Fiscal Policy in an Open Economy

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Abstract

This paper addresses the macroeconomic implications of a fiscal policy regime based on exogenous tax rates paths and public debt/GDP target in an open economy. In this setup, government spending accommodates tax revenues and target deficits. The analysis is motivated by the Israeli fiscal policy experience during the 2000s. We use a model where domestic production requires imported inputs. The model is calibrated and the effects of pre-announced tax cuts, and adoption of a lower debt target, are simulated. The analysis focuses on the dynamics generated by the announcements of these policy shifts followed by their implementation. The open-economy setup has the property that demand shifts—as government spending being cut to comply with a lower tax rate or lower debt target—have macroeconomic effects which are similar to those of productivity shocks.

1. Introduction

This paper addresses the macroeconomic implications of fiscal policy in a small-open economy when this policy is characterized by (a) an exogenous path of tax rates, generated for example by international tax competition, and (b) a public debt/output target, motivated by guidelines as the 60 percent Maastricht benchmark. Government spending should then accommodate the tax rates and the debt target. The paper focuses on the interaction of this fiscal setup and the open nature of an economy. In the following paragraphs we elaborate first on the fiscal policy setup, then on the implications of the open nature of the economy, and then on the interaction of these two elements.

The analysis in this paper focuses on the effects of exogenous changes in the tax rates paths and the public debt target. Note that this fiscal setup reverses the role of tax rates, government spending and public debt, relative to the usual setup as in Barro's (1979) classic treatment of tax rates and public debt determination. In that framework, government spending fluctuates exogenously, whereas the tax rates and the public debt are determined endogenously.

An example of the present fiscal setup seems to be the fiscal policy conducted in Israel during the 2000s. In 2003, the government announced a multi-year tax-cut program as well as a commitment to reduce the debt to GDP ratio. Between the years 2003 and 2008, the tax-cut program had been fully implemented, and the debt to GDP ratio decreased from 100 to 76 percent. Accordingly, government consumption dropped from 28 percent of GDP in 2003 to 24 percent in 2008. In December 2009, in spite of the world economic crisis, the government renewed its commitment to cut tax rates and to further reduce the public debt/GDP ratio to 60 percent—the Maastricht benchmark—within a decade.

Compared to a closed economy, the open nature of the economy has distinct implications for the transmission mechanism of demand changes—as private consumption reacting to a tax change or government spending reacting to a tougher debt target. In the typical closed-economy macroeconomic model, a demand shock raises the interest rate, which in turn induces higher work effort and output by making current leisure more expensive.

First, the transmission mechanism of demand changes in the present model is affected by the degree of international capital mobility. In the benchmark case of perfect capital markets, the interest rate is constant from abroad, so that the expansionary effect via labor supply cannot take place. Imperfect capital mobility brings back some of the interest rate effect depending on the severity of the imperfection. Second, regardless of capital mobility, the present model incorporates an additional mechanism. Given that domestic production uses imported inputs, an increase in the demand for domestic output reduces the relative price of imports in terms of the domestic good—a "real appreciation". The resulting boost to imported inputs works similarly as the typical productivity shock in the standard real business cycle model by increasing the marginal productivity of labor.

There is an important interaction between exogenous changes in tax rates or in public debt targets and the open-economy nature of the model: Changes in tax rates or public debt targets necessitate government spending adjustment. This change in government demand affects macroeconomic activity as described above.

To illustrate this interaction, assume a predicted lump-sum tax cut. Realistically, tax changes are predicted in advance either from announcements or from public discussion and formal steps leading to the change. The announcement and later the implementation of the tax cut generate a cycle in economic activity. First, the prediction of a future tax cut has a positive wealth effect on private consumption. As mentioned above, such increase in demand causes an appreciation which triggers higher imported inputs, labor input, and output. Subsequently, when the tax cut is implemented, the fiscal rule dictates a reduction in government spending which amounts to an opposite change in demand. Hence, the initial expansion is followed by a contraction. Of course, this is a stylized example. The type of cycle generated by a policy shift depends on the nature of the policy. If the tax being cut in the previous illustration is not lump sum but a tax rate on labor income, for example, the expansionary effects of the anticipation remain similar, but the contractionary impact of reducing government spending when the tax rate is actually cut is combined with the expansion of labor supply. Hence, if the latter effect is sufficiently stronger than the contractionary effect of reducing government spending, the initial expansion is followed by an additional expansion.

The paper proceeds as follows. The model is presented in Section 2 and Section 3 reports the model's calibration. The macroeconomic analysis of the fiscal policy changes is presented in Section 4 using impulse responses. Section 5 concludes.

2. The Model

The model has the basic features of the small-open economy framework: Identical households and firms—owned by the domestic households—perform dynamic optimization within a competitive environment. The economy is open to the world capital markets, but there is a friction associated with financial transactions. Capital and goods are mobile internationally, but labor is not.

The main additional feature to the basic open-economy framework is that production requires an imported input. Hence, the production function includes three factors: Capital, labor, and imports. All imports are treated as intermediate products, as their use requires domestic value added. The productive role of imports implies that the resulting aggregate supply function is decreasing in the relative price of imports.

Aggregate demand includes private and public consumption, investment and exports. The economy's output does not have a perfect substitute abroad. The world demand for the economy's exports is an increasing function of the price of an imperfect foreign substitute relative to domestic output. We assume that the price of that substitute relative to imports—two foreign goods—is exogenous. Therefore, given that exogenous relative price, the foreign demand for exports is an increasing function of the relative price of imports. This relative price coincides with the terms of trade because the economy exports domestic output.

The relative price of imports is determined so as to clear the goods market: It equates the aggregate demand to the aggregate supply of domestic output. This equilibrium concept is based on Bruno and Sachs (1985). In this model, the current account is balanced only in the long run.

Agents in the economy can borrow or save abroad at the interest rate $\bar{r}$. However, financial transactions involve a friction adopted from Schmitt-Grohe and Uribe (2003): Deviations of the private sector assets F_t at time t from an exogenous level F^* involve a cost. We define below the effective domestic interest rate r_t, which includes the marginal financial cost. Only the government is free of this friction.

The introduction of this feature has the important technical implication that the model possesses a steady state, which greatly facilitates the computational solution. Additionally, the financial friction generates realistic deviations of durable and nondurable consumption from permanent income behavior.

2.1. Production

In period t, the representative firm produces output Q_t according to the Cobb-Douglas technology

$$Q_t = Y_t^{\gamma} M_t^{1-\gamma}, \qquad 0 < \gamma < 1, \tag{2.1}$$

where Y_t is domestic value added in period t and M_t is imports of intermediate products. All imports are treated as intermediate inputs in the production of domestic output. This treatment of imports is supported by the following observations from the Israeli economy: This treatment of imports is supported by the following observations from the Israeli economy: Raw materials for production account for about 50 percent of goods imports, and market prices of the remaining imports—investment and consumption goods—include a large domestic value added share composed of importers' services, domestic transportation and taxation.

In this setup, the degree of openness of the economy, as measured by the ratio of imports to GDP, equals $1 - \gamma$; hence, openness in this model is dictated by technology.

Value added, or GDP, is produced with capital, K, and labor input, L:

$$Y_t = K_t^{\alpha} L_t^{1-\alpha}, \qquad 0 < \alpha < 1. \tag{2.2}$$

We ignore technological progress, given our focus on fiscal policy effects.

Substituting (2.2) into (2.1), we get

$$Q_t = K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma} M_t^{1-\gamma}. \tag{2.3}$$

The capital stock evolves according to

$$K_{t+1} = K_t(1 - \delta^k) + I_t, \quad 0 < \delta^k < 1, \tag{2.4}$$

where I_t is gross investment and δ^k is the depreciation rate of capital.

Changing the capital stock involves adjustment costs of the form

$$J_t^k = \frac{\omega^k}{2} \left(K_{t+1} - K_t\right)^2, \quad \omega^k > 0. \tag{2.5}$$

The firm takes prices as given. In terms of domestic output, these prices are the wage, W_t, and the price of imports P_t^m.

2.2. The Firm's Optimization Problem

The after-tax dividend paid by the firm to the shareholders in period t is

$$\Pi_t = (1 - \tau_t^c) \left[K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma} M_t^{1-\gamma} - W_t L_t - P_t^m M_t\right] - J_t^k - I_t, \tag{2.6}$$

where τ_t^c is the corporate tax rate. We assume for simplicity that the depreciation of the capital stock and it's adjustment cost are not tax deductible. We also assume that firms are fully owned by the domestic households.

Note that investment is fully financed by reducing dividends—which could become negative. In other words, investment is financed by borrowing from share holders. Given the effective interest rate is the same for both firms and households, it is unsubstantial whether the firms or the households do the borrowing.

The firm maximizes the sum of discounted dividends

$$\Pi_t + \frac{\Pi_{t+1}}{1+r_t} + \frac{\Pi_{t+2}}{(1+r_t)(1+r_{t+1})} + ...,$$

where r_t is the effective domestic real interest rate in period t, which is defined later on.

The first-order conditions are:

$$1 + \omega^k (K_{t+1} - K_t) = \frac{1}{1+r_t} \left[\begin{array}{c} \left(1-\tau_{t+1}^c\right) \alpha\gamma K_{t+1}^{\alpha\gamma-1} L_{t+1}^{(1-\alpha)\gamma} M_{t+1}^{1-\gamma} + \\ 1 - \delta^k + \omega^k (K_{t+2} - K_{t+1}) \end{array} \right], \tag{2.7}$$

$$W_t = (1-\alpha)\gamma K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma-1} M_t^{1-\gamma}, \tag{2.8}$$

$$P_t^m = (1-\gamma) K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma} M_t^{-\gamma}. \tag{2.9}$$

In the absence of adjustment costs, (2.7) reduces to the familiar equality

$$\left(1-\tau_{t+1}^c\right) \alpha\gamma K_{t+1}^{\alpha\gamma-1} L_{t+1}^{(1-\alpha)\gamma} M_{t+1}^{1-\gamma} = r_t + \delta^k,$$

between the after-tax marginal productivity of capital and it's marginal cost, and (2.8), (2.9) equate the marginal productivities of labor and intermediate inputs to their relative prices. Solving these two equations for L_t and M_t yields the demands for these two inputs as functions of the prices:

$$L_t = \vartheta^l K_t (W_t)^{-\frac{1}{\alpha}} (P_t^m)^{-\frac{(1-\gamma)}{\alpha\gamma}}, \tag{2.10}$$

$$M_t = \vartheta^m K_t (W_t)^{-\frac{1-\alpha}{\alpha}} (P_t^m)^{-\frac{1-\gamma(1-\alpha)}{\alpha\gamma}}, \tag{2.11}$$

where $\vartheta^l = [(1-\alpha)\gamma]^{\frac{1}{\alpha\gamma}} \left(\frac{1-\gamma}{(1-\alpha)\gamma}\right)^{\frac{1-\gamma}{\alpha\gamma}}$, $\vartheta^m = [(1-\alpha)\gamma]^{\frac{1}{\alpha\gamma}} \left(\frac{1-\gamma}{(1-\alpha)\gamma}\right)^{\frac{1-\gamma(1-\alpha)}{\alpha\gamma}}$. A key property of these demand functions is the negative effects of the relative price of imported goods.

2.3. Preferences and Household's Constraints

The household consumes nondurable consumption goods, C_t^n, services from a durable goods stock, D_t, and supplies labor, L_t. An aggregate consumption good is defined as $C_t = (C_t^n)^{1-\theta} D_t^{\theta}, \ \ 0 < \theta < 1$.

Preferences of the representative household are of the form proposed by Jaimovich-Rebelo (2009), extended to include durable goods:

$$\sum_{t=0}^{\infty} \beta^t \frac{(C_t - \psi L_t^{\varphi} Z_t)^{1-\sigma}}{1-\sigma}, \quad 0 < \beta < 1, \quad \varphi > 1, \quad \psi > 0, \quad \sigma > 0, \tag{2.12}$$

$$C_t = (C_t^n)^{1-\theta} D_t^{\theta}, \quad 0 < \theta < 1,$$

$$Z_t = C_t^{\xi} Z_{t-1}^{1-\xi}, \quad 0 \leq \xi \leq 1. \tag{2.13}$$

In this formulation, the parameter ξ in the equation for Z_t captures the strength of the income effect on labor supply: When $\xi = 1$, $Z_t = C_t$, and then this utility function corresponds to the standard King, Plosser and Rebelo (1988) form, i.e., with full income effect. The other extreme is when $\xi = 0$, where there is no income effect.

A property of this utility function is that as long as $\xi > 0$, regardless of how small it is, in the long run $Z_t = Z_{t-1} = C_t$. Hence, although the wealth effect on labor supply can be small in the short run, there is a full income effect in the long-run. The motivation for adopting this utility function is similar as in Jaimovich and Rebelo: To deal with anticipation effects on labor supply in a quantitatively realistic manner. Because changes in tax rates are in general announced in advance, the expectation of a future tax cut can be consistent with a small wealth effect—i.e., this expectation does not cause a large immediate decline in output. Over time, however, the wealth effect builds up.

Similarly as for productive capital, changes in the stock of durable goods involve adjustment costs of the form

$$J_t^d = \frac{\omega^d}{2} (D_{t+1} - D_t)^2 . \tag{2.14}$$

Households can borrow or save at the international interest rate $\bar{r}$, but, deviating from a target level of assets involves a cost. Let us denote net financial assets at the beginning of period t with F_t, and the exogenous target with F^*. The cost J_t^f of being away from target is

$$J_t^f = \frac{\omega^f}{2} \left(F_{t+1} - F^*\right)^2, \; \omega^f > 0, \tag{2.15}$$

adopted from Schmitt-Grohe and Uribe (2003) as a way to provide a steady state to the model. This formulation also produces realistic deviations from permanent income behavior: Excess sensitivity to temporary income changes, as in Flavin (1985), and excess smoothness to permanent income changes, as in Deaton (1987). We return below to these implications.

The introduction of financial costs generates deviations of the domestic effective interest rate, r_t, which includes the marginal financial costs, from the world interest rate $\bar{r}$. Included in F are foreign assets only. We assume that the government issues it's debt abroad and ownership of firms is already captured by the dividends Π_t.

The household receives income from labor, dividends and transfers from the government, T_t. For the household, the relevant tax rates are: τ_t^l on labor income, τ_t^n on nondurable consumption, and τ_t^d on durable purchases. We assume for simplicity that dividends are not taxed. Hence, τ^c reflects all capital income taxation. The one-period household's budget constraint is given by

$$(1 + \tau_t^n)\, C_t^n + \left(1 + \tau_t^d\right) C_t^d + J_t^d = (1-\tau_t^l) W_t L_t + \Pi_t + T_t + (1+\bar{r}) F_t - F_{t+1} - J_t^f, \tag{2.16}$$

where

$$C_t^d = D_{t+1} - \left(1 - \delta^d\right) D_t \tag{2.17}$$

is purchases of durable goods, and $0 < \delta^d < 1$ is their depreciation rate.

2.4. The Household's Optimization Problem

The household chooses sequences of C_t^n, D_{t+1}, L_t and F_{t+1} to maximize the utility function in (2.12) and (2.13), subject to the sequences of constraints in (2.16), the adjustment and financial costs functions in (2.14) and (2.15), the evolution of the durable stock in (2.17) and the initial stocks F_0 and D_0.

Defining

$$S_t \equiv \left(C_t^n\right)^{1-\theta} D_t^\theta - \psi L_t^\varphi Z_t,$$

$$U_{c^n}(t) \equiv S_t^{-\sigma}\left[(1-\theta)\left(C_t^n\right)^{-\theta} D_t^{\theta}\right],$$

$$U_d(t) \equiv S_t^{-\sigma}\left[\theta\left(C_t^n\right)^{1-\theta} D_t^{\theta-1}\right],$$

$$U_l(t) \equiv S_t^{-\sigma}\left[-\psi\varphi L_t^{\varphi-1} Z_t\right],$$

$$U_z(t) \equiv S_t^{-\sigma}\left(-\psi L_t^{\varphi}\right),$$

and Υ_t^c and Υ_t^z as the Lagrange multipliers of the budget constraint (2.16) and the equation for Z_t in (2.13), the first-order conditions are:[1]

$$0 = U_{c^n}(t) - \Upsilon_t^c\left(1+\tau_t^n\right) - \Upsilon_t^z\left[(1-\theta)\,\xi\left(C_t^n\right)^{(1-\theta)\xi-1} D_t^{\theta\xi} Z_{t-1}^{1-\xi}\right], \tag{2.18}$$

$$0 = -\Upsilon_t^c\left[1+\omega^f\left(F_{t+1}-F^*\right)\right] + \beta\Upsilon_{t+1}^c(1+\bar{r}), \tag{2.19}$$

$$\begin{aligned} 0 = & -\Upsilon_t^c\left[1+\tau_t^d+\omega^d\left(D_{t+1}-D_t\right)\right] + \beta U_d(t+1) \\ & + \beta\Upsilon_{t+1}^c\left[\left(1+\tau_{t+1}^d\right)\left(1-\delta^d\right)+\omega^d\left(D_{t+2}-D_{t+1}\right)\right] \\ & - \beta\Upsilon_{t+1}^z\left[\theta\xi\left(C_{t+1}^n\right)^{(1-\theta)\xi} D_{t+1}^{\theta\xi-1} Z_{t+1}^{1-\xi}\right], \end{aligned} \tag{2.20}$$

$$0 = U_l(t) + \Upsilon_t^c(1-\tau_t^l)W_t, \tag{2.21}$$

$$0 = U_z(t) + \Upsilon_t^z - \beta\Upsilon_{t+1}^z\left(C_{t+1}^n\right)^{(1-\theta)\xi} D_{t+1}^{\theta\xi}\left(1-\xi\right) Z_t^{-\xi}. \tag{2.22}$$

To provide intuition on these optimality conditions, we concentrate now on the case where the utility function is standard, i.e., $\xi = 1$ (or $Z_t = C_t$), tax rates in periods t and $t+1$ are equal, and there are no adjustment costs. In this case, the first-order conditions can be written as:

$$U_{c^n}(t) = \beta\frac{(1+\bar{r})}{1+\omega^f\left(F_{t+1}-F^*\right)}U_{c^n}(t+1), \tag{2.23}$$

$$U_{c^n}(t) = \beta U_d(t+1)\left(\frac{1+\tau^n}{1+\tau^d}\right) + \beta U_{c^n}(t+1)\left(1-\delta^d\right), \tag{2.24}$$

$$-U_l(t) = U_{c^n}(t)\left(\frac{1-\tau^l}{1+\tau^n}\right)W_t. \tag{2.25}$$

Equation (2.23) is the Euler equation which leads to consumption smoothing

[1] For each period t, there are 7 unknowns: $C_t^n, F_{t+1}, D_t, L_t, Z_t, \Upsilon_t^c, \Upsilon_t^z$ and 7 equations (the 5 first-order conditions, the budget constraint and the equation for Z_t.

when $\omega^f = 0$, (2.24) equates the purchasing cost of the durable good to it's marginal utility plus it's discounted resale value, and (2.25) determines optimal labor supply.

The nonstandard element here appears in (2.23). As mentioned above, the costs of deviating from the assets target F^* generate excess sensitivity to temporary income changes, as in Flavin (1985), and excess smoothness to permanent income changes, as in Deaton (1987). To illustrate this, consider first a temporary increase in the wage, dividends, or transfers from the government, starting from a steady state with $F_t = F^*$. The desire to save to smoothen consumption over time increases F_{t+1}. According to (2.23), this implies that $U_{c^n}(t)/U_{c^n}(t+1)$ falls, and thus current consumption reacts more than predicted by permanent income theory. This is the excess sensitivity property.

Consider now the anticipation of a transfer or tax cut beyond $t+1$. The desire to upscale nondurable consumption and the durable stock to the new optimal levels requires borrowing—a reduction of F_{t+1}. In (2.23) this implies that $U_{c^n}(t)/U_{c^n}(t+1)$ goes up rather than remain equal to one as permanent income theory predicts. Hence, nondurable consumption adjusts upwards gradually rather than immediately. This is the excess smoothness property. Note in equation (2.24), that $U_d(t+1)/U_{c^n}(t+1)$ must also go up. This implies that also the durable stock adjusts gradually. In terms of labor supply, the gradual adjustment of nondurable consumption weakens the wealth effect of the good news on hours worked.[2]

The effective interest rate is defined as

$$1 + r_t \equiv \frac{(1+\bar{r})}{1 + \omega^f \left(F_{t+1} - F^*\right)}. \tag{2.26}$$

The effective rate declines when assets go up beyond F^* and increase when they go down below this level. This mechanism is similar to a flexible rate which depends on the debt level. Substituting (2.26) into (2.23) yields the standard Euler equation

$$U_{c^n}(t) = \beta \left(1 + r_t\right) U_{c^n}(t+1),$$

where higher borrowing costs appear as a higher interest rate.

[2]Quantitatively, however, it turns out that the wealth effect on labor supply with $\xi = 1$ is still very strong.

2.5. Government

The modeling of the public sector captures it's behavior in Israel since 2003. In that year, the government announced simultaneously a multi-year tax-cut program and a commitment to reduce the public debt to GDP ratio. Between the years 2003 and 2008, the tax-cut program had been fully implemented, while the public debt decreased from 100 percent of GDP to 76 percent. Accordingly, government consumption dropped from 27.8 percent of GDP in 2003 to 23.8 percent in 2008. In December 2009, in spite of the world crisis, the government renewed its committed to cut tax rates according to the plan and further reduce the public debt/GDP ratio to 0.6—the Maastricht Accord benchmark—in about a decade. Along these lines, we model government expenditures as endogenous to the exogenous tax rates, public debt target and expected tax revenues.

Specifically, the government determines exogenously the tax rate paths

$$\left\{\tau_t^l, \tau_t^c, \tau_t^n, \tau_t^d\right\}_{t=0}^{\infty}$$

and the target ratio public debt/GDP η. Hence, the debt target as of the current period is

$$B_{t+1}^* = \eta E_t\left(Y_{t+1}\right). \tag{2.27}$$

The government plans to achieve this target gradually. The intermediate target, i.e., the target for the next-period debt is

$$\hat{B}_{t+1}^* = \hat{B}_t^* \left(B_{t+1}^*/\hat{B}_t^*\right)^{\lambda^b}, \ 0 < \lambda^b < 1, \tag{2.28}$$

where λ^b governs the speed of adjustment to the target.

Total revenue from taxation is

$$R_t = \tau_t^l W_t L_t + \tau_t^c\left(Q_t - W_t L_t - P_t^m M_t\right) + \tau_t^n C_t^n + \tau_t^d C_t^d. \tag{2.29}$$

The government spends G_t in goods and services, T_t in transfers to the public, and $(1+\bar{r})B_t$ in debt servicing and repayment. The government is free from financial costs. Given tax revenues, transfers, the outstanding debt and the intermediate debt target, the amount the government spends in goods and services should satisfy

$$G_t \leq R_t + \hat{B}_{t+1}^* - T_t - (1+\bar{r})B_t. \tag{2.30}$$

We assume that this constraint always binds, and hence actual debt at the end of every period is

$$B_{t+1} = \hat{B}^*_{t+1}. \tag{2.31}$$

2.6. Rest of the World

The rest of the world demands the domestic good according to

$$X_t = X^0 \left(P^x_t\right)^{\chi}, \quad \chi > 0, \tag{2.32}$$

where X^0 is a scale parameter reflecting, for example, the volume of the world trade, and P^x_t is the price of a foreign substitute of the domestic good relative to the price of the domestic good.

The price of the foreign substitute to the domestic good relative to the price of imports—two foreign goods—is

$$P^{xm}_t = \frac{P^x_t}{P^m_t}, \tag{2.33}$$

which is exogenously given from the world markets.

The interest rate in the world capital market is constant at the rate $\bar{r}$, which satisfies

$$\bar{r} = \frac{1-\beta}{\beta}. \tag{2.34}$$

This is consistent with foreign financial traders having the same time preference as domestic households.

2.7. Equilibrium

The dynamic nature of the model implies that equilibrium involves the simultaneous computation of the expected future paths of the economy. However, as a version of the Bruno and Sachs' (1985) framework, the equilibrium in this model can be given the following, heuristic, aggregate demand-aggregate supply interpretation by holding expectations of future variables constant.

In the equilibrium condition in the output market

$$Q_t = C^n_t + C^d_t + I_t + G_t + X_t + J^k_t + J^d_t + J^f_t, \tag{2.35}$$

the left-hand side and the right-hand side represent aggregate supply and aggregate demand in the space of Q_t and $1/P_t^m$—the relative price of domestic output in terms of foreign goods. Aggregate supply follows from substituting labor demand from (2.10) and imports demand (2.11) into the production function (2.3), while the wage equals the households' rate of substitution between consumption and leisure as in (2.21), which describes labor supply. This implies equilibrium in the labor market. Because of the negative effect of P_t^m on the demand for intermediate inputs and labor, output supply can be visualized as an upward sloping curve. Regarding aggregate demand, the positive link between exports and P_t^m from (2.32) and (2.33) implies that aggregate demand can be represented by a downward sloping curve. Hence, the model's solution can be interpreted as a standard intersection of demand and supply curves. Accordingly, the equilibrium values of Q_t and $1/P_t^m$ increase with positive demand shifts—higher economic activity accompanied by a appreciation—while a positive supply shift causes higher economic activity and a depreciation. This is a basic intuition that will be used to interpret the simulations of the model.

2.8. The Trade and the Current Account

The current account balance, CA_t and the corresponding capital flows follow from (2.35) by adding $\bar{r}\,(F_t - B_t) - P_t^m M_t$ on both sides:

$$Q_t+\bar{r}\,(F_t - B_t)-P_t^m M_t = C_t^n+C_t^d+I_t+G_t+X_t+J_t^k+J_t^d+J_t^f+\bar{r}\,(F_t - B_t)-P_t^m M_t,$$

or, rearranging,

$$CA_t \equiv X_t+\bar{r}\,(F_t - B_t)-P_t^m M_t = Q_t+\bar{r}\,(F_t - B_t)-P_t^m M_t-C_t^n-C_t^d-I_t-G_t-J_t^k-J_t^d-J_t^f. \tag{2.36}$$

The current account balance equals the difference between receipts from abroad from exports and assets less payments abroad for imports.

The trade balance is

$$TB_t \equiv X_t - P_t^m M_t.$$

2.9. Conversion of Variables from Output Units to GDP Units

The usual macroeconomic analysis and the national income accounts emphasize GDP, or domestic product, rather than domestic output. In particular, relative prices of imports and exports are computed using GDP price indices, and not output price indices. Hence, we derive here the theoretical counterparts of variables as they are usually measured.

From equation (2.1), efficient production implies that the relative price of value added in terms of output equals

$$P_t^y = \gamma \frac{Q_t}{Y_t}.$$

Substituting Y from (2.1) we get

$$P_t^y = \gamma \frac{Q_t M_t^{\frac{1-\gamma}{\gamma}}}{Q_t^{\frac{1}{\gamma}}} = \gamma \left(\frac{M_t}{Q_t} \right)^{\frac{1-\gamma}{\gamma}}. \tag{2.37}$$

Then, to convert variables expressed in terms of output to GDP terms we divide by P_t^y.

In particular, the relative price of imports in terms of GDP, or the "real exchange rate" equals the relative price of imports in terms of output divided by the relative price of GDP in terms of output:

$$Rer_t = \frac{P_t^m}{P_t^y} = P_t^m \frac{1}{\gamma} \left(\frac{Q_t}{M_t} \right)^{\frac{1-\gamma}{\gamma}}. \tag{2.38}$$

3. Parameter Values

Most of the parameter values, taken from Friedman and Hercowitz (2010), were computed or estimated using Israeli data for the 2000s. Parameters of the utility function are from Jaimovich and Rebelo (2009). The details can be found in those papers. Here, we present only a summary of the procedure regarding the main parameters.

The unit of time is defined as one quarter. The parameter values are listed in Table 1.

Table 1: Parameters Values		
Production and Utility Functions		
GDP share in output	γ	0.7
Capital share in GDP	α	0.3
Depreciation rate of capital	δ^k	0.02
Depreciation rate of durables	δ^d	0.025
Discount rate	β	0.99
World interest rate	$\bar{r}$	0.01
Utility: Relative importance of durable goods	θ	0.165
Utility: Curvature	σ	1
Utility: Jaimovich-Rebelo	ξ	0.001
	φ	1.5
	ψ	1
Fiscal Policy		
Public Debt to GDP ratio target	η	0.6
Public debt convergence	λ^b	0.025
Effective corporate tax	τ^c	0.15
Average tax on labor	τ^l	0.15
Tax on nondurables (VAT)	τ^n	0.165
Tax on durables (VAT + purchase)	τ^d	0.50
Other Parameters		
Adjustment costs of capital	ω^k	0.25
Adjustment costs of durable goods	ω^d	0.25
Financial costs	ω^f	0.01
Exports elasticity	χ	0.2
Real interest rate	r	0.01
Net private portfolio position	F^*/Y	0.6
Unilateral transfers (% of GDP)	T	0

The technology parameters γ and α corresponds to the relevant shares: The parameter γ was set equal to the average ratio of imports to output, and the value of α equals the average nonlabor income share in GDP. The depreciation rate of productive capital δ^k is 2 percent, the average of the quarterly depreciation rates across capital goods.[3] The depreciation rate of durable goods, δ^d, was set at 2.5

[3] This is the average depreciation rate from the detailed perpetual capital stock system at the Bank of Israel.

percent. Note that durable goods do not include housing; thus, the depreciation of these goods is higher than that of productive capital which includes structures—the productive counterpart of housing.

The value of the financial costs parameter, $\omega^f = 0.01$ indicates a nonnegligible friction in the financial market. Hence, consumption decisions in the model will be affected by fluctuations in the effective interest rate. The value of the elasticity of exports with respect to the relative price of the domestic good, $\chi = 0.2$, is from Friedman and Lavi (2006).

For the utility function, the value of the parameter θ was based on the average ratio $C^d/C^n = 0.14$ (excluding housing services in C^n). The discount rate β was set such that the steady state level of the real interest rate $(1/\beta - 1)$ equals one percent, or 4 percent annualized. As stressed by Jaimovich and Rebelo in a similar context, setting $\xi = 0.001$ implies that there is very little income effect on labor supply in the short run. Setting $\varphi = 1.5$ implies that the elasticity of labor supply to the real wage in the case of $\xi = 0$, is 2.

The target ratio of public debt to GDP, η, was set equal to the Maastricht Treaty required ratio, 0.6, adopted by the Israeli government as well. The rate of convergence of the public debt to the target is determined as follows. According to the rule adopted by the Israeli government in December 2009, this target should be met by 2020. For the public debt/GDP ratio to reach the target of 0.6, when starting from 0.8, in about 40 quarters implies that λ^b should be approximately 0.025[4] Note that this applies to any tax schedule because the G should adjust to tax revenues given the path for the debt. The tax rates were calibrated using the average effective rates during the 2000s.

The net portfolio position of the private sector F^* is calibrated as $F^* = \eta Y$ so that $F^* + B^* = 0$, which is approximately the net foreign assets of the Israeli economy as of 2010.

4. Policy Analysis

In this section we present the results from the analysis of fiscal policies similar to those in Israel in the 2000s: Pre-announced tax rate cuts and the adoption of a lower public debt/GDP target. We simulate and discuss the impulse responses computed from the calibrated model. These responses are plotted in percentage

[4] The approximation follows from looking at achieving the middle range ratio 0.7 in half the time, 20 quarters.

deviations from the initial steady state along periods of time expressed in quarters since the announcement.

4.1. Expected Tax Changes

We address reductions in three tax rates: the labor income tax, τ^l, the corporate profits tax, τ^c, and the tax on durable goods purchases, τ^d. Changes in the tax rate on nondurable consumption have similar effects as those for the labor tax.[5] These tax cuts are permanent and announced 10 quarters in advance. We follow the effects from the time of the announcement to the time of implementation, and from then onwards.

Figure 4.1 shows the effects of a one percentage point reduction of τ^l; from 0.15 to 0.14. The response of Y summarizes the effects of this policy: GDP expands to some extent prior to the actual tax decline, and then it increases much further at the time of implementation. The early expansion is demand driven, and the transmission mechanism, as discussed earlier, is a basic feature of the present open economy model. Demand for consumption of both types goes up with the announcement, as shown in the CN and CD panels, from the wealth effect of expected lower taxes. This demand increase is reinforced by higher government spending, as shown in the G panel, which is fueled by the higher tax revenues generated by the additional economic activity—as the tax rate is unchanged yet.

The demand increase following the announcement causes an appreciation, as it can be seen in the RER panel. The decline in the relative price of imported inputs induces higher imports—and thus a trade deficit shown in the TB panel—which increase the marginal productivity of labor. This is the mechanism expanding labor demand before the actual lowering of the tax rate. The initial increase in the wage rate in panel W is a result of the higher labor demand. At the time of implementation, the wage goes down due to the labor supply surge when the labor income tax is cut. This is the force behind the further increase in the domestic product, which this time can be described as supply driven. The depreciation and the trade balance turning from deficit to surplus at the time of implementation are consistent with this interpretation. The hike in consumption of both types at

[5] As it is well known, both taxes have identical roles in the labor supply condition—equation (2.25) here. Regarding savings, only in the period prior to the implementation, τ_t^n differs from τ_{t+1}^n, and thus the consumption tax does not cancel out from the savings conditions only in this period. Hence, reducing the labor income tax and the consumption tax have similar but not identical effects.

that time is due partly to the complementarity of labor supply and consumption in utility, and partly to higher income.

As shown in the K panel, investment declines at the time of announcement. This implies that the crowding out effect of higher consumption on investment via higher interest rates—as households borrow to finance their consumption—dominates the productivity effect of the imports surge. The latter tends to increase investment in a similar way as it increases labor demand. Over time, domestic product, the capital stock and labor input converge to higher steady-state values, while government spending converges to a lower steady state value given the decline in tax revenues.

Figure 4.2 addresses a reduction in the corporate income tax τ^c from 0.15 to 0.14. Here, the tax-cut announcement impacts the economy mainly by increasing the optimal capital stock. Higher investment demand causes an appreciation which has the same type of expansionary effect discussed earlier. Given high investment expenses, dividends are temporarily cut and thus households increase borrowing to smooth consumption. Durable consumption, which is highly sensitive to the interest rate, declines then due to the higher rates. Nondurable consumption fluctuates very little following the announcement, and most of it's changes at this stage are due to the positive interaction of consumption and hours worked in utility.

The employment cycle—in panel L—illustrates the example of the effects of the present fiscal rule in an open economy discussed in the Introduction. The announced tax cut generates a demand driven boom. Later, when the tax cut is implemented, government expenditures need to be cut, and this generates a demand driven contraction. This cycle is present also in output—as it can be seen in the Y panel—but capital accumulation following the corporate tax cut reduces the amplitude of the cycle as the economy experiences an upward trend for several years. In other words, the contraction due to the government spending cut is obscured by the supply driven expansion at the time of implementation—which appeared above also in the case of the cut in τ^l.

Over time, the economy approaches a new steady state with higher output and inputs. The long-run depreciation is due to the expansionary effect of the tax cut on output supply.

Figure 4.3 shows the responses to a five percentage points reduction in the tax rate on durable goods purchases. This policy generates a cycle associated with the timing of durable goods purchases. The swings in the demand for these goods dominate the other effects stressed earlier.

Figure 4.1: Future Labor Income Tax Cut

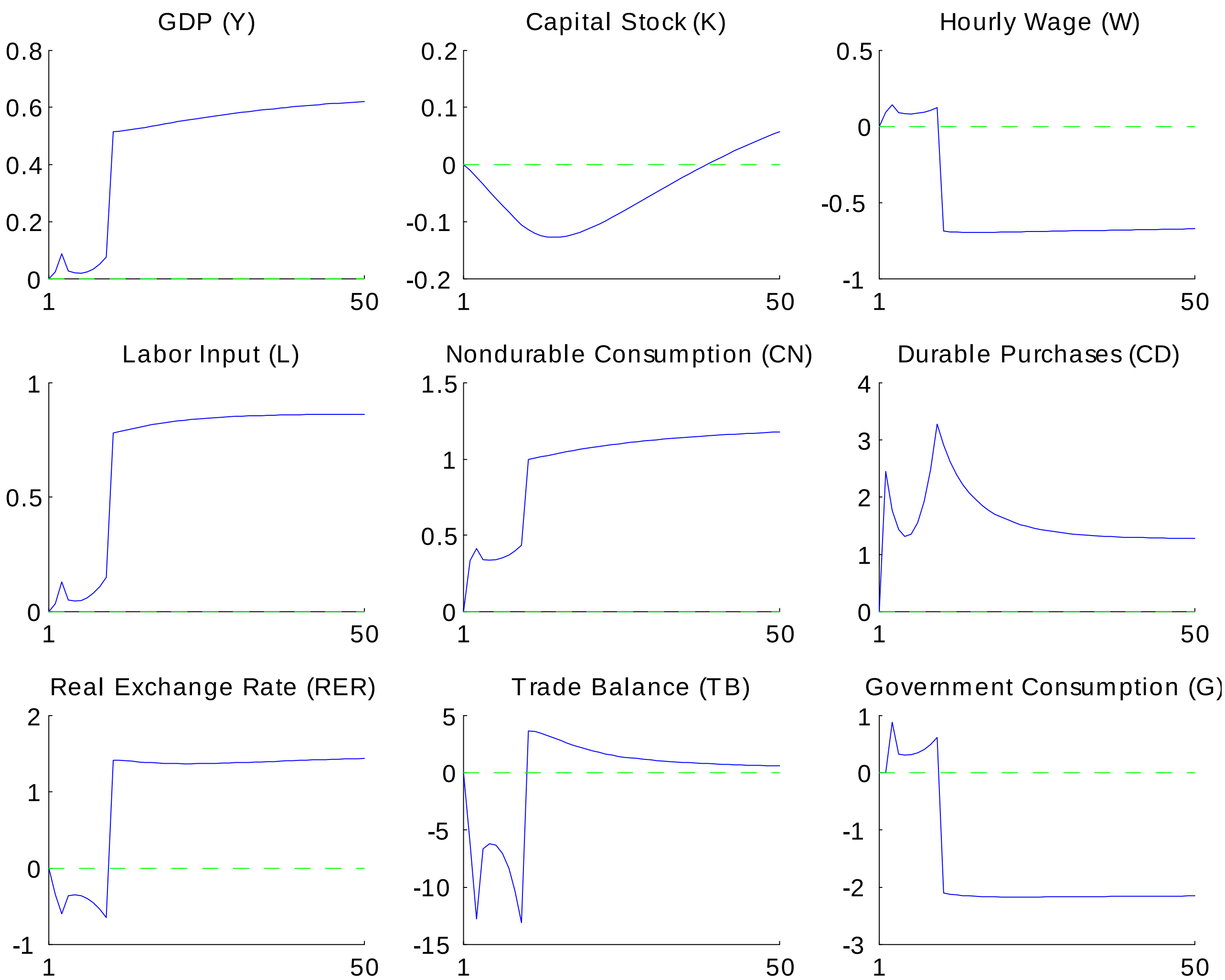
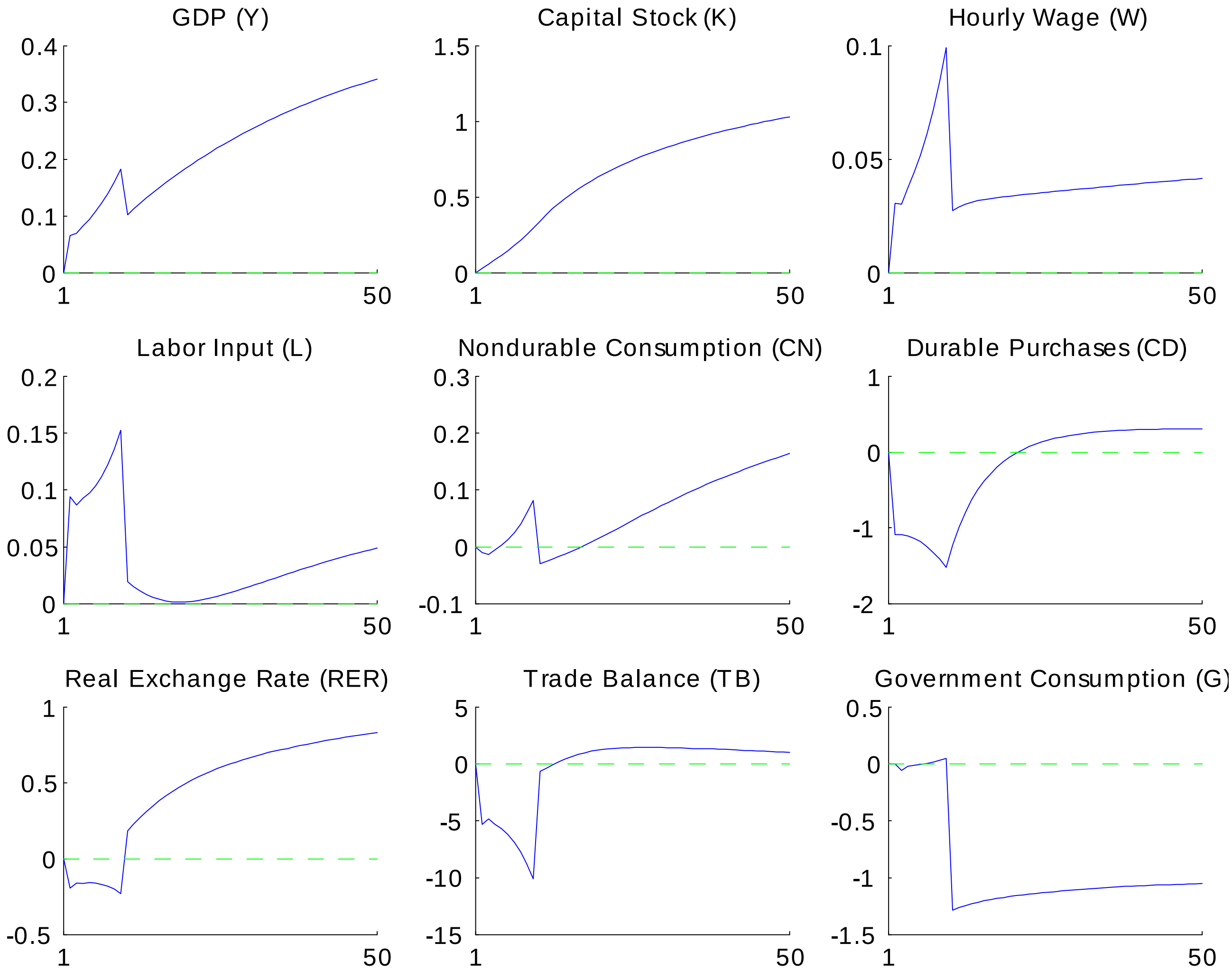


Figure 4.2: Future Corporate Tax Cut



As it can be expected, durable purchases decline at the time of the announcement as the price to the consumer is expected to go down. Demand for durable goods declines further till implementation—given that the time left to forgo utility from durable goods becomes shorter—and then it soars. This is reflected in corresponding fluctuations of the real exchange rate, and thus in production and employment. In the long run, not shown in the figure, the lower tax rate keeps total consumption demand higher than in the old steady state, leading to a higher level of output, in spite of the reduction in government demand.

4.2. Lowering the Public Debt Target

Figure 4.4 shows the responses to the adoption of a public debt/GDP target of 0.6 when the current ratio is 0.8. The dominating effect here is the demand role of government spending. The immediate effect is quite contractionary due to the spending cut and the resulting depreciation: GDP and employment decline substantially.

A special feature of government spending here is it's positive comovement not only with output and employment, but also with consumption and investment. There is no crowding out of other demand sources as in the previous policy shifts, which affect directly investment or consumption. The reason for this difference is that the government is free from financial transactions costs. Hence, the change in government debt does not affect directly the effective interest rate. The only channel by which the spending cut affects the economy is the real exchange rate. Hence, this is the case of a pure small open-economy analysis of demand shifts.

Interestingly, following the initial cut government spending recovers, driving upwards the other macro variables. This expansion is due to the decline in government interest payments. This induces a shift of public expenditure towards government purchases of goods, which cause an appreciation. The resulting recovering imports increase labor demand and the optimal size of the capital stock, causing raising production. This cycle is quite long. Given the current calibration, GDP crosses the initial level after about 18 years. The economy then converges to an appreciated real exchange and thus a higher level of economic activity.

5. Concluding Remarks

We use an open-economy model to analyze exogenous changes in tax rates and in the public debt target. The model is a version of the Bruno-Sachs framework,

Figure 4.3: Future Tax Cut on Durable Goods Purchases

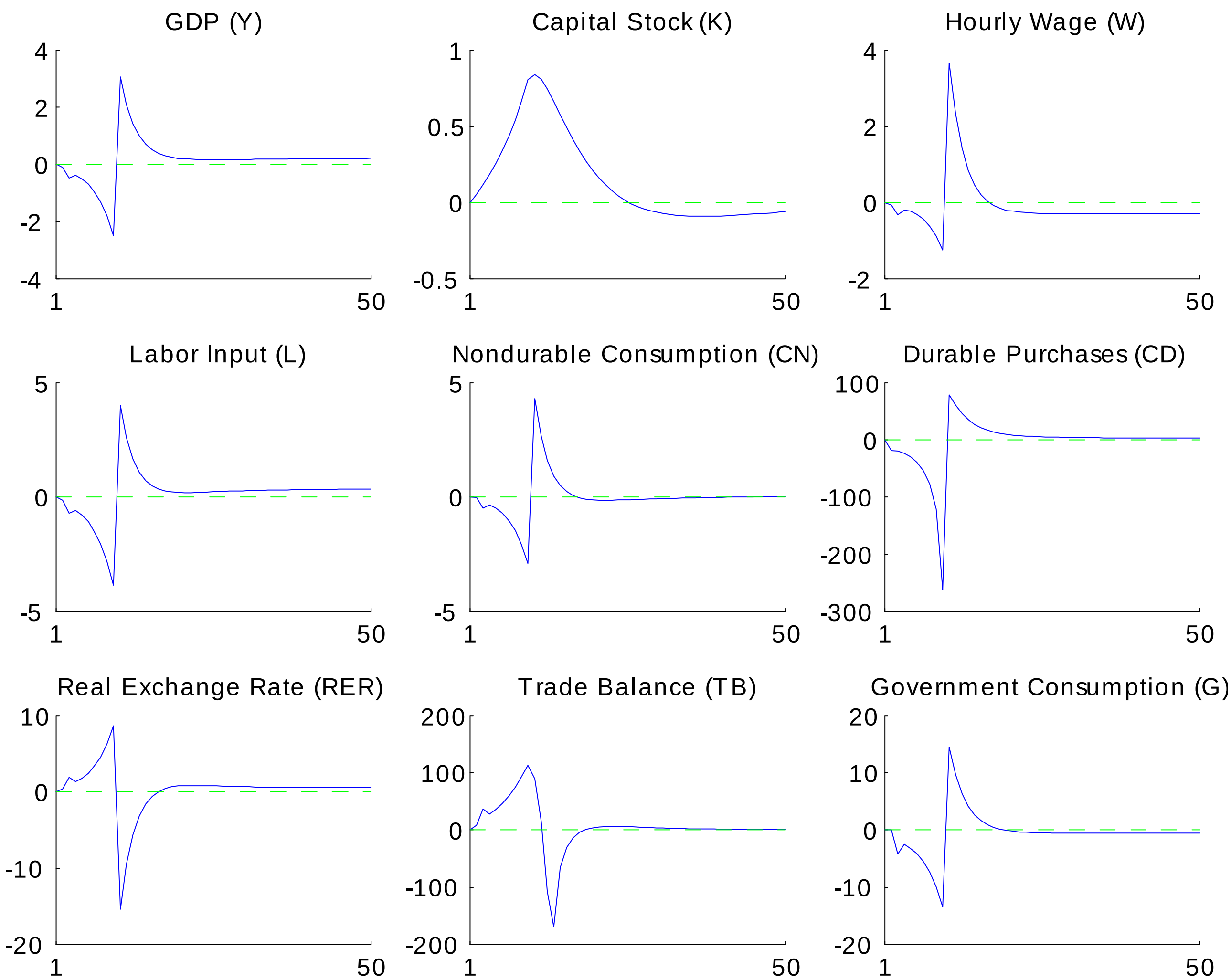
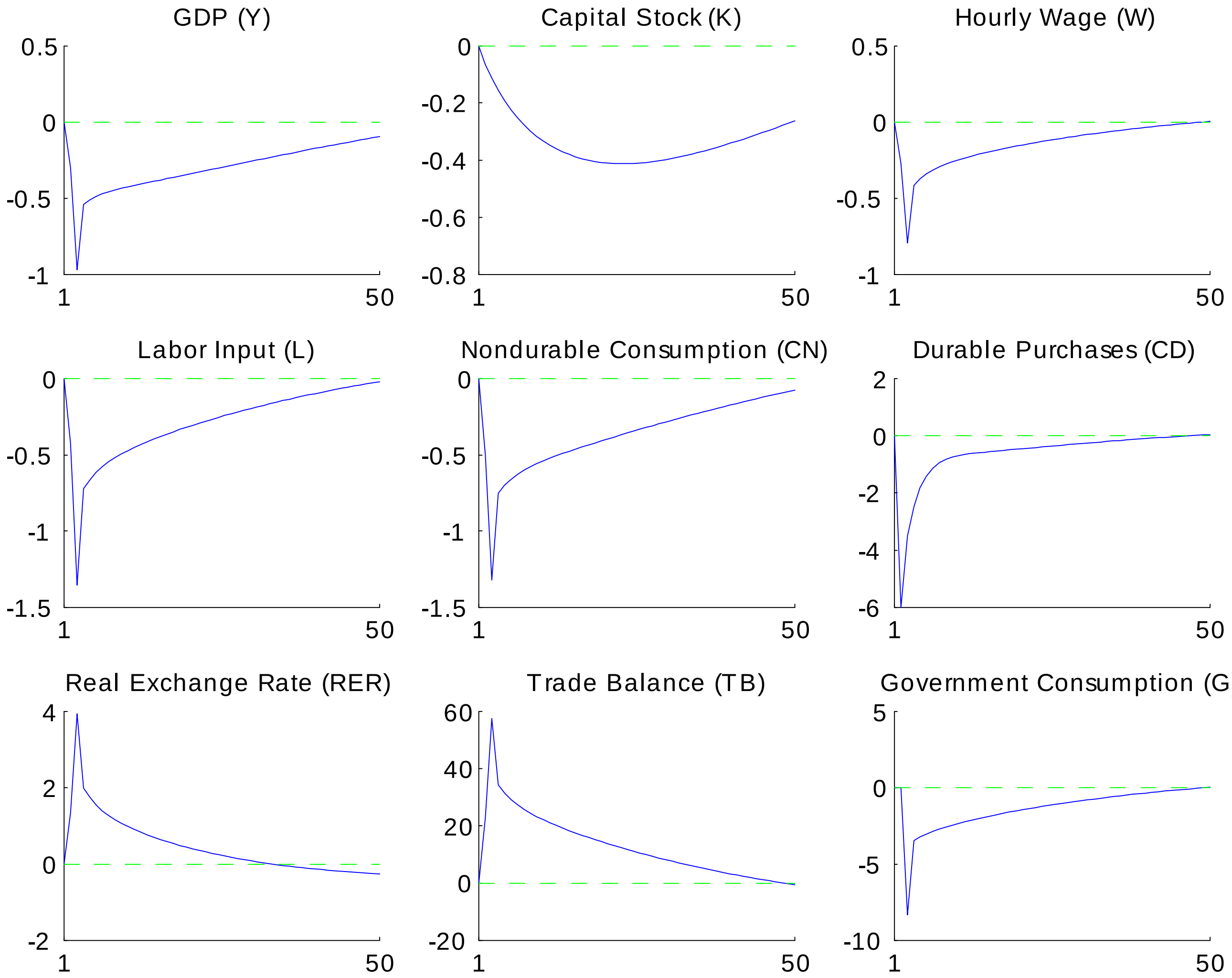


Figure 4.4: Lowering the Public Debt/GDP Target



where the relative price of the domestic good in terms of foreign goods clears the output market. The demand for goods depends negatively on the relative price of the domestic good through exports. The supply of goods depends positively on this relative through imports; a higher relative price implies a relatively lower cost of imported inputs and thus it encourages production. The model has the Keynesian characteristic that an increase in government spending has a positive comovement with output, labor and consumption—similarly as productivity shocks do in the neoclassical model.

The analysis focuses mainly on tax cuts. We trace their economic effects from announcement through implementation to convergence to the long-run levels. Specifically, we address tax cuts on labor income, corporate profits, and durable goods purchases. The dynamic effects of the tax cuts on labor income and corporations have similarities: Both generate: (a) real exchange rate appreciation from announcement to implementation—as consumption or investment demand increase due to wealth effects or higher profitability of investing—and (b) real exchange depreciation from implementation onwards. The latter is due to the expansion in labor input and the capital stock when the corresponding tax rates actually decline. The tax cut on durable goods purchases differs because it generates a cycle dominated by the swings in the demand for durable goods. The announcement reduces the demand for durables, and thus it has a contractionary effect. The implementation affects the economy in the opposite direction.

We then consider the lowering of the public debt/GDP target. The adoption of a lower target has a contractionary effect in the short run, as government spending has to be reduced. In the long-run, however, the lower level of interest payments on the public debt allows the government to spend more on goods. This expands economic activity, and the new steady state is characterized by higher levels of output, investment and private consumption.

The present analysis of expected tax rate changes is related to the literature on the cyclical effects of news about the future, as Beaudry and Portier (2007) and Jaimovich and Rebelo (2009). The open-economy nature of the current analysis differs from their closed-economy setup. Here, good news about the future causes an appreciation, which increases labor demand—and thus works similarly as a current productivity shock. Hence, labor supply faces not only the wealth effect which reduces the willingness to work, but also a higher current wage which works in the opposite direction.

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