Advances

Open Access

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Fiscal policy in an open economy

DOI 10.1515/bejm-2015-0064

Previously published online October 14, 2015

Abstract: This paper analyzes the quantitative 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. In particular, we concentrate on pre-announced tax cuts, as well as on the adoption of a lower debt target – following policies conducted in Israel during the 2000s. We construct a model where domestic production requires imported inputs, and simulate the effects of these policies. The analysis focuses on the dynamics generated by the announcements of these policy steps, followed by their implementation. The model has the implication that a credible announcement of a future tax cut has an expansionary effect on impact, similar in nature to the effects of productivity shocks. Also, the model implies that the announcement of a lower public debt/GDP target has a contractionary effect, while its implementation leads to higher output in the long-run.

Keywords: fiscal policy; open economy; preannounced tax cuts.

1 Introduction

This paper addresses the quantitative macroeconomic implications of preannounced fiscal policy changes in an open economy. A basic aspect of the analysis is a fiscal policy regime characterized by (a) an exogenous path of tax rates, generated for example by international tax competition or a political commitment, and (b) a public debt/output target, motivated by the desire to keep debt at internationally accepted levels such as the Maastricht 60 percent benchmark.

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Government spending then accommodates the tax rates and the debt target. The fiscal policies we analyze are changes in the announced paths of different tax rates and in the public debt target. The paper focuses on the interaction of this fiscal setup and the open nature of the economy. In the following paragraphs we elaborate first on the fiscal policy setup, on the implications of the openness of the economy, and then on the interaction of these two elements.

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 this fiscal setup is the type of fiscal policy conducted in Israel during the 2000s. In 2003, the government announced a multi-year tax-cut program. Between the years 2003 and 2008, the tax-cut program was fully implemented. In 2009, the government extended its commitment to cut tax rates, which was honored till 2012, when the declining tax rate path was abandoned. In a parallel manner, the government also committed to reduce the public debt to GDP ratio. In 2003, this ratio was 93 percent. In 2009, when public debt was 80 percent of GDP, the government adopted the Maastricht benchmark of 60 percent of GDP as a target to be reached by 2020. As a consequence of the resulting tightening of the budget, government expenditures as a fraction of GDP were gradually reduced during this period.

Although motivated by this historical episode, we do not see the paper as one about Israel only, but rather as a framework for the analysis of preannounced tax changes and fiscal consolidation in open economies in general. Such policies are widely adopted. For example, EU countries have a public debt target, and Japan's plan to reduce the corporate tax in 2015 and increase the VAT in 2017 is an example of a preannounced tax plan.

A key characteristic of these tax changes is that they are preannounced. We adopt this characteristic in our analysis, and study the macroeconomic behavior from announcement till implementation and from implementation onwards.

The main open economy aspect of the analysis is the role of imports as intermediate inputs in the production of domestic output. In this setup, a decline in the price of imports relative to domestic output – a “real appreciation” – increases the use of imported inputs. Correspondingly, a “real depreciation” reduces the demand for imported inputs.

To illustrate the interaction between the fiscal regime and the open nature of the economy, let us consider an announcement of a future tax cut on labor income. First, the prediction of a future tax cut has a positive wealth effect on private consumption. The Ricardian equivalence does not hold with the present

fiscal setup – given that government spending accommodates to lower tax revenues. Such increase in demand causes a real appreciation, which triggers higher imported inputs. The resulting boost to imported inputs has similar short-run effects to a typical productivity shock in the standard real business cycle model: It increases the marginal productivity of labor and capital; hence, it induces higher labor demand, investment and output. We summarize the effects of the announcement of a future tax cut as a positive demand shift, which brings about an appreciation and higher output.

Then, when the tax cut is implemented, two main effects take place. One follows directly from the fiscal rule. Lower taxes dictate lower government spending. Hence, when the tax cut is implemented government spending declines, reversing the initial rise in output demand. The other effect comes directly from the lower tax rate, which motivates higher labor supply and capital formation. This can be described as an expansion of output supply. Therefore, the resulting path of output from implementation onwards depends on the relative strength of lower demand and higher supply. In terms of the real exchange rate, both effects generate a real depreciation.

The analysis is carried out by running experiments of tax cut announcements, as well as the adoption of a lower public debt target in an open economy model calibrated to the Israeli economy.

The paper proceeds as follows. The model is presented in Section 2, and Section 3 reports the results from the quantitative analysis of the fiscal policy steps. Section 4 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.

We deviate from the standard functional forms only to adapt the model to the issue being analyzed. The main open economy aspect is that imported inputs are an argument of the production function. 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 domestic production is negatively affected by the relative price of imports. We also adopt costs of foreign borrowing or lending, as in

Schmitt-Grohe and Uribe (2003). This particular feature facilitates the computational solution of the model, and at the same time add realism by linking effective interest rates to borrowing. The utility function, adopted from Jaimovich and Rebelo (2009), allows us to deal in a sensible way with labor supply in the presence of expected future events.

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. The latter 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 at time t , F_t , from an exogenous level F^* involve a cost. We define below the effective domestic interest rate r_p , 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 consumption from permanent income behavior.

2.1 Production

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

$$Q_t = Y_t^\gamma M_t^{1-\gamma}, \quad 0 < \gamma < 1, \quad (1)$$

where Y_t is domestic value added 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: Raw materials for production account for about 50 percent of

imported goods, 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 :

$$Y_t = K_t^\alpha L_t^{1-\alpha}, \quad 0 < \alpha < 1. \quad (2)$$

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

Substituting (2) into (1), we get the production function for output:

$$Q_t = K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma} M_t^{1-\gamma}. \quad (3)$$

The capital stock evolves according to

$$K_{t+1} = K_t(1-\delta) + I_t, \quad 0 < \delta < 1, \quad (4)$$

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

Changing the capital stock involves adjustment costs of the form

$$J_t^k = \frac{\omega^k}{2} (K_{t+1} - K_t)^2, \quad \omega^k > 0. \quad (5)$$

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

$$\Pi_t = (1-\tau_t^k) [K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma} M_t^{1-\gamma} - W_t L_t - P_t^m M_t] - J_t^k - I_t, \quad (6)$$

where τ_t^k is the corporate tax rate. We assume for simplicity that the depreciation of the capital stock and the adjustment costs are not tax deductible. In the calibration, deductions are taken into account by using the effective tax rate. 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 can be financed by borrowing from shareholders. Given that 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

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

where r_t is the effective real interest rate, which is defined later on.

The first-order conditions are

$$1 + \omega^k (K_{t+1} - K_t) = \frac{1}{1+r_t} \left[(1-\tau_{t+1}^k) \alpha \gamma K_{t+1}^{\alpha\gamma-1} L_{t+1}^{(1-\alpha)\gamma} M_{t+1}^{1-\gamma} + \right. \\ \left. 1 - \delta + \omega^k (K_{t+2} - K_{t+1}) \right], \quad (7)$$

$$W_t = (1-\alpha) \gamma K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma-1} M_t^{1-\gamma}, \quad (8)$$

$$P_t^m = (1-\gamma) K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma} M_t^{-\gamma}. \quad (9)$$

Condition (7) for the optimal capital stock involves the effective interest rate – the financial cost – the adjustment costs for capital and corporate taxes, and (8), (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 demand for these two inputs as function of the prices:

$$L_t = \vartheta^l K_t (W_t)^{-\frac{1}{\alpha}} (P_t^m)^{\frac{(1-\gamma)}{\alpha\gamma}}, \quad (10)$$

$$M_t = \vartheta^m K_t (W_t)^{-\frac{1-\alpha}{\alpha}} (P_t^m)^{\frac{1-\gamma(1-\alpha)}{\alpha\gamma}}, \quad (11)$$

where $\vartheta^l = [(1-\alpha)\gamma]^{\frac{1}{\alpha\gamma}} \left(\frac{1-\gamma}{(1-\alpha)\gamma} \right)^{\frac{1-\gamma}{\alpha\gamma}}$ and $\vartheta^m = [(1-\alpha)\gamma]^{\frac{1}{\alpha\gamma}} \left(\frac{1-\gamma}{(1-\alpha)\gamma} \right)^{\frac{1-\gamma(1-\alpha)}{\alpha\gamma}}$. A key property of (10) and (11) is the negative effect of the relative price of imported goods on the demand for labor and imports.

2.3 Preferences and household's constraints

The household consumes consumption goods, C_t and supplies labor, L_t .

To deal realistically with anticipation effects on labor supply – as elaborated below – preferences of the representative household have the form proposed by Jaimovich-Rebelo (2009):

$$\sum_{t=0}^{\infty} \beta^t \frac{(C_t - \psi L_t^\varphi Z_t)^{1-\sigma}}{1-\sigma}, \quad 0 < \beta < 1, \quad \varphi > 1, \quad \psi > 0, \quad \sigma > 0, \quad (12)$$

$$Z_t = C_t^\xi Z_{t-1}^{1-\xi}, \quad 0 \leq \xi \leq 1. \quad (13)$$

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.

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

$$J_t^f = \frac{\omega^f}{2} (F_{t+1} - F^*)^2, \quad \omega^f > 0, \quad (14)$$

adopted from Schmitt-Grohe and Uribe (2003) as a way to provide a steady state to the model. Additionally, 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 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 . The tax rates directly affecting the household's decisions are: τ_t^l on labor income and τ_t^c on consumption.¹ We assume for simplicity that dividends are not taxed. Hence, τ^k reflects all capital income taxation. The one-period household's budget constraint is given by

$$(1 + \tau_t^c)C_t = (1 - \tau_t^l)W_t L_t + \Pi_t + T_t + (1 + \bar{r})F_t - F_{t+1} - J_t^f. \quad (15)$$

¹ The corporate tax rate has only an income effect working via the dividends.

2.4 The household's optimization problem

The household chooses sequences of C_t , L_t and F_{t+1} to maximize the utility function in (12) and (13), subject to the sequences of financial costs in (14) and the constraint in (15), as well as the initial assets F_0 .

Defining

$$\begin{aligned} S_t &\equiv C_t - \psi L_t^\varphi Z_t, \\ U_c(t) &\equiv S_t^{-\sigma}, \\ U_l(t) &\equiv -S_t^{-\sigma} (\psi \varphi L_t^{\varphi-1} Z_t), \\ U_z(t) &\equiv -S_t^{-\sigma} (\psi L_t^\varphi), \end{aligned}$$

and Υ_t^c and Υ_t^z as the Lagrange multipliers of the budget constraint (15) and the equation for Z_t in (13), the first-order conditions are²

$$0 = U_c(t) - \Upsilon_t^c (1 + \tau_t^c) - \Upsilon_t^z \xi (C_t)^{\xi-1} Z_{t-1}^{1-\xi}, \quad (16)$$

$$0 = -\Upsilon_t^c + \beta \frac{(1 + \bar{r})}{1 + \omega^f (F_{t+1} - F^*)} \Upsilon_{t+1}^c, \quad (17)$$

$$0 = U_l(t) + \Upsilon_t^c (1 - \tau_t^l) W_t, \quad (18)$$

$$0 = U_z(t) + \Upsilon_t^z - \beta \Upsilon_{t+1}^z (C_{t+1})^\xi (1 - \xi) Z_t^{-\xi}. \quad (19)$$

To provide intuition on these optimality conditions, we concentrate now on the case where the utility function is standard, i.e. $\xi=1$ (or $Z_t=C_t$), and the tax rates in periods t and $t+1$ are equal. In this case, the first-order conditions can be written as

$$U_c(t) = \beta \frac{(1 + \bar{r})}{1 + \omega^f (F_{t+1} - F^*)} U_c(t+1), \quad (20)$$

$$-U_l(t) = U_c(t) \left(\frac{1 - \tau^l}{1 + \tau^c} \right) W_t. \quad (21)$$

Equation (20) is the Euler equation which leads to consumption smoothing when $\omega^f=0$, and (21) is the standard optimal labor supply condition, where the return to labor supply depends negatively on the tax rates. The nonstandard element appears in (20). Defining the effective interest rate as

² For each period t , there are six unknowns: C_t , F_{t+1} , L_t , Z_t , Υ_t^c , Υ_t^z and 6 equations (the 4 first-order conditions, the budget constraint and the equation for Z_t).

$$1+r_t \equiv \frac{(1+\bar{r})}{1+\omega^f(F_{t+1}-F^*)}, \quad (22)$$

it goes up when assets are driven down, or when borrowing. This mechanism is similar to a flexible interest rate which depends on the debt level. Substituting (22) into (20) yields the standard Euler equation

$$U_c(t) = \beta(1+r_t)U_c(t+1),$$

where financial costs are included in r_t .

2.5 Fiscal policy

The modeling of fiscal policy captures the main features of the actual policy in Israel in the period 2003–2012. In 2003, the government announced simultaneously a multi-year tax-cut program till 2008 and a commitment to reduce the ratio of public debt to GDP. In 2009, the declining tax rates and public debt were announced to be continued. The plan was fully implemented till 2012. Along those lines, we model government expenditures as endogenous to the exogenous tax rates and public debt target. We denote the tax rates path as

$$\{\tau_t^l, \tau_t^k, \tau_t^c\}_{t=0}^\infty,$$

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

$$B_{t+1}^* = \eta Y_{t+1}. \quad (23)$$

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

$$\hat{B}_{t+1}^* = \hat{B}_t^* (B_t^* / \hat{B}_t^*)^\lambda, \quad 0 < \lambda < 1, \quad (24)$$

where λ governs the speed of adjustment to the target.

Total revenue from taxation is

$$R_t = \tau_t^l W_t L_t + \tau_t^k (Q_t - W_t L_t - P_t^m M_t) + \tau_t^c C_t. \quad (25)$$

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 additional 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

$$G_t \leq R_t + \hat{B}_{t+1}^* - (1 + \bar{r})B_t - T_t. \quad (26)$$

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

$$B_{t+1} = \hat{B}_{t+1}^*. \quad (27)$$

2.6 Rest of the world

The rest of the world demands the domestic good according to

$$X_t = X^0 (P_t^x)^\chi, \quad \chi > 0, \quad (28)$$

where X^0 is a scale parameter reflecting, for example, the volume of the world trade, and P_t^x 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

$$P_t^{xm} = \frac{P_t^x}{P_t^m}, \quad (29)$$

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

$$\bar{r} = \frac{1 - \beta}{\beta}. \quad (30)$$

This is consistent with foreign financial traders having the same rate of 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.

The equilibrium condition in the output market is

$$Q_t = C_t + I_t + G_t + X_t + J_t^k + J_t^f. \quad (31)$$

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 (10) and imports demand from (11) into the production function (3), while the wage equals the households' rate of substitution between consumption and leisure in (18). 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 (28) and (29) 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 an 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 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 (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 (1) we get

$$P_t^y = \gamma \frac{Q_t M_t^{\frac{1-\gamma}{\gamma}}}{Q_t^{\frac{1}{\gamma}}} = \gamma \left(\frac{M_t}{Q_t} \right)^{\frac{1-\gamma}{\gamma}}. \quad (32)$$

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:

$$RER_t = \frac{P_t^m}{P_t^y} = P_t^m \frac{1}{\gamma} \left(\frac{Q_t}{M_t} \right)^{\frac{1-\gamma}{\gamma}}. \quad (33)$$

3 Quantitative policy analysis

In this section we first discuss the calibration of the model, and then present the results from the analysis of fiscal policies: preannounced tax rate cuts on corporate and labor income, and the adoption of a lower target for the ratio of public debt to GDP. The purpose of these experiments is to analyze and measure quantitatively the effects of changing each one of these fiscal variables. The starting point of the simulations is a steady state with $B/Y = B^*/Y = 0.8$.

The effects of each tax rate in isolation, we hold constant the other tax rates and other exogenous variables – as technology and foreign prices – and the public debt target. Otherwise the results would reflect a mixture of effects. Similarly, to see the effects of lowering the public debt target, we hold constant the tax rates and the exogenous variables.³

The results are presented by impulse responses computed from the calibrated model. These responses are plotted in percentage deviations from the initial steady state along periods of time expressed in quarters since the announcement.

The model is solved using a perfect foresight procedure given the future path of the particular tax rate. The equations keep their nonlinear form, i.e. there is no need to linearize. The initial situation is the steady state with the tax rate prior to the announced change. From the first period of the simulation, when the announcement arrives, till implementation, the tax rate stays at the initial level, i.e. the expectations are the only reason for changes. At implementation the tax rate actually changes, and then the economy converges to the steady state with the new tax rate. The graphs in the main text do not show the convergence in

³ In Israel, during the 2000s, these changes happened simultaneously and along with other exogenous changes. Our experiments disentangle the effects of these fiscal policies.

order to highlight the developments in the periods till implementation and right afterwards. Long-run convergence of the experiments are shown in the Appendix.

3.1 Calibration

The parameter values were computed using the Israeli quarterly data for the sample 2000–2012, or from empirical work on the Israeli economy. The parameter values are listed in Table 1 and discussed below.

The technology parameters γ and α corresponds to the relevant shares: The value $\gamma=0.7$ was computed using the average ratio of imports to GDP in the sample, which in the model equals $1/\gamma-1$, and the labor share in GDP, α , has the standard value 0.3. The depreciation rate of productive capital δ is 0.017.⁴

For preferences, 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. The

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	0.017
Discount rate	β	0.99
World interest rate	$\bar{r}$	0.01
Utility: Curvature	σ	1
Utility: Jaimovich-Rebelo	ξ	0.001
	φ	1.5
	ψ	1
Fiscal policy		
Public debt to GDP target ratio	η	0.6
Public debt to GDP initial ratio		0.8
Public debt convergence	λ	0.025
Effective corporate tax	τ^k	0.125
Average tax on labor	τ^l	0.209
Value added tax	τ^c	0.165
Transfer payments	T/Y	0.12
Other parameters		
Exports elasticity	χ	0.2
Net private portfolio position	F/Y	0.47
Adjustment costs of capital	ω^k	0.075
Costs of assets away from target	ω^f	0.001

4 The depreciation rate is from the perpetual capital stock system at the Bank of Israel.

other preference parameters are adopted from Jaimovich and Rebelo in a similar context. Setting $\xi=0.001$ implies a very weak income effect on labor supply in the short run, and $\varphi=1.5$ 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, which was adopted by the Israeli government as well. The initial ratio 0.8 corresponds to the average during the sample. 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 in 40 quarters, starting from 0.8 in 2009, implies that λ should be approximately 0.025.⁵

The tax rates are the average values during the sample. The corporate tax rate τ^k refers to the effective rate of 12.5 (18 percentage points lower than the statutory average rate of 30.5 percent). The labor tax rate corresponds to the marginal tax rate for the bracket including the average wage: $\tau^l=0.21$, and the consumption tax rate $\tau^c=0.165$ is the average value added tax rate. Average transfers to the public, T , amount in this sample to 12 percent of GDP.

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).

The fraction F^*/Y is computed using the equation: $NIIP/Y=F/Y-B/Y$, which says that the Net International Investment Position, which reflects the net assets of the economy as whole, equals the private net assets less government foreign debt. In this model we assumed that all government debt is foreign. Given the average ratio $NIIP/Y$ in the sample of -0.13 , and the public debt target B^*/Y of 0.6, we get $F^*/Y=0.47$.

Remain to be calibrated the parameters ω^f and ω^k . The calibration of ω^f is based on the definition of the effective interest rate in (22), which, expressing assets/debt as fractions of steady-state output, can be written as

$$\frac{1+\bar{r}}{1+r_t} = 1 + \omega^f Y^* (\mu_{t+1} - \mu^*), \quad (34)$$

where $\mu_{t+1} \equiv F_{t+1}/Y^*$, $\mu^* \equiv F^*/Y^*$. We base the calibration of ω^f on the typical premium Israeli banks paid in June 2014 on larger deposits. For maturities of 60–89 days, the rate on a deposit of 6 times per-capita quarterly GDP is 16.7 percent higher than the rate on per-capita quarterly GDP (about NIS 30,000, or U\$S 8500). For

⁵ The approximation follows from computing the time it takes to achieve the half-way ratio of 0.7, which equals 20 quarters.

maturities between 180 and 364 days the corresponding differential is 33 percent. We adopt the simple average of 25 percent. Centering steady state output on per-capita quarterly GDP, and using the rate differential on an asset of 6 times the size of steady state output, the implied value of ω^f from (34) is 0.001.⁶

The value of ω^k is based on the assumption that completing a large investment project takes 2 years. Practically, we set the capital stock 5 percent below the steady state, and search for the value of ω^k for which after four quarters the capital stock is 2.5 percent below the steady state. The resulting value is 0.075.

3.2 Expected tax changes

We address reductions of one percentage point in two tax rates: The corporate tax, τ^k , and the labor income tax, τ^l . Changes in the consumption tax rate have similar effects as those for the labor tax.⁷ 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. The graphs in the text describe the first 50 quarters in order to clearly see the before-and-after implementation cycle. The vertical dotted lines indicate implementation. Convergence to the long-run is shown in the Appendix.

Figure 1 shows the implications of reducing the corporate tax, τ^k , from 0.125 to 0.115. We look first at the 10 quarters prior to the implementation. The announcement of the corporate tax cut impacts the economy via increasing the optimal capital stock. Given adjustment costs, investment starts right away, causing an appreciation – as shown in the *RER* panel – which has the expansionary effect stressed earlier: The appreciation reduces the cost

⁶ Using equation (34), the computation is as follows:

$$\frac{1+\bar{r}}{1+1.25\bar{r}} = \frac{1.04}{1.05} = 1 - \omega^f Y^* \times (6-1),$$

$$\omega^f \approx \frac{0.002}{Y^*} = 0.00113,$$

where $Y^*=1.77$ is the steady state output given the other parameter values. Note that the steady state does not depend on the values of the parameters ω^f and ω^k , which affect only the dynamics.

⁷ As it is well known, both taxes have identical roles in the labor supply condition – equation (21) here. Regarding savings, only in the period prior to the implementation, τ_c^c differs from τ_{t+1}^c , 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 1: Corporate tax cut.

of intermediate inputs, and thus motivates higher labor demand. This shows in higher wages (W) and labor input (L), as well as higher GDP . Consumption increases for two reasons: First, there is a positive wealth effect of future higher dividends, and, given the utility function adopted, higher labor supply increases the marginal utility from consumption. Households finance the consumption surge by borrowing – reflected in the reduction of private assets (F). Private borrowing finances also the drop in dividends, which are cut by firms to finance investment. This borrowing triggers higher effective interest rates – not shown because it behaves opposite to F according to equation (22). Higher effective interest rates moderate the consumption and investment surges. Government spending (G) also increases, given that higher economic activity increases tax revenues.

At the time of implementing the tax cut, government spending drops according to the fiscal rule. This decline in the demand for output causes the real exchange rate to move from below the initial level to above the initial level. This depreciation slows down economic activity by increasing the cost of imported

inputs. Labor demand goes down, thereby reducing wages and labor input, as well as *GDP*.

This slowdown following the acceleration prior to implementation constitutes the cycle generated by the fiscal rule stressed in this paper. The corresponding consumption decline implies that household start to save after the period of borrowing – which shows in the positive slope of the private assets *F*.

Figure 2 shows the effects of a one percentage point reduction of τ^l ; from 0.21 to 0.20. As for the corporate tax cut, the early expansion is demand driven. In the present case, it is the demand for consumption, generated by the wealth effect from expected lower taxes, which drives the expansion. The consumption surge is shown in the *C* panel, and the resulting appreciation is shown in the *RER* panel. The decline in the relative price of imported inputs induces higher imports, which increase labor demand, the real wage, and labor input.

The developments from implementation onwards differ from the corporate tax case because the actual reduction of the labor tax causes a large labor supply

Figure 2: Labor income tax cut.

surge, which increases economic activity further. The wage (W) drops with implementation due to the labor supply surge. This is the force behind the further increase in domestic output. Hence, we not observe a cycle, but rather a two-step increase in economic activity.⁸

The behavior of private assets is similar to that in the corporate tax case – initial borrowing to finance current consumption. Borrowing generates higher effective interest rates – which, again, can be inferred directly from the behavior of F – which dampen the consumption reaction.

Convergence to the long-run levels of the two tax cuts is shown in the Appendix. The utility function, in which the wealth effect on labor supply takes place very slowly, generates a slow convergence, as well as an over-shooting of the effects – specially for the labor tax cut – while the income effect of the tax cuts on labor supply are weak. The tax cuts have the expected long-run positive effects on the capital stock, *GDP* and consumption, as well as the expected negative effect on G due to the fiscal rule. The long-run depreciation follows from the positive effect of the tax cuts on the long-supply of domestic goods. On labor input, the effect of lowering the labor income tax is positive – as it can be expected – while the effect of lowering the corporate tax is negative. The latter effect is due to the dominating wealth effect on labor supply.

It should be noted that these simulations assume that the target public debt to GDP ratio remains at the initial value of 0.8. Otherwise, the simulations would show a mixture of the dynamics generated by a gap between the actual and the public debt target – analyzed next – and the effects of the tax changes themselves.

3.3 Lowering the public debt target

Figure 3 shows the response to the adoption of a public debt to GDP target of 0.6 when the current level is 0.8 – the sample 2000–2012 average. The driving force following adoption of the new target is the reduction of government demand. The immediate effect is contractionary due to the resulting depreciation: GDP and employment decline substantially.

Following the initial cut, government spending recovers, driving upwards the other macro variables. This expansion is due to the decline in government interest payments, which, given the fiscal rule, makes possible to shift public

⁸ Also in the corporate tax case there was an increase in an input – the capital stock in that case. However, capital has a lower share in the production function than labor.

Figure 3: Lowering the target public debt to GDP ratio.

expenditure towards government purchases of goods. This spending recovery causes an appreciation that increases labor demand, capital accumulation and output. This cycle is quite long. Eventually, GDP crosses the initial level, and the economy converges to an appreciated real exchange rate – following higher government demand for output – and thus a higher level of economic activity. Convergence to the long-run levels is shown in the Appendix.⁹

⁹ Given that our model is deterministic, we ignore the possible link between public debt and sovereign risk. The analysis of tax changes should not be affected by ignoring this link because the debt target is held constant, and thus actual debt does not move much during the dynamics. Here, however, the situation is different. As shown in Figure 3, adopting the 0.6 target starts a gradual process of debt decline. Hence, in the short run the debt is not far from the initial value, and hence the missing link with sovereign debt is probably not very important. In the longer run, however, as the debt approaches the lower level, the issue of declining sovereign risk should be more relevant. Hence, not dealing with endogenous changes in sovereign risk probably underestimates the long-run benefits of the lower public debt.

4 Concluding remarks

We use an open-economy model to analyze exogenous changes in tax rates and in the public debt target. The equilibrium concept is based on the Bruno-Sachs framework (Bruno and Sachs 1985), 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 price 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 one source of output demand, say investment due to lowering corporate taxes, generates positive comovement of output with investment, consumption and labor input. This positive comovement does not hold with demand shocks in the closed economy neoclassical model due to crowding out. In this open-economy setup, demand shocks generate higher productivity of factors of production – similarly as productivity shocks do in the neoclassical model.

The analysis focuses on tax cuts, from announcement to implementation and beyond. Specifically, we address tax cuts on labor income and corporate profits. 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.

We then consider lowering of the public debt to 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 adds a new effect relative to the closed-economy setup. Here, news of higher disposable income in the future causes an appreciation that increases labor demand – and thus works similarly as a current positive productivity shock.

Acknowledgments: We thank an anonymous referee for very useful comments.

Appendix: Convergence Graphs

Figure A1: Long-run effects of a corporate tax cut.

Figure A2: Long-run effects of a labor income tax cut.

Figure A3: Long-run effects of lowering η .

References

- Barro, Robert J. (1979) "On the Determination of the Public Debt." *Journal of Political Economy* 87: 940–971.
- Beaudry, Paul, and Franck Portier (2007) "When Can Changes in Expectations Cause Business Cycle Fluctuations in Neo-Classical Settings?" *Journal of Economic Theory* 135(1): 458–477.
- Bruno, Michael, and Jeffrey Sachs (1985) *Economics of Worldwide Stagflation*. Cambridge, MA: Harvard University Press.
- Friedman, Amit, and Yaacov Lavi (2006) "The Real Exchange Rate and Foreign Trade in Israel." *Bank of Israel Review* 79: 37–86 (Hebrew).
- Jaimovich, Nir, and Sergio Rebelo (2009) "Can News about the Future Drive the Business Cycle?" *American Economic Review* 99(4): 1097–1118.
- King, Robert G., Plosser, Charles I., and Sergio T. Rebelo (1988) "Production, Growth and Business Cycles I. The Basic Neoclassical Model." *Journal of Monetary Economics* 21, 195–232.
- Schmitt-Grohe, Stephanie, and Martin Uribe (2003) "Closing Small Open Economy Models." *Journal of International Economics* 61(1): 163–185.