The Dynamic Effects of Legislated Tax Changes on Tax Revenues – Evidence from Israel

By ADI BRENDER AND ERAN POLITZER*

We estimate the effect of legislated tax changes on revenues in Israel from 1991 to 2012. We exploit numerical revenue forecasts, prepared alongside the proposed tax changes, to control for the information policy makers had. Estimating an error-correction model, we find that the average tax change ultimately yields about 70 percent of its static revenue effect. The dynamic offset is consistent with a large tax multiplier. The steady state estimated collection rate is 90 percent for a change in the corporate income tax, 65 percent for the personal income tax, and 58 percent for indirect taxes. (JEL: E62, H24, H25)

How much revenue is collected from a tax increase and to what extent does a tax cut pay for itself? Does the answer differ across types of taxes and over different time horizons? Such questions are prevalent in the public debate over tax reform, and are important for policy makers. In an attempt to answer these questions, we investigate the macro effect of legislated tax changes on tax revenues. Our estimation uses a comprehensive database of legislated tax changes that were implemented in Israel from 1991 until 2012. We use a novel way to identify the effects of tax changes and tackle the endogeneity problem, by exploiting numerical tax forecasts that were formed alongside the proposed tax changes.

* Brender: Research Department, Bank of Israel, P.O.B 780, Jerusalem, Israel (email: adi.brender@boi.org.il); Politzer: Harvard University (e-mail: epolitzer@g.harvard.edu). We are grateful to Michel Strawczynski and Mirko Licchetta for their comments and suggestions, as well as to participants at seminars at the Bank of Israel's Research Department, Tel Aviv University, Ben-Gurion University of the Negev, and the Public Economics Workshop at the Bank of Italy.

Estimating the dynamic effect of tax changes on revenues is the aim of the budget scoring process used in many countries, including the US, the UK and the Netherlands (Holtz-Eakin, 2015). This process tries to assess the *future* impact of a specific proposal for a tax change, using economic models and a series of assumptions, and can be informed by the empirical literature on the tax multiplier. This literature examines the effect of an *average* tax change on GDP while aggregating over tax changes that may have different effects on incentives and economic activity. The tax multiplier can then be used to mechanically calculate the effect on revenue, based on the tax burden and the elasticity of revenues to GDP in a specific country. However, this calculated effect may be incomplete. For example: tax changes may lead to shifts between tax bases with different rates, without an effect on the level of GDP, but affecting revenues; A shift from local production to imports may reduce GDP growth, but increase revenues if imports are taxed at a higher rate, etc. The micro-based literature on the elasticity of taxable income (ETI) can also assist in estimating the dynamic effect of (personal income) tax changes on revenues. The ETI encompasses many ways in which taxpayers respond to changes in tax rates and incentives. However, as Carroll and Hrung (2005) explain, the ETI captures only part of the macro-dynamic responses on the supply-side, and demand effects and shifting between tax bases are generally not reflected at all.

In this paper we build on the tax multiplier literature, but estimate directly the effect of tax changes on revenues. Thus, we complement the indirect ways of calculating the revenue effect using the tax multiplier or the ETI. Our estimation takes into account possible non-GDP effects on tax revenues, and allows capturing the cumulative macroeconomic effects of the supply and the demand sides, as well as base-shifting. As with the macroeconomic literature on tax multipliers, our estimates are for the effect of an *average* tax change during our sample period. We also estimate separately the effects of legislated changes in personal income taxes (PIT), corporate income taxes (CIT), and indirect taxes.

The main empirical challenge in identifying the effect of a tax change on revenues grows from the possible simultaneity between tax changes and expected future tax revenues. For example, if policy makers expect an economic crisis that will shrink revenues, they may decide to raise tax rates pro-cyclically. Revenues might still decrease due to the materialized crisis, creating a negative correlation between tax changes and the revenues, but this correlation should not be interpreted as causal. To identify the effect of tax changes on GDP, Blanchard and Perotti (2002) (hereinafter: BP) use the time elapsed between a change in economic activity and when policy makers become aware of the change and respond with a tax change. They use this gap to identify structural tax shocks using a quarterly SVAR model. Romer and Romer (2010) (hereinafter: RR) use documents related to the legislative process in order to identify “exogenous” tax changes, i.e., changes that are motivated by ideological reasons or by a will to deal with accumulated deficits, and are not a response to trends in economic activity. On the assumption that the narrative identification of these changes is accurate, the changes affect economic activity but are not affected by it.[1] However, at least for the case of Israel, the narrative method has two severe limitations. First, the motivation given in legislative documents may be biased due to the political will to achieve approval for the tax change and for the budget in which it is included. Second, even for tax changes whose motivation is truly exogenous – their timing is often strongly influenced by the state of the deficit and the growth forecast.[2]

[1] Nevertheless, Favero and Giavazzi (2012) show that the differences between the results of BP and RR reflect their different econometric estimation techniques and not the use of the narrative approach by RR.

[2] This was the case for the "ideological" plan that reduced direct taxes in Israel since 2003. When revenues were higher than expected, the execution of the plan was accelerated and rates were reduced, sometimes even retroactively. Another

In this paper, the unique availability of tax revenue forecasts — prepared at the same time as tax change proposals — makes it possible to explicitly control for the information possessed by decision-makers at that time. We test and reject the existence of potential manipulations in the revenue forecasts due to the tax changes. Thus, it is possible to identify the effect of a tax change, independent on the expected tax revenue, and use all the tax changes that have been implemented and not just those with an ideological motivation.

Another potential source of endogeneity grows from the way policy makers respond to revenue forecasts, e.g. whether the policy is pro- or counter-cyclical. If the response pattern changes much from period to period, using the revenue forecast might not fully account for the link between expected revenues and tax changes. While this remains a concern, Strawczynski (2014) provides evidence supporting a stable response pattern of the Israeli tax policy to expected changes in activity and revenues. Comparing a shorter sample period (1988-2011) to a longer one (1970-2011), Strawczynski finds that the response of indirect taxes remained pro-cyclical, and direct taxes remained a-cyclical. The steady response pattern facilitates the identification of the effects of tax changes in this paper. We are also assisted by the practice of the Israeli Ministry of Finance to estimate the effects of proposed tax changes on revenues using a simple static calculation, that assumes a constant tax base and does not account for neither behavioral responses nor the impact on economic activity. These static estimates were used in proposed budgets until 2012 – the last year in our sample period. We use these estimates as benchmarks for the effect of tax changes on revenues.

We estimate an error-correction model and find a co-integrative relationship between tax revenues, the macroeconomic factors that influence them in the long run, and tax changes, while controlling for tax revenue forecasts. We find that an

example is the "structural" decrease in sales tax in 2000. The State Revenue Division report explicitly states that the decrease was possible "due to an increase in tax collection".

average tax increase raises tax revenue by only about 70 percent of the amount predicted by a static calculation (that assumes no change in the tax base). The offsetting effect, mainly through the effect of the tax change on economic activity, is higher during the first two years after the change comes into effect: actual revenue amounts to 60 percent of the static forecast at the first year, and it declines at the second year. Similar dynamics are found in the tax multipliers literature: BP found that the response of GDP to a tax change peaks during the second year after the change, and the peak in RR occurs two and a half years after the change was affected. The peak offsetting effect we find, -0.72 of the predicted revenue, is closer to the -0.84 effect derived from RR than to the offsetting effects derived from BP (-0.21 or -0.36), and is thus more consistent with a large tax multiplier.[3]

We find markedly different effects for each type of tax over the short run and the medium-long run. During the first year, the highest rates of tax collection, relative to the static forecast, are achieved for indirect taxes – 78 percent of the expected revenue, or the PIT – 76 percent. In contrast, a change in the CIT has almost no effect on revenues during the first year. Two years after the tax change goes into effect, and thereafter, the ranking changes – an increase in the CIT yields the highest rate of collection (89%), and the collection rate is lower from the PIT (65%) and from indirect taxes (58%). Our long-term results contrast those of Mertens and Ravn (2013) who found that changes in the CIT have a minor effect on revenues. However, the offset effect we find is consistent with the marginal deadweight cost of CIT rates, found in the micro-based estimation in Devereux et al. (2014). For PIT changes, our offsetting effect (-0.4 at the peak) is

[3] The calculations use the share of tax revenues in Israel's GDP and build on former empirical results, assuming a unit elasticity of tax revenue to GDP. For the calculation, we used the baseline tax multipliers from RR (-3.08), and from BP (-0.78 or -1.33). A caveat for the comparison is that the calculated offsetting effects account only for revenue impacts through GDP, while our estimation allows for non-GDP impacts so it makes it difficult to directly derive the multiplier from our estimated equations.

consistent with the PIT multiplier estimated in Mertens and Ravn (2013). These offsets are higher than the micro-based offsets derived from the elasticity of taxable income literature. For the US, Saez et al. (2012) derive an offset of about -0.2 for an across-the-board federal income tax increase, and an offset of -0.34 for a tax increase focused on high earners. Lastly, we find that the incidence of a PIT increase falls also on employers - their cost of labor (i.e. gross wages) rises by 35 percent of the expected revenue from the tax increase. The effect of a reduction in PIT is symmetrical.

The remainder of the paper is structured as follows: Section I presents the data. Section II presents a simple theoretical model that demonstrates the problem of endogeneity in estimation, and explains how forecasts of tax revenue address it. Section III estimates a system of dynamic equations for tax revenue as part of an error-correction model. Section IV examines the separate effects of changes in the PIT, the CIT and indirect taxes. Section V presents robustness tests, and section VI concludes.

I. Data on legislated tax changes in Israel 1991–2012

We use a Bank of Israel database of tax changes introduced by the central government during the period 1991–2012. We updated and verified the database using primarily the annual reports of the State Revenue Division of the Ministry of Finance.[4] The reports estimate the impact of legislative changes on tax revenue in each of the subsequent years. Up to 2012 these estimates were based on a simple static calculation – the change in the tax rate multiplied by the size of the tax base. As tax changes in Israel do not expire or have sunset clauses, any change

[4] Missing data were obtained from the following sources: the proposed budgets presented to the Knesset, legislation passed by the Knesset and explanations accompanying proposed legislation, government decisions and Bank of Israel's budget reviews.

is considered permanent until another legislation modifies it. We transformed the annual estimates to quarterly data, using information on the exact date in which the change would go into effect. The database makes it possible to differentiate between fees, indirect taxes and direct taxes – and within the latter between the PIT and the CIT. The database consists of 218 unique tax changes, of which 83 were changes in indirect taxation, 66 in PIT, 34 in the CIT, and 35 in other direct taxes (primarily related to the capital market and real estate). Most of the tax changes (164) went into effect during the first quarter of the year and 34 were affected during the third quarter. Figure 1 presents the quarterly amount of tax changes. There were changes in 62 out of the 84 quarters in the sample period, of which 43 had relatively large aggregate changes, exceeding 0.1% of GDP. The data on all the tax changes is available in the online appendix.

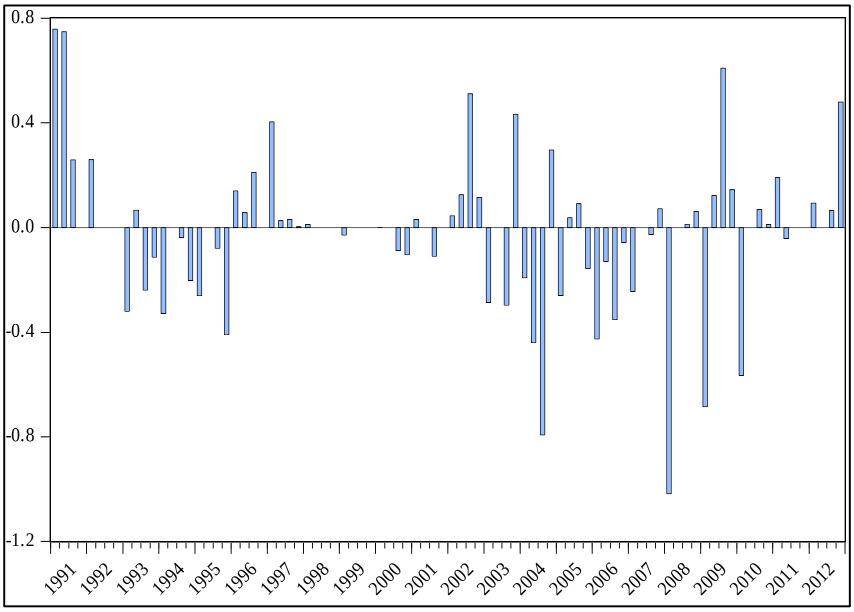

FIGURE 1. SIZE OF TAX CHANGES, BY QUARTER IN WHICH THEY CAME INTO EFFECT, IN THE YEARS 1991-2012, STATIC REVENUE EFFECT AS A PERCENT OF GDP

Notes: Tax changes that came into effect in each quarter over the years 1991 to 2012. The size of the change is the Ministry of Finance's static prediction of the annual revenue effect, divided by annual GDP.

For each tax and for each quarter, we aggregate the static revenue estimates of the tax changes during the quarter (in fixed prices), and then calculate the ratio of the tax changes in each quarter (multiplied by 4) to the total tax revenue in the calendar year preceding the change. These ratios are accumulated to get the percent sum of tax changes from the beginning of the sample (1991q1) until each quarter. Figure 2 shows the cumulative amount of changes in each of the tax categories, as a share of the fixed-prices *total* tax revenue in 1990. The annual tax revenue forecasts, without the effect of the proposed tax amendments, are also taken from the reports of the State Revenue Division or from the proposed budgets presented to the Knesset. The forecasts we use start from 1992, because 1991 was a shortened fiscal year lasting only 9 months. Data on tax revenue are taken from the reports of the State Revenue Division and from the Tax Authority and are adjusted for one-off events.[5]

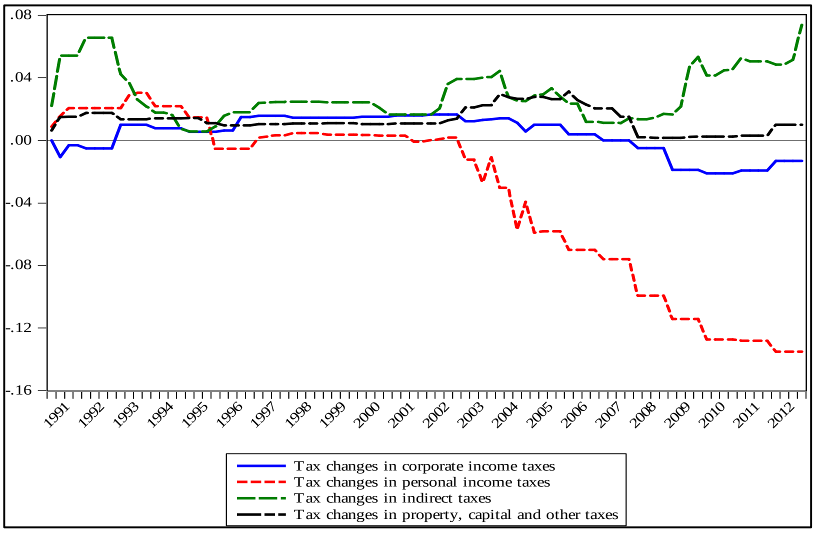

FIGURE 2. CUMULATIVE TAX CHANGES IN THE YEARS 1991-2012, SHARE OF 1990 TOTAL TAX REVENUE (IN FIXED PRICES)

Notes: Quarterly tax changes, relative to prior-year total tax revenue, are accumulated over the years 1991 to 2012.

[5] One-off revenue adjustments included income changes due to particularly large transactions of a one-time nature, e.g. purchases of large Israeli firms, and fluctuations in tax collection due to work slowdowns by the employees of the Tax Authority. Tax revenue outliers in terms of timing or magnitude as a result of tax changes were not adjusted for.

II. The analytical framework

We first construct a simple specification to describe the effect of tax changes on revenues:

(1) $$\Delta T_t = a * \Delta\tau_t + \Delta T'_t = a * \Delta\tau_t + \alpha + b * \Delta X_t + \varepsilon_t$$

where ΔT_t is the change in tax revenue in period t, $\Delta\tau_t$ is the (static) value of the tax changes that went into effect in period t, and $\Delta T'_t$ is the change in tax revenue less the effect of legislated changes in that period. $\Delta T'_t$ depends on changes in the tax bases, and X_t is the vector of macro variables that affect those tax bases. ε_t represents temporal shocks to tax revenue that are not dependent on macro variables, and we assume $E_{t-1}(\varepsilon_t) = 0$. α may represent constant independent factors affecting the trend in tax revenues. The coefficient of tax changes — a — reflects the proportion of revenue actually collected as a result of the tax increase; 'a' will equal 1 if there is full realization of the static estimate, i.e. if the tax base is constant. We assume, for the sake of simplicity, that the tax changes in period t were legislated in period t-1, since even if the changes were legislated in an earlier period, it was still possible to modify or cancel them in t-1 (as was indeed the fate of a few tax changes in Israel).[6] Tax changes are determined as follows:

(2) $$\Delta\tau_t = d * E_{t-1}(\Delta T'_t) + \omega_{t-1} = d * (\alpha + b * E_{t-1}(\Delta X_t)) + \omega_{t-1}$$

If policy makers have decided to implement a tax change, this may be in response to the expectations in t-1 of a change in the adjusted tax revenue in t, i.e. $E_{t-1}(\Delta T'_t)$. Following Equation (1), these expectations depend on forecasts (prepared in t-1) for changes in macroeconomic variables in period t. According

[6] In formulating the basic model, we essentially ignore the differences between anticipated and unanticipated tax changes. This assumption, similarly to BP, also means that tax changes cannot be a response to shocks that happened in the same quarter in which they go into effect. Later, we test the effect of expected changes for a one-quarter-ahead horizon.

to this specification, the effect of changes in tax revenue on tax changes remains fixed from one period to the next (there is no time sub-index for the coefficient d). In principle, the direction and magnitude of this effect may change from one period to the next due to the changing preferences of policy makers, e.g. regarding the degree of pro-cyclicality or counter-cyclicality of tax policy. However, for Israel, Strawczynski (2014) showed that the degree of pro- or counter-cyclicality of tax policy remains stable over time both during the period 1998–2011 and for a longer sample starting in 1970. This finding supports our assumption of a stable d coefficient in our data. Tax changes can also be the result of the shock ω_{t-1}, which is not dependent on expected tax revenue, e.g. is the result of an ideological choice made by policy makers. Such tax changes are the exogenous changes that RR try to identify using the narrative method.

Combining the equations for tax revenue and tax changes, and assuming that the forecast of tax revenue is formulated rationally according to the model (as described in Equation 2), yields the following equation:

(3) $$\Delta T_t = (1 + a * d) * \alpha + b * \Delta X_t + [a * d * b * E_{t-1}(\Delta X_t) + a * \omega_{t-1}] + \varepsilon_t$$

Equation (3) illustrates the risk that the estimation of Equation (1) will lead to a biased estimate of the effect of tax changes on revenue. If the policy makers' forecast for future macro variables cannot be controlled for, then some variables in the vector X_t might be included in the residual. That will lead to correlation between the tax changes and the residual, resulting in endogeneity.

RR deal with the problem of endogeneity by omitting any tax changes that are not exogenous. In other words, according to our notation, they only include tax changes for which d=0 and are therefore only the result of ω shocks, which are not dependent on macro forecasts during the legislation period. RR explained that the choice to use the narrative method to identify exogenous changes was also based on the lack of exact forecasts that accompany the tax changes[7]:

"… it is impossible to proxy for all the information about the future output movements that policymakers may have had. The kind of numerical forecasts of what policymakers thought would happen to output in the absence of tax changes, that would be ideal for this exercise, are generally not available even for recent tax changes."

We deal with the problem of endogeneity in a novel way, by explicitly controlling for the numerical forecasts of tax revenue that were presented by the Ministry of Finance in the proposed budgets, alongside the proposed tax changes. The forecasts are based on the forecasted changes in the macro variables (primarily GDP growth), and allow controlling for the information possessed by policy makers at the time the tax change was proposed. They do not reflect the effect of proposed tax changes on economic activity or on tax revenue itself. Essentially, we explicitly include $\mathrm{E}_{t-1}(\Delta\mathrm{T}_t')$ in the regression and thus deal with the correlation described above between the tax changes and the residual, eliminating the resulting endogeneity. The inclusion of the forecasts allows us to use all the tax changes implemented during the sample period, not only the "exogenous" ones.

One may claim that the forecasts published by the Ministry of Finance as part of the proposed budget may be manipulated, and do not always reflect the actual forecast being considered by policy makers. We examine this claim in Section V and show that the concern of intentional manipulation is not supported by the data. In the following section, we estimate a system of equations based on Equation (1) above.

[7] In RR's model, the effect of the (expected) economic activity on tax changes can vary from one period to the next, i.e. 'd' in our notation is d_t in theirs.

III. The effect of an average tax change on tax revenue

We use a dynamic system of equations within an error-correction model, to estimate the effect of tax changes on revenues. We first examine whether the effects of a tax change on economic activity can solely explain the fluctuations in the tax base after the change. Then we examine the dynamics of revenues and offsetting effects in the first few years after a change goes into effect.

A. The estimated error correction model

The system of equations is based on the Bank of Israel's quarterly real tax model (Brender (2001), and Brender and Navon (2010)), and includes two equations: First, a *long-run equation* for the relationship between the level of tax revenues and total legislated tax changes up to that point (in percent of total tax revenue). The equation controls for domestic economic variables: the levels of GDP, the average wage, and imports of consumption goods. In addition to the domestic economic variables, we included two variables that affect revenues, but are plausibly exogenous to it: the world trade index, and the number of tourists. Although world trade does not constitute a tax base and does not directly influence tax revenue, it is one of the external variables that significantly affect economic activity in Israel, which is a small open economy. As common in analyses of the Israeli economy, incoming tourism serves as a proxy for changes in the security situation that affects activity and revenues. We included the tax changes alongside the activity variables, in order to test whether the changes have additional effects on tax revenue beyond their effect on measured economic activity. If such effects do not exist, we expect that the tax change coefficient will be equal to one. Second, the system includes a *differences equation* that describes the relationship between the quarterly change in tax revenue and the quarterly tax changes, controlling for other activity variables that may affect the change in revenues[8]. A list of the variables appears in the appendix (Table A.1).

We exclude in our estimations the period starting in 1997:Q2 and ending in 2001:Q4. There were only few legislated tax changes in this period, but it had large fluctuations in total tax revenues, resulting from external outlier events (such as the Asian crisis in 1998 and the high-tech bubble and its aftermath in 2000–01). As a test of robustness, we also estimated the model for the period 2002–12 and found the results to be similar (see section V). All the equations include quarterly dummy variables, to account for seasonality, and a dummy variable that takes the value of one for the quarters starting from 2002:Q1. The coefficient of the latter variable was found to be negative and significant, which indicates a downward shift in tax revenue starting from 2002.

Many of the variables in the long-run equation are I(1) and are non-stationary (see Table A.1 in the appendix). However, in all the estimated regressions, the Engle-Granger test rejects the hypothesis that there is no co-integrative relation between the variables. For the regression estimated using 2SLS, an ADF test of the residual rejects the existence of a unit root. Apart from that regression, all of the long-run equations in the paper are estimated using Static OLS (i.e., Dynamic OLS without leads and lags). The standard deviations are calculated using the Newey-West method, which corrects for autocorrelation and heteroscedasticity.

B. The effect on revenues through the channel of economic activity

We first estimate the long-run equations (Table 1), controlling for the revenue forecasts in all versions. In the first version, the only activity variable included in the equation is the log of GDP, instrumented by the exogenous log of world trade

[8] Changes in: GDP, imports of consumption goods, the average wage in the economy, the shekel value of foreign currency credit, stock prices, sales of new homes, and the sale of Israeli companies to foreign investors through mergers and acquisitions.

index and log of the number of tourists. The results of the 2SLS estimation show that when GDP is controlled for, a tax change that is statically expected to raise tax revenue by one percent indeed increases it by close to one percent (0.941). In the second version, we added the index of world trade and the number of tourists, alongside (log of) local macro variables: GDP, imports of consumption goods and the average gross wage in the economy.[9] Again, a tax change which is meant to increase tax revenue by one percent will indeed increase tax revenue by one percent (0.996).

TABLE 1— THE LONG-RUN EQUATION LINKING TAX RATE CHANGES TO TAX REVENUE

Dependent Variable: Log of total tax revenue	(1) 2SLS	(2) SOLS	(3) Excluding domestic economic variables	(4) Including all domestic economic variables
Sum of tax changes until the present	0.941	0.996		
	(0.456)	*(0.209)*		
Tax changes within the last year			0.636	1.067
			(0.358)	*(0.282)*
Tax changes during the year before last			0.317	1.139
			(0.386)	*(0.352)*
Tax changes implemented more than two years ago			0.724	1.270
			(0.351)	*(0.365)*
Instrumented log GDP	1.070			
	(0.184)			
Exogenous economic variables [a]		+	+	+
Domestic economic variables [b]		+		+
Log of forecast of tax revenue	+	+	+	+
Adjusted R-squared	0.910	0.967	0.943	0.966
Durbin-Watson statistic	0.960	1.587	1.521	1.628
Residual ADF test statistic	-4.81			
Engle-Granger tau-statistic		-7.17	-6.95	-7.31

Notes: Standard errors appear in parentheses. The sum of tax changes is the cumulated sum of quarterly changes, measured by the static prediction of the revenue effect of the change, divided by the total revenue in the previous year. The regressions include a constant, quarterly dummy variables and a dummy variable for 2002 and onward. As explained, for each tax change variable, an interaction between tax changes and a dummy variable for the period 1997:Q1 to 2001:Q4 was included. In the 2SLS estimation, the logs of the number of tourists, and of the world trade index with 1 and 2 lags, serve as instruments for the log of GDP. [a] Exogenous variables: Log index of world trade, Log number of tourists. [b] Domestic variables: Log GDP, component of imports not correlated with GDP, component of average wage not correlated with GDP. Complete results are presented in Table A2.1 in the online appendix.

[9] Changes in wages and imports of consumption goods are correlated with changes in GDP growth. Following Brender and Navon (2010), we replaced these variables in all equations with the residual obtained from a regression of wages/imports on lagged GDP and a constant.

The second equation in the dynamic system is a differences equation in which the dependent variable is the change in tax revenue during the current quarter relative to the previous quarter (Table 2). The residual from version (2) of the long-run equation is included here as an explanatory variable. Its coefficient was estimated to be -0.8, a negative coefficient confirming the existence of an error-correction type relationship, and indicating that deviations from the long-run relationship between tax revenue and the explanatory variables are largely corrected within two quarters. The estimation shows that a tax increase from the current quarter, that is meant to raise tax revenue by one percent, will add only 0.77 percentage points to the change in tax revenue (when macro variables are controlled for). This estimate indicates that a tax change is only partially manifested in revenue during the first quarter it goes into effect. This may be due to the timing in which a tax change goes into effect during the quarter or due to possible shifting of activity or tax payments near that time. As noted above, the remaining gap from the long-term relationship is closed quickly.

In the second version of the differences equation, we also included tax changes with a lead of one quarter. In most cases, tax changes are known about at least one quarter before they are affected, since they are included in a prior budget proposal. Expected tax changes may cause a shift in activity to and from the current quarter and thus may affect tax revenue even before they go into effect. According to the results, a tax change that is expected (using a static calculation) to raise tax revenue in the following quarter by one percent, will raise tax revenue already in the current quarter by 0.5 percent. This effect can help explain why a tax change has only a partial impact in the quarter when it takes effect.

The role of anticipated tax changes was examined within the tax multiplier literature, but no empirical consensus has developed. BP did not find evidence that the expectation of a tax change in the next quarter affects the GDP, and RR did not find a significant effect of the present value of future tax changes on GDP.

In contrast, Mertens and Ravn (2012), who considered the realization horizon of each tax change, found a large impact in the year before an expected change goes into effect. However, Perotti (2012) warned that when one takes into account the difference between anticipated and unanticipated future changes, and possible different effects for each realization horizon, there is only minimal evidence for the effect of future tax changes on GDP.

TABLE 2— THE SHORT-RUN LINK BETWEEN LEGISLATED TAX CHANGES TO TAX REVENUE

Dependent Variable: Log of quarterly change in tax revenue	Differences equation	Differences equation with a lead
Tax changes during the current quarter	0.767	0.708
	(0.315)	*(0.311)*
Tax changes in the next quarter		0.522
		(0.294)
Residual of the long-run equation	-0.779	-0.768
	(0.128)	*(0.127)*
Change in exogenous economic variables [a]	+	+
Change in domestic economic variables [b]	+	+
Adjusted R-squared	0.925	0.928
Durbin-Watson statistic	2.195	2.247

Notes: Standard errors appear in parentheses. The regressions include a constant, quarterly seasonality variables and interactions of the tax changes with the break period. [a] *Exogenous variables: change in the world trade index, change in log number of tourists.* [b] *Domestic variables: GDP growth in the previous quarter, GDP growth two quarters ago, change in the component of imports not correlated with GDP, change in the component of average wage not correlated with GDP, change in the log of TASE index*dummy for 2004 and on, change in the log of foreign currency credit in the previous quarter. Complete results are presented in Table A2.2 in the online appendix.*

C. The dynamic effects

This section examines the dynamic effects that legislated tax changes have on tax revenue, over three periods: changes that went into effect during the previous year, during the year before that, and all the changes introduced two or more years ago.[10] First, we estimate the long-run equation without any domestic activity variables (Table 1, version 3). The presence of exogenous economic variables, i.e., the world trade index and number of tourists, serves here as a control for shocks that are not the result of the domestic economy. The estimated coefficient

[10] Due to the lags, this version was estimated starting only from 1993:Q1.

of the tax changes reflects the actual effect of changes on revenues. This effect is the sum of the 'direct' mechanical effect on tax revenue holding the tax base constant (a positive effect), and the ‘indirect’ dynamic effect on tax revenue through the effect of tax changes on macro variables (which we generally expect to be negative). The estimation indicates that a tax change, that was predicted (statically) to increase tax revenue by one percent, will increase it by only about 60 percent of that amount during the first year after it goes into effect. In the second year, tax revenue collection reaches a trough of only about 30 percent of the expected amount (and this proportion is not significantly different from zero). After two years, tax revenue rebounds and in the long run the tax change yields about 70 percent of the static prediction. [11]

Second, domestic economic activity variables (GDP, imports of consumption goods and the average wage) are added, and we estimate the coefficient of tax changes while controlling for these variables (Table 1, version 4). The coefficients of tax changes are not different from one in a statistically significant way, implying again that the legislative tax changes have an offsetting effect on revenues only through the channel of economic activity.

The bias created in the coefficients of tax changes, when domestic activity variables are omitted, serves as an estimate of the 'indirect' effect of tax changes on revenue via the economic activity channel. However, this estimate should be treated with caution since it is obtained from the difference between coefficients in two different regressions and it is impossible to explicitly test hypotheses on it. Table 3 presents the calculated 'indirect' effects of tax changes on tax revenue. It presents both the difference between the tax coefficients, and the difference relative to a static forecast (in which the tax change coefficients equal to 1). Like

[11] All the tax change coefficients reflect the effect of tax changes according to the average composition of tax changes during the sample period. A different composition of tax changes may yield different results. In the following section, we will examine the effect of each type of tax separately.

previous papers on the tax multiplier, we find a dynamic effect of tax changes on economic activity, whereby the effect increases in strength over a two-year period and then declines. For the US, RR found that the effect of an exogenous tax change on GDP peaks after 10 quarters and declines subsequently. A similar result for the UK was obtained by Cloyne (2013). Mazar (2011) found in Israel a similar short-run effect for changes in direct taxes, and estimated the peak of their influence to occur after 18 months. For indirect taxes, he found a more rapid process, with the peak occurring after only six months.

TABLE 3— 'INDIRECT' EFFECTS OF TAX CHANGES (I.E. DIFFERENCES BETWEEN THE TAX CHANGE COEFFICIENTS)

Indirect effect of a tax increase that is intended to raise tax revenue by one percent	The effect on revenues via all domestic economic variables (percent of revenue)	The effect on revenues via all domestic economic variables, relative to a static forecast (i.e. tax coefficient = 1)
Tax increase during the last year	-0.40	-0.364
Tax increase during the year before last	-0.72	-0.683
Tax increases more than two years ago	-0.43	-0.274

Notes: The indirect effect of tax changes on revenues is the difference between the effect of a tax change on revenues in a regression that controls for domestic activity variables, and the effect in a regression, where these domestic variables are omitted. The second column shows the difference, assuming that the coefficient of tax changes in the long regression is 1 (i.e. is according to the static forecast).

The focus of this paper is the effect of tax changes on total tax revenue, and we do not attempt to estimate the tax multiplier directly. Nonetheless, in order to compare the magnitude of our results with the tax multipliers in the literature, we estimated the implications of these multipliers for tax revenue, given the characteristics of the tax system in Israel.[12] Using RR's multiplier, the offsetting effect of a tax change on tax revenue through the effect on GDP is -0.84 at its peak. Using BP's multiplier, the offset ranges from -0.21 to -0.36. The offsetting

[12] We used the tax burden in order to calculate, in terms of percent of tax revenue collection, the size of a tax change of one percent of GDP. For a tax to GDP ratio of 27.2 percent (the average ratio during the sample period) the change amounts to 3.68 percent of tax revenue collection. We assumed a unit elasticity of tax revenue collection relative to GDP (according to the coefficients of the long-run equation above) and used it to calculate the offset effect of a change in GDP on total tax revenue. Thus, for example, RR's tax multiplier of -3.08 implies that a tax increase of 3.68 percent of tax revenue leads to an offset of 3.08 percent of tax revenue through its effect on GDP. Therefore, a tax increase of one percent of tax revenue will lead to an offset of -0.84 percent of the additional revenue.

effect we obtained is -0.72 at the peak and therefore our result is more consistent with the multiplier obtained by RR than with the smaller multiplier found by BP (with the caveat that in our estimation, the offsetting effect can manifest not only via GDP but also via other macroeconomic variables).

IV. The effect of changes in the PIT, the CIT and indirect taxes on revenues

Up to this point, we have examined the impact of tax changes without relating to the composition of the change. However, the various types of taxes may have different effects on tax revenue, both with respect to the size of the effect and its timing, and with respect to the channels through which it works. The importance of differentiating between the various types of taxes is clear from the literature. Mazar (2011) found large differences in the effect on GDP between indirect and direct taxes in Israel. Mertens and Raven (2013) found different dynamic effects for PIT and CIT changes in the US.

In this section, we estimate three error-correction models for the PIT, the CIT and indirect taxes.[13] For each type of tax, we recalculate the tax changes relative to tax revenue from that type of tax in the previous calendar year. Each estimated equation includes the forecast of revenue from each type of tax, which reflects the relevant information available to policy makers when the tax change was legislated.[14]

[13] In order to preserve comparability with the previous section, we estimated the models from 1993 to 2012 and controlled for the period between 1997:Q1 and 2001:Q4.

[14] The budget includes a forecast of revenue from all income taxes - PIT and CIT combined. In our estimations we use the component of this forecast that is independent of prior PIT or CIT changes (i.e. a residual from a regression of the forecast on prior changes in the specific tax).

A. The personal income tax

We estimate an error-correction model for tax revenue from the PIT (on salaries and labor income of self-employed individuals[15]). First, a long-run equation was estimated for the relationship between tax revenue and tax changes using three versions (Table 4). The estimation of the equation without domestic economic activity variables (version 1) shows that a tax change intended to raise tax revenue by one percent, in fact raises it by 0.76 percent during the first year, by 0.36 percent in the second year (this coefficient is not significant), and by 0.65 percent in the long run (after two or more years). When domestic activity variables are controlled for (version 2), PIT yields in the short run only about 80 percent of the (statically) expected amount of revenue, and tax changes that have been in effect for two years or longer affect revenues precisely according to the static calculation.

The difference between the coefficients indicates that in the first year, the effect of tax changes on tax revenue, through the channel of domestic activity, is only marginal. The effect through this channel increases subsequently. In the long run, an increase in the PIT that is meant to raise tax revenue by one percent has a negative effect on economic activity that offsets 0.4 percent of the tax revenue increase. Mertens and Ravn (2013) find a PIT multiplier of -2.5 which, in the context of the Israeli economy, yields a similar offset of -0.34 percent (although our offset appears to be of a more permanent nature). These offsets are higher than estimates derived from the micro-based literature on the elasticity of taxable income. Saez et al. (2012) survey this literature, and using the best surveyed estimates of the ETI, derive an offset of 0.195$ for every dollar of US federal income tax revenue raised by an across-the-board proportional tax increase.

[15] In Israel, taxes on capital income are not part of the PIT system. They are calculated and withheld separately at flat rates.

TABLE 4— THE LONG-RUN EFFECT OF CHANGES IN THE PIT ON PIT REVENUE

Dependent variable: Log revenue from the personal income tax	(1) Excluding domestic economic variables	(2) Including all domestic economic variables	(3) Excluding the wage variable only
Tax changes in the last year	0.760	0.805	1.196
	(0.405)	*(0.253)*	*(0.263)*
Tax changes year before last	0.355	0.782	1.150
	(0.447)	*(0.289)*	*(0.307)*
Tax changes implemented more than two years ago	0.647	1.084	1.539
	(0.245)	*(0.217)*	*(0.213)*
Component of income taxes revenue forecast, which is independent of prior PIT changes	0.354	0.048	0.120
	(0.146)	*(0.093)*	*(0.102)*
Exogenous economic variables [a]	+	+	+
Domestic economic variables [b]		+	+
Adjusted R-squared	0.839	0.926	0.897
Durbin-Watson statistic	1.272	1.771	1.828
Engle-Granger tau-statistic	-6.75	-8.48	-8.60

Notes: Standard errors appear in parentheses. The regressions include a constant, and quarterly seasonality variables. For each tax change variable, an interaction is included between the tax changes and a dummy variable for the period 1997:Q1 to 2001:Q4. [a] Exogenous variables: Log index of world trade, Log number of tourists. [b] Domestic variables: Log GDP, component of imports not correlated with GDP, and in version 2 only: component of average wage not correlated with GDP. Complete results are presented in Table A2.3 in the online appendix.

The difference in the coefficients between versions (2) and (3) implies that a PIT change has a positive effect on tax revenue via its positive effect on wages.[16] Even after taking into account the negative effect of the tax change on wages via GDP,[17] the wage will still rise in reaction to a PIT increase – an estimated rise of 0.07 percent after a PIT change that is intended to increase tax revenue by one percent. Essentially, 35% of the tax incidence falls on employers that compensate their workers for a decline in their net salary, by raising their gross salary. Employees carry 65% of the additional tax burden. These incidence rates are

[16] A PIT hike of one percent of revenues will increase the component of real average gross wage not correlated with GDP by 0.34 percent, leading to a 0.46 percent increase in tax revenue.

[17] To calculate this negative effect, we estimated a version of the long-run equation that excluded only the GDP variable. Using the differences in the coefficients of the tax changes, we derived the effect of a tax change on the tax revenue through the effect on GDP. Using the elasticity of average wage to GDP in Israel (0.27), as estimated in Brender and Navon (2010), we derived the effect of a tax increase on the component of the wage which is correlated with GDP.

similar to the average in non-Nordic countries, as Gonzalez-Paramo and Melguizo (2013) found in their meta-analysis.[18]

Furthermore, we estimated a differences equation for the short-term relationship between changes in the PIT and changes in its revenues (Table 5). The coefficient of the long-run residual (-0.8) is negative and statistically significant, and supports the specification of an error-correction model in which deviations are corrected within two quarters. According to the estimation (version 1), 60 percent of the expected increase in revenue (according to a static calculation) is achieved in the first quarter after the change goes into effect, and an additional 50 percent in the subsequent quarter. Version 2 shows that a PIT change expected in the next quarter has a positive effect on tax revenues already in the current quarter, but the effect is on the border of being significantly different than zero.

TABLE 5— THE SHORT-RUN EFFECT OF CHANGES IN THE PIT ON THE CHANGE IN PIT REVENUE

Dependent variable: The change in log revenue from the PIT	(1)	(2) Adding a lead
Change in the PIT in the current quarter	0.604 *(0.204)*	0.686 *(0.209)*
Change in the PIT in the previous quarter	0.490 *(0.214)*	0.432 (0.214)
Change in the PIT in the next quarter		0.317 *(0.192)*
The long-run residual	-0.787 *(0.110)*	-0.784 *(0.111)*
Change in exogenous variables [a]	+	+
Change in domestic economy variables [b]	+	+
Adjusted R-squared	0.778	0.783
Durbin-Watson statistic	2.232	2.233

Notes: Standard errors appear in parentheses. Includes a constant, seasonality variables, interactions of the tax changes with the structural break period and an interaction between imports and a dummy variable for the period 2001 and onward and for the period 2006 and onward. [a] Exogenous variables: change in log world trade index, change in log number of tourists. [b] Domestic variables: GDP growth, change in the component of imports not correlated with GDP, change in the component of average wage not correlated with GDP. Complete results are presented in Table A2.4 in the online appendix.

[18] We found no significant evidence of an asymmetric effect of tax increases and tax decreases. To examine this issue we estimated another version of the equation (available from the authors), in which we added interactions between the tax changes in the last two years and a dummy variable that indicated whether there was a tax increase in each year.

B. The corporate income tax

We estimate an equation for the long-run relationship between changes in the CIT and the revenue from this tax (Table 6). Estimation of the equation without the domestic economic variables (version 1) shows that a change in the CIT has almost no effect on revenues during the first year. The effect during the second year is positive, but still insignificant. In the long run, tax changes implemented two or more years earlier produce about 90 percent (0.89) of the expected revenue. Even when the effect of a change in the CIT on domestic activity is controlled for (version 2), CIT changes appear to cause large and significant shifts of activity and tax payments in the short run – there is under-collection in the first year and over-collection in the second year following the change. In the long run and when account is taken of the domestic activity, a change in the CIT yields the revenues expected according to a simple static calculation.

The difference between the coefficients indicates that the 'indirect' effect of changes in the CIT on tax revenue, via the economic activity channel, reaches a peak in the second year following the change – a decrease in the CIT that is intended to reduce revenue by one percent, stimulates economic activity, and thus offsets 0.73 percent of the expected revenue reduction in the second year. The positive effect on economic activity declines later, and in the long run the offset is 0.27 percent of the expected revenue reduction. This offset is similar to the 0.29 marginal deadweight cost of CIT rates, found by Devereux et al. (2014) in a micro-based paper that exploited kink points in the tax schedule in the UK. Our estimates contrast those of Mertens and Ravn (2013) that found little effect of CIT changes on revenues in the US, due to large and negative elasticity of the tax base with respect to tax changes. The lower long-term elasticity of the CIT tax base in Israel might be affected by the fixed preferential CIT rates for large exporters, that make changes in the general rate irrelevant for most large mobile firms.[19] It should be noted that the tax changes in our data refer not only to changes in the CIT rates, but also to non-rate aspects of the CIT system, e.g. changes to tax depreciation allowances. As Kawano & Slemrod (2016) warn, ignoring such non-rate tax changes may bias the estimates of the effect of CIT rates on CIT revenues.

TABLE 6— THE LONG-RUN EFFECT OF CIT CHANGES ON TAX REVENUE

Dependent variable: Log revenue from the CIT	(1) Excluding domestic economic variables	(2) Including all domestic economic variables
Tax changes in the last year	0.110	0.745
	(0.530)	*(0.693)*
Tax changes in the year before last	0.767	1.495
	(0.580)	*(0.796)*
Tax changes implemented two years ago or longer	0.888	1.154
	(0.494)	*(0.642)*
Component of income taxes revenue forecast, which is independent of prior CIT changes	0.787	0.005
	(0.329)	*(0.380)*
Exogenous variables [a]	+	+
Domestic economic variables [b]		+
Adjusted R-squared	0.731	0.786
Durbin-Watson statistic	1.486	1.857
Engle-Granger tau-statistic	-6.80	-8.36

Notes: Standard errors appear in parentheses. The regressions included a constant and quarterly seasonality variables, and interactions between tax changes and the structural break period. [a] Exogenous variables: Log of the NASDAQ index, log number of tourists [b] Domestic variables: Log GDP in the previous quarter, component of imports not correlated with GDP, component of average wage not correlated with GDP. Complete results are presented in Table A2.5 in the online appendix.

We also estimate a differences equation for the short term relation between changes in the CIT and changes in revenue from it (Table 7). The negative coefficient of the long-run residual (-0.57) is statistically significant and supports the specification of an error-correction model, in which deviations from the long-run relation are largely corrected within two quarters. The fluctuating effect of tax changes on tax revenue is apparent again. At first, raising the CIT decreases the revenues from this tax, and only after 3 quarters the revenues increase in a

[19] The revenue predictions for CIT changes consider the smaller tax base due to preferential rates.

significant way (by 0.74 percent of revenue). Revenues continue to rise (by close to an additional percent of tax revenue) in the parallel quarter, a year after the change. This result is likely to be evidence of the time-shifting of activity and tax payments, and is consistent with the fact that a significant proportion of CIT payments relates to past profits.[20]

TABLE 7— THE SHORT-RUN EFFECT OF CIT CHANGES ON REVENUES

Dependent variable: The change in the log of CIT revenue	
Changes in the corporate tax in the current quarter	-0.943 *(0.761)*
Changes in the corporate tax in the previous quarter	-0.629 *(0.392)*
Changes in the corporate tax two quarters ago	-0.008 *(0.415)*
Changes in the corporate tax three quarters ago	0.740 *(0.412)*
Changes in the corporate tax four quarters ago	0.927 *(0.429)*
The long-run residual	-0.567 *(0.131)*
Change in exogenous variables [a]	+
Change in domestic economy variables [b]	+
Adjusted R-squared	0.633
Durbin-Watson statistic	2.493

Notes: Standard errors appear in parentheses. Includes a constant, seasonality variables, and interactions between tax changes and the structural break period. [a] Exogenous variables: change in log NASDAQ index, change in log number of tourists. [b] Domestic variables: GDP growth in the previous quarter, GDP growth 12 quarters ago, change in the component of imports not correlated with GDP, change in the component of average wage not correlated with GDP, change in TASE index, change in foreign mergers and acquisitions four quarters ago. Complete results are presented in Table A2.6 in the online appendix.

C. Indirect taxes

We estimate an error-correction model to examine the effect of a change in indirect taxes on total revenue from these taxes. We first estimate an equation for the long-run relationship (Table 8). The estimation of the equation without domestic economic variables (version 1) shows that a change in indirect taxes, that under a constant tax base would have increased indirect tax revenue by one

[20] A version that included a lead variable for the tax changes in the next quarter (available from the authors) found a positive, but statistically insignificant effect on current revenues.

percent, in fact increases it by 0.78 percent during the first year. Past changes in indirect taxes produce today only about 60 percent of the expected revenue. When the effect of the tax changes on domestic economic activity is controlled for (version 2), the collected revenue is in line with the static forecast. The difference between the coefficients indicates an offsetting effect of about 25 percent of the expected revenue during the first year. This effect, through the channel of economic activity, subsequently increases in size and in the long run offsets about 40 percent of the (statically) expected revenue.

TABLE 8— THE EFFECT OF CHANGES IN INDIRECT TAXES ON REVENUES FROM INDIRECT TAXES

Dependent variable: Log revenue from indirect taxes	(1) Excluding domestic economic variables	(2) Including all domestic economic variables
Tax changes in the last year	0.779 *(0.237)*	1.022 *(0.208)*
Tax changes in the year before last	0.671 (0.208)	0.947 (0.185)
Tax changes implemented two years ago or longer	0.578 (0.270)	0.981 (0.218)
Component of indirect taxes revenue forecast, which is independent of prior changes in indirect taxes	-0.019 *(0.118)*	-0.212 *(0.091)*
Exogenous variables [a]	+	+
Domestic economic variables [b]		+
Adjusted R-squared	0.953	0.970
Durbin-Watson statistic	1.719	1.894
Engle-Granger tau-statistic	-5.63	-8.57
Engle-Granger z-statistic	-114.66	-76.67

Notes: Standard errors appear in parentheses. The regressions include a constant, quarterly seasonality variables, a dummy variable for the years 2002 and onward, and interactions between tax changes and the structural break period. [a] Exogenous variables: Log of the world trade index, log number of tourists. [b] Domestic variables: Log GDP, component of imports not correlated with GDP, component of average wage not correlated with GDP. Complete results are presented in Table A2.7 in the online appendix.

In addition to the long-run equation, we estimate a differences equation for the short-run relationship between changes in indirect taxes and the change in their revenue (Table 9). The negative coefficient of the long-run residual (-0.96) is statistically significant and supports the specification of an error-correction model, in which deviations from the long-run relationship are almost totally corrected for within a quarter. With activity variables controlled for, a change in indirect taxes achieves the revenues expected by a static forecast, already in the first quarter. Version 2 provides evidence of shifting of economic activity around a tax change. The estimation results indicate that an expected tax change in the next quarter, that is intended to raise revenue by one percent, will increase the change in revenue already in the current quarter, by close to 0.72 percentage points.

TABLE 9— THE SHORT-RUN EFFECT OF CHANGES IN INDIRECT TAXES ON REVENUES

Dependent variable: Change in the log of revenue from indirect taxes	(1)	(2) Adding a lead
Changes in indirect taxes during the current quarter	1.102	0.916
	(0.301)	*(0.308)*
Changes in indirect taxes during the next quarter		0.715
		(0.342)
Residual from the long-run equation	-0.999	-0.955
	(0.137)	*(0.136)*
Change in exogenous variables [a]	+	+
Change in domestic economy variables [b]	+	+
Adjusted R-squared	0.912	0.915
Durbin-Watson statistic	2.256	2.237

Notes: Standard errors appear in parentheses. The equations include a constant, quarterly seasonality variables, and interactions between tax changes and the structural break period. [a] Exogenous variables: change in log world trade index, change in log world trade index in the last quarter, change in log number of tourists. [b] Domestic variables: GDP growth in the previous quarter, change in the component of imports not correlated with GDP. Complete results are presented in Table A2.8 in the online appendix.

D. Response functions

As a further step, we examine the impact of a tax increase using a simulation that takes into account both the long-run and the short-run coefficients. Figure 3 presents the response functions over a horizon of 16 quarters, and an area of one standard deviation around them.

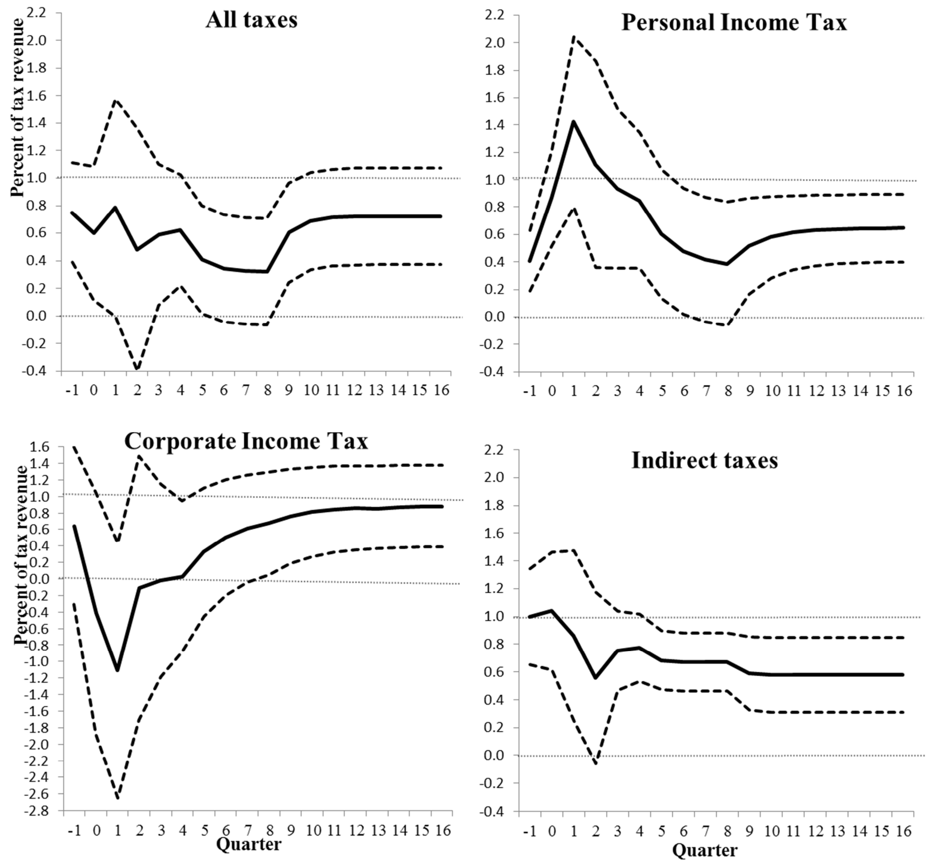

FIGURE 3. THE SIMULATED RESPONSE OF THE RELEVANT TAX REVENUE TO A TAX RISE THAT WOULD HAVE INCREASED REVENUES BY ONE PERCENT IN A STATIC CALCULATION

Notes: To perform the simulation, we estimated uniform differences equations for each type of tax. In all these equations the dependent variable is the change in log tax revenue (for the specific tax). The explanatory variables included tax changes from four quarters – next quarter (expected changes), the current quarter, and lagged changes from the previous two quarters. They included also the residual from the long-run equation (the version without domestic activity variables), the change in the world trade index, the change in log number of tourists, quarterly dummy variables, and a constant. The estimation results are available from the authors.

V. Robustness

A. Bias in the tax revenue forecasts

Tax revenue forecasts are used in this study as a tool to deal with possible endogeneity of tax changes. This raises the questions whether the forecasts are accurate, and if not, whether the bias reduces their benefit for identification. One should first note that as long as policy makers believe in the forecasts and determine tax changes based on them, errors in the forecasts will reduce the problem of endogeneity described in Section II. [21] Essentially, if policy makers ignore reality and decide on legislated tax changes only according to a random forecast, then changes are exogenous to future revenues and activity. Bias in tax forecasts becomes problematic if the published forecast does not reflect the private information used by policy makers when tax changes were legislated. In this case, we would like to include the private forecast as a control variable in the regressions, not the public one. The motivation for intentionally publishing a biased forecast could be the desire to recruit political support for a tax change that is proposed in the budget, or to delay painful fiscal steps.

We tested whether the revenue forecasts suffer from a bias that is correlated with the tax changes. We estimated a regression in which the dependent variable is forecast errors[22] and the explanatory variables are tax changes during the forecast year, and during the two years before that. We controlled for other sources of (unintentional) errors in the tax revenue forecasts – the error in the IMF forecasts of world trade[23], economic volatility, and "one-off" revenues. The regression also included the previous forecast error as an explanatory variable[24]. All the variables are I(0) and the equation was estimated by OLS. The main results are presented in Table 10. The coefficient of tax changes, during the year for which the forecast was made, is positive and not significantly different from zero. This makes it less likely that revenue forecasts were intentionally biased to

[21] According to Equation 3, if the tax revenue forecast, $E_{t-1}(\Delta T_t')$, reflects predicted macro changes, $E_{t-1}(\Delta X_t)$, that are less correlated with their actual results (i.e., ΔX_t), there is less concern of correlation between the macro variables in the residual and the tax changes.

[22] The error was calculated as the difference between the annual forecast of tax revenue and actual tax revenue. A positive value indicates that the forecast was overly optimistic relative to actual tax revenue. Although the forecasted and actual tax revenue are annual data, there were several years (2002, 2003 and 2009) in which the forecast was changed when a new budget was passed or a special budget was introduced in mid-year. Thus, the estimation makes use of quarterly data, which for each quarter give the revenues for that year and the forecast that was valid during that quarter.

[23] IMF forecasts serve as inputs to the growth and revenue forecasts of the Israeli Ministry of Finance.

[24] The tax revenue forecast in the budget is built upon the estimated revenue in the year the forecast is made, and therefore the error in a particular year affects the error in the subsequent one.

persuade that tax changes are necessary, since in that case we would have expected a negative coefficient – revenues would have been biased higher to support a purposed tax decrease, and lower to support a desired tax increase. The coefficient remains positive when we take into account the error that originates from using a static forecast.[25]

Tax changes made in the previous two years are significantly correlated with forecast errors. As forecasts ignored the dynamic effects of tax changes, they were doomed to become overly optimistic during the second year after a tax increase went into effect (hence the positive coefficient). The forecast in the third year following a tax increase is based on the lower tax collection during the first two years, and therefore it became overly pessimistic when the negative dynamic effect of the change weakened. In view of the difference in timing, these two coefficients do not constitute evidence of an intentional bias in the forecast.

TABLE 10— THE EFFECT OF TAX CHANGES ON ERRORS IN THE TAX REVENUE FORECASTS

Dependent variable: Errors in the tax revenue forecast for the current year	
Sum of tax changes in the current year	0.377 *(0.301)*
Sum of tax changes in the previous year	0.298 *(0.170)*
Sum of tax changes two years ago	-0.229 (0.121)
Adjusted R-squared	0.862

Notes: Standard errors appear in parentheses. The regression included also the following variables: error in the previous forecast (when prepared for a full year), error in the previous forecast (when prepared mid-year), error in the forecast of world trade, squared error in the forecast of world trade, deviation of the rate of increase in the NASDAQ index from its multiyear average, squared deviation of the NASDAQ index, the change in GDP growth between this year and two years ago, one-off tax revenue. Complete results are presented in Table A2.9 in the online appendix.

[25] The result is valid for another version of the equation (available from the authors), in which we deducted from the variable "Sum of tax changes in the current year" the dynamic effect of the tax change on the revenue (as found in this paper). In this version, the coefficient of the variable "Sum of tax changes in the previous year" remains positive (0.377) and not significantly different from zero.

B. Controlling for government expenditure

Tax changes are often correlated with changes in government expenditure. The correlation can be negative when the government adopts a pro-cyclical or counter-cyclical policy. The correlation can be positive when the government raises taxes to finance an increase in expenditure. If the effect of the expenditure on tax revenue is not reflected in the tax revenue forecast, the correlation may lead to biased estimates of the effect of tax changes.

To examine this issue, we re-estimated the equations in Table 1 (versions 3 and 4) with the addition of the log of government expenditure in the current quarter as an explanatory variable (Table 11). A reduction of one percent in expenditure is correlated with an increase of 0.15 percent in revenues, but the estimated effect of tax changes on tax revenue remains very similar.

TABLE 11— THE LONG-RUN RELATIONSHIP BETWEEN TAX CHANGES AND TAX REVENUE - CONTROLLING FOR GOVERNMENT EXPENDITURE

	Including government expenditure		Base version	
Dependent variable: Log of total tax revenue	(1) Excluding domestic activity variables	(2) Including domestic activity variables	(1) Excluding domestic activity variables	(2) Including domestic activity variables
Sum of tax changes in the last year	0.724 *(0.362)*	1.119 *(0.274)*	0.636 *(0.358)*	1.067 *(0.282)*
Sum of tax changes in the year before last	0.293 *(0.386)*	1.191 *(0.342)*	0.317 *(0.386)*	1.139 *(0.352)*
Sum of tax changes implemented two or more years ago	0.652 *(0.353)*	1.333 *(0.355)*	0.724 *(0.351)*	1.270 *(0.365)*
Log of government expenditure	-0.156 *(0.104)*	-0.155 *(0.084)*		
Adjusted R-squared	0.945	0.968	0.943	0.966
Durbin-Watson statistic	1.354	1.539	1.521	1.628
Engle-Granger tau-statistic	-6.35	-6.98	-6.95	-7.31

Notes: Standard errors appear in parentheses. Version (1) also includes the log index of world trade, the log number of tourists and the component of the revenue forecast uncorrelated with tax changes executed by the end of the previous year. Version (2) added logged GDP, the component of imports not correlated with GDP, and the component of the average wage not correlated with GDP.

B. Estimation for the period 2002–2012

Our sample period includes the years 1992–2012, where the period 1997:Q2 to 2001 was excluded from the estimations. In order to test the stability of the tax change coefficients, we re-estimated the equations in Table 1 (versions 3 and 4) also for the shorter period of 2002–2012. Using this subsample, the direct effects of tax changes on revenues during the first two years are somewhat higher than in the full sample (0.87 and 0.42 in the first two years vs. 0.64 and 0.32 with the full sample). However, the coefficient remains almost identical for tax changes implemented two or more years ago. See Table A2.10 in the online appendix for full results.

C. Cross-tax effects

The revenue in each type of tax may also be influenced by tax changes in other types of taxes. For example, a PIT increase may lead high-income individuals to incorporate, in order to shift income from the PIT base to the CIT base, thus increasing CIT revenues; The projections we use, from the State Revenue Authority, rarely acknowledge such cross influences.[26] Thus, cross influences that are not included in our data may bias our estimates. To examine this issue, we estimate a version of our long-run equations for each type of tax, in which we add the changes in the other two types of taxes to the explanatory variables. In these estimations (available from the authors), we find no significant evidence for a bias in the coefficients of the tax changes in any type of tax.

[26] Most of the cross influences mentioned in the data from the State Revenues Authority refer to the mechanical impact on CIT revenues from changes in employer-borne social security fees, and from changes in the excise duty on diesel fuel.

VI. Conclusions

We examine the effect of legislated tax changes on tax revenue in Israel during the period 1991–2012, using a comprehensive database of the tax changes implemented by the government during that period. We deal with the problem of endogeneity in a novel way, by using the numerical tax revenue forecasts that were presented by the Ministry of Finance alongside the annual budget proposals. The forecasts essentially reflect all the information policy makers had when they decided on the tax changes for the coming budget year. The use of these forecasts makes it possible to exploit all the implemented tax changes, rather than only (allegedly) exogenous ones. We also verify that there is no connection between biases in tax revenue forecasts and the proposed tax changes, alleviating concerns regarding manipulation of the forecasts in order to politically justify the changes. In addition, the identification of the effect of tax changes benefits from the way policy makers formulated their tax revenue forecasts – up to 2012 *static* forecast were used in the budget to estimate the effect of tax changes on revenues. The stability in the way in which the tax policy in Israel responded to fluctuations in activity and revenues, also assists in dealing with the endogeneity problem, facilitating the identification.

Four separate error-correction models are estimated: for total tax revenue, revenue from the PIT, revenue from the CIT and revenue from indirect taxes. In all cases, a co-integrative relationship is found over the long run, between the level of tax revenue and the explanatory variables. Deviations from the long-run relationship are largely corrected within two quarters.

We find that after a tax change, a significant portion of the revenue that would have been expected, had the tax base been static, is offset through the change's influence on economic activity. As a result of the offset, during the first year after a tax change goes into effect, a tax increase is expected to produce only about 60 percent of the static expectation of additional revenue. The offset peaks during the second year, when a third of the expected revenue is collected. From the third year onward the additional revenue rises to about 70 percent of the expected collection. We show that ignoring these dynamic effects and their timing increased the errors in the tax revenue forecasts that were included in the budget.

In the long run, an average tax change affects the tax base only through its effect on (measured) economic activity. Apart from this channel, we do not find evidence that tax changes affect the scope of tax planning or tax evasion. Our estimation for the size of the revenue offsetting is higher than the offsetting factor that is derived from the tax multiplier found by Blanchard & Perotti (2012), and is closer to the one derived from Romer & Romer (2010). Thus, our findings are consistent with the existence of the relatively high tax multiplier that Romer & Romer find using the narrative method. Despite the significant offsetting effect, we find that during the last two decades Israel was not on the “wrong” side of the Laffer curve, whereby a tax rate reduction raises tax revenue. This conclusion is valid both for aggregate taxes and for each type of tax that we examined.

In analyzing each type of tax separately, we find that in the steady state, a change in the CIT yields the highest collection rate relative to a static revenue forecast – about 90 percent. A change in the PIT yields 65 percent of the forecast, and a change in indirect taxes leads to a collection of 58 percent. This tax ranking is in contrast to the ranking in the short run, when CIT changes hardly affect the revenues. In addition to that, we find that a reduction in the PIT has a negative effect on the real average gross wage (and the effect is symmetric for a PIT increase). Thus, the incidence of a PIT reduction is split between the employees, whose net wage increases by 65 percent of the static value of the tax change, and their employers, who benefit from the rest of the amount through lower gross wage.

There is no consensus in the literature as to the unique effects of anticipated tax changes as compared to unanticipated ones. We deal with this issue here only by testing the possible effect of a tax change with a one-quarter-ahead horizon (assuming that for such a short horizon it is reasonable that most of the tax changes are known). We find that a tax increase in the next quarter increases tax revenue already in the current quarter. This effect is also found in the separate estimation for indirect taxes. The effect of expected tax changes in Israel is worthy of continued investigation, including the case in which there is a long delay between the approval of a tax change and when it goes into effect. This is particularly relevant with regard to the long-term programs to reduce direct taxes in Israel during the last two decades.

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Table A.1.a: Description of tax and revenue variables and the results of their unit-root tests

Variable Name	Unit root tests		Description
	ADF test statistic for the level	ADF test statistic for 1st diff.	
Total tax revenue	-1.57	-3.88***	Total tax revenue, net of 'one-off' income (from exceptional M&A deals and events)
PIT revenue	-1.76	-3.00**	Personal Income Tax revenue, net of 'one-off' income
CIT revenue	-1.05	-12.37***	Corporate Income Tax revenue, net of 'one-off' income
Indirect tax revenue	-0.40	-8.42***	Indirect tax revenue, net of 'one-time' income
Tax changes	-9.81***		Quarterly tax changes, as percent of the revenue in the previous calendar year
Sum of tax changes	-0.73	-9.81***	Accumulated sum of the quarterly tax changes, since 1991q1 until the current quarter
CIT changes	-9.20***		Quarterly changes in the Corporate Income Tax, as percent of CIT revenue in the previous calendar year
Sum of CIT changes	-0.73	-9.20***	Accumulated sum of the quarterly CIT changes, since 1991q1 until the current quarter
PIT changes	-3.92***		Quarterly changes in the Personal Income Tax, as percent of CIT revenue in the previous calendar year
Sum of PIT changes	0.37	-3.92***	Accumulated sum of the quarterly PIT changes, since 1991q1 until the current quarter
Indirect tax changes	-6.45***		Quarterly changes in indirect taxes, as percent of indirect tax revenue in the previous calendar year
Sum of indirect tax changes	-0.82	-6.45***	Accumulated sum of the quarterly changes in indirect taxes, since 1991q1 until the current quarter
Tax revenue forecast	-0.87	-9.29***	Forecast of the tax revenue in the current calendar year, as presented in the latest budget proposal for the current year. The forecast does not include the effect of tax changes on the activity or the revenues
Income tax revenue forecast	-0.66	-9.55***	Forecast of revenue from Income Tax in the current year, as presented in the last budget proposal. This includes CIT and PIT. The forecast does not include the effect of tax changes on the activity or the revenues
Indirect taxes revenue forecast	1.28	-9.55***	Forecast of the revenues from indirect taxes in the current calendar year, as presented in the latest budget proposal for the current year. The forecast does not include the effect of tax changes on the activity or the revenues
Tax forecast error	-7.31***		Error in the total tax revenue forecast for the current calendar year, comparing to the actual revenue.
One-off tax revenue	-4.99***		'One-off" tax revenue, from exceptional M&A deals and events

* All variables are of quarterly duration. All variables in NIS values are stated in constant 2000 prices (in CPI terms). ADF tests were conducted with an intercept and an automatic selection of the lag length by the Schwartz Info Criterion. The source for all original variables is the Israeli Ministry of Finance and the State Revenue Administration within the ministry.

Table A.1.b: Description of activity variables and the results of their unit-root tests

Variable Name	Source	Unit root tests		Description
		ADF test stat. for the level	ADF test stat. for 1^{st} difference	
World Trade Index	IMF[a]	-0.23	-5.61***	World Trade Index
Error in trade index	IMF	-3.06**		Error in the IMF forecast for the World Trade Index. The forecast error was calculated as the difference between the forecasts published by the IMF in its WEO survey in April of the year prior to the forecast year and the actual growth in world trade. When Israel's revenue forecasts were prepared mid-year, we used the WEO forecasts made in April of that year.
NASDAQ index		-1.71	-6.76***	NASDAQ-100 Stock index
Tourists	CBS[b]	-1.11	-9.87***	Number of tourists arriving in Israel
GDP	CBS	0.30	-4.14***	Gross Domestic Product, in NIS millions
Government expenditures	BOI[c]	-1.98	-16.33***	Expenditures by the central government
Imports	CBS	-1.54	-4.99***	Imports of consumption goods to Israel, in NIS millions
Component of imports not correlated with GDP	BOI	-2.81*		Residual of an equation in which the dependent variable is log of imports, and the explanatory variables are a constant and the GDP with a lag of one quarter. i.e. This is the component of consumption goods imports, which is independent of the GDP.
Average Wage	NII[d]	-2.04	-3.78	Gross average wage per employee post
Component of average wage not correlated with GDP	BOI	-1.89	-4.48***	Residual of an equation in which the dependent variable is log of Average Wage, and the explanatory variables are a constant and the GDP with a lag of one quarter. i.e. This is the component of wage, which is independent of the GDP.
TASE Index	TASE[e]	-1.53	-7.03***	Tel-Aviv Stock Exchange general stock index in points. A quarterly average, adjusted for CPI inflation
Foreign Credit	BOI	-1.52	-5.35	Credit in foreign currency or foreign-currency terms (in US$), multiplied by the USD-ILS exchange rate, adjusted for CPI inflation
Foreign M&A	BOI	-9.49***		Mergers and acquisitions of Israeli firms with/by foreign citizens and entities (NIS hundreds of millions)

* All variables are of quarterly duration. All variables in NIS values are stated in constant 2000 prices (in CPI terms). ADF tests were conducted with an intercept and an automatic selection of the lag length by the Schwartz Info Criterion. [a] The International Monetary Fund [b] Israel's Central Bureau of Statistics [c] The Bank of Israel [d] Israel's National Insurance Institute [e] Tel Aviv Stock Exchange