

Terms of Trade Shocks and Fiscal Policy in a Small Open Economy with Credit Constrained Consumers

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Abstract

In this paper we examine macroeconomic effects of alternative fiscal policies implemented in the face of an oil price shock by government, which is a receipt of oil revenues within two-sector dynamic stochastic general equilibrium framework. We analyze tax reduction and debt retirement policies that are implemented by means of simple fiscal feedback rules. We show that fiscal policy can help to moderate real exchange rate appreciation caused by the oil boom depending on the fiscal strategy used.

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1 Introduction

When economies, well endowed with natural resources (e.g., oil) and highly dependent on their exports, face with an improvement in their terms of trade, they become vulnerable to the Dutch disease problem. An increase in the price of oil results in an increase in demand for non-traded goods and could lead to an appreciation of the real exchange rate. It is widely discussed that such an appreciation of the exchange rate creates risks for (non-oil) the traded sector, by making the traded goods sector less competitive and depressing output and employment in that sector. This could also impede growth in the long-run if the traded sector is a source of learning-by-doing.

However, this is not a necessary outcome. In Kuralbayeva and Vines (2006), when there is an oil income shock, in the long-run the real exchange rate appreciation disappears and there is further expansion of the non-traded sector and even stronger decline in the (non-oil) traded sector. However, the contraction of the traded sector, rather than constituting a macroeconomic problem, simply reflects the appropriate resource allocation responses to the permanent change in transfer payments from abroad caused by the permanent improvement in the price of oil. Further, given that an improvement in the terms of trade is associated with a decrease in the risk-premium on lending to this economy, as Kuralbayeva and Vines (2007) discusses further, this can lead to a Dutch party in which real exchange rate appreciation is associated with an expansion of the capital-intensive traded sector.

Thus, in analyzing appropriate macroeconomic adjustment to the shock, it is essential to know its character. In particular, if the improvement in the terms of trade is permanent which

is caused, for example, by a permanent increase in the demand for a country's output or by a permanent increase in the price of the country's output, then long-run real effects require changes in the relative prices, resulting in an appreciation of the real exchange rate. But if the shock is temporary, then monetary policy may not be enough to rely on as the sole macroeconomic stabilization mechanism. There are several reasons why there is a scope for fiscal intervention in stabilizing the economy in the face of the shock¹.

One reason is real costs associated with adjustment to the temporary changes in the terms of trade. Imagine an increase in the price of oil, which leads to fall in the return on capital in (non-oil) tradeable sector, resulting in a capital outflow from that sector. Over time, the capital stock diminishes in the traded sector as well as employment, and when the shock is over and the economy returns back to its initial equilibrium, there is need to re-install capital and attract labor to that sector again. Such movements in the capital stock are likely to be prolonged due to the real adjustment costs and thus unsatisfactory from the welfare point of view. As these medium-run fluctuations in the capital stock originate in shifts in demand induced by the positive oil shock, and if could be offset by policy, then fiscal policy may be more suitable in dealing with them rather than monetary policy. This is because changes in government expenditure directly involves changes in demand in contrast to indirect effect of monetary policy through changes in intertemporal relative prices (Solow, (2005))².

There is another argument in favor of fiscal policy in small open economies subject to terms of trade shocks. Specifically, monetary policy's objective is price stability as defined by the inflation target. The exchange rate is not an objective of monetary policy. At times of rising oil prices and high demand, monetary policy might not be able to prevent large imbalances between the traded and the non-traded sectors resulting in distress for the (non-oil) traded sectors (see King (2000), Brash (2001)). In that case, fiscal policy could assist monetary policy in limiting the swings in the relative prices of the non-traded goods and moderating the real exchange rate appreciation, as it would be also apparent from our analysis.

So, in this paper we examine the macroeconomic affects of two fiscal strategies that government follows in the face of the oil price shock. We assume that oil is appropriated by the government and analyze tax reduction and debt retirement policies that are implemented by means of simple fiscal feedback rules. The purpose is to evaluate quantitatively differences in a response of the real exchange rate across two fiscal regimes and to analyze the impact of the rule-of-thumb behavior on this response. The goal is to study which of these two effects result in stronger appreciation of the real exchange rate caused by the oil boom. The framework we use is dynamic stochastic general equilibrium model (DSGE) of the New Open Economy Macroeconomics (NOEM) paradigm.

NOEM models have been extensively used to analyze monetary policy. A standard NOEM model typically assumes an infinitely lived representative agent in a perfect-foresight framework with nondistortionary taxation, which implies that Ricardian equivalence holds. However, Ri-

¹On macroeconomics of fiscal policy see, e.g., Allsopp and Vines (2005)

²This issue is related to the literature which examines various ways in which public investment could help to overcome the Dutch Disease effect (real appreciation of the exchange rate) caused by aid flows in developing countries. See e.g. Rajan and Subramanian (2005), Adam and Bevan (2006).

cardian equivalence eliminates the scope for a fiscal stabilization policy. Ricardian equivalence states that, for a given expenditure path of the government, substitution of debt for taxes has no effect on aggregate demand. The argument is that borrowing by government today has to be repaid in the future, so that future taxes will have to rise. Consumers, anticipating the increase in the future taxes, realize that their life-cycle incomes have not increased and do not change their consumption.

Thus, to study the fiscal policy issues for this economy, we need to break down Ricardian equivalence, which vitiates any interesting effects of the fiscal policy. This can be done either by including features such as liquidity constraints, finite horizons or distortionary taxation. In this paper we follow the first approach and introduce "rule-of-thumb" consumers, who have neither assets nor liabilities and consume each period their current disposable income. Liquidity constrained consumers coexist in the model with optimizing consumers. The presence of rule-of-thumb consumers enables a break down of Ricardian equivalence, because they do not optimize intertemporally. It matters for them whether the budget deficits are financed through an increase in taxes or via borrowing. In the first case their current income is affected as well as their consumption. In the second case their current income is not altered.

By introducing liquidity constrained consumers into the model, our analysis relies on a number of models which have incorporated rule-of-thumb consumers into the DSGE framework. Most of the literature has been motivated by empirical evidence. Specifically, standard New Keynesian models without such rule-of-thumb consumers typically predict a strong negative response of consumption to a government spending shock; while the empirical literature suggests that such shocks have a positive effect on consumption (Perotti (1999)). Different solutions have been proposed in the literature to solve this consumption puzzle. One of the ways of capturing the dynamic effects of government spending on consumption within the New Keynesian DSGE model is to introduce rule-of-thumb consumers. And this is what has been done by Galí et al. (2003). Following their work, many papers that study fiscal policy effects have introduced rule-of-thumb consumers into their models³.

Our paper is also related to studies that examine implications of terms of trade shock for fiscal policy within two-sector overlapping generations models. Examples of such studies include Steigum and Thøgersen (2003) and Macklem (1993). The most relevant to our study is a paper by Macklem, who examines the interaction between terms of trade shocks and the government in two different fiscal settings. The first one, which he calls exogenous fiscal policy, is the case where the temporary terms of trade shock held both tax revenues and government expenditures constant, thus having no impact on the government's fiscal stance. The second case is endogenous fiscal policy, under which the fiscal authorities follow a tax rule, where taxes are proportional to wage income as well as to the level of the government debt. Comparing the dynamic responses of consumption and the real exchange rate, which are less pronounced in the second case, he concludes that fiscal policy can be used to dampen the short-run effects of the terms of trade shocks on consumption. However, this outcome has the effect of magnifying both current account imbalances and the reallocation of factors of production between sectors.

The remainder of the paper is organized as follows. Section 2 describes the model and devises

³See, for example, Bilbiie and Straub (2004), Coenen and Straub (2005), Erceg et al. (2005), Furlanetto (2006)

two fiscal strategies following an oil boom. Section 3 examines the dynamic adjustments of the model triggered by alternative fiscal strategies in response to the oil shock. Finally section 4 concludes.

2 Model of a Small Open Economy with Rule-of-Thumb Consumers

We consider a two-sector dynamic general equilibrium model with nominal rigidities. The economy consists of two types of consumers, a continuum of firms producing differentiated non-traded goods, a continuum of firms producing flexible price traded goods, an oil sector, and a central bank in charge of monetary policy and fiscal authority. We assume that oil production requires no domestic factor inputs, and all its production is exported. We assume Calvo-type price stickiness in the non-traded sector. The model is an extension of the model with rule-of-thumb consumers developed in Galí et al. (2005) to a two-sector set up with capital.

2.1 Consumers

There is a continuum of households, indexed by $i \in [0, 1]$. We assume two types of households. Households in the first group benefit from access to the capital markets, can buy and sell physical capital in both sectors, and they are referred as to *Ricardian* or *optimizing* households. The proportion of optimizing consumers in the economy is given by $1 - \omega_C$. The remaining fraction ω_C of households follow a *rule-of-thumb* and consume out of current disposable income, as they do not own any assets nor have any liabilities.

2.1.1 Consumption: definitions

For both groups of optimizing and rule-of-thumb consumers the total consumption bundle is given by a standard constant-elasticity-of-substitution (CES) function of traded goods and non-traded goods, with

$$C_t^i = [a^{\frac{1}{\rho}} (C_{N,t}^i)^{(\rho-1)/\rho} + (1-a)^{\frac{1}{\rho}} (C_{T,t}^i)^{(\rho-1)/\rho}]^{\rho/(1-\rho)}, \quad \rho > 0, \quad \text{for } i = o, r \quad (2.1)$$

with $C_{N,t}^i$ and $C_{T,t}^i$ being indexes of consumption of non-traded and traded goods respectively. Under such specification of the composite consumption function, the parameter σ measures the (inverse) intertemporal elasticity of substitution and the parameter ρ is the intratemporal elasticity of substitution between non-traded and traded goods. The implied consumer price index is then

$$P_t = [aP_{N,t}^{1-\rho} + (1-a)P_{T,t}^{1-\rho}]^{\frac{1}{1-\rho}}$$

where $P_{N,t}$ is the price index of the composite differentiated non-traded good, $P_{T,t}$ is the price of the flexible-price traded good, expressed in national currency, and P_t is the consumer price index⁴. Indexes of consumption of non-traded goods, in turn, is given by CES aggregators of

⁴The price index P_t is the minimum expenditure required to purchase one unit of aggregate consumption good C_t . For a derivation see, for example, Obstfeld and Rogoff (2002).

the quantities consumed of each variety, with elasticity of substitution across different categories equal to λ :

$$C_{Nt}^i = \left(\int_0^1 C_{N,t}^i(j)^{\frac{\lambda-1}{\lambda}} dj \right)^{\frac{\lambda}{\lambda-1}}, \text{ with } \lambda > 1, i = o, r \quad (2.2)$$

where $C_{N,t}^i(j)$ is consumption of variety j by representative household i ($i = o, r$). When λ tends to infinity all varieties are perfect substitutes for each other. The price of variety j is denoted $P_{N,t}(j)$, and the price of a consumption basket of non-traded goods $P_{N,t}$ is defined as a CES index⁵ with elasticity $1/\lambda$:

$$P_{N,t} = \left(\int_0^1 P_{N,t}(j)^{1-\lambda} dj \right)^{1/(1-\lambda)} \quad (2.3)$$

The optimal allocation of any given expenditure on non-traded goods by household i ($i = o, r$) yields the total demand for variety $j \in [0, 1]$:

$$C_{N,t}^i(j) = \left(\frac{P_{N,t}(j)}{P_{N,t}} \right)^{-\lambda} C_{N,t}^i; \quad (2.4)$$

Given a decision on consumption C_t^i households (both Ricardian and rule-of-thumb) allocate optimally the expenditure on $C_{N,t}^i$ and $C_{T,t}^i$ by minimizing the total expenditure $P_t C_t^i$ under the constraint (2.1), so demands for non-traded and traded goods are:

$$C_{Nt}^i = a \left(\frac{P_{N,t}}{P_t} \right)^{-\rho} C_t^i, \text{ for } i = o, r \quad (2.5)$$

$$C_{Tt}^i = (1 - a) \left(\frac{P_{T,t}}{P_t} \right)^{-\rho} C_t^i, \text{ for } i = o, r \quad (2.6)$$

2.1.2 Optimizing consumers

A representative household j from the group of Ricardian consumers maximizes:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t u(C_t^o, H_t^o) \quad (2.7)$$

subject to the budget constraint:

$$\begin{aligned} & P_t C_t^o + P_t(\phi_{Nt} K_{Nt}^o + \phi_{Tt} K_{Tt}^o) + P_{Tt}(I_{Nt}^o + I_{Tt}^o) + R_t^{-1} B_{t+1}^o + R_{Ft}^{-1} S_t B_{F,t+1}^o + P_t T_t^o + P_t \frac{\kappa}{2} (B_{F,t+1}^o - B_F^o) \\ & = (1 - \tau_W) W_t H_t^o + (1 - \tau_K) [R_{Nt} K_{Nt}^o + R_{Tt} K_{Tt}^o] + B_t^o + S_t B_{F,t}^o + \frac{1}{1 - \omega_C} \int_0^1 \Pi_t^o(j) dj \end{aligned} \quad (2.8)$$

where the terms on the left-side indicate how the consumer uses its resources, while the terms on the right-hand side show the resources that the household has at its disposal. In equation (2.8) B_t^o represents the quantity of non-state contingent government bonds purchased by an optimizing household at time t , and $R_t (\equiv 1 + i_t)$ is the total return on government bonds. Households can also acquire foreign bonds, which are subject to portfolio adjustment costs. In particular, if

⁵This price index is the minimum expenditure required to buy one unit of aggregate consumption non-traded good $C_{N,t}$. For a derivation see, for example, Corsetti and Pesenti (2005).

households purchase an amount of $B_{F,t}^o$ foreign bonds, then these portfolio adjustment costs are $\frac{\kappa}{2}(B_{F,t}^o - B_F^o)$ (denominated in the composite good), where B_F^o is an exogenous steady state level of net foreign assets. Each optimizing household earns after-tax labor income $(1 - \tau_W)W_t H_t^o$, where τ_W is fixed tax on labor income. The household accumulates capital, which is rented to goods producing firms. Capital income, as labor income, is subject to taxation at rate τ_K ; household also receives an equal share $\frac{1}{1-\omega_C} \int_0^1 \Pi_t^o(j) dj$ of the profits of the non-traded goods firms, and pays a lump-sum tax $P_t T_t^o$.

Capital accumulation equations in both non-traded and traded sectors are:

$$K_{N,t+1}^o = I_{N,t}^o + (1 - \delta)K_{N,t}^o, \quad (2.9)$$

$$K_{T,t+1}^o = I_{T,t}^o + (1 - \delta)K_{T,t}^o, \quad (2.10)$$

where investment in both sectors is a traded good. Installation of capital in both sectors requires adjustment costs, which represent a basket of goods composed by non-traded goods and traded goods in the same mix as the household's consumption basket. We define capital adjustment costs as:

$$\phi_{i,t} \left(\frac{I_{i,t}^o}{K_{i,t}^o} \right) K_{i,t}^o = \frac{\psi_I}{2} \left(\frac{I_{i,t}^o}{K_{i,t}^o} - \delta \right)^2 K_{i,t}^o, \text{ where } i = N, T,$$

We assume the following functional form of the utility function

$$u(C_t, H_t) = \frac{C_t^{1-\sigma}}{1-\sigma} - \eta \frac{H_t^{1+\psi}}{1+\psi} \quad (2.11)$$

The optimization produces the standard first order conditions:

$$(1 - \tau_W)W_t = \eta(H_t^o)^\psi P_t (C_t^o)^\sigma \quad (2.12)$$

$$1 = \beta E_t \left[\frac{(C_t^o)^\sigma P_t}{(C_{t+1}^o)^\sigma P_{t+1}} (1 + i_t) \right] \quad (2.13)$$

$$\frac{1}{1 + i_t^F} + \kappa \frac{P_t}{S_t} (B_{F,t+1}^o - B_{F,t}^o) = \beta E_t \left[\frac{(C_t^o)^\sigma P_t}{(C_{t+1}^o)^\sigma P_{t+1}} \frac{S_{t+1}}{S_t} \right] \quad (2.14)$$

$$q_t^N = \beta E_t \frac{(C_t^o)^\sigma P_t}{(C_{t+1}^o)^\sigma P_{t+1}} \left\{ (1 - \tau_K) R_{N,t+1} + P_{t+1} (\phi'_{N,t+1} \frac{I_{N,t+1}^o}{K_{N,t+1}^o} - \phi_{N,t+1}) + q_{t+1}^N (1 - \delta) \right\} \quad (2.15)$$

$$q_t^N = P_{Tt} + P_t \phi'_{N,t} \quad (2.16)$$

$$q_t^T = \beta E_t \frac{(C_t^o)^\sigma P_t}{(C_{t+1}^o)^\sigma P_{t+1}} \left\{ (1 - \tau_K) R_{T,t+1} + P_{t+1} (\phi'_{T,t+1} \frac{I_{T,t+1}^o}{K_{T,t+1}^o} - \phi_{T,t+1}) + q_{t+1}^T (1 - \delta) \right\} \quad (2.17)$$

$$q_t^T = P_{Tt} + P_t \phi'_{T,t} \quad (2.18)$$

along with capital accumulation, (2.9)-(2.10), and budget constraint, (2.8), equations.

Equation (2.12) equates the marginal disutility of the labor effort to the utility value of the wage rate, and defines the households labor supply curve. Equation (2.13) is a Euler equation that determines intertemporal allocation: it equates the intertemporal marginal rate of substitution in consumption to the real rate of return on domestic bonds. Equation (2.14) is the counterpart of equation (2.13) for foreign bonds. Equation (2.15) is the pricing condition for physical capital in the non-traded sector. It equates the revenue from selling one unit of capital today (q_t^N), to the discounted value of renting the unit of capital for one period, and then selling it, $R_{N,t+1} + q_{t+1}^N$, net of depreciation and adjustment costs⁶. Equation (2.16) relates the cost of producing a unit of capital in the non-traded sector to the shadow price of installed capital, or Tobin's Q, q_t^N . Equations (2.17), and (2.18) are the traded sector counterparts of (2.15) and (2.16).

2.1.3 Rule-of-thumb consumers

Rule-of-thumb consumers do not smooth their consumption in face of fluctuations in their labor income, nor do they intertemporarily substitute in response to changes in interest rates. Rule-of-thumb consumers' income consists of labor income only:

$$u(C_t^r, H_t^r) = \frac{(C_t^r)^{1-\sigma}}{1-\sigma} - \eta \frac{(H_t^r)^{1+\psi}}{1+\psi} \quad (2.19)$$

subject to the budget constraint:

$$P_t C_t^r = (1 - \tau_W) W_t H_t^r - P_t T_t^r \quad (2.20)$$

Accordingly, the rule-of-thumb households consumer out of their disposable income, so that consumption is given by:

$$C_t^r = \frac{(1 - \tau_W) W_t}{P_t} H_t^r - T_t^r \quad (2.21)$$

The labor supply of rule-of-thumb consumers satisfies:

$$(1 - \tau_W) W_t = \eta (H_t^r)^\psi (C_t^r)^\sigma P_t \quad (2.22)$$

2.1.4 Aggregation

The aggregate level of any household-specific variable X_t^h is given by $X_t = \int_0^1 X_t^h(i) di = \omega_C X_t^r + (1 - \omega_C) X_t^o$, because households in each of the two groups are identical. Hence, from (2.5), aggregate consumption demand for a single differentiated non-traded good j is given by:

$$C_{N,t}(j) = \omega_C C_{N,t}^r(j) + (1 - \omega_C) C_{N,t}^o(j) = \left(\frac{P_{N,t}(j)}{P_{N,t}} \right)^{-\lambda} C_{N,t} \quad (2.23)$$

⁶Adjustments are costs stemming from decreasing the capital stock. The installation function $\phi_{Nt} K_{Nt}$ as a function of I_{Nt} shifts upwards as K_{Nt} decreases, which is represented by $\partial/\partial K_{Nt+1}(\phi_{Nt+1} K_{Nt+1}) = -\phi'_{Nt+1} I_{N,t+1}/K_{Nt+1} + \phi_{Nt+1}$ in (2.15).

where $C_{N,t}$ aggregate consumption of the non-traded goods is determined as:

$$C_{N,t} \equiv \omega_C C_{N,t}^r + (1 - \omega_C) C_{N,t}^o \quad (2.24)$$

Similarly, using (2.5) and (2.6), aggregate consumption demands for non-traded and traded goods are given by:

$$C_{N,t} = a \left(\frac{P_{N,t}}{P_t} \right)^{-\rho} C_t; \quad C_{T,t} = (1 - a) \left(\frac{P_{T,t}}{P_t} \right)^{-\rho} C_t \quad (2.25)$$

where aggregate consumption of traded goods and aggregate total consumption are defined as:

$$C_{T,t} \equiv \omega_C C_{T,t}^r + (1 - \omega_C) C_{T,t}^o; \quad C_t \equiv \omega_C C_t^r + (1 - \omega_C) C_t^o \quad (2.26)$$

Similarly, hours, aggregate investment in traded and non-traded sectors, governments bonds as well capital stock in both sectors are given by:

$$H_t = \omega_C H_t^r + (1 - \omega_C) H_t^o \quad (2.27)$$

$$I_{T,t} = (1 - \omega_C) I_{T,t}^o; \quad I_{N,t} = (1 - \omega_C) I_{N,t}^o \quad (2.28)$$

$$K_{T,t} = (1 - \omega_C) K_{T,t}^o; \quad K_{N,t} = (1 - \omega_C) K_{N,t}^o \quad (2.29)$$

$$B_t = (1 - \omega_C) B_t^o \quad (2.30)$$

Because installation of capital in both sectors requires adjustment costs, which represent a basket of goods composed by a non-traded goods and traded goods in the same mix as the household's consumption basket, the aggregate demand for non-traded and traded goods is given by the following equations:

$$Y_{N,t} = a \left(\frac{P_{N,t}}{P_t} \right)^{-\rho} [C_t + (1 - \omega_C) \phi_{N,t} K_{N,t}^o + (1 - \omega_C) \phi_{T,t} K_{T,t}^o] \quad (2.31)$$

and

$$A_t = (1 - a) \left(\frac{P_{T,t}}{P_t} \right)^{-\rho} [C_t + (1 - \omega_C) \phi_{N,t} K_{N,t}^o + (1 - \omega_C) \phi_{T,t} K_{T,t}^o] + (1 - \omega_C) I_{N,t}^o + (1 - \omega_C) I_{T,t}^o \quad (2.32)$$

where $\phi_{i,t} \equiv \phi_{i,t} \left(\frac{I_{i,t}^o}{K_{i,t}^o} \right) = \frac{\psi_I}{2} \left(\frac{I_{i,t}^o}{K_{i,t}^o} - \delta \right)^2$, $i = N, T$.

2.2 Production by Firms

We assume a continuum of monopolistically competitive firms of measure unity in the non-traded sector, each producing output with the production function:

$$Y_{N,t}(j) = A_N K_{N,t}(j)^\alpha H_{N,t}(j)^{1-\alpha} \quad (2.33)$$

where A_N is a productivity parameter, the same across all firms in the non-traded sector. Firms in the traded sector operate under perfect competition with production function given by:

$$Y_{T,t}(j) = A_T K_{T,t}(j)^\gamma H_{T,t}(j)^{1-\gamma} \quad (2.34)$$

where A_T is a productivity parameter, the same across all firms in the traded sector. There are also a mass of one of firms producing traded goods. We assume all firms rent capital and labor in perfectly competitive factor markets. Cost minimization implies equations:

$$W_t = MC_{N,t}(1 - \alpha) \frac{Y_{N,t}}{H_{N,t}} \quad (2.35)$$

$$R_{N,t} = MC_{N,t} \alpha \frac{Y_{N,t}}{K_{N,t}} \quad (2.36)$$

$$W_t = P_{T,t}(1 - \gamma) \frac{Y_{T,t}}{H_{T,t}} \quad (2.37)$$

$$R_{T,t} = P_{T,t} \gamma \frac{Y_{T,t}}{K_{T,t}} \quad (2.38)$$

where $Y_{N,t} = A_N K_{N,t}^\alpha H_{N,t}^{1-\alpha}$ and $Y_{T,t} = A_T K_{T,t}^\gamma H_{T,t}^{1-\gamma}$ are aggregate supply functions of non-traded and traded goods⁷. Demand for labor and capital in the non-traded sector goods sector is described by equations (2.35)-(2.36), where $MC_{N,t}$ represents the (nominal) marginal costs in that sector. It is noteworthy that the marginal costs in the non-traded sector are identical across firms, as long as their production functions exhibit constant returns to scale and prices of inputs are fully flexible in perfectly competitive markets. Producers of the traded goods are price-takers, so that equations (2.37)-(2.38) describe demand for labor and capital inputs in the traded sector, with $P_{T,t}$ representing the unit cost of production.

2.3 Price setting in the non-traded sector

Firms in the non-traded sector set their prices as monopolistic competitors. We use Calvo (1983) sticky price specification and assume that the firm j changes its price with probability $(1 - \theta_N)$. That is, each period there is a constant probability $(1 - \theta_N)$ that the firm will be able to change its price, independent of past history. Following Yun (1996) and Erceg et. al. (2000), we also assume that if prices are not reset, the old price is adjusted by a steady state inflation factor: $\Pi_N = P/P_{-1}$ ⁸. Hence, even if the firm is not allowed to change its price, the latter grows at the same rate as trend inflation. Thus, the problem of the firm j changing price at time t consists of choosing price $P_{N,t}^{new}(j)$ to maximize:

⁷With respect to aggregation in the non-traded sector, in the appendix we show that the non-traded market equilibrium equation has an additional term that deals with the distribution of prices in the non-traded sector. However, as shown in the appendix (see also Yun (1996), Erceg et. al. (2000) and Christiano et. al. (2001)), this term does not appear in the log-linear approximation of the resource constraint in the non-traded sector.

⁸Most dynamic stochastic general equilibrium models assume that inflation is zero in the steady state. When trend inflation is considered, as it has been shown by many authors, both the long-run and short run properties of Calvo time-dependent staggered price model change dramatically (e.g., Rotemberg, 2002; Bakshi et. al. 2003; Ascari, 2004). Thus to tackle this problem we augment the Calvo sticky price model by indexation of prices to the trend inflation, which has been used in Yun (1996), and Jeanne (1998).

$$E_t \sum_{i=0}^{\infty} \theta_N^i \Phi_{t+i} [P_{N,t}^{new}(j) \Pi_N^i Y_{N,t+i}(j) - TC_{N,t+i}(j)]$$

subject to the total demand it faces:

$$Y_{N,t+i}(j) = \left(\frac{P_{N,t}^{new}(j)}{P_{N,t+i}} \Pi_N^i \right)^{-\lambda} Y_{N,t+i}$$

and where Φ_{t+i} is an appropriate stochastic discount factor, θ_N^i is the probability that the price $P_{N,t}^{new}(j)$ set for good j still holds i periods ahead, and $TC_{N,t+i}(j)$ represents total (nominal) costs. The discount factor relates to the way that households value their future consumption relative to the current consumption, and we define the discount factor as:

$$\Phi_{t+i} = \beta^i \frac{\Lambda_{t+i}}{\Lambda_t} = \beta^i \frac{P_{t+i}^{-1} C_{t+i}^{-\sigma}}{P_t^{-1} C_t^{-\sigma}}$$

Cost minimizing behavior of the firm in the non-traded sector yields the following expression for the total costs: $TC_{N,t+i}(j) = P_{N,t+i} mc_{N,t+i} Y_{N,t+i}(j)$, where $mc_{N,t+i} = MC_{N,t+i}/P_{N,t+i}$ represents real marginal costs.

The FOC of this maximization problem yields the following optimal price:

$$P_{N,t}^{new}(j) = \frac{\lambda}{\lambda - 1} \frac{E_t \sum_{i=0}^{\infty} (\theta_N \beta)^i \Lambda_{t+i} (P_{N,t}^{new}(j) \Pi_N^i / P_{N,t+i})^\lambda P_{N,t+i} mc_{N,t+i} Y_{N,t+i}}{E_t \sum_{i=0}^{\infty} (\theta_N \beta \Pi)^i \Lambda_{t+i} (P_{N,t}^{new}(j) \Pi_N^i / P_{N,t+i})^\lambda Y_{N,t+i}} \quad (2.39)$$

From (2.39) it is clear that all firms that reset their prices in period t , set it at the same level, so $P_{N,t}^{new}(j) = P_{N,t}^{new}$, for all $j \in [0, 1]$, and we could omit subscript j . If we define two new variables

$$P_{N,t}^1 = E_t \sum_{i=0}^{\infty} (\theta_N \beta)^i \Lambda_{t+i} \left(\frac{P_{N,t}^{new} \Pi_N^i}{P_{N,t+i}} \right)^\lambda P_{N,t+i} mc_{N,t+i} Y_{N,t+i} \quad (2.40)$$

and

$$P_{N,t}^2 = E_t \sum_{i=0}^{\infty} (\theta_N \beta \Pi)^i \Lambda_{t+i} \left(\frac{P_{N,t}^{new} \Pi_N^i}{P_{N,t+i}} \right)^\lambda Y_{N,t+i} \quad (2.41)$$

then (2.39) can be rewritten as:

$$P_{N,t}^{new} = \frac{\lambda}{\lambda - 1} \frac{P_{N,t}^1}{P_{N,t}^2} \quad (2.42)$$

Both $P_{N,t}^1$ and $P_{N,t}^2$ can be expressed recursively to avoid the use of infinite sums, such that:

$$P_{N,t}^1 = \Lambda_t \left(\frac{P_{N,t}^{new}}{P_{N,t}} \right)^{-\lambda} P_{N,t} mc_{N,t} Y_{N,t} + \beta \theta_N E_t P_{N,t+1}^1 \quad (2.43)$$

$$P_{N,t}^2 = \Lambda_t \left(\frac{P_{N,t}^{new}}{P_{N,t}} \right)^{-\lambda} Y_{N,t} + \beta \theta_N \Pi_N E_t P_{N,t+1}^2 \quad (2.44)$$

The price index in the non-traded sector is given by:

$$P_{N,t} = \left(\int_0^1 P_{N,t}(j)^{1-\lambda} dj \right)^{1/(1-\lambda)}$$

which can be expressed as the average of all prices set i periods ago (in period $t - i$) that still hold in period t :

$$P_{N,t} = \left(\sum_{i=0}^{\infty} (1 - \theta_N) \theta_N^i (\Pi_N^i P_{N,t-i}^{new})^{1-\lambda} \right)^{1/(1-\lambda)} \quad (2.45)$$

Expression in (2.45) can be rewritten recursively as:

$$P_{N,t} = [(1 - \theta_N)(P_{N,t}^{new})^{1-\lambda} + \theta_N(\Pi_N P_{N,t-1})^{1-\lambda}]^{\frac{1}{1-\lambda}} \quad (2.46)$$

Note that log-linearizing a general price level in (2.46) and the optimal reset price (2.39) around zero inflation steady state and putting them together, one gets the usual New Keynesian Phillips curve, which has become a basic component of recent models of the New Keynesian Synthesis⁹:

$$\pi_{N,t} = \frac{(1 - \beta\theta_N)(1 - \theta_N)}{\theta_N} \widehat{mc}_{N,t} + \beta E_t \pi_{N,t+1} = \lambda_N \widehat{mc}_{N,t} + \beta E_t \pi_{N,t+1} \quad (2.47)$$

where $\frac{(1-\theta_N\beta)(1-\theta_N)}{\theta_N} = \lambda_N$, and $\widehat{mc}_{N,t}$ represents the log deviation of real marginal costs in the non-traded sector from its steady state level.

2.4 Local Currency Pricing

We assume that the price of the traded good is flexible and determined by the law of one price, so:

$$P_{T,t} = S_t P_{T,t}^*$$

where $P_{T,t}^*$ is the foreign currency price of the traded good, and S_t is the nominal exchange rate. The economy is also small in respect that the economy's export share is negligible in the foreign aggregate price index, implying that the foreign price of traded goods is equal to the foreign aggregate price level, and we assume that it equals to unity, so $P_{T,t}^* = P_t^* = 1$, and $P_{T,t} = S_t$.

Defining the real exchange rate as, $e_t = S_t P_t^*/P_t$, so the real exchange rate depreciates (appreciates) when e_t rises (decreases). The rate of change of the real exchange rate is given as:

$$\frac{e_t}{e_{t-1}} = \frac{1 + \nu_t}{1 + \pi_t} \quad (2.48)$$

and the nominal exchange rate depreciation in period t is given by:

$$1 + \nu_t = \frac{S_t}{S_{t-1}} \quad (2.49)$$

2.5 Monetary policy

We assume that the monetary authority uses the nominal interest rate as the policy instrument. We also assume that monetary policy is characterized as a Taylor rule:

$$\log\left(\frac{1 + i_t}{1 + i}\right) = \rho_Y \log\left(\frac{Y_{Nt}}{Y_{N,t}^n}\right) + \rho_\pi \log\left(\frac{1 + \pi_{N,t}}{1 + \bar{\pi}_N}\right) \quad (2.50)$$

⁹see for example, Clarida, Galí, and Gertler (1999), Goodfriend and King (1997)

where $\overline{\pi_N}$ is the target for the annual inflation in the non-traded sector, i is the stationary values of the interest rate, and $Y_{N,t}/Y_{N,t}^n$ is output of the non-traded sector relative to its flexible-price equilibrium. Log-linearization of the feedback rule yields:

$$\hat{i}_t = \rho_Y \hat{y}_{N,t} + \rho_\pi \pi_t \quad (2.51)$$

where $\rho_Y > 0$, and $\rho_\pi > 1$ are the reaction coefficients on non-traded goods inflation and $\hat{y}_{N,t}$ is the output gap in the non-traded sector.

2.6 Fiscal policy

The government budget constraint is:

$$\tau_W W_t H_t + \tau_K [R_{Nt} K_{Nt} + R_{Tt} K_{Tt}] + P_{Tt} O_t + R_t^{-1} B_{t+1} = P_t G_t + B_t \quad (2.52)$$

where all quantities are expressed in aggregate terms. The fiscal authority purchases the final good, G_t (using the same aggregator as the household), raises taxes (lump-sum T_t and labor and capital income taxes), and issues bonds (B_{t+1}) consisting of one-period nominal discount bonds, paying 1 unit at the beginning of next period, and acquire oil revenues from export of oil ($P_{Tt} O_t$). The price of oil is determined exogenously at the world markets, so that oil income is also an exogenous, stochastic variable:

$$O_t = O \varepsilon_t \quad (2.53)$$

where

$$\log(\varepsilon_t) = \rho_{oil} \log(\varepsilon_{t-1}) + \xi_t \quad (2.54)$$

Since oil revenues are denominated in the units of the traded goods, and because $P_{T,t} = S_t$ following the assumption of a small open economy, ε_t can be described as the world price of oil, denominated in foreign currency. It implies that ξ_t shocks are international oil price shocks.

Government purchases are assumed to have no direct effect on the utility of a household and we assume that the log-linear counterpart of government purchases $g_t \equiv (G_t - G)/Y$, (Y is GDP), follows the process:

$$g_t = \rho_g g_{t-1} + \nu_t \quad (2.55)$$

Denoting $L_t \equiv \tau_W w_t H_t + \tau_K [r_{Nt} K_{Nt} + r_{Tt} K_{Tt}]$, $t_t \equiv (T_t - T)/Y$, $b_t \equiv (B_t/P_{t-1} - B/P)/Y$, and $l_t = (L_t - L)/Y$, log-linearization of the government budget constraint yields:

$$\beta b_{t+1} = g_t + b_t - t_t - l_t + \beta \frac{B}{PY} \hat{i}_t - \frac{B}{PY} \pi_t - \frac{p_{TO}}{Y} (\hat{p}_{Tt} + \hat{\varepsilon}_t) \quad (2.56)$$

Before an oil price shock hits the economy, the government follows a tax rule according to which lump-sum taxes are adjusted to finance any changes in government spending and debt service. When the oil price shock occurs, oil revenues increase so the government has to decide how to use additional oil revenues. In this paper we focus on two fiscal strategies that can be implemented by the government in response to the positive oil shock. First, the government may use oil revenues to cut lump-sum taxes (equivalent to increasing transfers to the households).

Alternatively, the oil windfall can be used to retire public debt. So, in the first case, we assume that the government follows the tax rule:

$$t_t + l_t = \phi_g g_t + (i\beta + \phi_b)b_t - \frac{B}{PY}i\beta\pi_t + \frac{B}{PY}\beta\hat{i}_t - \frac{p_{TO}}{Y}(\hat{p}_{Tt} + \hat{\varepsilon}_t) \quad (2.57)$$

and in the second case:

$$t_t + l_t = \phi_g g_t + (i\beta + \phi_b)b_t - \frac{B}{PY}i\beta\pi_t + \frac{B}{PY}\beta\hat{i}_t \quad (2.58)$$

2.7 Market clearing

Market clearing requires:

(i) in the non-traded sector:

$$\int_0^1 Y_{Nt}^S(j) di = \Delta_t Y_{Nt}^D \quad (2.59)$$

where Δ_t is a measure of relative price dispersion in the non-traded goods sector¹⁰ and Y_{Nt}^D is aggregate demand of non-traded goods in the economy defined as:

$$Y_{Nt}^D \equiv a\left(\frac{P_{Nt}}{P_t}\right)^{-\rho}[C_t + \phi_{N,t}K_{Nt} + \phi_{T,t}K_{Tt} + G_t] \quad (2.60)$$

(ii) in the traded sector:

$$A_{Tt} = Y_{Tt} + IM_{Tt} \quad (2.61)$$

where domestic absorption of traded goods A_{Tt} is met via domestic production of traded goods Y_{Tt} and imports IM_{Tt} :

$$A_{Tt} \equiv (1 - a)\left(\frac{P_{Tt}}{P_t}\right)^{-\rho}[C_t + \phi_{N,t}K_{Nt} + \phi_{T,t}K_{Tt} + G_t] + I_{Nt} + I_{Tt} \quad (2.62)$$

(iii) in the labor market:

$$H_t = \omega_C H_t^r + (1 - \omega_C) H_t^o \quad (2.63)$$

(iii) balance of payments:

$$A_{Tt} = Y_{Tt} + O_t \quad (2.64)$$

3 Calibration and Solution

3.1 Steady state

We consider steady state with zero inflation, but non-zero public debt. In steady state consumption by Ricardian and non-Ricardian consumers may differ, so we do not impose the restriction that $C^o = C^r$. However, we assume that they pay the same level of lump-sum taxes, so that $T_t^o = T_t^r$ for any t .

¹⁰See technical appendix of Kuralbayeva (2006) for more details on this.

3.2 Calibration

In calibrating the model one period is defined as one quarter. The parameter choices of the model are described in Table 1, while Table 2 reports macroeconomic ratios implied by the theoretical model. We set the following parameters of the utility function: σ , the inverse intertemporal elasticity of substitution in consumption, equal to 0.99;¹¹ the value of coefficient on labor $\eta = 1$. We set $\psi = 2$, which implies a Frisch elasticity of labor supply of 0.5. The elasticity of substitution between non-traded and traded goods (ρ) is set to 1.2.¹²

We set the value of a , the share of non-traded goods in CPI, equal to 0.65, which implies the steady state share of non-traded goods in GDP is 48 percent. We set the depreciation rate at 10 percent per annum, a standard value in the business cycle literature. The value of the adjustment cost parameter, ψ_I is set at 0.1. This number is consistent with empirical estimates of the adjustment cost parameter in the literature, although these estimates are for developed countries¹³.

We set the steady-state real interest rate faced by the small economy in international markets at 11 percent per annum, with a world interest rate r^* of 4 percent and a country premium of 7 percent. These parameters yield the value of subjective discount factor, β , of 0.973. The steady state value of oil income, O , was chosen such that oil transfers constitute 25 percent of GDP. The steady state value of the stock of foreign assets is set to equal to 40 percent of GDP, while the level of public debt is set to 60 percent of GDP. The elasticity of substitution between differentiated goods is set to equal 11, which implies a steady state mark-up of 10%. This is within the range suggested by the literature¹⁴. We follow the literature in setting $\theta_N = 0.75$, which implies that, on average, prices last for one year.

Table 1 Calibration of the model - baseline specification

¹¹Ostry and Reinhart (1992) provides estimate of σ for a group of Asian countries at 0.8. Aurelio (2005) uses the value of $\sigma = 1$ in her simulations. Gali and Monacelli (2002) assume log-utility of consumption, which also implies a unit intertemporal elasticity of substitution.

¹²Ostry and Reinhart's estimates of the parameter for Asian and Latin American countries equals 0.655 and 0.76 respectively, using one set of instruments, and 1.15 and 1.1 for a different set of instruments respectively. Mendoza (2001) sets $\rho = 1.46$.

¹³Hall (2002) estimates a quadratic adjustment cost for capital and finds a slightly higher value of 0.91 for ψ_I , on average, across industries. A much closer value of 0.096 is found recently by Groth (2005) for estimates of capital adjustment costs for UK manufacturing covering the period 1970-2000.

¹⁴Gali (2003) sets $\lambda = 11$ as well, while in Gali and Monacelli (2002) the value of this parameter is equal to 6. The empirically plausible range of 10% - 40% for markups, as Gali et. al. (2001) discuss, yields similar results.

| Parameter | Value | Description |
|--------------|---------|---|
| σ | 0.99 | Inverse of elasticity of substitution in consumption |
| β | 0.973 | Discount factor |
| ρ | 1.2 | Elasticity of substitution between non-traded and traded goods in consumption |
| η | 1 | Coefficient on labor in utility |
| ψ | 2 | Inverse of elasticity of labor supply |
| γ | 0.65 | Share of capital in traded sector |
| α | 0.25 | Share of capital in non-traded sector |
| δ | 0.025 | Quarterly rate of capital depreciation (same across sectors) |
| a | 0.65 | Share on non-traded goods in CPI |
| ψ_I | 0.1 | Investment adjustment cost (same across sectors) |
| θ_N | 0.75 | Probability of fixed price |
| λ | 11 | Elasticity of substitution between differentiated goods |
| ρ_Y | 0.5 | coefficient on output gap in Taylor rule |
| ρ_π | 1.5 | coefficient on inflation in Taylor rule |
| ω_C | 0.2/0.8 | share of liquidity constrained consumers |
| ϕ_b | 0.1 | elasticity of lump-sum taxes to government debt |
| ϕ_g | 0.3 | elasticity of lump-sum taxes to government expenditure |
| τ_W | 0.2 | labor tax rate |
| τ_K | 0.3 | capital tax rate |
| ρ_{oil} | 0.8 | persistence of the oil price shock |

In our simulations, perhaps the most important variable is ω_C , the proportion of rule-of-thumb consumers. Our model nests the standard representative-agent model, where Ricardian equivalence holds ($\omega_C = 0$), the model where the entire population is liquidity constrained ($\omega_C = 1$), as well as other models that allow for heterogeneity in terms of access to credit markets ($0 < \omega_C < 1$), which is consistent with empirical evidence (Campbell and Mankiw (1989), Mankiw (2000)). Reporting our simulation results, we focus particularly on two limiting cases, which correspond to values of $\omega_C = 0.2$ and $\omega_C = 0.8$, to examine how rule-of-thumb behavior changes the mechanisms through which implementation of alternative fiscal policies in response to the shock affect the economy.

The share of government spending in GDP equals 0.18. The response of lump-sum taxes to debt, ϕ_b , is set to 0.1, while the response to government spending, ϕ_g , is equal to 0.3. We set the size of the response of the monetary authority to the output gap, ρ_Y , to 0.5 and to inflation, ρ_π , to 1.5, values commonly used in the empirical Taylor rule.

In this paper we study a *temporary* improvement in the price of oil. We do not examine the impact of productivity shocks and we set the values of the productivity parameters, A_N and A_T , in two sectors equal to unity. In the model, shocks to oil prices are represented by shocks to ε_t , which, we assume, follow an AR(1) process with persistence 0.8, which is close to estimates of the persistence of the terms of trade shock for East Asian countries in Devereux et. al. (2006).

With the benchmark parameters summarized in the Table 1 the model generates an economy that has the following structure in the steady state:

Table 3 Structure of the theoretical economy

| | |
|--|------|
| External assets/GDP | 40% |
| Public debt/GDP | 60% |
| Traded production/GDP | 26% |
| Absorption of traded goods/GDP | 53% |
| Non-traded production/GDP | 48% |
| Oil/GDP | 25% |
| Government expenditure/GDP | 18% |
| Investment in non-traded sector/GDP | 4% |
| Investment in traded sector/GDP | 7% |
| Capital in non-traded sector/GDP | 1.67 |
| Capital in traded sector/GDP | 2.64 |
| Consumption/GDP | 73% |
| Consumption of non-traded goods/GDP | 39% |
| Consumption of traded goods/GDP | 34% |
| Labor income/GDP | 43% |
| Employment in non-traded sector/Total Employment | 78% |
| Employment in traded sector/Total Employment | 22% |

4 Lump-sum taxes

In this paper we analyze two options that the government can follow when faced with an increase in oil revenues. Government has the options of reducing lump-sum taxes and retiring public debt. It is important to note that in both cases taxes levied by the government are lump-sum. So, to analyze the dynamic adjustments triggered by the alternative fiscal strategies, we first need to understand how changes in lump-sum taxes affect decisions by households and we need to look closely at the labor market. Therefore, we first derive the labor supply curve and then discuss its properties for changes in lump-sum taxes.

4.1 Labor supply

In this section we outline the properties of the labor supply curve. First we solve for labor supply and consumption of non-Ricardian consumers as a function of the real wage and lump-sum taxes:

$$\widehat{H}_t^r = \left(\frac{1}{\psi} - \frac{\sigma a_2}{\psi}\right)\widehat{w}_t + \frac{\sigma}{\psi}a_1\frac{Y}{C^r}t_t \quad (4.1)$$

$$\widehat{C}_t^r = a_2\widehat{w}_t - a_1\frac{Y}{C^r}t_t \quad (4.2)$$

where w is real wages and t are lump-sum taxes and parameters value are:

$$a_1 = \frac{1}{1 + (1 - \tau_W)\frac{\sigma}{\psi}\frac{wH^r}{C^r}}; \quad a_2 = \frac{(1 - \tau_W)\frac{wH^r}{C^r}(1 + \frac{1}{\psi})}{1 + (1 - \tau_W)\frac{\sigma}{\psi}\frac{wH^r}{C^r}} \quad (4.3)$$

Note that hours (labor supply) are positively related to the real wage as $1 - \sigma a_2 > 0$, which always holds in the model irrespective of the value of σ .

The labor supply curve is:

$$(1 - \frac{\omega_C H^r}{H} \sigma a_2) \hat{w}_t = \psi \hat{H}_t - \frac{\omega_C H^r}{H} \sigma a_1 \frac{Y}{C^r} t_t + \frac{1 - \omega_C}{H} H^o \sigma \hat{C}_t^o \quad (4.4)$$

The labor supply shifts because of two channels. The first one is ‘wealth effect’, captured by the second term in (4.4) and is generated by lump-sum taxes on non-Ricardian consumers. The smaller the proportion of non-Ricardian consumers (ω_C), the higher labor elasticity (lower ψ) the weaker this effect, given the level of lump-sum taxes t_t . The second channel through which there is a shift in the labor supply comes via the effect on Ricardian consumers (shift in C_t^o), which depends on the following:

1. The persistence of the oil shock. The more persistent the shock, the higher is the present discounted value of the oil windfall, so is the wealth effect, which makes it less likely to get increase in labor supply by Ricardian consumers.

2. Response of monetary policy to inflation ϕ_π in the non-traded sector: a reduction in taxes (lump-sum or distortionary) generates a wealth effect which increases demand. The price of the non-traded goods rises to achieve equilibrium in the domestic markets. This produces inflation in the non-traded sector and an increase in the interest rate by monetary authorities. If the response is strong (that is the increase in the real interest rate is strong as well) then Ricardian consumers prefer to postpone consumption by intertemporal substitution.

3. Price stickiness θ_N : higher price stickiness makes the increase in price and thus in inflation smaller, generating a smaller response of monetary authorities and thus a smaller increase in the real interest rate.

5 Fiscal strategies in dealing with oil boom

In this section, we discuss adjustment dynamics for two alternative fiscal strategies in the face of the oil shock: tax reduction and debt repayment policies. In discussion below we look at the main differences concerning the effects of tax reduction versus debt retirement strategy on adjustment paths of the variables. We also evaluate quantitatively which of these two policies lead to a stronger appreciation of the real exchange rate and how rule-of-thumb behavior affects the dynamic path of the real exchange rate. The reason is that stronger appreciation of the real exchange rate implies bigger incentives for producers to reallocate production from traded to non-traded goods and thus larger need for reallocation of capital across sectors. Thus discussing our simulations results, we focus particularly on the response of the real exchange rate across 4 regimes (2 fiscal strategies \times 2 limiting values of the proportion of the liquidity constrained consumers).

5.1 Reduction in taxes

We first consider the case when government spending is financed by lump-sum taxes only. We assume that the government use oil revenues to cut lump-sum taxes. Figures 1 - 4 illustrate the adjustment dynamics for the reduction in lump-sum taxes when the ratio of liquidity constrained consumers is relatively low, $\omega_C = 0.2$, and when the ratio ω_C is relatively high, $\omega_C = 0.7$.

A reduction in lump-sum taxes affects the labor supply and consumption of households via the wealth effect. Ricardian consumers feel richer by the discounted present value of lump-sum taxes. This boosts consumption by Ricardian consumers. Consumption of non-Ricardian agents also rises due to the wealth effect.

The wealth effect on both Ricardian and non-Ricardian consumers increases demand for both traded and non-traded goods. As demand rises for both types of goods, the relative price of the non-traded goods must increase to restore home-market equilibrium. Such an increase in the price of non-traded goods relative to traded goods results in an increase in the real wage in the non-traded sector and then in the whole economy. Ricardian households are willing to work more because of the increase in the real wage and thus due to an income effect. Moreover, there is also substitution effect for Ricardian consumers, which is governed by ψ , the intertemporal elasticity of substitution in labor supply:

$$\psi(\widehat{H}_t^o - E_t\widehat{H}_{t+1}^o) = (\widehat{w}_t - E_t\widehat{w}_{t+1}) + \widehat{r}_t \quad (5.1)$$

where where real interest rate $r_t = i_t - E_t\pi_{t+1}$ and its linearized version $\widehat{r}_t = \ln[(1 + r_t)/(1 + r)]$. Equation (5.1) implies that if real wages are expected to be higher tomorrow than they are today, Ricardian agents prefer to postpone some work for tomorrow. The intertemporal substitution effect works in the opposite direction of the income effect if the real wage is expected to increase next period. In our case wage growth is expected to be negative, so that income and substitution effects work in the same direction. Moreover, there is also an intertemporal substitution effect of the real interest rate which says that Ricardian households find it optimal to work more today and postpone consumption.

In sum, there are four channels through which a tax reduction affects Ricardian consumers: (i) the wealth effect which tends to reduce the labor supply and increase their consumption today; (ii) the income effect, which increases the labor supply in response to an increase in real wages; (iii) the substitution effect, which has similar effect as the income effect; (iv) the real interest rate effect, which tends to increase labor supply today and postpone consumption today. It could be expected that wealth effect is relatively weak and is dominated by the other three effects. So, the net effect on labor supply by Ricardian consumers is positive on the impact of the shock.

It is obvious that the larger proportion of liquidity constrained consumers, the bigger the initial spending effect and thus a higher appreciation of the real exchange rate and stronger increase in real wages on the impact of the shock. Indeed, a comparison of the short-run reaction of the real exchange rate in figures 1 and 3, illustrates this point, namely the real exchange rate appreciates by almost 0.075 percent in case of $\omega_C = 0.2$, and it appreciates by more than 0.1 percent when $\omega_C = 0.7$.¹⁵

The stronger increase in real wages with a higher proportion of liquidity constrained consumers also means a stronger real interest rate effect, and as discussed earlier, implies that Ricardian households find it optimal to work more today and postpone their consumption. As

¹⁵It is clear that the steady states of the model for different values of the parameter ω_C are different. So, as may be argued quantitative comparison of adjustment dynamics of the variables may not be appropriate here. See the discussion section below on this point.

is seen in figures 1 and 3, consumption of Ricardian consumers falls in the short-run when the major part of the population is liquidity constrained, while it rises if the proportion of rule-of-thumb consumers is low ($\omega_C = 0.2$). Thus non-Ricardian agents' consumption *crowd outs* the consumption of the Ricardian households.

In summary, in this section we have shown that in an economy where the higher proportion of the economic agents are liquidity constrained, a reduction in lump-sum taxes, which can be undertaken with purpose of helping poor people, is simply spent away. This triggers real exchange rate appreciation, which is stronger the higher proportion of liquidity constrained consumers that induces the bigger immediate spending effect. The higher level of spending, the more capital accumulation is needed in the non-traded sector; the more capital is dismantled in the traded sector. Thus, the government fails to correct for the myopic behavior of non-Ricardian consumers by simply reducing lump-sum taxes¹⁶.

5.2 Debt retirement

In this section we consider the case where the government uses the increased oil revenues to retire public debt. We start by analyzing the dynamic adjustment to the shock when the ratio of Ricardian consumers in the economy is relatively small ($\omega_C = 0.2$). Figures 5 and 6 illustrate dynamic adjustments in that case.

In the short-run we have the conventional story of a reaction to the positive demand shock. In particular, as Ricardian consumers anticipate debt repayment in the subsequent periods, and thus a further reduction in debt servicing costs, that is a reduction in taxes, they demand more traded and non-traded goods. Excess demand for goods increases the relative price of the non-traded goods to restore equilibrium on the domestic market. A rise in the relative price of non-traded goods, which increases demand for labor in the non-traded sector, triggers an increase in employment in the non-traded sector and a decline in the traded sector.

An increase in the real wage in the economy also raises the income of non-Ricardian agents and thus their spending in the short-run.

The trade balance responds positively to the oil shock. The current account follows a similar behavior in the short-run where there are no changes in the stock of foreign assets and thus in interest rate payments.

Dynamic adjustment

Throughout the adjustment period, Ricardian consumers start replacing some retired domestic bonds by foreign assets. However, there is not one-to-one replacement of domestic bonds by the foreign ones, so financial wealth starts declining, and Ricardian households channel some of the retired funds to other assets in the economy, in particular in capital formation in both sectors of the economy.

In subsequent periods, according to (2.58) debt retirement is accompanied by a decline in lump-sum taxes which increases the disposable income of non-Ricardian agents. Given that they are not forward-looking agents, so at the beginning of the first period they are not anticipating

¹⁶It is necessary to note that this outcome is equivalent to the one obtained in the case where oil is appropriated by the private sector and divided evenly across the whole population.

favorable developments in their disposable income induced by debt repayment in the future, their consumption and spending adjustment paths mirror the path of lump-sum taxes and thus follow a hump-shaped response. Consequently, wages, employment and output of both sectors also follow the similar hump-shaped response to the shock.

The trade balance is in surplus throughout the adjustment period. Positive adjustment of the stock of foreign assets towards long-run equilibrium generates an interest rate payments surplus, which requires a current account surplus throughout the long-run value. It also reflects the fact that the real exchange rate appreciates on impact of the shock and continues to appreciate over time at a decreasing rate.

Now we turn to the analysis of the dynamic adjustment of the model to the shock when there is a high proportion of liquidity constrained consumers in the economy ($\omega_C = 0.7$). The relevant figures now are 7 and 8. The oil price shock gives rise to virtually the same dynamic adjustment as before, more substantive differences arise in the short-run reaction of the economy. Specifically, consumption by non-Ricardian consumers and the wage rate declines on the impact of the shock. Second, employment in the traded sector rises, while employment in the non-traded sector declines in the short-run in contrast to what was observed before. Third, the real exchange rate reaction is hump-shaped in contrast to a smooth reaction in the previous case. The reasons for such different adjustment of the variables can be seen as follows.

As before, a decline in lump-sum taxes in the short-run raises the disposable income of households, including non-Ricardian ones, creating excess demand for goods. As demand rises for both types of goods, the relative price of the non-traded goods must increase to restore home-market equilibrium. Now, two factors are at work, which trigger the decline in the production of non-traded goods in the short-run. First, an important characteristic of non-Ricardian consumers is that they do not substitute consumption intertemporally between periods, and thus they make only intratemporal decisions concerning consumption of the non-traded and traded goods. Their decision regarding the distribution of consumption between two types of goods is clearly affected by the relative price of the goods. Second, the initial rise in income of non-Ricardian households is not so sizable to increase their purchasing power large enough to enable them to purchase more expensive non-traded goods. For comparison, when the government follows a tax reduction strategy, lump-sum taxes are cut by almost 0.2 percent, as we can see from figure 4. While a public debt consolidation strategy implies a less than 0.025 percent reduction in taxes in the short-run. Thus, a marked increase in the relative price of the non-traded goods eliminates the demand for those goods from rule-of-thumb consumers' side. Given that liquidity constrained households represent the major part of the whole population, this leads to a decline in demand for output of non-traded goods and thus labor in that sector in the short-run, pulling down the economy-wide wage rate. This explains why non-traded goods production and wage rate fall on impact of the shock.

According to (4.2), a decline in real wages moves consumption of non-Ricardian consumers in the opposite direction of the tax cuts, and the net effect on the consumption of rule-of-thumb consumers is negative in the short-run if the first effect dominates. Such a sizable decline in consumption of constrained households is observed for very high levels of ω_C (e.g., 0.9, not reported here). For intermediate values of ω_C (from around 0.2 to roughly 0.8) these effects

largely offset each other, leading to a slight consumption response on the impact of the shock.

A decline in an employment in the non-traded sector together with reduction in wages results in reduction in (real) marginal costs of production of the non-traded goods. As in the non-traded sector, prices are sticky and output is demand-determined, the firms produce output as long as their prices are above marginal costs. As real marginal costs decline on the impact of the shock, firms that are able to reset their prices find it profitable to set a price below the average price of the previous period, which causes a decrease in the price of the non-traded good and thus deflation in that sector. The dynamics of inflation and the output gap are mirrored in the behavior of the interest rate, which declines on the impact of the shock and remains negative throughout the adjustment period.

Another important difference between dynamic adjustments of the model for different values of ω_C lies in the behavior of the real exchange rate, which is hump-shaped when the proportion of liquidity constrained consumers is high; this response is not observed for small values of ω_C , when the real exchange rate path is smooth. The intuition behind this is as follows. On the one hand, a real exchange rate appreciation reflects an increase in demand for both types of goods, which is maintained throughout the adjustment period to achieve domestic goods market equilibrium. On the other hand, a public debt consolidation strategy implies, after an initial slight change in lump-sum taxes, a gradual decline in taxes in subsequent periods. As a result, forward-looking consumers who anticipate that decline have an incentive to smooth and increase their consumption today. Hence, in the economy with a higher proportion of liquidity constrained consumers the real exchange rate tends to follow a hump-shaped adjustment path, which corresponds to strong domestic demand and an inability of most of the population to smooth consumption.

5.3 Discussion

Summarizing our discussion of adjustment dynamics for two alternative fiscal strategies in face of the oil shock, we first summarize the main mechanism through which implementation of fiscal options affect the economy. First, the fiscal strategy based on cutting lump-sum taxes (or increasing lump-sum transfers) operates mainly through the effect on the wealth of households and via responses of labor supply and consumption. Specifically, the increase in lump-sum transfers *directly* affects the disposable income of liquidity constrained agents and thus generates a sizable direct effect. This effect is stronger the larger the ratio of rule-of-thumb consumers. The effect on Ricardian consumers is more muted as they anticipate future favorable changes in disposable income and increase their spending by the present discounted value of all current and future transfers.

In contrast to the first option, the second fiscal strategy affects macroeconomic outcomes mainly by affecting Ricardian consumers via changes in their financial wealth and both types of households via debt elimination, thereby *indirectly* via changes in their disposable income.

These mechanisms through which implementation of fiscal policies in response to the shock are transmitted to the economy, have an important consequence for the dynamic paths of the variables. In particular, comparing adjustment dynamics triggered by the alternative fiscal policies, it is important to point out the differences in the response of the real exchange rate.

The size of the initial appreciation of the real exchange rate is unambiguously lower in the case of the debt-retirement strategy compared with what happens if the government follows a tax reduction strategy. Moreover, further appreciation of the real exchange rate reflected in the hump-shaped pattern of behavior in the case of debt consolidation policy still does not match the appreciation observed in the case of a tax cut strategy. Overall, these results depend on the share of liquidity constrained consumers in the economy. Specifically, as expected, hump-shaped behavior of the real exchange rate becomes smoother the lower the ratio of rule-of-thumb consumers. Secondly, there is no a marked distinction in reaction of the real exchange rate across fiscal strategies in an economy where unconstrained households represent most of the population. These results are not surprising, as a lower proportion of liquidity constrained consumers, that is a bigger share of Ricardian agents in an economy implies that no matter how a government chooses to manage additional oil revenues, whether with debt repayment or lump-sum tax cuts, the outcome will be almost indifferent.

6 Conclusion

In this paper we examine the adjustment mechanisms triggered by alternative fiscal policies which can be implemented by the government in the face of an oil price shock. We assume that oil is appropriated by the government and study tax reduction and debt retirement policies that are implemented by means of fiscal feedback rules. The purpose is to evaluate quantitatively which of these fiscal policies can moderate the Dutch disease effect caused by the real exchange rate appreciation on impact of the shock. As we demonstrate fiscal policy can play its role in limiting a disruptive exchange rate appreciation. However, the ability of fiscal policy to contribute to stabilization of the economy to the shock depends on the underlying fiscal policy regime. The proportion of liquidity constrained consumers also matter in this respect: a higher proportion of myopic consumers makes the distinction between the effects of alternative fiscal policies on the behavior of the real exchange rate more sizable.

If, for instance, fiscal authorities use oil revenues to lower lump-sum taxes, then they allow oil revenues to fuel primarily a consumption boom and do not prevent the oil boom from having an over-expansionary effect on the economy. It is necessary to note that this outcome is equivalent to the situation when oil is appropriated by the private sector and divided evenly across the whole population.

If, instead the government decides to retire public debt, then it could help to mitigate the boom by limiting appreciation of the real exchange rate. The downside of such a fiscal strategy, however, is that the real exchange rate behavior is sluggish and hump-shaped. Hence, even though our results show that a debt-retirement policy is favorable to the lump-sum tax reduction strategy in terms of moderating the Dutch disease effect of an oil boom, overall, our set-up does not allow us to evaluate the merits of various fiscal policy strategies in the face of such a shock. Such analysis requires welfare analysis when various fiscal adjustment costs are weighted against other objectives of the fiscal policy. This is a direction where future research should be developed.

Finally, it is necessary to note that while this paper deals with issues of neutralizing the

short-term effects of oil price fluctuations, the oil management issue is beyond the scope of this paper. Thus, this paper does not consider other potential stabilization mechanisms discussed in the literature, in particular stabilization funds and accumulation of foreign assets by the government. A broader discussion on this aspect can be taken up in future research.

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7 Appendix

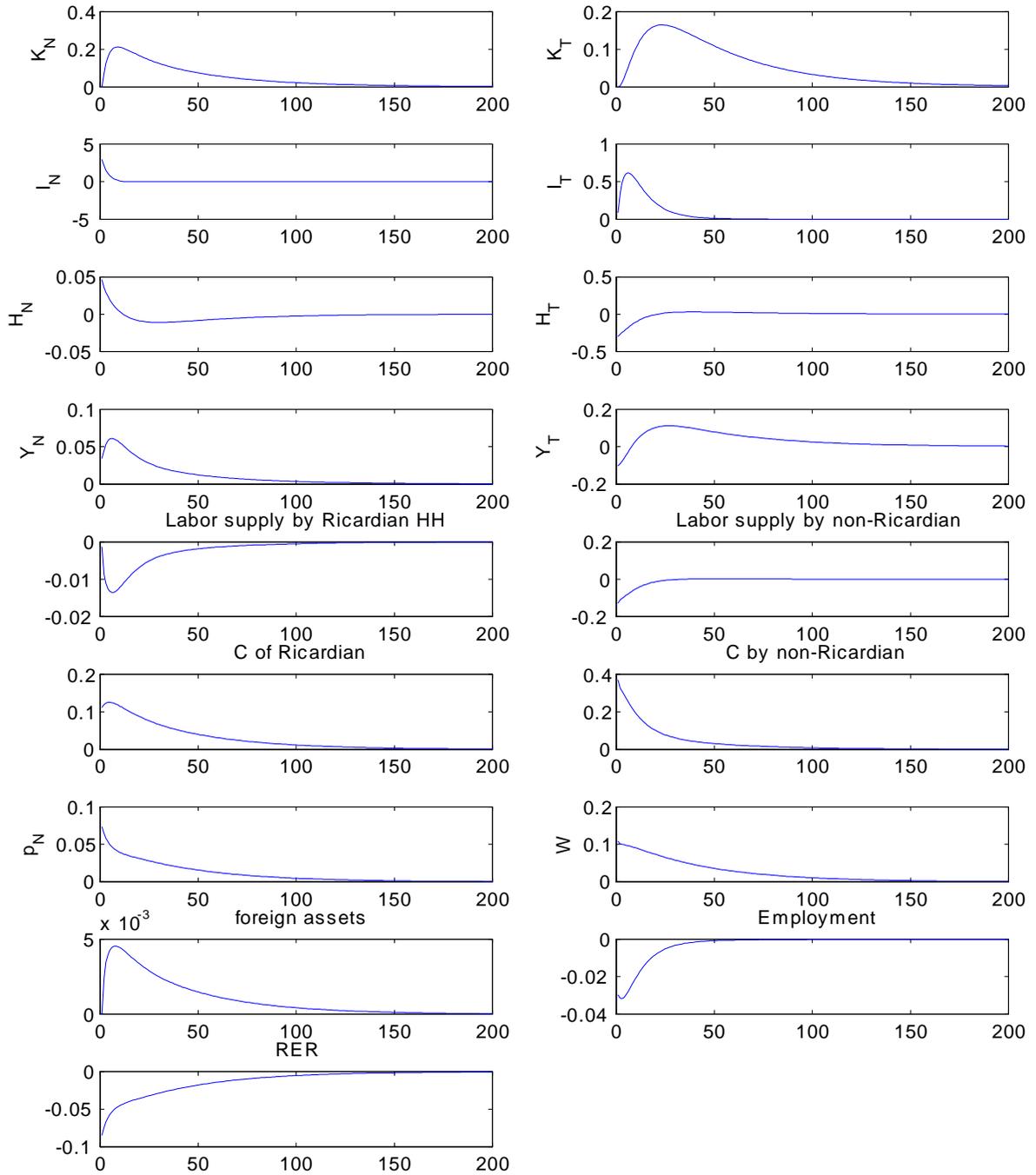


Figure 1: $\omega_C = 0.2$, tax reduction strategy

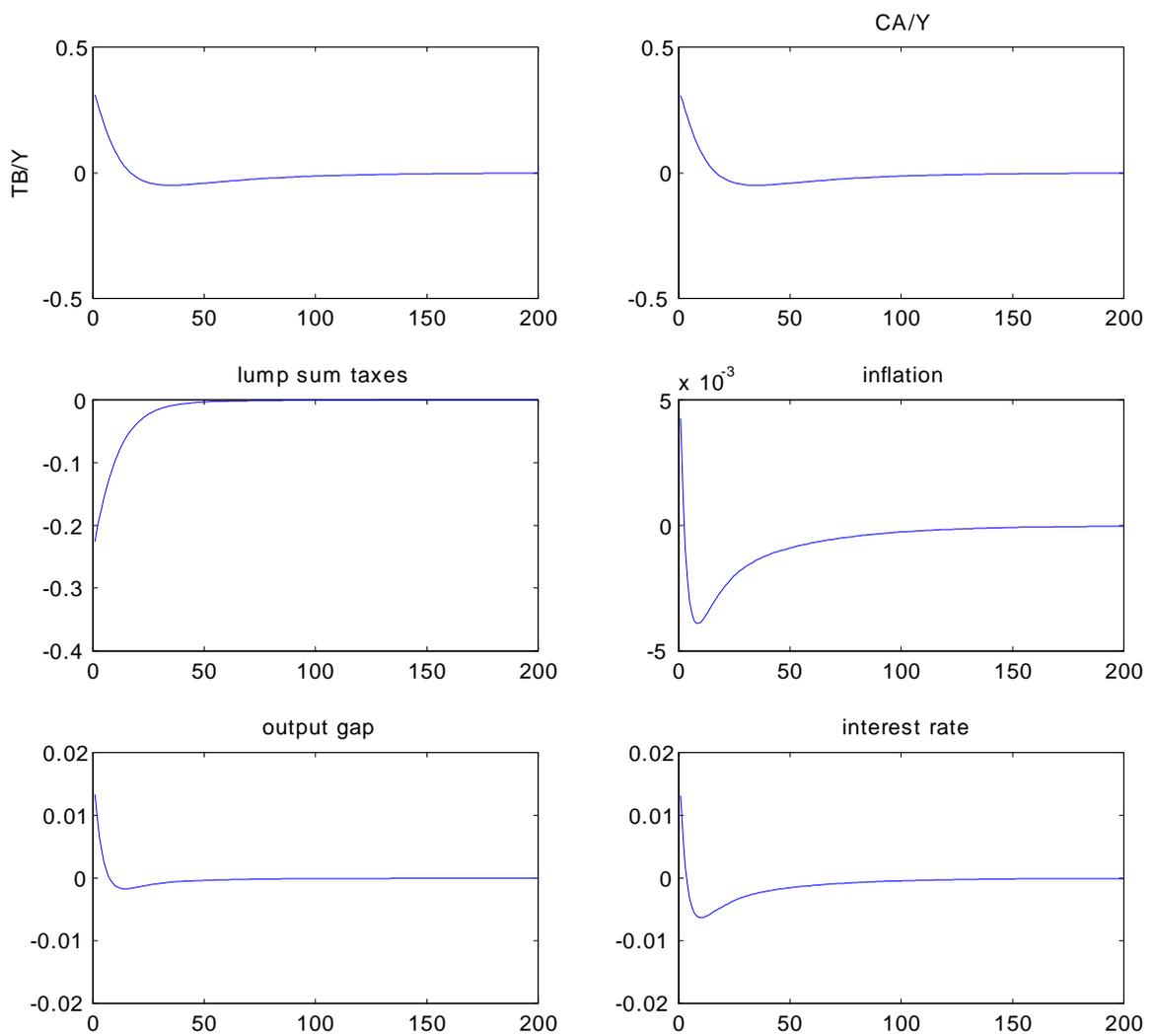


Figure 2: $\omega_C = 0.2$, tax reduction strategy

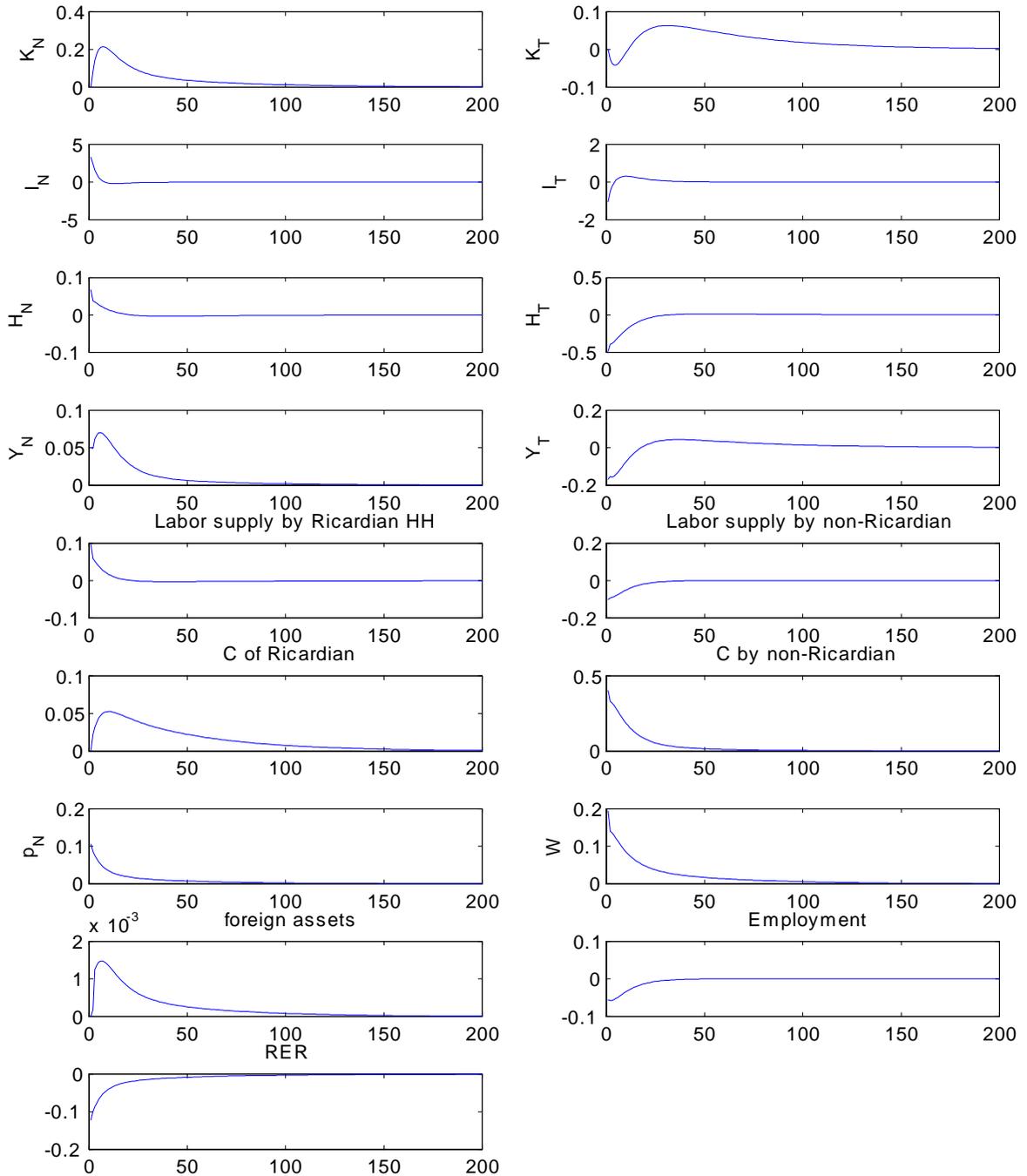


Figure 3: $\omega_C = 0.7$, tax reduction strategy

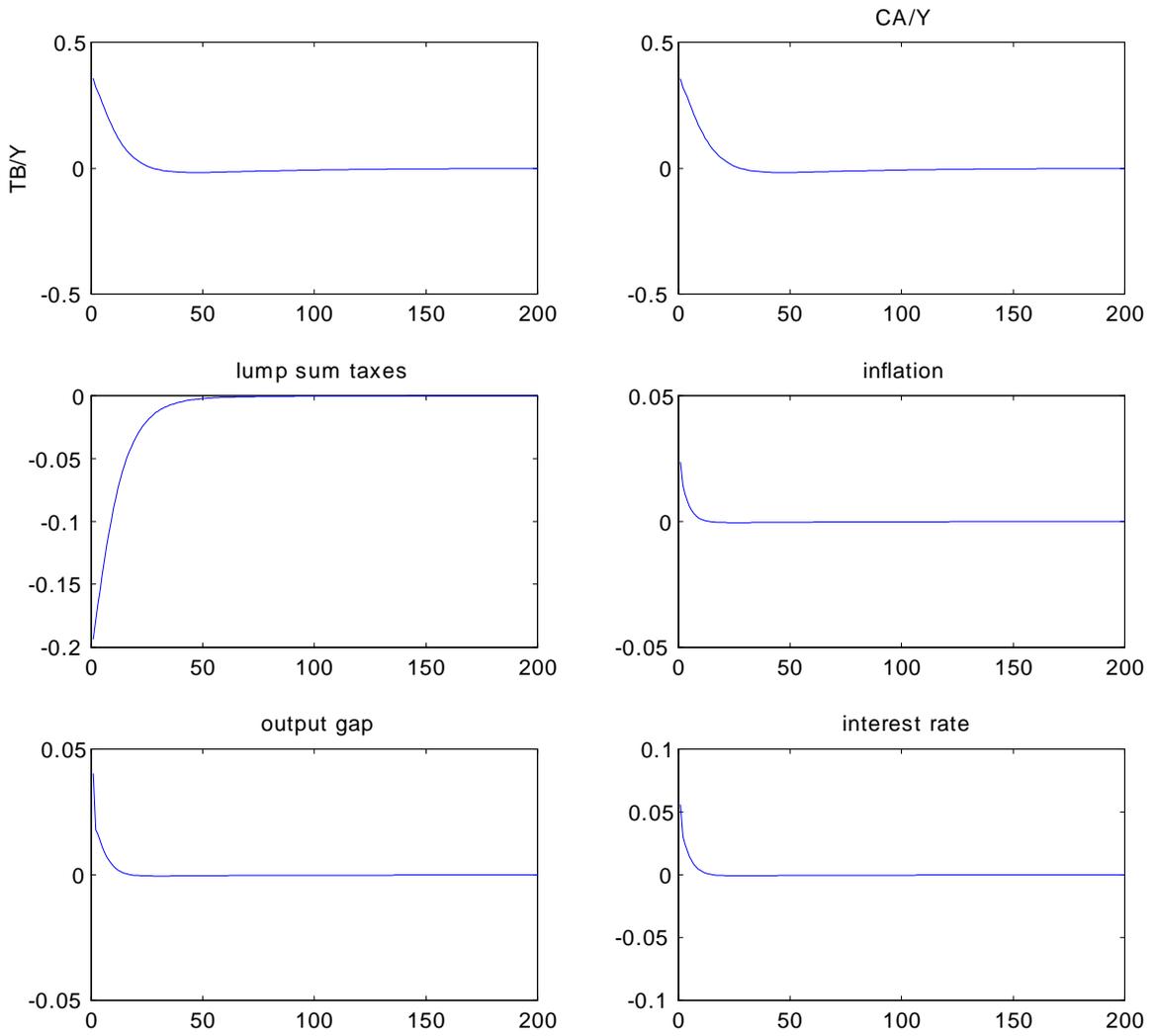


Figure 4: $\omega_C = 0.7$, tax reduction strategy

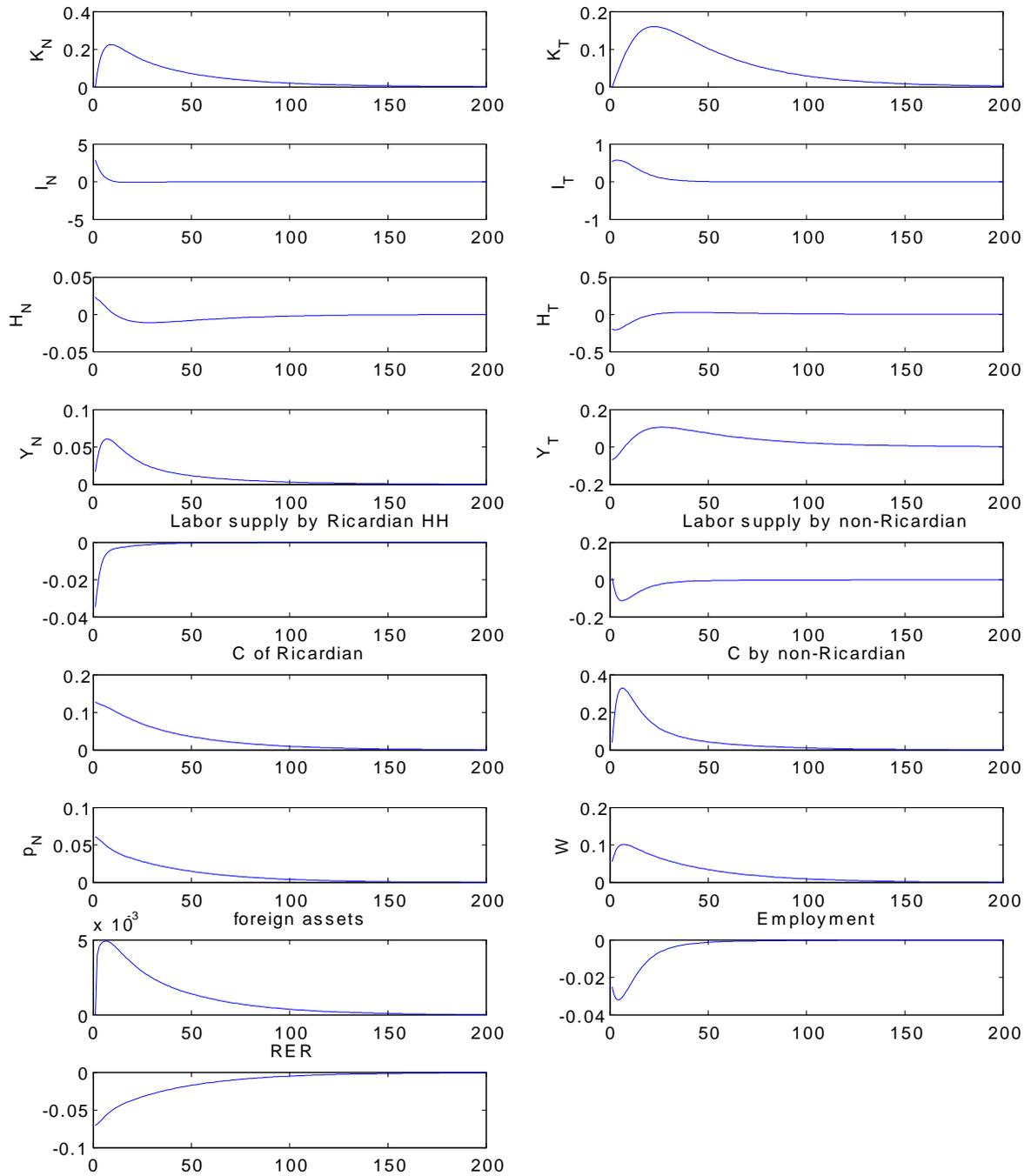


Figure 5: $\omega_C = 0.2$, debt retirement policy

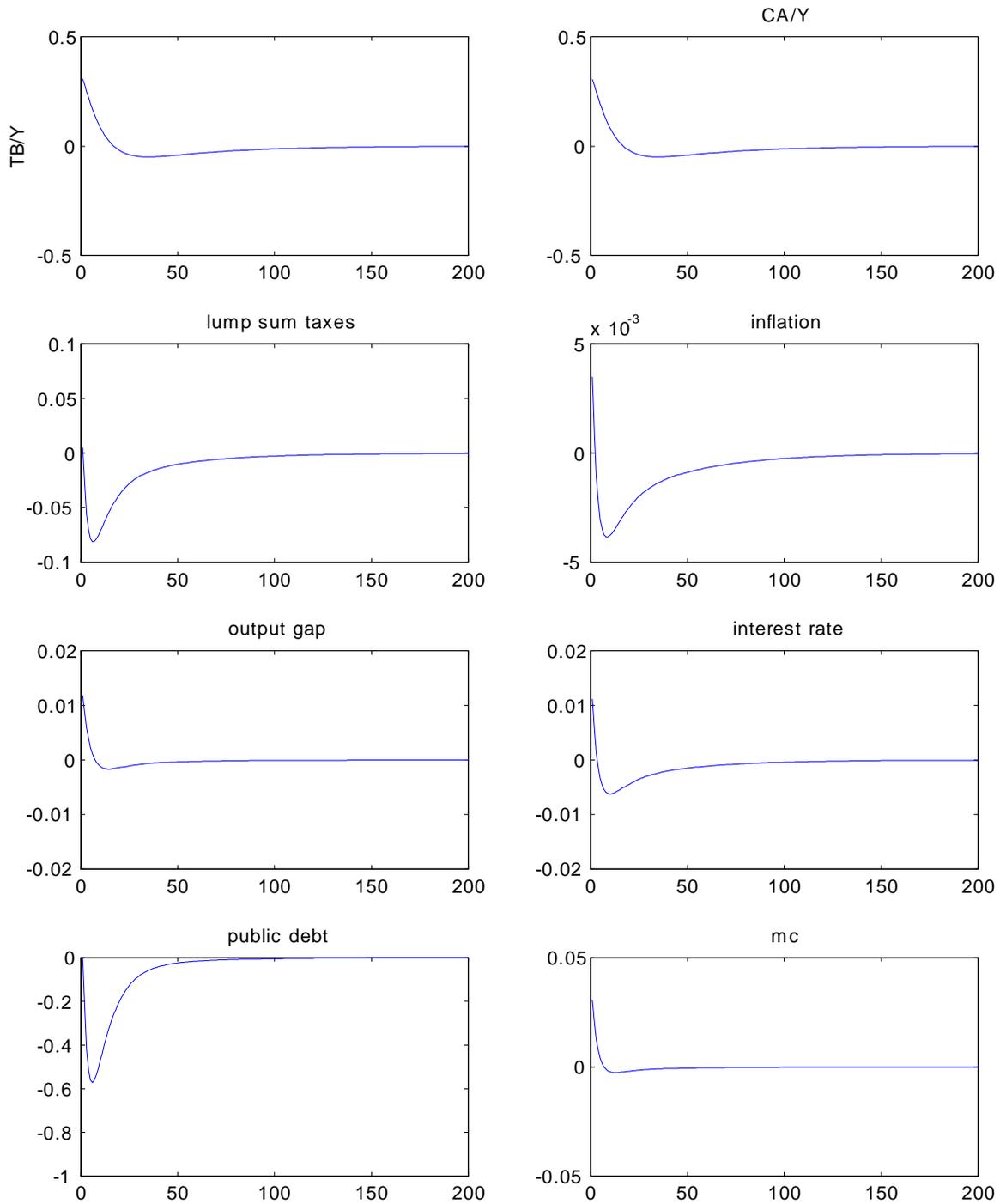


Figure 6: $\omega_C = 0.2$, debt retirement policy

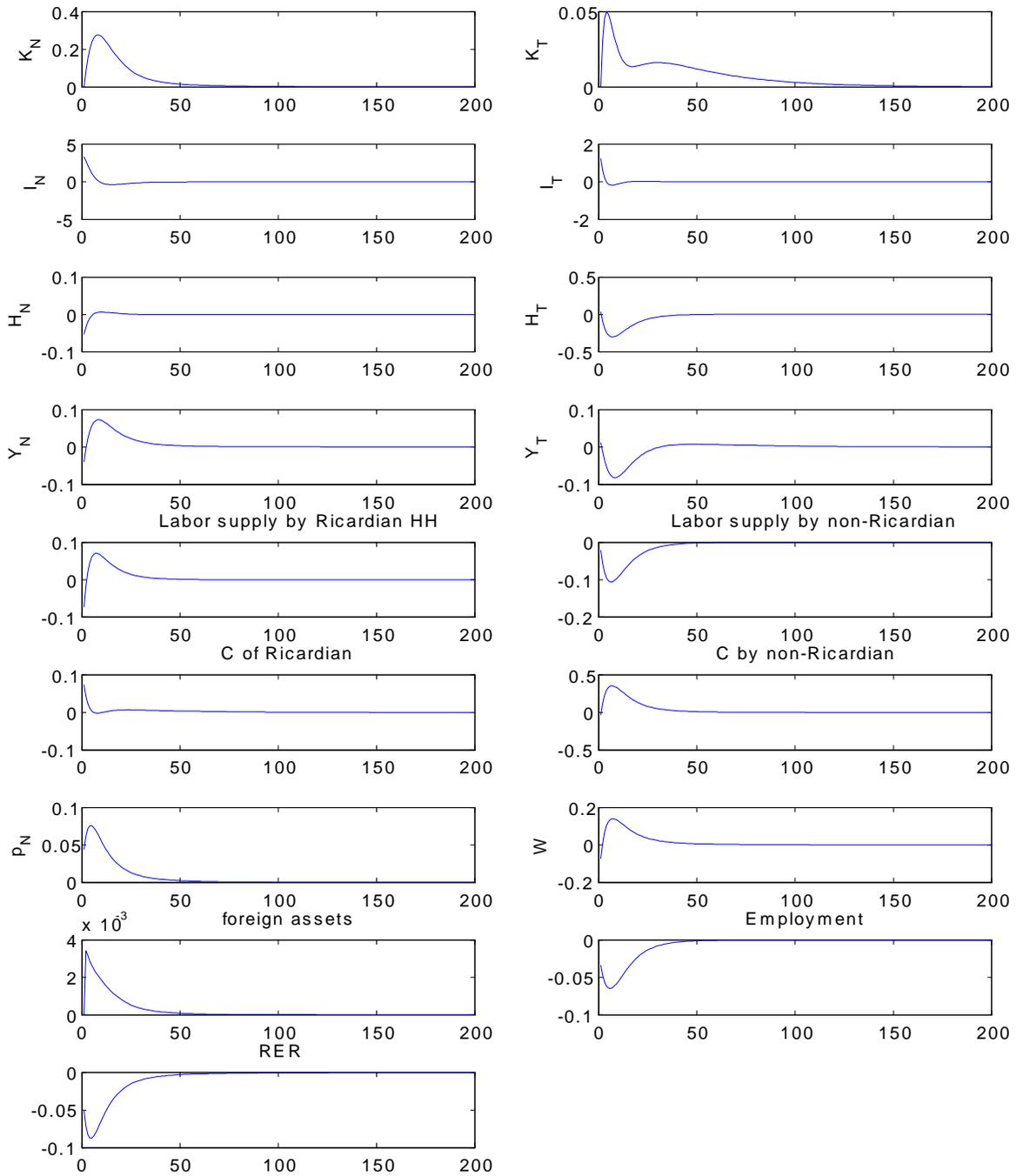


Figure 7: $\omega_C = 0.7$, debt retirement policy

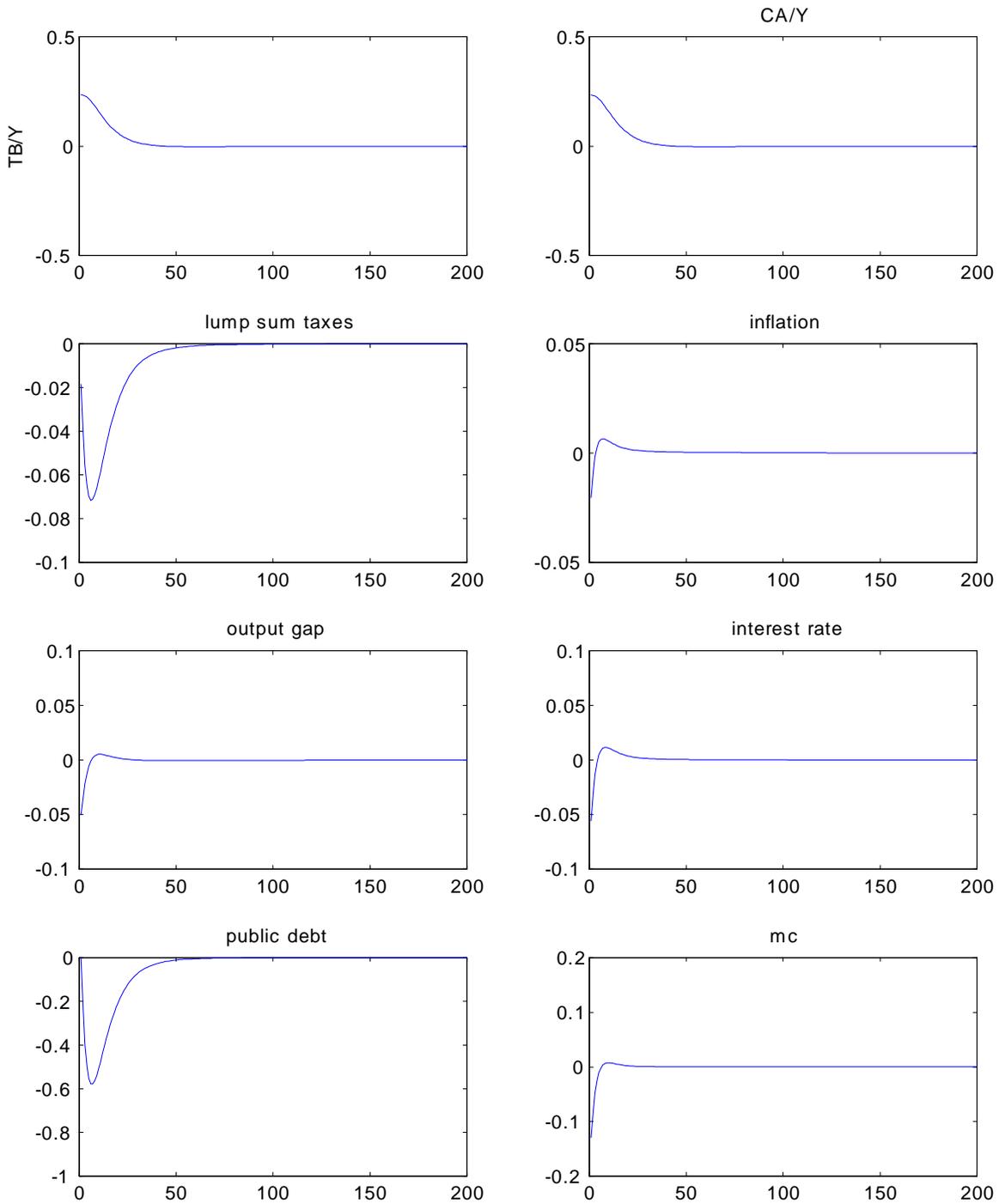


Figure 8: $\omega_C = 0.7$, debt retirement policy