Fiscal Policy in an Open Economy

Amit Friedman, Zvi Hercowitz and Jonathan Sidi

February 2012

Abstract

This paper considers macroeconomic implications of a fiscal policy regime with 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 addresses the dynamics generated by announcements of these policy shifts followed by their actual 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 that are similar to those of productivity shocks.
1. Introduction

This paper focuses on 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 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 is the fiscal policy 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 taxes 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. As stressed by Barro and King (1984), this interest rate movement crowds out the other sources of demand, preventing the positive comovement of private consumption, investment and public spending as consequence of a shock to one of them.

The transmission mechanism of demand changes in the present model is different. First, the interest rate is constant from the world capital market, so that
the expansionary effect via labor supply does not take place. Instead, because 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 models: The demand for labor and capital goes up along with production, and this generates a positive comovement of consumption, investment and 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 tax cut which for the simplicity of the argument is lump-sum. Realistically, tax changes are predicted in advance either from announcements or from the public discussion and formal steps leading to the change. The announcement and later the implementation of the tax change generates 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 a positive comovement of imported inputs, labor, investment 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 fluctuation or cycle generated by a policy shift depends on the nature of the policy. If the tax being cut in the previous example is not lump-sum but a tax rate on labor income, the expansionary effects of the anticipation will remain similar, but the contractionary impact of reducing government spending when the tax rate is actually cut will be combined with the expansion of labor supply. Hence, if the latter effect is stronger, the initial expansion will be followed by an additional expansion.

The paper proceeds as follows. The model is presented in Section 2. Section 3 reports the calibration of the model. The macroeconomic analysis of the fiscal policy changes is reported in Section 4 using impulse responses. Concluding remarks are given in Section 5.
2. The Model

The model has the basic features of the small-open economy framework: Identical households and firms perform dynamic optimization within a competitive environment, while the interest rate is exogenously given from abroad. Hence, the economy is small and open to the world capital markets. However, there is a friction associated with financial transactions which is elaborated below. Capital and goods are mobile internationally, but labor is not.

The main additional feature to the basic framework is that production requires an imported input which is a different good. Hence, the production function includes three factors: Capital, labor, and imports. All imports are treated as intermediate products, as we elaborate below. The productive role of imports implies that the resulting aggregate supply function is decreasing in their relative price.

Aggregate demand includes private and public consumption, investment and exports. The economy’s output does not have a perfect substitute abroad; hence, the economy is not “small” with respect to exports. The world demand for the economy’s exports is an increasing function of the price of a substitute abroad 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.

Financial mobility from abroad involves a friction adopted from Schmitt-Grohe and Uribe (2003): Deviations from a target level of foreign assets are costly. Hence, decreasing the level assets below that level, or borrowing from abroad, has a cost above the foreign interest rate. However, being symmetric, also saving abroad above the target level involves that cost. This mechanism has interesting implications for the behavior of nondurable and durable consumption, which we analyze below. As in Schmitt-Grohe and Uribe (2003) the additional implication of introducing an assets target is that the model possesses a steady state. Otherwise, given the exogenous foreign interest rate, assets would follow a random walk, and, thus, the long-run variances of assets and other variables would be infinite.
2.1. Production

The representative firm produces output \( Q_t \) according to the Cobb-Douglas technology

\[
Q_t = Y_t^\gamma M_t^{1-\gamma}, \quad 0 < \gamma < 1,
\]

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 observations from the Israeli economy that raw materials for production account for about 50 percent of goods imports, and that domestic market prices of the remaining imports—investment and consumption goods—including a large domestic value added share composed of importers’ services, domestic transportation and taxation.

Because all imports are treated as intermediate products, 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 a function of technology.

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

\[
Y_t = K_t^\alpha L_t^{1-\alpha}, \quad 0 < \alpha < 1.
\]  

(2.2)

We ignore technological progress, given our focus on fiscal policy effects. Substituting (2.2) into (2.1), we get

\[
Q_t = K_t^\alpha L_t^{1-\alpha} M_t^{1-\gamma}.
\]  

(2.3)

The capital stock evolves according to

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

(2.4)

where \( I_t \) is gross investment and \( \delta^k \) is the depreciation rate of capital.

Changing the capital stock involves the adjustment costs of the form

\[
J_t^k = \frac{\omega^k}{2} (K_{t+1} - K_t)^2, \quad \omega^k > 0,
\]

(2.5)

where \( \omega^k \) is a parameter governing the magnitude of these costs.

The firm takes prices as given. In terms of domestic output these prices are the wage, \( W_t \), and the price of imports \( P_t^m \).
The after-tax dividend paid by the firm to the share holders in period \( t \) is
\[
\Pi_t = (1 - \tau_t^c) \left[ K_t^{\alpha \gamma} L_t^{(1-\alpha)\gamma} M_t^{1-\gamma} - W_t L_t - P_t^m M_t \right] - J_t^k - K_{t+1} + K_t (1 - \delta^k), \tag{2.6}
\]
where \( \tau_t^c \) is the corporate tax rate. Note that in this case, the depreciation of the capital stock and its adjustment cost are assumed for simplicity not to be tax deductible. We also assume that firms are fully owned by the domestic households.

2.2. The Firm's Optimization Problem

The firm maximizes the sum of discounted dividends
\[
\Pi_t + \frac{\Pi_{t+1}}{1 + r} + \frac{\Pi_{t+2}}{(1 + r)^2} + ..., \tag{2.7}
\]
with \( r \) being the real interest rate in period \( t \).

The first-order conditions are:
\[
1 + \omega^k (K_{t+1} - K_t) = \frac{1}{1 + r} \left[ (1 - \tau_{t+1}^c) \frac{\alpha \gamma Q_{t+1}}{K_{t+1}} + 1 - \delta^k \right], \tag{2.7}
\]
\[
W_t = (1 - \alpha) \gamma K_t^{\alpha \gamma} L_t^{(1-\alpha)\gamma-1} M_t^{1-\gamma}, \tag{2.8}
\]
\[
P_t^m = (1 - \gamma) K_t^{\alpha \gamma} L_t^{(1-\alpha)\gamma} M_t^{-\gamma}. \tag{2.9}
\]

In the absence of adjustment costs, (2.7) reduces to the familiar equality
\[
(1 - \tau_{t+1}^c) \frac{\alpha \gamma}{K_{t+1}} L_{t+1}^{(1-\alpha)\gamma} M_{t+1}^{1-\gamma} = r + \delta^k,
\]
between the marginal productivity of capital and its 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 \( \vartheta^l = [(1 - \alpha) \gamma]^{1-\gamma} \left(\frac{1-\gamma}{(1-\alpha)\gamma}\right)^{\frac{1-\gamma}{\alpha\gamma}} \), \( \vartheta^m = [(1 - \alpha) \gamma]^{1-\gamma} \left(\frac{1-\gamma}{(1-\alpha)\gamma}\right)^{\frac{1-\gamma(1-\alpha)}{\alpha\gamma}} \). 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

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

\[
\sum_{t=0}^{\infty} \beta^t (C_t - \psi L_t^\sigma X_t)^{1-\sigma} \frac{1}{1-\sigma}, \quad 0 < \beta < 1, \quad \varphi > 1, \quad \psi > 0, \quad \sigma > 0,
\]

(2.12)

\[
C_t = (C_t^m)^{1-\theta} D_t^\theta, \quad 0 < \theta < 1,
\]

\[
Z_t = C_t^\xi Z_{t-1}^{1-\xi}, \quad 0 \leq \xi \leq 1.
\]

(2.13)

where \( C_t^m \) is nondurable consumption, \( D_t \) is the stock of durable goods, and \( L_t \) is labor supply. In the Jaimovich-Rebelo formulation, the parameter \( \xi \) in the equation for \( X_t \) 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, the wealth effect on labor supply can be very small in the short run, but in the long-run there is a full income effect. The motivation for adopting this utility function here is similar as in Jaimovich and Rebelo: To deal with anticipation effects on labor supply in a realistic manner. Because changes in tax rates are in general announced in advance, the expectation of a future tax cut is can be consistent with a very 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

\[
J_t^d = \frac{\omega^d}{2} (D_{t+1} - D_t)^2.
\]

(2.14)

This formulation is consistent with the findings in Caballero (1990), who found
strong support for slow adjustment of durable goods in the U.S.

We deviate from the standard permanent income hypothesis by allowing for a mechanism capturing liquidity effects. Households have an exogenous target level of assets. Let us denote net financial assets at the beginning of period $t$ with $F_t$, and the target with $F^*$. The cost $J^f_t$ of being away from target is

$$J^f_t = \frac{\omega^f}{2} (F_{t+1} - F^*)^2, \quad \omega^f > 0,$$

adopted from Schmitt-Grohe and Uribe (2003). They interpret this formulation as the costs of portfolio adjustment, and focus on the fact that it provides a steady state to the model of a small open economy.

Here, we prefer to see these costs as reflecting too much or too little liquidity relative to the exogenous $F^*$. This formulation 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 the implications of this specification. As in Schmitt-Grohe and Uribe, the cost of being away from target assets generates a steady state in the model. This is the element of the model which provides imperfect capital mobility from abroad, in spite of the exogenous world interest rate.

Included in $F$ are foreign assets and government bonds. Ownership of firms and physical capital is already captured by the dividends $\Pi_t$ received from the firms.

The household receives income from labor, dividends and transfers from the government, $T_t$. For the household, the relevant tax rates are: $\tau^l_t$ on labor income, $\tau^m_t$ on nondurable consumption, and $\tau^d_t$ on durable purchases. We assume for simplicity that dividends are not taxed. Hence, $\tau^c$ reflects all capital income taxation. The one-period household’s budget constraint is given by

$$(1 + \tau^n_t) C^n_t + (1 + \tau^d_t) C^d_t + J^f_t = (1 - \tau^l_t) W_t L_t + \Pi_t + T_t + (1 + r) F_t - F_{t+1} - J^f_t,$$ (2.16)

where

$$C^d_t = D_{t+1} - (1 - \delta^d) D_t$$

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), 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

\[
S_t \equiv (C_t^n)^{1-\theta} D_t^\theta - \psi L_t^z Z_t,
\]

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

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

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

\[
U_z(t) \equiv S_t^{-\sigma} \left( -\psi L_t^z \right),
\]

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

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

\( \text{(2.18)} \)

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

\( \text{(2.19)} \)

\[
0 = -\Upsilon_t^c \left[ 1 + \tau_t^d + \omega^d (D_{t+1} - D_t) \right] + \beta U_d(t + 1)
\]

\[
+ \beta \Upsilon_{t+1}^c \left[ (1 + \tau_{t+1}^d) (1 - \delta^d) + \omega^d (D_{t+2} - D_{t+1}) \right]
\]

\[
- \beta \Upsilon_{t+1}^z \left[ \theta \xi (C_{t+1}^n)^{(1-\theta)} \xi D_{t+1}^{\xi-1} Z_{t+1}^{1-\xi} \right],
\]

\( \text{(2.20)} \)

\[
0 = U_l(t) + \Upsilon_t^c (1 - \tau_t^l) W_t,
\]

\( \text{(2.21)} \)

\[
0 = U_z(t) + \Upsilon_t^z - \beta \Upsilon_t^{c+1} (C_t^n)^{(1-\theta)} \xi D_t^\xi (1 - \xi) Z_t^{-\xi}.
\]

\( \text{(2.22)} \)

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, \( \beta (1 + r) = 1 \) and there are no adjustment costs.

\footnote{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 \( Z_t \).}
In this case, the first-order conditions can be written as:

\[ U_{cn}(t) [1 + \omega^f (F_{t+1} - F^*)] = U_{cn}(t + 1), \quad (2.23) \]

\[ U_{cn}(t) = \beta U_{d}(t+1) \left( \frac{1 + \tau^n}{1 + \tau^d} \right) + \beta U_{cn}(t+1) (1 - \delta^d), \quad (2.24) \]

\[ -U_i(t) = U_{cn}(t) \left( \frac{1 - \tau^d}{1 + \tau^d} \right) W_t. \quad (2.25) \]

Equation (2.23) is the Euler equation on savings which leads to consumption smoothing when \( \omega^f = 0 \), (2.24) equates the purchasing cost of the durable good to its marginal utility plus its 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).\(^2\) To illustrate this, consider first a temporary increase in the wage, dividends or transfers from the government starting from a steady state situation of \( F_t = F^* \). The desire to save to smoothen consumption over time increases \( F_{t+1} \). According to (2.23), this implies that \( U_{cn}(t) = U_{cn}(t + 1) \) 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 future 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 \( F_{t+1} \)—counting on higher net income in the future. In (2.23) this implies that \( U_{cn}(t) / U_{cn}(t + 1) \) 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, which follows from the liquidity shortage. Note in equation (2.24), that \( U_d(t + 1) / U_{cn}(t + 1) \) must also go up. This implies that also the durable stock adjusts gradually.

In terms of labor supply, the wealth effect that reduces the willingness to work, encounters an opposite effect via the liquidity shortage. As assets decline, the gradual adjustment of nondurable consumption reduces the wealth effect on labor supply. Quantitatively, however, it turns out that the wealth effect on labor supply

\(^2\)Campbell and Hercowitz (2009) show that both phenomena can be explained by liquidity constraints.
supply with $\xi = 1$ is still very strong.

2.5. Government

The modelling 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 path for the debt, exogenous tax rates, and expected tax revenues.

The government has an exogenous target for the public debt to GDP ratio and a rate of convergence towards that target. Defining $\eta$ as the target ratio of government debt to GDP, the target debt is

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

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

$$B_{t+1}^* = B_t^* \left( B_{t+1}^{**}/B_t^* \right)^{\lambda^b}, \quad 0 < \lambda^b < 1,$$

where $\lambda^b$ govern the speed of adjustment to the final target.

Total revenue from taxation is

$$R_t = \tau^l_t W_t L_t + \tau^c_t (Q_t - W_t L_t - P^m_t M_t) + \tau^n_t C^n_t + \tau^d_t C^d_t.$$  \hspace{1cm} (2.28)

The government spends $G_t$ in goods and services, $T_t$ in transfers to the public, and $(1 + r)B_t$ in debt servicing and repayment. Given tax revenues, transfers, the outstanding debt and the intermediate debt target, the amount the government can spend in in goods and services should satisfy

$$G_t \leq R_t + B_{t+1}^* - T_t - (1 + r)B_t.$$  \hspace{1cm} (2.29)

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

\[ B_{t+1} = B_{t+1}^* \]  

(2.30)

2.6. Rest of the World

The rest of the world demands the domestic good according to the function

\[ X_t = X^0 (P^x_t)^\chi, \quad \chi > 0, \]  

(2.31)

where \( X^0 \) is a scale parameter reflecting 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 is

\[ P^{xm}_t = \frac{P^x_t}{P^m_t}, \]  

(2.32)

which is exogenously given from the world markets.

The interest rate is given from the world financial market, and equals the rate of time preference. Hence,

\[ r = \frac{1 - \beta}{\beta} \]  

(2.33)

for all \( t \). In other words, foreign financial traders have the same time preference as the 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

\[ Q_t = C^m_t + C^d_t + I_t + G_t + X_t + J^k_t + J^d_t + J^f_t, \]  

(2.34)

the left-hand side and the right-hand side represent aggregate supply and aggregate demand in the space of \( Q_t \) and \( 1/P^m_t \)—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. Therefore, this implies equilibrium in the labor market. Because of the negative effect of $P^m_t$ on the demand for intermediate inputs and labor, output supply can be visualized as an upward sloping curve with $1/P^m_t$ as the price. Regarding aggregate demand, the positive link between exports and $P^m_t$ from (2.31) implies that aggregate demand can be represented by a downward sloping curve. Hence, the equilibrium values of $Q_t$ and $1/P^m_t$ are positively affected by demand positive shifts—higher economic activity accompanied by a appreciation—while a supply positive 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 (2.34) by adding $r (F_t - B_t) - P^m_t M_t$ on both sides:

$$Q_t + r (F_t - B_t) - P^m_t M_t = C^m_t + C^d_t + I_t + G_t + X_t + J^k_t + J^d_t + J^f_t + r (F_t - B_t) - P^m_t M_t,$$

or, rearranging,

$$CA_t \equiv X_t + r (F_t - B_t) - P^m_t M_t = Q_t + r (F_t - B_t) - P^m_t M_t - C^m_t + C^d_t - I_t - G_t - J^k_t - J^d_t - J^f_t.$$

(2.35)

The current account balance equals the difference between receipts from abroad from exports and assets less payments abroad from imports and debt, or alternatively, total income less total expenditures.

The trade balance is

$$TB_t \equiv X_t - P^m_t M_t.$$

2.9. Conversion of Variables from Output Units to GDP Units

The usual macroeconomic analysis as well as 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—as the model naturally involves. Hence, prior to report-
ing the results from the model’s simulations, we derive 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

\[ P^y_t = \gamma \frac{Q_t}{Y_t}. \]

Substituting \( Y \) in terms of \( Q \) from (2.1) we get

\[ P^y_t = \gamma \frac{Q_t M_t^{1-\gamma}}{Q_t^{1-\gamma}} = \gamma \left( \frac{M_t}{Q_t} \right)^{1-\gamma}. \] (2.36)

Then, to convert variables expressed in terms of output to GDP terms we divide by \( P^y_t \).

In particular, the relative price of imports in terms of GDP, or the “real exchange rate” is

\[ R_{er,t} = \frac{P^m_t}{P^y_t} = P^m_t \frac{1}{\gamma} \left( \frac{Q_t}{M_t} \right)^{1-\gamma}, \] (2.37)

i.e., equals the relative price of imports in terms of output divided by the relative price of GDP in terms of output.

3. Parameter Values

Most of the parameter values are taken from Friedman and Hercowitz (2010), which were computed based on Israeli data for the 2000s. Parameters of the utility function are from Jaimovich and Rebelo (2009). The details of the calibration 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 calibrated parameter values are listed in Table 1.
### Table 1: Parameters Values

<table>
<thead>
<tr>
<th>Production and Utility Functions</th>
<th>GDP share in output</th>
<th>$\gamma$</th>
<th>0.7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital share in GDP</td>
<td>$\alpha$</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>Depreciation rate of capital</td>
<td>$\delta_k$</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Utility function parameter</td>
<td>$\theta$</td>
<td>0.165</td>
</tr>
<tr>
<td></td>
<td>Depreciation rate of durables</td>
<td>$\delta_d$</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>Discount rate</td>
<td>$\beta$</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Utility curvature</td>
<td>$\sigma$</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Jaimovich-Rebelo</td>
<td>$\xi$</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\varphi$</td>
<td>1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$\psi$</td>
<td>1</td>
</tr>
<tr>
<td>Fiscal Policy</td>
<td>Debt to GDP ratio target</td>
<td>$\eta$</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>Public debt convergence</td>
<td>$\lambda^b$</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>Effective corporate tax</td>
<td>$\tau^c$</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Average tax on labor</td>
<td>$\tau^l$</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Tax on nondurables (VAT)</td>
<td>$\tau^n$</td>
<td>0.165</td>
</tr>
<tr>
<td></td>
<td>Tax on durables (VAT + purchase)</td>
<td>$\tau^d$</td>
<td>0.50</td>
</tr>
<tr>
<td>Other Parameters</td>
<td>Adjustment costs of capital</td>
<td>$\omega^k$</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Adjustment costs of durable goods</td>
<td>$\omega^d$</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>Financial costs</td>
<td>$\omega^f$</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Exports elasticity</td>
<td>$\chi$</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Real interest rate</td>
<td>$r$</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Net portfolio position</td>
<td>$F^*$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Unilateral transfers (% of GDP)</td>
<td>$T$</td>
<td>0</td>
</tr>
</tbody>
</table>

The technology parameters $\gamma$ and $\alpha$ were calibrated using the relevant shares during the 2000s. The parameter $\gamma$ was set equal to the average ratio of imports to output, and the value of $\alpha$ equals the average nonlabor income share in GDP. The depreciation rate of productive capital $\delta_k$ is 2 percent, the average of the quarterly depreciation rates across capital goods.\(^3\) The depreciation rate of durable goods, $\delta_d$, was set at 2.5 percent. Note that durable goods do not include housing; thus,

\(^3\)This is the average depreciation rate from the detailed perpetual capital stock system at the Bank of Israel.
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, \( \omega^f = 0.01 \), estimated in Friedman and Hercowitz (2010), indicates a nonnegligible friction in the financial market. Hence, consumption decisions in the model will be affected by fluctuations in households’ available liquidity. The value of the elasticity of exports 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 \( \theta \) was based on the average ratio \( C^d/C^n = 0.141 \) during the 2000s (excluding housing services in \( C^n \)). The discount rate \( \beta \) 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 fiscal debt to GDP, \( \eta \), was set equal to the Maastricht Treaty required ratio, 0.6, adopted by the Israeli government as well. The rate of convergence of \( B \) to \( B^{**} \) is determined by \( \lambda^b \). According to the rule adopted by the Israeli government in December 2009, this target should be met by the end of the decade (2020). The decline in \( B^* \) when starting from a debt of 80% of GDP implies that, approximately, \( \lambda^b = 0.025 \) (40 quarters).\(^4\) Note this applies to any tax schedule, because the assumption is that \( G \) adjusts 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 to zero. Note that under this value for private net assets, government debt is held abroad.

4. Policy Analysis

In this section we present 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. For this analysis we simulate and discuss impulse responses from the model. These responses are plotted in percentage deviations from the initial steady state along periods of time expressed in quarters since the announcement.

\(^4\)The approximation follows from looking at achieving the middle range ratio 0.7 in half the time, 20 quarters.
4.1. Expected Tax Changes

We address reductions in three tax rates: the labor income tax, $\tau^l$, the corporate tax, $\tau^c$, and the tax on durable goods purchases, $\tau^d$. 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 $\tau^l$; 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 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 investment and for consumption of both types go up with the announcement, as shown in the K, CN and CD panels. 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; 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 balance deficit shown in the TB panel—which increase the marginal productivities of capital and labor. This is the mechanism expanding investment and labor demand before the actual lowering of the tax rate. The initial increase in the wage rate in panel W is a result from the higher labor demand. At the time of implementation, the wage goes down due to the labor supply surge as the labor income tax is cut. This is the force behind the further increase in the domestic product, which this time it can be described as supply driven. The depreciation at that time, and the trade balance turning from deficit to surplus, is consistent with this interpretation. The hike in consumption of both types at that time is due partly to the complementarity of labor supply and consumption in utility, and partly to the increased available liquidity. 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.

\(^5\)In terms of labor supply, both taxes have identical roles—as it can be seen in equation (2.25). Regarding savings, only in the period prior to the implementation, $\tau^c$ differs from $\tau^c_{i+1}$, 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.
Figure 4.1: Future Labor Income Tax Cut
Figure 4.2 addresses a reduction in the corporate income tax $\tau^c$ 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 expansionary effect discussed earlier. Consumption, in contrast, declines due to the liquidity effects of high investment expenses by firms: Dividends are temporarily cut and thus households wish to borrow to smooth consumption. However, lowering $F$ below $F^*$ is costly. As discussed in Section 2.4, this reduces liquidity, which in turn depresses consumption of both types.

The employment cycle—in panel L—is an illustration of the typical effects of the present fiscal rule in an open economy. 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 the large capital accumulation due to the corporate tax cut reduces the amplitude of the cycle as the economy experiences a strong upward trend for large number of 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 $\tau^f$.

Over time, the economy approaches a new steady state with higher capital and inputs. The long-run depreciation is due to the expansionary effect of the lower tax rate 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 demand for durable goods. This case differs from the previous tax cuts because of the sensitivity of investment—in this case in durable consumption goods—to changes in factors determining the optimal stock. The swings in the demand for durable goods purchases dominate here the other effects stressed earlier.

As it can be expected, durable purchases decline sharply at the time of the announcement—as the price to the consumer is expected to go down. Demand for durable goods declines even further till implementation, as 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, 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.
Figure 4.2: Future Corporate Tax Cut

Graphs showing the impact of a future corporate tax cut on various economic indicators:
- GDP (Y)
- Capital Stock (K)
- Hourly Wage (W)
- Labor Input (L)
- Nondurable Consumption (CN)
- Durable Purchases (CD)
- Real Exchange Rate (RER)
- Trade Balance (TB)
- Government Consumption (G)
Figure 4.3: Future Tax Cut on Durable Goods Purchases
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 initial effect is quite contractionary, due to the government spending cut and the resulting depreciation—GDP and employment decline substantially.

Interestingly, the long-run effects are expansionary due to the decline in the government interest payments. This induces a shift of public expenditure towards a higher $G$, which in turn causes a long-run appreciation. The resulting larger imports increase the optimal size of capital and labor demand, leading to a higher level of production. This cycle is, however, quite long. Given the current calibration, GDP becomes higher than the initial level after about 15 years.

5. Concluding Remarks

We use an open-economy model to analyze fiscal policy based on exogenous changes in tax rates and in the public debt target. The model is an updated version of the Bruno-Sachs framework, 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 because a higher relative price implies a relatively lower cost of imported inputs. The model has the Keynesian feature that aggregate demand shocks can generate positive comovements of production, labor input, consumption and investment, similarly as productivity shocks do in the neoclassical closed-economy model.

The analysis concentrates first on tax cuts. We trace their macroeconomic effects from the announcement through the implementation to convergence to the long-run levels. Specifically, we deal with cuts in the tax rates on labor income, corporations, 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 and investment demand increase due to wealth effects and 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 as the corresponding tax rates 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 sharply, and thus it
Figure 4.4: Lowering the Public Debt/GDP Target

GDP (Y)

Capital Stock (K)

Hourly Wage (W)

Labor Input (L)

Nondurable Consumption (CN)

Durable Purchases (CD)

Real Exchange Rate (RER)

Trade Balance (TB)

Government Consumption (G)
has a strong contractionary effect. The implementation affects the economy in the opposite direction.

The adoption of a lower public-debt/GDP 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 the economy, 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 works similarly as a productivity shock. Hence, labor supply reacts to two opposite forces: The wealth effect which reduces work effort, and the increased demand for labor which increases it by higher wages. The latter effect is absent in the closed-economy setup.
References


