

Non-linear effects of tax changes on output: A worldwide narrative approach*

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Abstract

Following the narrative approach developed by Romer and Romer (2010) for the United States, we use a novel dataset on value-added taxes for 51 countries (21 industrial and 30 developing) for the period 1970-2014 to identify 96 tax changes which, based on contemporaneous economic records, are classified into endogenous and exogenous to current (or prospective) economic conditions. First, using this classification, we quantify the biases that would be introduced by using all tax changes, as in the traditional methodology based on Blanchard and Perotti (2002). Second, we show that even within the category of exogenous tax changes, the size of tax multipliers varies greatly depending on the exact policy motivation. Lastly, we show the existence of strong non-linear effects of tax changes on output. In particular, and in line with existing theoretical arguments, we show that the effect of tax changes on output is larger (in absolute terms) the higher is the initial level of the tax rate and the larger is the size of the change in the tax rate. In fact, these non-linear effects are key in explaining the differences observed in the size of tax multipliers for different types of exogenous tax changes. We simultaneously evaluate the relevance of our arguments both for our global sample as well as for Romer and Romer's U.S. dataset.

JEL Classification: E32, E62, H20.

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1 Introduction

After the recent global financial crisis and ensuing recession, fiscal multipliers – the effects of fiscal policy on aggregate output – have taken central stage in the policy world. In the beginning, many governments across the world implemented aggressive countercyclical fiscal policies aimed at providing economic stimulus and counteracting the social repercussions of the fall in output. More recently, large fiscal deficits and concerns about debt sustainability in industrial countries (particularly in Europe) as well as in the developing world (as a result of the recent collapse in commodity prices and the global slowdown) have shifted the tone of the discussion from stimulus to fiscal adjustment. Motivated by the policy focus on fiscal stimulus first and on fiscal consolidation later, there has been a flourishing of studies estimating government spending multipliers and, to a lesser extent, tax multipliers.

The main challenge and point of contention among researchers has been how to address the possible endogeneity of fiscal policy or, put differently, how to identify exogenous fiscal policy shocks (i.e., changes in fiscal policy variables that are not directly or indirectly related to output changes). On the taxation front, which is the focus of this paper, there seems to be an emerging consensus in the literature that the so-called narrative approach developed by Romer and Romer (2010) (henceforth RR) in their study on the United States is better suited in identifying exogenous tax policy shocks than the approach championed by Blanchard and Perotti (2002) (hereafter BP). The BP approach imposes short term restrictions in the context of structural vector autoregressions (SVAR). While changes in tax policy may contemporaneously affect output, it is assumed that it takes the government at least one quarter to respond to news about the state of the economy. While appealing at first sight, this timing identifying strategy has been criticized on the basis that most changes in fiscal policy, including tax changes, are actually anticipated by agents (e.g., Ramey and Shapiro, 1998; Leeper, Walker, and Yang, 2008; Ramey, 2011; Auerbach and Gorodnichenko, 2013; and Riera-Crichton, Vegh, and Vuletin, 2015). Moreover, and especially for large and sudden falls in output, it is not obvious that within-the-quarter economic developments may not affect tax policy. For example, during episodes of natural disasters it is, indeed, often the case that governments quickly respond by increasing or reducing taxes. The earthquake cases of Ecuador in 2016, Japan in 2011, India in 2001, and California in 1989 prove to be clear

examples about the unsuitability of the BP time assumption.^{1,2,3,4}

In contrast, RR use the narrative record, such as Congressional reports and presidential speeches to identify the principal motivation behind all major postwar tax policy actions in the U.S.. The analysis of contemporaneous records enables RR to separate legislated tax changes into those taken for reasons related to current or prospective economic conditions (i.e., endogenous) from those taken for reasons exogenous to the business cycle, including those motivated by long-run considerations (e.g., by a belief that lower taxes will raise output in the long-run) and inherited deficit-driven tax changes (which reflect past economic conditions and budgetary decisions, not current or prospective ones). With this classification of tax changes in hand, RR analyze the behavior of output following exogenous tax changes. Not surprisingly, RR find large differences between tax multipliers based on exogenous tax changes compared to tax multipliers based on all tax changes as in BP. In particular, RR find that (i) the output effect of exogenous tax changes is negative, which implies that tax increases (cuts) are contractionary (expansionary) and (ii) the maximum effect when using all tax changes à la BP is biased toward zero and less than half as large as that found using exogenous tax changes. Interestingly, RR also find that the effect of tax changes on output varies depending upon the nature of the exogenous tax change. While the tax multiplier associated with long-run considerations is negative (and virtually identical to that of a generic exogenous tax

¹Ecuador suffered on April 16, 2016, a severe earthquake (with a moment magnitude of 7.8). According to contemporaneous estimates GDP was expected to fall about 1 as a consequence of the disaster, and reconstruction costs were estimated to be about 3 to 4 percent of GDP. On April 20 President Correa announced a 2% increase in the VAT rate (from 12% to 14%). Congress approved the VAT increase on May 12 and it was implemented on June 1. Therefore, the time elapsed between the natural disaster and the approval (implementation) of the tax change was of 26 (45) days.

²Japan suffered on March 11, 2011, the “triple disaster,” earthquake-tsunami-nuclear meltdown, with an earthquake magnitude of 9.0. According to contemporaneous reports the economic damage were estimated to be about 6 to 7 percent of GDP and the quake hit Japan’s north-east section, responsible for 6% to 8% of the country’s total production. On April 27 several “special” national tax laws were promulgated and became effective immediately. Also an expected cut of 5% of the Japanese corporate tax rate (announced on December 2010 by the Prime Minister), was deferred as consequence of the earthquake. Therefore, the time elapsed between the natural disaster and the approval and implementation of tax changes was of 46 days.

³India suffered on January 26, 2001, a severe earthquake (with a moment magnitude of 7.7). According to contemporaneous reports the economic damage were estimated to be about 0.8 percent of GDP. On February 1 the Cabinet imposed a nationwide 2 percent surcharge on both income and corporate taxes in order to help finance the reconstruction of the affected areas. Therefore, the time elapsed between the natural disaster and the tax change approval was of 6 days.

⁴California suffered on October 17, 1989, a severe earthquake (with a moment magnitude of 6.9). According to contemporaneous reports the economic damage were estimated to be about 1 percent of California’s GDP. The Governor called for a Special Session to address the needs for earthquake relief, to be held on November 2. On November 4, a package of legislation was approved, which included a one-year 0.25% surcharge to the State’s sales tax. The tax raise became effective on December 1. Therefore, the time elapsed between the natural disaster and the approval (implementation) of the tax change was of 18 (45) days.

change), the multipliers for deficit-driven tax changes are essentially zero. For this reason, RR cautiously suggest that “tax increases to reduce an inherited deficit may be less costly than other tax increases” (page 787).

Somewhat surprisingly, in spite of the tremendous influence of RR’s contribution, to our knowledge there is no study that analyzes the effect of tax changes on output in a larger group of countries that would include, for example, both industrial and developing countries.⁵ The main reason is surely the lack of data on legislated tax changes, which would be needed to capture the behavior of a tax policy instrument (i.e., a variable that is under the direct control of policymakers).⁶ Furthermore, unlike the BP approach, the RR narrative approach poses a major challenge in terms of gathering contemporaneous economic records to identify the motivation behind each tax change.

This paper takes on this challenge by focusing on 51 countries (21 industrial and 30 developing) for the period 1970-2014. Given the lack of readily-available data on average marginal individual and/or corporate income tax rates on a global scale, we focus our efforts on building a new series for quarterly standard value-added tax rates (VAT rate henceforth). We believe that this significant effort in collecting VAT rates is crucial for any study analyzing tax policy in the developing world as well as in Europe, where indirect/value-added taxation is the main tax revenue instrument. VAT rates were obtained from various primary sources, including countries’ revenue agencies and national libraries, books, newspapers, tax law experts, and research and policy papers. We identify a total of 96 VAT rate changes in 35 countries (17 developing and 18 industrial). As sources for the narrative analysis, we use contemporaneous International Monetary Fund (IMF) documents, OECD Economic Surveys, and news articles to gather evidence on policymakers’ intentions and primary motivations for each VAT rate change.

While closely following the RR identification strategy, we also incorporate some new elements that arise due to the global nature of the sample of countries as well as that of the tax measure. In particular, we allow endogenous tax changes to include countercyclical tax

⁵Riera-Crichton, Vegh, and Vuletin (2016)’s multi-country analysis uses an strategy close to that of the narrative approach but is limited to 14 industrial countries for the period 1980-2009.

⁶As discussed in RR and Mertens and Ravn (2014) for the case of the U.S. and in Riera-Crichton, Vegh, and Vuletin (2016) for a sample of 14 industrial countries, cyclically-adjusted changes in tax revenues are often used as a proxy for discretionary changes in tax policy. While appealing in principle, the use of cyclically-adjusted revenues suffers from serious measurement error because it implicitly attributes any change in revenues not associated with the estimated change in the tax base to policymakers’ discretionary behavior. As a result – and as shown in Riera-Crichton, Vegh, and Vuletin (2016) – tax multipliers estimated with cyclically-adjusted revenues yield misleading results.

changes (as in RR) as well as procyclical tax changes. While this latter type of policy behavior is not found by RR in the U.S., it is of critical importance in the developing world as well as in many other industrial countries (particularly European countries in recent times). When focusing on exogenous tax changes motivated by inherited fiscal factors, we consider inherited deficit-driven tax changes (as in RR) as well as inherited debt-driven tax changes. Since, over the last 60 years, the U.S. has not faced sustainability problems regarding the public debt, RR do not concern themselves with the latter case. In contrast, given the global nature of our sample, we also allow tax changes to respond to a stock of public debt that is viewed as unsustainable if current deficits persist.⁷ As our analysis will show, this distinction has important implications in terms of the size of the tax multipliers.

We can summarize our main empirical findings as follows:

1. We find that the output effect of exogenous tax changes is negative, which implies that tax increases are contractionary and tax cuts are expansionary. This finding is consistent with RR. Specifically, the multiplier is -1.2 on impact and increases (in absolute value) with longer horizons until reaching -2 after eight quarters.
2. *Biases due to misidentification.* Contrary to RR, we find that the estimated maximum effect when using all tax changes à la BP is more negative and about twice as large (the multiplier is -3.7 after eight quarters) to that found using exogenous tax changes. This bias is even more negative for developing economies and vanishes for industrial countries. We trace these differences in the biases due to misidentification (even for those identified by RR) to the degree of cyclicity of endogenous tax changes. On average (and even more so when focusing in the developing world) endogenous tax changes respond procyclically to GDP shocks. Therefore, the use of all tax changes à la BP would yield the wrong conclusion that tax multipliers are larger than what they truly are. For example, a tax increase implemented in response to a fall in output (i.e., an endogenous and procyclical tax change) would wrongly imply a larger contractionary effect of output in response to a tax increase (a quintessential problem of reverse causality). In contrast, in the industrial world where endogenous tax changes are, on average, acyclical, there is no bias resulting from using all tax changes. For the case of the United States (where according to RR classification endogenous tax

⁷As we will argue in Section 4, these exogenous tax changes are not triggered by lower cyclical tax revenues but are rather the result of inherited fiscal problems.

changes are countercyclical), the incorrect use of all tax changes à la BP would lead to an underestimation of the true effect of tax changes on output. For example, a tax hike enacted as a response to a rise in output (i.e., an endogenous and countercyclical tax change) would wrongly imply a smaller contractionary effect of output in response to a tax increase.

3. *The size of the tax multiplier differs significantly depending on the nature of the exogenous tax change.* We find that the effect of each type of exogenous tax changes on output varies greatly. As in RR, we find that the tax multiplier associated with long-run motivated tax changes is more negative than that driven by inherited fiscal factors. For this reason, RR cautiously suggest that “tax increases to reduce an inherited deficit may be less costly than other tax increases” (page 787). Even more puzzling, *within* the category of tax changes motivated by fiscal factors, we find that while inherited deficit-driven tax multipliers are essentially zero (like in RR’s inherited deficit-driven motivated changes), tax changes driven by inherited debt problems are quite contractionary.
4. *Non-linear effect of tax changes on output.* We show that the differences in size of tax multipliers just described (even for those identified by RR) can be explained by allowing tax changes to have a non-linear effect on output. In a recent theoretical paper, Jaimovich and Rebelo (2016) show theoretically that the output effect of tax changes is small at low initial levels of taxation but exponentially larger when initial tax levels are high. The reason is that the distortion imposed by taxation on economic activity is directly related to the level of tax rates. By the same token, for a given level of initial tax rates, larger changes in taxes have a larger effect on output.

The paper proceeds as follows. Section 2 outlines the conceptual framework that motivates our narrative analysis, which closely follows that of RR. Unlike RR, however, we highlight the critical role of procyclical/countercyclical fiscal policy in determining the sign of the bias of the estimator of the effects of tax changes on output. Section 3 discusses our sample and sources of data. Section 4 proceeds to identify the motivation behind all tax changes in our sample. We, first, discuss some general considerations and then classify all tax changes in our sample into endogenous and exogenous and, within each category, to various subcategories that will prove critical for the remainder of the analysis. We, then, turn to the econometric analysis. Section 5 first introduces our basic linear specification and then discusses our basic

results and the biases introduced by misidentification. Section 6 examines the output effects of different exogenous changes in tax rates. We find that the size of different tax multipliers varies greatly. Section 7 explains the results of Section 6 based on non-linear arguments. Section 8 provides some final thoughts.

2 Conceptual framework

This section outlines the conceptual framework that motivates our narrative analysis, which closely follows that of RR. Unlike RR, however, we highlight the critical role of procyclical/countercyclical fiscal policy in determining the sign of the bias of the estimator of the effects of tax changes on output. We first lay out the basic set-up and then illustrate the possible biases.

2.1 Basic set-up

To fix ideas, let us use the simplest specification capturing how tax changes affect real GDP:

$$\Delta y_t = \alpha + \beta \Delta t_t^{all} + \varepsilon_t, \quad (1)$$

where y_t is the logarithm of real GDP (and Δy_t is thus the real GDP growth rate, expressed as the difference in logarithms), Δt_t^{all} represents all legislated tax rate changes expressed in percentage points, and ε_t is the stochastic error, with zero mean and variance σ_ε^2 . Tax changes can be broken down into two types:

$$\Delta t_t^{all} = \Delta t_t^{exog} + \Delta t_t^{endog}, \quad (2)$$

where Δt_t^{endog} (*endog* stands for endogenous) are changes in tax rates enacted as a result of (i) current or forecasted output growth differing from normal and/or (ii) other factors likely to affect output growth in the near future. In contrast, Δt_t^{exog} (where *exog* stands for exogenous) captures changes in taxes driven by reasons unrelated to developments likely to affect output in the near term. Therefore, while Δt_t^{exog} are orthogonal to ε_t (i.e., $cov(\Delta t_t^{exog}, \varepsilon_t) = 0$), Δt_t^{endog} are not (i.e., $cov(\Delta t_t^{endog}, \varepsilon_t) \neq 0$). As indicated by RR, examples of exogenous tax changes would be a cut in taxes (i) based on the belief that lower marginal rates will increase long-run growth or (ii) with the hope that lower revenues will eventually shrink the size of the government.

Let us now focus on endogenous tax changes. Without loss of generality, we can write Δt_t^{endog} as

$$\Delta t_t^{endog} = \gamma \varepsilon_t, \quad (3)$$

where $\gamma \leq 0$ captures how endogenous tax changes respond to output shocks caused by factors other than taxes such as government spending, monetary policy, and terms of trade shocks, among many others. For example, suppose that a negative terms of trade shock reduces output (i.e., $\varepsilon_t < 0$), policymakers may decide to reduce taxes to fight off such a recession (i.e., $\gamma > 0$), or they may be “forced” (due to the ensuing fall in fiscal revenues) to increase taxes (i.e., $\gamma < 0$).⁸ More generally, countercyclical tax policies (aimed at smoothing out the business cycle) imply $\gamma > 0$, procyclical tax policies (which in principle tend to amplify output volatility) are captured by $\gamma < 0$, and acyclical tax policies (reflecting, on average, a non-systematic reaction of taxes to cyclical fluctuations) would imply $\gamma = 0$.

2.2 Biases in tax multipliers

Using equations (1)-(3), it is straightforward to show that there would be no bias if we only used exogenous tax changes to estimate (1). Formally, if we used Δt_t^{exog} (and not Δt_t^{endog}) to identify tax changes in expression (2), the bias associated with the OLS coefficient $\widehat{\beta}^{exog}$ (where $\widehat{\beta}^{exog}$ refers to the estimator for β in regression (1) when solely using Δt_t^{exog}) would be given by

$$Bias\ of\ \widehat{\beta}^{exog} \equiv E\left[\widehat{\beta}^{exog}\right] - \beta = \frac{cov(\Delta t_t^{exog}, \varepsilon_t)}{var(\Delta t_t^{exog})} = 0. \quad (4)$$

In contrast, if we used both Δt_t^{exog} and Δt_t^{endog} to identify tax changes as captured in expression (2), it is easy to show that the sign of the bias would critically depend on the sign of γ :

$$Bias\ of\ \widehat{\beta} \equiv E\left[\widehat{\beta}\right] - \beta = \frac{cov(\Delta t_t^{all}, \varepsilon_t)}{var(\Delta t_t^{all})} = \gamma \frac{\sigma_\varepsilon^2}{var(\Delta t_t^{all})}. \quad (5)$$

What would happen if $\gamma < 0$? Recall that $\gamma < 0$ implies that endogenous tax changes are procyclical. Then, $Bias\ of\ \widehat{\beta} < 0$, or $E\left[\widehat{\beta}\right] < \beta$. To fix ideas, suppose that $\beta < 0$ (indicating that higher taxes reduce output), then $E\left[\widehat{\beta}\right]$ would be more negative. Why would that be the case? The reason is that the procyclical nature of endogenous tax rates (which are wrongly

⁸We should note that these endogenous tax changes are triggered by lower cyclical tax revenues and thus are not the result of inherited fiscal problems. This important distinction will be discussed in detail in Section 4.

included in the set of tax changes used to estimate the effect of tax changes on output) implies that a tax hike enacted in response to a fall in tax revenues triggered by a fall in output would be (wrongly) taken as evidence of a larger contractionary effect of output due to an increase in taxes.

What if $\gamma > 0$? When $\gamma > 0$, endogenous tax changes are countercyclical. Hence, *Bias of $\widehat{\beta} > 0$* , or $E[\widehat{\beta}] > \beta$. Suppose that $\beta < 0$; then $E[\widehat{\beta}]$ would be less negative (or even positive). Intuitively, the wrong inclusion of countercyclical tax changes (i.e., increases in taxes during good times or reduction in taxes in bad times) would lead to an underestimation of the true effect of tax changes on output. Only in the case in which $\gamma = 0$ (reflecting, on average, a non-systematic response of taxes to output fluctuations) would there be no bias.

3 Narrative analysis: Sample and sources

As the conceptual framework makes clear, we need to identify the motivation behind each tax change (i.e., whether it was exogenous to the business cycle or not). To this effect, we first need to identify the size and timing of legislated tax changes, in terms of both their announcement and implementation. As in RR, we proxy the announcement of tax rate changes by the time of the approval of the corresponding tax law. This section first discusses our sample and sources of data and then proceeds to identify the motivation behind all tax changes in our sample.

3.1 Sample

Our sample comprises 51 countries (21 industrial and 30 developing) for the period 1970-2014. Given the lack of readily-available data on average marginal individual and/or corporate income tax rates on a global scale, we focus our efforts on building a new series for quarterly standard value-added tax rates (VAT rate henceforth), building on Vegh and Vuletin (2015) and Riera-Crichton, Vegh, and Vuletin (2016).⁹ We believe that this significant effort in collecting value-added tax rates is crucial for any study analyzing tax policy in the developing world as well as Europe, where indirect/value-added taxation is one of the main tax revenue

⁹Vegh and Vuletin (2015) build a novel annual dataset on tax rates for 62 countries for the period 1960-2013 that comprises corporate income, highest personal income, and standard VAT rates. Riera-Crichton, Vegh, and Vuletin (2016) build a new quarterly standard VAT rate series for 14 industrial countries for the period 1980-2009.

instrument.¹⁰

Due to data availability, we use the standard VAT rate to proxy for overall VAT policy. Such an approach could, in principle, raised concerns due to the omission, for some countries, of reduced value-added tax rates and/or exempted goods, as well as possible changes over time in the goods covered by the different rates. While data limitations prevent us from assessing the practical relevance of this concern for our whole sample of 51 countries, Vegh and Vuletin (2015) show for a subset of 9 industrial countries that these concerns are not warranted. First, the standard rate typically applies to most goods while (if at all) a single or multiple reduced tax rate(s) typically apply to a small subset of particular goods, including some food categories and child and elderly care. In fact, the average share of transactions covered by the standard VAT rate is about 75 percent of the total tax base. Second, the standard and average reduced VAT rates tend to be highly and positively correlated over time. In 80 percent of the countries, this correlation is larger than 0.5 and statistically significant at the one percent level. Third, the share of transactions covered by different statutory tax rates do not vary much over time in any given country. As a result, the standard VAT rate explains about 85 percent of the observed variability of the effective VAT rate (computed as the average of the different VAT rates weighted by their share in transactions as a percentage of taxable base).¹¹

3.2 Sources

The VAT rates were obtained from various primary sources, including countries' revenue agencies and national libraries, books, newspapers, tax law experts, and research and policy papers. In most cases, we were able to gather the complete time series of the VAT rate (i.e., since its introduction). However, since our study focuses on the output implication of tax changes, we only used those tax changes for which we have real GDP data collected on a quarterly basis (as opposed to interpolated based on annual data). As discussed in detail in Ilzetzki, Mendoza, and Vegh (2013), relying on quarterly interpolated data creates serious measurement error problems. The coverage, which varies across countries, varies from as early as 1970:Q1 to as late as 2014:Q4 (see column 1 in Table 1 for country specific coverage).

¹⁰Indirect (value-added) taxes represent, on average, 43 (28) percent of total tax revenues in industrial countries and 47 (32) percent in the developing world.

¹¹While the use of standard VAT rates is a good proxy for overall VAT tax policy, our narrative analysis will take into account the fact that, in some cases, changes in the standard VAT rate are intended to compensate for changes in the VAT base and/or VAT reduced rates.

As sources for the narrative analysis, we use contemporaneous International Monetary Fund (IMF) documents, OECD Economic Surveys, and news articles to gather evidence on policymakers' intentions and primary motivations for VAT rate changes. IMF documents include annual Staff Reports and Background Material for Annual Article IV Consultations, as well as additional IMF country reports and publications including Recent Economic Developments, Selected Issues, and Public Information Notices. IMF documents published prior to 1997 are available in digitalized hard copy at the IMF Archives in Washington, DC whereas documents from 1997 and onward are available on the IMF website. News articles were obtained from global media including BBC, Bloomberg News, EU Business, Financial Times, International Herald Tribune, Los Angeles Times, New York Times, Reuters, The Daily Mirror, The Daily Telegraph, The Guardian, The Independent, The Times, Wall Street Journal, and Xinhua News Agency as well as from individual countries' media outlets such as Mmegi (Botswana), National Post (Canada), The Globe and Mail (Canada), Prague Daily Monitor (Czech Republic), Intellinews-Czech Republic Today (Czech Republic), Irish Times (Ireland), The Belfast News Letter (Ireland), Sunday Business Post-Cork (Ireland), Baltic News Service (Latvia), The Southland Times (New Zealand), Sunday Star-Times (New Zealand), and El Pais (Spain).

4 Tax changes: Identifying motivation

This section carries out the actual identification of tax changes. We first discuss some general considerations and then classify all tax changes in our sample into endogenous and exogenous and, within each category, to various subcategories that will prove critical for the remainder of the analysis.

4.1 Identification strategy

We identify a total of 96 VAT rate changes in 35 countries (17 developing and 18 industrial). Given the time coverage for these 35 countries, there is, on average, a VAT rate change every 11 years with an average change (measured by the VAT rate change in absolute value terms) of 1.9 percentage points. The remaining 16 countries in our sample of 51 countries show no VAT rate change. Out of those 96 VAT rate changes, 60 occurred in industrial countries and 36 in developing ones.

As discussed in Section 2, and following the RR identification strategy, we separate VAT

rate changes into those taken as a consequence of current or forecasted output growth differing from normal and/or in response to other factor(s) likely to affect output growth in the near future, which are called *endogenous*, and those taken for other reasons, which are called *exogenous*. Table 1 summarizes the classification of each of the 96 tax changes according to the classification scheme described below. A thorough analysis of each tax rate change, including the list of key country-specific references is described in great detail in the Online Appendix.¹² When applying the criteria – and as discussed by RR – we typically found that there is substantial agreement across various sources on the nature of the tax change. When various motives come into the picture, we try to ascertain if one is given more weight than the others. The remainder of this section describes in great detail the nature of each classification category and discusses some illustrative examples. Table 1 characterizes each and every change in tax rate identified in this study according to the classification described below.

INSERT TABLE 1 HERE

INSERT FIGURE 1 HERE

4.2 Endogenous tax changes

As illustrated in Figure 1, we classify endogenous tax changes into two categories: (i) GDP-driven tax changes and (ii) offsetting tax changes.

- GDP-driven tax changes are changes in tax rates enacted by policymakers in response to deviations of (contemporaneous or prospective) output from trend. Clearly, such changes present a problem of reverse causality since we are trying to quantify the effect of tax changes on output.¹³

In turn, GDP-driven changes may be countercyclical or procyclical:

- Countercyclical tax changes: Tax changes aimed at stabilizing output around trend, which implies either cutting taxes during a recession or increasing taxes during booms. In our sample, the most common countercyclical tax change is a tax cut in response to a current or expected recession with the aim of stimulating

¹²Available at www.guillermovuletin.com.

¹³Of the 33 GDP-driven tax changes in our sample, 17 occurred in industrial countries and 16 in developing ones.

economic activity.¹⁴ A clear example would be Thailand in 1999. After increasing the VAT rate from 7 percent to 10 percent during the Asian crisis in the summer of 1997, Thai authorities attempted to revive domestic demand by reducing the VAT rate back to 7 percent in March 1999. The IMF supported the stimulus package. “The package is an important step in facilitating economic recovery,” said Reza Moghadam, the IMF representative in Thailand at the time.

While less common, there are also cases in our sample in which tax rates were increased to restrain domestic demand and cool off economic activity. An example would be the tax increase implemented in Sweden in 1990 (with the VAT rate increasing from 23.5 to 25 percent) that was intended to relieve pressure from very tight labor markets and wage increases.

- Procyclical tax changes: Tax hikes (cuts) enacted in response to a current or expected recession (boom).¹⁵ The natural question is, of course, why would policymakers pursue a tax policy that would tend to amplify the underlying business cycle? In fact, procyclical tax policy falls under the more general phenomenon of procyclical fiscal policy (which would also include increasing government spending in booms and reducing it in recessions) that has been explored in detail in the literature. The most common explanations for such procyclical fiscal policy have revolved around (i) political economy pressures that induce policymakers to loosen fiscal policy during booms and (ii) limited access to international credit markets in bad times, which forces policymakers to tighten fiscal policy.¹⁶ While procyclical fiscal policies have been most common in developing countries, several Eurozone countries have also pursued such policies more frequently since the global financial crisis of 2008-2009.

The most common procyclical tax change is a tax hike enacted in response to a current (or expected) recession which has dramatically reduced tax revenues. In effect, particularly when large and/or sudden contractions in economic activity are involved, the increase in the fiscal deficit that results from a sharp fall in tax revenues often leads to an unsustainable increase in public debt. In such circum-

¹⁴In line with the findings in Vegh and Vuletin (2015), most countercyclical tax policy is to be found in industrial countries (5 out of 7 countercyclical tax changes in our sample occurred in industrial countries).

¹⁵We identified 26 procyclical tax changes, 12 in industrial countries and 14 in developing ones.

¹⁶See, among others, Gavin and Perotti, 1997; Tornell and Lane, 1999; Kaminsky, Reinhart, and Vegh, 2004; Talvi and Vegh, 2005; Alesina, Campante and Tabellini, 2008; Frankel, Vegh, and Vuletin, 2013; Vegh and Vuletin, 2015; and Avellan and Vuletin, 2015.

stances, it is not uncommon for countries to face a sharp increase in borrowing costs or even lose access to international credit markets altogether, which leaves policymakers with no choice (other than defaulting) but to raise taxes.

In practice, typical examples of procyclical tax changes have taken place as a direct result of a sudden economic crisis, including the increases (i) from 10 percent to 15 percent in Mexico (March 10, 1995) as a consequence of the Tequila crisis, (ii) from 18 percent to 21 percent in Argentina (March 16, 1995) as a consequence of the contagion effects from the Tequila crisis, (iii) from 7 percent to 10 percent in Thailand (August 5, 1997) as a consequence of the Asian financial crisis, (iv) from 10 percent to 12 percent in Ecuador (October 26, 1999) after the 1998-1999 Ecuador economic crisis, as well as (v) several tax hikes in Europe (Czech Republic, Finland, Greece, Hungary, Ireland, Latvia, Lithuania, Portugal, Romania, Spain, and United Kingdom), during the 2008-2010 period, as a result of the global financial crisis.

While less frequent, procyclical tax changes also include tax cuts made during buoyant economic times, when fiscal revenues are higher than normal due to the increase in the tax base (be it income or consumption). In such circumstances, policymakers may be subject to powerful political pressures to reduce taxes. A good example would be the VAT rate cut passed by France (March 1, 2000), when a stronger than expected fiscal position led to a reduction in the VAT rate from 20.6 percent to 19.6 percent.

We should note that, as Figure 1 indicates, procyclical tax changes are much more prevalent than countercyclical ones, with close to 80 percent (or 26 out of 33) of GDP-driven tax changes being procyclical. Moreover, procyclical tax changes are more common in the developing world than in industrial countries: while about 70 percent (or 12 out of 17) of GDP-driven tax changes are procyclical in industrial countries, this figure increases to close to 90 percent (or 14 out of 16) in developing economies.

- Offsetting tax changes are those intended to offset another factor(s) that would likely move output growth away from normal. More specifically, they involve standard VAT rate changes intended to offset the effect of changes in (i) government spending, (ii)

other non-VAT taxes or (iii) the VAT base and/or VAT reduced rates.¹⁷ Since tax changes are, though indirectly, responding to changes in GDP, we have again a problem of reverse causality. As indicated in Figure 1, we identified 19 offsetting changes, 13 in industrial countries and 6 in developing ones. The proportion of offsetting tax changes is roughly the same in industrial and developing countries, with 22 percent (or 13 out of 60) in industrial and 17 percent (or 6 out of 36) in developing countries.

In line with the discussion in RR, contemporaneous IMF, OECD, and news articles often explicitly identify policymakers's intentions in this regard. However, even when that link was not made explicit, it is appropriate to classify these type of changes as endogenous. Specifically, we found the following cases:

- In 4 cases, taxes were raised because government spending was increased. For example, after twelve years of armed conflict in El Salvador that ended in 1992, the new government of President Armando Calderón Sol increased the VAT rate from 10 percent to 13 percent on July 1, 1995 to help finance a “National Reconstruction Plan which will provide for the rehabilitation of damaged infrastructure [during the civil war] and the reintroduction of different segments of society into the economic mainstream,” said Mr. Fernandez, the IMF official at the time. In the same vein, Norway increased the VAT rate from 23 percent to 24 percent on January 1, 2001 to ensure no budgetary implications of an increase in spending on health and education.
- In 11 cases, VAT rates were raised because other non-VAT taxes were reduced. In most cases these VAT hikes were implemented to offset a reduction in labor contribution taxes on employers and personal and corporate taxation aimed at increasing competitiveness and labor supply. For example, on June 18, 1979, the government of recently-elected Prime Minister Margaret Thatcher increased the VAT rate 7 percentage points (from 8 percent to 15 percent) as part of a major tax reform aiming at partially offsetting the impact of large cuts to marginal income tax rates.
- In 4 cases, the VAT rate was reduced because the VAT base was broadened and/or VAT reduced rates were increased or eliminated. For example, on May 1, 2004, the

¹⁷We include possible changes in other non-VAT taxes as well as changes in the VAT base and/or VAT reduced rates because the main tax series used in this study is the standard (as opposed to the effective) VAT rate.

Czech Republic reduced the standard VAT rate from 22 to 19 percent and shifted over 25 percent of the consumption basket of goods and services from the reduced to the standard VAT rate.

4.3 Exogenous tax changes

Following the RR identification strategy, exogenous tax changes are those *not* made in response to (i) current (or expected) output different from normal or (ii) other factors likely to affect output contemporaneously or in the near future. In other words, exogenous tax changes do not present a problem of reverse causality because, according to the historical narrative, they should be uncorrelated with contemporaneous output or output in the near future. Such tax changes would thus be legitimate right-hand variables in a regression of output on tax changes. In fact – and as a check on the accuracy of our historical narrative –, we will show in Section 5 that exogenous tax changes are not Granger-caused by GDP fluctuations. We identified a total of 44 exogenous tax changes, 30 in industrial countries and 14 in developing ones.

Exogenous tax changes are classified in turn into those motivated by long-run growth considerations or enacted in response to inherited fiscal factors:

- Long-run growth. As indicated by RR, this type of tax change responds to the belief that a tax cut will raise output in the long-run by unleashing supply-side forces related to labor, capital, or, more generally, a more efficient use of resources. This tax change is thus aimed at raising long-run growth, as opposed to responding to cyclical output fluctuations.

In total, we find 9 tax changes motivated by long-run growth considerations, representing 20 percent (or 9 out of 44) of exogenous tax changes. For example, Canada’s economy was operating close to potential and performing strongly during the mid 2000s. Yet both in 2006 and 2008, the government reduced the VAT rate 1 percentage point each time to promote long-term growth according to several news articles and IMF’s assessments.

- Inherited fiscal factors. These are tax changes that respond to either (i) fiscal deficits inherited from the past and thus determined by past actions (as opposed to fiscal deficits caused by current or prospective conditions) or (ii) a stock of public debt that is viewed

as unsustainable if current deficits persist.¹⁸ The critical point is that in neither case the change in tax rate responds to the current (or expected) state of the economy but rather to past actions that may have caused a fiscal deficit that is viewed as too large or a stock of public debt that has come to be seen as unsustainable. Such tax changes are thus exogenous to the current state of the business cycle.¹⁹ In general, the motivation for this type of tax changes due to inherited fiscal factors is clear from IMF documents and OECD Economic Surveys. In the rare cases where different sources disagree, we err on the safe side and exclude potentially legitimate observations.

In our sample, a clear example of tax changes motivated by inherited fiscal deficits can be found in Switzerland in 1999, 2001, and 2011, when VAT rates increased from 6.5 to 7.5, from 7.5 to 7.6, and from 7.6 to 8 percent, respectively. After running primary budget surpluses for much of the 1980s, a prolonged period of economic stagnation during 1991-1996 – with average growth rates of only 1 percent of GDP – caused the primary deficit to steadily increase, reaching about 2 percent of GDP in 1997 and remaining at that level in 1998. While low by international standards, the rapid growth in the fiscal deficit during the first half of the 1990s caused concern among the public. In June 1998, voters approved a constitutional amendment requiring the federal government to balance the budget by 2001. Annual deficit ceilings were imposed and an additional, more stringent constitutional amendment was planned for 2001. The VAT tax increases of 1999 and 2001 were thus a response to such legal/constitutional demands. A similar scenario arose in 2011. Despite the economic downturn associated with the global financial crisis, both the federal and general government balances remained in surplus throughout the 2007-2010 period with a general surplus of 0.2 percent of GDP in 2010. In addition, the debt-to-GDP ratio hovered around 55 percent of GDP throughout the period. However, Switzerland struggled to balance the social entitlement programs as the population aged. Voters in 2010 chose to increase the VAT rate from 7.6 percent to 8 percent in order to address deficits in the disability insurance program. According to the IMF Country Report No. 10/140 for the 2010 Article IV Consultation with

¹⁸Since, over the last 60 years, the US has not faced sustainability problems regarding the public debt, RR do not concern themselves with the later case.

¹⁹Occasionally fiscal packages aimed at dealing with inherited fiscal factors include not only tax increases but also cuts in government spending. To this effect, we will include government spending as a control in our empirical specifications. If we also included changes in corporate tax rates and/or the highest personal income tax rate (unfortunately, as discussed before, we do not have the average marginal personal tax rate) results would not be affected. Results are not shown for brevity's sake.

Switzerland, “[r]egarding disability insurance, the temporary increase in VAT will cover its deficit for the next six years.”²⁰ Clearly, all these tax changes responded to what was viewed as a large inherited fiscal deficit rather than to current economic conditions.

Examples of tax changes caused by inherited public debt can be found in Belgium in 1992 and 1996, when the VAT rate increased by 0.5 percentage points each time. According to the IMF Staff Report SM/92/206 for the 1992 Article IV Consultation with Belgium “[i]n the late 1970s and early 1980s, a combination of domestic political developments, attempts to cushion the effects of the oil price shocks, and international recession led to double-digit fiscal deficits (as ratios to GNP) and massive increases in government debt. The general government deficit (excluding net lending) peaked at over 13 percent of GNP in 1981. Despite a steady reduction in the deficit, the debt ratio rose for most of the decade, and general government debt net of short-term financial assets reached 124 percent of GNP in 1988 [...] Policy since the mid-1980s has been guided by the goal of first stabilizing and then reducing the public debt ratio.[...] However, after stabilizing in 1990, it rose once again to 124 percent of GNP in 1991.[...] The agreement reached in December 1991 at Maastricht on economic and monetary union (EMU) among EC countries requires countries proceeding to the third stage of EMU to have general government fiscal deficits that do not exceed 3 percent of GDP, unless due to temporary and exceptional circumstances, and general government debt ratios that are at most 60 percent of GDP, or else declining at a satisfactory pace.[...]” The new government (formed in March 1992) decided to increase the VAT rate from 19 to 19.5 percent. These fiscal efforts continued with a subsequent tax hike in 1996, also by 0.5 percentage points.

Other examples of tax changes triggered by inherited public debt are those that took place in Europe (Hungary, Ireland, Italy, Netherlands, Poland, Portugal, and United Kingdom) as a result of debt sustainability concerns, particularly during the 2011-2014 period. Unlike the tax hikes enacted during the early stages of the global financial crisis, which were triggered by large and sudden fall in economic activity, these more recent tax hikes were mainly motivated by debt-sustainability concerns driven by past economic conditions and budgetary decisions, rather than by current developments.

²⁰The VAT tax hike implemented on January 1, 2011 was referred to in the 2010 Article IV Consultation with Switzerland because it was approved by the Swiss government on April 21, 2010.

5 Linear estimations and biases due to misidentification

Having identified and classified all tax changes in our sample, we can now proceed to the econometric analysis. This section first introduces our basic linear specification and then discusses our basic results and the biases introduced by misidentification.

5.1 Basic specification

As has been the norm in the literature, in this section, we estimate the linear effect of tax changes on output. We proceed in steps. First, we estimate the effect of tax rate changes on economic growth using the single-equation approach proposed by Jorda (2005) and Stock and Watson (2007), which is based on linear “local projections” (LP). Second, we derive an expression for the standard tax multiplier as a function of our estimated regression coefficient.

The use of LP provides several advantages over the traditional SVAR methodology pioneered by Blanchard and Perotti (2002). Specifically, LP (i) can be estimated by single-regression techniques (least-squares dummy variables, LDSV, in our case), (ii) are more robust to potential misspecifications, and (iii) can easily accommodate highly non-linear and flexible specifications that may be impractical in a multivariate SVAR context, a feature that will prove crucial later in the paper.

In our basic linear specification, the cumulative response of output growth (in percent changes) at the horizon h is estimated based on the following regression:

$$\Delta y_{i,t+h} = \alpha_{i,h} + \beta_h \Delta t_{i,t+h}^{exog} + \lambda_h(L) \Delta y_{i,t-1} + \psi_h(L) \Delta t_{i,t-1}^{all} + \phi_h(L) \Delta g_{i,t-1} + \eta_{t,h} + \mu_{i,t,h}, \quad (6)$$

where i and t index country and time, respectively, α_i is the country fixed effect, η_t is the time fixed effect, y and g are the logarithm of real GDP and real government spending, respectively (and thus Δy and Δg measure the respective growth rates, expressed as the difference in logarithms), the changes in tax rates (Δt^{exog} and Δt^{all}) are expressed in percentage points, and μ is the error term.^{21,22} Unlike the SVAR specification, the estimated coefficients contained

²¹In all of our regression analysis, we use robust Driscoll and Kraay (1998) standard errors to correct for potential heteroskedasticity, autocorrelation in the lags, and error correlation across panels. Given concerns about the non-normal distribution of tax rate changes (which are zero most of the time) and small sample considerations, standard errors are computed using bootstrap techniques. In particular, standard errors are calculated from the average of 10,000 draws of the coefficient vector from a multivariate normal distribution with mean and variance-covariance matrix equal to the point estimates and variance-covariance matrix of the regression coefficients.

²²Announcements may lead to anticipated effects of tax changes. To control for this possible effect we follow RR and Riera-Crichton, Vegh, and Vuletin (2016) by adding to specification (6) a variable which represents

in the polynomial lags $\lambda_h(L)$, $\psi_h(L)$, and $\phi_h(L)$ are not used directly to build the IRF values but only serve as controls, “cleaning” the β_h from the dynamic effects of output and the effects of past changes in government spending and tax rates.^{23,24} For this reason, the tax rate changes serving as controls include all tax rate changes (i.e., Δt^{all}). In contrast, the tax rate changes used to identify the effect on output have to be exogenous in nature (i.e., Δt^{exog}). It is important to note that, in this LP approach, each step in the accumulated IRF is obtained from a different individual equation. Defining, $\Delta y_{i,t+h}$ and $\Delta t_{i,t+h}$ as the accumulated growth of output and accumulated change in exogenous tax rates from $t - 1$ to time $t + h$ (i.e., $\Delta y_{i,t+h} \equiv y_{i,t+h} - y_{i,t-1}$ and $\Delta t_{i,t+h}^{exog} = t_{i,t+h}^{exog} - t_{i,t-1}^{exog}$), the cumulative IRF values are obtained directly from the β_h estimated coefficients at each time horizon h . Therefore, each coefficient β_h represents the step in the accumulated IRF at a forward time h and reads as the accumulated response of output growth to a one percentage point increase in the accumulated change in tax rates.

While conceptually appropriate, a drawback of using changes in tax rates as the independent variable in equation (6) is that the estimated coefficients β_h do not correspond to the usual tax multiplier discussed in the literature, which measures the effect of a \$1 change in tax revenues on the level of GDP. In other words, the coefficients β_h link the change in GDP to the change in the tax rate and not in tax revenue. The standard multiplier for time horizon h is defined as²⁵

$$\text{Tax multiplier } (h) \equiv \frac{\Delta Y_{i,t+h}}{\Delta R_{i,t+h}}, \quad (7)$$

where Y and R refer to real GDP and real revenues, respectively, and $\Delta Y_{i,t+h} = Y_{i,t+h} - Y_{i,t-1}$ and $R_{i,t+h} = R_{i,t+h} - R_{i,t-1}$. The tax multiplier defined above is computed by exploiting the typical relationship of tax revenues to the tax rate. Let R be real VAT revenue, Y real output, I “implicit” VAT rate (defined as R/Y), and e the average relationship between I and t (i.e., $e \equiv I/t$). Following Barro and Redlick (2011, pp. 80-81), the tax multiplier at

the expected change of the tax rate at the time of the official passage of the law as well as its corresponding lags. Tax multiplier findings do not vary and output does not change to the passage of the law. Results are not shown for brevity.

²³We use four lags (i.e., $L = 4$). The selection of four lags balances the need to account for a sufficiently long structure of lags in order to study the effect of tax changes on output as well as to preserve most of our tax rate changes. Unfortunately, as we move towards longer lag structures, we are forced to drop some data points. Having said that, our results for the case of eight and twelve lags remain almost the same as in the four quarter specification. Figures showing the multipliers for the eight and twelve lag estimations are not shown for the sake of brevity.

²⁴We control for government spending for the reasons discussed in Section 4. However, not doing so would not affect our results.

²⁵No substantial difference in our results arises if the median real deposit rate is used for discounting purposes.

different time horizons h is then computed as²⁶

$$\text{Tax multiplier } (h) = \frac{\beta_h}{e + \beta_h \cdot \bar{I}_h}, \quad (8)$$

where β_h , our estimate of interest in equation (6), represents the cumulative response of the growth rate of output to a one percentage-point shock in taxes. \bar{I}_h measures the average “implicit” VAT rate (i.e., $\bar{I}_h \equiv (\sum_{j=0}^h I_j) / h$).²⁷

Using a first-order approximation of (8), the standard error of the tax multiplier can be written as

$$\text{Tax multiplier}_{SE} (h) = \frac{e}{(e + \beta_h \cdot \bar{I}_h)^2} \beta_h^{SE}, \quad (9)$$

where β_h^{SE} is the standard error of coefficient β_h . We now proceed to use this methodology to estimate the size of the tax multiplier, which will be reported, as is typically in the literature, throughout the paper together with one-standard-error bands.

5.2 Basic results

We now use the tax changes identified in Section 4 to (i) estimate the size of tax multipliers and (ii) assess the biases resulting from misidentification (i.e., when using all tax rate changes and relying on the BP timing assumption for identification purposes).

Using specification (6), Figure 2 shows the estimated tax multipliers at different time horizons when using all legislated tax rate changes (red/grey line) and exogenous legislated tax rate changes (blue/black line).²⁸ As discussed in Section 2, the use of all (as opposed to exogenous) legislated tax rate changes is subject to misidentification.

INSERT FIGURE 2 HERE

²⁶See Appendix 9.2 for the derivation of the next two expressions.

²⁷We use the sample average values of e (39 percent) and the “implicit” VAT rate (6.2 percent) for our tax multiplier calculations. While there is some variation across countries, the variability is fairly small. The standard deviations of e and the “implicit” VAT rate are 8 and 1.8 percent, respectively.

²⁸Jorda’s LP method does not consistently dominate the standard SVAR method for calculating impulse responses of endogenous variables with contemporaneous effects. Since Jorda’s LP does not impose any restrictions linking the impulse responses at h and $h+1$, estimates can display an erratic behavior due to the loss of efficiency. Additionally, as the horizon increases, one loses observations from the end of the sample. Finally, the impulse responses sometimes display oscillations at longer horizons. Comparing Jorda to a standard SVAR and a dynamic simulation, Ramey (2012) finds that the results are qualitatively similar for the first 16 quarters. For longer horizons, however, Jorda’s LP method tends to produce statistically significant oscillations not observed in the other two methods. For these reasons, and to err on the safe side, we report estimates until 8 quarters after fiscal and GDP shocks. Similar results would be obtained if we reported estimates until 12 quarters after fiscal and GDP shocks.

The multiplier using exogenous legislated tax rate changes is consistently and significantly negative indicating that tax hikes reduce economic activity while tax cuts increase it. Specifically, the multiplier is -1.2 ($t = -2.6$) on impact and increases (in absolute value) with longer horizons until reaching -2 ($t = -2.2$) after eight quarters.

What happens when using all legislated tax rate changes? That is to say, when solely relying on the BP identification strategy? The red/grey line in Figure 2 shows that when using all legislated tax rate changes, the tax multiplier obtained is much larger in absolute value (i.e., more negative), particularly in the long-run. Indeed, after eight quarters, the multiplier is -3.7 ($t = -3.9$), which is about twice as large as the one obtained when using only exogenous tax changes.

5.3 Biases due to misidentification

Why is the multiplier using all tax changes larger than that based on properly identified exogenous tax changes? In other words, what is the nature of the bias associated with the misidentification? As discussed in Section 2, the bias arises because of the wrongful inclusion of endogenous – and on average procyclical – tax changes in the set of tax changes used to estimate tax multipliers. Doing so yields the wrong conclusion that tax multipliers are larger than what they truly are. For example, a tax increase enacted as a response to a fall in output (i.e., an endogenous and procyclical tax change) would wrongly imply a larger contractionary effect of output in response to a tax increase (a quintessential problem of reverse causality).

Indeed, Figure 3 shows the impulse response function of tax changes to a shock in GDP. Panel A shows that endogenous tax changes respond, on average, procyclically to GDP shocks. In other words, tax rates increase (decrease) in response to a negative (positive) GDP shock. In sharp contrast, Panel B in Figure 3 indicates that exogenous tax changes do not respond to a GDP shock. This offers, of course, a strong validation of our narrative-based identification strategy because it indicates that exogenous tax changes are indeed unrelated to past output

fluctuations.^{29,30}

INSERT FIGURE 3 HERE

We have thus established that endogenous tax changes are, on average, procyclical. But how about different types of endogenous changes (i.e., GDP-driven versus offsetting?). Figure 4 shows the results for GDP-driven tax changes (Panel A) and offsetting changes (Panel B). Panel A shows that tax changes identified as GDP-driven are, on average, procyclical. On the other hand, Panel B shows that offsetting tax changes (for which we really do not have a prior in terms of how they would react to a GDP shock) react, in fact, little to GDP shocks.³¹ In other words, the procyclical profile illustrated for endogenous tax changes (see Panel A in Figure 3) is driven by the procyclical response of GDP-driven changes (see Panel A in Figure 4) and not by offsetting tax changes (see Panel B in Figure 4). Moreover, Panel C shows that GDP-driven procyclical and countercyclical tax changes (identified based on the narrative approach) are indeed so, which further validates our narrative-based identification.

INSERT FIGURE 4 HERE

5.4 Biases in action I: Industrial versus developing countries

We now illustrate the practical importance of the biases introduced by misidentification considering industrial versus developing countries. The key idea is that, in terms of how taxes respond to cyclical output fluctuations, industrial countries tend to be, on average, acyclical whereas developing countries are typically procyclical. We would thus expect to find a downward bias (i.e., overestimation of the size of the tax multiplier) due to misidentification in developing countries but not in industrial ones. And this is exactly what our estimations will

²⁹As Figure 3 makes clear, we evaluate the effect of a GDP shock on tax rates after one quarter. When focusing on exogenous tax rate changes – and given our identification strategy – it would not be correct to allow a GDP shock to contemporaneously affect the tax rate. This is not the case when focusing on endogenous tax rate shocks which, in principle, could react to contemporaneous developments in economic activity. However, to maintain the symmetry in our analysis (i.e., not to have results depending upon the inclusion or not of the aforementioned lagged reaction), we evaluate the impulse response functions, for both exogenous and endogenous tax rate changes, allowing for a GDP shock to affect tax rates only after a quarter. Similar results, showing an even more pronounced procyclical profile, are observed if we allow a GDP shock to contemporaneously affect endogenous tax rate changes. Results are not shown for brevity's sake.

³⁰The response of exogenous subtypes legislated tax changes (i.e., long-run growth, inherited fiscal factors, as well as inherited deficit- and debt-driven) to a GDP shock taken one-at-a-time also show, like Panel B in Figure 3, a not responding profile. These results further validate our narrative-based identification strategy. Results are not shown for brevity.

³¹Specifically, in the first 3 quarters following a GDP shock, the response is, on average, about a tenth of that observed for GDP-driven changes and, after 3 quarters, the effects vanish.

show.

To conduct this empirical exercise, we split the sample into industrial and developing countries. While countries within each group clearly have different profiles and do not look fiscally alike in every respect, this classification recognizes the fact that countries within each group share more common fiscal attributes with countries within the group than with other countries outside the group. Before presenting estimates of tax multipliers for each group of countries, three points are worth noting. First, as described in Subsection 4.2, qualitatively speaking, industrial countries exhibit, compared to developing countries, (i) less procyclicality in tax policy and (ii) about the same share of offsetting tax changes. Second, Panel A in Figure 5 confirms that industrial and developing countries show remarkable differences regarding the average GDP-driven tax change. While industrial countries (blue/black line) show, on average, an acyclical response of tax changes to GDP shocks, developing countries show a strong procyclical pattern (red/grey line). In contrast – and as one might have expected – both group of countries show that offsetting tax changes are (like in Panel C in Figure 4) quite irresponsive to GDP shocks (see Panel B in Figure 5). Third, like in Panel A in Figure 4, the response of GDP-driven tax changes to GDP shocks in developing countries (red/grey line in Panel A in Figure 5) is more pronounced after four quarters and reaches its maximum after 2 years (i.e., 8 quarters). For this reason, we will evaluate the bias on tax multipliers after two years of the tax shock.

INSERT FIGURE 5 HERE

Figure 6 shows tax multipliers for industrial and developing countries using all (red/light-grey bars) as well as exogenous (blue/grey bars) tax changes. Three important findings follow. First, when properly identified (i.e., based on exogenous tax changes), the tax multipliers obtained in developing (-1.8) and industrial (-2.1) countries are statistically indistinguishable. Second, in the industrial world where endogenous tax changes show, on average, an acyclical pattern, there is no bias resulting from using all tax changes. Indeed, the multipliers are virtually identical (-2.1 versus -2.1). Last –and not surprisingly– the bias resulting from using all tax changes in the developing world is quite large and statistically significant. When properly identified (i.e., based on exogenous tax changes) the tax multiplier is -1.8. In sharp

contrast, when using all tax changes, the multiplier is -5.7.

INSERT FIGURE 6 HERE

5.5 Biases in action II: Explaining RR results for the United States

It is worth noting that our logic for the type of biases introduced by considering endogenous tax changes helps explain some of the key results of RR for the United States. In effect, let us consider Figure 7, taken from RR, which shows that the sign of the bias introduced by using all tax changes (dashed line) vis-a-vis exogenous tax changes (solid line) is the opposite of that of Figure 2. That is to say, misidentification relying on the use of all tax changes as a measure of a tax shock would lead, for the U.S., to an *underestimation* of the true tax multiplier. Why? Because endogenous tax changes in the United States are, following RR classification, strongly countercyclical. In fact, RR (i) identify no procyclical tax change, (ii) about one third of all tax changes (or 30 out of 84) are endogenous, and (iii) 37 percent of those endogenous changes (or 11 out of 30) are countercyclical in nature (the rest are offsetting type of tax changes).

INSERT FIGURE 7 HERE

6 Differential effects on output of exogenous tax changes

This section examines the output effects of different exogenous changes in tax rates.

6.1 Long-run growth versus inherited fiscal factors

Figure 8 shows the effects of tax rate changes motivated by long-run growth (Panel A) and inherited fiscal factors (Panel B), which includes both deficit- and debt-driven tax changes. Panel A in Figure 8 shows that the output effect of tax changes motivated by long-run growth is small in the very short-run, but increases rapidly (in absolute terms) and reaches -5.3 ($t = -1.8$) after two years. In contrast, Panel B shows that tax changes motivated by inherited fiscal factors have a smaller effect on output, reaching just -1.2 ($t = -1.3$) after 2 years. In other words, and as shown by the first two bars in Figure 9, tax changes motivated by long-run growth trigger, especially in the medium- and long-run, a much larger effect (in

absolute terms) on output than those driven by inherited fiscal factors.

INSERT FIGURE 8 HERE

INSERT FIGURE 9 HERE

A similar difference is identified by RR when comparing long-run growth and deficit-driven tax changes (recall that, given the nature of tax changes in the U.S., RR do not include in their classification of tax changes what we call inherited debt-driven tax changes). Figure 10 shows the findings by RR. While changes motivated by long-run growth motives have a negative effect on output (see Panel A), especially in the medium- and long-run, deficit-driven tax changes point estimates are consistently positive, yet statistically insignificant (see Panel B).

INSERT FIGURE 10 HERE

6.2 Deficit-driven versus debt-driven

We now focus our attention on possible differential output effects within the category of inherited fiscal factors. Panels A and B in Figure 11 show tax multipliers resulting from deficit- and debt-driven tax changes, respectively.

INSERT FIGURE 11 HERE

Interestingly, Panel A in Figure 11 shows that inherited deficit-driven tax multipliers are, like in RR's inherited deficit-driven motivated changes (see Panel A in Figure 10), essentially zero (see also third bar in Figure 9). In contrast, tax changes motivated by inherited debt-driven changes are clearly negative (Panel B in Figure 11). In particular, the multiplier is -1.4 ($t = -1.1$) after 2 years (see also fourth bar in Figure 9). In other words, the negative tax multiplier estimate associated with inherited fiscal factors (see Panel B in Figure 8) is driven by the negative response of output to inherited debt-driven tax changes (see Panel B in Figure 11) and not by the zero multiplier associated with inherited deficit-driven tax changes (see Panel A in Figure 11).

6.3 Why?

The differences observed in the size of tax multipliers depending on the source of exogenous tax variation naturally raises the question of why would this be the case. Specifically, why are tax multipliers larger (in absolute terms) in response to changes motivated by long-run growth considerations than in response to changes motivated by fiscal factors? And why do tax changes motivated by fiscal deficits have no effect on output while tax changes motivated by debt considerations reduce output?

A possible explanation is, of course, that the mechanism involved in each case is different. In other words, a tax reduction motivated by a desire to reduce the overall tax burden and thus increase long-term growth may operate through wealth effects arising from non-Ricardian channels, whereas a tax increase motivated by closing an inherited fiscal gap may operate through short-term aggregate demand effects. While not obvious, some plausible theoretical argument might also explain a zero response to a tax increase associated with inherited deficit-driven tax hike and a negative effect in output in response to a debt-driven tax increase. While, in principle, we cannot rule out such considerations, we show in the next section that this need not be the case and that a simpler explanation could simply rely on non-linear effects of tax rates on output.³²

7 The non-linear effect of tax changes on output

In a recent theoretical paper, Jaimovich and Rebelo (2016) (thereafter JR) show that the effect of taxation on output is highly non-linear. In particular, the authors show theoretically that while under low or moderate initial tax rate levels the impact of tax changes is very small on long-run economic activity, the impact increases in a non-linear way as the initial level of tax rate rises. This occurs because the distortion imposed by taxation on economic activity is increasing with the level of tax rates. By the same token, for a given level of the initial tax rate, larger changes in taxes have larger effects on output.

³² Another possibility is that the macroeconomic environment associated with different tax changes varies across different type of tax changes which, in turn, could affect the size of the multiplier. While it proves impossible to consider all possible factors, recent empirical findings show that spending multipliers tend to be larger under fixed exchange rate regimes (Ilzetzki, Mendoza, and Vegh, 2013) and under low debt (Ilzetzki, Mendoza, and Vegh, 2013; Huidrom, Kose, and Ohnsorge, 2016). However, these types of arguments do not seem to be at work in our case since we cannot reject the null hypothesis that the prevalence of fixed exchange rate regimes in both long-run growth and inherited fiscal factors is the same (67 percent in both cases) and that public debt over GDP is, statistically speaking, also the same (59 and 57 percent in fiscal driven tax changes and long-run growth driven ones, respectively).

Motivated by such theoretical arguments, we now proceed to explain the differential effects found in the previous section based on the non-linear effects of tax rates on output. First, Subsections 7.1, 7.2, and 7.3 evaluate how the effect of tax rate changes on output depend upon the initial level of tax rate as well as on the size of of tax rate changes. Second, Subsection 7.4 shows that these non-linear empirical findings, indeed, help explain the differences in tax multipliers (based on linear estimations) identified in Section 6. Last, but certainly not least, Subsection 9.3 shows that the same non-linear arguments are present and also help explain the effect of different type of exogenous tax changes when using RR's sample.

7.1 Multipliers for different levels of initial tax rates

We will first evaluate how the effect of tax rate changes on output depends upon the initial level of the tax rate. For this purpose, we modify our linear specification (6) as follows:

$$\begin{aligned} \Delta y_{i,t+h} = & \alpha_{i,h} + \beta_h \Delta t_{i,t+h}^{exog} + \delta_h \left[\Delta t_{i,t+h}^{exog} \cdot t_{i,t-1}^{all} \right] + \gamma_h t_{i,t-1}^{all} + \\ & + \psi_h(L) \Delta t_{i,t-1}^{all} + \lambda_h(L) \Delta y_{i,t-1} + \phi_h(L) \Delta g_{i,t-1} + \eta_{t,h} + \mu_{i,t,h}, \end{aligned} \quad (10)$$

where the only difference is the introduction of the initial tax rate level (measured as the level of the pre-tax tax rate change) interacting with the changes in the tax rate (and naturally the inclusion of the term associated with the initial tax rate for control purposes).³³

Panel A in Figure 12 shows the estimated tax multipliers after two years, evaluated at different initial levels of tax rates. The red (grey) line shows a clear non-linear effect of tax changes on output depending on the initial level of the tax rate. While the multiplier is virtually zero at low/moderate levels of initial tax rates (i.e., for initial tax rate levels lower than 15 percent), it decreases markedly and becomes negative as the initial tax rate increases. In other words, the fall (increase) of output associated with increasing (reducing) revenues by \$1 tends to be zero for low levels of initial tax rates and increases as the initial tax rate increases. For example, multipliers reach -4.7 ($t = -2.4$) when starting at 25 percent level of the initial tax rate. For comparison purposes, we also report (see blue (black) line in Figure 12) the tax multiplier obtained based on the linear specification (6) (which takes a value of -2 ($t = -2.2$)). The multiplier based on our linear specification implicitly gives us a sort of

³³In this non-linear specification, the tax multiplier defined in expression (8) becomes *Tax multiplier* (h) = $[\omega_h] / [e + \omega_h \cdot \bar{I}_h]$, where $\omega_h \equiv \beta_h + \delta_h \cdot t^{all*}$ and t^{all*} represents the initial tax rate level at which the multiplier is evaluated. Similarly, the standard error of the tax multiplier defined in expression (9) becomes *Tax multiplier*_{SE} (h) = $[e \cdot \omega_h^{SE}] / [(e + \omega_h \cdot \bar{I}_h)^2]$, where ω_h^{SE} is the standard error of expression ω_h .

“weighted average” multiplier of those depending on alternative initial tax rates.

INSERT FIGURE 12 HERE

This evidence strongly supports JR’s arguments regarding a non-linear effect of tax rate changes on economic activity in the long-run, with negligible effects under relatively low/moderate initial tax rate levels and much larger effects as the initial level of tax rates increases. The policy implications of this non-linear dimension are clearly important. While countries in need of higher tax rates might be able to do so without hurting economic activity too much when starting at low/moderate levels of tax rates, the economy will inevitably suffer when taxes are increased at higher initial tax rate levels. By the same token, reductions in tax rates will increase output considerably only when starting with high initial tax rate levels (i.e., there will be no output benefits of cutting taxes when tax rates are low to begin with).

7.2 Multipliers for tax rate changes of different sizes

We now focus our attention on non-linear effects based on the *size* of tax rate changes (as opposed to the initial level of tax rates). The idea is to evaluate whether the tax multiplier associated with larger tax changes is larger (in absolute value). For starters, we analyze this non-linear dimension without considering the one associated with the initial level effect. In the following subsection, we will combine both non-linear arguments. For this purpose, we modify our linear specification (6) as follows:

$$\begin{aligned} \Delta y_{i,t+h} = & \alpha_{i,h} + \beta_{1h} \Delta t_{i,t+h}^{exog} + \beta_{2h} \left(\Delta t_{i,t+h}^{exog+} \right)^2 - \beta_{2h} \left(\Delta t_{i,t+h}^{exog-} \right)^2 + \beta_{3h} \left(\Delta t_{i,t+h}^{exog} \right)^3 + \\ & + \psi_h(L) \Delta t_{i,t-1}^{all} + \lambda_h(L) \Delta y_{i,t-1} + \phi_h(L) \Delta g_{i,t-1} + \eta_{t,h} + \mu_{i,t,h}, \end{aligned} \quad (11)$$

where Δt^{exog+} and Δt^{exog-} refer to positive (i.e., increases) and negative (i.e., reductions) exogenous tax changes, respectively. Unlike linear specification (6) and non-linear specification (10), specification (11) includes non-linear terms of the tax changes themselves.³⁴ In

³⁴In specification (10), the non-linear effect of tax changes is the result of interacting tax changes with the initial level of tax rate. Tax changes themselves (i.e., term $\beta_1 \Delta t^{exog}$) as well as tax changes interacting with the initial level of the tax rate (i.e., term $\delta [\Delta t^{exog} \cdot t^{all}]$) both entered in a linear way.

particular, we include quadratic and cube terms.^{35,36} Raising *tax changes* to the power of an even number (quadratic in our case) combined with the fact that some tax changes are positive while others are negative, poses a specification challenge that was not present in specifications (6) or (10). Since raising any tax change (either positive or negative change) to the power of two always delivers a positive number, any proposed specification should differentiate increases in tax changes from reductions. Not doing so would imply, in terms of this quadratic term, that both increases and reductions in tax changes have the same effect on output. This is naturally not a concern when focusing on the linear term associated with the tax change (i.e., $\beta_1 \Delta t^{exog}$) or when raising tax changes to the power of an odd number (e.g., $\beta_3 (\Delta t^{exog})^3$). In these cases, the sign of the tax change would be maintained. Obviously, this would not be an issue either if the empirical specification under consideration dealt with the non-linear effect of a variable expressed in levels (as opposed to its change). To deal with this issue in a manner that allows us to use the entire set of exogenous tax changes, specification (11) constrains the quadratic coefficient associated with $\Delta t^{exog -}$ to be that of $\Delta t^{exog +}$ with the opposite sign.^{37,38}

Panel B in Figure 12 shows the estimated tax multipliers using specification (11) after two years, evaluated at different values of the tax rate change; see red (grey) line. The profile depicted shows that, indeed, the size of tax multipliers varies depending on the size of the tax change. While the multiplier is zero when low/moderate tax changes are involved (in particular when lower than a 1 percentage point), it decreases and becomes negative as the

³⁵Since theory does not point to a specific non-linear form, nested models tests (using F-tests) support the selection of a cubed specification. Comparing linear (i.e., restricted) and squared (i.e., unrestricted) models, both offer the same predicting power at all time (in our case h) horizons. While a cubed specification is more powerful than a squared or linear one at most time horizons, adding a term of exogenous tax changes to the fourth power does not yield additional power (particularly after a year of the tax shock). Hence, for parsimonious considerations, a cubed specification is used. Similar tax multipliers are obtained if one also includes terms to the fourth power. Results are not shown for the sake of brevity.

³⁶In this non-linear specification, the tax multiplier defined in expression (8) is now modified for *Tax multiplier* (h) = $[\nu_h] / [e + \nu_h \cdot \bar{I}_h]$, where $\nu_h \equiv \beta_{1_h} + \beta_{2_h} \cdot \Delta t^{exog * } + \beta_{3_h} (\Delta t^{exog * })^2$ and $\Delta t^{exog * }$ represents the change in the tax rate (expressed positively for convenience) at which the multiplier is evaluated. Similarly, the standard error of the tax multiplier defined in expression (9) is now modified for *Tax multiplier_{SE}* (h) = $[e \cdot \nu_h^{SE}] / [(e + \nu_h \cdot \bar{I}_h)^2]$, where ν_h^{SE} is the standard error of expression ν_h .

³⁷If we allowed the quadratic coefficient associated with $\Delta t^{exog -}$ to differ from that associated with $\Delta t^{exog +}$, we could not reject the null hypothesis that both coefficients are statistically the same (but with different signs) at any horizon level. If we allowed all coefficients (linear, quadratic, and cubed) associated with $\Delta t^{exog -}$ to differ from those associated with $\Delta t^{exog +}$, we could not reject the null hypothesis that all coefficients associated with positive and negative changes are statistically the same at any horizon level (in the case of the linear and cubed coefficients with the same sign and in the case of the quadratic coefficients with opposite signs). Results are not shown for the sake of brevity.

³⁸Similar results would obtain if the quadratic terms were excluded from specification (11). Results are not shown for the sake of brevity.

size of the tax change increases. In other words, the fall (increase) of output associated with increasing (reducing) revenues by \$1 tends to be zero when small tax changes are involved and increases with the size of the tax change. This evidence also strongly supports JR's non-linear arguments in that small changes in tax rates have no effects on output while larger changes seem to have a larger effect on output. This non-linear dimension has important implications when dealing, for example, with growing fiscal problems. Based on these findings, it would be advisable to solve fiscal problems when they start developing (i.e., when they can still be addressed by making small increases in tax rates) as opposed to postponing fiscal adjustments which, in turn, will eventually require larger changes in tax rates.

7.3 Multipliers for different initials levels of tax rates and size of tax changes

We now consider both non-linear arguments; that is to say, the initial tax rate level and the size of tax rate changes. Figure 13 shows that, conveniently for identification purposes, there is no systematic relation between these two dimensions. In other words, the initial tax rate level does not condition, on average, the size of tax rates changes.

INSERT FIGURE 13 HERE

To evaluate the join effect, we modify our linear specification (6) to include the considerations present in specifications (10) and (11):

$$\begin{aligned}
\Delta y_{i,t+h} = & \alpha_{i,h} + \beta_{1h} \Delta t_{i,t+h}^{exog} + \beta_{2h} \left(\Delta t_{i,t+h}^{exog+} \right)^2 - \beta_{2h} \left(\Delta t_{i,t+h}^{exog-} \right)^2 + \\
& + \beta_{3h} \left(\Delta t_{i,t+h}^{exog} \right)^3 + \delta_{1h} \left[\Delta t_{i,t+h}^{exog} \cdot t_{i,t-1}^{all} \right] + \delta_{2h} \left[\left(\Delta t_{i,t+h}^{exog+} \right)^2 \cdot t_{i,t-1}^{all} \right] + \\
& - \delta_{2h} \left[\left(\Delta t_{i,t+h}^{exog-} \right)^2 \cdot t_{i,t-1}^{all} \right] + \delta_{3h} \left[\left(\Delta t_{i,t+h}^{exog} \right)^3 \cdot t_{i,t-1}^{all} \right] + \gamma_h t_{i,t-1}^{all} \\
& + \psi_h(L) \Delta t_{i,t-1}^{all} + \lambda_h(L) \Delta y_{i,t-1} + \phi_h(L) \Delta g_{i,t-1} + \eta_{t,h} + \mu_{i,t,h}. \tag{12}
\end{aligned}$$

Figure 14 shows the estimated tax multipliers after two years, evaluated at alternatives initial tax rate levels and tax changes.³⁹ The results clearly support our previous findings. We can

³⁹In this non-linear specification, the tax multiplier defined in expression (8) becomes *Tax multiplier* (h) = $[\varphi_h] / [e + \varphi_h \cdot \bar{T}_h]$, where $\varphi_h \equiv \beta_{1h} + \beta_{2h} \cdot \Delta t^{exog*} + \beta_{3h} (\Delta t^{exog*})^2 + \delta_{1h} \cdot t^{all*} + \delta_{2h} [(\Delta t^{exog*})^2 \cdot t^{all*}] + \delta_{3h} [(\Delta t^{exog*})^3 \cdot t^{all*}]$ and Δt^{exog*} and t^{all*} represent the change in the tax rate (expressed positively for convenience) and initial tax rate level, respectively, at which the multiplier is evaluated. Similarly, the standard er-

see that the most negative multipliers occur for high levels of both the initial tax rate and of the size of the tax rate change. In other words, the fall (increase) of output associated with increasing (reducing) revenues by \$1 tends to be zero for low levels of initial tax rates and when small tax changes are involved and increases as the initial tax rate and the size of changes increases. Hence, the evidence shows that the output effects of tax increases is, as theoretically shown by JR, highly non-linear.

INSERT FIGURE 14 HERE

7.4 Can non-linear arguments explain the effects of different exogenous tax changes?

So far, Subsections 7.1, 7.2, and 7.3 show that, indeed, the non-linear effect of tax changes on output matters a great deal when determining the size of the tax multiplier. But do the differences in the initial levels of tax rates and/or the respective size of the changes in taxes across different types of exogenous tax changes help explain some of the differences in tax multipliers (based on linear estimations) identified in Section 6? Answering this question is the main focus of this subsection.

To answer this question, we analyze whether the different initial tax rate and/or size of tax changes observed across different exogenous tax changes can explain the differences observed across exogenous tax multipliers in Section 6. Table 2 shows that, indeed, this seems to be the case. Panel A shows that long-run growth tax changes typically have initial VAT rates that are higher than those observed for inherited fiscal factors. The same is not true for the size of the tax change, which are very similar. Panel B shows that inherited deficit- and debt-driven tax changes typically share similar initial tax rate levels, yet the size of the median tax change is two times larger for debt-driven tax changes than for deficit-driven ones. This last finding should not come as a surprise since debt motivated changes are driven by fiscal sustainability and debt stock considerations requiring larger fiscal efforts than deficit-driven changes, which are solely motivated by fiscal flow shortcomings.

INSERT TABLE 2 HERE

ror of the tax multiplier defined in expression (9) becomes $Tax\ multiplier_{SE}(h) = [e \cdot \varphi_h^{SE}] / [(e + \varphi_h \cdot \bar{I}_h)^2]$, where φ_h^{SE} is the standard error of expression φ_h .

The above mentioned differences in the initial tax rate and/or size of tax changes observed across different exogenous tax changes suggest that the reason why, for example, long-run growth driven tax multipliers are larger (in absolute value) than those driven by inherited fiscal factors is the fact that that, typically, long-run growth driven changes have higher initial tax rates. By the same token, the debt-driven tax multiplier may be larger than that of deficit-driven tax changes because the size of their changes tends to be larger in the first group.

Moreover, Figure 15 further supports that these non-linear arguments are actually at work because the median value of tax multipliers calculated for each tax change under different type of exogenous tax change (based on non-linear specification (12)) matches quite well that of the multiplier estimated in a linear fashion in Section 6. In other words, our evidence shows that differences in the initial tax rate and/or size of tax changes observed across different exogenous tax changes coupled with non-linear effects of tax changes on output provide a unifying explanation of the ex-ante “puzzling” differences in tax multipliers observed across types of exogenous tax changes. Appendix 9.3 shows that, when relying on RR’s dataset for the U.S., the same type of non-linear arguments are present and, moreover, that like in this section they can help explain the different response of output to tax changes motivated by long-run growth considerations relative to deficit-driven tax changes.

INSERT FIGURE 15 HERE

8 Final thoughts

This paper has estimated tax multipliers for a large group of countries following the narrative approach. Specifically, based on a novel dataset on VAT rates in 51 countries (20 industrial and 31 developing) and contemporaneous economic records and sources, we have identified 96 tax changes and classified them into endogenous and exogenous to current (or prospective) economic conditions. The analysis has made clear the critical importance of relying on a narrative approach as opposed to the much more common (due its considerable ease of implementation) Blanchard-Perotti approach. In fact, the Blanchard-Perotti approach yields severely-biased estimates for developing countries due to the numerous tax changes that have responded procyclically to the business cycle.

Even when properly identified (i.e., using only tax changes that are not driven by the

current or prospective business cycle), we have shown that the size of tax multipliers critically depends on the motivation behind particular tax changes. Tax multipliers associated with tax changes motivated by long-run growth considerations are much larger (in absolute value) than those associated with changes motivated by inherited fiscal factors. While this difference could, in principle, be due to different underlying mechanisms, we show that non-linearities in the effects of taxation on growth could explain our results on the differential size of tax multipliers. In particular, we show that, for a given tax change, multipliers are, in absolute value, larger (smaller) when the initial level of tax rates is large (small). In the same vein, for a given initial level of tax rates, multipliers are exponentially larger (in absolute value) the larger is the size of the tax change. These findings have important policy implications given that the initial level of taxes varies greatly across countries and thus so will the potential output effects of changing tax rates.

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9 Appendices

9.1 Data definitions and sources

9.1.1 Gross domestic product, government spending, and VAT revenue

We constructed quarterly seasonally-adjusted real measures of gross domestic product, government spending, and VAT revenue using data from Global Financial Data, Data Stream, International Financial Statistics, OECD-FRED, and Eurostat.

9.1.2 VAT rate

See online appendix at www.guillermovuletin.com

9.2 Computation of tax multiplier and standard error

The derivation of equation (8) is as follows. First, let us define $\Delta X_h \equiv X_h - X_0$ and $\bar{X}_h \equiv \left(\sum_{j=0}^h X_j \right) / h$ where the variable X may be Y, R, I, t . Notice that $\Delta Y_h / \Delta R_h = (\Delta Y_h / \bar{Y}_h) / (\Delta R_h / \bar{Y}_h)$. From equation (6), $\Delta Y_h / \bar{Y}_h = \beta_h \Delta t_h$. Therefore, $\Delta Y_h / \Delta R_h = \beta_h \Delta t_h / (\Delta R_h / \bar{Y}_h)$. Since $R \equiv I \cdot Y$, then $\Delta R_h \approx \bar{Y}_h \cdot \Delta I_h + \bar{I}_h \cdot \Delta Y_h$. Further, given that $e \equiv I/t$ is taken as a constant, then $\Delta I_h = e \cdot \Delta t_h$. Hence, $\Delta Y_h / \Delta R_h = \beta_h \Delta t_h / (\Delta I_h + \bar{I}_h \cdot \beta_h \Delta t_h) = \beta_h / (e + \beta_h \cdot \bar{I}_h)$. In our empirical calculations, \bar{I}_h is proxied by the sample average.

The derivation of equation (9) is as follows. From (8), *Tax multiplier* = $f(x)$, where $f(x) = x / (e + \bar{I}_h \cdot x)$. Using a first-order approximation, it follows that *Tax multiplier* (h) = $f(\beta_h) + f'(\beta_h)(x - \beta_h) = f(\beta_h) + f'(\beta_h)x - f'(\beta_h)\beta_h$. Hence, $Var [Tax\ multiplier(h)] = [f'(\beta_h)]^2 Var[x]$. Evaluating $f(x)$ at $x = \beta_h$, $Var [Tax\ multiplier(h)] = [f'(\beta_h)]^2 Var[\beta_h]$. Hence, $Tax\ multiplier_{SE}(h) = f'(\beta_h) \cdot \beta_h^{SE}$. Using (8), it follows that $Tax\ multiplier_{SE}(h) = [e / (e + \beta_h \cdot \bar{I}_h)^2] \cdot \beta_h^{SE}$.

9.3 Can non-linear arguments explain the effects of different exogenous tax changes when using RR's sample?

In Section 7.4, we explained the effects of different exogenous tax changes based on non-linear arguments using our global sample and narrative strategy. This appendix analyses whether the same type of non-linear arguments are present in RR's dataset for the U.S. and the extent to which they can explain the different response of output to tax changes motivated by long-run growth considerations relative to deficit-driven tax changes. In order to maintain the comparability with RR's study, we use their specification and econometric strategy. In particular, RR's basic specification is as follows:

$$\Delta y_t = \alpha + \sum_{i=0}^{12} \beta_i \Delta t_{t-i}^{exog} + \sum_{j=1}^{12} \gamma_j \Delta y_{t-j} + \mu_t, \quad (13)$$

where y is the logarithm of real GDP and thus Δy measures the real GDP growth rate and Δt^{exog} is RR's measure of legislated tax change.

First, we proceed as in Subsections 7.1, 7.2, and 7.3 and evaluate whether the effect of tax changes on output depends upon the initial tax level, size of the tax change, and both arguments jointly, respectively. Using the same type of interaction strategy proposed in specifications (10), (11), and (12), Figures 16 and 17 show similar findings to those obtained before using a global sample of countries.⁴⁰ This evidence further supports that the output

⁴⁰As noted before, and in order to maintain the comparability with RR's study, we do not report the tax multiplier (i.e., the response of output measured in \$ to an increase in revenues of a 1\$). Rather, we directly use the effect coming from the coefficients associated with exogenous legislated tax changes. For this reason, we show the growth effects associated with those legislated tax changes. In order to make the non-linear arguments when including non-linear terms of the tax changes themselves (i.e., Panel B in Figure 16 and Figure 17) comparable when evaluating tax changes of different sizes (e.g., 1 percent versus 2 percent increase)

effects of tax increases is, as theoretically shown by JR, highly non-linear and increases (in absolute value) with the initial tax level and size of the tax change.

INSERT FIGURE A1 HERE

INSERT FIGURE A2 HERE

Second, we analyze whether the differences in the initial tax levels and/or the respective size of the tax changes across long-run and inherited deficit-driven tax changes may help explain the differences in tax multipliers identified by RR and reported in Section 6. Table 3 and Figure 18 are equivalent to Table 2 and Figure 15 from the previous section (i.e., Section 7.4). Table 3 and Figure 18 also support that a key reason why RR's tax changes driven by long-run motivations have a larger (in absolute value) effect on output than that of inherited deficit-driven ones lies on the larger initial tax rate observed for the first group of tax changes.

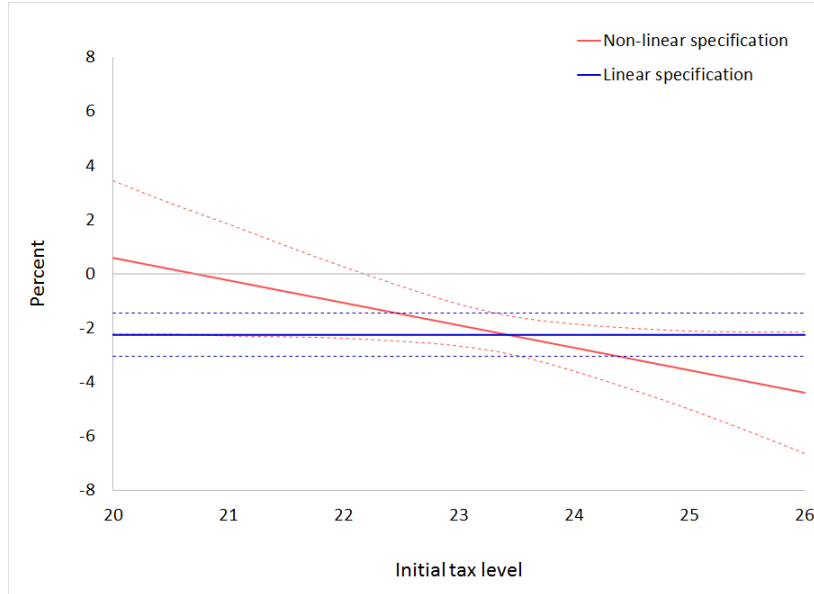
INSERT TABLE A1 HERE

INSERT FIGURE A3 HERE

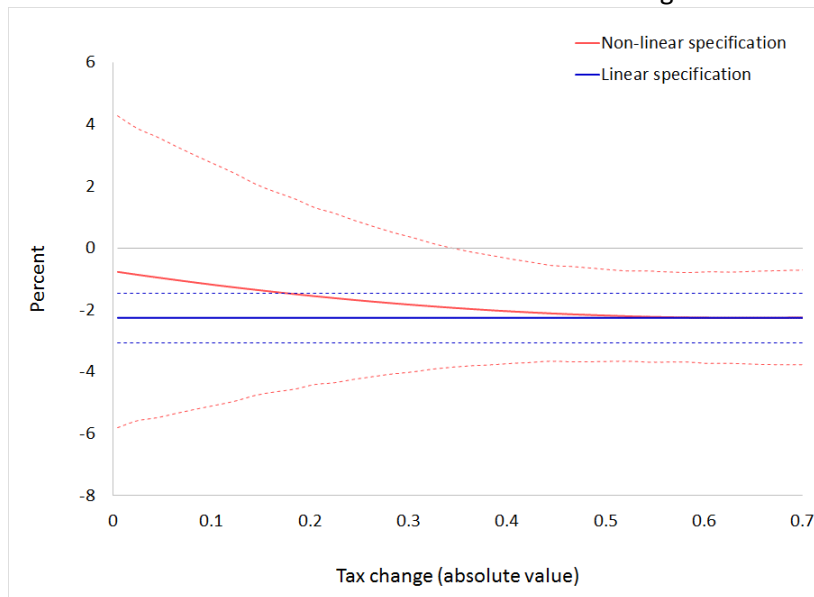
we report the 1 percent equivalent figure. The 1 percent equivalent figure is constructed by dividing the growth effect of a n percent increase in tax by n . Otherwise, and given the non-linear effect of tax changes on output, the effect on growth would capture both the non-linear effects themselves plus the fact that large changes will have by construction a larger effect on output. Reporting the equivalent tax change figure, the effect is comparable across tax changes of different sizes. This was not an issue when using tax multiplier because that "normalizing" role was achieved by the transforming growth effects into $\%$ (i.e., by the use of equation (8)).

**Figure A1. Non-linear cumulative effect of a tax change on GDP growth after two years using Romer and Romer (2010) dataset:
The role of initial tax level and size of the tax change**

Panel A. The role of initial tax level

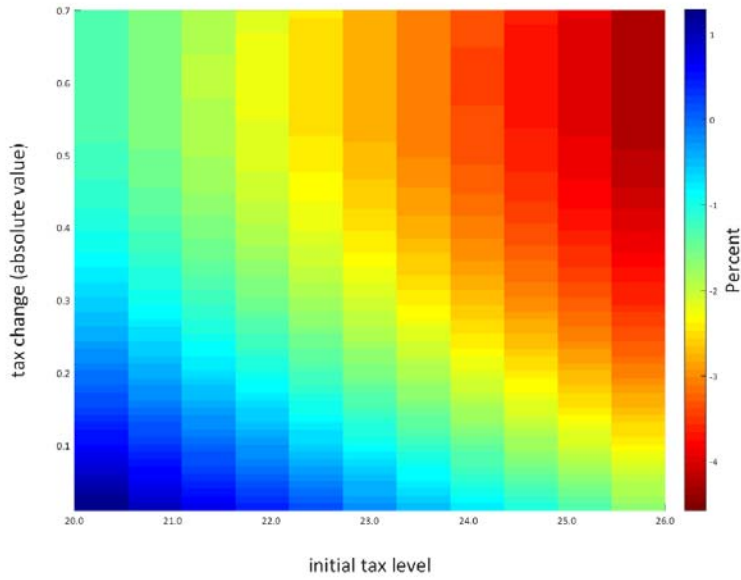


Panel B. The role of the size of the tax change



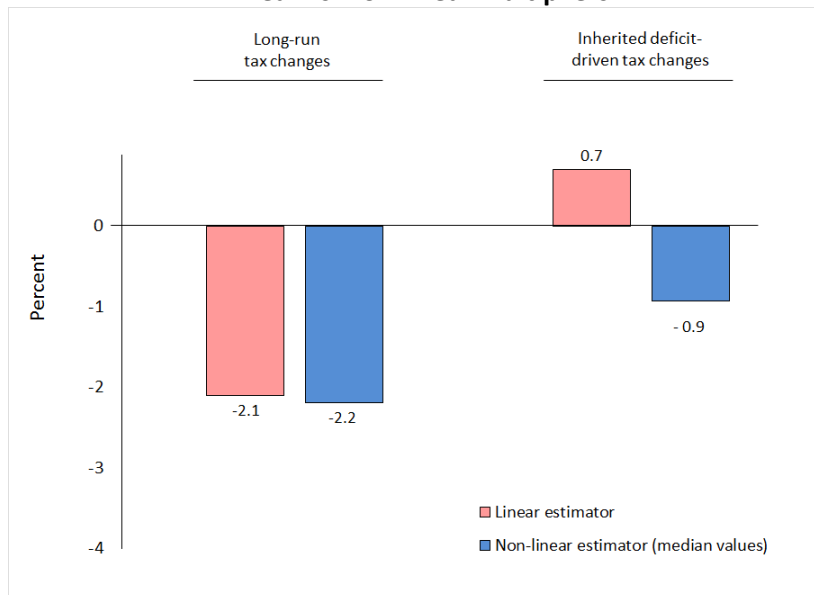
Notes: Standard errors are robust standard errors and bootstrapped. Panels A and B exclude the top and bottom 10 percent of initial tax levels and tax change (absolute value), respectively

Figure A2. Non-linear cumulative effect of a tax change on GDP growth after two years using Romer and Romer (2010) dataset: The joint role of initial tax rate level and size of the tax change



Notes: Standard errors are robust standard errors and bootstrapped. The heat map figure excludes the top and bottom 10 percent of initial tax levels and tax change (absolute value)

Figure A3. Cumulative effect of a tax change on GDP after two years using Romer and Romer (2010) dataset: Linear vs. non-linear multipliers.

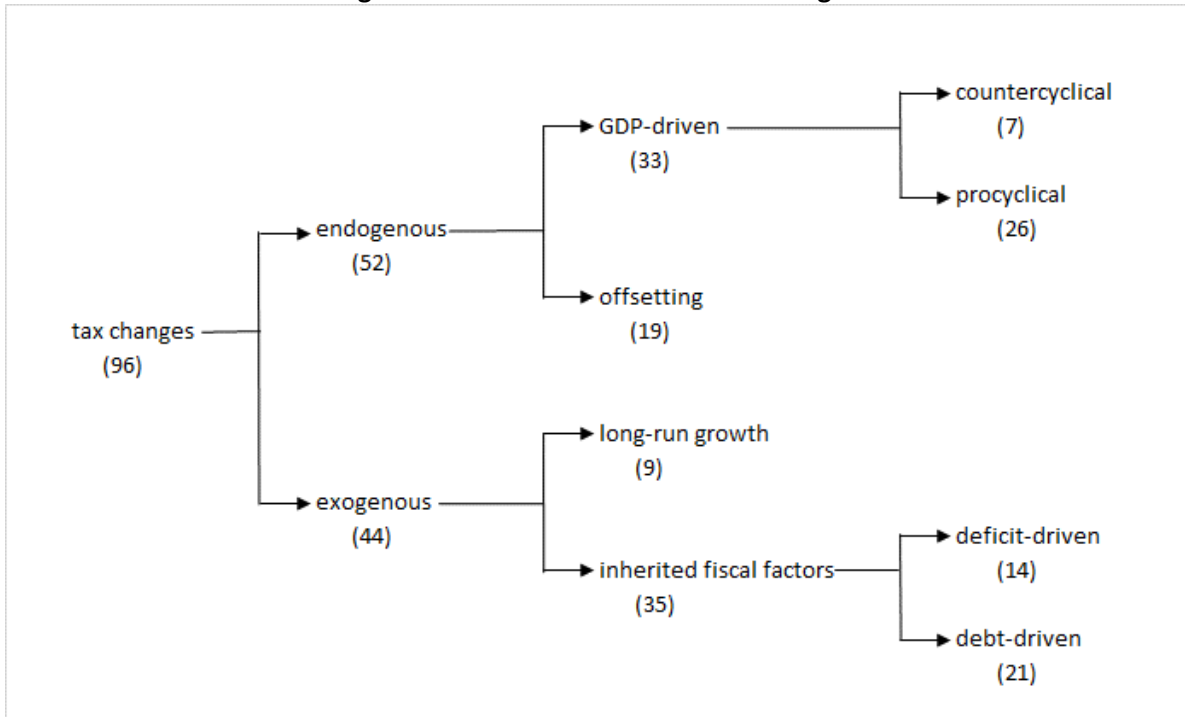


**Table A1. Median test comparisons of initial levels of tax rates and size of tax rate changes for different type of exogenous tax changes using Romer and Romer (2010) dataset:
Long-run versus Inherited deficit-driven tax changes**

	Long-run (1)	Deficit-driven (2)	Difference (1) - (2)
Initial tax rate	23.7	23.3	0.4**
Size of tax change	0.34	0.22	0.12

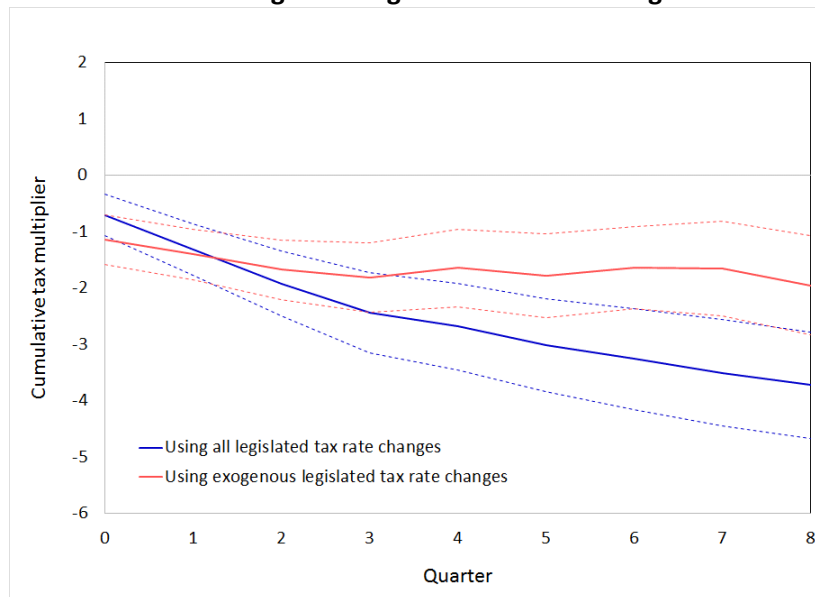
In column (3) we compare median values across different types of exogenous changes. Defining the difference in medians as median value of column (1) minus the median value of column (2), the null hypothesis is that such a difference is smaller or equal than zero and the alternative hypothesis is that such a difference is larger than zero. *, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively

Figure 1. Classification of VAT rate changes



Note: The numbers in brackets represent the number of tax changes in each category.

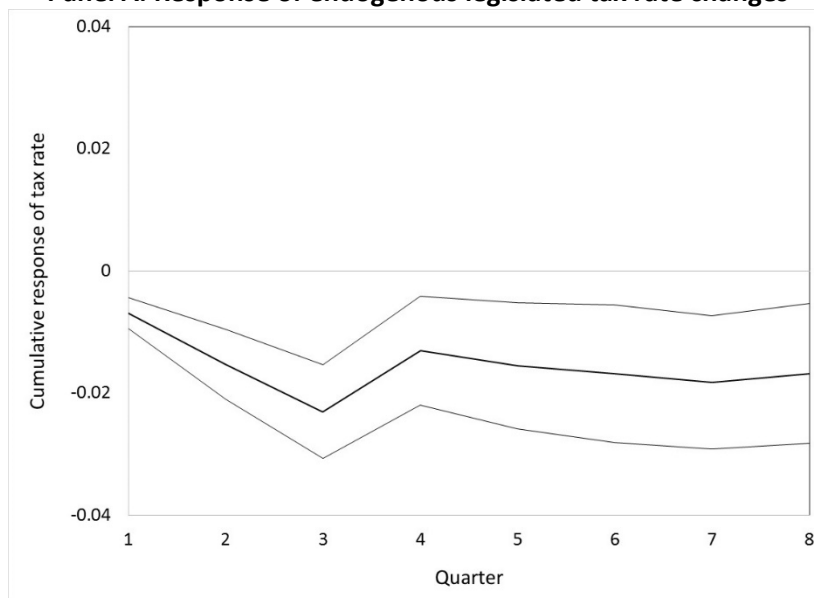
**Figure 2. Cumulative tax multiplier:
All vs. Exogenous legislated tax rate changes**



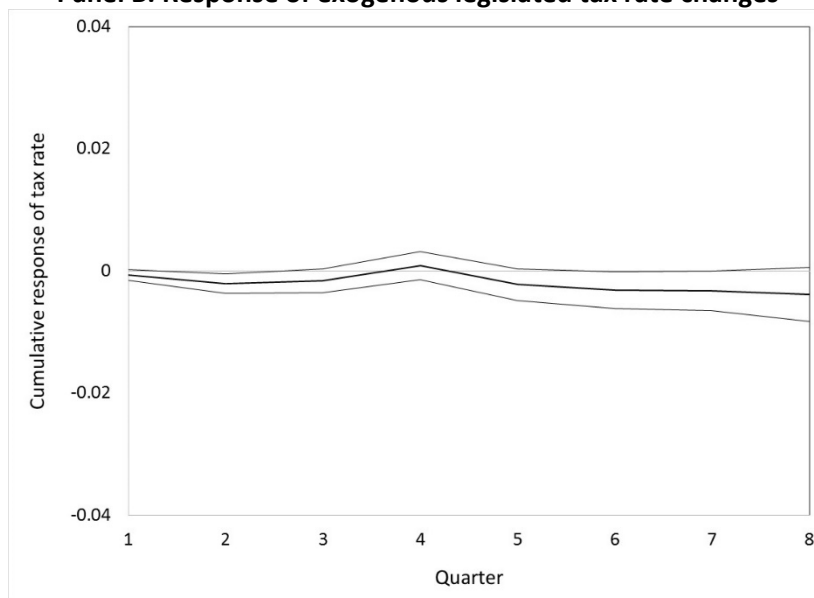
Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

**Figure 3. Cumulative response of the tax rate to a GDP shock.
One percent impulse response function:
Endogenous vs. exogenous legislated tax rate changes**

Panel A. Response of endogenous legislated tax rate changes



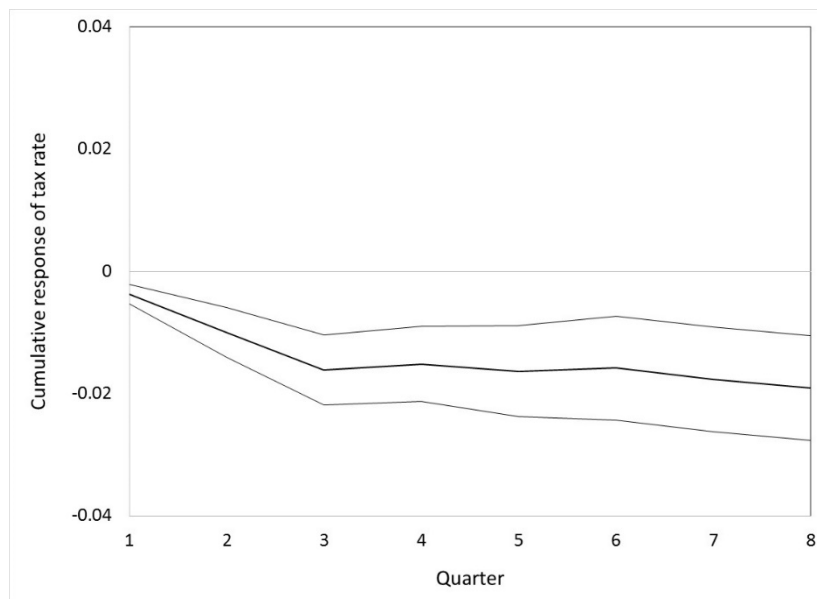
Panel B. Response of exogenous legislated tax rate changes



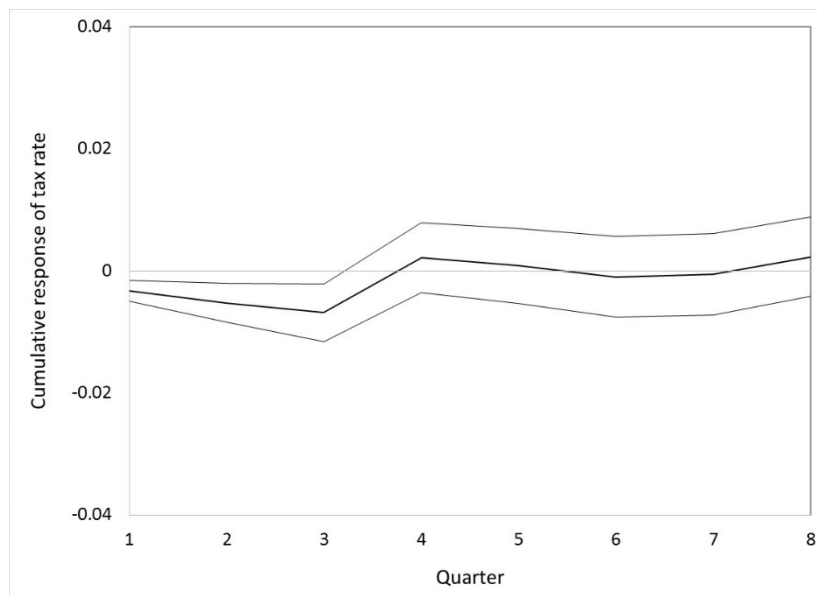
Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

**Figure 4. Cumulative response of the tax rate to a GDP shock.
One percent impulse response function:
Sub-types of endogenous legislated tax rate changes**

Panel A. Response of GDP-driven legislated tax rate changes



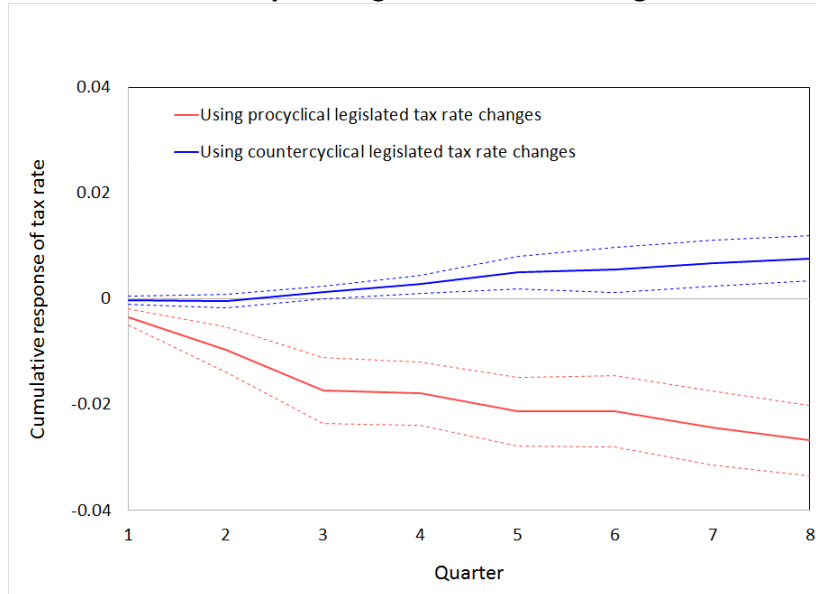
Panel B. Response of offsetting legislated tax rate changes



Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

**Figure 4 cont. Cumulative response of the tax rate to a GDP shock.
One percent impulse response function:
Sub-types of endogenous legislated tax rate changes**

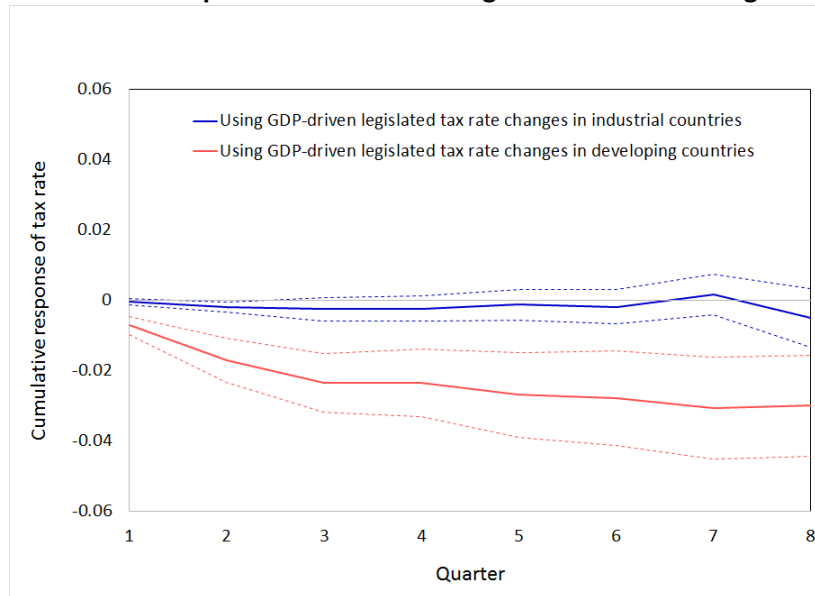
**Panel C. Response of GDP-driven procyclical vs.
countercyclical legislated tax rate changes**



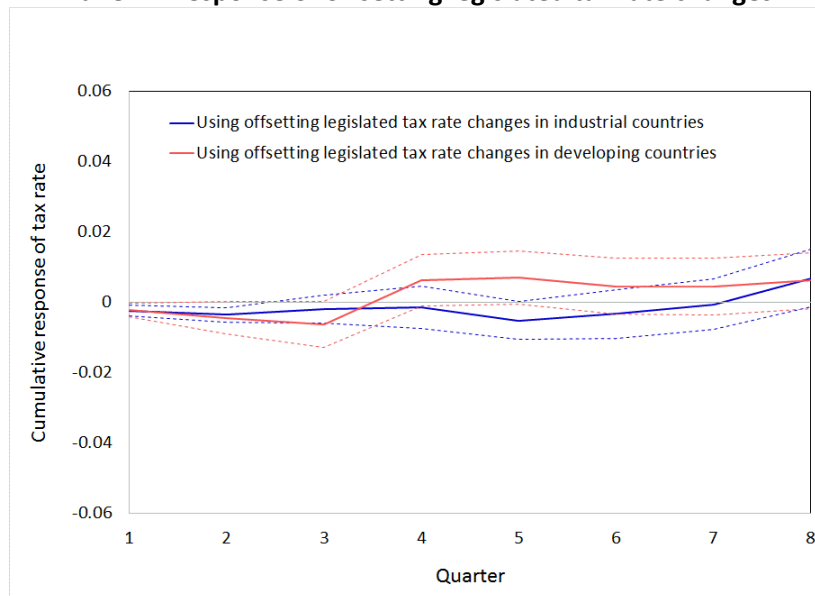
Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

Figure 5. Cumulative response of endogenous legislated tax rate to a GDP shock. One percent impulse response function: Industrial vs. Developing countries

Panel A. Response of GDP-driven legislated tax rate changes

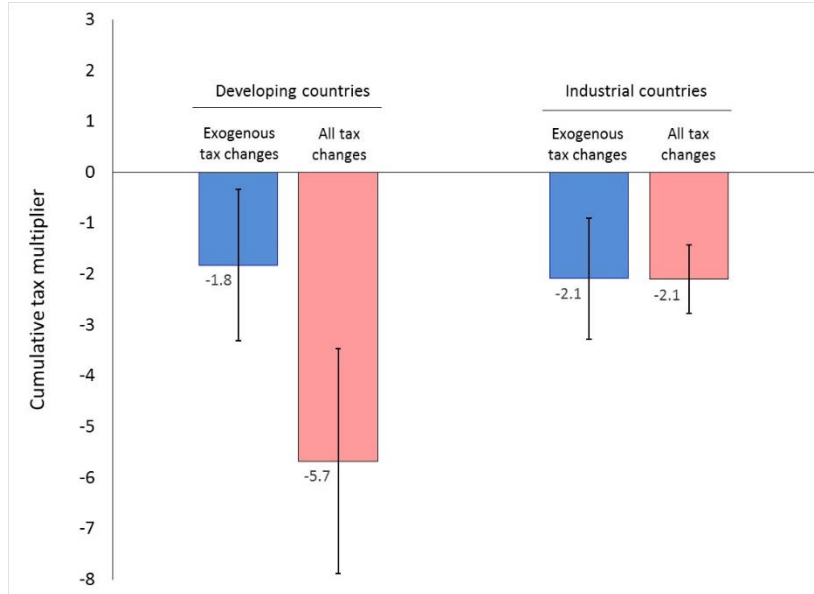


Panel B. Response of offsetting legislated tax rate changes



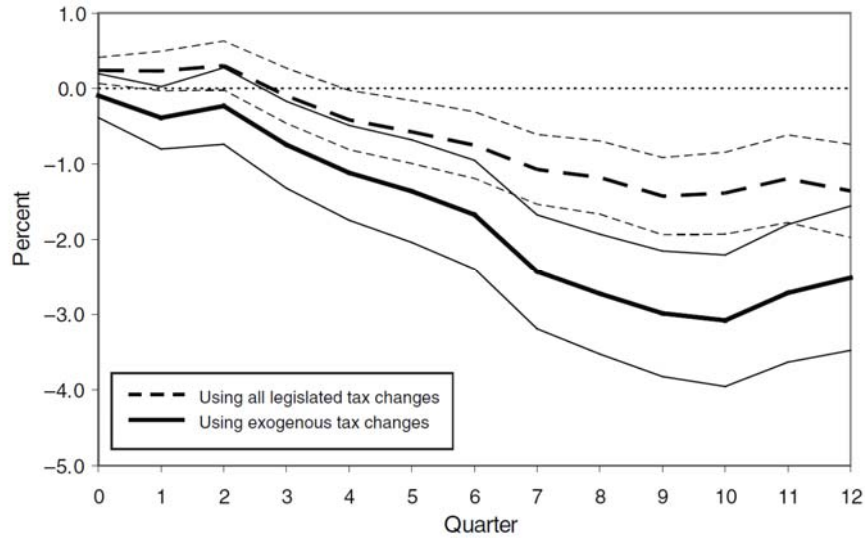
Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

Figure 6. Cumulative tax multiplier evaluated after two years of the tax shock: Industrial vs. Developing countries



Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

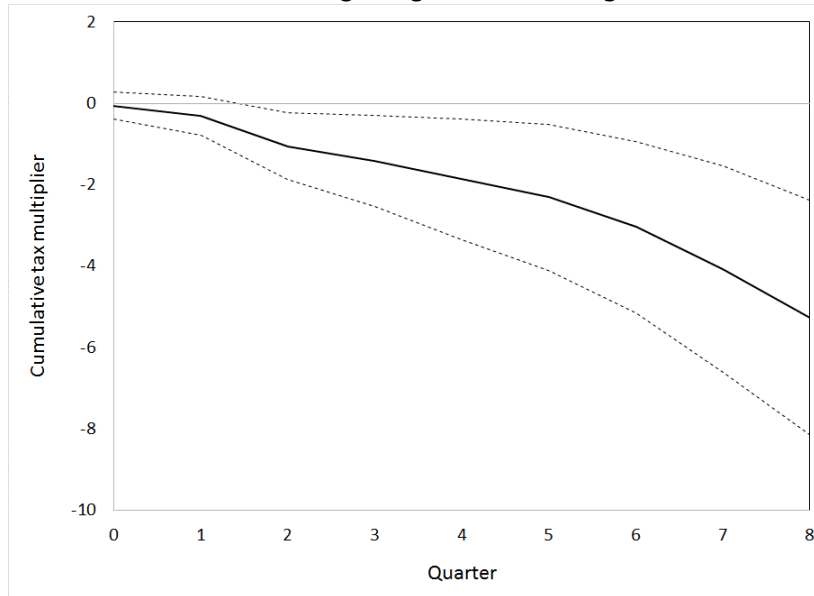
Figure 7. Cumulative impact of a tax increase of 1 percent of GDP on GDP: All vs. Exogenous tax changes from Romer and Romer (2010)



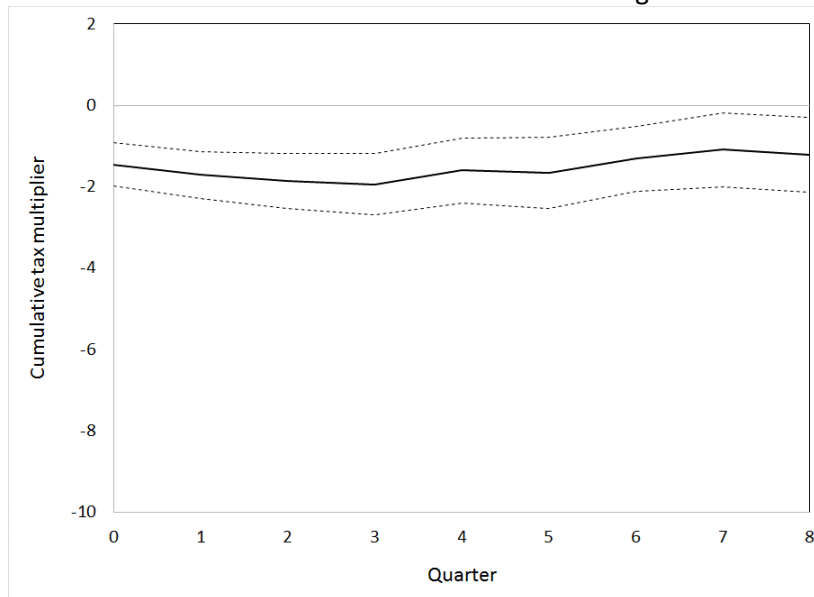
Notes: This figure is from RR, Panel A in Figure 7, page 785.

Figure 8. Cumulative tax multiplier: Exogenous long-run growth versus inherited fiscal factors tax changes

Panel A. Long-run growth tax changes

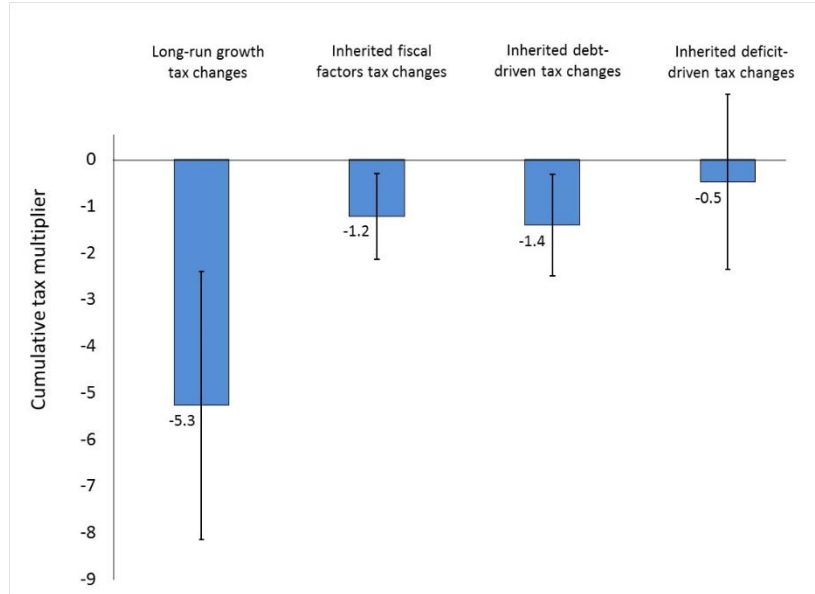


Panel B. Inherited fiscal factors tax changes



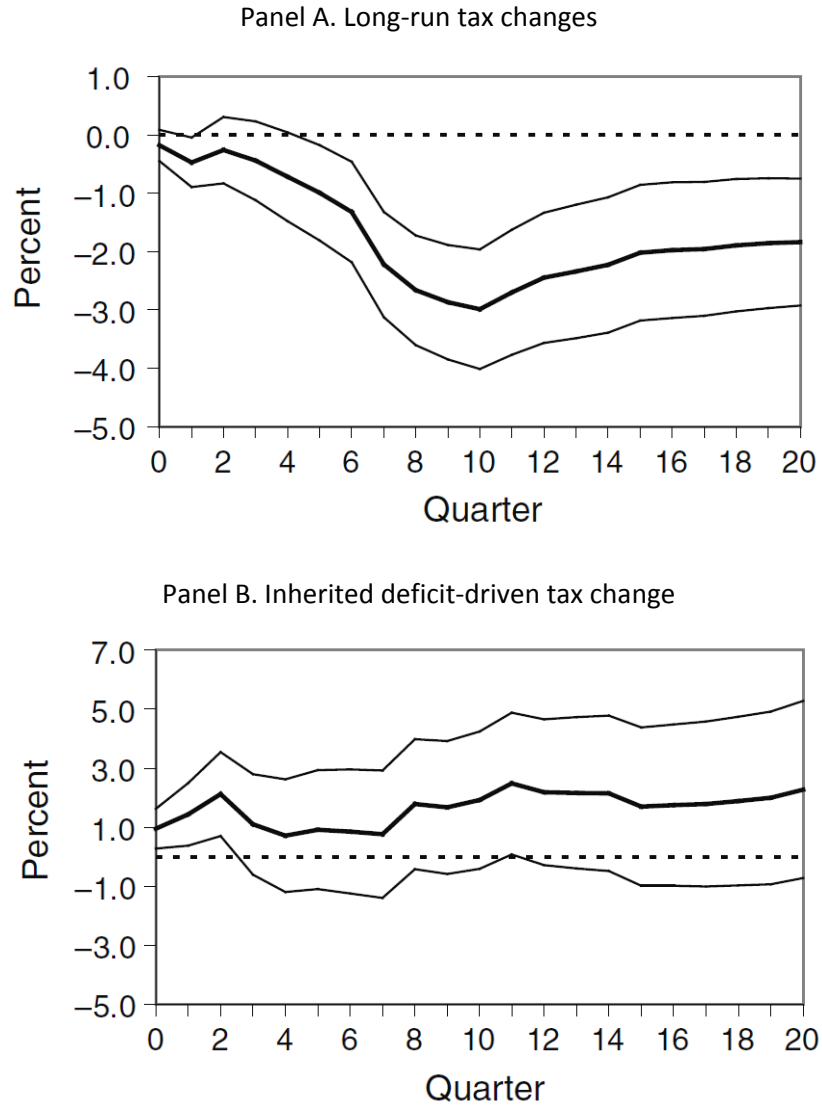
Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

Figure 9. Cumulative tax multiplier evaluated after two years of the tax shock: Output effects of different exogenous tax changes



Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

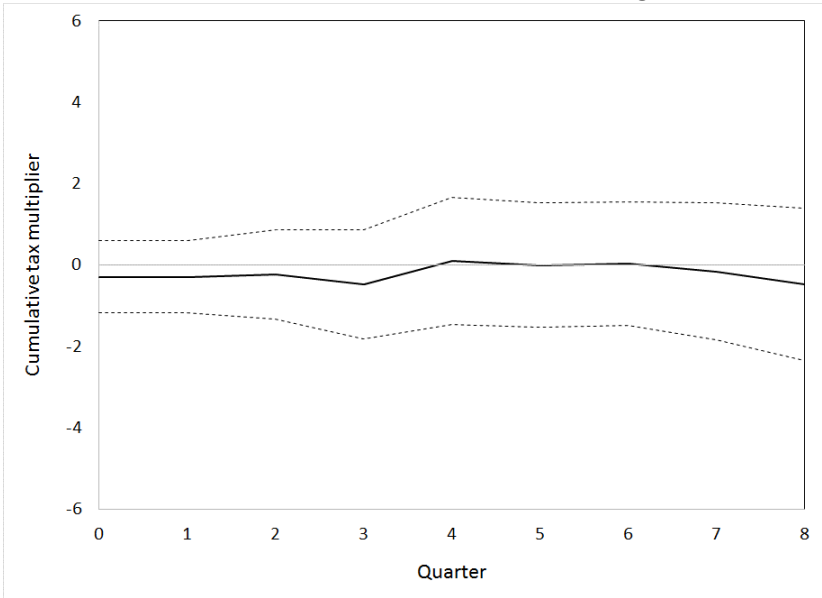
Figure 10. Cumulative impact of a tax increase on GDP: Exogenous long-run versus inherited deficit-driven tax changes from Romer and Romer (2010)



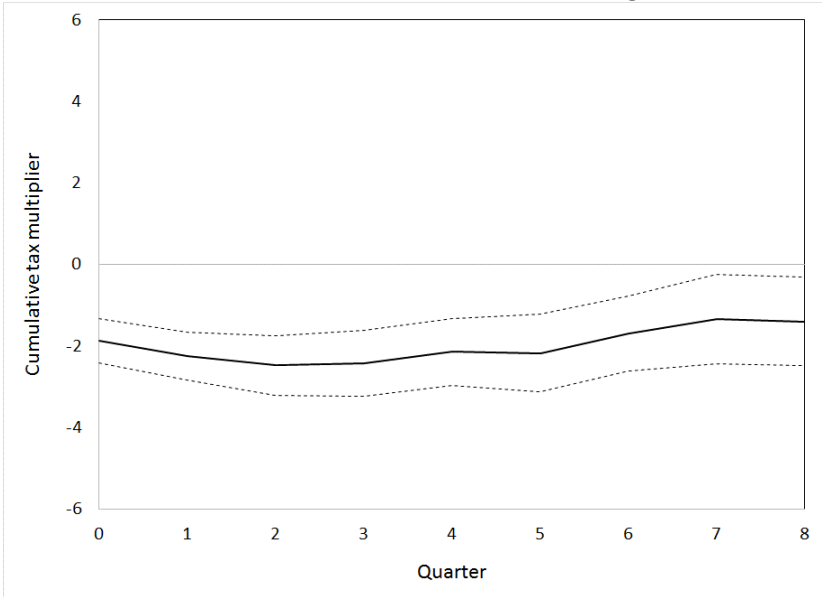
Notes: These figures are from RR, Panels C and D in Figure 9, page 787.

Figure 11. Cumulative tax multiplier: Exogenous inherited deficit-driven versus inherited debt-driven tax changes

Panel A. Inherited deficit-driven tax changes



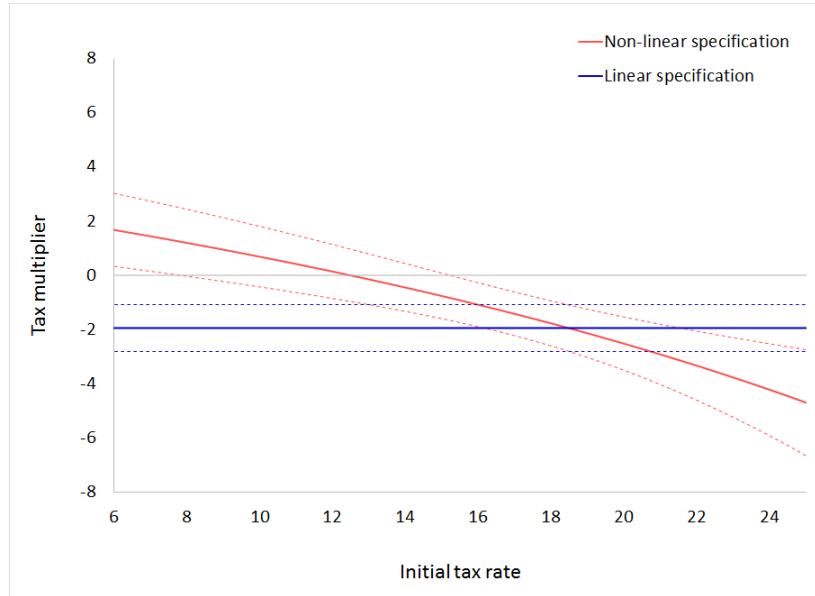
Panel B. Inherited debt-driven tax changes



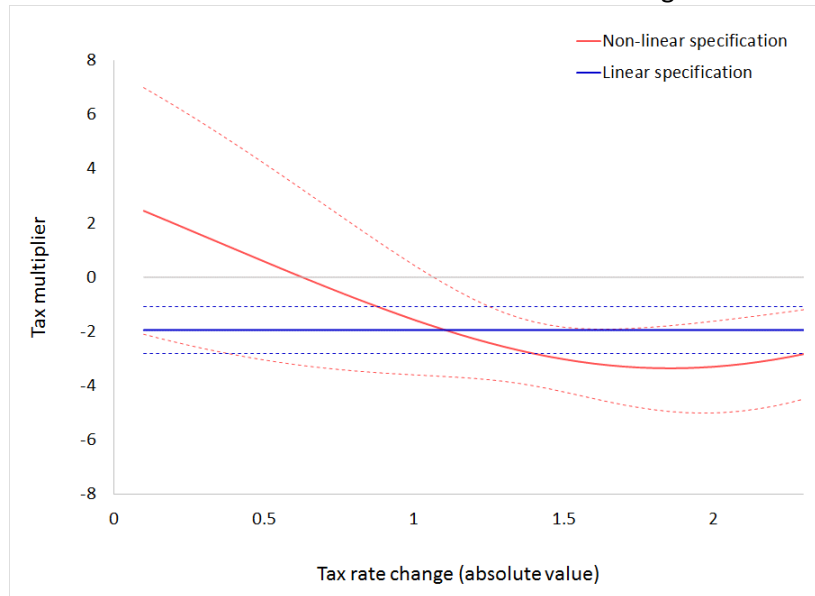
Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

**Figure 12. Non-linear cumulative tax multiplier after two years:
The role of initial tax rate level and size of the tax change**

Panel A. The role of initial tax rate level

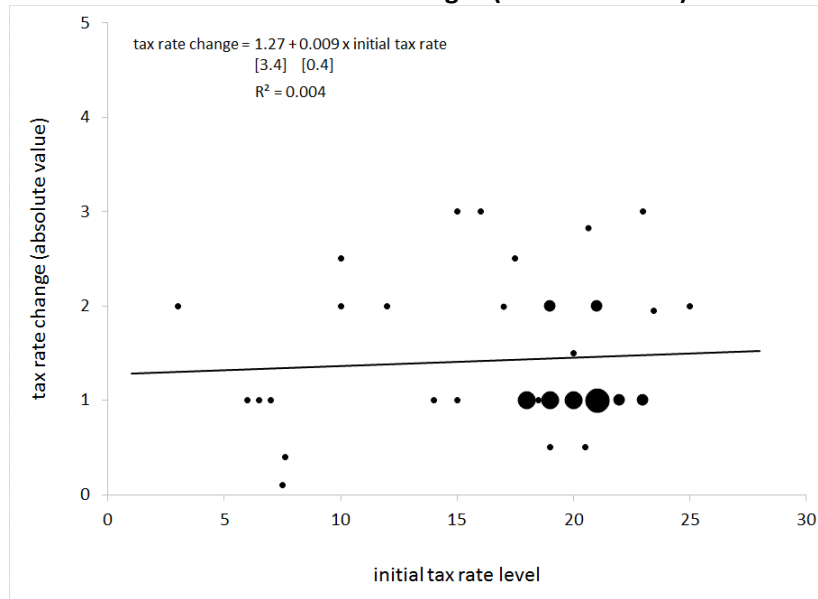


Panel B. The role of the size of the tax change



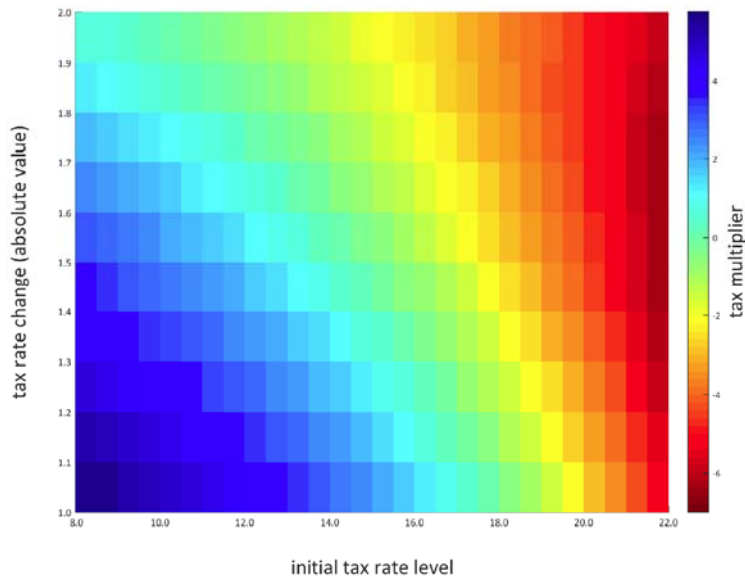
Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped.

Figure 13. Relation between initial level of tax rate and size of tax rate changes (absolute value)



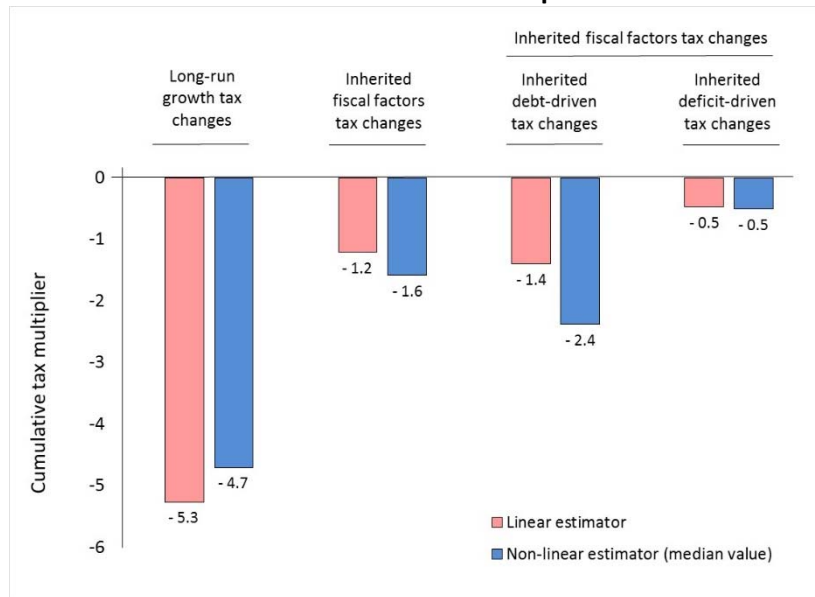
Notes: Size of circled point identifies the number of observations per pair of initial tax rate and tax rate change, with larger circled points identifying more observations per pair of initial tax rate and tax rate change. The number of observations per pair of initial tax rate and tax rate change range between 1 and 4.

Figure 14. Non-linear cumulative tax multiplier after two years: The joint role of initial tax rate level and size of the tax change



Notes: Country and time fixed effect panel regression, standard errors are Driscoll-Kraay standard errors and bootstrapped. The heat map figure excludes the top and bottom 10 percent of initial tax rate levels and tax rate change (absolute value)

**Figure 15. Cumulative tax multiplier evaluated after two years:
Linear vs. non-linear multipliers.**



Notes: Country and time fixed effect panel regression.

Table 1. Period covered per country and classification of each tax rate change

Country and period coverage	Total number of VAT rate changes	All tax rate changes							
		Endogenous					Exogenous		
		GDP-driven		Offsetting			Long-run growth	Inherited fiscal factors	
		Procyclical	Countercyclical	Other tax	Within VAT	Spending	Deficit-driven	Debt-driven	
Argentina (1993:Q2 - 2013:Q1)	1	(April 1995, 3 pp.)							
Australia* (2000:Q3 - 2014:Q3)	0								
Austria* (1964:Q2 - 2014:Q1)	0								
Belgium* (1983:Q2 - 2014:Q2)	3	(January 1994, 1 pp.)					(April 1992, 0.5 pp.) (January 1996, 0.5 pp.)		
Botswana (2002:Q3-2013:Q4)	1						(April 2010, 2 pp.)		
Bulgaria (1999:Q2-2014:Q2)	n								
Canada* (1991:Q1-2014:Q3)	2						(July 2006, -1 pp.) (January 2008, -1 pp.)		
Chile (1991:Q2-2014:Q3)	1						(October 2003, 1 pp.)		
China (1994:Q1-2014:Q3)									
Czech Republic (1995:Q2-2014:Q2)	3	(January 2010, 1 pp.)		(May 2004, -3 pp.)			(January 2013, 1 pp.)		
Denmark* (1980:Q4-2014:Q2)	1	(January 1992, 3 pp.)							
Ecuador (1992:Q2-2014:Q2)	3	(November 1999, 2 pp.)	(September 2001, -2 pp.)					(May 2001, 2 pp.)	
Egypt (2004:Q2-2014:Q2)									
El Salvador (1992:Q3-2014:Q2)	1						(July 1995, 3 pp.)		
Finland* (1994:Q3-2014:Q2)	2	(July 2010, 1 pp.)					(January 2013, 1 pp.)		
France* (1977:Q2-2014:Q2)	3	(April 2000, -1 pp.)		(July 1982, 1 pp.)		(August 1995, 2 pp.)			
Germany* (1983:Q4-2014:Q3)	3	(January 1993, 1 pp.)					(April 1998, 1 pp.) (January 2007, 3 pp.)		
Greece* (1995:Q2-2014:Q2)	3	(March 2010, 2 pp.) (July 2010, 2 pp.)					(April 2005, 1 pp.)		
Hungary (1995:Q2-2014:Q2)	3	(January 2006, -5 pp.) (September 2009, 5 pp.)					(January 2012, 2 pp.)		
India (2005:Q2-2014:Q3)									
Ireland* (1997:Q2-2014:Q2)	5	(March 2002, 1 pp.) (December 2008, 0.5 pp.)	(January 2010, -0.5 pp.)					(January 2001, -1 pp.) (January 2012, 2 pp.)	
Italy* (1981:Q1-2014:Q2)	6						(January 1981, 1 pp.) (August 1982, 3 pp.) (August 1988, 1 pp.) (October 1997, 1 pp.) (November 2011, 1 pp.) (October 2013, 1 pp.)		
Jamaica (2010:Q1-2014:Q1)									
Japan* (1989:Q1-2014:Q3)	1						(April 1997, 2 pp.)		
Korea, Rep. (1977:Q1-2014:Q3)									
Latvia (1995:Q2-2014:Q1)	3	(January 2009, 3 pp.)					(July 2012, -1 pp.)	(January 2011, 1 pp.)	

Table 2. Median test comparisons of initial levels of tax rates and size of tax rate changes for different type of exogenous tax changes

Panel A. Long-run growth versus inherited fiscal factor tax changes

	Long-run growth (1)	Inherited fiscal factors (2)	Difference (1) - (2)
Initial tax rate	21	19	2**
Size of tax change	1	1	0

Panel B. Inherited deficit- versus debt- driven tax changes

	Debt-driven (1)	Deficit-driven (2)	Difference (1) - (2)
Initial tax rate	19	18.5	0.5
Size of tax change	2	1	1**

In column (3) we compare median values across different types of exogenous changes. Defining the difference in medians as median value of column (1) minus the median value of column (2), the null hypothesis is that such a difference is smaller or equal than zero and the alternative hypothesis is that such a difference is larger than zero. *, ** and *** indicate statistically significant at the 10%, 5% and 1% levels, respectively