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Macroeconomic Effects of Tax Changes: Evidence from a Sample of OECD Countries

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Abstract

This paper investigates the macroeconomic effects of tax changes. Using annual data from 1870 to 2013 for a panel of seventeen OECD economies, the empirical findings show that changes in the tax rate have temporary effects on the real growth rate but permanent effects on the level of output. The tax multiplier is estimated at –0.25 for the first year and around –0.60 in the long run. The evidence shows that tax changes have much stronger effects on investment than on consumption, and that they exert only short-term influence on the interest rate. An increase in the tax rate appears to raise the price level permanently and the inflation rate temporarily, implying stronger aggregate-supply than aggregate-demand effects.

JEL classification: E32, E62, H20
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1. Introduction

The limitations of monetary policy that were made apparent by the global financial crisis have also rekindled interest in fiscal policy, which is no longer considered of secondary importance, even for stabilization purposes. The role of taxes in the economy forms a large part of this issue. Though the topic was being consistently addressed even before the global crisis, interest in it has risen meteorically after it.

What accounts for this sustained, intense interest in the macroeconomic effects of taxes? One obvious reason of course is the undeniable importance of the topic, made more urgent by the recent heavy reliance of many economies on fiscal remedies, especially after monetary options had been weakened. But there is another, rarer feature that contributes to the fascination with taxes and growth: it is a topic that combines both widespread consensus and extensive differences of opinion.

There is near-universal consensus, for example, both theoretically and empirically, that higher taxes reduce economic activity – and the other way around. At the sane time, there are extreme disagreements about how strong the effect is (often expressed in terms of the "tax multiplier"), about its exact nature (for example, whether tax rates affect the growth rate or the level of income), and about the economic mechanisms that generate the estimated effects.

Part of the problem stems from the fact (not unusual in applied economic research) that the empirical approaches have been divided. One large strand of studies adopts a standard dynamic modeling (often in the form of a VAR) approach. Prominent examples on US data include Blanchard and Perotti (2002) and Barro and Redlick (2011). Studies on other countries are more rare, but Perotti (2002) and Alesina, Azzalini, Favero, Giavazzi, and Miano (2018) have looked at various OECD countries using similar techniques.

A relatively recent alternative is the "narrative" approach that relies on the legislative record to identify tax shocks and estimate their effects. Pioneered for tax analysis by Romer and Romer (2010) on US data, the main attraction of this approach is the potential of a more convincing resolution of the problem of endogeneity between taxes and economic activity. Mertens and Ravn (2013) and Romer and Romer (2014) also use this approach on US data; while Cloyne (2013) and Cloyne, Dimsdale, and Postel-Vinay (2018) focus on the UK; and Kato, Miyamoto, Nguyen, and Sergeyev (2018) employ it for Japan. Typically, the narrative approach has estimated larger multipliers, and sometimes substantially so. Favero and Giavazzi (2012), and Perotti (2012) thoughtfully discuss and compare the two approaches, using US data. Along similar lines, Hebous and Zimmermann (2018) identify some of the limitations of the narrative approach using data from the US and the UK.[1]

The goal of the present paper is to contribute to this literature using a unique data set of seventeen countries over the period 1870-2013. The main advantage of using such a long data set is that it includes a variety of economic experiences, regarding both tax rates and real GDP growth, that are not typically (or not at all) found in more commonly used post-World War II data sets.

We begin by estimating simple dynamic models, similar to the Romer and Romer (2010) specification and gradually generalize them to investigate robustness. Our findings are robust to all specifications and estimation techniques tried, including the local projection estimation technique, and an alternative identification of "tax shocks" that is aimed at addressing potential endogeneity issues.

In a nutshell, the paper's findings suggest that changes in the average tax rate, defined as tax revenue divided by GDP, affect the level of output permanently, and the real growth rate temporarily. An increase in the tax rate by 1% lowers real GDP by about 0.25% in the first year, and about 0.60% in the long run. Looking separately at the components of GDP, we find that both private consumption and investment are negatively affected by the tax rate, but the investment is response is much more sizeable and statistically significant. The evidence also points to weak and only short-term effects of the tax rate on the interest rate, which is consistent, however, with the standard IS/LM model. Finally, an increase in the tax rate appears to increase the CPI price level permanently and the inflation rate temporarily, a finding that suggests that the aggregate-supply effects of taxes may have dominated their aggregate-demand effects.

[1] The literature is vast and growing rapidly, so the papers mentioned above are far from an exhaustive list. Mineshima, Poplawski-Ribeiro, and Weber (2014) and Batini, Eyraud, Forni, and Weber (2014) survey the literature.

The rest of the paper is organized as follows. Section 2 presents 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 implements three extensions that investigate the effects of the tax rate on additional variables, hoping to shed additional light on the economic mechanisms involved. Section 5 discusses the findings and policy implications, and concludes.

2. Data

All data are from the Jordà-Schularick-Taylor Macrohistory Database (see Jordà, Schularick, and Taylor, 2017). Using i to index over countries and t over time, the tax rate is simply defined as $\tau_{i,t} = \frac{T_{i,t}}{GDP_{i,t}} \cdot 100$, where $T_{i,t}$ is Government Revenue (nominal, local currency), and $GDP_{i,t}$ is Gross Domestic Product (nominal, local currency). Using $Y_{i,t}$ to denote real GDP, the real growth rate is defined as $\Delta y_{i,t} = \frac{Y_{i,t} - Y_{i,t-1}}{Y_{i,t-1}} \cdot 100$. The data set consists of annual observations over the period 1870 – 2013 for seventeen OECD countries: Australia, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, Great Britain, Italy, Japan, the Netherlands, Norway, Portugal, Sweden, and the US.

Figures 1a and 1b plot the tax rates, $\tau_{i,t}$, and growth rates, $\Delta y_{i,t}$, for each of the seventeen economies over the entire period. The general picture that emerges is remarkably similar across the countries. While short-run fluctuations, that appear temporary, are present in both series, only the tax rates have been clearly trending in the long run. Not surprisingly, the trend is positive, so that at the end of the period, the tax rate is substantially higher than it was at the beginning of the period for each of the countries. On the contrary, no trend is apparent in any of the growth rates of real GDP, the only visible change there being the well-established moderation of growth volatility over time in the majority of countries.

Figure 2 condenses this information, reporting simple time averages, $\bar{\tau}_t$ and $\overline{\Delta y}_t$, of the two series across the seventeen countries.[2] Once again, the long-run positive trend in the tax growth rate is apparent. While short-run fluctuations are also present, the most striking feature of the tax rate is its near-steady long-run climb from about 5% of GDP in 1870 to about 25% in 2013. The real GDP growth rate, on the other hand, is dominated by short-run fluctuations, that correspond to recognizable turning points of the business cycle.

Summing up, tax rates appear to have been subject to both permanent and temporary shocks, while real growth rates mostly to temporary shocks. This will help motivate the formal modeling of the relationship between the two variables, which is the objective of the next section.

3. Empirical Evidence

This section presets the paper's central empirical evidence. Section 3.1 begins with a benchmark specification between output and the tax rate, section 3.2 generalizes to a richer dynamic structure, and section 3.3 considers an alternative identification technique of "tax shocks" that addresses the issue of endogeneity.

[2] Specifically, $\bar{\tau}_t = \frac{1}{17}\sum_{i=1}^{17} \tau_{i,t}$ and $\overline{\Delta y}_t = \frac{1}{17}\sum_{i=1}^{17} \Delta y_{i,t}$.

3.1 The Benchmark Specification

We start with the simplest possible dynamic relationship that can capture the responses of output to changes in the tax rate. Following Romer and Romer (2010, 2012), we specify:

$$\Delta y_{i,t} = w_i + v_t + \sum_{j=0}^{J} \beta_j \Delta\tau_{i,t-j} + u_{i,t} \tag{1a}$$

where the ws and vs are, respectively, country- and time-specific fixed (or random) effects; the βs are parameters to be estimated; and u is the error term. In addition, and for the purposes of robustness, we will also use the local projection method of Jordà (2005). Using similar notation, the benchmark specification can now be written as:

$$\Delta y_{i,t+h} = w_i^h + v_t^h + \beta^h \Delta\tau_{i,t} + \sum_{j=1}^{J} \beta_j^h \Delta\tau_{i,t-j} + u_{i,t} \tag{1b}$$

where h indicates the horizon (years after time t) considered. The desired impulse response function now consists of the estimated β^hs, which capture the dynamic responses of the growth rate to a change in the tax rate.

Figure 3 shows the responses of output to an increase in the tax rate by 1% of GDP when models (1a) and (1b) are estimated for the full 1870-203 period with fixed country and time effects. Real GDP falls contemporaneously (within the year) by about a quarter of a percentage point, and then continues declining to a long-run drop of approximately 0.6%. All estimated responses are statistically significant, and the two specifications are in general agreement.[3] Figure 4 shows that the results remain virtually unchanged when equations (1a) and (1b) are estimated with random, rather than fixed, country and time effects.

For several of the economies in the present sample, the full period of 1870-2013 includes a number of unusual observations, such as those associated with World Wars I and II, and the Great Depression. To ensure that the results are not somehow driven by these extreme economic experiences, we also plot the responses of GDP to an increase in the tax rate by 1 percentage point when models (1a) and (1b) are estimated over the post-war period, defined here as 1950-2013. These are reported in Figures 5 and 6, for fixed and random effects, respectively. Perhaps surprisingly, the picture changes very little. While the estimated responses are more moderate across the forecasting horizon, they remain negative, and statistically significant. They also remain robust between models (1a) and (1b), as well as between fixed and random effects.

Table 1 reports overall significance of the tax rate and its long-run effects on output from various specifications of the benchmark model for the purposes of comparing with the literature. As expected, the results strongly reject the null hypothesis that the tax rate has no effect on the real output growth rate, in all specifications. Moreover, the long-run "tax multiplier" is estimated at –0.6 for the entire period and –0.4 for the postwar period, both highly statistically significant.[4]

[3] In fact, the impulse responses implied by the local projection model (1b) are well within the two-standard-deviation confidence intervals of the responses from model (1a), except for the very last year, when the local projection diverges.

[4] These estimates are smaller than those obtained by Romer and Romer (2010) for the US using a narrative approach. They are very similar to the average revenue multipliers reported by Mineshima, Poplawski-Ribeiro, and Weber (2014) for advanced economies. See also Batini, Eyraud, Forni, and Weber (2014) for similar evidence.

Summing up, the benchmark model finds that an increase in the tax rate by 1% of GDP is associated with a long-run reduction in the level of output by about 0.6% (or 0.4% in the post-war period) which is permanent, and a decrease in the real growth rate which is temporary but long lasting (four to five years).

3.2 A More General Specification

We now move to a richer dynamic specification, allowing for an autoregressive structure in the estimated equations. In particular, the benchmark model is generalized to

$$\Delta y_{i,t} = w_i + v_t + \sum_{j=1}^{J} \alpha_j \Delta y_{i,t-j} + \sum_{j=0}^{J} \beta_j \Delta \tau_{i,t-j} + u_{i,t} \tag{2a}$$

while the local projection specification becomes

$$\Delta y_{i,t+h} = w_i^h + v_t^h + \sum_{j=1}^{J} \alpha_j^h \Delta y_{i,t-j} + \beta^h \Delta \tau_{i,t} + \sum_{j=1}^{J} \beta_j^h \Delta \tau_{i,t-j} + u_{i,t} \tag{2b}$$

where the αs and α^hs are the autoregressive parameters, added to better capture persistence in the real growth rate. The value of the long-run tax multiplier is now given by $LRM = \frac{\sum_{j=0}^{J} \beta_j}{1 - \sum_{j=1}^{J} \alpha_j}$.

Figure 7 collects the responses of output to an increase in the tax rate by 1% of GDP when models (2a) and (2b) are estimated with fixed (top row) or random (bottom row) country and time effects. The left column reports the results for the full period, 1870-2013; while the right column those for the postwar period, 1950-2013. It is apparent that adding the autoregressive coefficients does not materially change the results. Once again, following the increase in the tax rate by one percentage point, real GDP declines contemporaneously (within the year) by about a quarter of a percentage point, and then keeps falling, converging to a permanently lower value that depends somewhat on the specification (see discussion of Table 2, below). Just like before, models (2a) and (2b) produce responses that are not statistically different from each other.[5]

The overall significance of the tax rate in models (2a) an (2b), as well as the implied long-run multipliers are reported in Table 2. As was the case in the benchmark models, the reported F-tests suggest that the tax rate coefficients are jointly statistically significant in all specifications. Depending on the specification, the estimated long-run tax multiplier varies from –0.53 to –0.67, being slightly bigger (in absolute value) than in the models without autoregressive terms, but still statistically significantly negative in each of the specifications.[6]

3.3 An Alternative Identification

A standard concern in the empirical literature of taxes and growth is that tax changes may be endogenous, in the sense that tax policy may be responding to economic conditions. If that's

[5] Again, the responses from model (2a) lie within the two-standard-deviation bands of the local projection estimates.

[6] Estimates were also obtained for the 1980-2013 period. The estimated long-run multipliers remain negative in all specifications but are generally smaller in size and statistically insignificant. This is not surprising given the smaller sample size and the smaller range of growth and tax rate values over this period. For models (2a) for example, estimated *LRM*s are – 0.178 (0.224) and – 0.251 (0.237) under Fixed and Random effects, respectively (with standard errors in parentheses). I am grateful to an anonymous referee for suggesting this test.

true, the estimated αs and βs in models (1) and (2) may be biased, which will make both the same-year and long-run multipliers biased, as well.

One way of trying to identify exogenous tax shocks would be the narrative approach, employed by Romer and Romer (2010) for the US, and DeVries, Guajardo, Leigh, and Pescatori (2011) for a sample of OECD countries. Used by a rapidly increasing part of the literature, this approach uses historical documents to construct series that should be exogenous and relevant. Ramey (2019) has a thorough survey of this literature for fiscal shocks. While this approach has been subject to various criticisms,[7] it can offer interesting insights and would have been useful in the present context. Unfortunately, this is not currently feasible as no narrative measure of tax shocks exists that goes back to the 1870s for any of the countries in our sample.

Instead we rely on a more straightforward approach by now allowing tax changes to react to the level of economic activity, specifying the following equation for $\Delta\tau_{i,t}$:

$$\Delta\tau_{i,t} = x_i + z_t + \sum_{j=1}^{J} \gamma_j \Delta y_{i,t-j} + \sum_{j=1}^{J} \theta_j \Delta\tau_{i,t-j} + \pi_{i,t} \tag{3}$$

where the xs and zs are country- and time-specific effects, and the γs and θs are parameters to be estimated. The γs capture the role of the economy's real growth rate in the determination of tax rates, while the θs capture persistence. We interpret $\pi_{i,t}$ as the exogenous tax "shock" in country i at time t – that is, the part of the change in the tax rate that is not explained by past economic activity or its own persistence.

We then revise the benchmark model to:

$$\Delta y_{i,t} = w_i + v_t + \sum_{j=1}^{J} \alpha_j \Delta y_{i,t-j} + \sum_{j=0}^{J} \beta_j \hat{\pi}_{i,t-j} + u_{i,t} \tag{4a}$$

and the local projection specification to:

$$\Delta y_{i,t+h} = w_i^h + v_t^h + \sum_{j=1}^{J} \alpha_j^h \Delta y_{i,t-j} + \beta^h \hat{\pi}_{i,t} + \sum_{j=1}^{J} \beta_j^h \hat{\pi}_{i,t-j} + u_{i,t} \tag{4b}$$

where $\hat{\pi}_{i,t}$, the residual from regression (3), is the estimated tax "shock".[8]

Figure 8 shows the responses of output to an exogenous tax shock of 1% of GDP when systems (3)-(4a) and (3)-(4b) are estimated with fixed (top row) or random (bottom row) country and time effects. It is obvious that our basic results are quite robust to this alternative identification.

Beginning with the full-period (1870-2013) estimates in the left column of Table 8, a positive tax shock is found to reduce output in the same year by about 0.25%. Output keeps falling for several years after that, resulting in a long-run cumulative loss of about 0.6% of GDP. Both short-run and long-run effects are statistically significant. The effects on the real growth rate

[7] Some of the most common criticisms of narrative approaches are that they yield multiplier values that are "surprisingly large" (Ramey, 2019), that the measured shocks are not truly exogenous (Hernández de Cos and Moral-Benito, 2016; Jorda and Taylor, 2015), and that the constructed shocks rarely measure the entirety of the actual shock (Stock and Watson, 2016). Similar criticisms have been noted for the monetary applications of the narrative approach (see Leeper, 1997).

[8] Favero and Giavazzi (2012) and Mertens and Ravn (2014) are two of several attempts to reconcile the narrative and VAR-based approaches.

are temporary, but persist for at least half a decade. The right column of Figure 8 shows the impulse response functions for the postwar (1950-2013) period, which reach very similar conclusions.[9]

Summing up, the output effects of tax changes are found to be consistent with the predictions of the standard neoclassical growth model. An increase in the tax rate is shown to reduce the level of real GDP permanently, and the real growth rate temporarily. Quantitatively, the tax multiplier is estimated at –0.25 for the first year, and –0.5 to –0.6 in the long run.

4. Three Extensions: Inspecting the Mechanism

This section looks deeper into the mechanisms that determine the output effects estimated above. It does that by pursuing three extensions that can shed light on the precise way these output effects are generated. Because of data limitations, this section focuses on the postwar period which has a fuller data availability.

4.1 Consumption and Investment

The first extension is the simplest. Instead of looking at aggregate GDP, as in the previous sections, we now investigate the effects of the tax rate on two of its components: private consumption, typically the largest component, and investment, usually the most volatile. We adopt the same methodology that was used for output earlier, but to preserve space, only the full autoregressive models (2a) and (2b) will be reported.

Figure 9 shows the response of real consumption to an increase in the tax rate by 1% of GDP when the models are estimated with fixed effects. As expected, the response is negative, and traces a trajectory qualitatively similar to that of output. Specifically, consumption declines within the year by about 0.10%, and then continues falling, converging to a cumulative long-run decline of about 0.25%. This is quite robust to using the local projection technique (also shown in Figure 9), as well as estimating with random effects (not shown, but available on request). These effects, however, are not as precisely estimated as those for GDP, and in fact they are not statistically significant.

Next, Figure 10 reports the response of real investment to the same increase in the tax rate by 1% of GDP. Again, as expected, the response is negative and qualitatively similar to that of output and consumption, though very different in terms of magnitude and statistical significance. Numerically, investment drops by about 0.40% within the first year, and then keeps falling, converging to a cumulative long-run decline of about 1.5%. Once more, this is quite robust to using the local projection technique and to estimating with random effects. Compared to consumption, these effects are not just considerably more sizeable, but also much more precisely estimated and statistically significant.

Table 4 provides another way of looking at these effects, reporting both F-statistics for the overall significance of the tax rate, as well as long-run “multipliers” for consumption and investment. The difference is apparent. The effects of an increase in the rate on consumption are relatively small and statistically insignificant, whereas on investment they are both substantially larger and statistically significant. The lesson from the first extension is that investment is much more sensitive to tax changes than consumption.

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[9] The main discernible difference is that, compared with the entire period, the intensity of the tax multipliers is somewhat reduced in the postwar period: –0.20 (rather than –0.25) for the first-year multiplier, and roughly –0.50 (rather than –0.60) for the long-run multiplier.

4.2 The Interest Rate

The second extension attempts to extract information from the credit market, investigating the effects of changes in the tax rate on the interest rate. The standard IS/LM model, for example, predicts that an increase in the tax rate should lower the equilibrium interest rate. Figure 11 estimates the response of the short-term real interest rate to an increase in the tax rate by 1% of GDP, using the autoregressive models (2a) and (2b).[10] As expected, the interest rate is shown to decrease, but the drop lasts for only two years. In particular, the interest rate falls by about 0.10% in the first year, stays about there for one more year, and then returns to its original value beginning with the third year. IN addition these interest-rate effects are very imprecisely estimated. Even the short-run reductions, consistent as they may be with the simple IS/LM model, are not statistically significant.

4.3 The Price Level

The third and final extension of this section looks at the effects on inflation. The objective here is to assess the relative strengths of the aggregate-supply and aggregate-demand effects of tax changes. Theoretically, a change in the tax rate can have both supply-side and demand-side effects. The former originate in changes to productivity and work effort, while the latter include effects on government saving and private spending. Both supply- and demand-side effects are pushing output in the same direction, so they cannot be disentangled using an output regression. They can be easily distinguished with an inflation regression, however. If the price level increases (decreases) after a tax increase, the aggregate supply (demand) effects must be dominant.

Figure 12 shows the response of the CPI price level to the increase in the tax rate by 1% of GDP. In both specifications, the response is positive and permanent. The price level jumps up by about 0.15% in the first year and continues increasing to a cumulative long-run increase of more than 0.50%. Note that the price level increases permanently while inflation only temporarily. Combined with the decrease in output identified above, this suggest that the supply-side effects of tax changes have been stronger than their demand-side effects.

Table 5 adds a cautionary note to the last two extensions. The Table reports “short-run” (i.e., first-year) and long-run effects on the interest rate and the price level and their statistical significance. Unlike the output effects, which are almost always tightly estimated and strongly statistically significant, the effects on the interest rate and price level are much less precisely estimated. The only exception to this on Table 5 is the short-run effect of tax changes on the price level which is not only positive but also strongly statistically significant.

5. Discussion and Conclusions

How do changes in the tax rate affect the economy? While the theoretical and empirical consensus is that higher tax rates reduce economic activity, there is considerable disagreement on the strength of the relationship and the economic mechanisms that generate it.

[10] A subtle difference in the setup of the interest-rate models in worth mentioning. Whereas in the other specifications the dependent variable ($\Delta y_{i,t}$) is the growth rate of the variable in question (real GDP, consumption, investment, or the price level – see below), in the interest-rate equations the dependent variable is the simple difference of the interest rate: $r_{i,t} - r_{i,t-1}$.

Using a unique data set of seventeen countries over the period 1870-2013, the paper has estimated the effects of changes in the tax rate on various macroeconomic variables, enabling us to reveal a rather comprehensive picture. The main findings are easy to summarize.

First, as expected, increases in the tax rate are shown to reduce overall economic activity. Specifically, a higher tax rate lowers the level of real GDP permanently, and the real growth rate temporarily. This is consistent with the predictions of the standard neoclassical growth model. Numerical estimates vary only moderately by specification, and the implied tax multiplier is estimated around –0.25 for the first year, and –0.5 to –0.6 in the long run.

Next, it is clear that private consumption and investment do not respond equally strongly to the tax rate. While both components of GDP decline after an increase in the tax rate, the response of consumption is weak (and statistically insignificant), whereas that of investment is substantial (and statistically significant).

The evidence is less clear on the interest-rate effects. A higher tax rate is shown to have no effect on interest rates in the long run, but it appears to reduce the interest rate for a couple of years, an effect that is consistent with the standard IS/LM model.

Finally, the results suggest that an increase in the tax rate raises the price level immediately and permanently, and the inflation rate temporarily (and statistically significantly). This suggest that the supply-side effects of tax changes have generally dominated the demand-side effects. This is a finding that is worth investigating more closely in future research.

The policy implications of our findings are straightforward.[11] Two obvious recent applications are the 2017 Trump Administration tax cuts in the US (formally, the Tax Cuts and Jobs Act, or TCJA) and the even more recent tax breaks announced by China in February 2019. The objectives of both policies include boosting investment and speeding up growth. The evidence of the present study can be used to predict that the first objective will be achieved, while the second will succeed only temporarily: the tax cuts will raise investment permanently, but will produce only a transitory boost on the growth rate.

Symmetrically, our results can be used to quantify the effects of the tax increases that have been recently adopted by European countries, including Greece, or those that may accompany a "Green New Deal" proposed in the US.[12] The evidence suggests that the economic costs of such increases include permanently lower investment and income levels, and temporarily reduced growth rates.

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[11] I am grateful to an anonymous referee for pointing out some of these connections.
[12] See the Economist (2019).

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Table 1

Estimated Effects of Tax Changes on GDP

Model (1): No Autoregressive Lags

	Entire Period: 1870-2013		Post-War Period: 1950-2013	
	FE	RE	FE	RE
$\sum_i \beta_i$	–0.602**	–0.605**	–0.404**	–0.410**
	(0.147)	(0.143)	(0.142)	(0.138)
F-Tests				
Null: $\beta_j = 0, \ \forall j$	16.68**	17.97**	8.13**	8.85**

Note: "FE" denotes Fixed effects and "RE" Random Effects. FE and RE models have been estimated with both country and time effects (not reported). Estimated standard errors in parentheses. **:significant at 1%, *:significant at 5%.

Table 2

Estimated Effects of Tax Changes on GDP

Model (2): Autoregressive Structure

	Entire Period: 1870-2013		Post-War Period: 1950-2013	
	FE	RE	FE	RE
LRM	–0.549** (0.147)	–0.675** (0.174)	–0.533** (0.198)	–0.619** (0.215)
F-Tests				
Null: $\beta_j = 0,\ \forall j$	6.03**	6.18**	3.14**	3.34**

Note: See notes to Table 1. "LRM" denotes the Long-Run Tax Multiplier. Estimated standard errors obtained by the Delta method in parentheses. **:significant at 1%, *:significant at 5%.

Table 3

Estimated Effects of Exogenous Tax Shocks on GDP

Model (4): Recursive VAR

	Entire Period: 1870-2013		**Post-War Period: 1950-2013**	
	FE	RE	FE	RE
LRM	–0.581**	–0.639**	–0.457**	–0.525**
	(0.166)	(0.182)	(0.176)	(0.213)
F-Tests				
Null: $\beta_j = 0,\ \forall j$	5.67**	5.72**	2.65*	2.62*

Note: See notes to Table 1. "LRM" denotes the Long-Run Tax Multiplier. Estimated standard errors obtained by the Delta method in parentheses. **:significant at 1%, *:significant at 5%.

Table 4

Estimated Effects of Tax Changes

Model (2): Autoregressive Structure

	Consumption		**Investment**	
	FE	RE	FE	RE
LRM	-0.219	-0.274	–1.441**	–1.507**
	(0.222)	(0.251)	(0.482)	(0.463)
F-Tests Null: $\beta_j = 0,\ \forall j$	0.66	0.69	2.54*	2.74*

Note: See notes to Table 1. “LRM” denotes the Long-Run Tax Multiplier. Estimated standard errors obtained by the Delta method in parentheses. **:significant at 1%, *:significant at 5%.

Table 5

Estimated Effects of Tax Changes

Model (2): Autoregressive Structure

	Real Interest Rate		Price Level	
	FE	RE	FE	RE
SR	–0.089	–0.085	0.147**	0.157**
	(0.058)	(0.053)	(0.054)	(0.053)
LRM	–0.003	–0.008	0.628	0.894
	(0.089)	(0.075)	(0.489)	(0.568)
F-Tests Null: $\beta_j = 0,\ \forall j$	1.26	1.24	1.94	2.10

Note: See notes to Table 1. "SR" is the short-run (contemporaneous, i.e. within the year) effect of a tax change. "LRM" denotes the Long-Run Tax Multiplier. Estimated standard errors obtained by the Delta method in parentheses. **:significant at 1%, *:significant at 5%.

Figure 1a

Tax rates (black lines) and real GDP growth rates (blue lines)
1870-2013

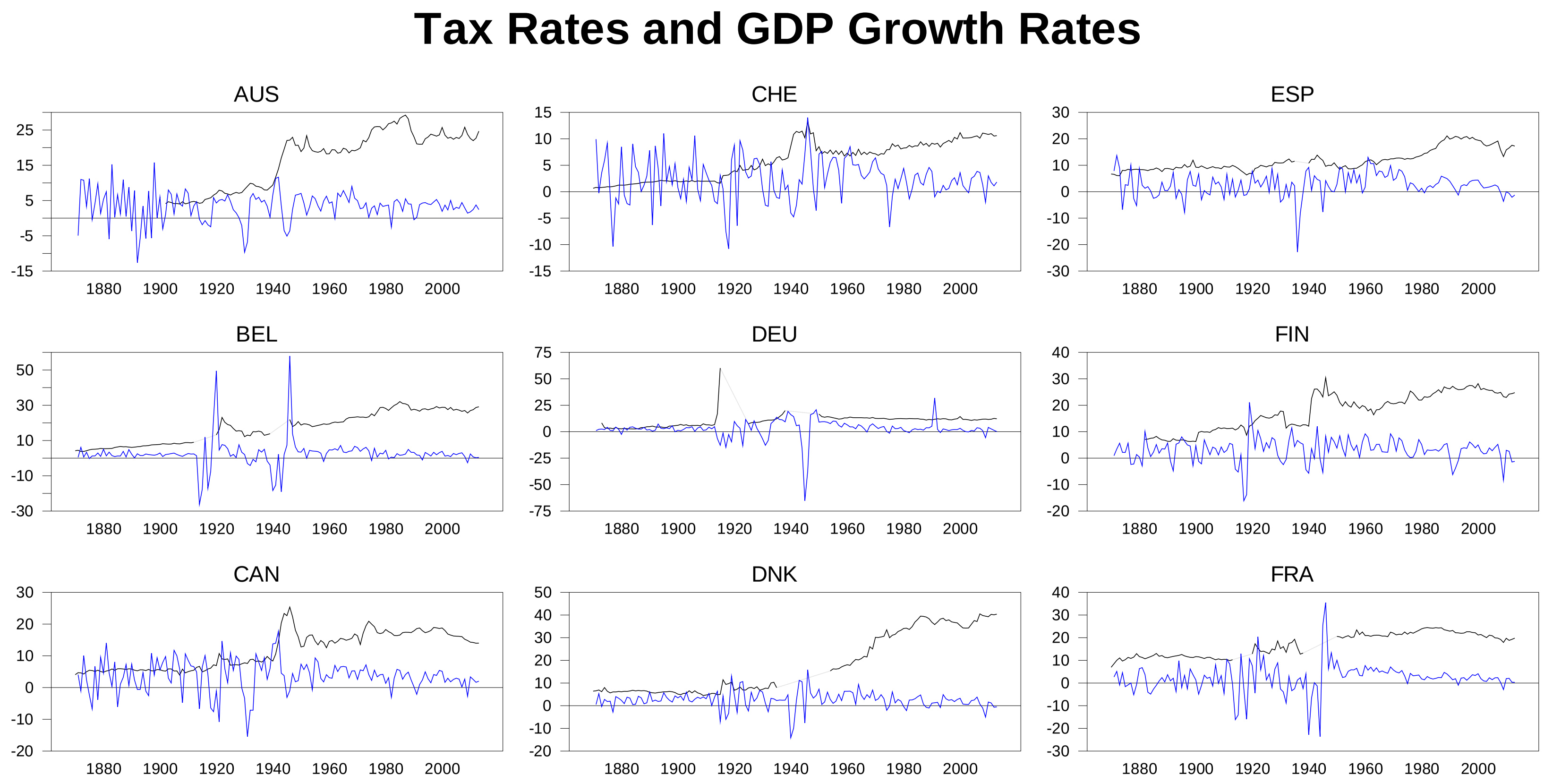


Figure 1b

Tax rates (black lines) and real GDP growth rates (blue lines)
1870-2013

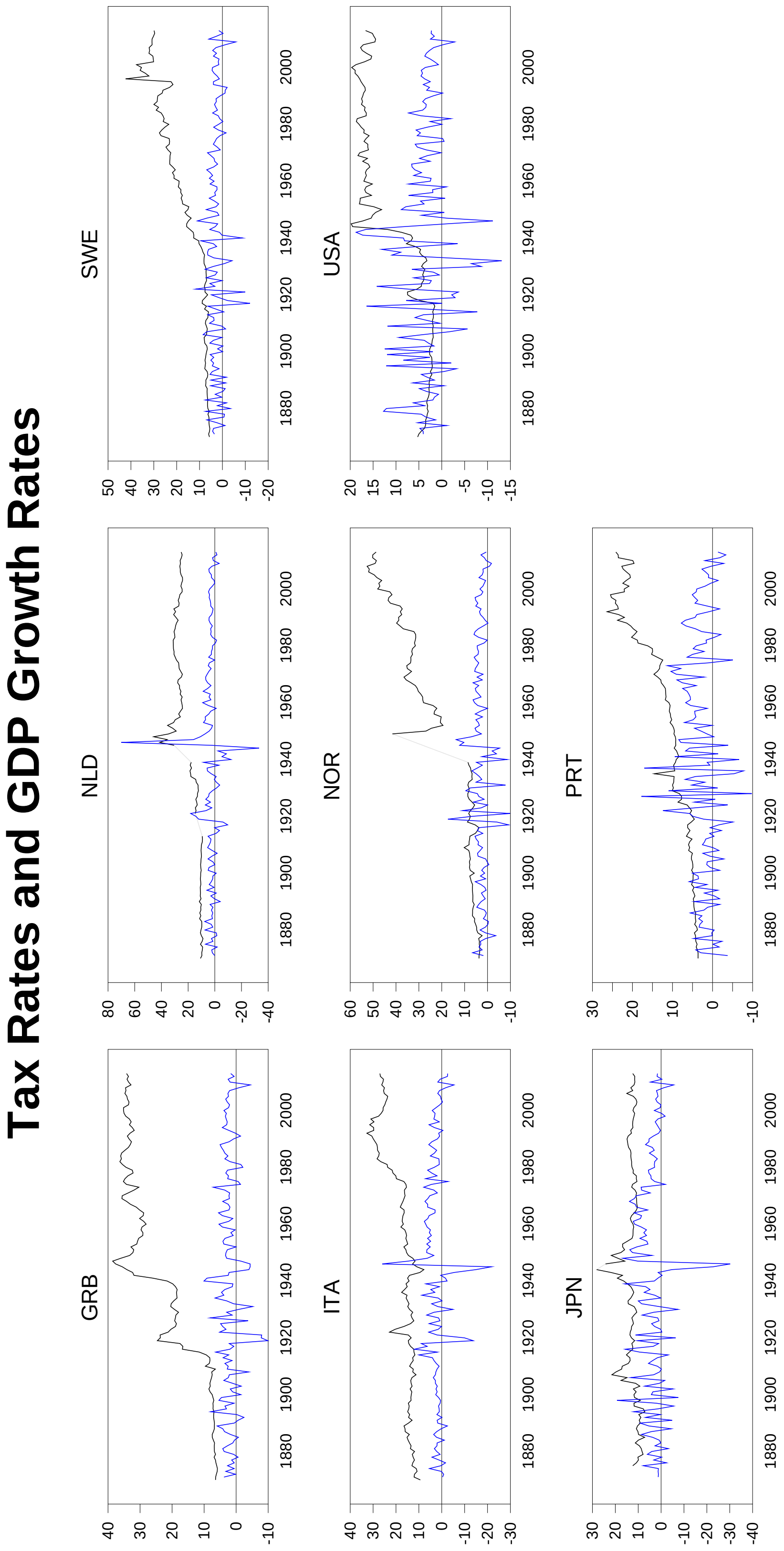
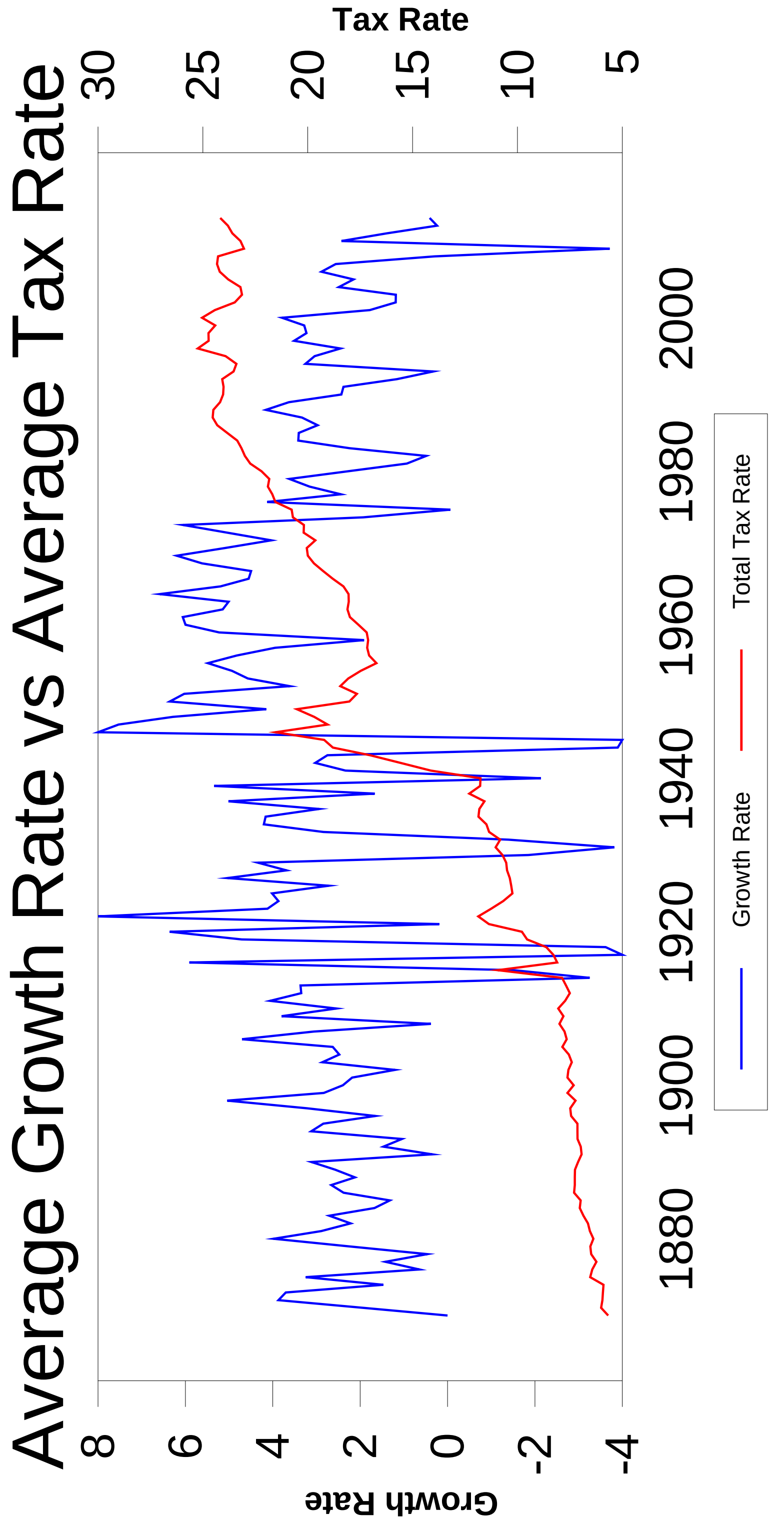


Figure 2

Average growth rate (blue line, LHS) and average tax rate (red line, RHS)



1870-2013

Figure 3

Response of real GDP to an increase in the Tax Rate by 1% of GDP. Models (1a) and (1b) estimated over 1870-2013 with country and time fixed effects. Dashed lines are two-standard-error confidence intervals.

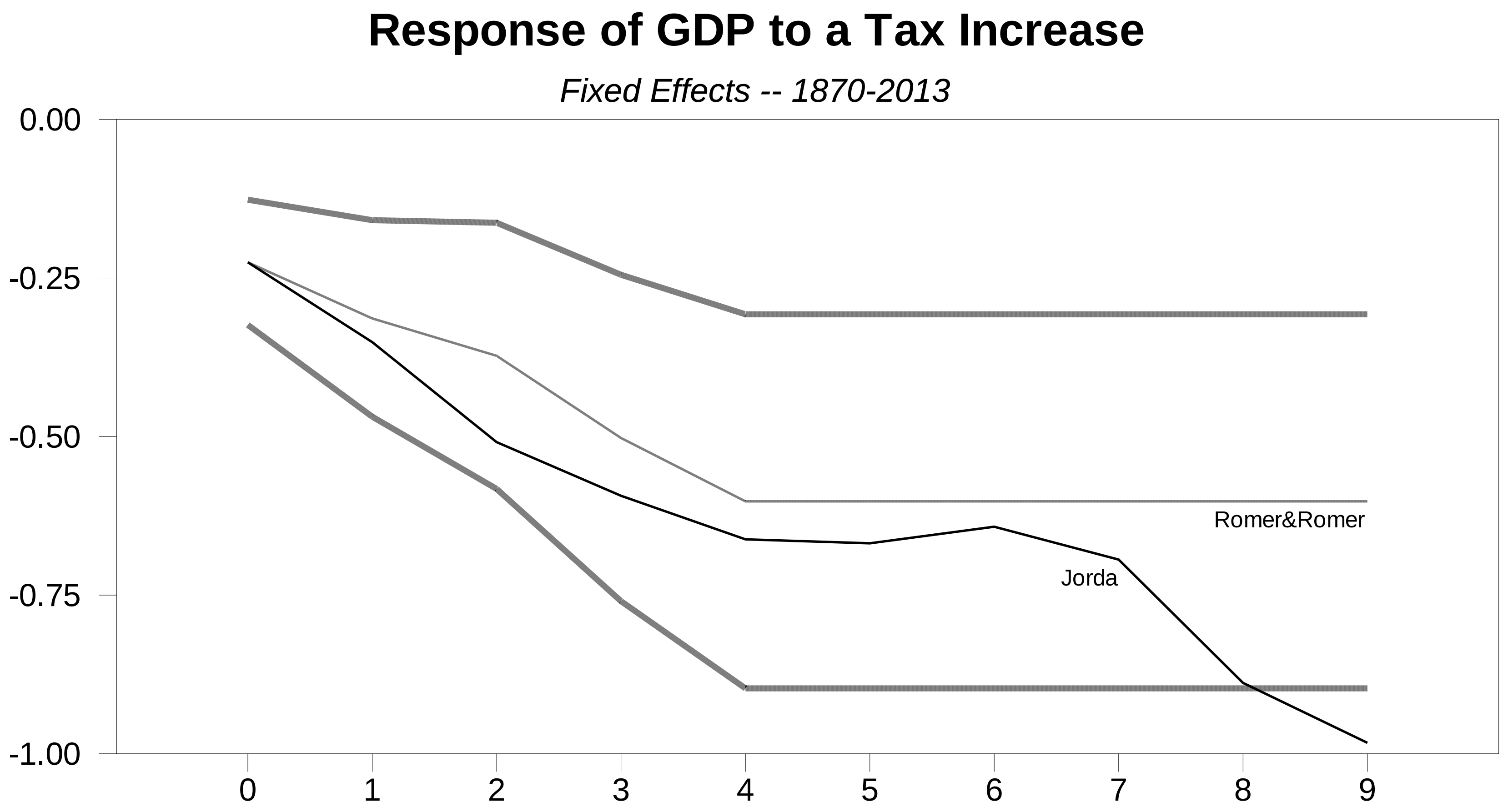


Figure 4

Response of real GDP to an increase in the Tax Rate by 1% of GDP. Models (1a) and (1b) estimated over 1870-2013 with country and time random effects. Dashed lines are two-standard-error confidence intervals.

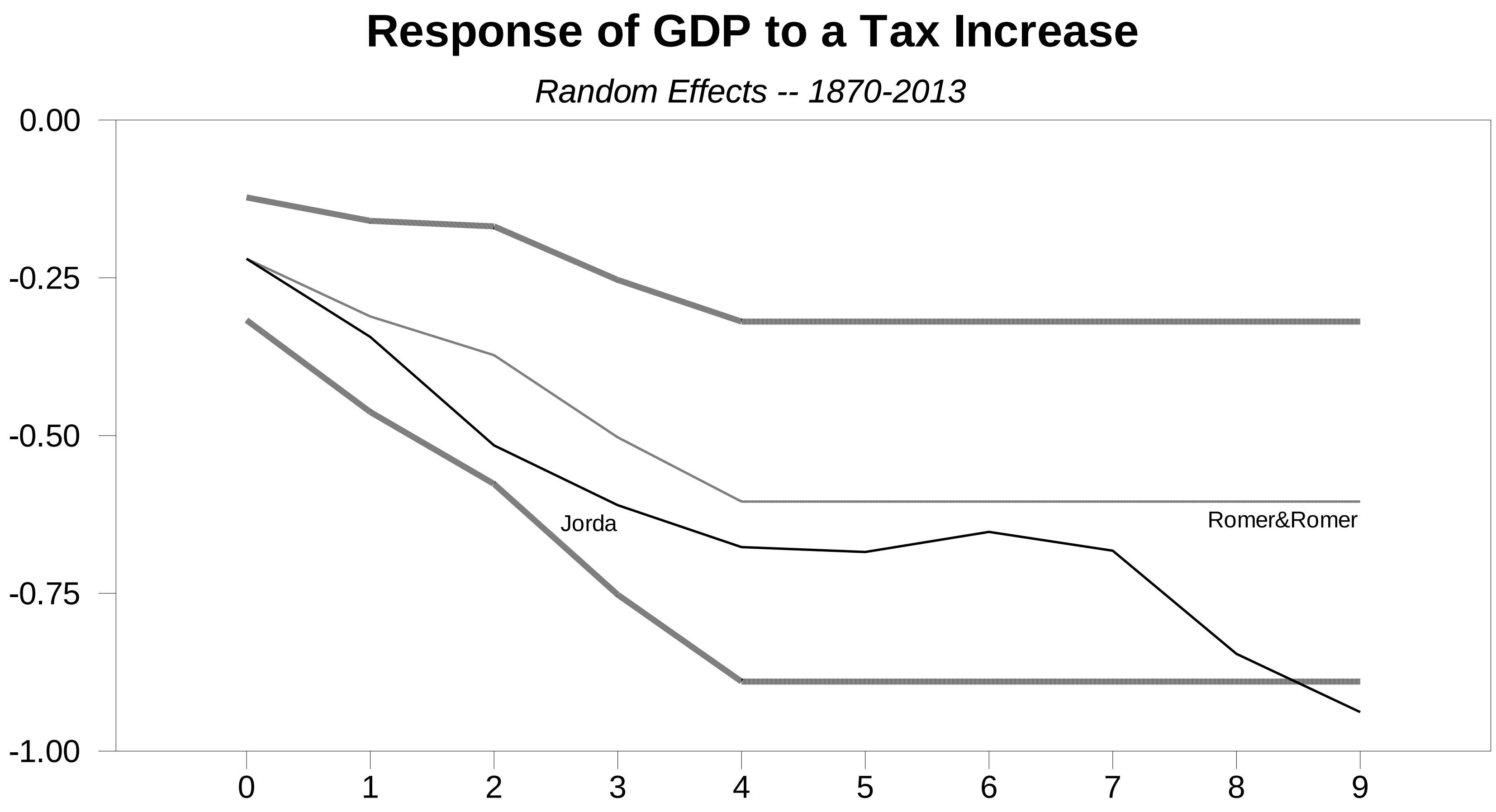


Figure 5

Response of real GDP to an increase in the Tax Rate by 1% of GDP. Models (1a) and (1b) estimated over 1950-2013 with country and time fixed effects. Dashed lines are two-standard-error confidence intervals.

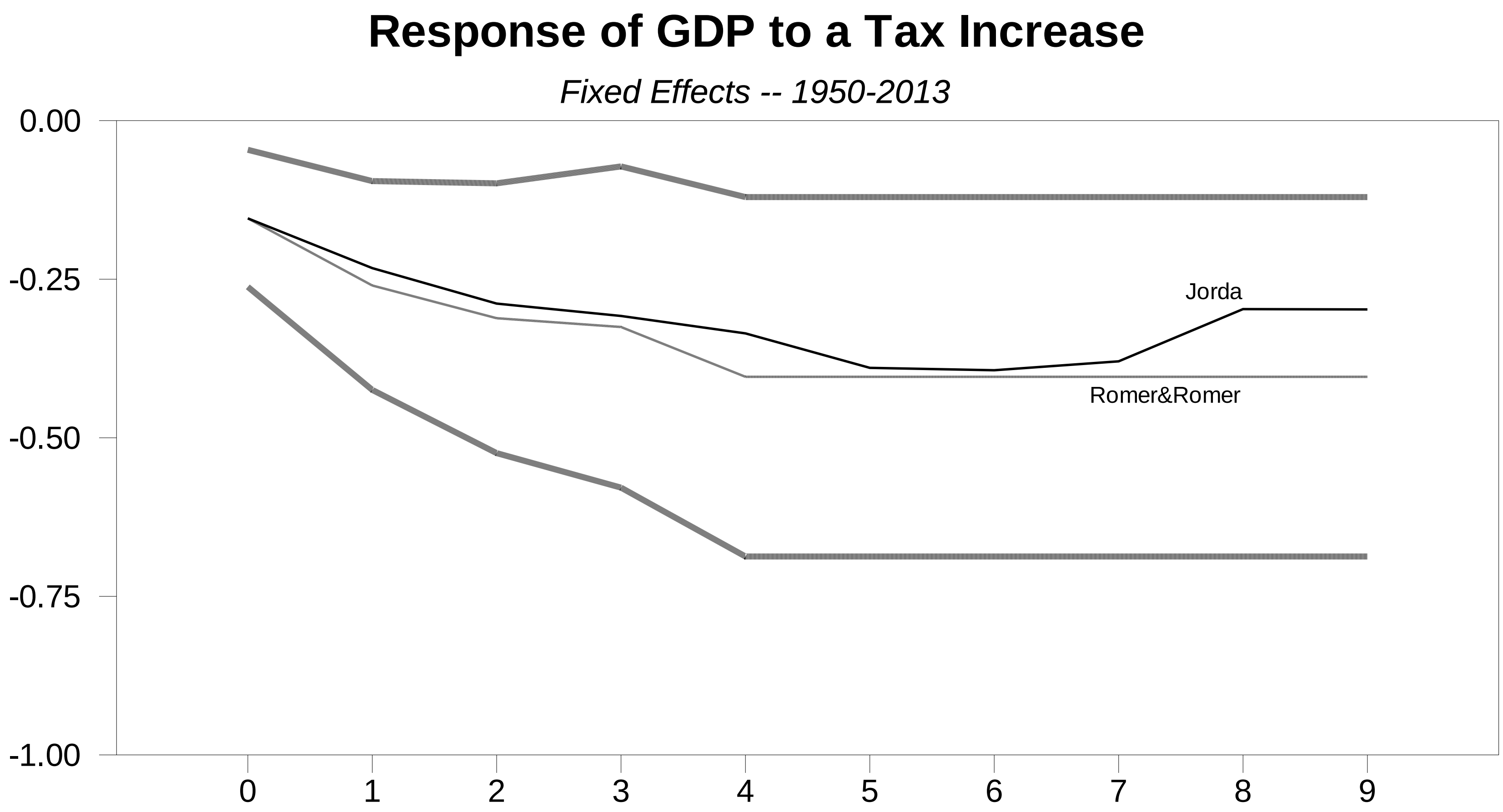


Figure 6

Response of real GDP to an increase in the Tax Rate by 1% of GDP. Models (1a) and (1b) estimated over 1950-2013 with country and time random effects. Dashed lines are two-standard-error confidence intervals.

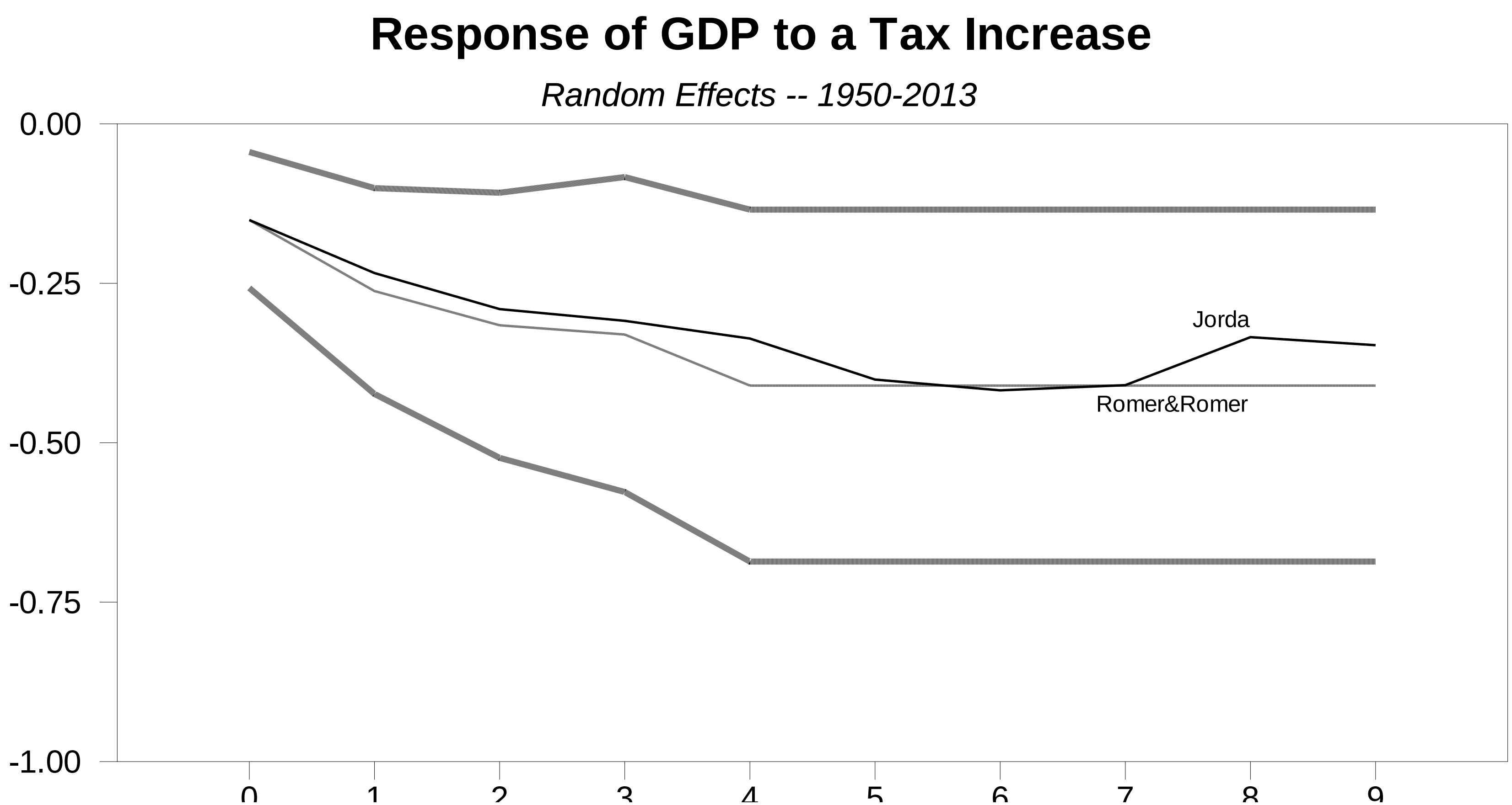


Figure 7

Response of real GDP to an increase in the Tax Rate by 1% of GDP. Models (2a) and (2b) estimated over the time periods indicated with country and time fixed or random effects. Dashed lines are two-standard-error confidence intervals.

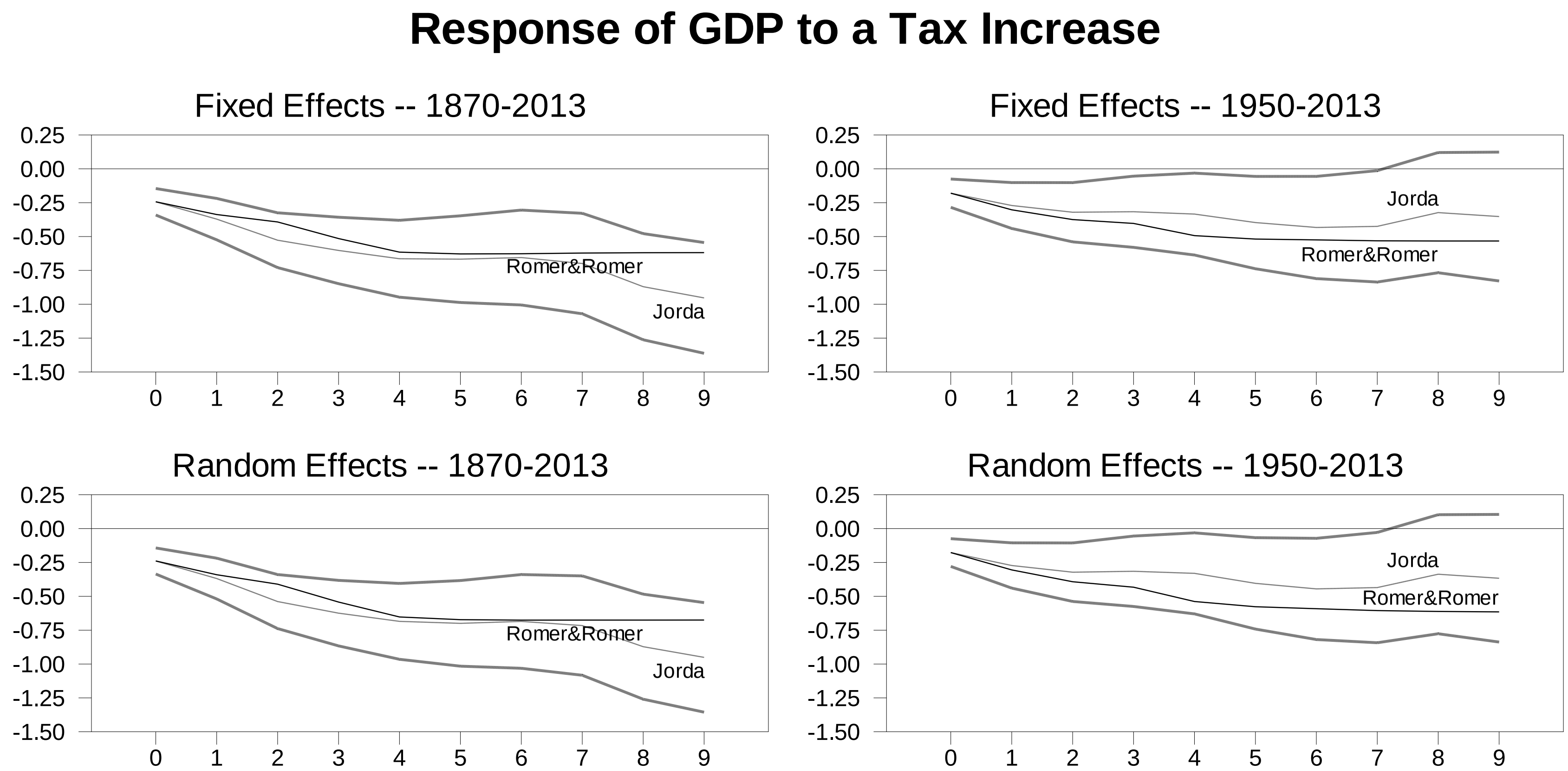


Figure 8

Response of real GDP to an increase in the Tax Rate by 1% of GDP. Models (3a) and (3b) estimated over the time periods indicated with country and time fixed or random effects. Dashed lines are two-standard-error confidence intervals.

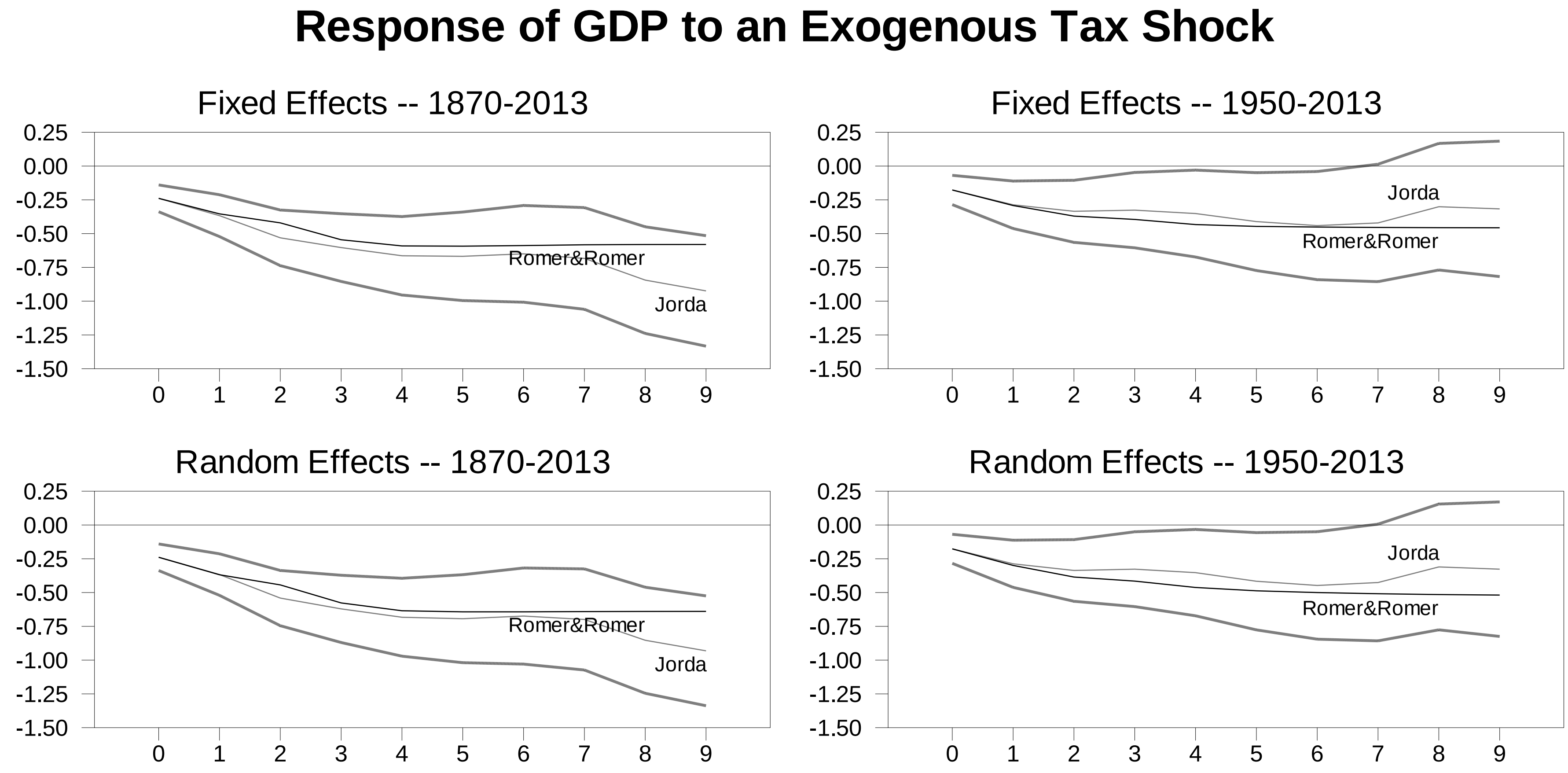


Figure 9

Response of real Consumption expenditure to an increase in the Tax Rate by 1% of GDP. Models estimated over 1950-2013 with country and time fixed effects. Dashed lines are two-standard-error confidence intervals.

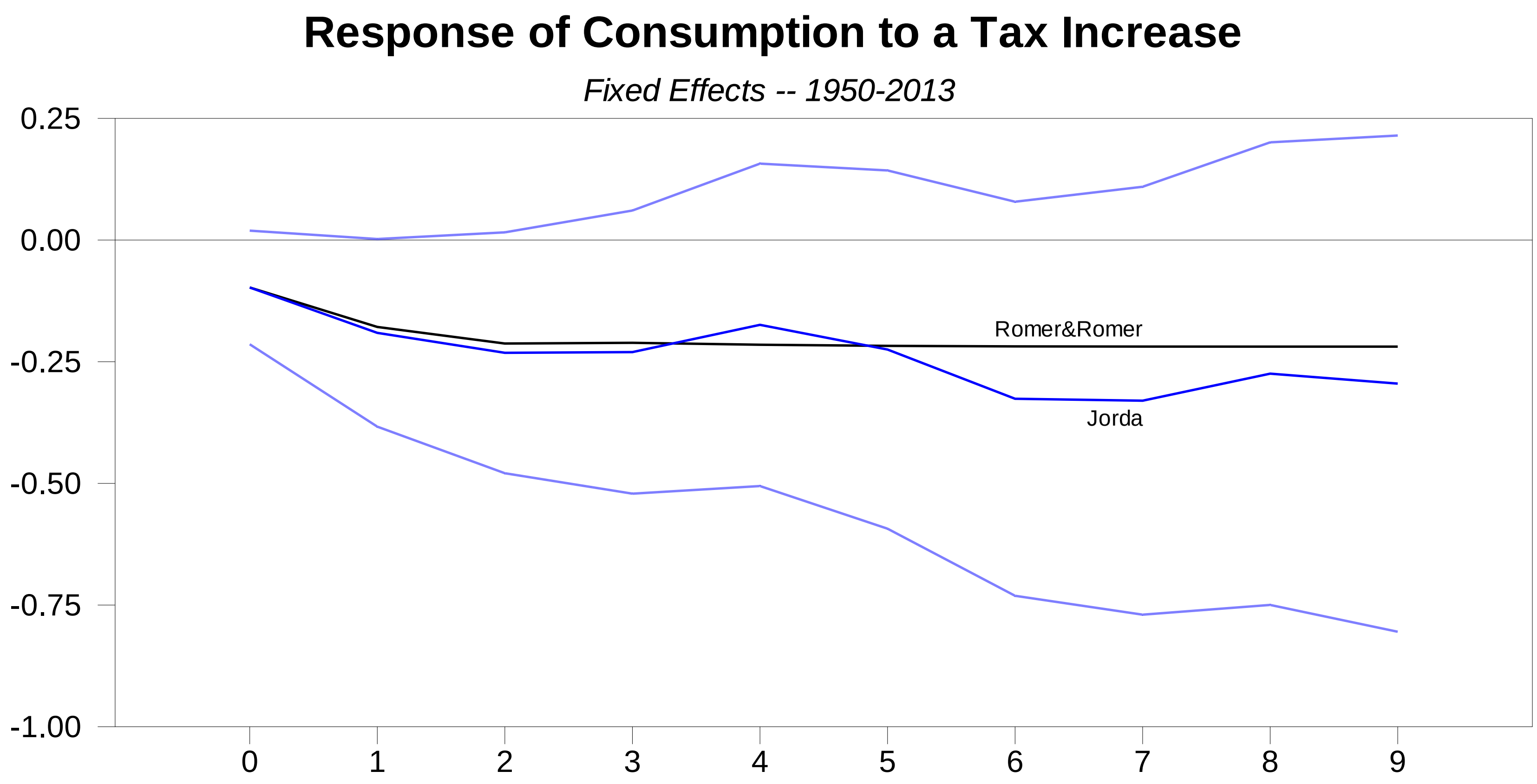


Figure 10

Response of real Investment expenditure to an increase in the Tax Rate by 1% of GDP. Models estimated over 1950-2013 with country and time fixed effects. Dashed lines are two-standard-error confidence intervals.

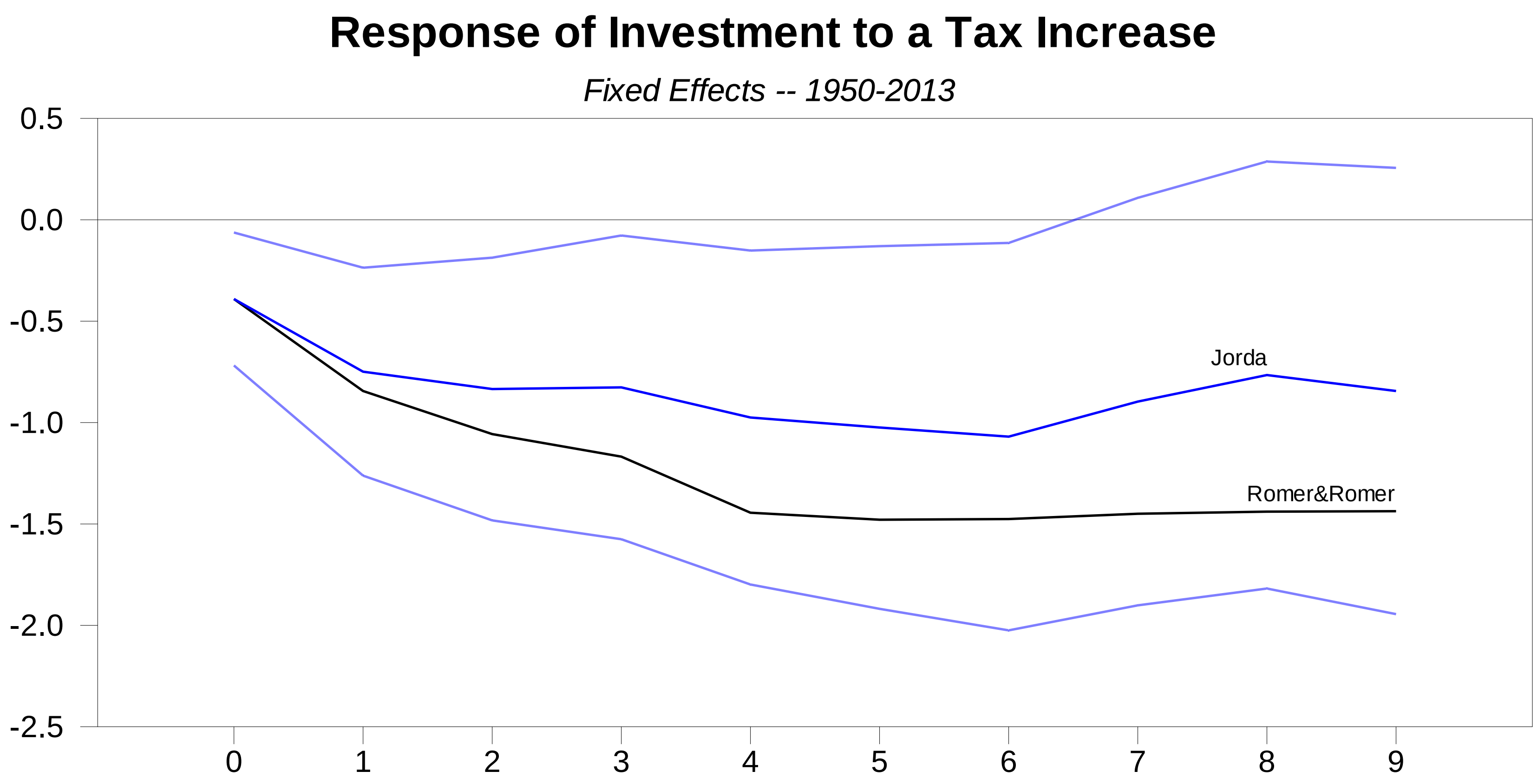


Figure 11

Response of the real interest rate to an increase in the Tax Rate by 1% of GDP. Models estimated over 1950-2013 with country and time fixed effects. Dashed lines are two-standard-error confidence intervals.

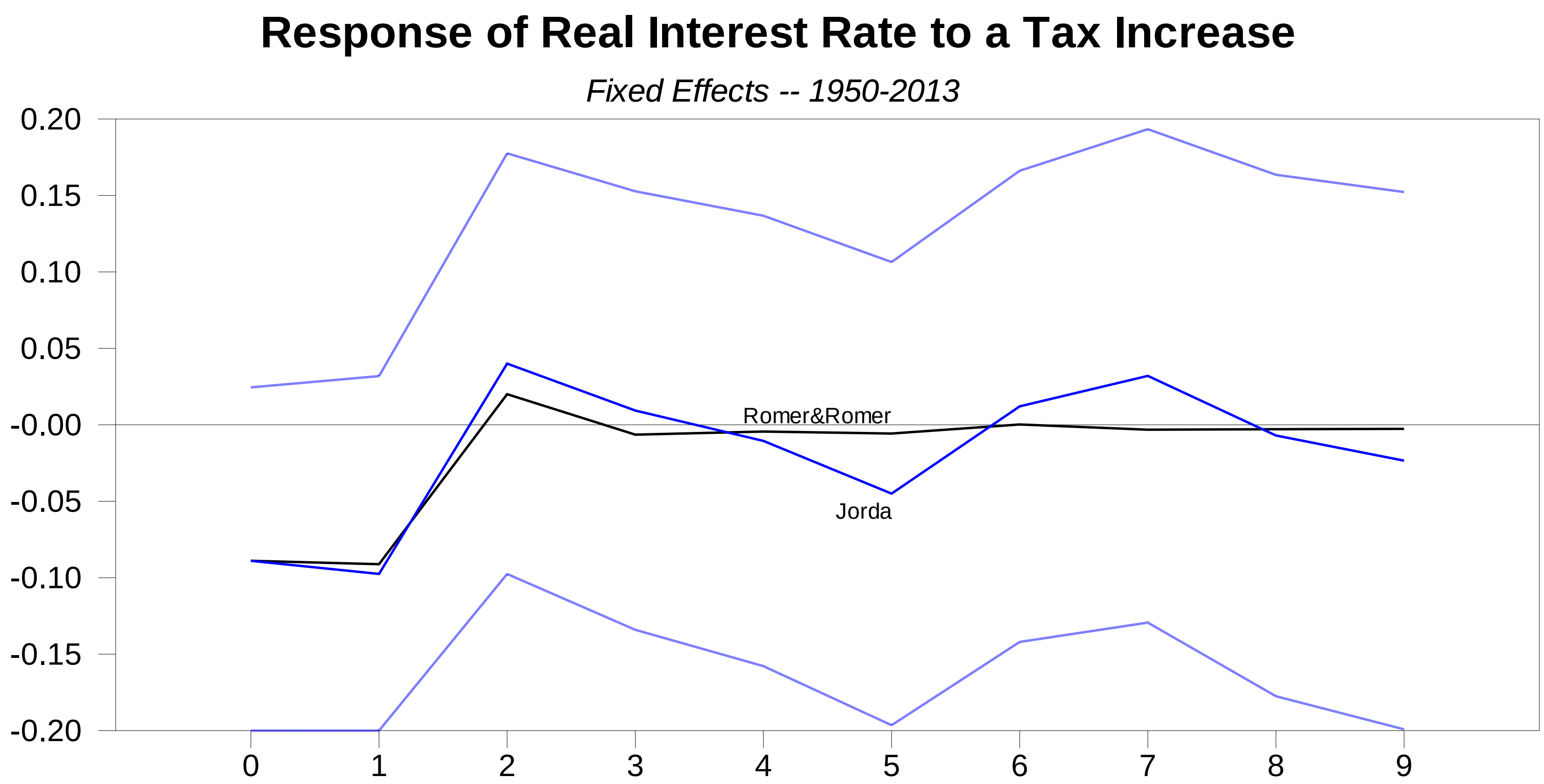


Figure 12

Response of the CPI price level to an increase in the Tax Rate by 1% of GDP. Models estimated over 1950-2013 with country and time fixed effects. Dashed lines are two-standard-error confidence intervals.