Tax changes and economic growth: Empirical evidence for a panel of OECD countries*

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Abstract

This paper investigates the effects of changes in taxes on economic growth. Using annual data from 1965 to 2007 for a panel of twenty-six economies, the results show that the effect of an increase in taxes on real GDP per capita is negative and persistent: an increase in the total tax rate (measures as the total tax ratio to GDP) by 1% of GDP has a long-run effect on real GDP per capita of –0.5% to –1%. Our findings also imply that an increase in social security contributions or taxes on goods and services has a larger negative effect on per capita output than an increase in the income tax.

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1. Introduction

The effect of taxes on aggregate economic activity is one of the least contested areas in theoretical macroeconomics. Both neoclassical and Keynesian theoretical models, for example, predict that higher taxes reduce economic activity, even though there is less agreement on the exact mechanisms that generate this result.[1]

However, in spite of this, albeit imperfect, consensus (or perhaps because of it), the issue has not been pursued empirically with anything like the dedication that has characterized the much more vigorously debated effects of monetary policy. The most recent important exception has been the study by Romer and Romer (2007) who construct a novel measure of "exogenous" tax shocks and estimate its short-run and long-run economic effects.[2]

The goal of the present paper is to contribute to the empirical side of the question using a panel methodology that analyzes annual data from the 1965 to 2003 period for 26 OECD economies. Our empirical findings show that higher taxes do indeed result in a reduction of GDP per capita that is sizable and persistent. While the exact size of the effect depends on how the "tax shock" is measured, our estimates suggest that an increase in the total tax rate by 1% of GDP will have a long-run effect on GDP per capita of –0.5% to –1%. This is smaller than Romer and Romer's (2007) rather large estimated effect (approximately

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[1] See, for example, Eaton (1981), Dotsey (1990), King and Rebelo (1990), Rebelo (1991), Jones et al. (1993, 1997), Stokey and Rebelo (1995), Milesi-Ferretti and Roubini (1998), Kims (1998).

[2] Other recent examples of empirical studies include Reinhar and Kormendi (1989), Easterly and Perotti (1993a), Easterly and Perotti (1993b), Agell et al. (1997, 1999, 2006), Bleaney et al. (2001), Folster and Nerekson (1999, 2001, 2006) Perotti (1999), Karras (1999), Daveri and Tabellini (2000), Bleaney et al. (2001), Folster and Nerekson (1999, 2001, 2006), Blanchard and Perotti (2002), Afonso and Furceri (2008) Arnold (2008), Johansson et al. (2008).

–3%), but much closer to the effects obtained by Karras (1999) for a smaller OECD sample, and by Blanchard and Perotti (2002) for the U.S.

We also look at the effects of four of the largest types of taxes: taxes on income, profits, and capital gains; taxes on property; social security contributions; and taxes on goods and services. We find that they all have negative effects on GDP per capita (though not statistically significant in the case of property taxes), and that an increase in social security contributions or taxes on goods and services has a larger negative effect on per capita output than an increase in the income tax.

The rest of the paper is organized as follows. Section 2 discusses the sources of the data and defines the variables to be used in the estimation. Section 3 outlines the estimation methodology, derives the main empirical results, and implements a number of robustness checks. Section 4 discusses the findings and some possible extensions, and concludes.

2. The Data

The data cover 26 OECD countries and are obtained from OECD's Statistical Compendium on CD-ROM for the time period 1965-2007. All tax data are from the *Revenue Statistics of OECD Member Countries* database, and measure various taxes as a percentage of GDP. In addition to (i) the total tax rate, we also focus on (ii) taxes on income, profits, and capital gains, (iii) social security contributions, (iv) taxes on property, and (v) taxes on goods and services. Our other main variable of interest is *growth*, the growth rate of real GDP per capita. Both real GDP and population data are obtained from the OECD's *Economic Outlook* database.

Table 1 provides a list of these 26 OECD economies together with country averages over 1965-2007 for the *growth* and the five tax series.[3] Average annual growth of real GDP per capita has ranged from 1.3% in Switzerland to 4.2% in Ireland. Over the same time period, the average total tax to GDP ratio has varied from 17.6% in Mexico to 46.1% in Sweden. Though these OECD countries have relied very differently on the various forms of taxes, income taxation has been the largest revenue generator for most of them.[4] Taxes on income, profits, and capital gains have ranged from 4.76% of GDP in Mexico to 25.% of GDP in Denmark. In nine of the countries, most revenue has been raised by taxes on goods and services.[5] Only in three countries has the largest share been generated by social security taxes,[6] and in none of the countries by property taxes, which are generally the smallest.

Figure 1 plots the cross-sectional relationship between the average growth rate of real GDP per capita and the averaged total tax rate for the 26 countries of our sample over 1965-2007. The relationship is moderately negative (the correlation coefficient between the two variables is –0.32)[7].

On the face of it, this negative correlation is consistent with the theoretically predicted inverse relationship between taxation and economic growth. However, while it

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[3] Country selection is dictated by data availability only. Social security contributions were unavailable for Australia and New Zealand.

[4] To be specific, for 14 countries out of the 26: Australia, Belgium, Canada, Denmark, Finland, Japan, Luxembourg, the Netherlands, Norway, New Zealand, Sweden, Switzerland, the UK, and the US.

[5] The nine are Austria, Greece, Iceland, Ireland, Korea, Mexico, Portugal, Spain, and Turkey.

[6] These three are France, Germany, and Italy.

[7] Figure 1 suggests that Korea may be regarded as an outlier. Indeed, repeating the computation excluding Korea from the sample, the correlation is -0.15.

may be tempting to read it as evidence supportive of this theoretical proposition, we believe it would be imprudent to interpret it as causal.

Figure 2 repeats the correlation exercise for the four categories of taxes mentioned above, by looking at the cross-sectional relationship between average growth and each of these four taxes over 1965-2007. As Figure 2 makes clear, the cross-sectional relationship is negative between average growth and the average income tax rate (the correlation coefficient is –0.42); also negative between average growth and the average social security tax rate (correlation –0.28); weakly negative between average growth and the average property tax rate (correlation -0.07); and weakly positive between average growth and the tax rate on goods and services (correlation 0.08)[8]. Once again, we would caution against a causal interpretation of these correlations.

Figures 3 and 4 add a time dimension to these numbers. Figure 3 shows how the total tax rate has evolved in each of the 26 countries, while Figure 4 graphs the growth rates of real GDP per capita for each of the 26 economies. The most striking feature of Figure 3 is that the "long-term trend" in each of the 26 countries has been positive, in the sense that all total tax rates in 2007 exceed those of 1965. The pattern for the tax rate, however, differs substantially. Whereas many of the countries (such as Australia, Austria, Greece, Korea, and Portugal) have been fluctuating around a mostly upward sloping path, others (such as Germany, Mexico, the UK, and the US) have been much steadier, or have followed hump-shaped patterns (like those of Ireland, Japan, and the Netherlands).

[8] Also figure 2 suggests that Korea may be regarded as an outlier. Indeed, repeating the computations for different types of taxes excluding Korea from the sample, the correlation are -0.34 for income tax, -0.12 for social security tax, -0.12 for property tax, and 0.20 for tax on goods and services.

This substantial variability both across countries and over time should facilitate the empirical identification of the effects of tax changes on growth. We now turn to a model that will attempt to do just that.

3. Evidence on the Effects of Taxes on Growth

3.1. The benchmark model

We start with the simplest possible dynamic approach that relates growth and the tax rate, a model similar to the empirical specification in Romer and Romer (2007):

$$growth_{i,t} = w_i + v_t + \sum_{j=0}^{J} b_j dtax_{i,t-j} + u_{i,t}, \qquad (1)$$

where *growth* is the growth rate of real GDP per capita, i is indexing over countries and t over time, w and v represent country- and time-specific effects, the b's are parameters to be estimated, *dtax* is the change in the tax rate ($dtax_{i,t} = tax_{i,t} - tax_{i,t-1}$), J is the number of lags, and u is the error term.

The first two columns of Table 2 estimate equation (1) for $J = 5$.[9] The first column models the w's and v's as fixed effects (FE), and the second column as random effects (RE). Interestingly, all estimated b's have a negative sign, and all but the 5th lags are statistically significant. In addition, the differences between the fixed-effects and random-effects specifications are very small.

[9] Different lag lengths were also tried, but the contemporaneous term and the first four lags are generally statistically significant. The model was also estimated without country- or time-specific effects, and with only country fixed or random effects. Results are very robust and are not reported to preserve space. All results are available on request.

The "FE" and "RE" lines of Figure 5 plot the estimated response of real GDP to an increase in the total tax rate by 1% of real GDP, using the estimated parameters of the first two columns of Table 2. These "impulse response functions" show that such an increase in the tax rate immediately reduces GDP. The decline then continues for about four to five years, when the cumulative decrease in GDP has reached approximately 1%. This long-run effect of the tax increase on GDP is captured by the sum of the estimated *b* coefficients. As Table 2 shows, the sum of the estimated *b*'s is –1.06 for the fixed-effects specification, and –0.97 for random effects. Both are negative and highly statistically significant. This suggests that changes in the total tax rate have a statistically significant negative effect on GDP that is both sizable and persistent.

The rest of this section investigates the robustness of this result. The most obvious correction has to do with the presence of serial correlation.[10] To allow for this, we modify model (1) to:

$$growth_{i,t} = w_i + v_t + \sum_{j=1}^{K} a_j growth_{i,t-j} + \sum_{j=0}^{J} b_j dtax_{i,t-j} + u_{i,t}\,, \qquad (2)$$

where the *a*'s are parameters to be estimated.

The last two columns of Table 2 estimate equation (2) and report the estimated *b*'s for $J = K = 5$ (the estimated *a*'s are not reported to preserve space). Once more, all estimated *b*'s have a negative sign, and now the contemporaneous tax terms, as well as the 2nd and 4th lags, are statistically significant. Again, the differences between the fixed-effects and random-

[10] When we used ρ, the estimated AR(1) parameter for the residuals, as proposed by Wooldridge (2002), serial correlation was detected in both the FE and RE specifications. Instead of imposing a first-order structure, however, we prefer to allow for the more general form of model (2).

effects specifications are virtually nil, and the sums of the estimated *b*'s are negative (–0.95 with fixed effects and –0.81 with random effects) and highly statistically significant.

The "FE & dy(lags)" and "RE & dy(lags)" lines of Figure 5 plot the estimated response of GDP to an increase in the total tax rate by 1% of GDP, using the estimated parameters of model (2). It is readily apparent that these are very close to those obtained from model (1). It follows that allowing for autoregressive structure, does not alter our conclusion that changes in the total tax rate have a statistically significant negative effect on growth that is both sizable and persistent.[11]

3.2. Additional Robustness Extensions

Unlike Romer and Romer's (2007) tax measure, ours is not guaranteed to be exogenous. Our estimated *b*'s in models (1) and (2), therefore, could be biased. We address this issue of potential bias in four different ways. First, we eliminate the contemporaneous *dtax* term in models (1) and (2). Second, we correct for the effects of economic activity on tax revenue, in the spirit of Perotti (1999), and Blanchard and Perotti (2002). Third, we estimate the impact of taxes on growth by using the GMM approach proposed by Arellano and Bover (1995) and Blundell and Bond (1998). Fourth, we consider 5 years moving averages in order to iron out business cycle fluctuations.

For the first, more modest fix, we simply revise models (1) and (2) to:

$$growth_{i,t} = w_i + v_t + \sum_{j=1}^{J} b_j dtax_{i,t-j} + u_{i,t}, \tag{1'}$$

[11] This is similar to the finding of Romer and Romer (2007).

and

$$growth_{i,t} = w_i + v_t + \sum_{j=1}^{K} a_j growth_{i,t-j} + \sum_{j=1}^{J} b_j dtax_{i,t-j} + u_{i,t}, \quad (2')$$

respectively, thereby simply excluding the contemporaneous tax term from the original equations. We do not report the estimated *a*'s and *b*'s because of space considerations, but we report the sums of the estimated *b*'s and we summarize the dynamic responses of an increase in the tax rate.

The sums of the estimated *b*'s from models (1') and (2') are reported in the last row of Table 2, for both the fixed-effects and random-effects specifications. It can be seen that all four are negative and statistically significant, just like the sums of the estimated *b*'s from models (1) and (2). However, they are smaller in absolute value than the sums from the models that include the contemporaneous tax term, which is not surprising since the excluded contemporaneous term is amply negative.

Figure 6 summarizes the estimated responses of GDP to an increase in the total tax rate by 1% using models (1') and (2') with fixed and random effects. The pattern of these responses is virtually identical to that of Figure 5, the only difference being the somewhat smaller long-run effects.

The second robustness check considered in this subsection intends to construct a more exogenous measure of changes in the tax rate. To that end, we estimate the VAR-type system

$$dtax_{i,t} = x_i + z_t + \sum_{j=1}^{J} c_j dtax_{i,t-j} + \sum_{j=1}^{J} f_j growth_{i,t-j} + \tau_{i,t}, \quad (3)$$

and

$$growth_{i,t} = w_i + v_t + \sum_{j=1}^{K} b_j dtax_{i,t-j} + \sum_{j=1}^{J} a_j growth_{i,t-j} + u_{i,t}, \tag{4}$$

where x and z (like w and v) represent country- and time-specific effects, and the c's and f's (like the a's and b's) are parameters to be estimated. Equation (4) is a special case of (2'). Equation (3) allows *dtax* to respond to *growth*, recognizing the fact that economic activity plays a role in the determination of the tax rate. We interpret τ as an "exogenous" tax rate shock.

We estimate the system of equations (3) and (4), and plot in Figure 7 the estimated dynamic responses of GDP to an exogenous tax-rate shock of 1% of GDP for the two specifications of fixed ("FE") and random ("RE") effects for $J = 5$. While quantitatively these effects are weaker (and more so for the random effects specification) than those of the plain tax changes, the pattern of these impulse response functions is very similar to the plots of Figures 5 and 6: a positive tax rate shock has a negative and persistent effect on GDP.

In order to control for endogeneity and provide robustness for our results, we also estimate model (2) using the GMM approach proposed by Arellano and Bover (1995) and Blundell and Bond (1998). The results are reported in the first column of Table 3. Analyzing the Table we can see that both the current values of *dtax* as well as its three lags are statistically significant. Moreover, the sum of the estimated b's is –0.75, which is negative and highly statistically significant.

The fourth robustness check consists of estimating model (2) using years moving averages in order to iron out cyclical fluctuations (Bleaney et al. 2001). The results are reported in the second column of Table 3. While, as it is possible to expect, the lag of *dtax* are not statistically significant, the current value of *dtax* as well as the cumulative effect is statistically significant and is magnitude is comparable to the one obtained using yearly data.

Finally is worth to mention that unlike the correlation charts presented in Figure 1 and 2, all the estimated results are robust to the inclusion of Korea in our sample.

3.3. The Effects of Different Types of Taxes

We now ask whether our four available types of taxes (income, property, social security, and goods and services) have similar effects on per capita real GDP growth with those we observed above for the total tax rate, and whether differences exist among them, as often suggested by economic theory.

We begin by estimating the benchmark model (1) for each of the four types of tax, and plot in Figure 8 the estimated responses of GDP to an increase in each of the four tax types by 1% of GDP. An increase in income taxes, social security taxes, and taxes on goods and services is followed by an immediate drop in GDP which continues for three to five years, until it stabilizes at a lower level.

An increase in property taxes, is associated with a counterintuitive short-run increase in GDP; this effect disappears after three years and is actually reversed in the longer term, eventually reducing GDP. However, the sum of the estimated *b*'s for the property taxes (–0.53, with a standard error of 1.01) is not statistically significant.

The other three types of tax, however, have more sizable and statistically significant growth effects. Interestingly, an increase in the social security contributions is predicted to have the largest negative growth effects, both in the short- and long-run. The sum of the estimated b's for the social security tax is –1.98 (standard error 0.41), which is twice as high as the corresponding value we estimated for total taxes, and highly statistically significant. Higher taxes on goods and services have the second most detrimental growth effects, with a sum of estimated b's equal to –1.38 (standard error 0.44). This is both statistically significant and somewhat larger than the effect of total taxes. Finally, and somewhat surprisingly, taxes on income, profits, and capital gains, have a smaller effect than either social security taxes or taxes on goods and services. Their effects, however, are consistently negative and statistically significant, with a sum of estimated b's equal to –0.70 (standard error 0.28).

We know from the previous subsection that model (1) may overestimate the growth effects of a tax change. Therefore, all other models discussed above for the total tax have also been estimated for each of the four specific tax types. To preserve space, we only report the results of estimating the VAR-type systems of equations (3) and (4). Figure 9 plots the estimated dynamic responses of GDP to an "exogenous" tax-rate shock of 1% of GDP in each of the four tax types. As expected, the responses of GDP to those exogenous tax shocks are smaller in absolute value (roughly by one half) than the corresponding responses to raw tax changes. The general picture, however, is unaffected. With the exception of the property tax (whose short-term and long-term effects are statistically insignificant, just like before), an increase in any of the other three types of tax has a negative and persistent effect on GDP.

4. Discussion and Conclusions

This paper estimated the effects of tax changes on real GDP growth per capita using annual data from the 1965 to 2003 period for a panel of 26 OECD economies.

The empirical findings show that an increase in taxes has a negative and persistent effect on real GDP per capita. The size of the effect depends on how the "tax shock" is measured, but our estimates suggest that an increase in the total tax rate by 1% of GDP will have a long-run effect on real GDP per capita of –0.5% to –1%. This is smaller than Romer and Romer's (2007) rather large estimated effect (approximately –3%), but their identification of a "tax shock" is very different from ours, and their measure of GDP is aggregate (not per capita). In addition, our estimates are much closer to those of Karras (1999) for a smaller OECD sample, and Blanchard and Perotti (2002) for the U.S.

We also look at the effects of what are usually the four largest types of taxes: taxes on income, profits, and capital gains; taxes on property; social security contributions; and taxes on goods and services. Our findings imply that all four have negative effects on real GDP per capita, though those of property taxes are not statistically significant. Of the other three, our estimates suggest that an increase in social security taxes or taxes on goods and services has a larger effect on output than an increase in the income tax.

Our study suggests that a number of interesting extensions can be pursued. First, it would be useful to examine the effects of taxes on variables other than income, such as consumption, investment, employment, or unemployment.[12] Preliminary evidence on consumption and investment is presented in Figures 10 for the benchmark model (1) and

[12] Daveri and Tabellini (2000), among others, have looked at the relationship between taxation and

Figure 11 for the VAR-type system of equations (3) and (4). In each case, the original variable *growth* (the growth rate of per capita GDP) has been replaced by the growth rate of aggregate GDP, consumption, and investment (all in real terms, obtained form the OECD's *Economic Outlook* database).

Just like for the GDP per capita series, the evidence of Figures 10 and 11 shows that a tax increase has a clear negative effect on aggregate GDP, consumption, and investment. However, the effect of a tax change on investment is much larger than the effect on GDP or consumption. This finding is robust to the construction of the tax "shocks" and the method of estimation, and it is consistent with the findings of Blanchard and Perotti (2002) and Romer and Romer (2007) who also estimated larger negative effects on investment than on output or consumption.

Pursuing this further would be interesting not only because of the obvious importance of these variables and others, but also because it can shed light on the way the effects of tax changes are transmitted to the rest of the economy. It might also be worthwhile to include government spending in the estimated models in order to capture possible interactions between it and taxes.

An additional promising direction would be to investigate whether the effects of taxes are asymmetric. One type of asymmetry includes effects that may be different (in absolute value) for tax increases than tax decreases, as has been claimed for monetary policy.[13]

unemployment and growth.

[13] In a long literature beginning with Cover (1992).

Another type of asymmetry would test whether tax changes have different effects when undertaken in different economic circumstances, as in Perotti (1999).

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Table 1

Country Averages over 1965-2007

Country	growth	Taxes as a % of GDP				
		total	*income*	*property*	*goods*	*social security*
1. Australia	2.1	26.7	14.9	2.5	8.0	NA
2. Austria	2.6	39.4	10.6	1.0	12.5	12.3
3. Belgium	2.4	41.3	15.4	1.5	11.5	12.8
4. Canada	2.1	32.8	15.0	3.4	9.7	4.0
5. Denmark	2.1	44.0	25.4	2.1	15.4	1.0
6. Finland	2.9	39.8	16.0	1.0	13.4	8.9
7. France	2.3	40.2	7.4	2.4	12.0	16.0
8. Germany	1.3	35.3	11.4	1.2	9.9	12.6
9. Greece	3.0	25.4	4.8	1.6	10.8	8.1
10. Iceland	2.7	32.6	10.7	2.3	16.6	2.0
11. Ireland	4.2	31.2	11.0	2.2	13.6	4.1
12. Italy	2.4	34.2	10.6	1.5	9.8	11.5
13. Japan	3.3	24.9	10.5	2.4	4.5	7.5
14. Korea	5.8	19.1	5.5	2.2	9.1	1.8
15. Luxembourg	3.2	34.6	13.7	2.5	8.5	9.6
16. Mexico	2.4	17.6	4.7	0.3	9.7	2.6
17. Netherlands	2.3	40.3	12.2	1.5	10.9	15.4
18. Norway	2.9	40.3	15.8	1.0	14.6	8.8
19. New Zealand	1.5	31.9	20.1	2.3	9.5	NA
20. Portugal	3.3	26.1	6.3	0.7	11.2	7.5
21. Spain	2.8	26.6	7.2	1.6	7.6	10.2
22. Sweden	2.1	46.1	20.0	1.1	12.1	11.3
23. Switzerland	1.3	25.3	11.3	2.2	5.9	5.8
24. Turkey	2.7	15.8	5.3	0.7	6.2	2.4
25. UK	2.2	35.2	13.6	4.2	10.8	6.0
26. USA	2.1	26.7	12.6	3.2	4.9	5.9

Notes: *growth*: the average annual growth rate of real GDP per capita.
All taxes are expressed as a percentage of GDP.
total: total taxes;
income: taxes in income, profits and capital gains;
property: taxes on property;
goods: taxes on goods and services; and
social security: social security taxes.

Table 2

Estimated Effects of Tax Changes on GDP

	Without *growth* lags: model (1)		With *growth* lags: model (2)	
	FE	RE	FE	RE
dtax	-0.27***	-0.25**	-0.29***	-0.29**
	(0.07)	(0.07)	(0.07)	(0.06)
dtax(-1)	-0.18***	-0.17**	-0.12	-0.09
	(0.07)	(0.07)	(0.07)	(0.07)
dtax(-2)	-0.22***	-0.20**	-0.22***	-0.19**
	(0.07)	(0.07)	(0.07)	(0.07)
dtax(-3)	-0.18***	-0.17**	-0.13	-0.10
	(0.07)	(0.07)	(0.07)	(0.07)
dtax(-4)	-0.16**	-0.15**	-0.16**	-0.13**
	(0.07)	(0.07)	(0.07)	(0.07)
dtax(-5)	-0.04	-0.01	-0.03	0.00
	(0.07)	(0.04)	(0.07)	(0.07)
Sum of *dtax* terms	-1.06***	-0.97***	-0.95***	-0.81***
	(0.19)	(0.18)	(0.19)	(0.18)

	Without *growth* lags: model (1’)		With *growth* lags: model (2’)	
	FE	RE	FE	RE
Sum of *dtax* terms	-0.71***	-0.66***	-0.58***	-0.45***
	(0.17)	(0.17)	(0.18)	(0.17)

Notes: “FE” denotes Fixed effects and “RE” Random Effects. All models estimated with both country and time effects. The coefficients of the growth lags in model (2) are not reported. Estimated standard errors in parentheses. ***, ** and * denote statistical significance at the 1% , 5% and 10% significance levels.

Table 3

Estimated Effects of Tax Changes on GDP

	GMM model (2)	Five years moving averages (2)
dtax	-0.31*** (0.07)	-0.62*** (0.11)
dtax(-1)	-0.11* (0.07)	0.02 (0.11)
dtax(-2)	-0.12* (0.07)	0.01 (0.11)
dtax(-3)	-0.11* (0.07)	0.01 (0.13)
dtax(-4)	-0.06 (0.07)	-0.11 (0.11)
dtax(-5)	-0.03 (0.07)	0.01 (0.11)
Sum of *dtax* terms	-0.75*** (0.19)	-0.68** (0.32)

Notes: The coefficients of the growth lags in model (2) are not reported. Estimated standard errors in parentheses. ***, ** and * denote statistical significance at the 1% , 5% and 10% significance levels.

Figure 1. Growth of Real GDP per Capita vs Total Tax Rate, 1965-2007

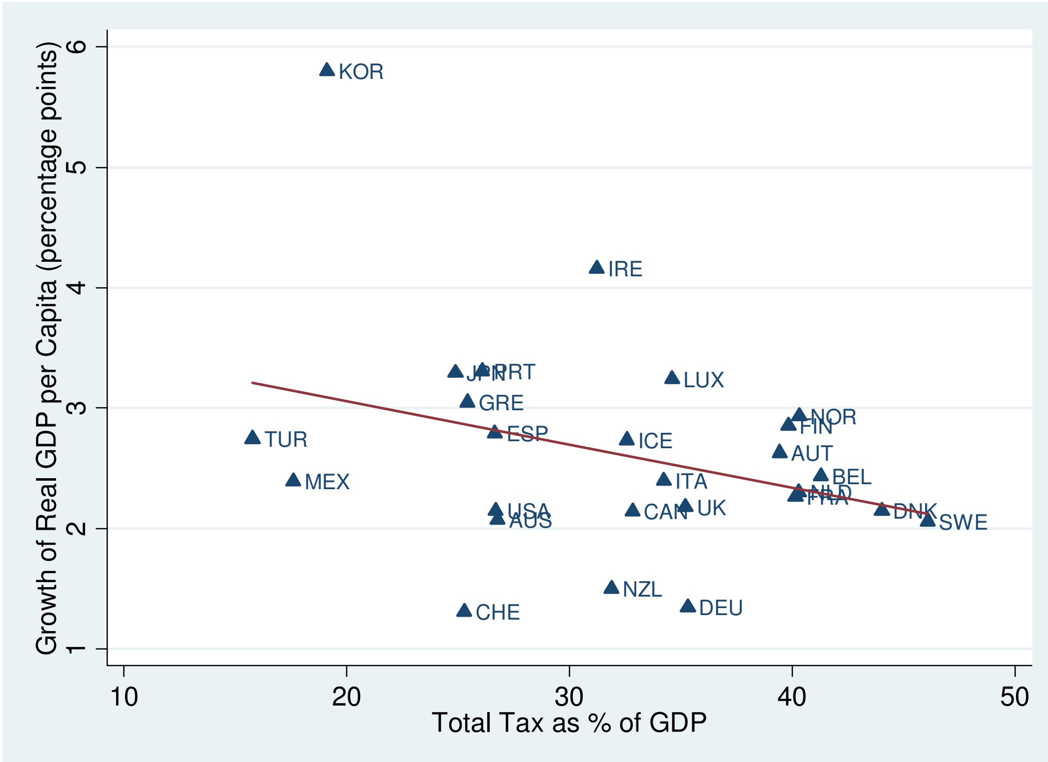


Figure2. Growth of Real GDP per Capita vs Various Tax Rates, 1965-2007

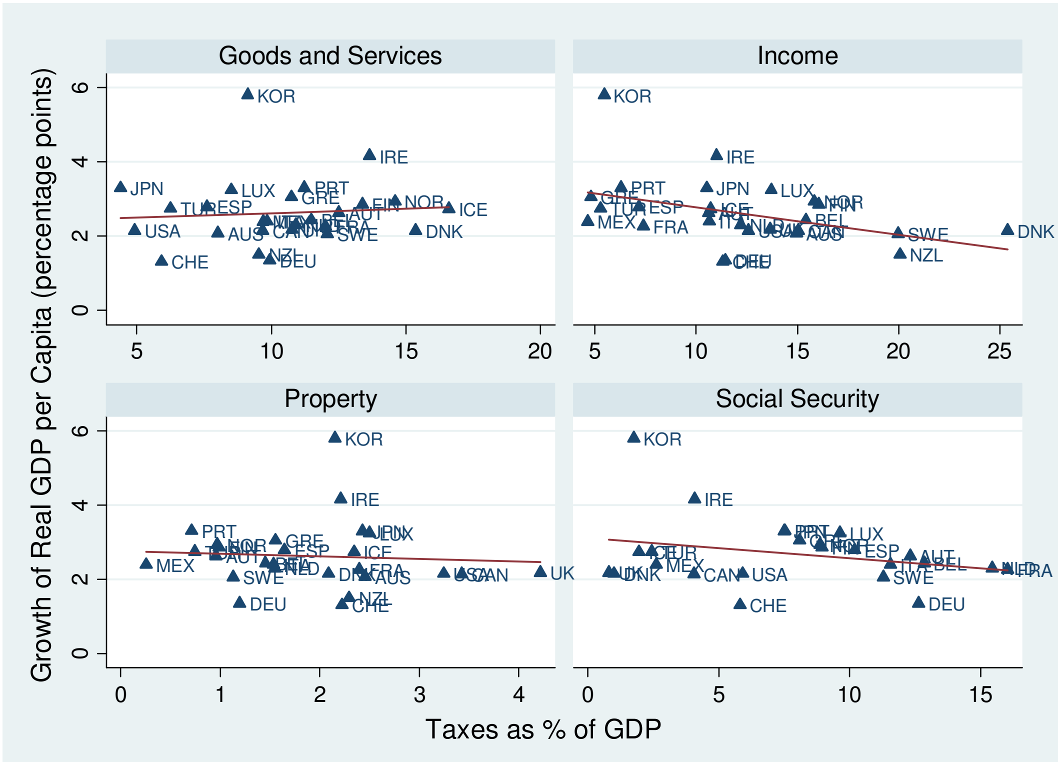


Figure 3. Total Tax Rates, 1965-2007

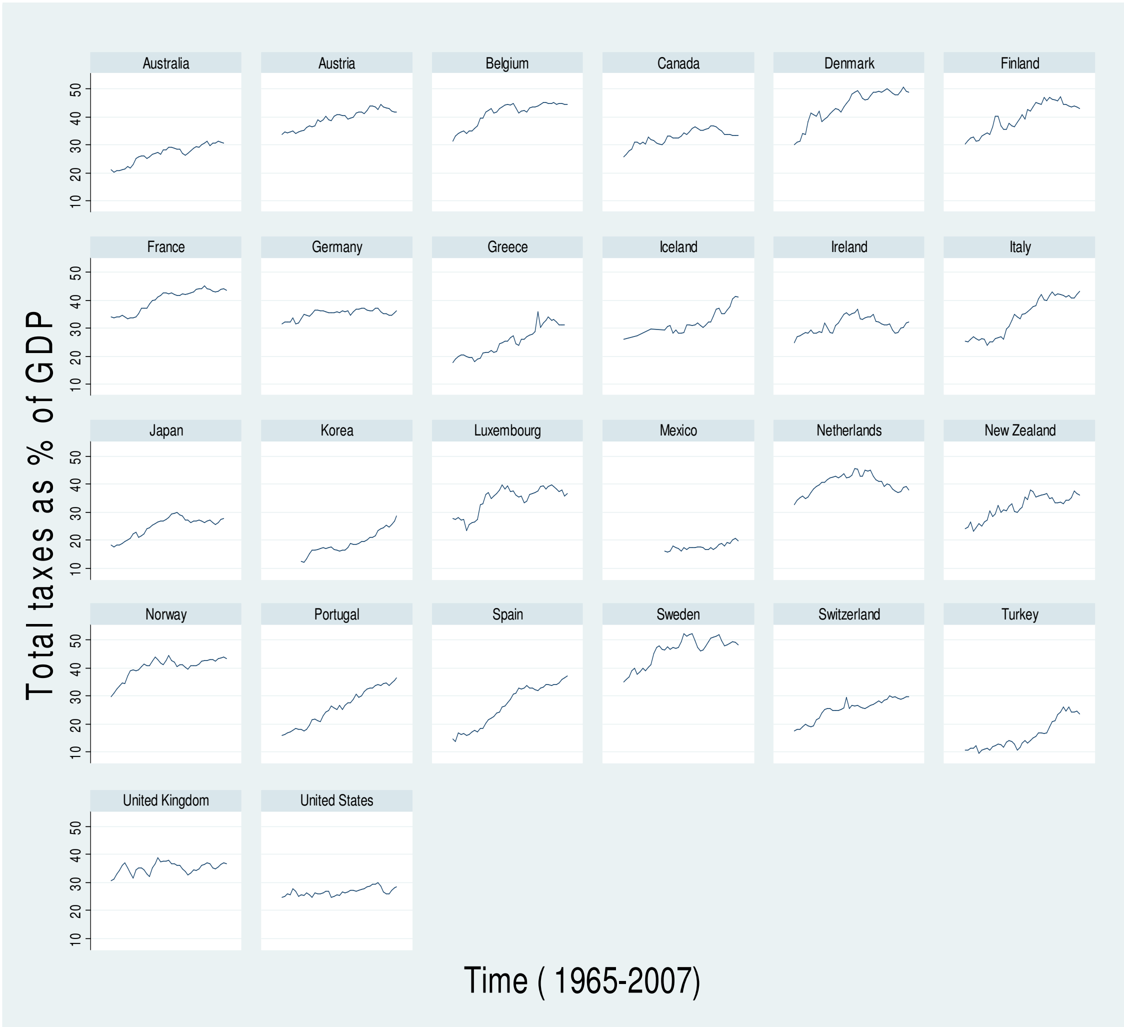


Figure 4. Real Growth Rates of GDP per Capita, 1965-2007

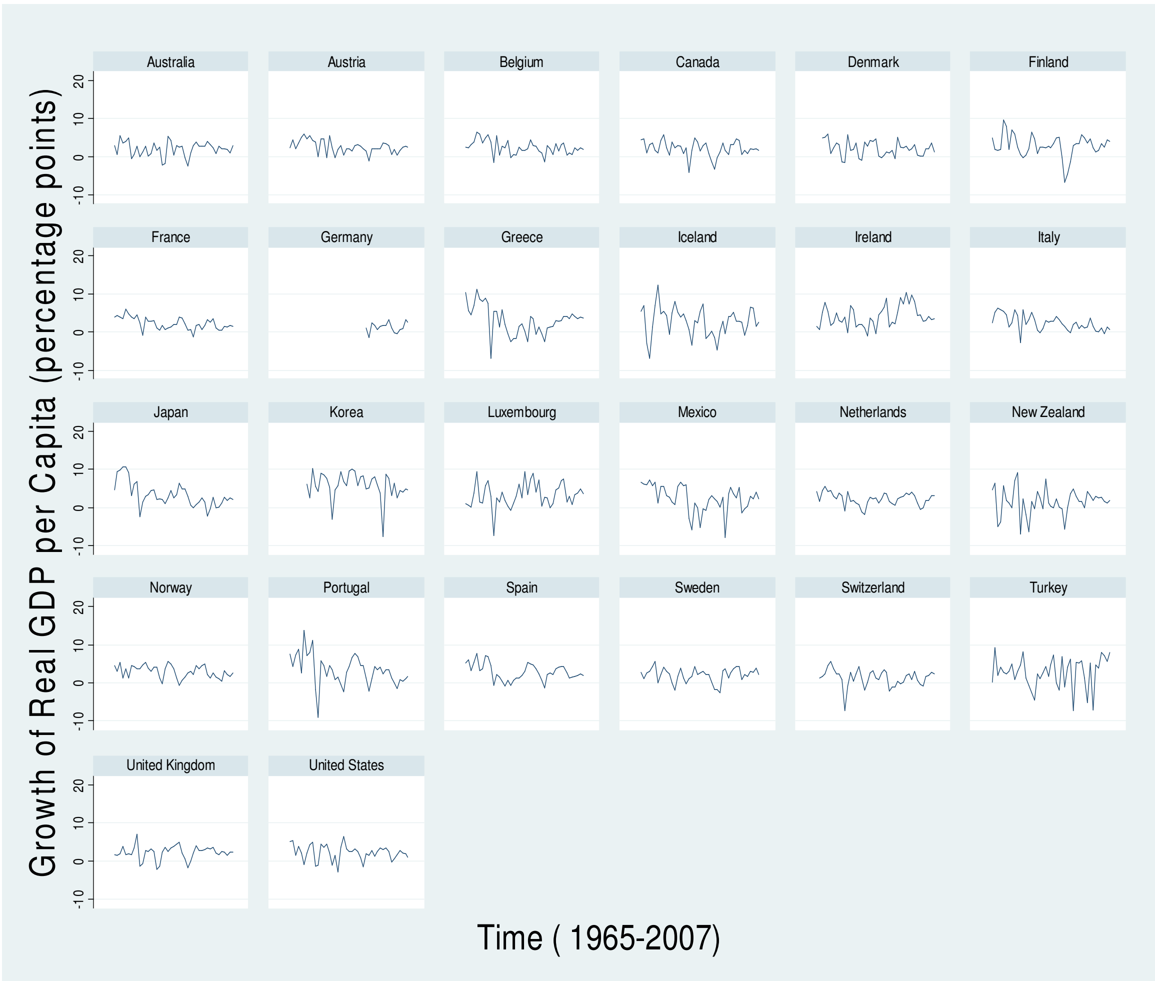
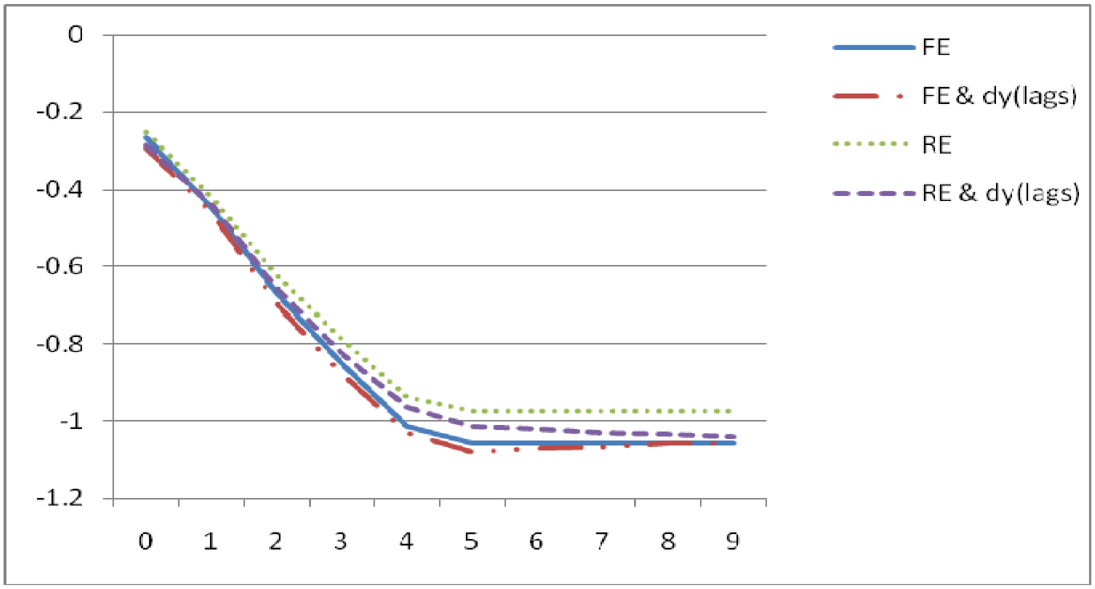
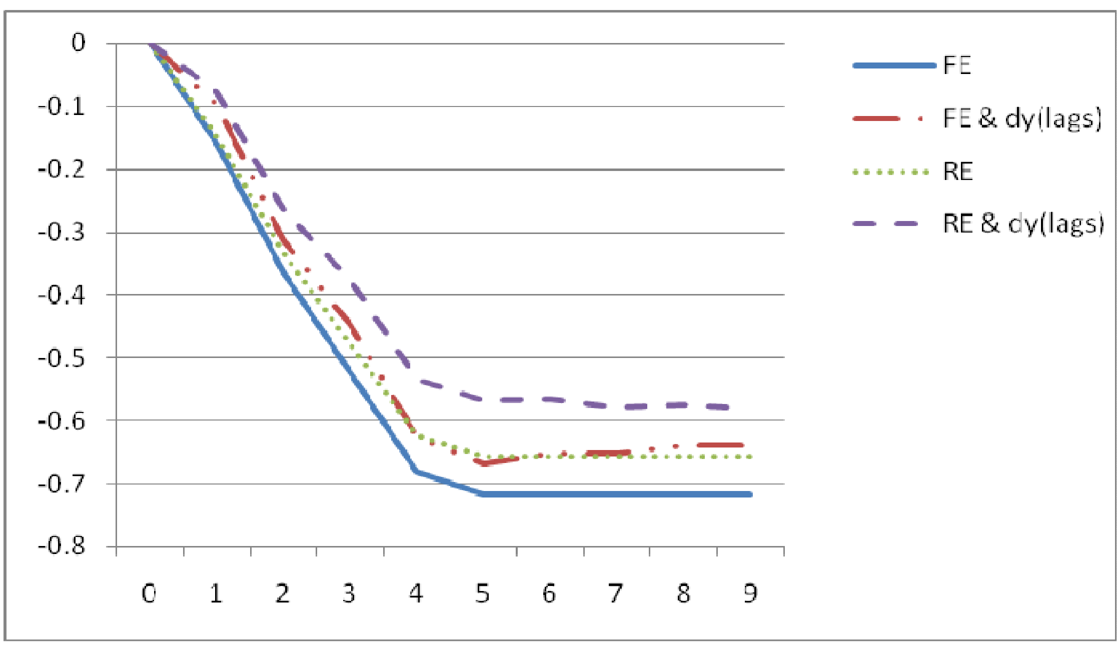


Figure 5. Response to an increase in Total Tax by 1% of GDP*



* Contemporaneous tax term included.

Figure 6. Response to an increase in Total Tax by 1% of GDP*



* No contemporaneous tax term included.

Figure 7. Response to an exogenous increase in Total Tax by 1% of GDP

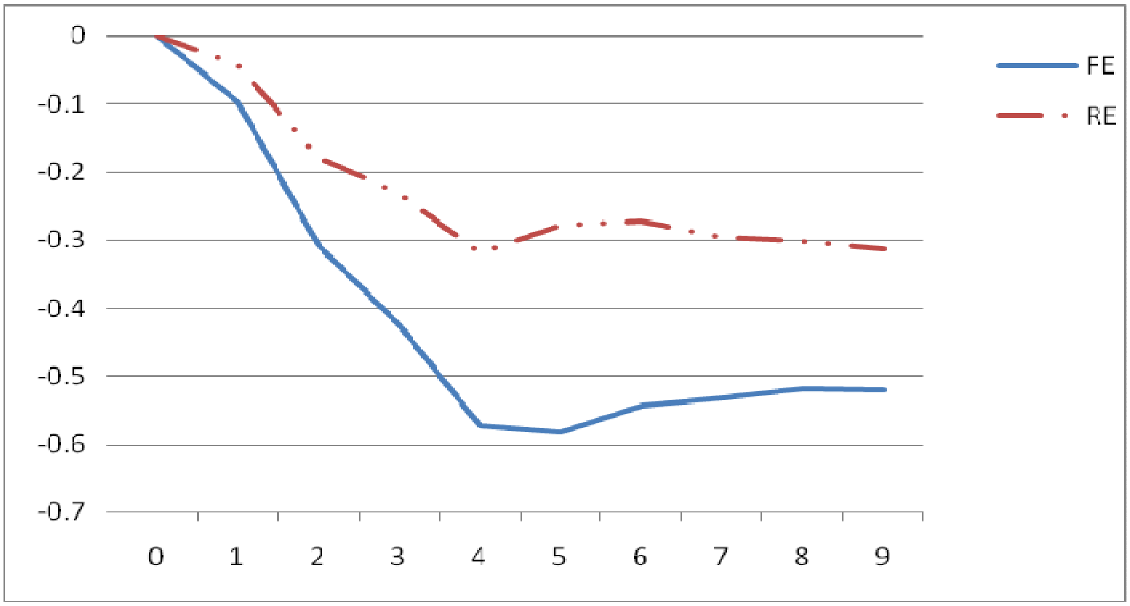
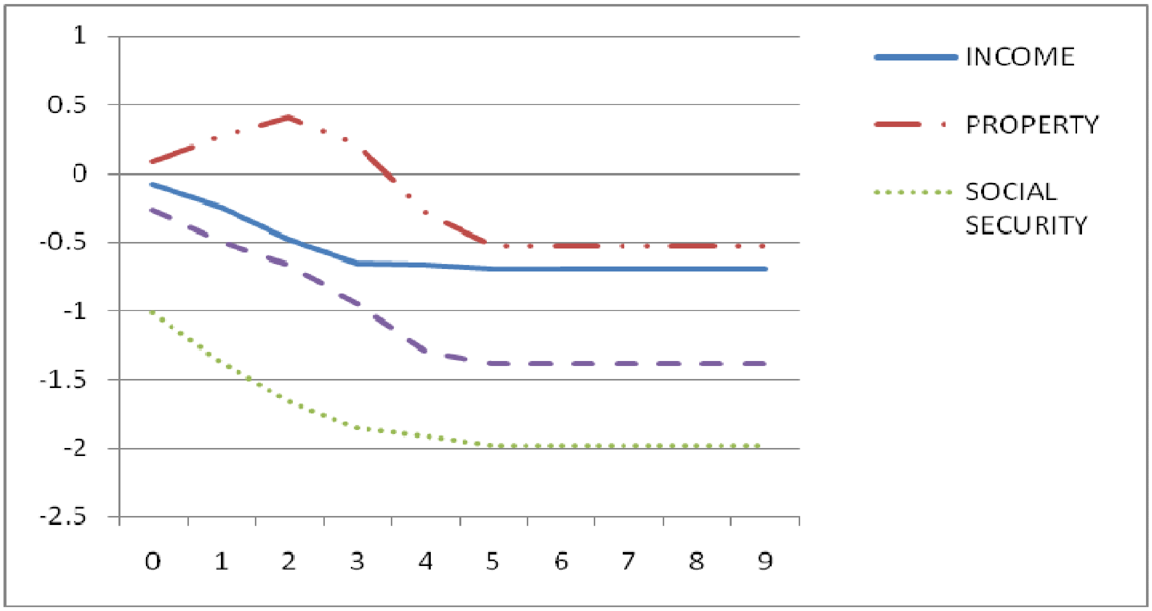
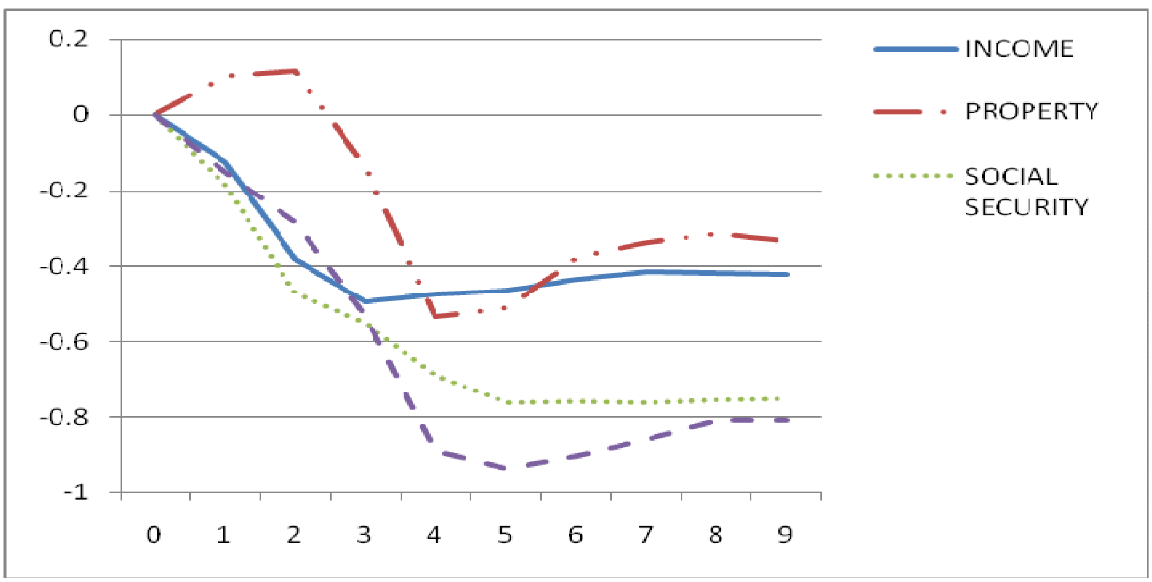


Figure 8. Responses to an increase in Various Taxes by 1% of GDP*



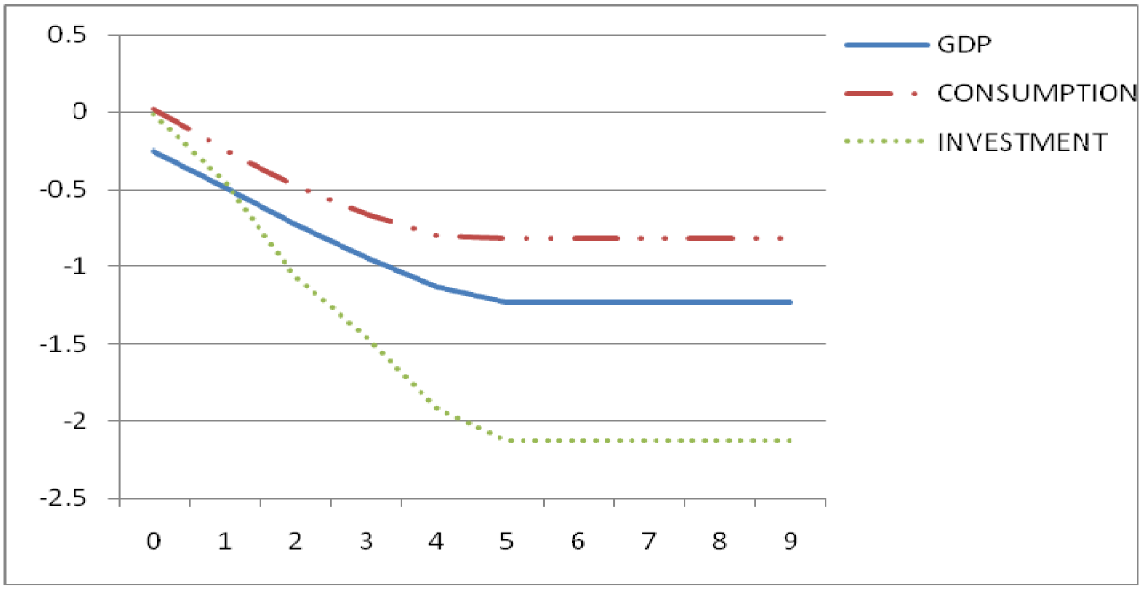
* Country and time Fixed Effects.

Figure 9. Responses to an Exogenous increase in Various Taxes by 1% of GDP*



* Country and time Fixed Effects.

Figure 10. Responses of GDP and components to an increase in Total Tax by 1% of GDP*



* Benchmark model

Fgure11. Responses of GDP and components to an exogenous increase in Total Tax by 1% of GDP