

TAX CUTS AND ECONOMIC ACTIVITY: ISRAEL IN THE 2000s

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Abstract

This paper evaluates the quantitative macroeconomic effects of the persistent decline of income and corporate tax rates in Israel during the 2000s. The analysis is based on the simulation of a calibrated model, given a parameterized version of the tax rates process in this period. The results indicate an important contribution of the tax process to the expansion of GDP during the 2000s.

1. INTRODUCTION

Income and corporate tax rates in Israel declined persistently from 2002 to 2011. The statutory corporate tax rate declined from 36 percent to 24 percent, and the average marginal rate on labor income went down from 33 percent to 19 percent.¹

Table 1 shows the declining paths of the statutory corporate tax rate and the average marginal tax rate over this period. The table also shows the planned continuing decline of the corporate tax rate until 2016—as of 2009—and the reversal in 2012.

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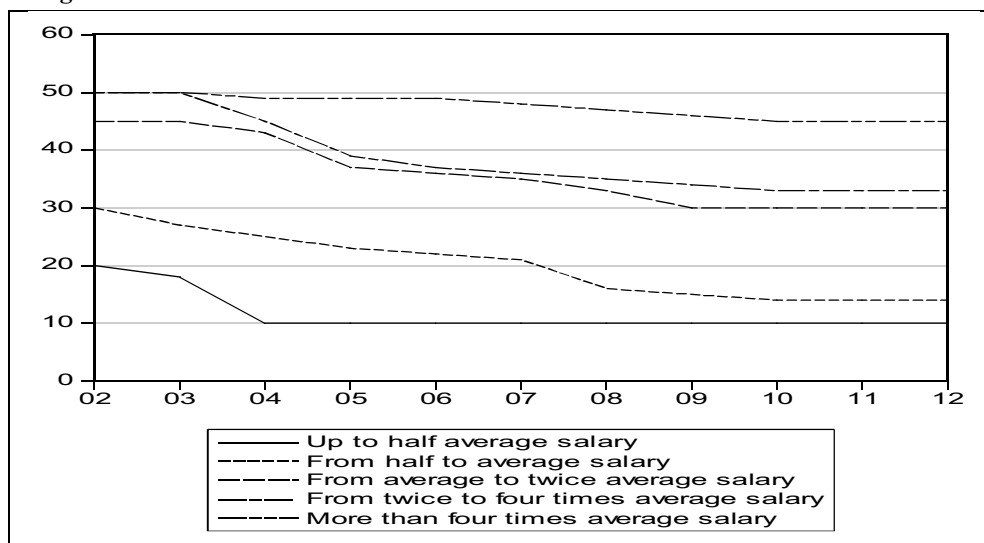
¹ The average marginal rate is computed using the marginal rates for five groups: (1) Up to half the average salary; (2) From half to the average salary; (3) From the average to twice the average salary; (4) From twice to four times the average salary; and (5) More than four times the average salary. The weights of these five groups, corresponding to 2005, are: 0.27, 0.40, 0.20, 0.11 and 0.02.

Table 1
Tax Rates in Israel

Actual 2002–2012 – Planned as of 2009 in parentheses		
	Labor Average Marginal Rate	Statutory Corporate Rate
2002	33	36
2003	31	36
2004	27	35
2005	24.5	34
2006	24	31
2007	23	29
2008	20.5	27
2009	19.5	26
2010	19	25
2011	19	24
2012	19(19)	25(23)
2013	(19)	(22)
2014	(19)	(22)
2015	(19)	(20)
2016	(19)	(18)

Figure 1 portrays the marginal tax rates by five income brackets, from less than half the average salary to more than four times the average salary. Of these five brackets, the three in the middle are those for which the rate declined the most—15–16 percentage points. The top bracket rate declined 5 percentage points and the lowest bracket rate declined 10 percentage points.

Figure 1
Marginal Tax Rates on Labor Income



During the same period, which includes the global financial crisis, output growth in Israel was high by world standards. Average per capita GDP growth in Israel from 2002 to 2011 was 1.8 percent—in spite of the strong contractionary effect of the Second Intifadah in the early years of this period—while in the OECD, per capita growth in the same period was only 1 percent.

This paper addresses the question how much of the high growth rate in Israel can be attributed to the declining path of tax rates. The underlying hypothesis is that lowering tax rates on labor and corporate income encourages labor supply and capital accumulation. Hence, the declining path of tax rates should induce higher growth rates during the adjustment to the lower tax rates. The sudden reversal of this process in 2011 should then affect the economy in the opposite direction.

Given budget constraints, government spending during this period declined along with the tax rates. Clearly, this reduction in government services should have an impact in the short run or in the long run on the private sector, either on output, welfare, or both. Attempting to evaluate the combined effect of lowering taxes and government services on economic activity or welfare is well beyond the scope of this paper. Hence, the present analysis cannot provide an answer to the question whether the fiscal behavior during this period was a good or a bad policy. We concentrate here on the effects of tax changes on economic activity—interpreting this approach as evaluating the macroeconomic cost of financing government spending. The decision whether a government expenditure for a given purpose should be undertaken or not is made by the elected institutions. Our quantitative results can be useful in this type of decision by providing estimates of the costs in terms of economic activity.

The Israeli experience during the 2000s provides a close-to-natural experiment in exogenous tax changes, induced apparently by similar tax changes abroad in the previous decade, and by the ideological view guiding fiscal policy during the period. In 2002/3, the government announced a multi-year gradual tax-cut program to last until 2007. In 2005, the declining tax rate path was extended until 2010. The steps of the plan were fully implemented. In 2009, given the global economic crisis, the government committed to further corporate tax cuts until 2016. However, the declining tax rate path was abandoned in 2011 in response to widespread social unrest and demands for greater government services. The corporate tax rate was increased from 24 percent in 2011 to 25 percent in 2012 instead of the planned 23 percent on its way down to 18 percent in 2016. Hence, the experiment includes not only a credible declining tax path until 2011, but also an unexpected change of direction in 2012.

In spite of the exogenous nature of these tax changes, they are in fact one episode which cannot be used for econometric testing. Instead, we adopt a simulation methodology to evaluate the implications of these tax changes using a model calibrated to the Israeli economy.

The evaluation is carried out as follows. We parameterize and calibrate the tax rate process from 2002/3 onwards, involving the initial announcements and the probabilities of modifying and abandoning the plan. Then, we impose this process on a calibrated model of the Israeli economy. Because we leave out all other possible exogenous changes, the evolution of the model economy is due solely to the tax process. In this way we control for all

other sources of macroeconomic changes quite differently than the way econometricians do, which is to incorporate these other exogenous changes in order to control for them. Then, by comparing actual growth during the 2001–2012 period to that generated by the model, we can evaluate the contribution of the tax rate changes.

The tax changes are analyzed in the context of the following interpretation of the fiscal regime in place in Israel during the 2000s: Tax rates are exogenous, as is the public debt/GDP target of 0.6. Hence, government expenditures are endogenous to tax revenues and to the public debt convergence process to the target. This fiscal setup reverses the role of the fiscal variables relative to the usual setup, as in Barro's (1979) classic fiscal framework. There, government spending is exogenous, whereas the tax rates and the public debt are determined endogenously.

This fiscal regime implies that the results reflect not only the direct effect of the changes in tax rates, but also the indirect effects of the required adjustments in government spending.

We use a real small open economy model optimizing households and firms, and a government following the fiscal rule described above. There is imperfect capital mobility from and to abroad. Production requires an imported input, whose endogenous relative price in terms of domestic output—the real exchange rate—is an important transmission mechanism of exogenous changes.

The tax process affects the economy first through the announcements of future tax changes, and then through the actual tax changes once they are implemented. The announcement of a reduction in income or corporate tax rates increases households' demand for consumption and firms' demand for physical capital. This surge in demand generates a real appreciation which makes imported inputs cheaper. As a consequence, in the early stages of the tax change domestic production increases along with an appreciation. Later on, as labor supply expands and capital accumulates, the supply of goods increases along with a depreciation.

The paper proceeds as follows. The model is presented in Section 2, while Section 3 reports the model's quantitative implementation—solution method, calibration and simulation results. Section 4 concludes.

2. THE MODEL

The present framework is based on the model in Friedman, Hercowitz and Sidi (2015). We incorporate a tax rate process involving uncertainty about the future evolution of tax rates, and evaluate the implications of adopting this process for macroeconomic dynamics.

a. Production

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

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

where Y_t is domestic value added and M_t is imports of intermediate products. All imports are treated as intermediate inputs, as in reality their market price includes a large fraction of domestic value added.

Value added, or GDP, is produced with capital, K_t , and labor input, L_t :

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

Technology is held constant, given our methodology of allowing only taxes to be the source of exogenous changes.

Capital stock evolves according to

$$(3) \quad K_{t+1} = K_t(1 - \delta) + I_t, \quad 0 < \delta < 1,$$

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

Changing the capital stock involves adjustment costs of the form

$$(4) \quad J_t^k = \frac{\omega^k}{2}(K_{t+1} - K_t)^2, \quad \omega^k > 0.$$

b. The Firm's Optimization Problem

The firm takes prices as given. These prices are the wage, W_t , and the price of imports, P_t^m , both in terms of domestic output, and the effective interest rate r_t to be defined later.

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

$$(5) \quad \Pi_t = (1 - \tau_t^k) \left[K_t^{\alpha\gamma} L_t^{(1-\alpha)\gamma} M_t^{1-\gamma} - W_t L_t - P_t^m M_t \right] - J_t^k - I_t,$$

where τ_t^k is the corporate tax rate. We assume for the simplicity of the model that the depreciation of the capital stock and its adjustment cost are not tax deductible. For the quantitative analysis, the calibration in Section 3.2 takes into account all deductions by setting τ_t^k so that government revenue from corporate taxation as a share of GDP is at the actual levels. We also simulate an alternative specification of deductible expenses, and report it in Section 3.4, devoted to sensitivity analysis.

We assume that firms are fully owned by domestic households. This formulation of dividends implies that investment is fully financed by reducing dividends—which could become negative. In other words, investment is financed by borrowing from shareholders. We assume that the effective interest rate is the same for both firms and households, and thus it is immaterial whether the firms or the households do the borrowing.

The firm maximizes the expected sum of discounted dividends

$$E_0 \left\{ \Pi_0 + \frac{\Pi_1}{1 + r_0} + \frac{\Pi_2}{(1 + r_0)(1 + r_1)} + \dots \right\}.$$

The first-order conditions for maximum profits are

$$(6) \quad 1 + \omega^k (K_{t+1} - K_t) = \frac{1}{1 + r_t} E_t \left[\begin{array}{c} (1 - \tau_{t+1}^k) \alpha \gamma K_{t+1}^{\alpha \gamma - 1} L_{t+1}^{(1-\alpha)\gamma} M_{t+1}^{1-\gamma} + \\ 1 - \delta + \omega^k (K_{t+2} - K_{t+1}) \end{array} \right],$$

$$(7) \quad W_t = (1 - \alpha) \gamma K_t^{\alpha \gamma} L_t^{(1-\alpha)\gamma - 1} M_t^{1-\gamma},$$

$$(8) \quad P_t^m = (1 - \gamma) K_t^{\alpha \gamma} L_t^{(1-\alpha)\gamma} M_t^{-\gamma}.$$

Equation (foc for K) equates the marginal productivity of capital next period— net of taxes, depreciation and adjustment costs—to its marginal cost, and (7) and (8) equate the marginal productivities of labor and intermediate inputs to their relative prices. Solving the latter two equations for L_t and M_t yields the demands for these two inputs as functions of prices and the predetermined capital stock:

$$(9) \quad L_t = \mathcal{G}^l K_t (W_t)^{-\frac{1}{\alpha}} (P_t^m)^{\frac{(1-\gamma)}{\alpha \gamma}},$$

$$(10) \quad M_t = \mathcal{G}^m K_t (W_t)^{-\frac{1-\alpha}{\alpha}} (P_t^m)^{\frac{1-\gamma(1-\alpha)}{\alpha \gamma}},$$

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

c. Preferences and Household's Constraints

The representative household consumes consumer goods, C_t and supplies labor, L_t . Preferences are of the form proposed by Jaimovich-Rebelo (2009):

$$(10) \quad E_0 \sum_{t=0}^{\infty} \beta^t \ln(C_t - \psi L_t^\varphi Z_t), \quad 0 < \beta < 1, \quad \varphi > 1, \quad \psi > 0,$$

$$(11) \quad Z_t = C_t^\xi Z_{t-1}^{1-\xi}, \quad 0 \leq \xi \leq 1.$$

In this formulation, the parameter ξ determines the strength of the income effect on labor supply: When $\xi = 1$, $Z_t = C_t$, and then this utility function becomes standard, i.e., with a full income effect. The other extreme corresponds to $\xi = 0$, where there is no income effect. As long as $\xi > 0$, there is full income effect in long run. The motivation for adopting this utility function is similar to Jaimovich and Rebelo: to deal with anticipation effects on labor supply in a realistic manner. Because changes in tax rates are generally announced in advance, the expectation of a future tax cut can be consistent with a small wealth effect—i.e., the expectation of a future tax cut does not cause an immediate substantial decline in labor supply and output.

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

$$(13) \quad J_t^f = \frac{\omega^f}{2} (F_{t+1} - F^*)^2, \quad \omega^f > 0,$$

adopted from Schmitt-Grohe and Uribe (2003) as a way to provide a steady state to the model.

The household receives wages, dividends, and transfers from the government, T_t . Labor income is taxed at the rate τ_t^l . In order to fit the tax rate data to the actual government revenue from labor taxation, we define $\kappa\tau_t^l\bar{W}_t\bar{L}_t$, where \bar{W}_t, \bar{L}_t are economy-wide averages, as an intramarginal tax deduction which the household takes as given. Consumption is taxed at the constant rate τ^c , and dividends are not taxed.² The one-period household budget constraint is

$$(14) \quad (1 + \tau^c)C_t = (1 - \tau_t^l)W_tL_t + \Pi_t + T_t + \kappa\tau_t^l\bar{W}_t\bar{L}_t + (1 + \bar{r})F_t - F_{t+1} - J_t^f.$$

d. The Household's Optimization Problem

Defining Υ_t^c and Υ_t^z as the Lagrange multipliers of the budget constraint (14) and the equation for Z_t in (12), the first-order conditions of the household's constrained maximization of (11) are:

$$(15) \quad (C_t - \psi L_t^\varphi Z_t)^{-1} - \Upsilon_t^c (1 + \tau^c) - \Upsilon_t^z \xi (C_t)^\xi Z_t^{1-\xi} = 0,$$

$$(16) \quad (C_t - \psi L_t^\varphi Z_t)^{-1} \psi \varphi L_t^{\varphi-1} Z_t - \Upsilon_t^c (1 - \tau_t^l) W_t = 0,$$

$$(17) \quad (C_t - \psi L_t^\varphi Z_t)^{-1} \psi L_t^\varphi - \Upsilon_t^z + E_t [\beta \Upsilon_{t+1}^z (1 - \xi) (C_{t+1})^\xi Z_{t+1}^{-\xi}] = 0,$$

$$(18) \quad \Upsilon_t^c [1 + \omega^f (F_{t+1} - F^*)] - E_t [\Upsilon_{t+1}^c \beta (1 + \bar{r})] = 0.$$

The effective interest rate in (18) is defined as

$$(19) \quad 1 + r_t \equiv \frac{(1 + \bar{r})}{1 + \omega^f (F_{t+1} - F^*)}.$$

The introduction of financial costs generates deviations of the domestic effective interest rate r_t from the world interest rate \bar{r} . The effective rate declines when assets go up above

² Consumption taxation is introduced only to provide realistic magnitude to the government budget.

F^* and increase when they decline below this level. This mechanism is similar to a flexible rate which depends negatively on the level of assets, or negatively on the level of debt when $F_{t+1} < 0$.

Only foreign assets are included in F . We assume that the government issues its debt abroad, and ownership of firms is already captured by the dividends Π_t .

e. The Rest of the World

The rest of the world demands the domestic good according to

$$(20) \quad X_t = X^0 (P_t^x)^\chi, \quad \chi > 0,$$

where X^0 reflects the level of the demand for the domestic good abroad, and P_t^x is the price of a foreign substitute to 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—the two foreign goods—is

$$(21) \quad P_t^{xm} = \frac{P_t^x}{P_t^m},$$

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

$$(22) \quad \bar{r} = \frac{1 - \beta}{\beta}.$$

This implies that foreign financial traders have the same time preference as domestic households. This equation is consistent with the assumption that there is no technological progress—and therefore no long-run growth.

f. Government

Fiscal policy is characterized by exogenous tax rates and a public debt target. Government spending then accommodates tax revenues and debt repayment. We model the tax rate process in two alternative ways: (1) the basic version, in which the plan can only be abandoned, i.e., it cannot not be extended beyond the original plan, and (2) the extended version, in which the original plan can be extended twice, and not only abandoned. The latter version is more complex, but it is a more accurate description of reality during the period being studied.

1. Tax Rates Plan -- Simple Version

In this version, the government announces a tax rates plan, which can be abandoned at any time later. Exiting the plan can happen only once. The planned tax rates are

$$(23) \quad \{\bar{\tau}_t\}_{t=2}^{\infty},$$

where $\tau_t = [\tau_t^l, \tau_t^k]$ and period $t = 1$ is the time when the announcement is made—the model's counterpart of 2002. The tax rates for the initial period 1 are exogenously given at the levels τ_1 . Taxes are set for the following period, which in reality corresponds to the following budget year. In our quantitative section, the plan is based on Table 1, i.e., from 2002 to 2016.

In any period q , the plan is abandoned with probability p_e . Then, the tax rates starting from $q + 1$ onwards will be constant at the exit levels

$$(24) \quad \tau_t = \bar{\tau}_q + \mathcal{G}, \quad t = q + 1, q + 2, \dots, \infty,$$

where $\mathcal{G} = [\mathcal{G}^l, \mathcal{G}^k]$ can be smaller than, equal to, or larger than, 0.

This stochastic structure implies that, conditional on the government not abandoning the plan in period t , the expected future tax rates are

$$(25) \quad E_t \tau_{t+1} = \bar{\tau}_{t+1},$$

$$(26) \quad E_t \tau_{t+2} = (1 - p_e) \bar{\tau}_{t+2} + p_e (\bar{\tau}_{t+1} + \mathcal{G}),$$

$$(27) \quad E_t \tau_{t+3} = (1 - p_e)^2 \bar{\tau}_{t+3} + (1 - p_e) p_e (\bar{\tau}_{t+2} + \mathcal{G}) + p_e (\bar{\tau}_{t+1} + \mathcal{G}),$$

In (25), the tax rates next year will comply with the plan with certainty. In (26), the expectation weights the tax rates if staying with the plan and if abandoning it in period $t + 1$. In (27) the expected rates three periods ahead involve the possibilities of sticking to the plan in periods $t + 1$ and $t + 2$ —the first term—sticking to the plan in period $t + 1$ but abandoning it in period $t + 2$ —the second term—and abandoning the plan in period $t + 1$ —the third term.

Once the plan is abandoned, the future rates are known with certainty at the level determined in (24).

2. Tax Rate Plan—Extended Version

Here we consider the possibility that there is a basic plan that not only can be abandoned, but can also be extended. The motivation for this formulation comes from the extensions of the 2002 tax plan which took place in 2005 and 2009.

The basic plan is

$$(28) \quad \{\tau_t^0\}_{t=2}^{\infty}.$$

The government can exit the plan at any time with probability p_e , as in the simple version, but also can modify it. We assume here, as in our quantitative analysis, that there can be only two modifications, 1 and 2. The probability of the first modification, conditional on

the plan not being abandoned, is p_1 , and the probability of the second modification, conditional on the first modification being implemented in the past and the plan not being abandoned, is p_2 . The earliest date for the first modification is period 2, and the earliest date for the second is period 3. In our empirical work, the first modification is realized in 2005 and the second modification is realized in 2009. The announcement that the plan is abandoned comes in 2011, freezing the tax rates starting from 2012.

A modified plan is defined as a vector of tax rate differences from the previous plan. The first modification is denoted as

$$(29) \quad \{\Delta_t^I\}_{t=1}^{\infty}.$$

If the first modification is adopted in period s , the planned tax rates for period $t > s$ are

$$(30) \quad \{\tau_{s,t}^I = \tau_t^0 + \Delta_{t-s}^I\}_{t=s+1}^{\infty}, \quad s = 2, 3, \dots$$

In our empirical work, the tax rate differences correspond to the tax reductions on top of the 2002 plan that were adopted in 2005 and implemented starting from 2006. For example, according to the basic plan the average marginal tax rate on labor income for 2007 (the 6th year of the plan) was supposed to be $\tau_6^{I,0} = 0.24$. This rate was reduced to 0.23 in the 2005 modification. Given that 2005 is the 4th year of the plan, and 2007 is the 2nd year of the modified plan, then $\Delta_2^{I,I} = -0.01$ and $\tau_{4,6}^{I,I} = \tau_6^{I,0} + \Delta_2^{I,I} = 0.24 - 0.01 = 0.23$.

Similar to the first modification, the second modification is denoted as

$$\{\Delta_t^{II}\}_{t=1}^{\infty}.$$

If the second modification is adopted in period $r > s$, the tax rates for period r are still set according to the first modification. Then, the planned tax rates for period $t > r$ are

$$(31) \quad \{\tau_{s,r,t}^{II} = \tau_{s,t}^I + \Delta_{t-r}^{II}\}_{t=r+1}^{\infty}, \quad s = 2, 3, \dots, \quad r = s + 1, s + 2, \dots$$

In our empirical work, the second modification corresponds to the tax reductions adopted in 2009, on top of the 2005 first modification, and implemented starting from 2010 onwards.

If in period q the plan is abandoned, the tax rates for period $t > q$ are

$$\{\tau_t = \tau_q^i + \mathcal{G}\}_{t=q+1}^{\infty}, \quad i = 0, I, II.$$

Next, we describe the stochastic structure of tax rates conditional on the basic plan still being in effect. As we discuss later, the description conditional on the first or the second modification being in effect is a simplification of the discussion below.

There is no uncertainty about the tax rates for the current period t , which are τ_t^0 . There is no uncertainty for $t + 1$ either, given the condition that the basic plan is in effect—as tax rates are determined one period in advance.

Setting the initial period as $t=0$ for simplicity of notation, in any future period $j = 2, 3, \dots$. The possible realizations and their corresponding probabilities are the following:

- **Still in the basic plan:** The tax rates are τ_j^0 and the probability of this realization is

$$P(\tau^0, j) = (1 - p_e)^{j-1} (1 - p_1)^{j-1},$$

which corresponds to the case that the basic plan is not abandoned and not extended for consecutive $j - 1$ periods.

- **The basic plan was abandoned:** Exit took place in period q , $1 \leq q < j$. Here, the tax rates are $\tau_q^0 + \mathcal{G}$, and the probability is

$$P(\tau^0, q - 1) \cdot p_e,$$

which corresponds to the case that the basic plan still in effect after $q - 1$ periods and then it is abandoned.

- **The first modified plan is in effect** (for $j \geq 2$): If the first modified plan τ^I was adopted in period s , $1 \leq s < j$, the rates are $\tau_{s,j}^I$ and the probability of this event is

$$P(\tau^I, s, j) = P(\tau^0, s - 1) \cdot (1 - p_e) p_1 \cdot (1 - p_e)^{j-s-1} (1 - p_2)^{j-s-1}.$$

This is the probability that the basic plan is in effect for $s - 1$ periods, it is modified in period $t + s$, and then this first modification stays in effect for additional $j - s - 1$ periods.

- **Exit from the first modified plan** (for $j \geq 3$): The first modification was adopted in period s , $1 \leq s < j - 1$ and it was abandoned in period q , $s < q < j$. In this case the tax rates are $\tau_{s,q}^I + \mathcal{G}$ and the probability is

$$P(\tau^I, s, q - 1) \cdot p_e,$$

corresponding to the case that the first modification takes place in period s , it is in effect until period $q - 1$, and then it is abandoned.

- **The second modified plan is in effect** (for $j \geq 3$): The first modification was adopted in period s , $1 \leq s < j - 1$, the second modification was adopted in period r , $s < r < j$ and it is still in effect in period $j - 1$. The tax rates here are $\tau_{s,r,j}^{II}$ and the probability of this realization is

$$P(\tau^{II}, s, r, j) = P(\tau^I, s, r - 1) \cdot (1 - p_e) p_2 \cdot (1 - p_e)^{j-r-1}.$$

This is the probability that the first modification is in effect from period s to period $r - 1$, then the second modification is adopted in period r , and stays in effect for

additional $j - r - 1$ periods.

• **Exit from the second modified plan** (for $j \geq 4$): The first modification was adopted in period s , $1 \leq s < j - 2$, the second modification was adopted in period r , $s < r < j - 1$, and then the plan was abandoned in period q , $r < q < j$. The tax rates in this case are $\tau_{s,r,q}'' + \mathcal{G}$ and the probability is

$$P(\tau'', s, r, q - 1) \cdot p_e,$$

which corresponds to the case that the first modification is adopted in period s , the second modification is adopted in period r , and is in effect until period $q - 1$, when the plan is abandoned.

As mentioned above, this list refers to the possibilities conditioned on the basic plan being in effect in period t . If the first modification is in effect in period t , then the list excludes the last two realizations, as only one additional modification is possible. If the second modification is in effect, then the list includes only the first two realizations, as no additional modification is possible.

3. Public Debt and Government Spending

The government has an exogenous and constant public debt/GDP target, following the Maastricht Accord benchmark. The debt target as of the current period is

$$(32) \quad B_{t+1}^* = \eta Y_{t+1}.$$

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

$$(33) \quad \hat{B}_{t+1}^* = \hat{B}_t^* \left(B_{t+1}^* / \hat{B}_t^* \right)^\lambda, \quad 0 < \lambda < 1,$$

in which λ governs the speed of adjustment to the target.

Total revenue from taxation is

$$(34) \quad R_t = \tau_l^l W_t L_t + \tau_l^k (Q_t - W_t L_t - P_t^m M_t) + \tau^c C_t - \kappa \tau_l^l \bar{W}_t \bar{L}_t.$$

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, the outstanding debt and the intermediate debt target, the amount the government spends on goods and services as well as on transfers should satisfy

$$(35) \quad G_t + T_t \leq R_t + \hat{B}_{t+1}^* - (1 + \bar{r})B_t,$$

with $T_t = \zeta G_t$.

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

$$(36) \quad B_{t+1} = \hat{B}_{t+1}^*.$$

g. Equilibrium

Equilibrium involves the solution of the firm's problem, the household's problem, the equality of demand to supply of labor, and of demand to supply of goods, i.e.,

$$(37) \quad Q_t = C_t + I_t + G_t + X_t + J_t^k + J_t^f.$$

A key endogenous variable to be solved for is the relative price of imports, P_t^m , which is closely related to the real exchange rate.³ Heuristically speaking, lower taxes induce more investment and consumption demand, which tend to cause a real appreciation in the short run, i.e., a lower P_t^m , but in the longer run they induce higher production and thus a real depreciation.

h. The Real Exchange Rate

In order to compare the model's results about the real exchange rate to actual data, in which this relative price is computed in terms of GDP instead of output, we need to express the model's relative price in the same way.

From equation (1), efficient production implies that the relative price of value added, or GDP, in terms of output equals

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

Substituting Y from the production function of output—equation (1)—we get

$$(38) \quad P_t^y = \gamma \frac{Q_t M_t^{\frac{1-\gamma}{\gamma}}}{Q_t^{\frac{1}{\gamma}}} = \gamma \left(\frac{M_t}{Q_t} \right)^{\frac{1-\gamma}{\gamma}}.$$

Then, to convert the model's real exchange rate to GDP terms we divide by P_t^y :

$$(39) \quad \text{Re } r_t = \frac{P_t^m}{P_t^y} = P_t^m \frac{1}{\gamma} \left(\frac{Q_t}{M_t} \right)^{\frac{1-\gamma}{\gamma}}.$$

³ We show the link below. The real exchange rate is usually defined as the relative price of imports (or exports) to domestic product, or GDP. The relative price P_t^m refers to domestic output.

3. QUANTITATIVE ANALYSIS

In this section we describe the solution method, the calibration of the model, and then we present the results.

a. Solution Method

The model presented here does not have a Markov structure as the typical dynamic macroeconomic models do. In those models, the exogenous forces follow stationary processes, and solving the model implies the computation of constant equilibrium relationships between the endogenous variables and the exogenous forces. Here, the exogenous forces are pre-announced tax rates associated with given dates in the future. Hence, as time passes, the equilibrium relationships change.

We follow a rolling certainty equivalence method, where the model is solved period by period. In each period, the path of future tax rates is treated as certain at the expected levels as of that period, as derived in Section 2.6. The treatment of expected values as certain would apply directly if we had used a linearized approximation of the model. The current procedure has the advantage of preserving the nonlinear form of the equations.

b. 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) and the unit of time is defined as one year. The parameter values are listed in Table 2.

The technology parameters γ and α correspond to the relevant shares: The parameter γ is set equal to the average ratio of imports to output, and α is the average nonlabor income share in GDP. Given the estimate of the quarterly depreciation rate of productive capital of 2.3 percent, the annual counterpart is $\delta = 1 - (1 - 0.023)^4 = 0.089$.⁴

As for preferences, the discount rate β is set equal to $1/1.04$, a standard value for annual intervals. 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. In Section 3.4 we test the implications of assuming a smaller labor supply elasticity—i.e., a larger φ —as well as a larger short-run income effect—i.e., larger ξ . These two modifications reduce the effects of tax changes on labor supply, and hence they should diminish the impact of the tax cuts on economic activity.

We turn to the fiscal parameters. The target ratio of public debt to GDP, η , is set equal to the Maastricht Treaty required ratio of 0.6, adopted by the Israeli government. The rate of convergence of the public debt to the target is determined as follows. According to the rule

⁴ The quarterly estimate is the average depreciation rate across capital goods from the perpetual capital stock system at the Bank of Israel.

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 10 years implies that λ should be approximately 0.117.⁵ This applies to any tax schedule because of the assumption that $G + T$ adjusts to tax revenues given the path for the debt.

Table 2
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	0.089
Discount factor	β	0.96
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	0.117
Initial effective corporate tax (2001)	τ^k	0.17
Initial labor tax rate (2001)	τ^l	0.33
Tax deductible fraction of labor income (2001)	\mathcal{K}	0.787
Abandoning the plan: Probability	p_e	0.15
Corporate tax change (2012)	g^k	0.01
Labor income tax change (2012)	g^l	0
Modifying the plan: Probability	p_1, p_2	0.15
Tax rate on consumption	τ^c	0.165
Unilateral transfers as a fraction of government purchases	ζ	0.5
Other Parameters		
World interest rate: $1/\beta - 1$	\bar{r}	0.04
Adjustment costs of capital	ω^k	0.08
Financial costs	ω^f	0.0025
Elasticity of exports	χ	0.2

The initial tax rates correspond to 2001. We compute the effective corporate tax rates using the average corporate tax revenue/GDP ratio over the 2001–2012 sample, which equals 0.0367. Hence, all the tax deductions are taken into account in the calibration of τ^k . In the model, this ratio corresponds to $\tau^k \alpha$. Hence, $\tau^k = 0.0367 / \alpha = 0.112$, which is 0.191 lower than the sample average of the statutory corporate tax rate 0.303. Hence, we

⁵ The approximation follows from looking at achieving the middle range ratio 0.7 in half the time, 5 years.

adjust the statutory corporate rates downwards by 0.191.⁶ The plan was to lower the statutory rate from 0.36 in 2001 to 0.18 in 2016. However, we apply the parallel decline only up to 2012—otherwise it would lead to the rate minus one percent in 2016. Hence, the planned effective rates decline from 0.17 in 2001 to 0.04 in 2012. From then onwards, we assume that the planned rate declines linearly to reach 0.03 in 2016.

As for labor taxes, we use the average of the marginal rates for five income brackets: (1) Up to half the average salary; (2) From half to the average salary; (3) From the average to twice the average salary; (4) From twice to four times the average salary; and (5) More than four times the average salary. The weights on these five groups, corresponding to 2005, are: 0.27, 0.40, 0.20, 0.11 and 0.02, and we treat them as fixed. For the initial period, the value $\tau^l = 0.33$ corresponds to the 2001 average marginal rate. The fraction \mathcal{K} of the statutory labor taxes— $\tau^l \overline{W}_t \overline{L}_t$ —that is tax deductible is computed so that the labor tax revenues/GDP ratio at the beginning of the simulation is at the 2001 level of 7.3 percent, and is set at 0.7871.

The next fiscal parameter is p_e . The 2011 government decision to abandon the plan of reducing tax rates followed the 2011 social unrest and demands to increase government services. In the fourth quarter of 2010, shortly before the social unrest, the Bank of Israel Companies Survey (2011) reported that 38 percent of the companies surveyed (444 businesses) replied that they expect the tax plan to be completed more or less in full. Interpreting this as giving probability one to the event of completing the plan, and that the rest of the companies, 62 percent, assign zero probability to completing the plan, the weighted average probability is 0.38. This should equal $(1 - p_e)^6$, i.e., the probability that the plan will not be abandoned till the end of 2016. The solution of this equation is $p_e \approx 0.15$. We adopt this estimate for the basic calibration.⁷

We do not have evidence regarding the public's perceptions about the probabilities of modifying the basic plan, p_1 and p_2 . Hence, we assume the same value as for p_e , i.e., 0.15. However, the sensitivity of the results to the size of these two probabilities turns out to be very small.

The corporate tax change when exiting the plan \mathcal{G}^k is set to 0.01, which is the corporate tax increase in 2012—from 24 to 25 percent. Income taxes were not changed when exiting the plan, so that $\mathcal{G}^l = 0$. The tax rate on consumption τ^c —treated as constant in our analysis—is 16.46 which is the average value added tax rate in the 2001–2012 sample. Transfers, T , are set equal to half of government purchases, i.e., $\zeta = 0.5$. This is the

⁶ The feature that the effective rate declines by approximately the same number of percentage points as the statutory rates is from Figure 9-4 in the Ministry of Finance document "The law for encouragement of capital investment—empirical findings about subsidized firms during the years 2003–2010" (Hebrew), by Galit Ben Nayim.

⁷ This is probably an upper bound. Among the remaining 62 percent only 16 percent replied that the plan will not be implemented to a significant extent, which can be associated with a zero probability of completing the plan. The other 46 percent replied that the plan will be implemented only partially, which is quantitatively unclear. If we interpret only partially as a 50 percent probability of completing the plan, then one can split this group into two of 23 percent each, one of which assign probability one and the other probability zero to the event of completing the plan. Here, the group assigning probability one goes up to 61 percent. From $(1 - p_e)^6 = 0.61$ we get $p_e \approx 0.08$.

average proportion of transfers, excluding interest payments, to government domestic purchases in the 2000s.

The other parameters are set as follows. The 4 percent world real interest \bar{r} is standard. The adjustment and financial costs parameters, are annual counterparts of the quarterly estimates in Friedman and Hercowitz (2010). 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).

Table 3 shows the tax rates announced in 2002–2003, the modifications introduced in 2005 and 2009, and the exit rates in 2011. The corporate tax rates in the table are the effective rates, and the labor tax rates are the average marginal rates—both discussed above. What we define as the basic plan was announced in two consecutive years: The income tax rates were reduced in 2002, and the corporate tax rates in 2003. The modification columns indicate the tax rate changes relative to the previous plan.

Table 3
Tax Plans—Actual Timing and Announced Rates

	Basic Plan		1st Modification		2nd Modification		Exit Modifications	
	Corp ¹	Labor ²	Corp ¹	Labor ²	Corp ¹	Labor ²	Corp ¹	Labor ²
2001	17	33						
2002*	17	33						
2003*	17	31						
2004	16	27						
2005*	15	24.5						
2006	13	24	-1	0				
2007	11	24	-1	-1				
2008	11	24	-3	-3.5				
2009*	11	24	-4	-4.5				
2010	11	24	-5	-5	0	0		
2011*	11	24	-5	-5	-1	0		
2012	11	24	-5	-5	-2	0	2	0
2013	11	24	-5	-5	-2.25	0	2.25	0
2014	11	24	-5	-5	-2.50	0	2.50	0
2015	11	24	-5	-5	-2.75	0	2.75	0
2016	11	24	-5	-5	-3	0	3	0

¹ Effective corporate tax rates. ² Average salary tax bracket. * Announcements.

c. Simulation Results

We simulate the calibrated model given the tax rate process described above, starting from a steady state corresponding to the 2001 tax rates. In each year of the simulation, the expected future tax rates take into account the probabilities of modifications and exit—as derived in Section 2.6. The simulation takes into account the fiscal policy regime, i.e., the government revenue equation (34) and the government purchases in equation (35). Hence, the results reflect both the direct effects of the tax cuts on economic decisions as well as the indirect effects of the required adjustments in government spending. The purpose is to evaluate the

impact of this process on the economy, especially on GDP growth.

All factors except tax changes are held constant. For example, starting from a steady state controls for one of these factors, which is the dynamics generated by the convergence to a steady state given the actual situation of the economy in 2001.⁸

We present the results for the extended version of the tax process—given that the simple version, in which the modifications in 2005 and 2009 are assumed to be known as of 2002, yields similar results. We simulate the realization of the tax process, i.e., with the modifications taking place in 2005 and 2009, and exit in 2011. This realized path for the model can be compared to the actual path of the Israeli economy. However, the agents in the model do not know in advance that this will be the realization. At each point in time prior to the exit they take into account that the plan can be modified or abandoned at any future point in time according to the corresponding probabilities.

Figure 2 displays the simulation results for labor tax reductions only. The decline in the labor tax rate during the period increases labor supply, resulting in expanding labor input and declining wages as long as the tax reductions continue—until fully implemented in 2010. The decline in wages expands domestic production and thus reduces the price of the domestic good relative to the imported good, i.e., a real depreciation takes place. As a consequence, imports go down and exports go up. As capital is a complementary input to labor, the increase in labor input causes firms to increase their capital stock as well.

The decline of labor taxes lowers government revenues, and thus government expenditures as well. The downward adjustment of the purchases component (G) of government spending affects production negatively by reducing output demand. The net effect on GDP during the period is still strongly positive, about 13 percent. Both the increase in output supply and the reduction in government demand lower the relative price of domestic output -- i.e., cause a depreciation.

⁸ If we attempted to match the initial situation to that prevailing in 2001, the dynamics thereafter would show a mixture of the tax effects on which we focus and the dynamics that would prevail regardless of the tax changes.

Figure 2
Simulation of Reducing Labor Taxes Only

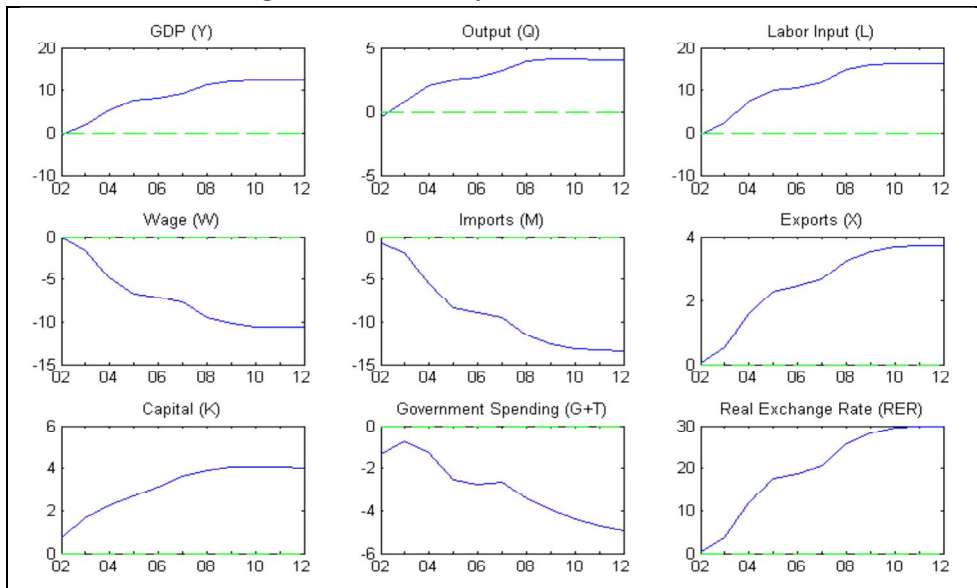


Figure 3
Simulation of Reducing Corporate Taxes Only

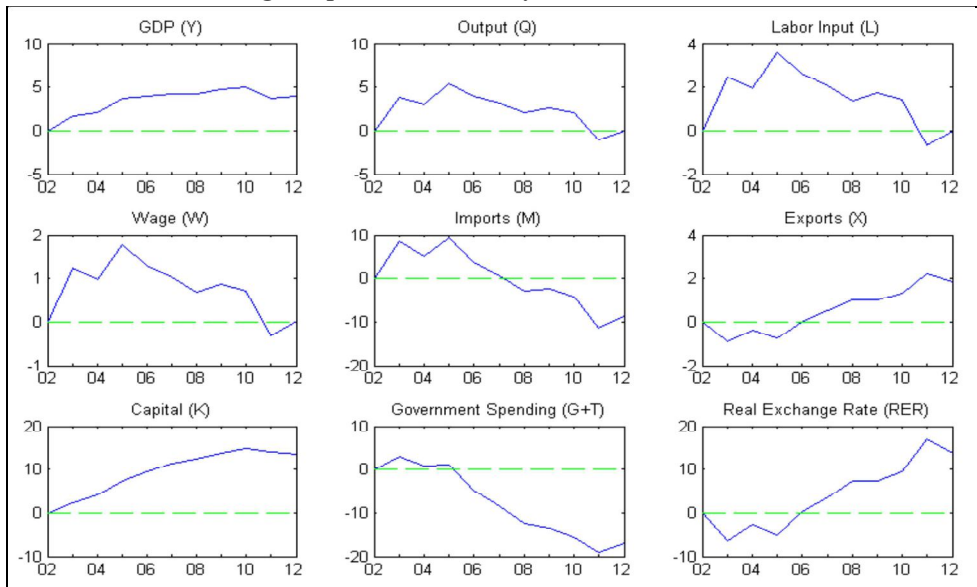


Figure 3 displays the simulation results for corporate tax reductions only. Here, the main channel of effect is the firms' incentive to accumulate capital. Once the tax plan is announced, investment jumps and capital stock starts to grow starting from the following year. This early wave of investment demand causes an initial real appreciation. Additional but smaller waves of investment and appreciation occur later in 2005 and 2009, times at which further corporate tax cuts are announced. The initial surge in output, and hence in revenues, allows the government to increase its spending during the first few years, which strengthens the initial appreciation. Capital accumulation increases the firms' demand for labor, thereby raising wages and labor input. Once the initial investment is over, the real exchange rate starts to go up due to both increasing supply of goods and declining government spending following the tax cut. This real depreciation reduces imports—which in turn lowers labor demand due to factor complementarity. The announcement in 2011 that the tax reduction path would be abandoned starting in 2012—and of tax increases—causes investment and labor demand to fall, generating a real depreciation. This in turn reduces imports, labor input and GDP.

Table 4
Summary of Changes—Main Variables

	Labor Taxes				Corporate Taxes				Both Taxes			
	<i>Y</i>	<i>L</i>	<i>W</i>	<i>Rer</i>	<i>Y</i>	<i>L</i>	<i>W</i>	<i>Rer</i>	<i>Y</i>	<i>L</i>	<i>W</i>	<i>Rer</i>
2001/10	.13	.16	-.11	.30	.05	.014	.01	.1	.182	.181	-.10	.42
2010/11	-.00	-.00	-.00	.00	-.01	-.021	-.01	.07	-.013	-.022	-.01	.07
2011/12	-.00	-.00	-.00	.00	.00	.007	.00	-.03	.002	.007	-.00	-.03
Total	.13	.16	-.11	.30	.04	-.000	-.00	.14	.17	.163	-.11	.48

Table 4 summarizes the quantitative effects of both types of tax cuts, before and after the exit announcement in 2011. The decline of labor tax rates until 2010 increases output by 13 percent, while the decline of corporate tax rates contributes 5 percent. The stronger effect of labor taxes is due mainly to the larger labor share (0.7). For labor input, the rates of change until 2010 are 16 percent due to labor taxes and 1.4 percent due to corporate taxes. Labor taxes affect the labor market directly, while corporate taxation affects it via the growing capital stock.

The exit announcement in 2011 takes place after labor taxation stabilizes in 2010—which explains the zero effect of labor taxation after exit. In contrast, corporate tax rates shift direction with exit, wiping out the labor input gain, and reducing the GDP gain to 3.8 percent.

The conclusion from Table 4 is that from 2001 to 2012, the tax cuts increase GDP by 17 percent, which is a large percentage relative to actual per capita GDP growth during this period of 21.4 percent.

d. Sensitivity Analysis

We present different modifications of the model in order to gauge their implications for the results.

1. *Alternative Elasticities of Labor Supply*

The results above were obtained under what we consider a standard parameterization of labor supply parameters in macro models. As in most of these models, the elasticity of labor supply corresponds to the household and not to the individual, i.e., it captures both the extensive and intensive margins. Additionally, as in Jaimovich and Rebelo (2009), a realistic analysis of anticipations requires a small elasticity of labor supply to income changes. However, it is interesting to compare the results above with those under alternative values of these two elasticities. We consider here $\varphi=2$ rather than 1.5—which implies a wage elasticity of 1 instead of 2—and $\xi=0.5$ rather than 0.001—corresponding to a substantial short-run income effect rather than a very small one.

These modifications reduce the contribution of the tax cuts to GDP: Both the smaller wage elasticity and the larger income elasticity generate less labor supply response—resulting in a smaller increase in GDP than 17 percent—as in the basic simulation. When $\varphi=2$, output in the model grows 13.1 percent from 2001 to 2012, and when $\xi=0.5$, 10.9 percent. With both parameters at the alternative values, output grows 9.7 percent.

We conclude that lowering the labor supply elasticity and increasing the wealth effect do have a substantial impact on the effect of tax changes on economic activity. However, the effects remain quantitatively important. In any event, the alternative parameter values are, in our view, unrealistic.

2. *An Alternative Specification of Tax-Deductible Expenses*

In equation (5) for dividends, only wages and intermediate inputs were considered tax deductible. Here, we consider also including a fraction κ^k of capital depreciation costs as well as adjustment costs. The corresponding after-tax dividend is

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

and the first-order condition for optimal investment is

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

Government revenue is

$$R_t = \tau_t^l W_t L_t + \tau_t^k (Q_t - W_t L_t - P_t^m M_t - \kappa^k \delta K_t) + \tau^c C_t - \kappa \tau_t^l \bar{W}_t \bar{L}_t.$$

In the current specification, deductions in addition to wages and intermediate inputs are modelled explicitly, rather than captured by the effective corporate tax rates. Hence, here we

equate τ_i^k to the statutory rates, and calibrate κ^k so that the revenue from the corporate tax as a ratio to Y equals the average corporate tax revenue/GDP ratio at the beginning of the sample, 2001. The resulting value is $\kappa^k=0.927$. From that year onwards, the statutory rates decline in parallel with the effective rates from Section 3.2, while κ^k remains constant.

Under this specification, the tax cuts increase per capita GDP by 15 percent from 2001 to 2012—compared to 17 percent for the basic specification. The corporate tax cuts contribute 2 percent to GDP growth instead of 4 percent in the basic specification.⁹

e. Other Effects on Output Growth

The 2001–2012 period includes two other important events that dramatically decreased output growth: the Second Intifadah starting in 2000, and the global economic crisis in 2008–2009. In this subsection we compare quantitative measures of the effects of these two events to that of the declining tax rates. We use the basic model.

We start with the impact of the global crisis, as reflected in the drastic drop in world trade in 2009.¹⁰ We use the model to conduct the following exercise: We assume that X_0 in the exports demand equation drops unexpectedly in 2009 by 14.3 percent, and then stays constant at this level. This is the decline in the volume of per capita world trade.¹¹ In other words, we look at the effect of the crisis itself, abstracting from long-term growth in world trade. The immediate effect on GDP in 2009 is a drop of 12.4 percent. Then, there is a partial GDP recovery, and in 2012 the model's GDP is 9.9 lower than in 2001. Hence, this is the negative contribution of the global crisis to 2001–2012 growth according to the model.¹²

The second negative event is the Second Intifadah. In the 2011 Bank of Israel Annual Report (Chapter 2, Figure 2.5), the computed output gap has a trough of about minus 7 percent in 2002—starting from about zero in early 2001. We take this measure as the negative contribution of the Intifadah.

Adding up the negative effects of these two events, the total has the same magnitude as the positive 17 percent of the tax cuts. Hence, according to this calculation one may say that the tax cuts approximately neutralized the negative growth effects of the global crisis and the Intifadah, leaving the actual growth of 21.4 percent to be explained by other factors, such as long-run growth of technology and world trade.¹³

⁹ If firms had some market power, profits would be larger and corporate tax changes would then have a stronger effect on investment decisions—as well as affect the number of firms. The current setup with constant returns to scale and perfect competition is likely to provide a lower bound to the effects of corporate tax changes on economic activity for any realistic specification of deductible expenses.

¹⁰ In 2008, world trade kept growing at a similar rate to the previous years.

¹¹ We deflate world trade by the Israeli population given that we match the model's exports variable to actual per capita exports—as for all other national income account variables.

¹² It can be argued that given that the global crisis started at the end of 2007, this drop could be considered expected as of 2008. Incorporating this assumption, the model's output already drops in 2008, but the cumulative effects of the crisis remain very similar.

¹³ Flug and Strawczynski (2009) estimate the contribution of different factors, including tax rates, to persistent positive growth—defined as growth periods of at least five years. Hence, their focus is different than ours—given that we address the contributions to growth of any length and sign. In that context they found a relatively small contribution of tax rates. Their sample ends in 2008, and hence the contribution of the

f. Implications of the Fiscal Regime

The result above, that the tax changes can explain 17 percent growth during the 2001–2012 period, incorporates the effects of the spending adjustments dictated by the fiscal regime. Declining tax revenues necessitate spending cuts, which lower output demand. This causes a real appreciation which slows down the economy by making imported inputs more expensive.

Here we report the computation of the net effects of the tax changes, i.e., holding government spending and the public debt constant. In the original simulations, total government spending is composed of two-thirds purchases and one-third transfers. In the current simulation, transfers are cut by the decline in tax revenues, while purchases and public debt are frozen at the initial 2001 absolute values. Hence, these results reflect the substitution effects of lowering taxes, given that the additional after-tax income is absorbed by reducing transfers.

The resulting growth from 2001 to 2012 is only slightly higher: 17.2 percent.

g. Relative Price Behavior

The model predicts two key relative prices—the real exchange rate and the real wage. We compare these predictions to the data by contrasting the 2002–2012 period with the earlier 1987–2001 period which has relatively stable tax rates.¹⁴

Figures 4 and 5 show the average marginal rate on labor income and the statutory corporate tax rates for the combined sample 1987–2012. In Figure 4, the marginal rate is stable prior to the 2000s, except for 1995, followed by the steep decline during the 2000s. Figure 5 shows that although the corporate tax rate declines in the earlier period by 9 percentage points, in the 2000s it is cut by even more—12 percentage points until 2011. Hence, during the 2000s there are larger cuts in both labor income and corporate taxes than in the previous period. In any event, as discussed in Section 3.3, the model predicts that the results for the labor tax decline should be the dominant ones.

tax declining process from 2003 to 2011 cannot be measured. However, given their methodology, even an extended sample would probably not change their results because the global crisis in 2008–2009 stopped persistent growth in 2008.

¹⁴ We start this sample after the high inflation years, during which effective corporate tax rates are hard to compute. In the 1980–1986 period, statutory corporate rates are higher than those from 1987 onwards, but the revenue from this tax relative to GDP is smaller.

Figure 4
Average Marginal Labor Tax (%)

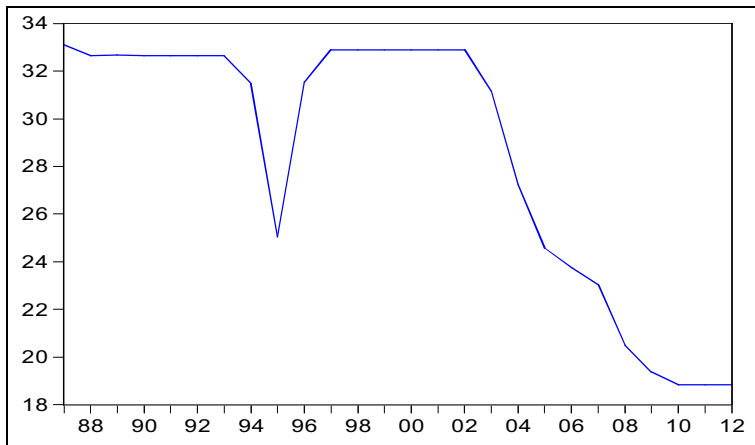
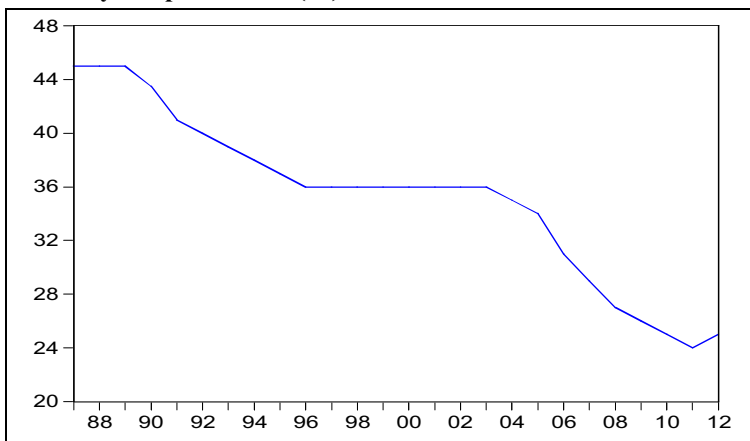


Figure 5
Statutory Corporate Tax (%)



The model has a clear prediction about the behavior of the relative price of imports in terms of the domestic product, i.e., the real exchange rate. As taxes go down, so do the domestic costs of production; hence, the real exchange rate should increase during the 2000s.

Figure 6 shows the behavior of the real exchange rate in Israel during the period 1987–2012. In the period prior to the 2000s it displays the typical decline predicted by the Balassa-Samuelson effect. During the 2000s, however, the trend turns positive.

Figure 6
Real Exchange Rate*

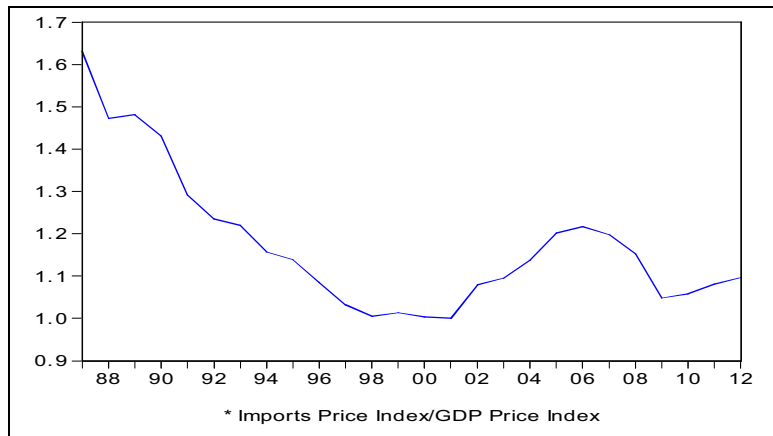
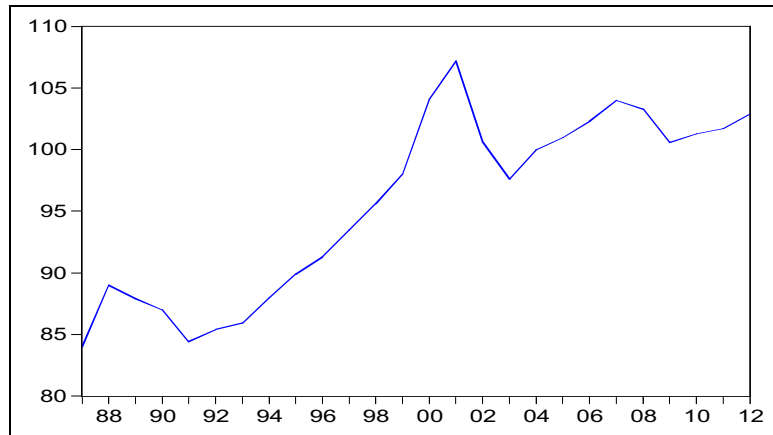


Figure 7
Real Wage Index



Regarding the real wage, the model predicts a decline during the 2000s. Lowering income tax rates encourages labor supply, thereby pushing the pre-tax real wage downwards. Figure 7 shows an index of the real wage from 1987 to 2012.¹⁵ Prior to the 2000s the real wage has a positive trend—as one can expect from the typical effect of technological progress.¹⁶ However, during the 2000s the trend becomes flat.

The break in the actual behavior of both the real exchange rate and the real wage at the beginning of the 2000s is consistent with the model's predictions.

¹⁵ The real wage index is from the Statistical Supplement to the Bank of Israel Annual Report 2012.

¹⁶ The effect of the large wave of immigration from the former Soviet Union to Israel during the 1990s can be assessed in Figure 7 by imagining a straight line from 1988 to 1999.

h. The Results in Perspective

Here we look at the results from the perspective of two relevant points of view. The first is existing econometric estimates, and the second is an alternative simple model.

1. Existing Econometric Estimates

Existing econometric estimates of the effect of tax changes on the level of output vary significantly. We also comment below about the effects on the growth rate of output.

Barro and Redlick (2011) use data on the average marginal tax rate on labor income in the US, and obtain the estimate of -0.5 in a GDP equation. Translating this result to the present case of a 14 percent decline in the labor income tax, the increase in GDP should be 7 percent—much less than the 13 percent obtained here and reported in Table 4.

Romer and Romer (2010) construct a series of fiscal shocks using narrative records, such as US presidential addresses and congressional reports, as a way to isolate exogenous tax changes. Their results indicate a very strong effect on GDP. They find that an increase in taxes of one percent of GDP has a gradual negative impact on GDP thereafter, reaching about 3 percent after two-and-a-half years. According to this estimate, the tax reduction in Israel during the 2001–2012 period has a very strong effect on GDP. Let us consider labor income only. Because the last tax cut occurs in 2010, i.e., two years before the end of the sample, we can approximate the impact of the 14 percent cut according to Romer and Romer's estimates as follows. Given the labor share of 0.7, the decline in labor tax rates as a fraction of GDP amounts to $0.7 \times 14 = 9.8$ percentage points. Hence, their 3 percent estimate implies an increase in output of about 30 percent, i.e., much higher than the current 13 percent.

Using Israeli data, Mazar (2013) estimates the effects of government purchases and taxes on GDP using a VAR methodology. He finds a weak effect of direct tax changes on GDP. In contrast, Lavi and Strawczynski (2002) find a strong effect: a one percent of GDP reduction in taxation increases GDP by 1.8 percent. The implications of their result in the present context are approximated as follows. First, the tax rate reductions on labor income and corporations from 2002 to 2012 can be translated to a fraction of GDP using the labor and capital shares: $0.7 \times 14 + 0.3 \times 11 = 13.1$. Then, their coefficient implies that the contribution of the tax process to GDP during this period is $1.8 \times 13.1 = 23.6$, which is higher than the estimated effect in the current paper.

Other empirical literature focuses on growth rates across countries, which are interpreted as long-run growth. In particular, Sala i Martin (1997) tests the impact of different measures of government spending—capturing tax rate levels—and finds no significant effect on growth rates across countries. However, there is no contradiction between these results and the large positive multipliers found in papers referenced above. The present model is consistent with both types of results, as steady-state growth is zero regardless of the tax rate levels.¹⁷

¹⁷ Introducing exogenous productivity growth in the current model would not substantially affect the quantitative results.

2. A Simple Theoretical Framework

The model in this paper has specific preferences and an open economy structure. Here, we put the results in perspective by looking at a simple closed-economy model with standard preferences—and use it to compute the steady state effects for the same tax changes. This discussion illustrates the role of the open aspect of the economy in the results.

We consider a closed economy where the utility function of the representative infinite-lived household is

$$U(C_t, L_t) = \varphi \ln C_t + (1 - \varphi) \ln(1 - L_t),$$

the production function of the representative firm is

$$Y_t = K_t^\alpha L_t^{1-\alpha},$$

and the evolution of the capital stock is

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

The notation is the same as in the main text. Taxes are imposed on labor income at the rate τ^l and on firm's profits at the rate τ^k . The proceeds are refunded to households as lump-sum transfers. The subjective discount factor is β , households maximize discounted utility and firms maximize discounted profits net of investment. The parameter values are $\varphi = 0.35$, $\beta = 0.96$, $\alpha = 0.3$, $\delta = 0.089$

We compute an initial steady state with $\tau^l = 0.33$, and $\tau^k = 0.17$, and a second steady state with $\tau^l = 0.19$ and $\tau^k = 0.05$. GDP across steady states grows 24.9 percent.

We now compute a similar pair of steady states with an open economy version of this model—similar to the model in the main text but with the logarithmic utility function, and taxes being refunded as lump-sum transfers in a balanced budget.

The resulting GDP growth from steady-state to steady-state is 20.1 percent—lower than the closed economy growth of 24.9 percent. The lower growth rate in the open economy follows from the real depreciation caused by the tax cuts. Lower taxes motivate higher production of the domestic good, and thus a decline in its relative price. The real devaluation is 50.8 percent. This increase in the relative price of imports reduces the demand for labor and capital, inducing lower growth.

The order of magnitude of the results in this simple comparison supports the main results.

4. CONCLUDING REMARKS

Tax rates in Israel declined persistently during the 2000s. At the same time, output growth was high relative to the developed countries. Empirically, it is hard to separate the effects of the tax cuts from other events that happened in this period—the exit from a deep recession at the beginning of the 2000s and the global crisis in 2008–2009. This paper adopts a model-based counterfactual methodology to isolate the effects of the declining tax path. The analysis is based on simulating the case that the only source of exogenous changes is the tax

rates process.

The results indicate a very large effect of the tax changes. The declining path of tax rates can be responsible for per capita growth of 17 percent during the 2001–2012 period. In comparison, actual per capita GDP growth during the same period is 21.4 percent. Evidence from real wage and real exchange rate behavior, which indicates a trend shift in the 2000s, suggests a large positive influence on the supply of labor and goods during this period. Tax reductions on labor income and corporations promote such positive effects.

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