply cause an additional income effect, so that in reaction to the lost pension income agents increase savings by 2.14 percent. Since Egypt exports a lot of this additional capital (capital imports drop by over 65 percent), the output effects are still moderate at 0.63 percent of GDP.

Steady state analysis with an adjustment in capital taxes. Table 5 (fourth column) presents the results for this case. The capital tax rate decreases by 11.6 percent. This drop causes a large positive savings effects so that physical capital stocks increase by over 27 percent. Since world market prices for capital and energy are fixed due to the small open economy assumption, Egypt starts exporting capital and becomes a capital net exporter. Capital used in the fuel and final goods sector stays roughly constant so that output drops by 2.2 percent. On the other hand, the additional income from capital exports allows households to increase aggregate consumption by almost 5 percent.

Steady state analysis with an adjustment in investments in public capital. Finally, in the last case of experiment 2 (fifth column in table 5) we let investments into public capital adjust to clear the government budget constraint. As a result of the lower pension payments, the government is able to increase investments into the public capital from 3 percent to 3.4 percent of GDP. Together with increases in the savings rate by 3.65 percent and increases in the productive public good G by 5.5 percent, the economy now generates output increases of almost 2 percent. In addition, aggregate consumption levels increase and generate welfare gains.

4.3 Experiment 3: Reduction of the public sector wage premium

In this experiment we simulate a decrease in the public sector wage premium (wage markup of public sector workers) by 15 percent and report the steady state results in table 6.

Steady state analysis with an adjustment in consumption taxes. A direct consequence of this wage cut is that public sector workers supply less labor (average weekly hours drop from 30.83 to 28.95,compare column two in figure 6) so that human capital employed in the public sector drops by more than 4 percent. This drop in human capital employed in the public sector decreases the production of the public good G which is a factor in the final goods production function by a substantial 2.5 percent. Also, due to the decrease in income of public sector workers, the savings rate of this group will decrease so that domestic capital accumulation drops by 3.6 percent. In order to compensate for this drop, the economy increases imports of physical capital by 43.7 percent.

On the consumption side we now observe a drop in the consumption tax rate from 18 to 15.24 percent (column two in table 6). This drop in the price of consumption together with the stable output performance (the stability comes from capital imports to compensate for the loss of domestic physical capital) results in a moderate loss of aggregate consumption of roughly 1.2 percent. The capital imports and slight increases in human capital employed in the private sector result in relatively stable output. GDP decreases by slightly over 0.4 percent.

Transition dynamics with an adjustment in consumption taxes. The welfare dynamics paint a different picture than in the previous experiments (figure 5 contains the welfare results). It shows that private sector agents born before the reform gain more under this scenario than under policy reform 1 (i.e. the cut in public sector pensions), whereas private sector agents born after the reform gain less than in experiment 1. Moreover in this reform early generations experience larger welfare gains than later generations.

We already see this in the lower aggregate consumption level from the steady state analysis. In addition, we now find that the wage cuts in the public sector lead to massive welfare losses for public sector workers, especially for workers that are still active. Again, public sector workers born after the reform are hit the hardest. In addition, we see that this reform would cost the government up to 3 percent of GDP in compensating consumption in every year after the reform. This negative result can be linked to the sizeable drop in the productive public good G (i.e. infrastructure). It is noteworthy, that we find this negative effect despite a conservative assumption that only 40 percent of public sector workers contribute to the production of the public good G.

Steady state analysis with an adjustment in labor taxes. Labor taxes drop from 2.9 to -1.15 percent to accommodate the drop in the public sector wage bill. Labor is now subsidized. Households therefore do not experience a net income loss (see third column in table 6). The drop in wage income is offset by the subsidy on labor. In addition, the drop in labor taxes not only increases a households income directly, but also removes some of the tax distortions for the rest of the economy. As a result, households' net income increases slightly and the economy's domestic capital accumulation increases by 3.3 percent. This in turn allows Egypt to decrease capital imports by over 43 percent. GDP therefore slightly outgrows GDP from the experiment with consumption taxes adjusting but still decreases slightly compared to the old regime. However, the loss in output is very moderate at 0.15 percent.

Steady state analysis with an adjustment in capital taxes. Capital taxes drop by 20 percent points to accommodate the drop in the public sector wage bill. Households therefore do not experience a net income loss (see forth column in table 6). Again increased savings increase the physical capital stock by over 41 percent and Egypt again turns from a net importer of physical capital to a net exporter due to the fixed world market prices. Because of drops in the public good, the domestic final goods production sector becomes less productive, so that it becomes more lucrative to export capital than to use it internally. This causes a drop in output of roughly 6.7 percent combined with an increase in aggregate consumption of 5.8 percent. The latter is again partly financed with revenues from capital exports.

Steady state analysis with an adjustment in investment in public capital. Finally, case four (see the fifth column in table 6) results in expected increases in infrastructure investments of 0.8 percent of GDP. The savings rate drops slightly. However due to increases in the production of the public good G by more than 8 percent, more physical capital is now used in the final goods production (due to complementarities with G) so that Egypt increases its imports of physical capital and pulls out some capital from the energy sector (K_M decreases by 0.58 percent and capital imports increase by 33.38 percent) . The result of these effects is an increase in final goods production. Output increases by 2.39 percent.

4.4 Experiment 4: Decrease in energy subsidy

Energy is heavily subsidized in Egypt and the total energy subsidy amounts to roughly 5.29 percent of GDP. We simulate a decrease in the subsidy rate by 15 percent. Steady state results are presented in table 7.

Steady state analysis with an adjustment in consumption taxes. A drop in the subsidy rate increases the price of energy used in the final goods production. This does not have much of an effect on the domestic production of energy though, as energy can always be traded at fixed world market prices. As energy use in domestic production decreases by over 7 percent (column two in table 7), energy exports increase from 6.02 to 7.38 percent of GDP. At the same time the domestic production sector of final goods and services experiences a drop in output of almost 2 percent of GDP as it now uses less energy.

Negative income effects from decreases in output affect the savings rate of the households, so that physical capital accumulation decreases and steady state capital drops by more than 2 percent. The economy therefore increases its imports of physical capital by 9.14 percent. Aggregate consumption stays stable as income losses are compensated for by drops in the consumption tax rate from 18 to 15.13 percent as well as by income from exports of energy (exports increase by 20.53 percent). The drop in the consumption tax is a reaction to lower financing needs by the government due to the decrease in energy subsidies.

Transition dynamics with an adjustment in consumption taxes. The trans- ition dynamics point to welfare increases that stem from increases in consumption of energy by the households (see figure 6). This consumption is made possible by cuts in the sales tax but also by increases in energy exports. It is apparent that these welfare gains are uniformly larger with compensating consumption reaching between 8 to 10 percent for both public and private sector workers which we consider to be very large effects.

Steady state analysis with an adjustment in labor taxes. When labor taxes adjust from 2.9 to −1.3 percent to accommodate the decrease in energy subsidies, we observe an increase in capital accumulation of 5.49 percent due to income effects (see third column in table 7). This allows Egypt to decrease its imports of physical capital by 85 percent. The overall effect on aggregate consumption is larger than in the previous case where consumption taxes adjusted. However, the increase is mainly due to income effects from lower taxes. The net effects on output are similar and exhibit a more moderate drop of 1.4 percent in GDP.

Steady state analysis with an adjustment in capital taxes. When capital taxes decrease by over 20 percentage points to accommodate the decrease in energy subsidies, we observe an increase in capital accumulation of 45.7 percent due to income effects (see fourth column in table 7). Egypt again becomes a net exporter of physical capital. In addition much less energy is used in the production process due to the lack of the subsidies so that output drops significantly. Despite the drop in output aggregate consumption again increases, financed by capital exports.

Steady state analysis with an adjustment in investment in public capital. Lower energy subsidies lower the amount of energy used in the final goods production process by almost 4.5 percent (see table 7, column five). At the same time the economy increases investments into public capital from 3 to 3.87 percent of GDP. The public good production increases therefore by more than 11 percent. This will increase GDP by 1.22 percent. The additional income generated allows households to not only consume more final consumption goods (increase of 0.7 percent) but also of energy (9 percent increase).

4.5 Experiment 5: Decrease the size of the workforce in the public sector

In this experiment we decrease the workforce in the public sector by 15 percent from originally 25 percent to 21.25 percent. Steady state results are presented in table 8.

Steady state analysis with an adjustment in consumption taxes. A decrease in the overall workforce in the public sector that produces the public good G results in growth effects as the economy has more private human capital available in its production process. The productivity of private human capital is larger than the productivity of the public good G used in the final goods production process so that having the extra workers in the private sectors triggers output effects of 1.2 percent.

Transition dynamics with an adjustment in consumption taxes. The trans- ition dynamics point to welfare increases for generations born before the reform. Since the cut in the public sector workforce does not affect the retired public sector workers they gain from this reform (see figure 7). Despite positive effects on efficiency, the welfare effects are negative as more time passes. The negative welfare effects are caused by large drops in the stock of infrastructure G and the household energy consumption compared to a very moderate increase in the household final goods consumption.

Steady state analysis with an adjustment in labor taxes. The labor tax rate decreases from 2.9 to −0.85 percent as the public sector wage bill decreases (column three in table 8). The income effects that are generated by this drop cause an increase of physical capital stock of 4.55 percent, so that output increases by 1.45 percent. The increases in income also allow households to increase their consumption of the final good and of energy by 2.24 and 1.94 percent respectively.

Steady state analysis with an adjustment in capital taxes. The capital tax rate decreases by 19 percentage points as the public sector wage bill decreases (column four in table 8). Egypt becomes a capital net exporter, since fewer people work to produce the public good, G drops by more than 13 percent. As G enters the final goods production, output decreases despite increase in physical capital of more than 41 percent.

Steady state analysis with an adjustment in investment in public capital. When the economy adjusts investments into public capital from 3 percent to over 3.75 percent of GDP (column five in table 8) growth effects of more than 3.86 percent are realized. Due to the higher investments into the public capital, more public good G is produced despite the fact that less labor is available in the public sector. The increases in G cause output to increase.

4.6 Sensitivity analysis

In addition, we provide sensitivity analysis for this last experiment and decrease the size of the public sector work force by 5, 15, 25, and 35 percent respectively and let labor taxes adjust to clear the government budget constraint. From table 9 we see that larger cuts in the size of the public sector result in larger output effects. A cut of 15 percent (like in the previous experiment) increases GDP by 1.45 percent, whereas a decrease of the public sector workforce by 35 percent increases GDP by 2.23 percent. These output increases go hand in hand with increases in aggregate consumption levels. For a 35 percent cut of the size of the public sector labor force aggregate consumption rises by over 4 percent.

5 Conclusion

We have constructed a dynamic general equilibrium model, calibrated it to Egypt and used it to conduct a variety of policy reforms. All of the reforms we studied involved a decrease in public sector expenditures. The specific reforms we studied are: (*i*) a decrease public sector pensions, (*ii*) a decrease private sector pensions, (*iii*) a decrease in the public sector wage premium, (*iv*) a decrease in the energy subsidy, and (*v*) a decrease in the size of the public sector workforce.

The overall findings that emerge from this analysis are: a 15 percent reduction in the above public expenditures can lead to an increase in GDP or private sector aggregate consumption of up to 1 percent. Most of the time, the gains in output and consumption are smaller. We find that the gains in output and in aggregate consumption are largest when the freed-up resources are used for investment in infrastructure capital or for lowering the tax on household assets (i.e. lowering the capital tax which in the model is approximating the tax on profits). For most of the reductions in public expenditures considered in this paper, there exists an adjustment of the tax side of the government budget constraint which generates sizeable welfare effects. The gains in GDP and in consumption are more moderate and are typically smallest when the consumption tax rate is decreased to balance the government budget. Although the reforms result in relatively modest changes in GDP, welfare gains are more substantial at up to 4% of GDP in compensating consumption.

There are a few modeling choices we made. First, we have not modeled explicitly the international trade side and the question of how these fiscal policy reforms would influence the trade balance. We have abstracted from explicitly modeling the formal and informal sector. These policy reforms undoubtedly would impact workers in the informal sector differentially since they would be excluded from pension benefits but also from some forms of taxation. Finally, some of these public sector reforms may have an adverse effect on women, since women are predominantly employed in the public sector.

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6 Appendix

6.1 Tables and Figures

Parameters	Model:	Observation/Source:
Preferences		
Discount factor	$\beta = 1.035$	To match $\frac{K}{Y}$ and R
Inverse of intertemp. elast. of subst.	$\sigma = 1.15$	To match $\frac{K}{Y}$ and R
Weight on consumption	$\gamma = 0.27$	To match average hours worked.
Weight on c and l	$\Theta = 0.90$	
Elasticity of substitution between c and m is $\frac{1}{1-\rho}$	$\rho = -0.25$	c and m are complements
Private Production:		
TFP	$A_1 = 1$	Normalization
Productivity of public good G	$\alpha_1 = 0.09$	
Capital productivity	$\alpha_2 = 0.52$	Worldbank communication
Human capital productivity	$\alpha_3 = 0.36$	
Intermediate good productivity	$\alpha_4 = 0.12$	
Capital depreciation	$\delta = 20\%$	
Long run growth rate	$g = 1\%$	Worldbank communication
Intermediate Good Production:		
TFP for intermediate good	$A_2 = 0.89$	To match size of Energy sector
	$\eta_{21} = 0.78$	Positive profit in energy sector
	$\eta_{22} = 0.05$	Positive profit in energy sector
Public Production:		
TFP for public good production	$A_3 = 0.6$	To match public sector size
	$\eta_3 = 0.4$	Sensitivity analysis
Prodcutive civil servants	$\omega_h = 40\%$	Sensitivity analysis
Public capital depreciation	$\delta_G = 15\%$	To match public sector size
Human Capital:		
Efficiency profile	$e_j(\theta)$	To match size of public good sector and hours worked
Efficiency profile low vs. high skilled	2 : 1	
Distribution low vs. high skilled, public	70% / 30%	Worldbank (2008)
population growth rate	$n = 1.8\%$	UN World Population Prospects

Table 1: Model Parameters

	Model:	Observation/Source:
Labor Allocation:		
fraction of civil servants	N^G = 25%	Worldbank (2009)
private sector employees	N^P = 75%	Worldbank (2009)
Expenditures:		
Public wages markup	ξ^W = 1.20	Worldbank (2009)
Replacement rates (generosity of pensions)	Ψ_P = 28%, Ψ_G = 85%	to match pension sizes
Investment in public good (in % of private sector output)	Δ_G = 3%	Worldbank communication
Residual gov't consumption (in % of private sector output)	Δ_{C_G} = 0%	Residual (thrown into ocean), to match labor tax revenue
Government bonds (in % of private sector output)	Δ_B = 26%	To match debt level of 65% of GDP, Worldbank communication
Taxes:		
Labor tax rate; private	τ_L^P = 17.02%	Adjusts endogenously
Labor tax rate; public	τ_L^G = 17.02%	Adjusts endogenously
Consumption tax rate	τ_C = 26%	To match consumption tax share in tax revenue
Capital/profit tax rate	τ_K = 40%	To match capital/profit tax share in tax revenue
Energy tax HH	τ_{M_C} = −36%	To match subsidy, 5.39% of GDP
Energy tax firms	τ_{M_P} = −28%	To match subsidy, 5.39% of GDP
Tax on bequests	τ_{Beq} = 9%	To match tax revenue of labor tax
Social security tax-private	τ_{SS}^P = 3%	To match pension deficit −0.9% of GDP
Social security tax-public	τ_{SS}^G = 18%	To match pension deficit +0.1% of GDP

Table 2: Policy Parameters

Moments	Model:	Data:	Observation/Source:
Capital output ratio: $\frac{K}{Y}$	3.2	3.1	Worldbank communication
Annual interest rate: r	3.2%	3%	Worldbank communication
Public sector share of GDP: $\frac{G+\bar{p}_M M}{Y}$	27.9%	27%	Worldbank communication, 17% from energy, 10% from public good.
Hours worked/week:	35	30 − 35	Worldbank communication
Hours worked/week, private:	36.4	30 − 35	Worldbank communication
Hours worked/week, public:	31	30 − 35	Worldbank communication
Public good production: $\frac{G}{Y}$	11%	10%	Worldbank communication
Energy prod. in % of GDP	18%	17%	Worldbank (2009)
Energy profits in % of GDP	4%	3%	Worldbank communication
Energy exports in % of GDP	6%	5.8%	Worldbank communication
Capital imports in % of GDP	−5.1%	−5.4 − 6.6%	Worldbank communication average in past 3 years
Government Size: (all in % of GDP)			
Total tax revenue	15.7%	15 − 20%	Worldbank (2009) 25% from income, 25% from profits, 50% from sales/excise taxes
Energy subsidy	5.2%	5.29%	Worldbank (2009)
Labor tax revenue	1.3%	1.7%	Worldbank (2009)
Consumption tax revenue	7.3%	7.5%	Worldbank (2009)
Capital/profit tax revenue	3.3%	3.4%	Worldbank (2009)
Soc.Sec.Rev.:private sector	1.1%	1.1%	Gupta et al. (2009)
Soc.Sec.Rev.:public sector	1.4%	1.6%	Gupta et al. (2009)
Bequest tax revenue	1.3%		to match size of tax revenue
Expenditures: (all in % of GDP)			
Wage bill public sector	7.8%	8%	Worldbank (2009)
Private pensions	2.1%	2%	Gupta et al. (2009)
Public pension	1.3%	1.5%	Gupta et al. (2009)
Debt	65%	65%	Worldbank (2009)
Pension Deficit: (all in % of GDP)			
Total pension deficit	−0.88%	−0.8%	Gupta et al. (2009)
Pension balance priv. sector			Gupta et al. (2009)
Pension balance pub. sector	±0.1% 0.99%	±0.1% 0.9%	Gupta et al. (2009)

Table 3: Model Outcomes that Match Egyptian Data

	Benchmark	τ_C	τ_L	τ_K	Δ_G
GDP	100.000	100.182	100.233	99.664	100.625
Output Y	100.000	100.182	100.224	99.638	100.626
Capital K	100.000	101.664	102.756	108.574	102.123
Capital in fuel K_M	100.000	99.911	99.904	99.944	99.788
Capital in final K_P	100.000	100.182	100.224	99.638	100.626
Human capital private H_P	100.000	99.870	99.889	99.460	99.874
Human capital public H_G	100.000	101.915	102.032	101.494	101.897
Public good G	100.000	101.218	101.308	100.758	102.935
Consumption C	100.000	100.649	100.917	101.613	100.629
Energy production $p_M * M$	100.000	99.911	99.904	99.944	99.788
Energy consumption $p_M * M_C$	100.000	100.194	100.781	101.312	100.535
Energy used in prod. $p_M * M_P$	100.000	100.182	100.224	99.638	100.626
Exp: Capital (imp. if neg.)	-100.000	-80.108	-66.453	-62.126	-78.245
Exp: Energy (imp. if neg.)	100.000	99.098	98.801	100.454	97.304
Energy Profit	100.000	99.911	99.904	99.944	99.788
Wages w	100.000	100.303	100.325	100.189	100.726
Change in after tax interest rate Δr in %	3.231	0.000	-0.000	0.163	0.000
Change in labor tax $\Delta\tau_L$ in %	2.892	0.000	-0.650	0.000	0.000
Change in consumption tax $\Delta\tau_C$ in %	18.000	-0.525	0.000	0.000	0.000
Change in capital tax $\Delta\tau_K$ in %	40.000	0.000	0.000	-3.420	0.000
Infrastruc. Inv. Δ_G in %	3.000	3.000	3.000	3.000	3.151
Energy subsidy τ_M in %	14.505	14.532	14.546	14.611	14.594
K/GDP	3.380	3.430	3.465	3.202	3.430
Energy production/GDP in %	24.009	23.944	23.931	23.760	23.810
Capital exp./GDP (imp. if neg.) in %	-5.040	-4.030	-3.341	-8.281	-3.919
Energy exp./GDP (imp. if neg.) in %	6.018	5.953	5.932	5.793	5.820
Energy profits/GDP in %	5.073	5.059	5.056	5.020	5.030
Energy susidies/GDP in %	5.165	5.165	5.167	5.156	5.164
Debt to GDP ratio in %	64.938	65.032	65.059	65.405	65.262
Hours worked:	35.040	35.110	35.123	35.218	35.109
Hours worked private	36.444	36.362	36.366	36.481	36.363
Hours worked public	30.829	31.355	31.391	31.431	31.347

Table 4: Experiment 1: Reduction of the public sector pension replacement rate by 15%. Column one presents the benchmark economy. We then let consumption taxes (column 2), labor taxes (column 3), capital taxes (column 4), or infrastructure investments (column 5) adjust to clear the government budget constraint.

	Benchmark	τ_C	τ_L	τ_K	Δ_G
GDP	100.000	100.517	100.627	97.894	101.950
Output Y	100.000	100.527	100.610	97.799	101.964
Capital K	100.000	102.130	105.573	127.273	103.636
Capital in fuel K_M	100.000	100.004	99.983	100.192	99.606
Capital in final K_P	100.000	100.527	100.610	97.799	101.964
Human capital private H_P	100.000	100.525	100.532	98.517	100.529
Human capital public H_G	100.000	99.555	99.960	97.114	99.531
Public good G	100.000	99.939	100.226	97.426	105.513
Consumption C	100.000	101.024	101.968	104.930	101.228
Energy production $p_M * M$	100.000	100.004	99.983	100.192	99.606
Energy consumption $p_M * M_C$	100.000	99.940	101.690	103.989	101.056
Energy used in prod. $p_M * M_P$	100.000	100.527	100.610	97.799	101.964
Exp: Capital (imp. if neg.)	-100.000	-77.947	-34.405	24.003	-71.688
Exp: Energy (imp. if neg.)	100.000	98.598	97.826	106.009	92.797
Energy Profit	100.000	100.004	99.983	100.192	99.606
Wages w	100.000	99.985	100.057	99.350	101.351
Change in after tax interest rate Δr in %	3.231	0.000	-0.000	0.566	0.000
Change in labor tax $\Delta \tau_L$ in %	2.892	0.000	-1.914	0.000	0.000
Change in consumption tax $\Delta \tau_C$ in %	18.000	-1.375	0.000	0.000	0.000
Change in capital tax $\Delta \tau_K$ in %	40.000	0.000	0.000	-11.587	0.000
Infrastruc. Inv. Δ_G in %	3.000	3.000	3.000	3.000	3.403
Energy subsidy τ_M in %	14.505	14.572	14.611	14.413	14.775
K/GDP	3.380	3.434	3.546	3.821	3.436
Energy production/GDP in %	24.009	23.887	23.856	24.250	23.457
Capital exp./GDP (imp. if neg.) in %	-5.040	-3.908	-1.723	3.257	-3.544
Energy exp./GDP (imp. if neg.) in %	6.018	5.903	5.851	6.224	5.478
Energy profits/GDP in %	5.073	5.047	5.040	5.124	4.956
Energy susidies/GDP in %	5.165	5.162	5.170	5.178	5.160
Debt to GDP ratio in %	64.938	65.206	65.263	64.475	65.949
Hours worked:	35.040	35.056	35.083	34.823	35.054
Hours worked private	36.444	36.534	36.524	36.235	36.534
Hours worked public	30.829	30.620	30.761	30.586	30.613

Table 5: Experiment 2: Reduction of the private sector pension replacement rate by 15%. Column one presents the benchmark economy. We then let consumption taxes (column 2), labor taxes (column 3), capital taxes (column 4), or infrastructure investments (column 5) adjust to clear the government budget constraint.

	Benchmark	τ_C	τ_L	τ_K	Δ_G
GDP	100.000	99.586	99.841	94.335	102.394
Output Y	100.000	99.627	99.828	94.178	102.445
Capital K	100.000	96.351	103.290	141.250	99.154
Capital in fuel K_M	100.000	100.193	100.157	100.611	99.417
Capital in final K_P	100.000	99.627	99.828	94.178	102.445
Human capital private H_P	100.000	100.301	100.374	96.360	100.330
Human capital public H_G	100.000	95.988	96.606	90.561	95.898
Public good G	100.000	97.412	97.888	92.052	108.280
Consumption C	100.000	98.884	100.862	105.772	99.204
Energy production $p_M * M$	100.000	100.193	100.157	100.611	99.417
Energy consumption $p_M * M_C$	100.000	97.091	100.644	104.391	99.219
Energy used in prod. $p_M * M_P$	100.000	99.627	99.828	94.178	102.445
Exp: Capital (imp. if neg.)	-100.000	-143.884	-56.499	96.714	-133.547
Exp: Energy (imp. if neg.)	100.000	102.556	100.924	117.970	91.216
Energy Profit	100.000	100.193	100.157	100.611	99.417
Wages w	100.000	99.347	99.468	97.951	102.009
Change in after tax interest rate Δr in %	3.231	0.000	-0.000	0.970	0.000
Change in labor tax $\Delta \tau_L$ in %	2.892	0.000	-4.042	0.000	0.000
Change in consumption tax $\Delta \tau_C$ in %	18.000	-2.757	0.000	0.000	0.000
Change in capital tax $\Delta \tau_K$ in %	40.000	0.000	0.000	-20.011	0.000
Infrastruc. Inv. Δ_G in %	3.000	3.000	3.000	3.000	3.809
Energy subsidy τ_M in %	14.505	14.410	14.493	13.946	14.808
K/GDP	3.380	3.270	3.497	4.400	3.273
Energy production/GDP in %	24.009	24.156	24.085	25.270	23.311
Capital exp./GDP (imp. if neg.) in %	-5.040	-7.281	-2.852	13.619	-6.573
Energy exp./GDP (imp. if neg.) in %	6.018	6.198	6.084	7.187	5.361
Energy profits/GDP in %	5.073	5.104	5.089	5.339	4.925
Energy susidies/GDP in %	5.165	5.152	5.169	5.199	5.149
Debt to GDP ratio in %	64.938	64.723	64.855	62.592	66.178
Hours worked:	35.040	34.714	34.766	34.137	34.714
Hours worked private	36.444	36.634	36.641	35.962	36.647
Hours worked public	30.829	28.951	29.142	28.662	28.916

Table 6: Experiment 3: Reduction of public sector wages by 15%. Column one presents the benchmark economy. We then let consumption taxes (column 2), labor taxes (column 3), capital taxes (column 4), or infrastructure investments (column 5) adjust to clear the government budget constraint.

	Benchmark	τ_C	τ_L	τ_K	Δ_G
GDP	100.000	98.246	98.513	92.863	101.220
Output Y	100.000	98.111	98.317	92.517	101.093
Capital K	100.000	97.961	105.475	145.739	101.082
Capital in fuel K_M	100.000	100.596	100.554	100.982	99.761
Capital in final K_P	100.000	98.111	98.317	92.517	101.093
Human capital private H_P	100.000	100.197	100.256	95.926	100.229
Human capital public H_G	100.000	100.309	101.082	95.488	100.240
Public good G	100.000	99.478	100.046	94.430	111.425
Consumption C	100.000	100.281	102.416	107.697	100.705
Energy production $p_M * M$	100.000	100.596	100.554	100.982	99.761
Energy consumption $p_M * M_C$	100.000	106.563	110.670	115.044	109.079
Energy used in prod. $p_M * M_P$	100.000	92.704	92.898	87.418	95.521
Exp: Capital (imp. if neg.)	-100.000	-109.279	-14.502	121.656	-96.282
Exp: Energy (imp. if neg.)	100.000	120.529	118.748	135.955	108.856
Energy Profit	100.000	100.596	100.554	100.982	99.761
Wages w	100.000	98.000	98.139	96.732	100.818
Change in after tax interest rate Δr in %	3.231	0.000	-0.000	1.002	0.000
Change in labor tax $\Delta\tau_L$ in %	2.892	0.000	-4.206	0.000	0.000
Change in consumption tax $\Delta\tau_C$ in %	18.000	-2.875	0.000	0.000	0.000
Change in capital tax $\Delta\tau_K$ in %	40.000	0.000	0.000	-20.638	0.000
Infrastruc. Inv. Δ_G in %	3.000	3.000	3.000	3.000	3.873
Energy subsidy τ_M in %	14.505	11.619	11.696	11.246	11.962
K/GDP	3.380	3.370	3.619	4.612	3.375
Energy production/GDP in %	24.009	24.584	24.507	25.765	23.663
Capital exp./GDP (imp. if neg.) in %	-5.040	-5.606	-0.742	17.403	-4.794
Energy exp./GDP (imp. if neg.) in %	6.018	7.383	7.255	8.414	6.472
Energy profits/GDP in %	5.073	5.194	5.178	5.444	5.000
Energy susidies/GDP in %	5.165	4.211	4.227	4.259	4.208
Debt to GDP ratio in %	64.938	64.025	64.164	61.810	65.571
Hours worked:	35.040	35.128	35.187	34.463	35.132
Hours worked private	36.444	36.525	36.522	35.701	36.539
Hours worked public	30.829	30.936	31.183	30.750	30.912

Table 7: Experiment 4: Decrease in energy subsidies. Column one presents the benchmark economy by 15%. Column one presents the benchmark economy. We then let consumption taxes (column 2), labor taxes (column 3), capital taxes (column 4), or infrastructure investments (column 5) adjust to clear the government budget constraint.

	Benchmark	τ_C	τ_L	τ_K	Δ_G
GDP	100.000	101.200	101.446	96.132	103.860
Output Y	100.000	101.243	101.439	95.983	103.913
Capital K	100.000	97.822	104.541	141.423	100.568
Capital in fuel K_M	100.000	100.698	100.659	101.047	99.970
Capital in final K_P	100.000	101.243	101.439	95.983	103.913
Human capital private H_P	100.000	103.649	103.704	99.613	103.676
Human capital public H_G	100.000	84.730	85.345	81.071	84.672
Public good G	100.000	90.969	91.454	86.789	100.415
Consumption C	100.000	100.321	102.239	107.143	100.668
Energy production $p_M * M$	100.000	100.698	100.659	101.047	99.970
Energy consumption $p_M * M_C$	100.000	98.563	101.932	105.693	100.586
Energy used in prod. $p_M * M_P$	100.000	101.243	101.439	95.983	103.913
Exp: Capital (imp. if neg.)	-100.000	-143.250	-58.611	89.887	-132.307
Exp: Energy (imp. if neg.)	100.000	99.778	98.199	114.266	89.061
Energy Profit	100.000	100.698	100.659	101.047	99.970
Wages w	100.000	97.662	97.791	96.520	100.104
Change in after tax interest rate Δr in %	3.231	0.000	-0.000	0.926	0.000
Change in labor tax $\Delta \tau_L$ in %	2.892	0.000	-3.743	0.000	0.000
Change in consumption tax $\Delta \tau_C$ in %	18.000	-2.536	0.000	0.000	0.000
Change in capital tax $\Delta \tau_K$ in %	40.000	0.000	0.000	-19.037	0.000
Infrastruc. Inv. Δ_G in %	3.000	3.000	3.000	3.000	3.749
Energy subsidy τ_M in %	14.505	14.642	14.722	14.202	15.019
K/GDP	3.380	3.267	3.483	4.324	3.273
Energy production/GDP in %	24.009	23.890	23.823	24.905	23.110
Capital exp./GDP (imp. if neg.) in %	-5.040	-7.134	-2.912	12.421	-6.420
Energy exp./GDP (imp. if neg.) in %	6.018	5.934	5.826	6.831	5.161
Energy profits/GDP in %	5.073	5.048	5.033	5.262	4.883
Energy susidies/GDP in %	5.165	5.152	5.167	5.196	5.149
Debt to GDP ratio in %	64.938	65.561	65.688	63.545	66.935
Hours worked:	35.040	34.885	34.937	34.299	34.885
Hours worked private	36.444	36.289	36.279	35.554	36.297
Hours worked public	30.829	30.673	30.914	30.532	30.648

Table 8: Experiment 5: Decrease in public sector size by 15%. Column one presents the benchmark economy. Column one presents the benchmark economy. We then let consumption taxes (column 2), labor taxes (column 3), capital taxes (column 4), or infrastructure investments (column 5) adjust to clear the government budget constraint.

	Benchmark	5%	15%	25%	35%
GDP	100.000	100.554	101.446	102.028	102.228
Output Y	100.000	100.552	101.438	102.013	102.204
Capital K	100.000	101.587	104.551	107.271	109.649
Capital in fuel K_m	100.000	100.204	100.659	101.189	101.813
Capital in final K_p	100.000	100.552	101.438	102.013	102.204
Human capital private H_p	100.000	101.240	103.703	106.168	108.630
Human capital public H_g	100.000	95.130	85.345	75.480	65.572
Public good G	100.000	97.264	91.454	85.151	78.318
Consumption C	100.000	100.810	102.243	103.431	104.305
Energy production $p_M * M$	100.000	100.204	100.659	101.189	101.813
Energy consumption $p_M * M_c$	100.000	100.699	101.935	102.959	103.715
Energy used in prod. $p_M * M_p$	100.000	100.552	101.438	102.013	102.204
Exp: Capital (imp. if neg.)	-100.000	-85.952	-58.537	-31.384	-5.065
Exp: Energy (imp. if neg.)	100.000	99.127	98.198	98.475	100.245
Energy Profit	100.000	100.204	100.659	101.189	101.813
Wages w	100.000	99.309	97.791	96.061	94.073
After tax interest rate r in %	3.231	3.231	3.231	3.231	3.231
Labor tax τ_L in %	2.896	1.657	-0.851	-3.434	-6.099
Energy subsidy τ_M in %	14.505	14.587	14.722	14.812	14.849

Table 9: Sensitivity Analysis - Experiment 5: Decrease in public sector size by 5%, 15%, 25%, and 35% with labor taxes adjusting to clear the government budget constraint.

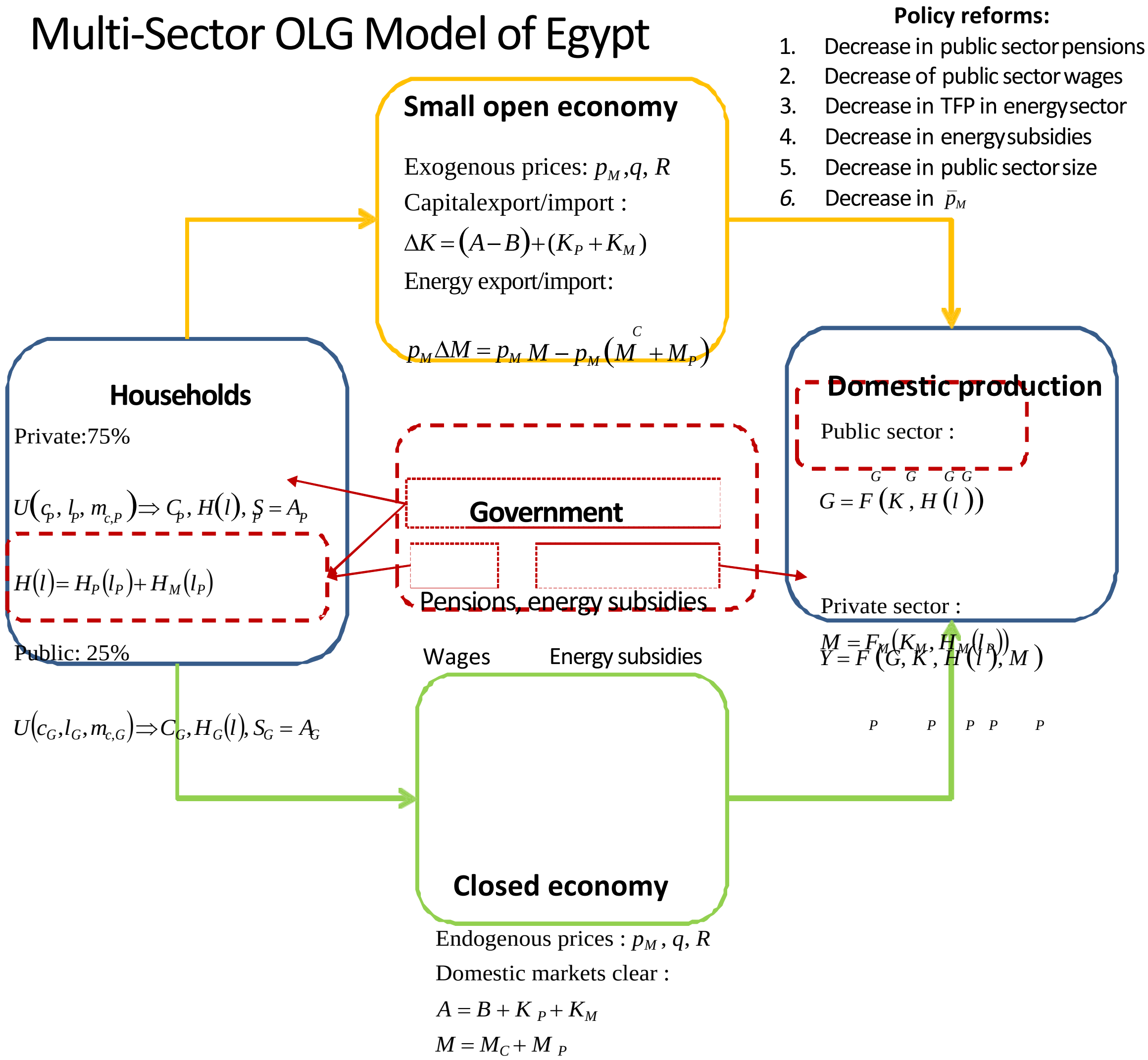

Figure 1: Multi sector OLG model of Egypt.

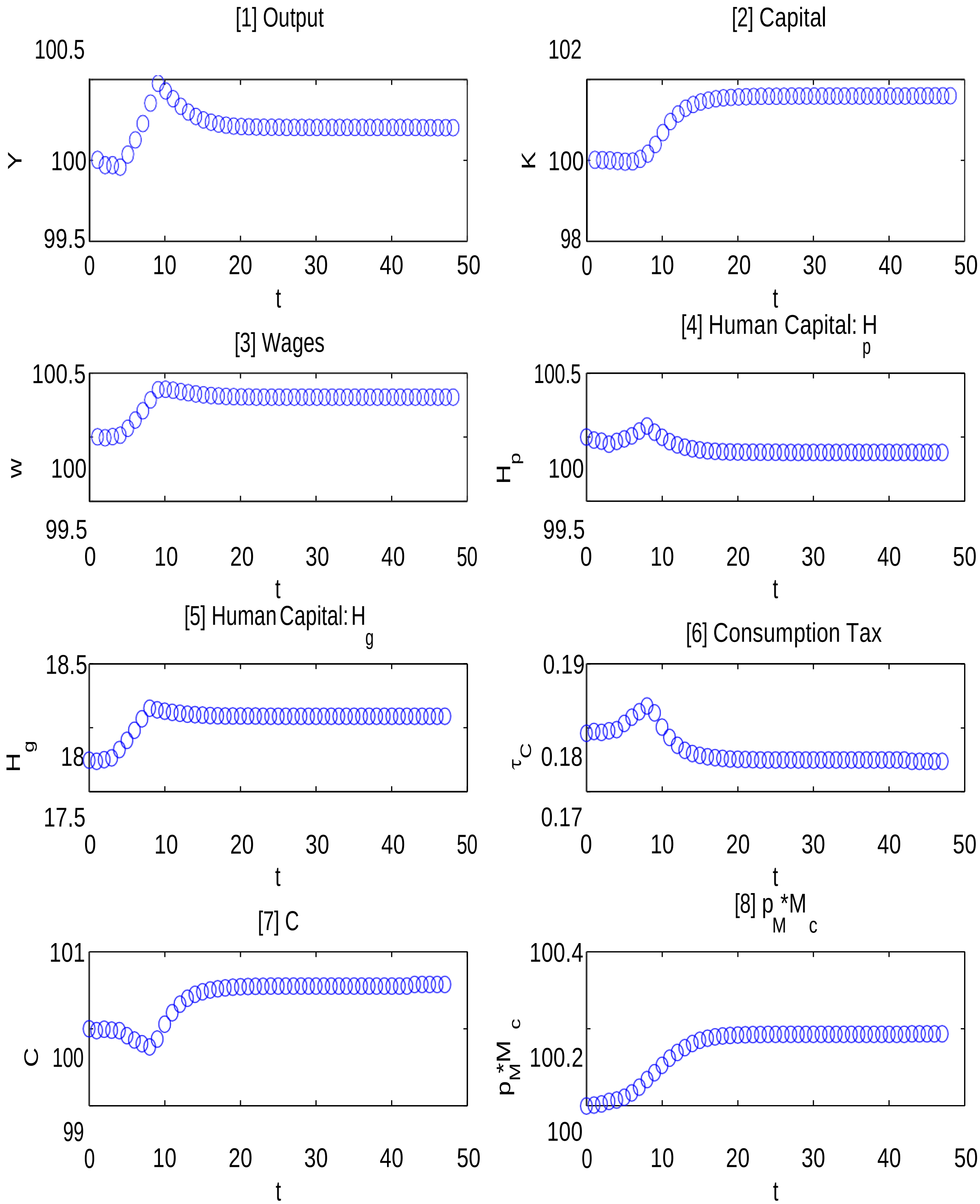

Figure 2: Experiment 1: Transition dynamics. Consumption taxes adjust to accommodate the drop in the pension replacement rate in the public sector.

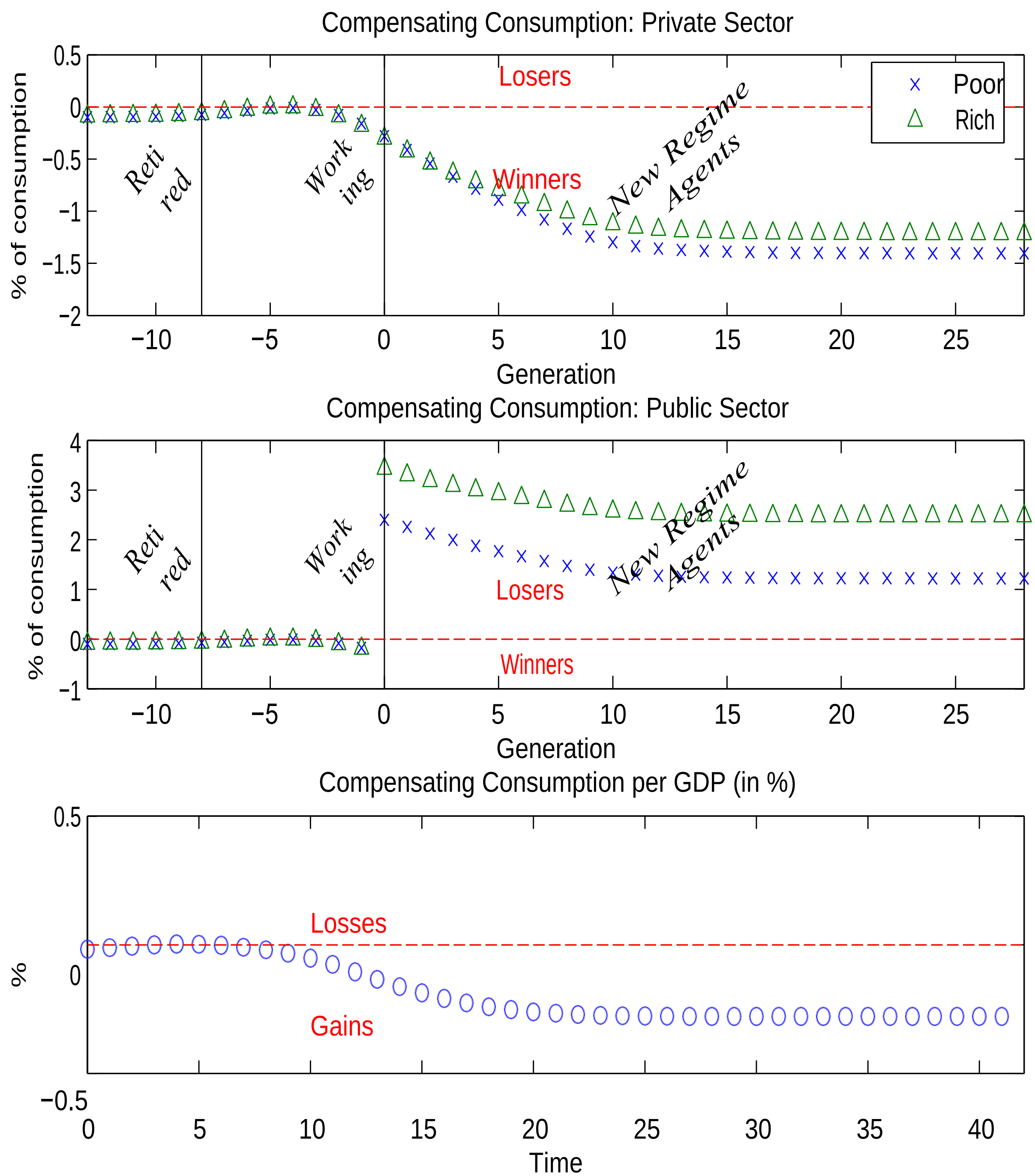

Figure 3: Experiment 1: Welfare dynamics. Consumption taxes adjust to accommodate the drop in the pension replacement rate in the public sector.

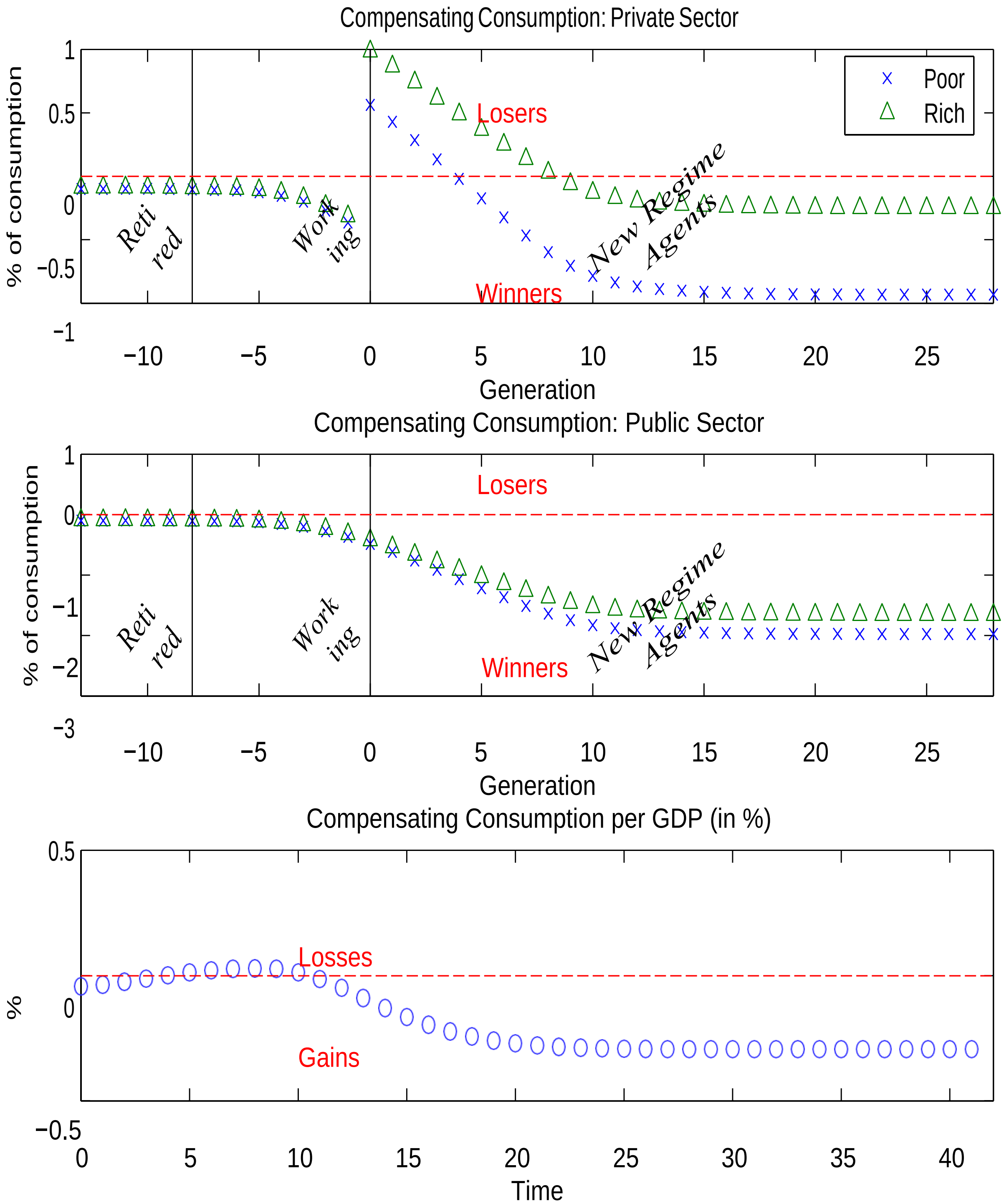

Figure 4: Experiment 2: Welfare dynamics. Consumption taxes adjust to accommodate the drop in the pension replacement rate in the private sector.

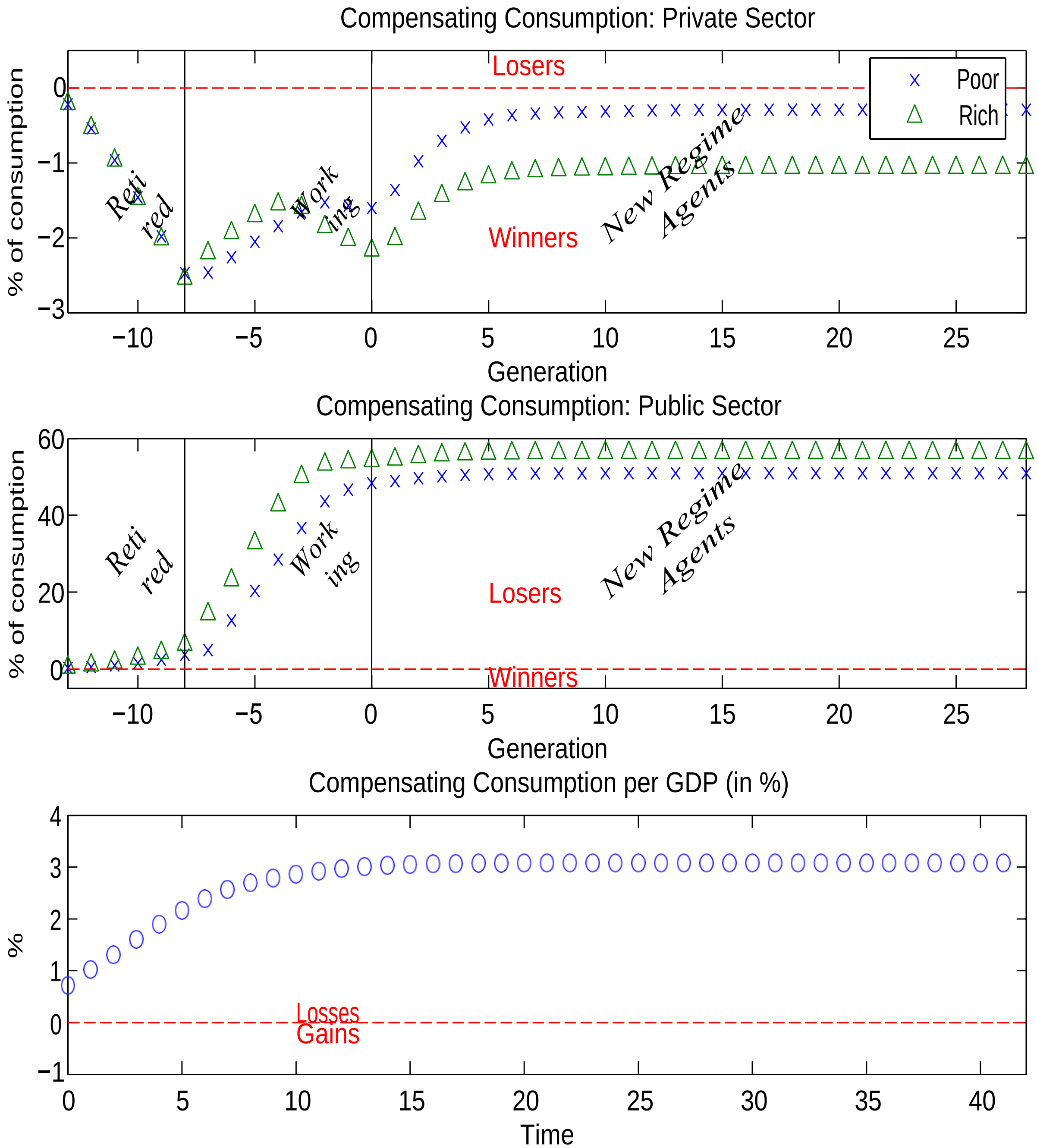

Figure 5: Experiment 3: Welfare dynamics. Consumption taxes adjust to accommodate the drop in the public sector wagerate.

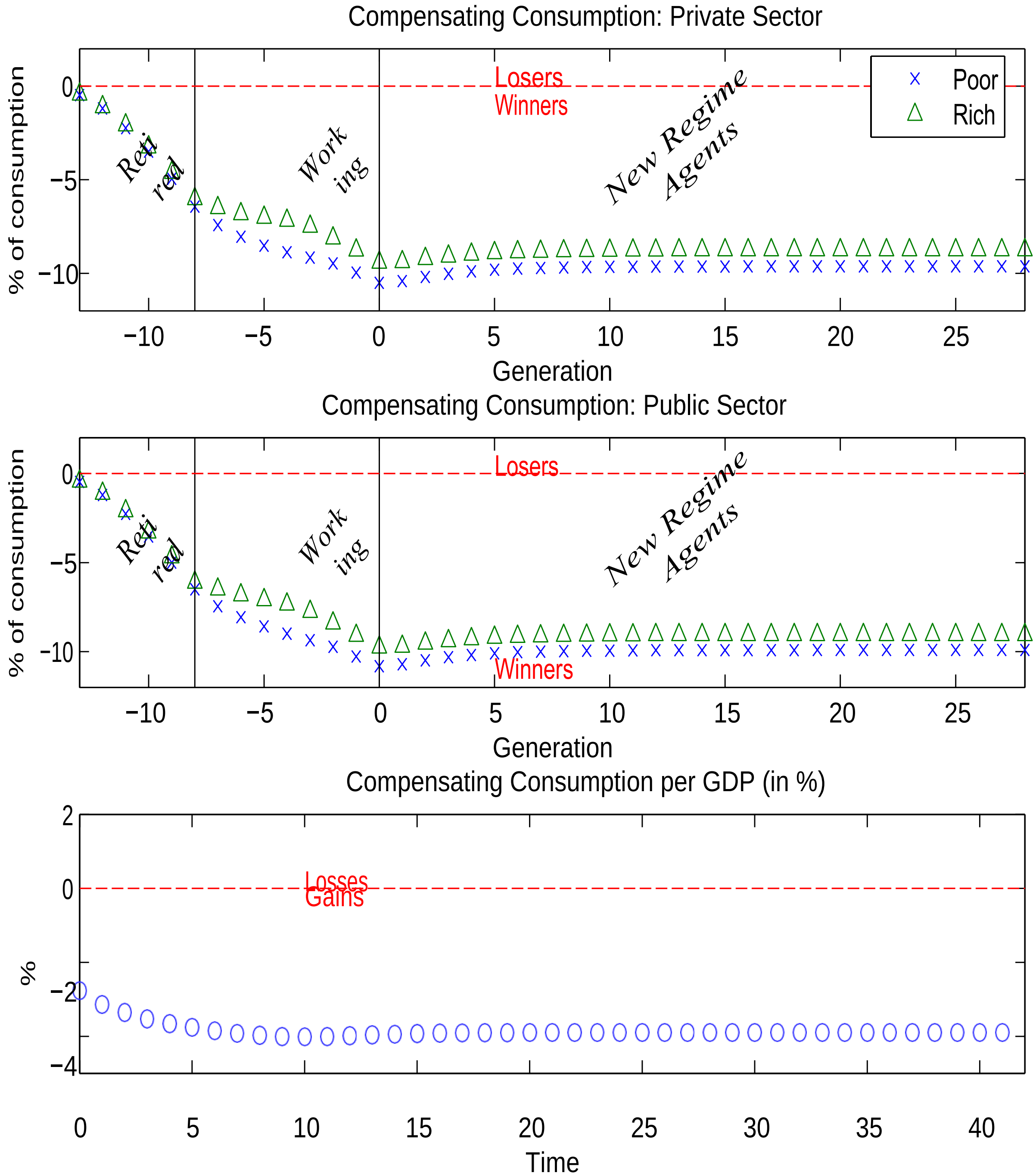

Figure 6: Experiment 4: Welfare dynamics. Consumption taxes adjust to accommodate the drop in energy subsidies.

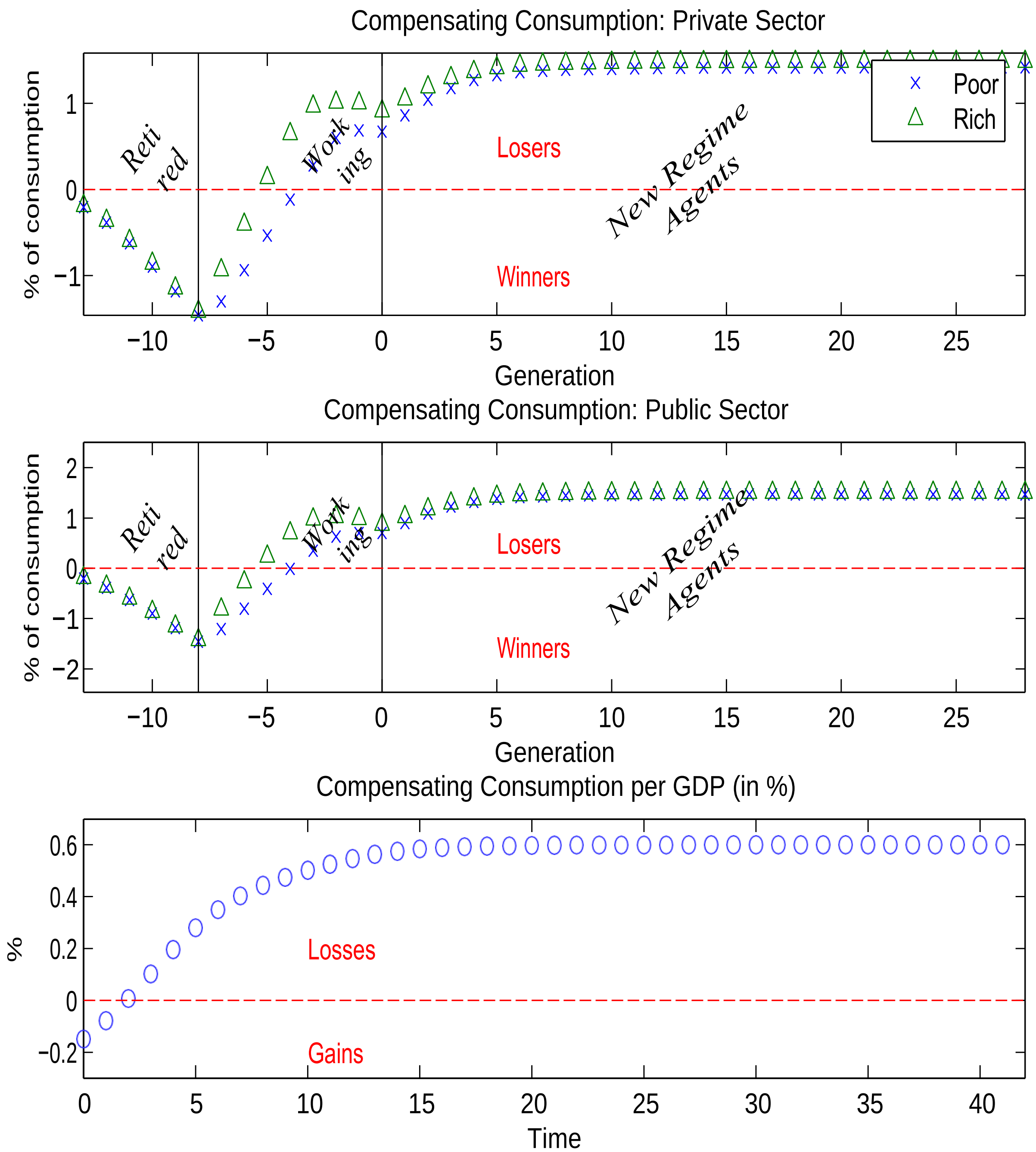

Figure 7: Experiment 5: Welfare dynamics. Consumption taxes adjust to accommodate the reduction of the public sector workforce.