

Scharrer, Christian; Heer, Burkhard

**Conference Paper**

## The Burden of Unanticipated Fiscal Policy

Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel -  
Session: Business Cycles: Policy and Entrepreneurship, No. C08-V2

**Provided in Cooperation with:**

Verein für Socialpolitik / German Economic Association

*Suggested Citation:* Scharrer, Christian; Heer, Burkhard (2016) : The Burden of Unanticipated Fiscal Policy, Beiträge zur Jahrestagung des Vereins für Socialpolitik 2016: Demographischer Wandel - Session: Business Cycles: Policy and Entrepreneurship, No. C08-V2, ZBW - Deutsche Zentralbibliothek für Wirtschaftswissenschaften, Leibniz-Informationszentrum Wirtschaft, Kiel und Hamburg

This Version is available at:

<https://hdl.handle.net/10419/145542>

**Standard-Nutzungsbedingungen:**

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

**Terms of use:**

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

# The Burden of Unanticipated Fiscal Policy\*

Preliminary Version - February 21, 2016

JEL classification: E62, E30, E12, E24, D31

Key Words: Fiscal Policy, Debt Financing, Wealth Distribution, Overlapping Generations

## **Abstract:**

We study the impact of a government spending shock on the distribution of wealth and income between cohorts in a dynamic stochastic overlapping generations model with two types of households, a Ricardian household and a rule-of-thumb consumer. We demonstrate that an unexpected increase in government spending increases income inequality and decreases wealth inequality. In contrast to conventional wisdom that the financing of the additional expenditures by debt rather than taxes especially burdens young on behalf of the old generations, we find that a bond-financed increase in government spending rather harms the Ricardian households during both working age and retirement, while the rule-of-thumb consumers benefit at working age. The crucial element in our analysis is a wealth effect that results from the decline in the price of capital due to higher government debt.

---

\*We would like to thank Johann Scharler for his comments. All remaining errors are ours.

# 1 Introduction

The distributional consequences of higher government spending between different generations constitutes a major concern for economy policy in modern industrialized countries. As a consequence of the demographic transition, the voters are greying and the economic well-being of older people becomes increasingly more important in the political decision-making process. Thus, it is quite likely that politicians are interested in imposing a considerably lower economic burden on older workers and retirees when they increase government spending. The appropriate fiscal rule, which controls the response of taxes and government debt if government consumption changes, plays a crucial role in this regard. A positive government spending shock financed by bonds transfers a real economic burden on present young or even future generations, whereas a tax-financed increase in government spending shifts the burden into the present. Therefore, it is generally believed that older workers prefer a higher government debt to higher taxes because they won't have to repay this debt and, for this reason, the politician will rather adopt a debt-financed increase in government spending in view of the aging voters.

Contrary to this conventional wisdom, we show that, to finance additional government spending, deferred taxation may also harm a large fraction of the elderly. For this reason, we consider a New Keynesian stochastic Overlapping Generations (OLG) model with two types of households, a Ricardian household who saves for old age and a rule-of-thumb consumers who does not accumulate any wealth.<sup>1</sup> In addition, we introduce an investment goods sector that results in a variable price of capital. In this setting, a debt-financed increase in government spending leads to a larger crowding-out effect on productive private investment than a tax-financed increase. The real price of capital decreases strongly and partially transmutes into an

---

<sup>1</sup>Rule-of-thumb consumers have been prominently introduced in the business cycle analysis by Galí, Lopez-Salido, and Vallés (2007). They show that, in the presence of rule-of-thumb consumers, the standard New Keynesian model is able to replicate the empirical fact that private consumption rises in response to an unexpected increase in government consumption.

additional negative wealth shock affecting the wealth accumulation and consumption decisions of workers and retirees. Retired Ricardian households are completely exposed to this shock because they have accumulated considerable wealth and cannot increase their labor supply to benefit from higher wages. In contrast, young workers with little wealth and rule-of-thumb consumers suffer much less from debt financing of unexpected government expenditure. As a consequence of this wealth effect, the burden of a debt-financed increase in government spending is shifted mainly from the households with little wealth to the income-rich and wealth-rich households.

The main wealth channel in our model – higher government consumption crowds out capital and decreases the value of wealth — is supported by empirical evidence: 1) Over the life cycle, stocks play an important role in the accumulation of wealth in the US economy. From 2001 till 2007 the stock holdings share of total financial assets of families headed by a person between an age of 55 and 74 years exceeded a value of 50 percent in the United States as documented by Bricker, Detting, Henriques, Hsu, Moore, Sabelhaus, Thompson, and Windle (2014). 2) Fiscal policy shocks have significant price effects on wealth. Agnello and Sousa (2013) estimate a panel vector autoregression model and provide empirical evidence for a sample of ten industrialized countries that a positive fiscal policy shock leads to an immediate and negative response of stock prices influencing the wealth of different cohorts.

Our New Keynesian model is broadly consistent with empirical evidence from VAR studies. In particular, an increase of government spending results in 1) an increase of output,<sup>2</sup> 2) private consumption,<sup>3</sup> 3) a strong decline in investment and the price

---

<sup>2</sup>Blanchard and Perotti (2002) provide evidence for the US postwar economy that GDP increases after an expansion of fiscal spending. Using panel structural VAR analysis from four industrialized countries, Ravn et al. (2012) also provide cross-country evidence for this hypothesis.

<sup>3</sup>There is some mixed evidence with regard to the effect of government consumption increases on private consumption. The prevalent view, however, indicates a positive effect of higher government consumption as in the studies presented by, for example, Blanchard and Perotti (2002), Galí et al. (2007), and Ravn et al. (2012).

of capital, 4) higher employment,<sup>4</sup> and 5) higher wages<sup>5</sup> and lower mark-ups.<sup>6</sup> The presence of rule-of-thumb consumers helps to reconcile the model with the data and to effectuate the observed responses of output, employment, consumption, and wages. Since rule-of-thumb consumers are not subject to a wealth effect from higher government consumption, their labor supply curve shifts out less than that of the Ricardian households. As a consequence, there is more upward pressure on the real wage. In addition, higher wages allow for an increase of consumption. In the absence of rule-of-thumb consumers, we do not find an increase of aggregate private consumption in response to higher government spending.

In our model, we also introduce workers with different productivity types. Therefore, we are also able to model the empirically observed high concentration of wealth and the somewhat smaller concentration of income. The Gini coefficients of wealth and gross income in our model amount to 0.75 and 0.60, respectively, which is broadly consistent with evidence presented by Budría Rodríguez, Díaz-Giménez, Quadrini, and Ríos-Rull (2002).<sup>7</sup> Higher government consumption increases income inequality in our model since higher wages have a stronger incentive effect on the labor supply of the high-productive workers than on the labor supply of low-productive workers.<sup>8</sup> In addition, the high-productive workers are also the households with higher wealth and, for this reason, the accompanying effect of lower wealth prices also reinforce the rise in their labor supply. Wealth inequality declines with higher government

---

<sup>4</sup>See, for example, Blanchard and Perotti (2002).

<sup>5</sup>Here, again, the empirical evidence is mixed. Rotemberg and Woodford (1992) present evidence that real wages also increase after a government spending shock, while Monacelli et al. (2010) only find an statistically insignificant rise of the real wage for men.

<sup>6</sup>Again, Monacelli et al. (2010) only find evidence for a decline of the mark-ups that is statistically insignificant at the 95 percent confidence level.

<sup>7</sup>Budría Rodríguez et al. (2002) report Gini coefficients of (gross) wealth and income equal to 0.803 and 0.553.

<sup>8</sup>Of course, this effect also depends on our assumption that the wage income is taxed linearly rather than progressively.

consumption since the price of capital decreases. Therefore, the values of the existing wealth holdings decline, while it becomes more beneficial to build up savings for the less affluent younger cohorts.

Our work is most closely related to Brinca et al. (2015) who study the effects of wealth inequality and the average wealth level on fiscal multipliers. In a sample of 15 OECD countries, they find that fiscal multipliers increase with the country Gini of wealth and decrease with the capital-output ratio. The regression coefficients in their SVARs are quantitatively significant and an increase of one standard deviation in the wealth Gini raises the multiplier by about 17% of the average multiplier value. Similar to our model, their Overlapping Generations model is able to replicate the empirically observed heterogeneity in income and wealth. While Brinca et al. (2015) also include uncertainty with regard to idiosyncratic productivity, we focus on aggregate uncertainty in the form of stochastic government spending. In addition, we consider a New Keynesian model with sticky prices, while these authors abstract from any nominal friction. Therefore, our model is able to generate a positive response in private consumption to an increase in government consumption, while private consumption drops in the model of Brinca et al. (2015). In addition, these authors do not consider a variable price of capital that is central to our main result.

The rest of our paper is organized as follows: Section 2 describes and explains the OLG model. In Section 3, we calibrate the non-stochastic steady state of our model and explain the algorithm used for the numerical computation. In Section 4, we characterize the steady state and the associated distribution of consumption, income, wealth, and labor supply over the life-cycle. We show that a permanent rise of government spending decreases income and wealth inequality in the long run in our benchmark economy. Section 5 presents our main results with regard to the effects of an unanticipated temporary increase in government spending on the distribution of wealth and disposable income on the one hand and the welfare of the different cohorts, productivity types, and consumers (Ricardian versus rule-of-thumb consumers) on the other hand. We contrast the effects of a debt-financed government expenditures with those of tax-financed expenditures. In Section 6,

we summarize the main findings of the paper and point out directions for future research.

## 2 The Model

We use an overlapping generations model with 240 generations and aggregate uncertainty. The period length is set to one quarter. Ricardian equivalence does not hold in our model so that the financing of government spending has real effects. The economy consists of households, firms, a government sector, and a monetary authority. We distinguish two types of households. The first kind of households which we name Ricardian households solve an inter-temporal maximization problem, while the second type behave as rule-of-thumb consumers. The firm sector is composed of three types of firms. A perfectly competitive firm produces a single final good and employs differentiated intermediate goods as inputs. These inputs are produced by a continuum of monopolistic competitive firms which use capital and labor in their production process. In addition, there is a capital producer who transforms investments (in terms of the final good) into new capital. The government both collects taxes and accidental bequests and issues risk-less bonds in order to finance its government purchases. The monetary authority monitors the inflation rate and sets the nominal interest rate according to a simple Taylor rule.

In the following, we present the model as follows. First, we describe the demographics. Next, we specify the production sectors of the economy which provides a rate of return on capital that depends on the utilization rate of capital,  $u_t$ . The rate of return on capital is a composite of multiple rates since capital is first used in the production of the intermediate good (over the whole period  $t$ ) before it is rented to the capital producers at the end of period  $t$ . Finally, we describe the behavior of the households who also choose the utilization rate of capital,  $u_t$  (see Christiano et al. (2005)).

## 2.1 Demographics

Every period, a new cohort of constant size at age  $s = 1$  (corresponding to a real life age of 21) enters the economy. Households live at most  $T = 260$  quarters (corresponding to 85 years) and each  $s$ -year old household faces a probability  $\phi_s$  of surviving up to age  $s + 1$ . More precisely, the parameter  $(1 - \phi_s)$  denotes the probability of dying at the end of age  $s$ . The number of living agents  $\psi_{s,t}$  at age  $s$  in period  $t$  evolves according to the following formula:

$$\psi_{s+1,t+1} = \phi_{s,t}\psi_{s,t}, \quad (1)$$

where, the total number of living households,  $\sum_{s=1}^T \psi_{s,t}$ , is normalized to one. Furthermore, we assume that the composition of the population remains constant so that we can set  $\psi_{s,t} = \psi_s$ .

## 2.2 Firms

### 2.2.1 Final goods firm

There is a representative, perfectly competitive firm which produces a final good  $Y_t$  using a constant returns to scale technology:

$$Y_t = \left( \int_0^1 Y_{j,t}^{(\epsilon-1)/\epsilon} dj \right)^{\epsilon/(\epsilon-1)}. \quad (2)$$

This firm assembles the imperfectly substitutable output  $Y_{j,t}$  of intermediate producers and takes the price  $P_t$  of the final good  $Y_t$  as well as the prices  $P_{j,t}$  of intermediary products as given. Moreover,  $j \in [0, 1]$ , and  $\epsilon$  denotes the price elasticity of demand for good  $j$ . After maximization of the profit function  $P_t Y_t - \int_0^1 P_{j,t} Y_{j,t} dj$  with respect to  $Y_{j,t}$ , we can derive the following demand function for intermediary goods:

$$Y_{j,t} = \left( \frac{P_{j,t}}{P_t} \right)^{-\epsilon} Y_t. \quad (3)$$

Furthermore, the zero profit condition in a perfectly competitive market implies

$$P_t = \left( \int_0^1 P_{j,t}^{1-\epsilon} dj \right)^{1/(1-\epsilon)}. \quad (4)$$



### 2.2.2 Intermediate goods firm

The intermediate goods sector consists of a continuum of monopolistic firms indexed by  $j \in [0, 1]$ . Each firm  $j$  uses capital  $K_{j,t}$  and labor  $N_{j,t}$  as input factors. The production technology is identical across firms and takes the form

$$Y_{j,t} = N_{j,t}^{1-\alpha} (u_t K_{j,t})^\alpha - F, \quad \alpha \in (0, 1), F > 0. \quad (5)$$

The constant  $F$  denotes a fixed cost and can be considered as a loss of output in the production process. The utilization rate  $u_t$  is considered exogenous by the firm and will be set by the Ricardian households who rents the capital stock (in efficiency units) to the firm (see also next section).

Each firm sets prices according to a Calvo (1983) mechanism. However, it is more appropriate to solve the firm's cost minimization problem first, where  $r_t^{is}$  is the real interest rate in the intermediate goods sector and  $w_t$  is the real wage:

$$\min_{K_{j,t}, N_{j,t}} C_{j,t} = w_t N_{j,t} + r_t u_t K_{j,t} \quad \text{s.t.} \quad Y_{j,t} = N_{j,t}^{1-\alpha} (u_t K_{j,t})^\alpha - F.$$

The first order conditions of this cost-minimization problem with respect to  $N_{j,t}$  and  $K_{j,t}$  are presented by:

$$w_t = (1 - \alpha) g_{j,t} \left( \frac{u_t K_{j,t}}{N_{j,t}} \right)^\alpha, \quad (6a)$$

$$r_t^{is} = \alpha g_{j,t} \left( \frac{u_t K_{j,t}}{N_{j,t}} \right)^{\alpha-1}, \quad (6b)$$

where  $g_{j,t}$  denotes the Lagrange multiplier which also describes the real marginal cost of production. Moreover, since we assume that the production of  $Y_{j,t} + F$  is characterized by a constant returns to scale technology, the variable  $g_{j,t}$  also equals the variable unit costs of production. The first order conditions (6a) and (6b) imply that marginal costs are equal across all firms, since every firm uses the same capital-labor ratio. Thus, we can drop the index  $j$ ,  $g_t = g_{jt}$  for all  $j \in [0, 1]$ .

**Price setting.** Firms choose their optimal nominal prices in a staggered fashion, according to Calvo (1983). There are two types of firms. The first type  $A$  sets

their optimal relative price by solving an inter-temporal profit optimization problem, whereas type  $N$  firms are only allowed to adjust their price in period  $t$  according to a simple rule of thumb:

$$P_{N,t+1} = \pi P_{N,t}, \quad (7)$$

where  $\pi$  denotes the stationary value of the inflation factor. The probability of being a firm of type  $A$  in period  $t$  is given by  $(1 - \varphi)$ . The description of the optimal price setting is delegated to the Appendix A.1.

### 2.2.3 Capital Producers

In the following, we introduce capital adjustment costs in this model so that the price of capital in units of the final goods is variable. By this device, we are able to study the impact of government financing on capital prices and, hence, individual wealth. To keep the model tractable, adjustment costs accrue in a separate capital production sector rather than at the individual household level. For this reason, we assume a representative, perfectly competitive firm that faces the following demand for newly installed capital:

$$I_t = K_{t+1} - (1 - \delta) K_t. \quad (8)$$

The variables  $K_t$  and  $I_t$  denote the existing aggregate capital stock and aggregate investment and both variables are expressed in terms of the final good. The production of the investment good is described by the following technology:

$$I_t = f(I_t^D / K_t) K_t, \quad (9)$$

where

$$f(I_t^D / K_t) = \frac{a_1}{1 - \zeta} \left( \frac{I_t^D}{K_t} \right)^{1-\zeta} + a_2, \quad \zeta > 0, \quad (10)$$

and  $I_t^D$  denotes the demand for final goods as input factors in the production process of  $I_t$ . The capital producers sell the investment goods at the price  $q_t$  and rents capital

at the rate  $r_t^{cs}$  so that profits of the capital producers,  $\Omega_t^c$ , are given by:

$$\max_{I_t^D, K_t} \Omega_t^c = q_t f(I_t^D/K_t) K_t - I_t^D - r_t^{cs} K_t. \quad (11)$$

Profit maximization of the capital producers with respect to  $I_t^D$  and  $K_t$  result in the following first-order conditions:

$$q_t = \frac{1}{f'(I_t^D/K_t)} = \frac{1}{a_1} \left( \frac{I_t^D}{K_t} \right)^\zeta, \quad (12a)$$

$$r_t^{cs} = q_t \left( f(I_t^D/K_t) - f'(I_t^D/K_t) \frac{I_t^D}{K_t} \right). \quad (12b)$$

In equilibrium, profits are equal to zero,  $\Omega_t^c = 0$ .<sup>9</sup>

## 2.3 Households

The households supply labor in the first  $T_w = 160$  periods and retire during the remaining  $T_r = 100$  periods of their life. Every newborn generation consists of  $v_{RoT}\psi_1$  rule-of-thumb consumers (RoT) that have no access to financial markets over the life-cycle<sup>10</sup> and  $(1 - v_{RoT})\psi_1$  Ricardian households, where the fraction  $v_{RoT}$  of rule-of-thumb-consumers is exogenously given. The household does not change its type over the life-cycle.

In addition to their consumption behavior, households also differ with respect to their idiosyncratic productivity level  $e_j^s$  that depends on the productivity type  $j \in \{1, 2, 3\}$  and age  $s$ . We assume that the share  $v_j$  of the productivity type  $j$  remains constant in each cohort and that a household does not change its productivity type  $j$  over the life-cycle. As a consequence, the wage income in period  $t$  of the Ricardian household, for example, is given by  $(1 - \tau_t^w)w_t e_j^s n_{t,j}^s$ , where  $w_t$  and  $n_{t,j}^s$  denote

---

<sup>9</sup>See Appendix A.2.

<sup>10</sup>The behavior of the rule-of-thumb consumers can be justified by a lack of access to financial markets, binding borrowing constraints, myopia, or simply no interest in inter-temporal trading. We follow Gali, Lopez-Salido, and Javier (2007).

the wage rate per efficiency unit and the labor supply of the  $s$ -year-old Ricardian household with productivity type  $j$  in period  $t$ . Wages are taxed at the rate  $\tau_t^w$ .

We describe the behavior of Ricardian and rule-of-thumb households in turn.

### 2.3.1 Ricardian Households

The Ricardian household with productivity type  $j \in \{1, 2, 3\}$  maximizes the following discounted expected lifetime utility at the beginning of period  $t$ :

$$U_{t,j} = E_t \sum_{s=1}^T \beta^{s-1} \left( \prod_{j=1}^s \phi_{j-1} \right) u(c_{t+s-1,j}^s, n_{t+s-1,j}^s). \quad (13)$$

Instantaneous utility  $u(c_{t,j}^s, n_{t,j}^s)$  is a function of consumption  $c_{t,j}^s$  and labor  $n_{t,j}^s$ :

$$u(c_{t,j}^s, n_{t,j}^s) = \frac{(c_{t,j}^s)^{1-\eta} - 1}{1-\eta} - \gamma_0 \frac{(n_{t,j}^s)^{1+\gamma}}{1+\gamma}, \quad (14)$$

where  $1/\eta$  and  $1/\gamma$  denote the intertemporal elasticity of substitution and the Frisch labor supply elasticity, respectively. For the retired household,  $s > T_w$ , labor supply is equal to zero,  $n_{t,j}^s \equiv 0$ .

The Ricardian household with productivity type  $j$  holds two kinds of assets, capital stock  $k_{t,j}^s$  and government bonds  $b_{t,j}^s$ . Let  $q_t$  denote the price of capital. The capital stock  $k_t^s$  yields the real return  $r_t$  and depreciates at rate  $\delta$ :

$$R_t = 1 + r_t = 1 + r_t^{is} u_t + r_t^{cs} - \delta(u_t) q_t + \frac{\Omega_t}{K_t}, \quad (15)$$

The total return on capital is a composite of two returns. We assume that the household first lends his capital stock in efficiency units,  $u_t k_{t,j}^s$ , to the intermediate goods firms over the period  $t$ . At the beginning of period  $t$ , the household also decides about the utilization rate  $u_t$ .<sup>11</sup> At the end of the period  $t$ , the intermediate goods firms pay the return  $r_t^{is}$  to the household and capital depreciates at the rate

---

<sup>11</sup>Since the first-order conditions of the households with respect to the utilization rate are identical and imply the same utilization rate for all households, we drop the indices  $j$  and  $s$  from the utilization rate  $u_{t,j}^s$ .

$\delta$  depending on the utilization rate  $u_t$ :

$$\delta(u_t) = \delta_0 + \delta_1 u_t^{1+\epsilon_u}, \quad (16)$$

where  $\epsilon_u$  is the elasticity of depreciation rate with respect to the utilization rate. The parameters  $\delta_0$  and  $\delta_1$  are positive constants. Since the value of the capital amounts to  $q_t k_{t,j}^s$ , the depreciation costs per unit of capital amounts to  $\delta(u_t)q_t$ . In addition, capital owners receive their share in total profits in the intermediate goods sector,  $\frac{\Omega}{K_t} k_{t,j}^s$ , where  $K_t$  denotes aggregate capital. Subsequently, the household lends the capital stock to the capital goods producers and earns the interest  $r_t^{cs}$ .

The price of government bonds  $b_{t,j}^s$  is denoted by  $1/R_{t-1}^b$  so that total assets of the individual Ricardian households with productivity type  $j$  and age  $s$  are presented by:

$$a_{t+1}^{s+1} = q_t k_{t+1,j}^{s+1} + \frac{b_{t+1,j}^{s+1}}{R_t^b}. \quad (17)$$

Let  $A_{t+1} = q_t K_{t+1} + \frac{B_{t+1}}{R_t^b}$  and  $\chi_{t+1}$  denote total assets and the fraction of bond holdings in total assets, respectively, with:

$$\chi_{t+1} = \frac{B_{t+1}/R_t^b}{A_{t+1}} \quad (18)$$

Since both assets will yield the same expected return in equilibrium, the household will be indifferent with respect to his portfolio allocation on government bonds  $b_{t,j}^s$  and capital  $k_{t,j}^s$ . We, therefore, assume that all Ricardian households hold these two assets in the same proportion implying:

$$b_{t,j}^s = R_t^b \chi_t a_t^s, \quad (19a)$$

$$k_{t,j}^s = \frac{(1 - \chi_t)}{q_t} a_t^s. \quad (19b)$$

Accordingly, the budget constraint of the  $s$ -year old Ricardian household with productivity type  $j$  in period  $t$  is presented by:

$$(1 + \tau_t^c) c_{t,j}^s + a_{t+1,j}^{s+1} = (1 - \tau_t^w) w_t e_j^s n_{t,j}^s + (q_t + (1 - \tau_t^k) r_t) k_{t,j}^s + \frac{b_{t,j}^s}{\pi_t} + tr_t + pens_{t,j}, \quad (20)$$

where  $\tau^c$  and  $\tau^k$  denote the consumption and capital income tax rates. In addition to his labor and capital income, the household receives lump-sum transfers  $tr_t$  and pensions  $pen_{t,j}^s$ . Pensions are only paid to retired agents,  $s > T_w$ , and depend on the productivity type  $j$ . The public pay-as-you-go pension scheme will be described in more detail below.

Maximization of (13) subject to (15), (16), and (20) with respect to  $c_{t,j}^s$ ,  $n_{t,j}^s$ ,  $k_{t+1,j}^s$ ,  $b_{t+1,j}^s$ , and  $u_t$  results in the following first-order conditions:

$$\left(c_{t,j}^s\right)^{-\eta} = \lambda_{t,j}^s \quad (21a)$$

$$\gamma_0 \left(n_{t,j}^s\right)^\gamma = \lambda_{t,j}^s (1 - \tau_t^w) w_t e_j^s, \quad (21b)$$

$$\lambda_{t,j}^s = \beta \phi_s E_t \left\{ \lambda_{t+1,j}^{s+1} \frac{(q_{t+1} + (1 - \tau_{t+1}^k) r_{t+1})}{q_t} \right\}, \quad (21c)$$

$$\lambda_{t,j}^s = \beta \phi_s E_t \left\{ \lambda_{t+1,j}^{s+1} \left( \frac{1 + r_t^b}{\pi_{t+1}} \right) \right\}, \quad (21d)$$

$$r_t^{is} = q_t \frac{\partial \delta(u_t)}{\partial u_t}. \quad (21e)$$

with  $r_t^b \equiv R_t^b - 1$ .

### 2.3.2 Rule-of-Thumb Consumers

The  $s$ -year old rule-of-thumb consumers with productivity type  $j \in \{1, 2, 3\}$  do not save. They maximize instantaneous utility in every period  $t$ :

$$u\left(\tilde{c}_{t,j}^{s,RoT}, n_{t,j}^{s,RoT}\right) = \frac{\left(\tilde{c}_{t,j}^{s,RoT}\right)^{1-\eta} - 1}{1-\eta} - \gamma_0 \frac{\left(n_{t,j}^{s,RoT}\right)^{1+\gamma}}{1+\gamma}. \quad (22)$$

subject to the budget constraint

$$(1 + \tau_t^c) \tilde{c}_{t,j}^{s,RoT} = (1 - \tau_t^w) w_t e_j^s n_{t,j}^{s,RoT} + tr_t + pens_{t,j}, \quad (23)$$

where  $\tilde{c}_{t,j}^{s,RoT}$  and  $n_{t,j}^{s,RoT}$  denote consumption and labor supply of rule-of-thumb consumers, respectively. The first-order conditions with respect to  $\tilde{c}_{t,j}^{s,RoT}$  and  $n_{t,j}^{s,RoT}$  are

represented by:

$$\left(C_{t,j}^{s, RoT}\right)^{-\eta} = \lambda_{t,j}^s \quad (24a)$$

$$\gamma_0 \left(n_{t,j}^{s, RoT}\right)^\gamma = \lambda_{t,j}^s (1 - \tau_t^w) w_t e_j^s. \quad (24b)$$

## 2.4 Government Sector

### 2.4.1 Government Budget

In the following sections, we aim to study the allocative, distributive, and welfare effects of a change in government consumption,  $G_t$ . For this reason, we assume that government expenditures are exogenous and follow an AR(1) process:

$$\ln G_t = \rho \ln G_{t-1} + \epsilon_t, \quad \epsilon_t \sim N(0, \sigma^2). \quad (25)$$

In addition, the government spends the amount  $Tr_t$  on transfers which are assumed to be constant,  $Tr_t \equiv Tr = \theta_{tr} Y$ . The parameter  $\theta_{tr}$  denotes the share of aggregate transfers to GDP. Furthermore, aggregate transfers  $Tr_t$  are always equal to individual transfers  $tr_t$  since the total population is normalized to one.

Government expenditures are financed by taxes  $\Psi_t$ , debt,  $B_{t+1}/(R_t^b) - B_t/\pi_t$ , and confiscated accidental bequests,  $Beq_t$ ,<sup>12</sup> so that the government budget is presented by:

$$\frac{B_{t+1}}{R_t^b} = Tr_t + \frac{B_t}{\pi_t} + G_t - \Psi_t - Beq_t. \quad (26)$$

The labor income tax  $\tau_t^w$  is composed of a payroll tax  $\tau_t^G$  and a social security

---

<sup>12</sup>Our results are insensitive with regard to the assumption that accidental bequests are used as government revenues in the government budget constraint. Alternatively, we could have assumed perfect annuity markets. In this case, however, the resulting consumption-age profile would be increasing over the entire life-cycle as also demonstrated by Hansen and Ímrohoroğlu (2008); this behavior, however, would be in contradiction to empirical findings of Fernández-Villaverde and Krueger (2007).

contribution  $\tau_t^p$ :

$$\tau_t^w = \tau_t^G + \tau_t^p, \quad (27)$$

so that the fiscal authority only collects  $\tau_t^G$ . Therefore, total tax revenues  $\Psi_t$  from consumption, the payroll tax, and capital income amount to:

$$\Psi_t = w_t \tau_t^G N_t + \tau_t^k r_t K_t + \frac{B_t}{\pi_t} + \tau_t^c C_t. \quad (28)$$

We follow Gali et al. (2007) and assume that the government adjusts its tax revenues to a change in government spending and debt according to the fiscal rule:

$$\frac{(\Psi_t - \Psi)}{Y} = \omega_g \frac{(G_t - G)}{Y} + \omega_b \frac{(B_t/\pi_t - B)}{Y}, \quad (29)$$

where  $\omega_G$  and  $\omega_b$  are positive constants that control the dynamics of tax revenues. In order to implement this fiscal rule, we assume that the government increases its tax on labor and capital income,  $\tau_t^G$  and  $\tau_t^k$ , and that, in accordance with empirical evidence for the US economy, the two income tax rates  $\tau_t^w$  and  $\tau_t^k$  are related by the following linear equation:

$$\tau_t^k = \beta_0^k + \beta_1^k \tau_t^w. \quad (30)$$

#### 2.4.2 Social Security

The social security authority collects contributions from workers to finance its pension payments to the retired agents. The individual pensions  $pen_{t,j}$  in period  $t$  for productivity types  $j \in \{1, 2, 3\}$  amounts to

$$pen_{t,j} = rep_t (1 - \tau_t^P - \tau_t^G) w_t \bar{n}_{t,j}, \quad (31)$$

where  $rep_t$  denotes the net replacement ratio with respect to wage income. The individual pension depends on the productivity type  $j$  of the household through the



average efficient labor supply  $\bar{n}_{t,j}$  in group  $j$  in period  $t$ .<sup>13</sup>

$$\bar{n}_{t,j} = \frac{\sum_{s=1}^{T_w} \psi_s v_j e_j^s \left( v_{RoT} n_{t,j}^s + (1 - v_{RoT}) n_{t,j}^{s,RoT} \right)}{\sum_{s=1}^{T_w} \psi_s v_j}. \quad (32)$$

In equilibrium, the budget of the social security authority is balanced:

$$\sum_{j=1}^3 \left( \sum_{s=T_w+1}^T \psi_s v_j pen_{t,j} \right) = w_t \tau_t^p N_t, \quad (33)$$

where  $N_t$  denotes aggregate efficient labor that will be defined below.

## 2.5 Central Bank

The monetary regime sets the nominal gross interest rate  $R_t^b = (1 + r_t^b)$  according to a simple Taylor rule:

$$\ln \left( \frac{R_t^b}{R^b} \right) = \phi_\pi \ln \left( \frac{E_t(\pi_{t+1})}{\pi} \right), \quad (34)$$

where  $R^b$  and  $\pi$  denote the nominal gross interest rate and inflation factor in the non-stochastic steady state.

## 2.6 Equilibrium Conditions

In equilibrium aggregate variables are equal to the sum of the individual variables:

---

<sup>13</sup>For simplification, we assume that pensions do not depend on past contributions and do not depend on whether the household is Ricardian or a rule-of-thumb consumer.

$$K_t = \sum_{s=1}^T \sum_{j=1}^3 (1 - v_{RoT}) \psi_{s-1} v_j k_{t,j}^s, \quad (35a)$$

$$I_t = \sum_{s=1}^T \sum_{j=1}^3 (1 - v_{RoT}) v_j (\psi_s k_{t+1,j}^{s+1} - (1 - \delta(u_t)) \psi_{s-1} v_j k_{t,j}^s), \quad (35b)$$

$$B_t = \sum_{s=1}^T \sum_{j=1}^3 (1 - v_{RoT}) \psi_{s-1} v_j b_{t,j}^s, \quad (35c)$$

$$N_t = \sum_{s=1}^T \sum_{j=1}^3 \psi_s v_j e_j^s \left( (1 - v_{RoT}) n_{t,j}^s + v_{RoT} n_{t,j}^{s,RoT} \right), \quad (35d)$$

$$C_t = \sum_{s=1}^T \sum_{j=1}^3 \psi_s v_j \left( (1 - v_{RoT}) c_{t,j}^s + v_{RoT} c_{t,j}^{s,RoT} \right), \quad (35e)$$

$$Beq_{t,j} = \sum_{s=1}^{70} (1 - v_{RoT}) \psi_{s-1} v_j (1 - \phi_{s-1}) \left( ((1 - \tau_t^k) r_t + q_t) k_{t,j}^s + \frac{b_{t,j}^s}{\pi_t} \right). \quad (35f)$$

Profits in the capital producer sector are equal to zero,  $\Omega_t^c = 0$  and the aggregate resource constraint is presented by:

$$Y_t = K_{t+1} - (1 - \delta)K_t + C_t + G_t. \quad (36)$$

The description of the steady state is delegated to the Appendix.

### 3 Calibration

Since we are interested in the short run effects of an unanticipated government spending shock, we calibrate the model on a quarterly basis and solve the model around a steady state with zero inflation. Most of our parameters are standard in the RBC/DSGE literature and are summarized in Table 1.

**Production.** With regard to the production technology, we pick a standard value of  $\alpha = 0.36$  for the production elasticity of capital. Moreover, we set the utilization rate  $u$  equal to 1 in the steady state of our model and determine the parameters  $\delta_0$  and  $\delta_1$  such that the depreciation rate  $\delta$  is equal to 0.025. The parameter  $\zeta$  from the capital adjustment cost function (10) is set to 1 following Galí et al. (2007). In

Production:	$\alpha = 0.36$	$\delta = 0.025$	$\epsilon = 6$	$\varphi = 0.75$
	$\zeta = 1$	$\epsilon_u = 1$	$u = 1$	
Demographics:	$T = 260$	$T_w = 160$	$T_r = 100$	$\nu_{rtc} = 0.4$
Preferences:	$\beta = 1.004$	$\eta = 2$	$\gamma_0 = 2200$	$\gamma = 5$
Government & PAYG:	$\rho_g = 0.9$	$G/Y = 0.2$	$B/Y = 2.5$	$\omega_g = 0.1$
	$\omega_b = 0.33$	$\tau^c = 0.05$	$rep = 0.45$	$\beta_0^k = 0.20$
	$\beta_1^k = 0.58$	$\theta_{tr} = 0.043$		
Central bank:	$\rho_\pi = 1.1$	$\pi = 1$		

**Table 1:** Quarterly Parameterization of the OLG model

addition, we report results for the case  $\zeta = 0.05$  where adjustment costs of capital only play a minor role in the transmission of fiscal policy. We choose a standard value for the price elasticity equal to  $\epsilon = 6$  implying a gross price markup of 1.2 in the steady state, where the degree of price stickiness  $\varphi$  is set to 0.75. Finally, our calibration of the elasticity  $\epsilon_u$  of the change in the depreciation rate with respect to the utilization rate follows Baxter and Farr (2005) who pick a value of 1 that is also supported by empirical estimates in Basu and Kimball (1997).

**Demographics and Individual Productivity.** A household lives  $T = 260$  quarters and supplies labor in the first  $T_w = 160$  quarters. The survival probabilities  $\psi_s$  stem from the UN (2002) and are projected for the year 2015. The idiosyncratic productivity level is given by  $e_j^s = z_j \bar{e}_s$ . The age-specific component  $\bar{e}_s$  denotes the average efficiency at age  $s$  which is taken from Hansen (1993) and is interpolated to in-between quarters. As a consequence, the model replicates the cross-section age distribution of earnings of the U.S. economy. With regard to the idiosyncratic component  $z_j$ , we follow Huggett (1996) and choose a log-normal distribution of earnings for the youngest households with a variance equal to  $\sigma_z^2 = 3.60$ . This variance is chosen so that the Gini coefficients of labor income, gross market income and wealth are close to the empirical values reported by Budría Rodriguez et al. (2002) that we outline in the next section.

The share of the rule-of-thumb consumers,  $\lambda_{roT}$  is a crucial parameter in our analy-

sis. Campbell and Mankiw (1989) estimate that around 50% of income is earned by rule-of-thumb consumers. In contrast, Fuhrer (2000) and Cogan et al. (2010) provide empirical evidence that the share of rule-of-thumb consumers is around 30%. Therefore, we use an average value and set  $\lambda_{RoT} = 0.40$ .<sup>14</sup>

**Preferences.** With respect to the preference parameters, we set the discount factor  $\beta = 1.004$  in order to match a risk-free interest rate on government bonds of  $r^b = 4\%$ . The elasticity of marginal utility with respect to consumption is equal to  $\eta = 2$  and the parameter  $\gamma_0$  is calibrated so that the average labor supply is equal to 33% of available time. The Frisch elasticity of labor supply is given by  $1/\gamma$ . The estimates of the Frisch elasticity implied by microeconomic studies vary considerably. MaCurdy (1981) and Altonij (1986) both use PSID data in order to estimate values of 0.23 and 0.28, respectively, while Killingsworth (1983) finds an US labor supply elasticity equal to 0.4. We will use the conservative estimate  $1/\gamma = 0.2$  in accordance with Galí et al. (2007).<sup>15</sup>

**Government.** Based on Uhlig (2010), we set the ratio of government debt to quarterly GDP equal to  $B/Y = 250\%$ . The share of government spending to GDP is set to  $G/Y = 20\%$  and the term  $\rho_g$  regarding the first order auto-regressive process of government spending is equal to 0.9. Moreover, we use a data-set provided by Gomme et al. (2011) in order to estimate the income tax parameters  $\beta_0^k = 0.20$  and  $\beta_1^k = 0.58$  for the 1985 to 2008 sample.<sup>16</sup> In addition, we choose  $\theta_{tr} = 0.04$  such that the income tax rates  $\tau^w$  and  $\tau^k$  match the corresponding average empirical values of 28% and 36%, respectively. The tax rate on consumption is given by  $\tau^c = 0.05$  and we choose  $rep = 0.45$  from OECD data in order to replicate the replacement ratio of pensions relative to average net wage earnings from 2014. With regard to the calibration of the dynamics of tax revenues and debt we use parameter values

---

<sup>14</sup>In the Appendix, we will provide a sensitivity analysis for the case  $\lambda_{RoT} = 0.30$ .

<sup>15</sup>We will also conduct a sensitivity analysis for a higher value  $1/\gamma = 1.0$  for the Frisch labor supply elasticity which has recently been used in dynamic general equilibrium studies on the distortionary effects of labor income taxation, e.g. by Trabandt and Uhlig (2011).

<sup>16</sup>In Appendix A.6 we provide a figure of U.S. tax rates on labor and capital income.

provided by Galí et al. (2007) who estimate an elasticity of tax revenues with respect to government spending of  $\omega_g = 0.1$  that is close to the estimate in Blanchard and Perotti (2002). We also follow these authors and set the elasticity of taxes with respect to debt equal to  $\omega_b = 0.33$ . Finally, the interest rate rule of the central bank satisfies the Taylor principle and we set the parameter  $\phi_\pi$  equal to 1.1 following Walsh (2005).

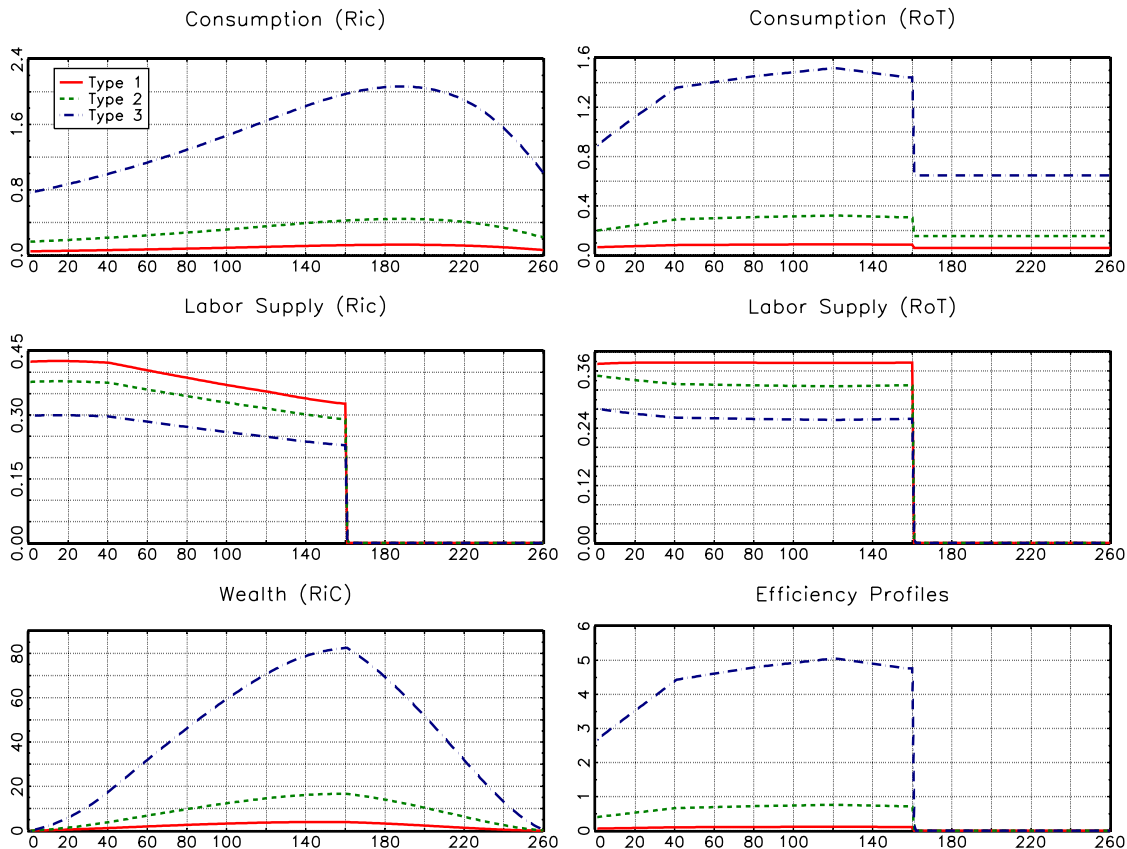
## 4 Steady State Behavior

First, we describe the life-cycle behavior of Ricardian (Ric) and rule-of-thumb (RoT) households in steady state. Second, we present inequality measures of income and wealth. Third, we demonstrate that a rise in permanent government expenditures increase income inequality, but decreases wealth inequality in the long run in our model.

### 4.1 Life-Cycle Profiles of Ricardian Households and Rule-of-Thumb Consumers

Fig. 1 presents the steady-state behavior of Ricardian (Ric) households and rule-of-thumb (RoT) consumers over the life-cycle with respect to the productivity types  $j \in \{1, 2, 3\}$ . The profiles of consumption as displayed in the upper panels are hump-shaped. The consumption of Ricardians declines only in retirement after age  $s = 188$  (corresponding to real life age 67) and accords with empirical observations in its qualitative features. For the US economy, Fernández-Villaverde and Krueger (2007) find that the empirical consumption-age profiles display a significant hump over the life cycle even after correcting for the change of the family size. For the high-education households (that are roughly corresponding to the high-productivity households in our model), the peak occurs at age 55, while the low-education households attain their consumption maximum at an earlier age close to 50 and the hump is much smaller. Therefore, in our model, the hump in consumption of the Ricardian

households occurs somewhat too late in the life cycle. However, the consumption of rule-of-thumb consumers in the upper right panel drops earlier in life at real-life age 50 so that total consumption of the different productivity types peaks much earlier in life in accordance with the aforementioned empirical evidence.



**Figure 1:** Steady-State Behavior of Ricardians (Ric) and Rule-of-Thumb Consumers (RoT)

The profile of working hours of Ricardian households is depicted in the middle left panel. Their labor supply stays almost constant during the first 10 years and decreases with advancing age. This pattern is mainly driven by the increasing wealth effect as agents build up savings for retirement and the hump-shaped efficiency profile over the life cycle that is displayed in the lower right panel. In contrast, the labor supply of rule-of-thumb consumers does not fall substantially beyond age  $s = 40$  (corresponding to real-life age 30) because the wealth effect is absent. Finally, since pensions are below the wage income, all Ricardian households save for retirement

and accumulate wealth until the last period  $s = T_w = 160$  of their working life as presented in the lower left panel.

## 4.2 Inequality

The heterogeneity with regard to individual productivity,  $z_j \bar{e}_s$ , and consumption type (Ricardian versus rule-of-thumb consumer) results in inequality of income and wealth among the households. The Gini coefficients of income and wealth amount to 0.542 (net income after taxes), 0.558 (gross income before taxes), 0.638 (labor income) and 0.778 (wealth). Our inequality measures are very close of values observed empirically. For example, Budría Rodríguez et al. (2002) report Gini coefficients of (gross) income, (gross) labor income and wealth that are equal to 0.553, 0.661 and 0.803, respectively.<sup>17</sup> Krueger et al. (2010) document the evolution of income and wealth heterogeneity over time and notice that the inequality of earnings has increased in many countries, including the US, over the last three decades.

## 4.3 Permanent Increase in Government Consumption

How does a permanent increase of government consumption by 1 percentage point change the income and wealth distribution? In order to finance an increase of the government consumption-output ratio from 20% to 21%, the government has to raise taxes. We assume that the consumption tax rate remains constant, while the labor

---

<sup>17</sup>Our model, however, falls short to replicate the high income and wealth shares of the top percentile for two reasons: 1) We do not consider self-employed workers and entrepreneurs. Quadri (2000) presents empirical evidence that the concentration of income and wealth is higher among entrepreneurs and that the introduction of an endogenous entrepreneurial choice in a dynamic general equilibrium model helps to reconcile the inequality in the model with that of the US economy. Cagetti and de Nardi (2009) introduce endogenous entrepreneur in an OLG model. 2) We omit bequests. Among others, De Nardi and Yang (2015) set up a model that considers both bequests of wealth and inheritance of abilities from the parents and is able to match the skewness of the distribution of income, wealth, and bequests. See De Nardi (2015) for a survey of modeling wealth heterogeneity in quantitative general equilibrium models.

and capital income tax rates,  $\tau^G$  and  $\tau^k$ , rise from 19.5% to 21.0% and 36.1% to 36.8%. As a consequence, the households earn less income and aggregate savings and capital fall. The negative income effect of lower net wages dominates the substitution effect and all productivity classes increase their labor supply. The increase in effective labor supply is most pronounced among the high-productive workers so that gross market income becomes more concentrated and the Gini coefficient increases by a small amount, from 0.5575 to 0.5579.

In our comparative steady state analysis, we assume that the net replacement ratio remains constant at 45%. Since net wages fall, the absolute level of pensions also decreases. Therefore, all Ricardian households spread out their savings over a longer time horizon so that the relative wealth of the retired Ricardian households increases. As a result, wealth inequality falls. The effect on the Gini coefficient of wealth is relatively small and it only declines from 0.7778 to 0.7775.

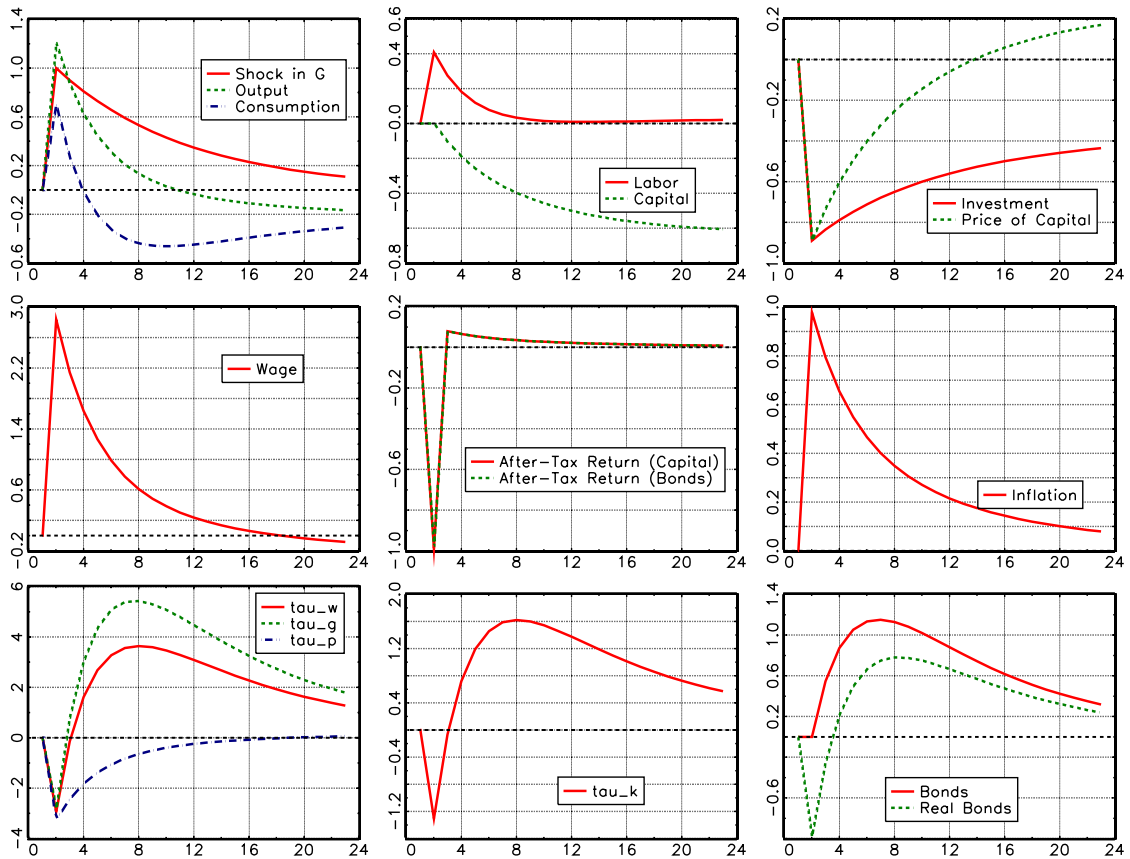
## 5 The Effects of a Government Spending Shock and Public Financing

In this section, we present our main results on the effects of an unanticipated increase of government consumption and dependence on its financing with either debt or taxes. First, we present the responses of aggregate variables and show that, in accordance with the empirical and theoretical results of Galí et al. (2007), output, consumption, employment, and real wages increase, while investment decline. Second, we illustrate the responses of individual consumption, labor, and income and derive the result that income inequality increases, while wealth inequality decreases. Third, we study welfare effects of government consumption shocks on lifetime utility and are able to distinguish households who favor tax financing from those who favor debt financing.



## 5.1 Aggregate Variables

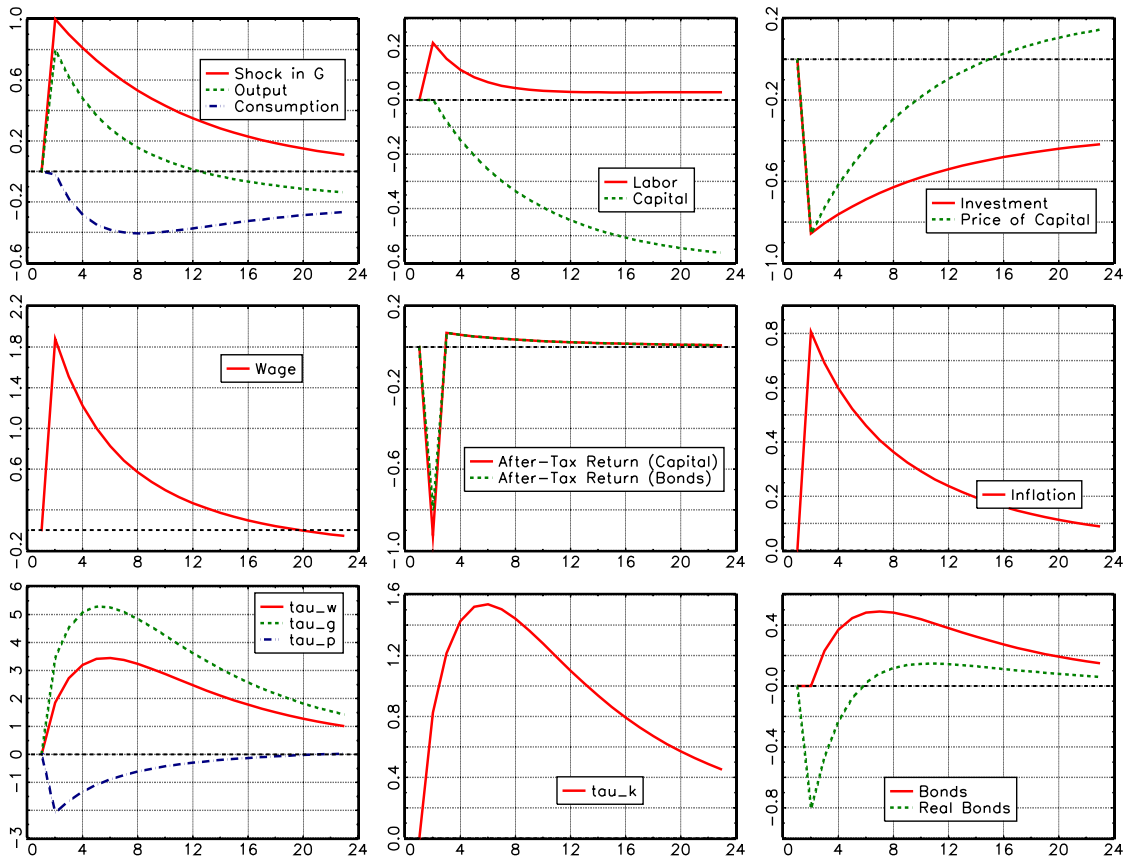
Fig. 2 presents the impulse responses of aggregate variables to a one percent increase of government consumption  $G_t$  in our benchmark case where additional government expenditures are mainly financed by bonds. In particular, we have set the relative weights of government expenditures and debt to  $\omega_g = 0.1$  and  $\omega_b = 0.3$  in our fiscal rule (29) that describes the reaction function of tax revenues. We will refer to this case as "debt financing". Below, we will compare it to the case of "tax financing" where we increase the reaction coefficient of taxes with respect to government expenditures,  $\omega_g$ , from 0.1 to 0.9.



**Figure 2:** Aggregate Variables and Bond Financing

An increase of government consumption in our New Keynesian model has the well-known effects on aggregate variables. Prices are sticky and when government demand increases, monopolistic firms increase production. As a consequence, output

increases by 1.2% (see upper left panel in Fig. 2). In addition, government consumption crowds out capital so that bonds  $B_t$  increase while investment  $I_t$  declines. As a consequence, the price of capital  $q_t$  falls by 0.9% (see upper right panel). Ricardian households increase their labor supply (see middle panel in the upper row) because present and future tax increases constitute a negative wealth effect. In our model, this wealth effect is reinforced for the Ricardian households with positive wealth because the price of capital  $q_t$  declines. Since prices are sticky and adjust only slowly, the mark-up falls and outweighs the effect of a lower marginal product of labor so that real wages (see left panel in the middle row) increase in accordance with empirical evidence.<sup>18</sup> While Ricardian households decrease consumption, rule-of-thumb consumers increase consumption so that aggregate private consumption increases.



**Figure 3:** Aggregate Variables and Tax Financing

<sup>18</sup>If we did not consider rule-of-thumb consumers, but only Ricardian households, real wages would fall because the labor supply response is stronger among the latter due of the wealth effect.

Fig. 3 presents the impulse responses for the case of higher tax financing. In this case, the qualitative responses are the same, but differ in size. As can be seen in the lower left panel, labor income taxes  $\tau_t^w$  (that are the sum of a payroll tax  $\tau_t^G$  and social security contributions  $\tau_t^p$ ) increase stronger on impact (by 2.0%), while  $\tau_t^w$  even declines by 2.8% in the case of bond financing and only increases in the second period after the impact.<sup>19</sup> As a consequence, households labor supply increases less and, hence, the output response is also smaller and only amounts to 0.8%. Since the net market income of households is also lower due to higher taxes, aggregate private consumption does not increase, but even declines.<sup>20</sup>

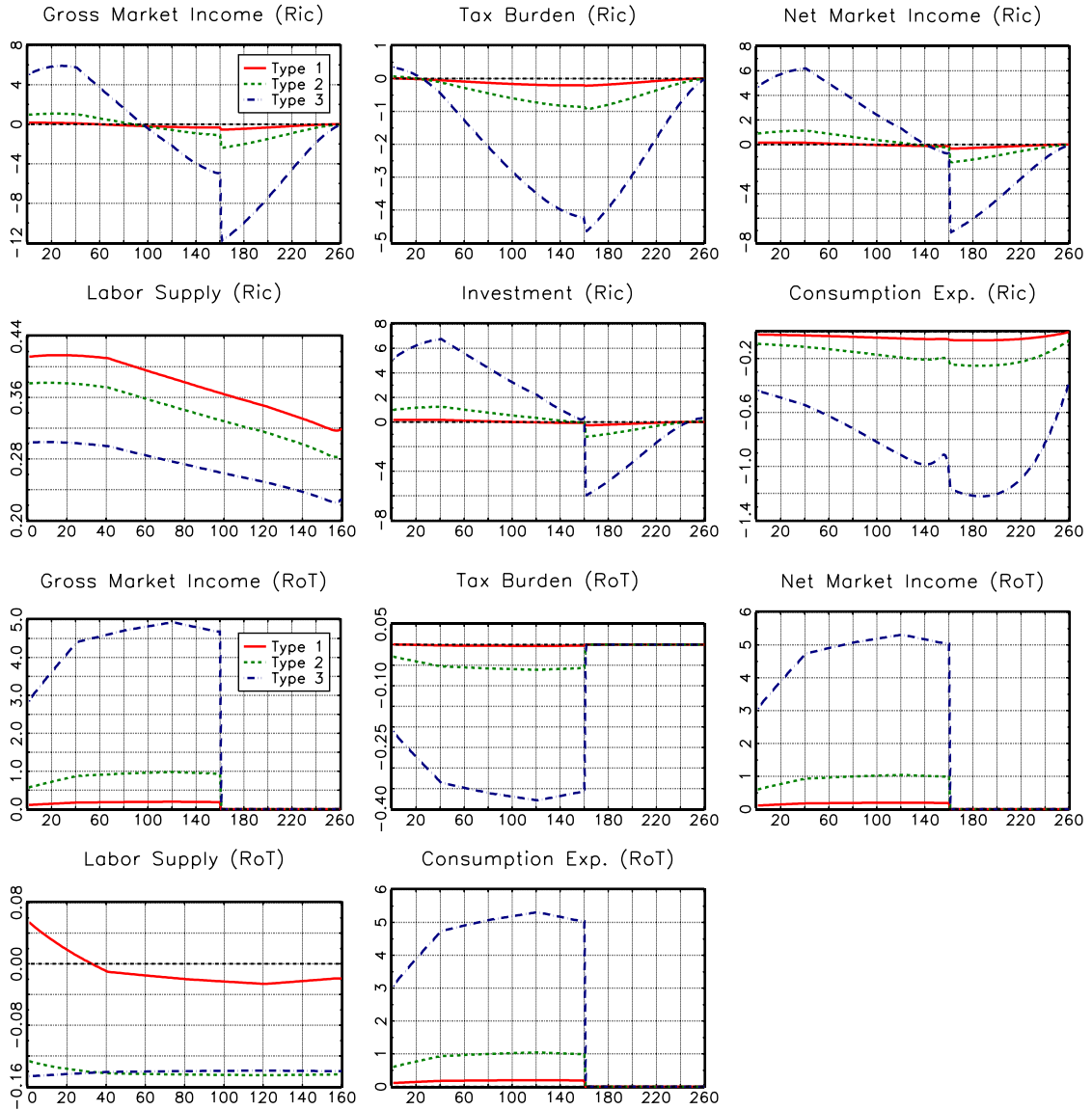
## 5.2 Income and Wealth Inequality

The responses of the individual variables labor, consumption, and savings depends on age  $s \in \{1, \dots, 260\}$ , the productivity type  $j \in \{1, 2, 3\}$ , and the consumer type, Ricardian or Rule-of-Thumb (RoT) consumer. Fig. 4 illustrates the behavior of the Ricardian consumers (top two rows) and the RoT consumers (bottom two rows) in the impact period  $t = 2$  when the shock occurs. Variables are presented as absolute deviations from their steady-state value (scaled by the factor 100).

---

<sup>19</sup>The initial decline in the labor income tax rate in the case of bond financing results from the increase of inflation so that real government debt and the real interest burden from government bonds decrease. Since nominal interest rates adjust according to the Taylor rule (34), this is only a one-period effect.

<sup>20</sup>The result is in accordance with the findings of Galí et al. (2007) who also finds a negative effect for this parameter value of  $\omega_g$  in their Fig. 7.



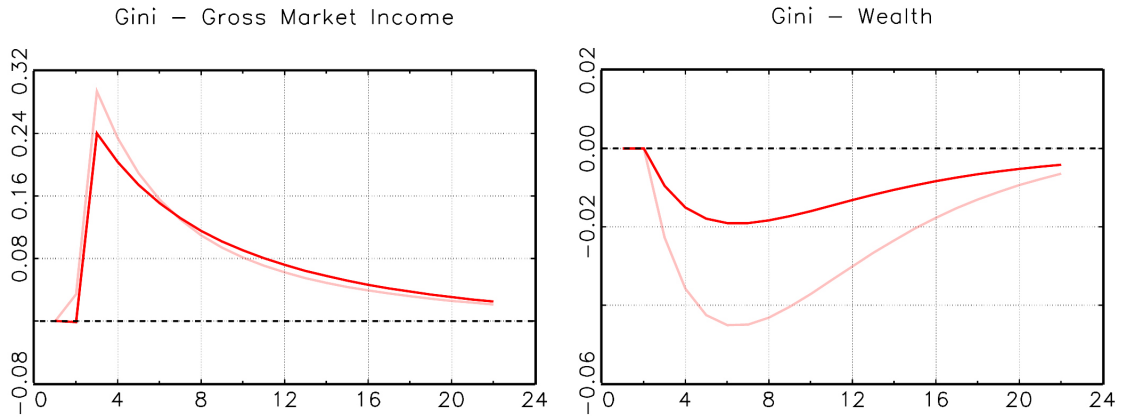
**Figure 4:** Cross-Section - Ricardian Households (Ric) & Rule of Thumb Consumers (RoT) in  $t=2$  (a.d. & s.f.=100)

When the shock hits the economy, net real wages increase on impact. The substitution effect on labor supply is dominated by the income effect for the RoT consumers except for the younger households with the lowest productivity type  $j = 1$  and  $s < 38$  (see right panel in the third row in Fig. 4). The Ricardian households are subject to an additional negative wealth effect so that they all increase their labor supply unanimously (see right panel in the first row). Notice that the absolute change in labor is strongest among the household with little income who are characterized by

the idiosyncratic productivity type  $j = 1$ .

As a consequence of the higher wages, gross market income of the RoT consumers increases even for those workers among them who reduce their labor supply (see left panel in the third row). Since the tax burden falls, net income rises as well. For the Ricardian household, gross labor income increases as well. However, as illustrated in Fig. 2, the real return from both bonds and capital falls in period  $t = 2$  so that the total effect on gross income depends on the individual's ratio of labor to capital. For the younger households with age  $s < 90$ , the increase in the labor income dominates the fall in capital returns so that gross market income increases (see upper left panel in Fig. 4). For the older households who receive a larger part of their income from asset returns gross market income falls.

In sum, the gross income increases among the young Ricardian households and for all Rule-of-Thumb consumers, while it falls among the older Ricardian workers and the retirees. Since the poorest income households are among the retirees, inequality increases, even though the gross income of the income-richest households (the Ricardian households with the highest productivity  $j = 3$  close to retirement) falls. This effect is illustrated in Fig. 5 that presents the impulse responses of the Gini coefficient of income and wealth. The shaded lines represent the case of bond financing. On impact, the Gini coefficient of gross market income increases only by 0.04%; however, the effect is more pronounced in later periods,  $t = 3, 4, \dots$ , because the return on capital increases after period  $t = 3$  so that the gross market income of the richer household rises. In period  $t = 3$ , the Gini of gross market income already increases by 0.30%.



**Figure 5:** Gini Coefficients - shaded colors = bond-financed increase in government spending

The fall in interest rates also results in an increase of present consumption among the Ricardian consumers, while savings fall. As a consequence, wealth accumulation decreases, particularly among the richer older Ricardian households, so that wealth heterogeneity falls, too. The maximum impact occurs after 5 periods in period  $t = 6$ , when the Gini coefficient of wealth has decreased by 0.05%.

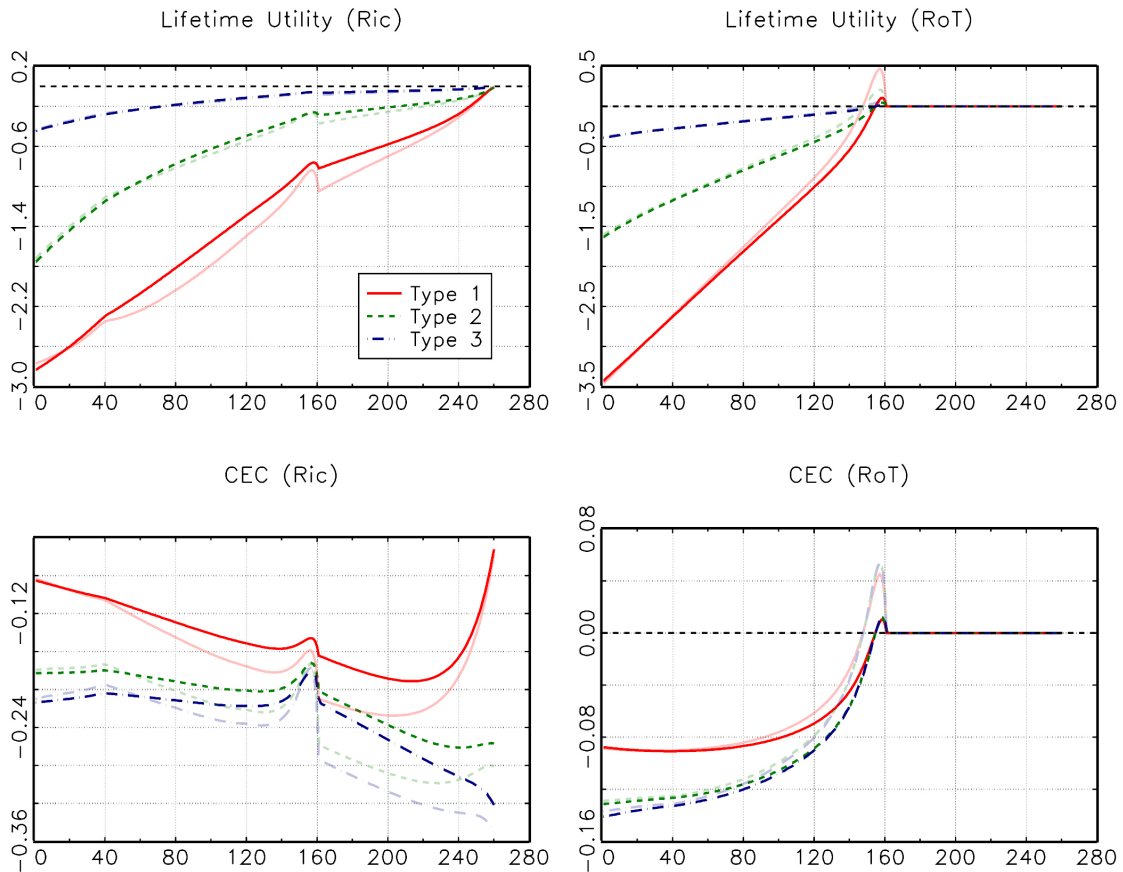
In the case of tax financing, the qualitative effects of the impulse responses are similar to those of bond financing.<sup>21</sup> However, since the responses of both net and gross wages are much smaller than in the case of bond financing, e.g. the gross wage increase by only 1.9% rather than 2.9% in period  $t = 2$ , the effect on the Gini coefficient of gross market income is less pronounced (see solid line in the left panel of Fig. 5). In addition, capital income taxes  $\tau^k$  increase more rapidly as a consequence of the fiscal rule (29) so that the net real return of assets falls stronger than in the case of debt financing. For this reason, young Ricardian households have smaller incentives to build up wealth for retirement and postpone the accumulation of savings to later years so that wealth inequality falls by a smaller amount than in the case of bond financing.

---

<sup>21</sup>The figures of the individuals' impulse responses for tax financing of additional government expenditures are presented in the Appendix A.6.

### 5.3 Welfare Effects

In the following, we consider the major question of this study who are the households that benefit from bonds rather than tax funding of additional government expenditures. For this reason, we compute the (remaining) lifetime utility of all households at ages  $s = 1, \dots, 260$ , and distinguish between the different productivity and consumer types. We compute the change in lifetime utility relative to that in steady state that results from an unanticipated shock to government consumption of 1% in period  $t = 1$  and zero thereafter. Since government consumption  $G_t$  is autocorrelated,  $G_t$  adjusts only gradually to its steady state value as depicted in Figs. 2 and 3 depending on whether additional expenditures are predominantly financed by bonds or taxes.



**Figure 6:** Lifetime Utility (a.d.) & Consumption Equivalent Change (CEC in %) - shaded colors = bond-financed increase in government spending

The absolute change of lifetime-utility is presented in the top row of Fig. 6. The case of bond (tax) financing is depicted by the shaded (solid) line. For the Ricardian households, all productivity types experience a drop in lifetime utility. In order to interpret utility changes, we computed the consumption equivalent change  $cec$  that is graphed in the bottom row.<sup>22</sup> Evidently, the high-productivity households experience the highest drop in lifetime utility and the welfare losses amount to 0.18%-0.32% depending on the individual's age when the shock occurs. In this period, labor of Ricardian households as presented in Fig. 4 increases, while consumption (not presented) decreases. Therefore, instantaneous utility in the period of the shock falls unanimously for the Ricardian consumers.

The effects of an unanticipated government consumption shock for the Rule-of-Thumb consumers are illustrated on the right-hand side of Fig. 6. In the case of bond-financing (shaded line), the majority of households loses from extra government spending. Welfare losses are smaller than in the case of the Ricardian households and only amount to a maximum of 0.14% of consumption, while the households close to retirement even benefit from such a fiscal policy. The reason why RoT households close to the retirement age  $s = 160$  even experience an increase in welfare is presented by the instantaneous increase of net wages that occurs in the period of the shock. This raises consumption and instantaneous utility of the RoT consumers. In the following periods  $t = 3, 4, \dots$ , net wages decline and fall below its steady-state value. If workers are close to retirement, however, they do not suffer as much from these wage decreases, but receive constant pensions instead. We also observe that the welfare losses of the Ricardian households are mainly larger than those of the RoT consumers because of the reduction in the price of capital and the temporary decline of asset returns.

In the case of tax financing (represented by the solid lines), welfare effects are more beneficial for the Ricardian households, while they are more detrimental for RoT

---

<sup>22</sup>The consumption equivalent change is computed by the percentage number that steady-state consumption has to be changed so that the resulting lifetime utility (for given steady-state labor supply) is equal to the lifetime utility obtained in the case of a shock to government consumption.



households at working age. The RoT households during retirement are indifferent because we have assumed pensions to be constant. Hence, Ricardian households favor tax funding of additional government expenditures, while working-age RoT households advocate bonds financing. In particular, and contrary to conventional wisdom, even retired Ricardian household prefer higher tax funding because it entails smaller reduction in capital prices and, hence, in the value of their wealth.<sup>23</sup>

Our result that, to the best of our knowledge, has not been pointed out in the literature yet is caused by the introduction of a variable price of capital  $q_t$ . The reaction of  $q_t$  to higher government debt and crowding out of investment depends crucially on the elasticity  $\zeta$  of adjustment costs  $f(I/K)$  with respect to the investment-capital ratio  $I/K$  according to (12a). We have calibrated the value  $\zeta = 1$  in line following Galí et al. (2007). If we set  $\zeta = 0.05$  instead, the volatility of the capital price  $q_t$  is reduced significantly and the case is almost equivalent to the one of a constant price of capital. In particular, the price of capital  $q_t$  only falls by 0.1% (rather than 1.0% in the benchmark case with  $\zeta = 1.0$ ) in response to a government consumption shock of 1%, while the return of capital only drops by 0.2% (rather than 1.0% in the case with  $\zeta = 1.0$ ). As a consequence, Ricardian households only experience a smaller drop in the value of their assets. For  $\zeta = 0.05$ , therefore, we find that Ricardian households prefer tax rather than debt financing of additional government expenditures.

---

<sup>23</sup>Notice that we have two non-Ricardian elements in our model so that Ricardian equivalence does not hold. On the one hand, we have Rule-of-Thumb consumers. On the other hand, lifetime is finite in our model and households are assumed not to be altruistic with respect to their children. As a consequence, they do not consider the loss in life-time utility of future generations that results from higher debt. The latter effect, however, is rather small in our model because we consider 240 periods and, according to Fig. 2, the real value of government debt has already shrunk from the maximum deviation of 0.8% to 0.2% of its steady state value within the first 24 periods (=6 years) after the shock. Therefore, only the very old households can pass on some of the extra debt to yet unborn generations.

## 6 Conclusion

The analysis has shown that an unanticipated increase in government consumption increases income inequality, but decreases wealth inequality. The quantitative effects are more noticeable if additional government expenditures are mainly financed by debt rather than taxes. An increase of 1 percentage point in government consumption increases the Gini coefficient of gross market income by 0.30% in the former case and only by 0.24% in the latter case. For the derivation of these results, we have presented a heterogeneous-agent extension of the standard New Keynesian model with two types of households, a Ricardian and a rule-of-thumb consumer using an OLG model with a variable price of capital. The model is able to replicate the inequality of income and wealth observed empirically in the US economy.

As our second main result, we have shown that contrary to conventional wisdom, also part of the old retired households prefer a tax financing over a debt-financing of expenditures. In particular, the Ricardian households of all ages prefer tax financing, while the rule-of-thumb households at working age prefer bond-financing. Welfare effects as measured by the differences in life-time utility from these two forms of government finances amounted to 0.1%-0.2% of consumption.

One should, however, be careful to use the welfare results from our fiscal policy experiment for normative implications. In particular, we find that bond financing implies a somewhat higher response of inflation and wages to an increase of government consumption than tax financing. Therefore, the form of financing might have additional effects on the welfare of households that we did not consider in this paper. First, we only considered a proportional income tax. If the tax code were progressive and income tax brackets were only partially adjusted for inflation (or with a lag), households who end up in higher tax brackets might be affected more severely from bonds financing because (relatively) higher inflation pushes them into higher tax brackets. Second, we assumed pensions to be constant over the business cycle. If pensions were adjusted for higher wages, retirees might advocate for bond financing instead. Incorporating these elements in the present model constitutes an interesting direction for future research.

## References

- Agnello, L. and R. M. Sousa (2013). Fiscal policy and asset prices. *Bulletin of Economic Research* 65, 154 – 177.
- Altonij, J. G. (1986). Intertemporal substitution in labor supply: Evidence from micro data. *Journal of Political Economy* 94, S176 – S215.
- Basu, S. and M. S. Kimball (1997). Cyclical productivity with unobserved input variation. *NBER working paper* 5915.
- Baxter, M. and D. D. Farr (2005). Variable capital utilization and international business cycles. *Journal of International Economics* 65, 335–347.
- Blanchard, O. and R. Perotti (2002). An empirical characterization of the dynamic effects of changes in government spending and taxes on output. *The Quarterly Journal of Economics* 117(4), 1329–1368.
- Bricker, J., L. J. Dettling, A. Henriques, J. W. Hsu, K. B. Moore, J. Sabelhaus, J. Thompson, and R. A. Windle (2014). Changes in u.s. family finances from 2010 to 2013: Evidence from the survey of consumer finances. *Federal Reserve Bulletin* 100(4).
- Brinca, P., H. H. Holter, P. Krusell, and L. Malafry (2015). Fiscal multipliers in the 21st century. *working paper*.
- Budría Rodríguez, S., J. Díaz-Giménez, V. Quadrini, and J.-V. Ríos-Rull (2002). Updated facts on the u.s. distributions of earnings, income, and wealth. *Federal Reserve Bank of Minneapolis Quarterly Review* 26, 2–35.
- Cagetti, M. and M. de Nardi (2009). Estate taxation, entrepreneurship and wealth. *American Economic Review* 99, 85 – 111.
- Campbell, J. Y. and N. G. Mankiw (1989). Consumption, income and interest rates: Reinterpreting the time series evidence. In *NBER Macroeconomics Annual 1989, Volume 4*, NBER Chapters, pp. 185–246.
- Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy* 113(1), 1–45.

- Cogan, J. F., T. Cwik, J. B. Taylor, and V. Wieland (2010). New keynesian versus old keynesian government spending multipliers. *Journal of Economic Dynamics and Control* 34(3), 281–295.
- De Nardi, M. (2015). Quantitative models of wealth inequality: A survey. *NBER working paper 21106*.
- De Nardi, M. and F. Yang (2015). Wealth inequality, family background, and estate taxation. *NBER working paper 21047*.
- Fernández-Villaverde, J. and D. Krueger (2007). Consumption over the life cycle: Facts from consumer expenditure survey data. *Review of Economics and Statistics* 89(3), 552 – 565.
- Fuhrer, J. C. (2000). Habit formation in consumption and its implications for monetary-policy models. *American Economic Review* 90(3), 367–390.
- Galí, J., J. D. Lopez-Salido, and J. Vallés (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association* 5(1), 227 – 270.
- Gomme, P., B. Ravikumar, and P. Rupert (2011). The return to capital and the business cycle. *Review of Economic Dynamics* 14(2), 262–278.
- Huggett, M. (1996). Wealth distribution in life-cycle economies. *Journal of Monetary Economics* 38, 373 – 396.
- Killingsworth, M. R. (1983). *Labor Supply*. Cambridge, MA: Cambridge University Press.
- Krueger, D., F. Perri, L. Pistaferri, and G. L. Violante (2010). Cross sectional facts for macroeconomists. *Review of Economic Dynamics* 13, 1–14.
- MaCurdy, T. E. (1981). An empirical model of labor supply in a life-cycle setting. *Journal of Political Economy* 89, 1059 – 1085.
- Monacelli, T., R. Perotti, and A. Trigari (2010). Unemployment fiscal multipliers. *Journal of Monetary Economics* 57, 531 – 553.
- Quadrini, V. (2000). Entrepreneurship, saving, and social mobility. *Review of Economic Dynamics* 3, 1–40.

- Ravn, M. O., S. Schmitt-Grohé, and M. Uribe (2012). Consumption, government spending, and the real exchange rate. *Journal of Monetary Economics* 59, 215–234.
- Rotemberg, J. J. and M. Woodford (1992). Oligopolistic pricing and the effects of aggregate demand on economic activity. *Journal of Political Economy* 100, 1153–1207.
- Trabandt, M. and H. Uhlig (2011). The laffer curve revisited. *Journal of Monetary Economics* 58, 305 – 327.
- Uhlig, H. (2010). Some fiscal calculus. *American Economic Review* 100(2), 30–34.
- UN (2002). World population prospects: The 2002 revision. *United Nations, New York*.
- Walsh, C. E. (2005). Labor market search, sticky prices, and interest rate policies. *Review of Economic Dynamics* 8(4), 829–849.

## 7 Appendix 1: Equilibrium Conditions

### A.1 Price Setting

Firms choose their optimal nominal prices in a staggered fashion, according to Calvo (1983). There are two types of firms indexed by “ $A$ ” and “ $N$ ” in each period  $t$ . Type  $A$  firms set their optimal relative price  $\frac{P_{j,t}}{P_t} = \frac{P_{A,t}}{P_t}$  by solving an inter-temporal optimization problem, whereas type  $N$  firms are only allowed to adjust their price in period  $t$  according to a simple rule of thumb (7).

The probability of being a firm of type  $A$  in period  $t$  is given by  $(1 - \varphi)$ . Hence, firms that are allowed to set their optimal price  $\frac{P_{A,t}}{P_t}$  in period  $t$  solve a standard maximization problem:<sup>24</sup>

$$\begin{aligned} \max_{P_{A,t}/P_t} E_t \sum_{s=0}^{\infty} \varphi^s z_{t+s} \left[ \left( \frac{\pi^s P_{A,t}}{P_{t+s}} \right) Y_{A,t+s} - g_{t+s} (Y_{A,t+s} + F) \right] \\ \text{s.t. } Y_{A,t+s} = \left( \frac{\pi^s P_{A,t+s}}{P_{t+s}} \right)^{-\epsilon} Y_{t+s}, \end{aligned}$$

where  $z_{t+s} := \beta^s \frac{\lambda_{t+s}}{\lambda_t}$  denotes the stochastic discount factor of the households. We get, after some tedious algebra, the following first order condition:

$$0 = E_t \sum_{s=0}^{\infty} (\beta\varphi)^s \lambda_{t+s} Y_{j,t+s} \left( \frac{\pi^s}{\prod_{i=1}^s \pi_{t+i}} \frac{P_{A,t}}{P_t} - \frac{\epsilon}{\epsilon - 1} g_{t+s} \right). \quad (\text{A.1.1})$$

This condition states that the optimal relative price must be chosen in such a manner that discounted real marginal cost equal discounted real marginal revenues. Moreover, it can easily be shown that the term  $\epsilon/(1 - \epsilon)$  defines the gross price mark-up in a steady state with an inflation of zero. The realized (aggregate) profit  $\Omega_t$  in period  $t$  is given by

$$\Omega_t = \int_0^1 \left( \frac{P_{j,t}}{P_t} Y_{j,t} - w_t N_{j,t} - r_t K_{j,t} \right) dj = \int_0^1 \left( \frac{P_{j,t}}{P_t} Y_{j,t} - g_t (Y_{j,t} + F) \right) dj, \quad (\text{A.1.2})$$

and the aggregate price level evolves according to the following equation:

$$P_t^{1-\epsilon} = (1 - \varphi) P_{A,t}^{1-\epsilon} + \varphi (\pi P_{t-1})^{1-\epsilon}. \quad (\text{A.1.3})$$

---

<sup>24</sup>Since all intermediate goods firms that are allowed to set their price optimally in period  $t$  are identical, we can drop the firm index  $j$  from the following equations.

Aggregate production  $Y_t$  as presented in (2) and total production in the intermediate goods sector  $\tilde{Y}_t$

$$\tilde{Y}_t = N_t^{1-\alpha} (u_t K_t)^\alpha - F. \quad (\text{A.1.4})$$

are related by the following equation:

$$Y_t = \frac{1}{q_t^p} \tilde{Y}_t \quad (\text{A.1.5})$$

where  $q_t^p$  measures the price dispersion in the intermediate goods sector and evolves according to the following dynamic equation:

$$q_t^p = (1 - \varphi) \left( \frac{P_{At}}{P_t} \right)^{-\epsilon} + \varphi \left( \frac{\pi_t}{\pi} \right)^\epsilon q_{t-1}^p.$$

The first-order condition of this price-setting problem are presented by

$$\frac{P_{At}}{P_t} \cdot \Gamma_{2t} = \frac{\epsilon}{\epsilon - 1} \cdot \Gamma_{1t}, \quad (\text{A.1.6})$$

where

$$\Gamma_{1t} = g_t Y_t \left( \frac{P_{At}}{P_t} \right)^{-\epsilon} + \varphi \Lambda_{t,t+1} \left( \frac{\pi (P_{At}/P_t)}{\pi_{t+1} (P_{At+1}/P_{t+1})} \right)^{-\epsilon} \Gamma_{1t+1}, \quad (\text{A.1.7a})$$

$$\Gamma_{2t} = Y_t \left( \frac{P_{At}}{P_t} \right)^{-\epsilon} + \varphi \Lambda_{t,t+1} \left( \frac{P_{At}/P_t}{P_{At+1}/P_{t+1}} \right)^{-\epsilon} \left( \frac{\pi}{\pi_{t+1}} \right)^{1-\epsilon} \Gamma_{2t+1}. \quad (\text{A.1.7b})$$

## A.2 Capital Producers

The production technology (10) implies:

$$\begin{aligned} \frac{d\Omega_t^c}{dI_t} &= q_t K_t \frac{a_1 (1 - \zeta)}{1 - \zeta} \left( \frac{I_t^D}{K_t} \right)^{-\zeta} \frac{1}{K_t} - 1, \\ &\Rightarrow q_t = \frac{1}{a_1} \left( \frac{I_t^D}{K_t} \right)^\zeta. \end{aligned} \quad (\text{A.2.1})$$

$$\begin{aligned} \frac{d\Omega_t^c}{dK_t} &= q_t \left( \frac{a_1}{1 - \zeta} \left( \frac{I_t^D}{K_t} \right)^{1-\zeta} + a_2 \right) - r_t^c, \\ &\Rightarrow r_t^{cs} = q_t \left( \frac{a_1 \zeta}{1 - \zeta} \left( \frac{I_t}{K_t} \right)^{1-\zeta} + a_2 \right). \end{aligned} \quad (\text{A.2.2})$$

Thus, profits are always equal to zero:

$$\begin{aligned}
\Omega_t^c &= q_t f(I_t^D/K_t) K_t - I_t^D - r_t^{cs} K_t, \\
&= q_t f(I_t^D/K_t) K_t - I_t^D - q_t \left( f(I_t^D/K_t) - f'(I_t^D/K_t) \frac{I_t^D}{K_t} \right) K_t, \\
&= q_t f(I_t^D/K_t) K_t - I_t^D - q_t f(I_t^D/K_t) K_t + I_t^D, \\
&= 0.
\end{aligned}$$

### A.3 Steady State

With  $\delta(u_t)$  given by (16) and the interest rate  $r_t^{is}$  from (6b), the optimal utilization rate implied by the household's first-order condition (21e) is given by

$$u_t = \left( \frac{\alpha g_t}{q_t \delta_1 (1 + \epsilon_u)} \left( \frac{K_t}{N_t} \right)^{\alpha-1} \right)^{1/(1+\epsilon_u-\alpha)}.$$

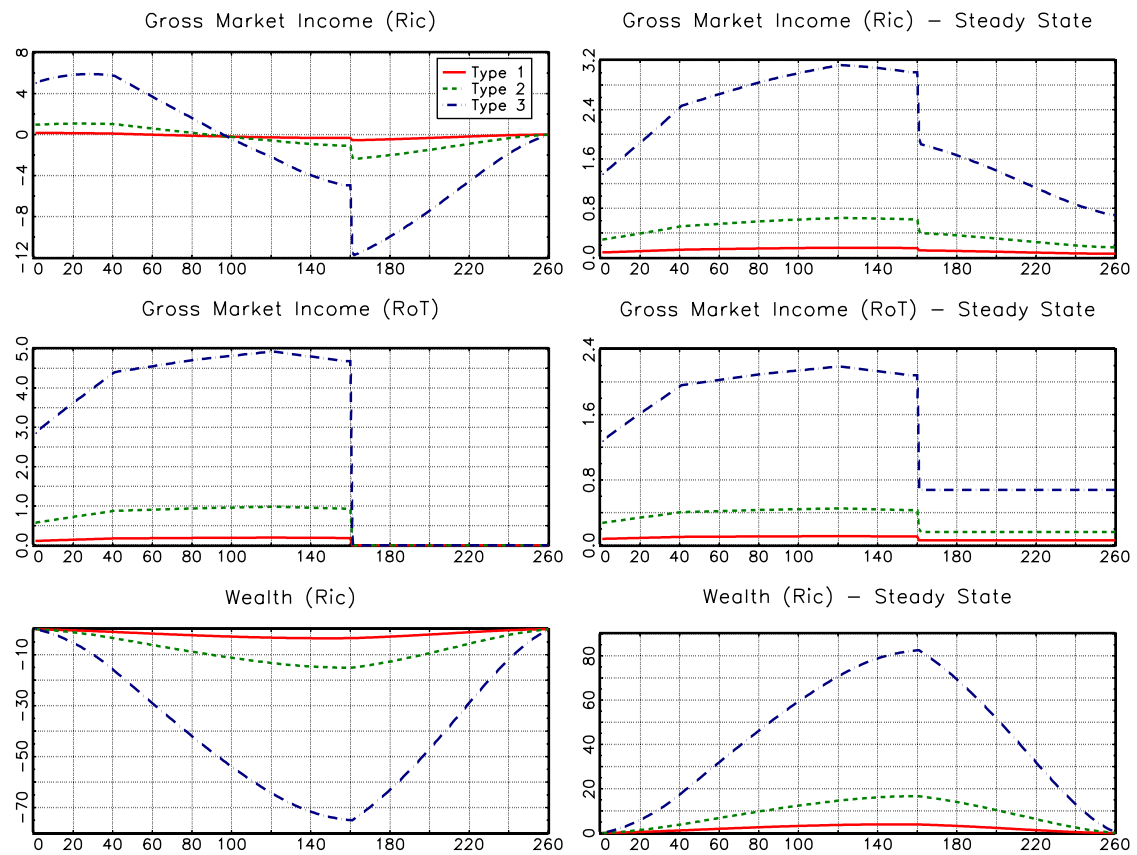
In steady state,  $u = 1$  and  $\delta(1) = \delta$  implying

$$\delta_1 = \left( \frac{\alpha g}{q (1 + \epsilon_u)} \right) \left( \frac{N}{K} \right)^{1-\alpha} \tag{A.3.1a}$$

$$\delta_0 = \delta - \delta_1. \tag{A.3.1b}$$

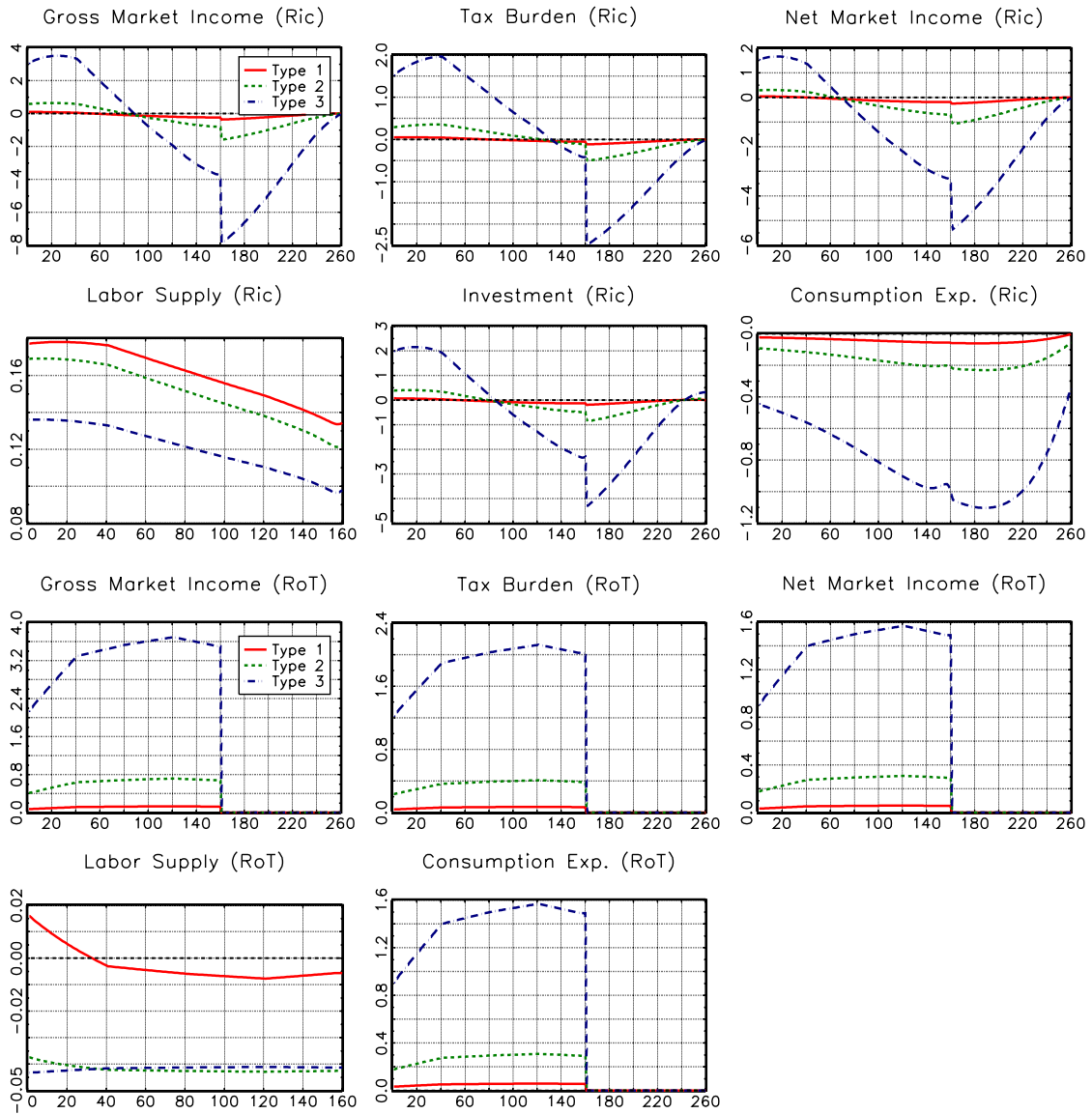


## A.4 Impulse Responses of Individual Market Income

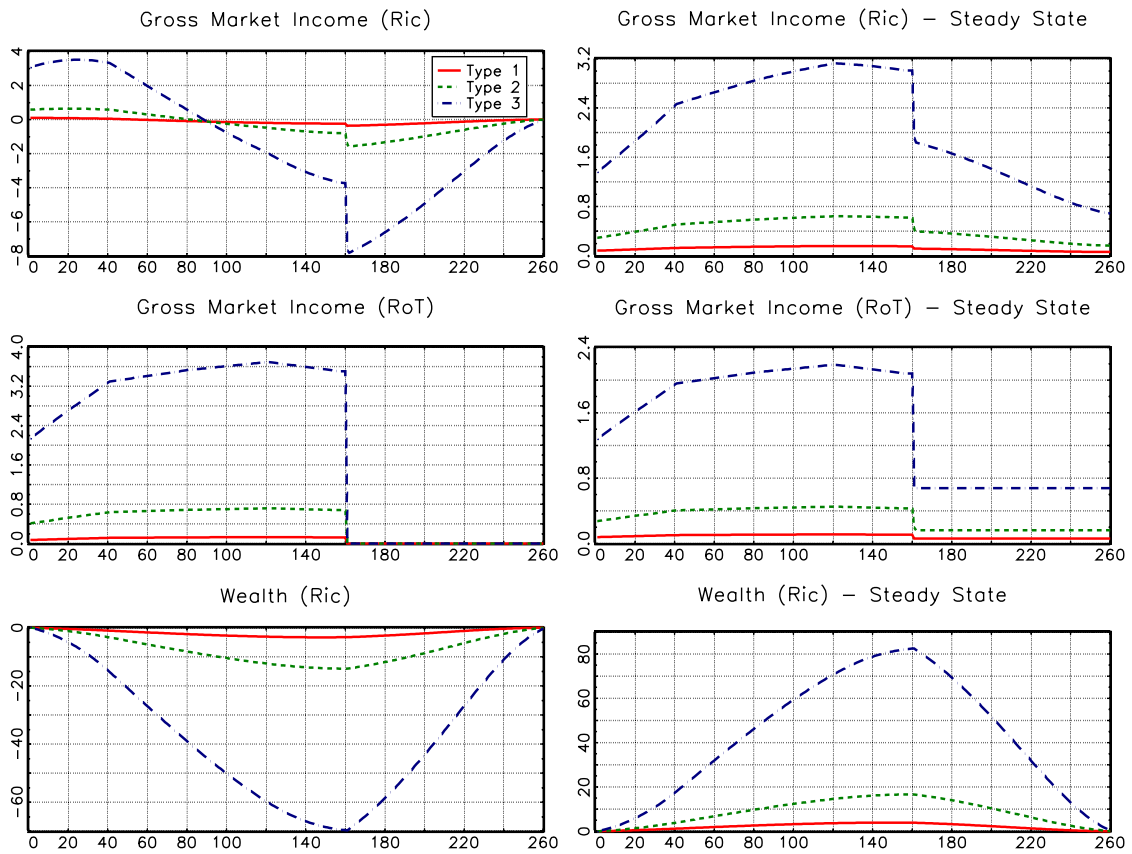


**Figure A.1:** Effects on Gini Coefficients in  $t=2$  - Left panels: Impulse Responses (a.d. & s.f.=100) - Right panels: Steady State

## A.5 Impulse Responses for a Tax-Financed Increase in Government Spending

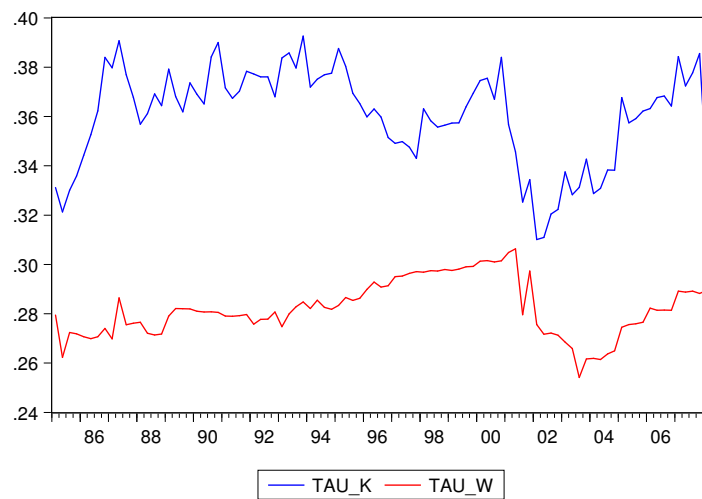


**Figure A.2:** Cross-Section - Ricardian Households (Ric) & Rule-of-Thumb Consumers (RoT) in  $t=2$  (a.d. & s.f.=100)



**Figure A.3:** Effects on Gini Coefficients in  $t=2$  - Left panels: Impulse Responses (a.d. & s.f.=100) - Right panels: Steady State

## A.6 U.S. tax rates on labor and capital income



**Figure A.4:** U.S. tax rates on labor ( $\tau_w$ ) and capital ( $\tau_k$ ) income