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Full Length Articles

Non-linear effects of tax changes on output: The role of the initial level of taxation☆

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ABSTRACT

We estimate the effect of worldwide tax changes on output following the narrative approach developed for the United States by Romer and Romer (2010). 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. We then use contemporaneous economic records to classify such changes as endogenous or exogenous to current (or prospective) economic conditions. In line with theoretical distortionary and disincentive-based arguments – and using exogenous tax changes – we find that the effect of tax changes on output is highly non-linear. The tax multiplier is essentially zero under relatively low initial tax rate levels and more negative as the initial tax rate increases. Based on a global sample, these novel non-linear findings suggest that the recent consensus pointing to large negative tax multipliers in industrial countries, particularly in industrial Europe (e.g., Alesina, Favero, and Giavazzi, 2015) may represent a special case driven by high initial tax rates in these countries.

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1. Introduction

After the 2007–2008 global financial crisis, fiscal multipliers – the effects of fiscal policy on aggregate output – have taken center stage in the policy world. Motivated early on by the policy focus on fiscal stimulus (to counter the economic recession that followed the crisis) and, later on, by fiscal consolidation (due to increasing concerns about debt sustainability), studies estimating government spending multipliers and, to a lesser extent, tax multipliers have flourished. The tax multiplier, which is the focus of this paper, measures the effect of a $1 change in tax revenues on the level of GDP. For example, a tax multiplier of −2 indicates that an increase in tax revenues of $1 decreases GDP by $2.

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, there is an emerging consensus in the literature that the so-called narrative approach developed by Romer and Romer (2010) (henceforth RR) in their study of the United States is better suited to identifying exogenous tax policy shocks than the traditional approach pioneered 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 are allowed to affect output contemporaneously, it is assumed that the government takes at least one quarter to respond to developments in 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 et al., 2008; Ramey, 2011; Auerbach and Gorodnichenko, 2012a; and Riera-Crichton et al., 2016). Moreover, and especially for large and sudden falls in output, it is not obvious that within-the-quarter economic developments do not affect tax policy. For example, during episodes of natural disasters, it is often the case that governments quickly respond by increasing or reducing taxes. The earthquakes in Ecuador (2016), Japan (2011), India (2001), and California (1989) are clear examples of the unsuitability of the BP timing assumption as tax responses occurred within 26, 47, 6, and 18 days following the earthquakes, respectively.[1,2]

In contrast, RR use narrative records, from Congressional reports to presidential speeches, to identify the principal motivation behind all major postwar tax policy measures in the U.S. The analysis of contemporaneous records enables RR to distinguish between legislated tax changes enacted for reasons related to current or prospective economic conditions (i.e., endogenous to the business cycle) and those taken for reasons exogenous to the business cycle, including those motivated by long-run growth considerations (e.g., 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. RR find that tax hikes (cuts) lead to contractions (expansions) in economic activity.

Since RR's seminal work, quite a few studies have used the narrative approach for individual or multi-country analyses (in all cases, focusing *only* on industrial economies, mostly European). These studies find large negative tax multipliers, ranging from −2 to −5.[3] This recent consensus pointing to large negative tax multipliers, especially in industrial European countries, carries important policy implications. For example, as part of a more comprehensive series of papers focusing on spending and tax multipliers, Alesina et al. (2015) point out that "policies based upon spending cuts are much less costly in terms of short run output losses than tax based adjustments." A natural question is whether large negative tax multipliers are the norm or, if not, whether there are some underlying forces behind the observed differences in tax multipliers across countries or groups of countries. In order to answer this highly relevant academic and policy question, one would ideally need to conduct a study using a more global sample including industrial and, particularly, developing countries. To the best of our knowledge, there is no such a study. The main reason is surely the lack of data on legislated tax changes in developing countries, which is needed to capture the behavior of a tax policy instrument (i.e., a variable that is under the direct control of policymakers).[4] Furthermore, unlike the BP approach, the RR narrative approach poses a major challenge in terms of the sheer time needed to gather 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 (henceforth VAT rates). We believe that this significant effort in collecting VAT rates is crucial for any study analyzing tax policy in Europe as well as in the developing world, where indirect/value-added taxation is the main tax revenue instrument.[5] VAT rates were obtained from various primary sources including countries' revenue agencies, national libraries, books, newspapers, tax law experts, and research and policy

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[1] See Appendix 1 for more details about the nature of these earthquakes, effects on GDP, and tax policy responses.

[2] See Chahrour et al. (2012) for a model-based evaluation of the implications of using SVAR vis-à-vis the narrative approach based on a DSGE model.

[3] Based on the narrative approach for fiscal consolidation episodes and using a multi-country analysis, Alesina et al. (2015) find, for a sample of 17 industrial countries, a tax multiplier of about −2 (after two years of the tax shock). Using a similar identification strategy, but based on value-added tax rate changes, Riera-Crichton et al. (2016) find, for a sample of 14 industrial countries, a tax multiplier of about −3.5 (after one year of the tax shock). Based on the narrative approach for country-specific studies, RR, Cloyne (2013), Hayo and Uhl (2013), Gil et al. (2017), and Pereira and Wemans (2013) find a tax multiplier of −2.7, −2, −2.4, −2, and −1.7 (after two years of the tax shock) for the U.S., U.K., Germany, Portugal, and Spain, respectively. Also based on a narrative approach, Pereira and Wemans (2013) and Gil et al. (2017) find for Portugal and Spain even more negative tax multipliers for *indirect* taxation of about −2.7 and −5 (after two years of the tax shock), respectively.

[4] As discussed in RR and Mertens and Ravn (2014) for the case of the U.S. and Riera-Crichton et al. (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 errors 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 et al. (2016) – tax multipliers estimated with cyclically-adjusted revenues yield misleading results.

[5] When analyzing the impact of specific taxes, Barro and Redlick (2011) focus on the effect of individual income and social-security payroll taxes in the U.S. Mertens and Ravn (2013) analyze the effect of individual and corporate income taxes in the U.S. Riera-Crichton et al. (2016) focus on the impact of VAT in 14 industrial countries.

papers. We identify a total of 96 VAT rate changes in 35 countries (18 industrial and 17 developing). 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 motivation behind each VAT rate change.

While closely following RR's identification strategy, we also incorporate some new elements that arise due to both the global nature of our sample of countries and the specific tax measures used. In particular, we allow endogenous tax changes to include countercyclical tax changes (as in RR) as well as procyclical tax changes. While the 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 industrial European countries after the 2007–2008 global financial crisis). Further, when focusing on exogenous tax changes motivated by inherited fiscal factors, we consider not only inherited *deficit*-driven tax changes (as in RR) but also inherited *debt*-driven tax changes. Since, over the last 60 years, the U.S. has not faced sustainability problems regarding the public debt, RR need not deal with the latter case.

Based on our novel worldwide narrative approach, we find that, for the entire global sample, the tax multiplier reaches −2.7 after two years of the tax shock. Compared to the range of estimated tax multipliers mentioned before, this figure is among the least negative ones. Interestingly, when splitting the sample into industrial European economies and the rest of the sample, we find tax multipliers of −3.6 and −1.4, respectively. While the tax multiplier in industrial European economies is thus rather large (in absolute value) and statistically significant (in line with recent studies), the multiplier for the rest of the sample is about 2.5 times smaller (in absolute value) and much weaker statistically speaking.

Motivated by this large difference in tax multipliers, the paper's main empirical contribution consists in evaluating the role of tax distortions and disincentives in generating non-linear effects of tax changes on output. Many different kinds of non-linearities have been found in the estimation of spending multipliers in recent years. In most cases, the non-linear effect of spending on output has been associated with the macroeconomic context in which spending decisions have taken place. In accordance with various macroeconomic theoretical frameworks, recent empirical findings have shown that spending multipliers tend to be larger under fixed exchange rate regimes (Ilzetzki et al., 2013), under low debt (Ilzetzki et al., 2013; Huidrom et al., 2016), in economies more closed to trade (e.g., Ilzetzki et al., 2013; Gonzalez-Garcia et al., 2013), and in recessions (Auerbach and Gorodnichenko, 2012a, 2012b; Riera-Crichton et al., 2015). Rather than focusing on macroeconomic-based non-linear effects, our paper analyzes the non-linear effects of tax changes on output generated by distortionary and disincentive-based arguments.[6,7] Based on different types of macroeconomic models (which in turn rely on different mechanisms), the output effect of tax changes is expected to be small at low initial levels of taxation but larger when initial tax levels are higher. Therefore, the distortions and disincentives imposed by taxation on economic activity are directly, and non-linearly, related to the level of tax rates. These theoretical results are present, for example, in Jaimovich and Rebelo (2017) (hereafter JR) who show that such a non-linear mechanism in income taxation may operate through heterogeneity in entrepreneurial ability and disincentives to innovate and invest. We also show that this non-linear mechanism is fairly easy to obtain, even when focusing on the VAT rate (which is the focus of this paper). To this effect, we write down a very simple and plausible static model with a labor/leisure choice, linear production, and a consumption tax. The model illustrates a mechanism through which, by making consumption more expensive and leisure cheaper, a higher tax rate reduces consumption and labor supply, which implies that output is a decreasing function of the tax rate. Furthermore, for high, but reasonable, values of the elasticity of substitution between consumption and leisure, the tax multiplier (in absolute value) is an increasing function of the tax rate. Intuitively, the higher is the tax rate, the larger is the response of the consumption/leisure distortion to an increase in the tax rate, thus resulting in a larger fall in labor supply and output.[8,9]

Using our novel worldwide narrative – and in line with the models just described – we find that the effect of tax changes on output is indeed highly non-linear. Our empirical findings show that the tax multiplier is essentially zero for relatively low initial tax rate levels and more negative as the initial tax rate increases. These novel non-linear findings suggest that the large negative tax multipliers, especially in industrial Europe, may *not* be a universal norm but are instead driven by high initial tax rates in these countries. Moreover, for an important part of the world, especially in developing countries, where tax multipliers are only slightly negative, the implied policy prescription would be the opposite of that of Alesina et al. (2015).

The paper proceeds as follows. Section 2 discusses our sample and data sources. Section 3 proceeds to identify the motivation behind all tax changes in our sample; that is, we classify all tax changes into endogenous and exogenous. We then turn to the econometric analysis. Section 4 first introduces our basic linear specification and then discusses our main results, the role of expectations, the mechanisms involved, and the difference observed between the tax multiplier obtained in industrial European countries and that for the rest of the countries in the sample. Section 5 shows, in line with theoretical arguments, the existence of strong non-linear effects of tax changes on output. In particular, tax multipliers are essentially zero under relatively low initial tax rate levels and more negative as the initial tax rate increases. We argue that these non-linear effects are critical in explaining the more negative tax multiplier found in industrial European countries (vis-a-vis the rest of the sample), as shown in Section 4. We illustrate the fact that the same non-linear arguments are present in RR's sample. Section 6 provides some final thoughts.

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[6] As will be discussed in Section 4.5, macroeconomic factors are not behind the non-linear effects associated with distortionary and disincentive-based type of arguments.

[7] While we believe that similar mechanisms may be at play with taxes other than VAT, it is important to note that our empirical results relate exclusively to changes in VAT rates.

[8] See Appendix 2 for details on the model.

[9] While different in terms of the object under analysis (output versus tax burden), JR and our simple model are also related to a well-established public finance literature (e.g., Harberger, 1964a, 1964b; Browning, 1975; Feldstein, 1995) that argues that the excess burden of taxation, or deadweight loss, associated with taxation is small at low tax rates, increases with higher tax rates, until, eventually, "a tax [is] imposed at so high rate that it eliminates the taxed activity." (Hines, 2007, p. 1).

2. Narrative analysis: Sample and sources

To apply the narrative approach as an identification strategy, we need to examine the motivation behind each tax change (i.e., whether it was exogenous to the business cycle or not).[10] 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 with the time of passage of the corresponding tax law. This section first discusses our sample and data sources and then proceeds to identify the motivation behind each tax change.

2.1. 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 at a global scale, we focus our efforts on creating a new series for quarterly standard VAT rates, building on Vegh and Vuletin (2015) and Riera-Crichton et al. (2016).[11] 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 one of the main tax revenue instruments.[12]

Due to data availability, we use the standard VAT rate as a proxy for overall VAT policy. Such an approach could, in principle, raise concerns due to the omission of reduced VAT rates and/or exempted goods for some countries or possible changes over time in the goods covered by the different rates. While data limitations prevent us from assessing the practical relevance of such concerns for our whole sample of 51 countries, Vegh and Vuletin (2015) show, for a subset of nine industrial countries, that these concerns are not warranted. First, the standard rate typically applies to most goods while reduced tax rates (if present at all) typically apply to a small subset of particular goods, including some food categories and child/elderly care. The average share of transactions covered by the standard VAT rate is about 75% of the total tax base. Second, the standard and average reduced VAT rates tend to be highly and positively correlated over time. In 80% of the countries, this correlation is larger than 0.5 and statistically significant at the 1% level. Third, the share of transactions covered by different statutory tax rates does not vary much over time in any given country. As a result, the standard VAT rate explains about 85% 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 the taxable base).[13]

2.2. Sources

The VAT rates were obtained from various primary sources, including countries' revenue agencies, 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 since its introduction. However, since our study focuses on the output implications of tax changes, we only use those tax changes for which we have real GDP data collected on a quarterly basis (as opposed to interpolated data). As discussed in detail in Ilzetzki et al. (2013), relying on interpolated quarterly data creates serious problems associated with measurement error. The coverage, which varies across countries, starts as early as 1970:Q1 and ends as late as 2014:Q4 (see column 1 in Table 1 for country-specific coverage).

As sources for the narrative analysis, we use contemporaneous IMF documents, OECD Economic Surveys, and news articles to gather evidence on policymakers' intentions and primary motivations behind VAT rate changes. IMF documents include staff reports and background material for Article IV consultations, other IMF country reports, and publications such as Recent Economic Developments, Selected Issues, and Public Information Notices. IMF documents published prior to 1997 are available in digitalized hard copies at the IMF Archives in Washington, D.C., whereas documents from 1997 onward are available at the IMF website. News articles were obtained from global media including BBC, Bloomberg News, E.U. 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).

3. Tax changes: Identifying motivation

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

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[10] We 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 3.

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

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

[13] While 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.

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

Country and period coverage	Total number of VAT rate changes	All VAT rate changes							
		Endogenous					Exogenous		
		Reverse causality		Taken to offset another factor(s) that would tend to move output growth away from normal			Growth driven	Inherited fiscal driven	
		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* (1984: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)	0								
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)	0								
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)	0								
El Salvador (1992:Q3–2014:Q2)	1								
Finland* (1994:Q3–2014:Q2)	2	(July 2010, 1 pp.)				(July 1995, 3 pp.)			
France* (1977:Q2–2014:Q2)	3	(April 2000, −1 pp.)		(July 1982, 1 pp.)		(August 1995, 2 pp.)		(January 2013, 1 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)	0								
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)	0								
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.)	
Lithuania (1994:Q2–2014:Q2)	2	(January 2009, 1 pp.) (September 2009, 2 pp.)							

Table 1 (*continued*)

| Country and period coverage	Total number of VAT rate changes	All VAT rate changes							
		Endogenous			Taken to offset another factor(s) that would tend to move output growth away from normal		Exogenous		
		Reverse causality		Other tax	Within VAT	Spending	Growth driven	Inherited fiscal driven	
		Procyclical	Countercyclical					Deficit driven	Debt driven
Luxembourg* (1995:Q2–2014:Q1)	0								
Malta (2004:Q2–2014:Q2)	0								
Mauritius (2002:Q2–2010:Q3)	0								
Mexico (1983:Q2–2014:Q2)	3	(March 1995, 5 pp.) (January 2010, 1 pp.)							(October 2012, 2 pp.)
Netherlands* (1986:Q2–2014:Q3)	4			(January 2001, 1.5 pp.)	(November 1991, −5 pp.)		(January 1989, −1.5 pp.) (October 1992, −1 pp.)		
New Zealand* (1986:Q4–2014:Q2)	2			(October 2010, 2.5 pp.)					(July 1989, 2.5 pp.)
Norway* (1970:Q2–2014:Q2)	4		(January 1993, 1 pp.)	(January 1995, 2 pp.) (January 2005, 1 pp.)		(January 2001, 1 pp.)			
Paraguay (1994:Q2–2014:Q2)	0								
Philippines (2006:Q2–2014:Q2)	0								
Poland (1995:Q2–2014:Q2)	1			(January 1995, 1 pp.)					
Portugal* (1992:Q3–2014:Q2)	6	(July 2010, 1 pp.)	(July 2008, −1 pp.)						(January 2011, 1 pp.) (June 2002, 2 pp.) (July 2005, 2 pp.) (January 2011, 2 pp.)
Romania (1998:Q2–2014:Q2)	3	(July 2010, 5 pp.)		(February 1998, 4 pp.)	(January 2000, −3 pp.)				
Russia (2004:Q2–2014:Q2)	0								
Singapore (2007:Q4–2014:Q3)	0								
Slovak Republic (1996:Q2–2014:Q2)	3				(January 2004, −1 pp.)		(January 2003, −3 pp.)	(January 2011, 1 pp.)	
Slovenia (1999:Q3–2014:Q1)	1							(January 2002, 1 pp.)	
South Africa (1991:Q4–2014:Q2)	1	(April 1993, 4 pp.)							
Spain* (1992:Q4–2014:Q2)	3	(July 2010, 2 pp.) (September 2012, 3 pp.)		(January 1995, 1 pp.)					
Sweden* (1980:Q2–2014:Q2)	4		(July 1990, 1.54 pp.)			(January 1983, 1.95 pp.)	(November 1981, −1.95 pp.)	(September 1980, 2.83 pp.)	
Switzerland* (1995:Q1–2014:Q2)	3							(January 1999, 1 pp.) (January 2001, 0.1 pp.) (January 2011, 0.4 pp.)	
Thailand (1993:Q2–2014:Q2)	2	(August 1997, 3 pp.)	(April 1999, −3 pp.)						
United Kingdom* (1975:Q1–2014:Q2)	5	(January 2010, 2.5 pp.)	(December 2008, −2.5 pp.)	(June 1979, 7 pp.) (April 1991, 2.5 pp.)					(January 2011, 2.5 pp.)
Uruguay (1979:Q2–2011:Q4)	5	(June 1984, 2 pp.)		(May 1995, 1 pp.)			(January 2007, −1 pp.)	(October 1987, 1 pp.)	(April 1990, 1 pp.)
Venezuela (2011:Q1–2013:Q)	0								
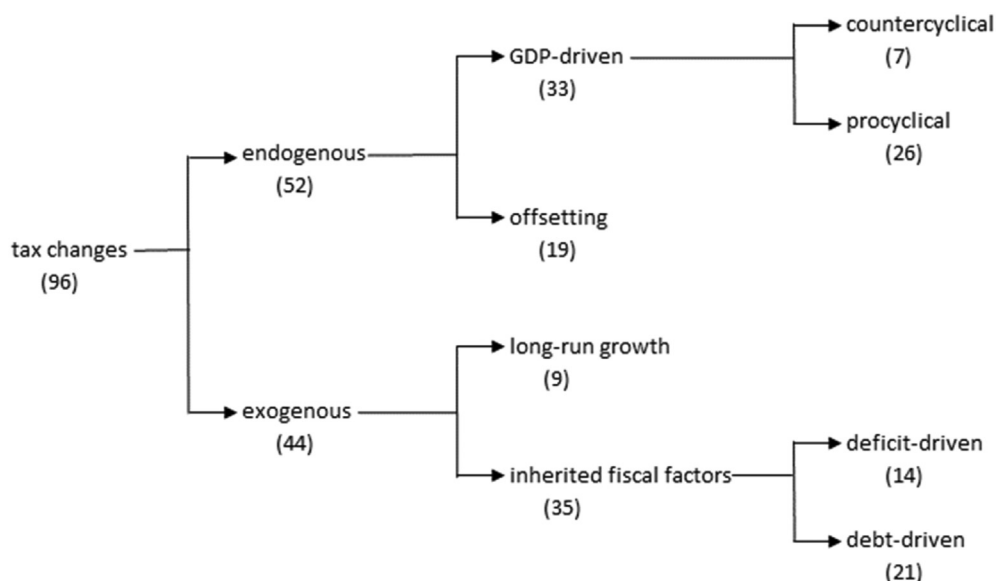
Fig. 1. Classification of VAT rate changes. Note: The numbers in brackets represent the number of tax changes in each category.

3.1. Identification strategy

We identify a total of 96 VAT rate changes in 35 countries (18 industrial and 17 developing). Given the time coverage of these 35 countries, there is, on average, a VAT rate change every 11 years with an average change (in absolute value) of 1.9 percentage points. The remaining 16 economies 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.

Following RR's identification strategy, we divide VAT rate changes into (i) those taken as a result of current or prospective output growth differing from normal and/or in response to other factor(s) likely to affect output growth in the near future, which are referred to as *endogenous*, and (ii) those taken for other reasons, which are referred to as *exogenous*. Table 1 summarizes the classification of each of the 96 tax changes according to the criteria described below.[14] When applying these criteria – and as discussed by RR – we typically find substantial agreement across various sources on the nature of each tax change. When different motives enter into the picture, we try to ascertain if one was given more weight than the others. The remainder of this section describes the nature of each classification category and discusses some illustrative examples.

3.2. Endogenous tax changes

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

• GDP-driven tax changes are those 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.[15]

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

– Countercyclical tax changes: Tax changes aimed at stabilizing output around trend, which implies either cutting taxes in recessions or increasing taxes during booms. In our sample, the most common countercyclical tax change is a tax cut in response to a current or prospective recession with the aim of stimulating economic activity.[16] A clear example would be Thailand in 1999. After increasing the VAT rate from 7% to 10% during the Asian crisis in the summer of 1997, Thai authorities attempted to revive domestic demand by reducing the VAT rate back to 7% 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.

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[14] A detailed analysis of each tax rate change, including a list of key country references, can be found in an online supplement.

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

[16] In 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).

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 hike implemented in Sweden in 1990 (with the VAT rate increasing from 23.5 to 25%) 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 prospective recession (boom).[17] 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.[18] The most common explanations for such procyclical behavior 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. While procyclical fiscal policies have been most common in developing countries, they have also been observed in several Eurozone countries since the global financial crisis of 2007–2008.

The most common procyclical tax change is a tax hike enacted in response to a current (or prospective) 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 public debt. Under these circumstances, 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 sudden economic crises, including the increases (i) from 10% to 15% in Mexico (March 10, 1995) as a result of the Tequila crisis, (ii) from 18% to 21% in Argentina (March 16, 1995) as a result of the contagion effects of the Tequila crisis, (iii) from 7% to 10% in Thailand (August 5, 1997) as a result of the Asian financial crisis, (iv) from 10% to 12% in Ecuador (October 26, 1999) after the 1998–1999 Ecuadorean economic crisis, and (v) several tax hikes in Europe (Czech Republic, Finland, Greece, Hungary, Ireland, Latvia, Lithuania, Portugal, Romania, Spain, and the United Kingdom) during the 2008–2010 period, following 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 enacted in France (March 1, 2000), when a stronger-than-expected fiscal position led to a reduction in the VAT rate from 20.6% to 19.6%.

We should note that, as Fig. 1 indicates, procyclical tax changes are much more prevalent than countercyclical ones, with close to 80% (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. Specifically, around 70% (or 12 out of 17) of GDP-driven tax changes are procyclical in industrial countries, compared to close to 90% (or 14 out of 16) in developing economies.

• Offsetting tax changes are those intended to offset other factor(s) that would likely move output growth away from normal. More precisely, offsetting tax changes 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.[19] Since these tax changes are, though indirectly, responding to changes in GDP, we have again a problem of reverse causality. As indicated in Fig. 1, we identify 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% (or 13 out of 60) of total tax changes in industrial and 17% (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' intentions in this regard. However, even when that link is not made explicit, it is appropriate to classify these type of changes as endogenous. Specifically, we found the following cases:

– In 4 cases, VAT rates 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 Calderon Sol increased the VAT rate from 10% to 13% 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," as stated by Mr. Fernandez, the IMF official at the time. In the same vein, Norway increased the VAT rate from 23% to 24% 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 reductions in personal, corporate, and labor taxes 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 by 7 percentage points (from 8% to 15%) as part of a major tax reform intended to partially offset 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 Czech Republic reduced the standard VAT rate from 22 to 19% and shifted over 25% of the consumption basket of goods and services from the reduced to the standard VAT rate.

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[17] We identified 26 procyclical tax changes (12 in industrial countries and 14 in developing ones).

[18] See Gavin and Perotti (1997), Kaminsky et al. (2004); Talvi and Vegh (2005), Alesina et al. (2008), Frankel et al. (2013), Vegh and Vuletin (2015) and Avellán and Vuletin (2015).

[19] We 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.

3.3. Exogenous tax changes

Following RR's identification strategy, exogenous tax changes are those *not* made in response to (i) current or prospective 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 conditional on observables. We identify a total of 44 exogenous tax changes (30 in industrial countries and 14 in developing ones).

In turn, exogenous tax changes are classified 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. Such 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% 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 in 2008, the government reduced the VAT rate by 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.[20] The critical point is that in neither case the change in the tax rate responds to the current (or prospective) state of the economy but rather to past actions that may have caused a fiscal deficit to be 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.[21] In general, the identification of this type of tax changes is clear from the sources. 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 and 2001, when VAT rates increased from 6.5 to 7.5% and from 7.5 to 7.6%, respectively. After running primary budget surpluses for much of the 1980s, a prolonged period of economic stagnation during 1991–1996 (with average GDP growth rates of only 1%) caused the primary deficit to steadily increase, reaching about 2% of GDP in 1997 and 1998. While low by international standards, the rapid growth in the fiscal deficit during the first half of the 1990s caused public concern. 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. Clearly, 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 for 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."

  Other examples of tax changes triggered by inherited public debt are those that took place in Europe (Hungary, Ireland, Italy, Netherlands, Poland, Portugal, and the 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 a 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.

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[20] 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.

[21] Occasionally, fiscal packages aimed at dealing with inherited fiscal factors include not only tax increases but also cuts in government spending. To this effect, government spending will be used as a control variable in our empirical specifications. If we also included changes in corporate tax rates and/or the highest personal income tax rate, results would not be affected. Unfortunately, as already discussed, we do not have the average marginal personal tax rate.

4. Linear estimations

Having identified and classified all the tax changes in our sample, we can now proceed to the econometric analysis.[22] This section first introduces our basic linear specification and then discusses the results, the role of expectations, and the mechanisms involved.

4.1. Basic specification

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

The use of LP provides several advantages over the traditional SVAR methodology pioneered by BP. Specifically, LP (i) can be estimated by single-regression techniques (least-squares dummy variables, LSDV, 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 at horizon h is estimated based on the following regression:

$$\Delta y_{i,t+h} = \alpha_{i,h} + \beta_h \Delta\tau_{i,t}^{exog} + \sum_{l=0}^{L} \lambda_{lh}\Delta y_{i,t-1-l} + \sum_{l=0}^{L} \psi_{lh}\Delta\tau_{i,t-1-l}^{all} + \sum_{l=0}^{h-1} \omega_{lh}\Delta\tau_{i,t+h-l}^{exog} + \sum_{l=0}^{L} \phi_{lh}\Delta g_{i,t-1-l} + \mu_{i,t+h}, \tag{1}$$

where subscripts i and t denote country and time, respectively, α_i is the country fixed effect, y and g are the logarithm of real GDP and real government spending, respectively, Δy and Δg measure the respective growth rates (expressed as the difference in logarithms), VAT tax rate changes ($\Delta\tau^{exog}$ and $\Delta\tau^{all}$) are expressed in percentage points, and μ is the error term.[23] In order to correct for the potential bias in the local projections estimator when ignoring shocks occurring between periods $t+1$ and h (see Teulings and Zubanov, 2014), we add a vector of leads of our main exogenous shock. Unlike the SVAR specification, the estimated coefficients contained in the polynomial lags are not used directly to build the impulse response function (IRF) values but only serve as controls, "cleaning" the β_h coefficients from the dynamic effects of output and the effects of past changes in government spending and past tax rates. For this reason, the VAT tax rate changes serving as controls include all VAT tax rate changes (i.e., $\Delta\tau^{all}$). In contrast, the VAT tax rate changes used to identify the effect on output have to be exogenous in nature (i.e., $\Delta\tau^{exog}$). It is important to note that, in this LP approach, each step in the cumulative IRF is obtained from a different individual equation. Defining $\Delta y_{i,t+h}$ as the accumulated output growth from $t-1$ to $t+h$ (i.e., $\Delta y_{i,t+h} \equiv y_{i,t+h} - y_{i,t-1}$), the cumulative IRF values are obtained directly from the estimated coefficients β_h at each time horizon h. Therefore, each coefficient β_h represents the step in the cumulative IRF at a forward time h and is read as the accumulated response of output growth to a one percentage point increase in the tax rate.

While conceptually appropriate, a drawback of using tax rate changes as the independent variable in Eq. (1) 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 percentage change in GDP to the change in the tax rate and not in the tax revenue. To think in terms of standard multipliers, we define the multiplier for time horizon h as[24]

$$Tax\,multiplier\,(h) \equiv \frac{\Delta Y_h}{\Delta R_h} \equiv \frac{\sum_{j=0}^{h}\Delta Y_j}{\sum_{j=0}^{h}\Delta R_j}, \tag{2}$$

where Y and R are real output and real VAT revenue, respectively. Following Barro and Redlick (2011, pp. 80–81), the tax multiplier (which links the change in GDP to the change in revenue) at time horizon h is then computed exploiting the typical relationship between tax revenue and the tax rate[25]:

$$Tax\,multiplier\,(h) = \frac{\beta_h}{e\cdot\rho_h + \beta_h\cdot I}, \tag{3}$$

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[22] See Appendix 3 for data definitions, sources, and sample of countries.

[23] To control for potential cross-sectional dependence, we use robust Driscoll-Kraay errors in all our baseline specifications. Given the large number of zeros in our dependent variable and following Romer and Romer (2010), the reported standard errors are computed by taking 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.

[24] No substantial difference in our results would arise if we discounted by the median real deposit rate.

[25] See Appendix 4 for the derivation of the following two expressions.

where I captures the relationship between real VAT revenue and real output, e measures the relationship between I and the VAT rate τ, and ρ_h captures how permanent is the initial tax shock at time horizon h.[26]

Using a first-order approximation of (3), the standard error of the tax multiplier can be written as

$$Tax\,multiplier_{SE}(h) = \frac{e \cdot \rho_h}{(e \cdot \rho_h + \beta_h \cdot I)^2} \beta_h^{SE}, \tag{4}$$

where β_h^{SE} is the standard error of coefficient β_h. We now use this methodology to estimate the size of the tax multiplier.

4.2. Basic results

Based on specification (1) and Eqs. (3)–(4), Fig. 2 shows the estimated tax multipliers at different time horizons using exogenous legislated tax rate changes (Panel A) and all legislated tax rate changes (Panel B).[27,28,29,30,31,32] Naturally, the use of all (as opposed to exogenous) legislated tax rate changes is subject to misidentification.

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 (see Panel A in Fig. 2). Specifically, the multiplier is -1.1 ($t = -2.5$) on impact and becomes more negative with longer horizons until reaching -2.7 ($t = -1.9$) after eight quarters. Notice that this tax multiplier of -2.7 is on the lower side (in absolute value) compared to recent evidence based only on industrial countries, which finds tax multipliers ranging from -2 to -5.

What happens when using all legislated tax rate changes? That is to say, when relying only on the BP identification strategy? Panel B in Fig. 2 shows that when using all legislated tax rate changes, the tax multiplier obtained is even more negative, particularly in the long run. Indeed, after eight quarters, the multiplier is -3.0 ($t = -3.1$), which is about 10% larger (in absolute value) than that obtained when using only exogenous tax changes. The difference arises because of the incorrect inclusion of endogenous – and, on average, procyclical – tax changes in the sample used to estimate tax multipliers.[33]

4.3. The role of expectations

In deriving our measure of tax multipliers, the date of tax changes corresponds to the date in which tax changes were actually implemented. Expectations, however, could also matter. As discussed in RR and Alesina et al. (2015), announcements may lead to anticipation effects of tax changes. To explore this issue, Fig. 3 shows the density function of the number of days between passage and implementation of exogenous tax rate changes. The lag between the official passage of the law and its implementation is relatively short, with a median lag of 57 days (i.e., less than a quarter). In particular, 66% (or 29 out of 44) of exogenous tax changes were officially enacted and implemented within the same quarter, 23% (or 10 out of 44) of exogenous tax changes were officially enacted one quarter before the shock, and 11% (or 5 out of 44) of exogenous tax changes were officially enacted at least two quarters before the shock.

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[26] For tax multiplier calculations, we use the sample average values of e (39%) and I (6.2%). While there is some variation across countries, the variability is fairly small. The standard deviations of e and I are 8 and 1.8%, respectively. The estimated ρ_h for different time horizons h ranges from 0.99 (for ρ_1) to 0.91 (for ρ_8). Out of the 44 exogenous cases, (i) in only 5 cases there is a tax change within a two-year period, and (ii) there is no tax change within a one-year period. This evidence, together with the fact that values of ρ_h are close to one, suggests that most VAT rate changes are, by and large, of permanent nature.

[27] We use four lags (i.e., $L = 4$) in specification (1). The selection of four lags balances the need to account for a sufficiently long structure of lags while preserving 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 lags remain almost the same as in the four-quarter specification. See Appendix 5.1 for more details.

[28] In specification (1), we control for government spending for reasons discussed in Section 3. As also discussed in Section 3, if we included changes in standard corporate and highest personal income tax rates, results would not be affected. Unfortunately, as already mentioned, we do not have the average marginal personal tax rate. See Appendix 5.2 for more details.

[29] We should note that Jorda'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 (2016) 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 up to 8 quarters after fiscal and GDP shocks.

[30] As discussed in Section 4.1 and in footnote 26, we use the sample average values of e, I, and estimated ρ_h for different time horizons h to transform the coefficients β_h (which link the percentage change in GDP to the change in the tax rate) for our tax multiplier calculations (which link the change in GDP to the change in revenues). Appendix 5.3 shows the percentage change in GDP in response to the change in the tax rate (i.e., coefficients β_h) obtained directly from specification (1). The profile depicted by Panel A in Fig. 2 is virtually identical to the one obtained when directly focusing on the coefficients β_h (i.e., without applying any transformation). Appendix 5.3 shows that this finding also applies to the non-linear arguments presented later.

[31] As a robustness check, Appendix 5.4 presents our basic results using an alternative structure of errors (i.e., two-way clustered robust standard errors).

[32] Specification (1) controls for real GDP. Since some VAT reforms might have reflected movements in consumption rather than GDP, Appendix 5.5 shows that if we also included changes in consumption and consumer price index, results would not change.

[33] This evidence of endogenous and procyclical tax changes is in line with the results of Vegh and Vuletin (2015).

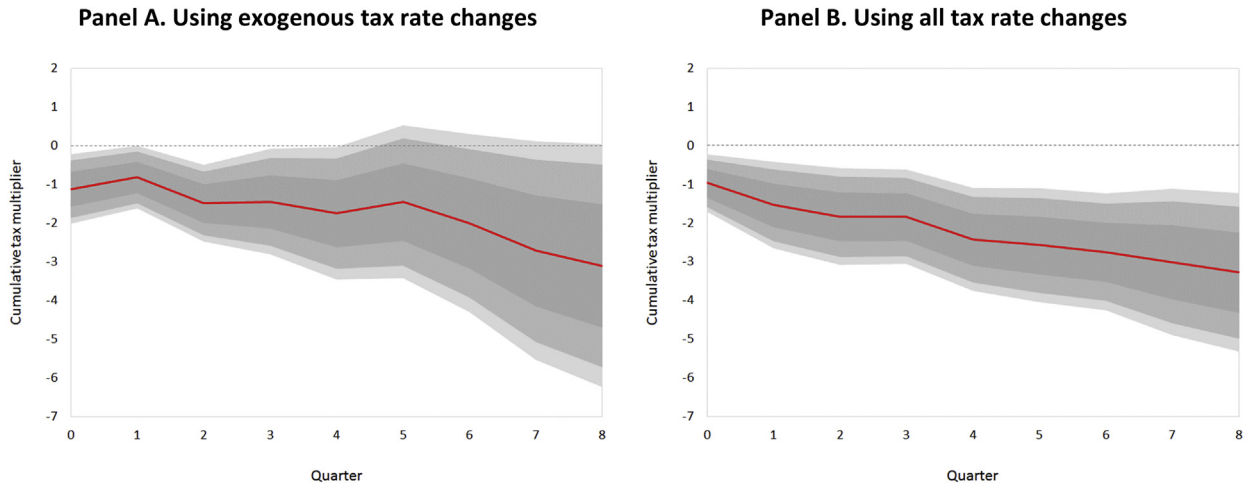**Panel A. Using exogenous tax rate changes**   **Panel B. Using all tax rate changes**

Fig. 2. Cumulative tax multiplier: All versus exogenous legislated tax rate changes. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.
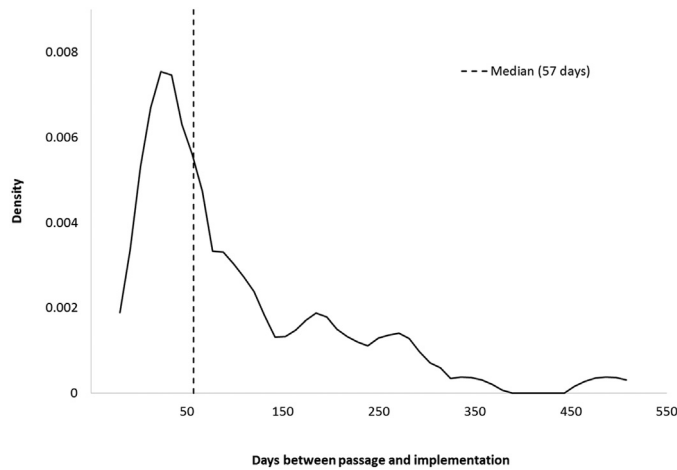

Fig. 3. Density function of days between official passage and implementation of exogenous tax rate changes.

In order to control for possible anticipation effects arising from announcements, we follow RR's strategy of adding to our previous specification (1) terms reflecting the news about future taxes when tax changes are officially enacted. Formally,
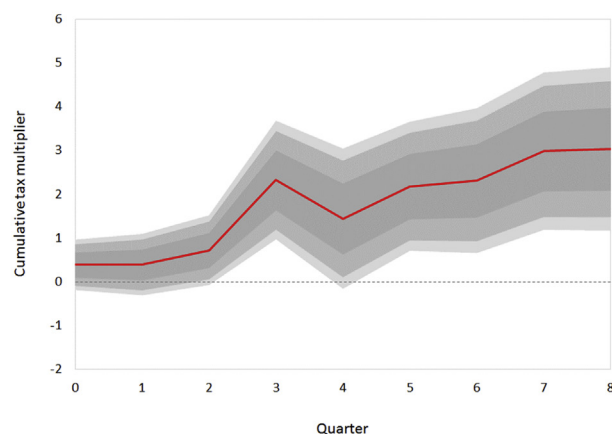
$$
\Delta y_{i,t+h} = \alpha_{i,h} + \beta_h \Delta \tau_{i,t}^{exog} + \gamma_h \Delta \text{News}_{i,t}^1 + \delta_h \Delta \text{News}_{i,t}^{2+} + \sum_{l=0}^{L} \lambda_{lh} \Delta y_{i,t-1-l} + \sum_{l=0}^{L} \psi_{lh} \Delta \tau_{i,t-1-l}^{all}
$$
$$
+ \sum_{l=0}^{h-1} \omega_{lh} \Delta \tau_{i,t+h-l}^{exog} + \sum_{l=0}^{L} \phi_{lh} \Delta g_{i,t-1-l} + \mu_{i,t+h},
$$

(5)

where ΔNews^1 indicates changes in exogenous tax rates in the quarter of the official passage of the law if the passage occurred one quarter before the shock, and ΔNews^{2+} indicates changes in exogenous tax rates in the quarter of the official passage of the law if the passage occurred at least two quarters before the shock. Fig. 4 then shows the response of output to the official passage of the law as well as to its implementation. Interestingly, Panel A in Fig. 4 shows that if the official passage of the law occurred one quarter before the shock, output does not show an anticipated reaction. In contrast, when the official passage of the law occurred at least two quarters before the shock, output increases at the time of the official passage (see Panel B). This suggests that anticipation effects exist

Panel A. Cumulative multiplier after the official passage of the legislated tax rate change if passage occured one quarter before the shock
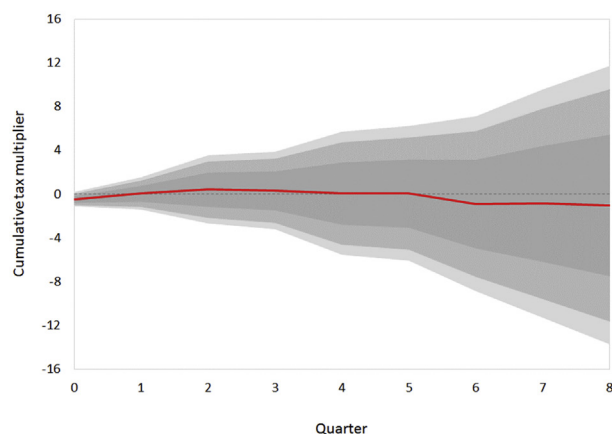
Panel B. Cumulative multiplier after the official passage of the legislated tax rate change if passage occured at least two quarters before the shock

Panel C. Cumulative multiplier after the implementation of the legislated tax rate change
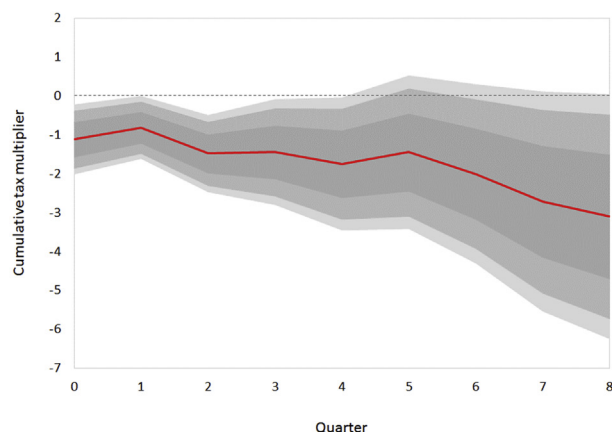

Fig. 4. Cumulative tax multipliers using exogenous legislated tax rate changes and controlling for the announcement date. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

only when there is enough time for agents to learn and react accordingly.[34] In particular, when the official passage of the law occurred at least two quarters before the shock, news about tax changes (proxied by the official passage of laws) seem to lead to intertemporal substitution effects in the sense that output increases in response to the news (Panel B) even though it falls when the law is actually implemented (Panel C). More importantly for our purposes, estimates of the tax multiplier itself remain robust, even if one considers the role of tax rate news (see Panel C).[35]

4.4. Transmission mechanisms

We have found that exogenous tax increases (decreases) have a strong contractionary (expansionary) effect on output. We now focus on the mechanisms involved by evaluating the response of aggregate components of GDP and labor-related variables. As expected – since consumption would be the first margin through which the VAT rate should operate – Panel A in Fig. 5 shows

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[34] As shown in Appendix 5.6, if we computed the overall effect of news (i.e., using one single ∆News resulting from the addition of ∆News[1] and ∆News[2+]), output does not react much like in Panel A, Fig. 4. This is not surprising considering the asymmetric response observed in Panels A and B in Fig. 4 and that only a third (or 5 out of 15) of anticipated exogenous tax rate changes are officially passed at least two quarters before the shock.

[35] The total effect of anticipated shocks after implementation is not shown in the plots. There are arguments against the use of anticipated shocks in a LP framework and concerns about potential endogeneity. As a robustness check, we ran the main regressions excluding the few anticipated shocks in our sample and only including exogenous unanticipated shocks. The results were quantitatively very similar and, qualitatively, our story remained intact. These results are available in Appendix 5.6.
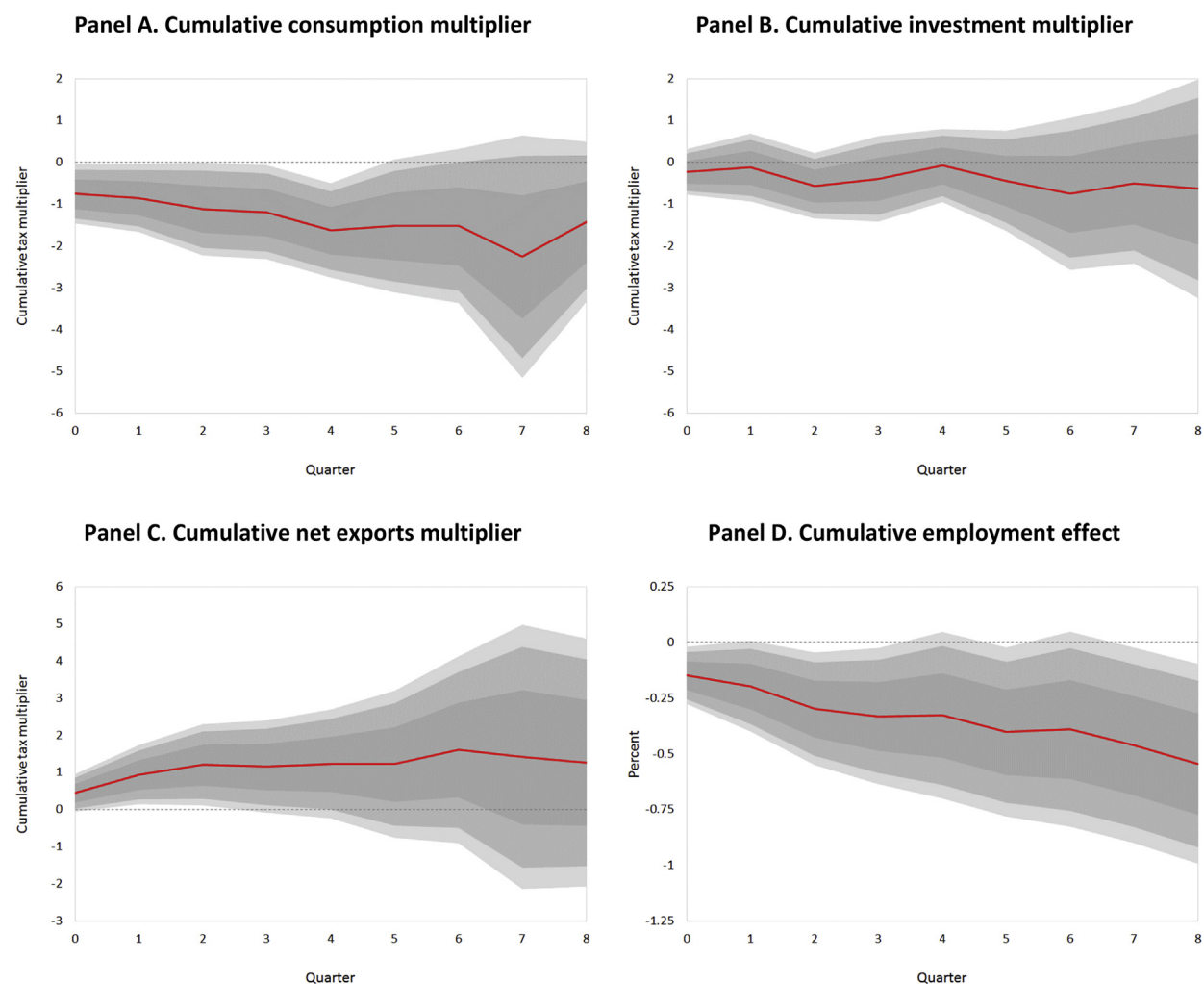
Fig. 5. Impact of exogenous legislated tax rate changes on components of GDP and employment-related variables. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

that increases (decreases) in the VAT rate reduce (increase) consumption. Panel B shows that changes in the VAT rate do not seem to significantly affect investment. Panel C shows that increases (decreases) in the VAT rate raise (reduce) net exports, which is consistent with the so-called fiscal devaluations since an increase in the VAT rate reduces consumption (and hence imported goods) but not exports (which are typically not subject to VAT).[36] Panel D in Fig. 5 shows that increases (decreases) in the VAT rate reduce (increase) employment, which is consistent with our simple static model with a labor/leisure choice in Appendix 2.

4.5. Industrial Europe versus rest of sample

As discussed in the Introduction, since RR's seminal contribution, a growing number of studies (especially with focus on industrial Europe) have found large (in absolute value) negative tax multipliers, varying between −2 and −5 (after two years of the tax shock). Motivated by such emerging consensus based on this group of countries, Fig. 6 shows the results when splitting our global sample into industrial European economies (Panel A) and the rest of our sample (Panel B). After two years of the tax shock, we find tax multipliers of −3.6 ($t = -1.9$) and −1.4 ($t = -0.7$), respectively. Hence, while the tax multiplier in industrial European countries is quite negative and statistically significant (and in the middle of the range of −2 to−5 found in recent studies), the tax multiplier in the rest of the countries is about 2.5 times smaller (in absolute value) and much weaker, statistically-speaking.

The difference in the size of tax multipliers observed in Fig. 6 naturally raises the question of why would this be the case. Specifically, why are tax multipliers larger (in absolute value) in industrial European economies (in line with recent studies) than those

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[36] Fiscal devaluations are changes in taxes which, by increasing the relative price of importables in terms of exportables, are expected to mimic the effects of a nominal devaluation of the currency; see, for example, Keen and de Mooij (2012).
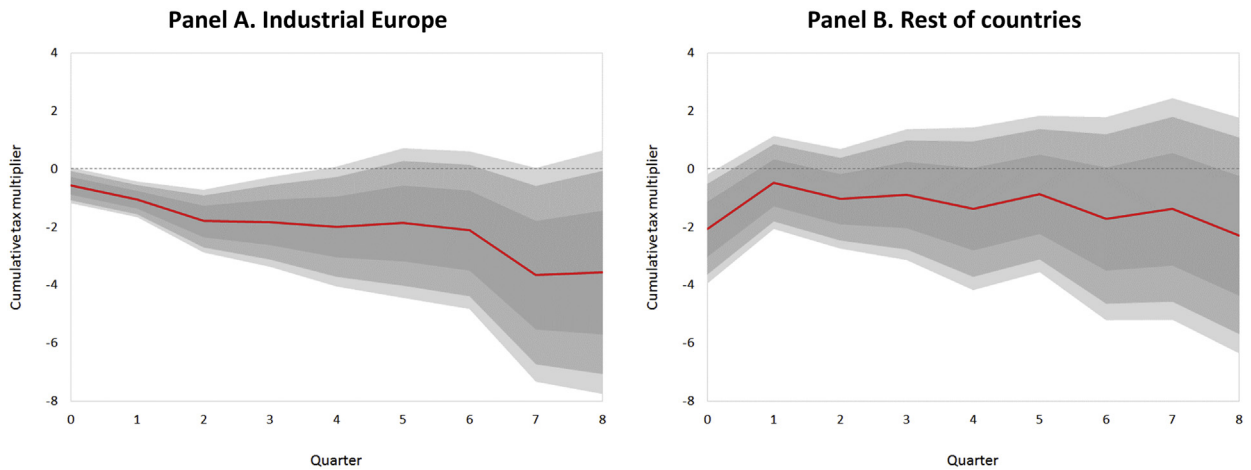
Panel A. Industrial Europe

Panel B. Rest of countries

Fig. 6. Cumulative tax multipliers for industrial Europe and rest of countries. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

observed elsewhere? One explanation could be that the macroeconomic context associated with different tax changes varies across these groups of countries which, in turn, could affect the size of the multiplier. While it proves impossible to consider all potential factors, at least we cannot reject the null hypothesis that the existence of different type of exchange rate regimes, the size of public debt as a percentage of GDP, and trade and capital account openness are the same for tax changes in industrial European and the rest of the sample.[37] While, in principle, we cannot rule out other plausible considerations, we show in the next section that a simpler explanation at work could simply rely on non-linear distortionary and disincentive-based effects of tax rates on output.[38]

5. The non-linear effect of tax changes on output

As discussed in the Introduction, and based on different types of distortionary and disincentive-based theoretical frameworks, the output effect of tax changes is expected to be small at low initial levels of taxation but exponentially larger (in absolute value) when initial tax levels are high. Therefore, the distortions and disincentives imposed by taxation on economic activity are directly, and non-linearly, related to the level of tax rates.

This section first shows that these non-linear theoretical arguments are actually present empirically, and then that they can also explain, to a large extent, the linear findings of Section 4.5 when estimating the tax multiplier for industrial Europe and the rest of the sample. We also show that the same non-linear arguments are present in RR's sample.

5.1. 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 (1) as follows:

$$\Delta y_{i,t+h} = \alpha_{i,h} + \beta_h \Delta \tau_{i,t}^{exog} + \kappa_h \left[\Delta \tau_{i,t}^{exog} \cdot \tau_{i,t-1}^{all} \right] + \upsilon_h \tau_{i,t-1}^{all} + \sum_{l=0}^{L} \lambda_{lh} \Delta y_{i,t-1-l} + \sum_{l=0}^{L} \psi_{lh} \Delta \tau_{i,t-1-l}^{all}$$
$$+ \sum_{l=0}^{h-1} \omega_{lh} \Delta \tau_{i,t+h-l}^{exog} + \sum_{l=0}^{L} \phi_{lh} \Delta g_{i,t-1-l} + \mu_{i,t+h},$$
(6)

where the only difference is the introduction of the initial tax rate level interacting with the change in the tax rate and, naturally, the term associated with the initial tax rate for control purposes, as captured by the third and fourth terms, respectively, on the right-hand side.[39,40]

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[37] See Appendix 5.7 for details.

[38] Appendix 5.7 also shows that common macroeconomic-based arguments are not related to the distortionary and disincentive-based channels emphasized in this paper.

[39] In this non-linear specification, the tax multiplier defined in expression (3) becomes *Tax multiplier* $(h) = [\omega_h]/[e \cdot \rho_h + \omega_h \cdot I]$, where $\omega_h \equiv \beta_h + \delta_h \cdot \tau^{all*}$, and τ^{all*} represents the initial tax rate level at which the multiplier is evaluated. Similarly, the standard error of the tax multiplier defined in expression (4) becomes *Tax multiplier*$_{SE}(h) = [e \cdot \rho_h \cdot \omega_h^{SE}]/[(e \cdot \rho_h + \omega_h \cdot I)^2]$, where ω_h^{SE} is the standard error of ω_h.

[40] In specification (6), the initial tax rate level interacting with the change in the tax rate is captured in $t-1$ which, in turn, might be correlated with the past history of structural shocks. Even though tax rate changes are infrequent, and since it is not obvious that controlling for the lagged dependent variable and government spending is enough to rule this out, Appendix 5.8 tests the proposed non-linearity using a set of constant initial conditions fixed at the beginning of our sample. The results are robust to this consideration.
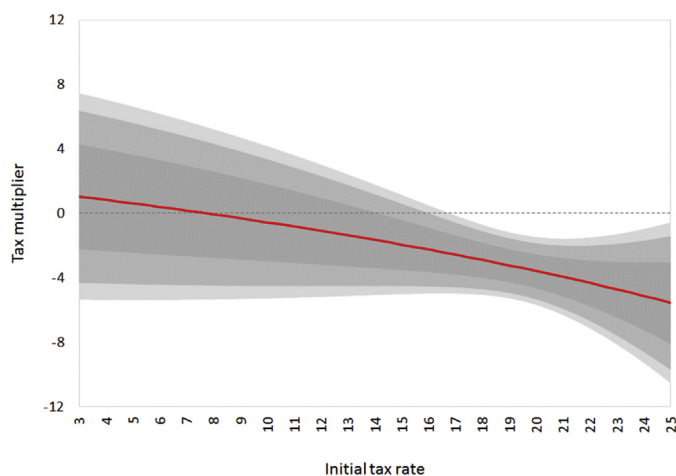
Fig. 7. Non-linear cumulative tax multiplier after two years: The role of the initial tax rate level. Notes: Country fixed-effects, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

Fig. 7 shows the estimated tax multipliers after two years, evaluated at different initial levels of tax rates. It is worth noting that our estimates are based on a global sample of 51 countries with VAT rates ranging from 3 to 25%.[41] There is 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 relatively low levels of initial tax rates, it becomes statistically significant and increasingly negative with higher initial tax rates. In other words, the fall (increase) of output associated with raising (reducing) revenues by $1 tends to be zero for low levels of initial tax rates and becomes larger as the initial tax rate increases. For example, the multiplier is -0.07 ($t = -0.02$) when the initial tax rate is 8%, -1.6 ($t = -0.9$) when the initial tax rate is 14%, and -4.3 ($t = -3.1$) when the initial tax rate is 22%. Recall that the tax multiplier based on the linear specification (1), and reported in Panel A of Fig. 2, takes a value of -2.7 ($t = -1.9$) after two years of the tax rate shock.

This evidence provides support for distortionary and disincentive-based arguments as plausible mechanisms in explaining a non-linear effect of tax rate changes on economic activity, with essentially zero effects under relatively low 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 more revenues might be able to raise tax rates without hurting economic activity too much when starting at low, or even 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 virtually no output increases when cutting taxes from low levels).

These findings have important policy implications given that the initial level of taxes varies greatly across countries and thus so will the potential output effect of changing tax rates. Fig. 8 shows that, given countries' current VAT rate, the tax multiplier can be relatively small (lighter colors), or moderate to high (more intense red colors). For example, tax increases would cause virtually no effect on GDP in countries with low tax rates such as Angola, Costa Rica, Guatemala, Nigeria, and Paraguay. In contrast, the same tax increase (decrease) would cause output to fall (increase) in countries with relatively high VAT rates including some emerging markets like Argentina and Uruguay and, especially, many industrial European countries. Appendix 6 shows that, when relying on RR's U.S. dataset, the same type of non-linear arguments are present.

5.2. Non-linearity in action: Industrial Europe versus rest of sample

So far, Subsection 5.1 showed that the aforementioned non-linear arguments regarding the effect of tax changes on output are of critical importance in determining the size of the tax multiplier. But do the differences in initial tax rate levels observed in industrial European and the rest of the sample actually help explain some of the differences in tax multipliers (based on linear estimations) identified in Subsection 4.5?

Indeed, tax changes in industrial European countries have higher initial VAT rates than those observed in other countries; 21% versus 19%, respectively.[42] These differences suggest that the reason behind the more negative tax multipliers observed in industrial European countries relative to those of the rest of the sample is that, typically, the former group of countries has higher initial tax rates. Fig. 9 provides further evidence that these non-linear arguments are actually at work. The median value of the tax multipliers computed for each group of countries, based on the non-linear specification (6), matches very well the tax multiplier for each group of countries estimated in a linear fashion in Subsection 4.5. Moreover, when focusing on current VAT rates for the

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[41] In the year 2018, VAT rates around the world range from 5 to 27%.
[42] Moreover, we can reject the null hypothesis that these medians are statistically the same at the 10% significance level.
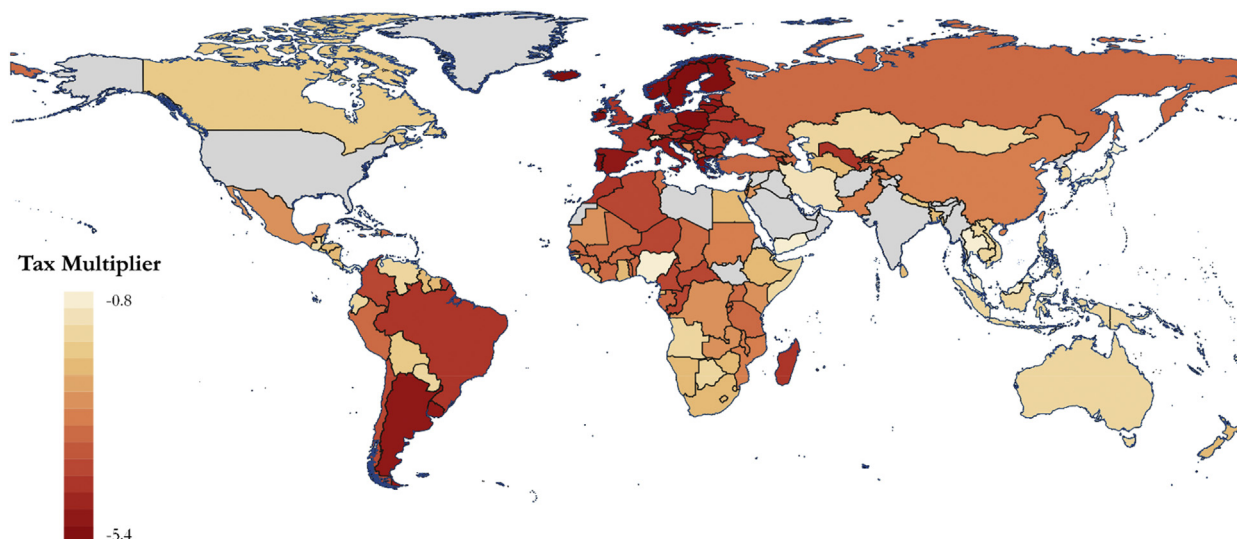
Fig. 8. Tax multipliers after two years for countries around the world.
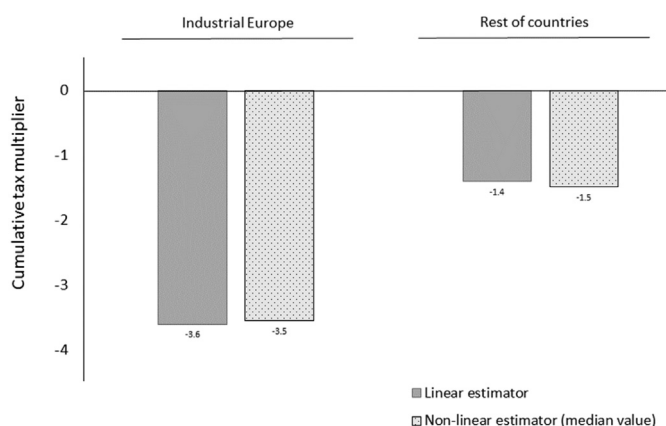

Fig. 9. Cumulative tax multiplier evaluated after two years: Linear versus non-linear multipliers. Notes: Country fixed-effects panel regression.

same group of countries used in Alesina et al. (2015), we obtain a tax multiplier (after two years of the tax shock) of −2.3 (versus −2 in their analysis).[43]

6. Final thoughts

This paper has estimated tax multipliers for a large group of countries following the narrative approach. Specifically, based on a novel dataset of VAT rates in 51 countries (20 industrial and 31 developing) and contemporaneous economic records and sources, we have identified 96 tax rate changes and classified them into endogenous and exogenous to current (or prospective) economic conditions. We show, as in RR, that the tax multiplier is negative, indicating that tax hikes reduce economic activity and tax cuts boost output. A plausible explanation is that increases (decreases) in the VAT rate reduce (increase) the incentives to consume and work. However, we found – both for our global sample and for RR's U.S. dataset – that such "average" multiplier hides important non-linearities. In line with theoretical models based on distortionary and disincentive-based type of arguments, we find that the tax multiplier is essentially zero for relatively low initial tax rate levels but markedly negative when initial tax levels are high. These findings lead to 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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[43] For Canada, we use the sum of (i) the federal goods and services tax of 5% and (ii) the average provincial sales tax of 8%, which results in an average sales tax of about 13%. For the United States, we combine state and average local sales tax rates, which results in an average of 6.5%.

Appendix 1. Responses of tax policy to recent earthquakes

Ecuador 2016: On April 16, 2016, Ecuador suffered a severe earthquake (of magnitude 7.8). According to contemporaneous estimates, GDP was expected to fall about 1% as a result of the disaster, and reconstruction costs were estimated to be about 3 to 4% of GDP. On April 20, President Correa announced an increase of 2 percentage points in the VAT rate (from 12 to 14%). Congress passed the VAT increase on May 12 and it was implemented on June 1. The time elapsed between the natural disaster and the passage (implementation) of the tax change was 26 (46) days.

Japan 2011: On March 11, 2011, Japan suffered a "triple disaster" (earthquake-tsunami-nuclear meltdown), with an earthquake of magnitude 9.0. According to contemporaneous reports, the economic damages were estimated to be about 6 to 7% of GDP. The earthquake hit Japan's North-Eastern region, responsible for 6 to 8% of the country's total production. On April 27, several special national tax laws were enacted and became effective immediately. Also, an expected cut of 5 percentage points in the corporate tax rate (announced on December 2010 by the Prime Minister) was deferred due to the earthquake. The time elapsed between the natural disaster and the passage and implementation of tax changes was 47 days.

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

California 1989: On October 17, 1989, California suffered a severe earthquake (of magnitude 6.9). According to contemporaneous reports, the economic damage was estimated to be about 1% of California's GDP. The governor called for a special session of the legislature to address the needs for earthquake relief to be held on November 2. On November 4, legislation was passed that included a one-year 0.25% surcharge to the state's sales tax. The tax increase became effective on December 1. The time elapsed between the natural disaster and the passage (implementation) of the tax change was thus 18 (45) days.

Appendix 2. Model

This appendix develops a simple static model with a labor/leisure choice, linear production, and a consumption tax. It then derives the corresponding tax multiplier.

2.1. Households

Preferences take the familiar CES form:

$$U = \log z, \tag{7}$$

where U is utility and z is a composite good given by

$$z = \left[qc^{\frac{\rho-1}{\rho}} + (1-q)h^{\frac{\rho-1}{\rho}} \right]^{\frac{\rho}{\rho-1}},$$

where c is consumption, h is leisure, $1 < q < 0$ is a parameter, and ρ is the elasticity of substitution between consumption and leisure.

The production function, operated by households, is linear:

$$y = 1-h. \tag{8}$$

The budget constraint is thus given by

$$c(1 + \tau) = 1-h + T, \tag{9}$$

where τ is the consumption tax rate and T is a lump-sum transfer from the government (to eliminate wealth effects from taxation).

Households choose c and h to maximize (7) subject to constraint (9). The first-order conditions can be combined to yield:

$$\left(\frac{h}{c} \right)^{\frac{1}{\rho}} = 1 + \tau, \tag{10}$$

where, to simplify and without loss of generality, we assumed $q = 1/2$. As expected, a higher tax rate increases the relative price of consumption in terms of leisure and hence leads to a higher ratio of leisure to consumption.

2.2. Government

The government transfers back to households the proceeds from the consumption tax:

$$T = \tau c. \tag{11}$$

2.3. Aggregate constraint

Combining constraints (9) and (11) yields the resource constraint for the economy as a whole:

$$c = 1 - h. \tag{12}$$

2.4. Solution of model

Using the optimality condition (10) and the resource constraint (12), we obtain reduced forms for consumption and leisure:

$$c = \frac{1}{1 + (1 + \tau)^\rho}, \tag{13}$$

$$h = \frac{(1 + \tau)^\rho}{1 + (1 + \tau)^\rho}. \tag{14}$$

As expected, consumption is a decreasing function of the tax rate and, as is trivial to show, leisure is an increasing function of the tax rate. This implies that labor is a decreasing function of the tax rate. Hence, the higher the tax rate, the lower are consumption and output.

2.5. Tax multiplier

Following the literature, the tax multiplier is defined as the change in output resulting from a change in tax revenues. Since, in our model, these changes are caused by variations in the tax rate, the formal expression for the multiplier is given by

$$\text{Multiplier} \equiv \frac{dy/d\tau}{dR/d\tau}, \tag{15}$$

where $R(\equiv \tau c)$ denotes tax revenues.

Using (8) and (14), the numerator of the multiplier is given by

$$\frac{dy}{d\tau} = -\frac{\rho(1 + \tau)^{\rho-1}}{[1 + (1 + \tau)^\rho]^2} < 0. \tag{16}$$

The denominator of the multiplier follows from (13) and is given by:

$$\frac{dR}{d\tau} = \frac{1 + (1 + \tau)^{\rho-1}[1 + \tau(1 - \rho)]}{[1 + (1 + \tau)^\rho]^2} > 0, \tag{17}$$

where the positive sign of this expression relies on the assumption that the fiscal authority would never choose to be on the "wrong" side of the Laffer curve because they could raise the same amount of revenues with a lower, and hence less distortionary, tax rate. Specifically, notice that for $\rho \leq 1$, this expression is positive for any value of τ. For values of $\rho > 1$ (and assuming that $\tau \leq 1$ to fix ideas), the numerical solution of the model shows that this expression is positive for values of ρ lower than 2.38. In other words, for values of ρ higher than 2.38, there is a Laffer curve (i.e., revenues as a function of the tax rate reach a relative maximum and then start to decline).

Taking into account (16) and (17), we can write the tax multiplier (15) as

$$\text{Multiplier} = -\frac{\rho(1 + \tau)^{\rho-1}}{1 + (1 + \tau)^{\rho-1}[1 + \tau(1 - \rho)]} < 0. \tag{18}$$

The multiplier is thus always negative. Notice already the special case $\rho = 1$ (i.e., preferences are separable in consumption and leisure), which yields a constant multiplier equal to -0.5.

In general, however, the multiplier will depend on the tax rate. Formally, differentiating (18) with respect to τ, we obtain

$$\frac{d\text{Multiplier}}{d\tau} = -\frac{\rho(\rho-1)(1+\tau)^{\rho-2}\{1+(1+\tau)^{\rho}\}}{\{1+(1+\tau)^{\rho-1}[1+\tau(1-\rho)]\}^2}.$$

This expression is zero for $\rho = 1$ (as we already knew), positive for $\rho < 1$, and negative for $\rho > 1$. Fig. A.2.1 illustrates this by plotting the multiplier as a function of the tax rate for three different values of ρ (0.5, 1, and 1.5). Hence, for values of $\rho > 1$, the model's prediction is consistent with the non-linear estimation shown in Fig. 7, which implies that the multiplier is larger (in absolute value), the larger is the tax rate.
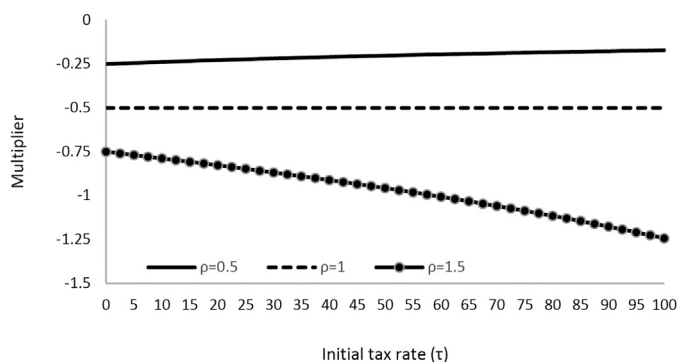

Fig. A.2.1. Tax multiplier as a function of tax rate.

Finally, are there any estimates in the literature that could help us in pinning down the value of ρ in practice? Three considerations come to mind. First, and as expected, direct estimates of ρ (i.e., empirical estimates of the consumption/leisure elasticity) are hard to come by due to obvious reasons (we would need reliable data on leisure). Second, existing estimates of the Frisch elasticity of labor supply provide us with little guidance on the value of ρ because, as is easy to check, the Frisch elasticity in this simple model (for $\tau = 0$) is one, irrespective of the value of ρ. The reason is that, in order to obtain a clean theoretical illustration, we have assumed logarithmic preferences over the consumption composite (or, equivalently, a unitary intertemporal elasticity of substitution if the model were multi-period).[44] In practice, and as reviewed by Reichling and Whalen (2012), Frisch elasticities vary from 0.2 to more than 1 based on micro data and between 2 and 4 based on macro data. Third, indirect evidence on the relevant value of ρ is provided by the fact that, if one believes that a Laffer curve should exist and the only question is the rate for which tax revenues reach a maximum, then $\rho > 1$ must be the relevant range because for any $\rho \leq 1$, there is no Laffer curve in the model. Under this logic, this simple model would predict that the tax multiplier increases (in absolute value) with the tax rate.[45]

Appendix 3. Data definitions, sources, and sample of countries

We constructed quarterly seasonally-adjusted real (using corresponding deflators) measures of gross domestic product, government spending, consumption, investment, net exports, VAT revenue, as well as employment, population, and inflation using data from Global Financial Data, Data Stream, International Financial Statistics, OECD-FRED, and Eurostat. Labor force is from the International Labour Organization. Real wage data are only available for OECD countries based on OECD data.

The sample of countries covers 51 countries, 30 developing and 21 industrial: Argentina, Australia, Austria, Belgium, Botswana, Bulgaria, Canada, Chile, China, Czech Republic, Denmark, Ecuador, Egypt, El Salvador, Finland, France, Germany, Greece, Hungary, India, Ireland, Italy, Jamaica, Japan, Korea, Latvia, Lithuania, Luxemburg, Malta, Mauritius, Mexico, Netherlands, New Zealand, Norway, Paraguay, Philippines, Poland, Portugal, Romania, Russia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, United Kingdom, Uruguay, and Venezuela. Out of the 21 industrial countries, 17 are industrial European. The industrial non-European countries comprise Australia, Canada, Japan, and New Zealand.

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[44] See Violante (2019) for the analytical foundations of the Frisch elasticity.

[45] As Blinder (1981) points out, the existence of a Laffer curve is a mathematical certainty and thus not open to question since tax revenues are zero when the tax rate is zero and would be zero for tax rates high enough to eliminate a given economic activity. Assuming that the function is continuous and differentiable, Rolle's theorem ensures the existence of a relative maximum.

Appendix 4. Computation of tax multiplier and standard error

The derivation of Eq. (3) is as follows. Recall that the multiplier for time horizon h is typically defined as $\Delta Y_h/\Delta R_h$, where R is real VAT revenue, Y is real output, $\Delta Y_h \equiv Y_{t+h} - Y_t$, and $\Delta R_h \equiv R_{t+h} - R_t$. Notice that $\Delta Y_h/\Delta R_h = (\Delta Y_h/Y)/(\Delta R_h/Y)$. From equation (1), $\Delta Y_h/Y = \beta_h \Delta t$. Therefore, $\Delta Y_h/\Delta R_h = \beta_h \Delta t/(\Delta R_h/Y)$. Since $R \equiv I \cdot Y$, then $\Delta R_h \approx Y \cdot \Delta I_h + I \cdot \Delta Y_h$. Further, given that $e \equiv I/t$ is taken as a constant, then $\Delta I_h = e \cdot \Delta t_h$. Hence, $\Delta Y_h/\Delta R_h = \beta_h \Delta t/(e \cdot \Delta t_h + I \cdot \beta_h \cdot \Delta t)$. Since $\Delta t_h \equiv \rho_h \cdot \Delta t$, then $\Delta Y_h/\Delta R_h = \beta_h/(e \cdot \rho_h + \beta_h \cdot I)$.

The derivation of Eq. (4) is as follows. From (3), $Tax\ multiplier = f(x)$, where $f(x) = x/(e \cdot \rho_h + x \cdot I)$. Using a first-order approximation, it follows that $Tax\ multiplier$ evaluated around a equals $f(x) \approx f(a) + f'(a)(x - a) = f(a) + f'(x)x - f'(x)a$. Hence, the variance of the tax multiplier equals $Var[f(x)] \approx 0 + [f'(x)]^2 Var(x) - 0 = [f'(x)]^2 Var(x)$. Evaluating $f(x)$ at β_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 (3), it follows that $Tax\ multiplier_{SE}(h) = [(e \cdot \rho_h)/(e \cdot \rho_h + \beta_h \cdot I)^2] \cdot \beta_h^{SE}$.

Appendix 5. Empirical robustness

5.1. Number of lags

As described in Section 4.2, we use four lags (i.e., $L = 4$) in our empirical specification (1). The plot below illustrates the case of eight lags (i.e., $L = 8$).
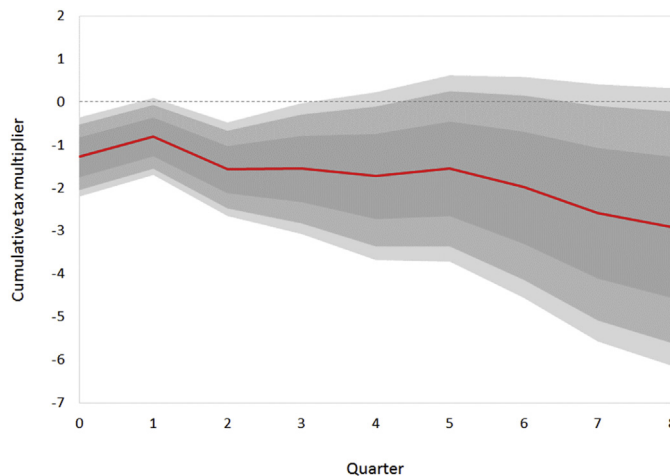

Fig. A.5.1. Cumulative tax multiplier: Using exogenous legislated tax rate changes and eight-lags (instead of four-lags) in specification (6). Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

Data definitions, sources, and sample of countries

We constructed quarterly seasonally-adjusted real (using corresponding deflators) measures of gross domestic product, government spending, consumption, investment, net exports, VAT revenue, as well as employment, population, and inflation using data from Global Financial Data, Data Stream, International Financial Statistics, OECD-FRED, and Eurostat. Labor force is from the International Labour Organization. Real wage data are only available for OECD countries based on OECD data.

The sample of countries covers 51 countries, 30 developing and 21 industrial: Argentina, Australia, Austria, Belgium, Botswana, Bulgaria, Canada, Chile, China, Czech Republic, Denmark, Ecuador, Egypt, El Salvador, Finland, France, Germany, Greece, Hungary, India, Ireland, Italy, Jamaica, Japan, Korea, Latvia, Lithuania, Luxemburg, Malta, Mauritius, Mexico, Netherlands, New Zealand, Norway, Paraguay, Philippines, Poland, Portugal, Romania, Russia, Singapore, Slovak Republic, Slovenia, South Africa, Spain, Sweden, Switzerland, Thailand, United Kingdom, Uruguay, and Venezuela. Out of the 21 industrial countries, 17 are industrial European. The industrial non-European countries comprise Australia, Canada, Japan, and New Zealand. Multipliers thus remain almost the same. The effect after two years of an exogenous tax change in Panel A of Fig. 2 is −2.7 ($t = -1.9$) compared to −2.6 ($t = -1.7$) in the case of eight lags.

5.2. Additional fiscal control variables

As described in Section 4.2, we use government spending in our empirical specification (1) as a fiscal control variable. The plot below shows the multipliers if changes in corporate tax rates and the highest personal income tax rate were also included as controls, like Δg in specification (1).
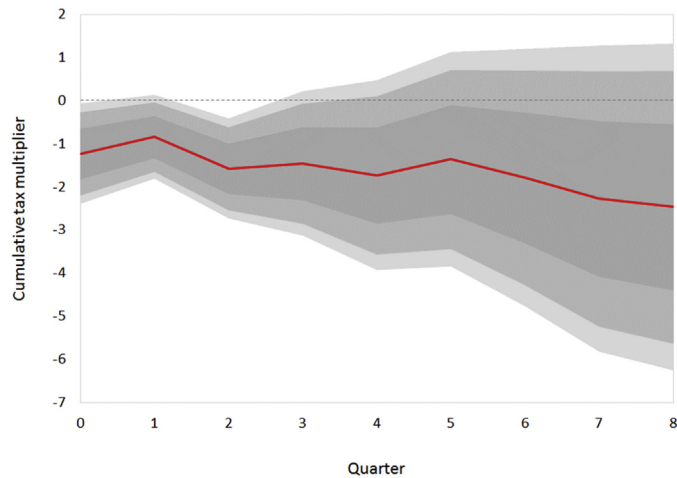
Fig. A.5.2. Cumulative tax multiplier: Using exogenous legislated tax rate changes and adding corporate tax rates and the highest personal income tax rate in specification (6). Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

Multipliers remain almost the same. The effect after two years of an exogenous tax change in Panel A of Fig. 2 is −2.7 ($t = -1.9$) compared to −2.3 ($t = -1.3$) in this case.

5.3. Growth effects of changes in tax rates

As discussed in Section 4.1 and in footnote 26, we use the sample average values of e, I, and estimated ρ_h for different time horizons h to convert the coefficients β_h (which link the percentage change in GDP to the change in the tax rate) into tax multipliers (which link the change in GDP to the change in revenues). For the sake of completeness, we report below the percentage changes in GDP in response to the change in the tax rate (i.e., coefficients β_h) directly obtained from specification (1).
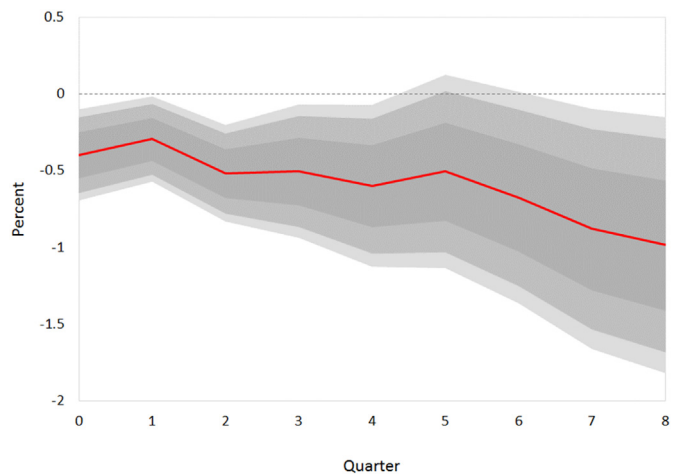

Fig. A.5.3.A. Cumulative percentage change in GDP in response to a one-percentage point increase in the exogenous legislated tax rate. Notes: Country fixed-effects panel regression, standard errors are Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

The profile illustrated in Panel A in Fig. 2 is virtually identical to that in Fig. A.5.3.A.

In the case of the non-linear specification (6), the plot below shows the percentage changes in GDP in response to the change in the tax rate (i.e., coefficients β_h) directly obtained from specification (6).
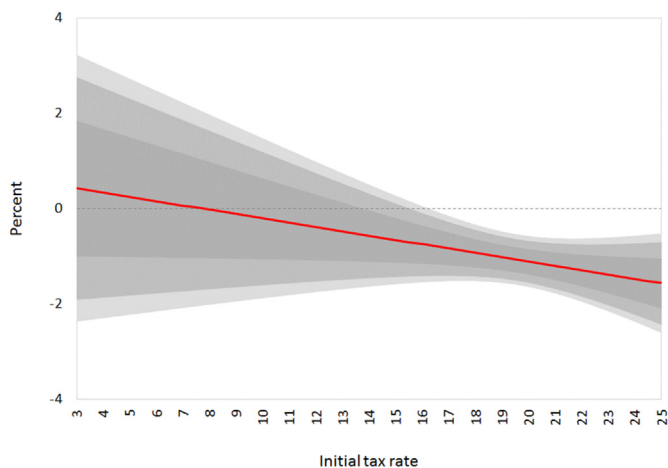
Fig. A.5.3.B. Cumulative percentage change in GDP in response to a one-percentage point increase in the exogenous legislated tax rate after two years: The role of the initial tax rate level. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

The profile illustrated in Fig. 7 is virtually identical to that in Fig. A.5.3.B.

5.4. Two-way clustered robust standard errors

As discussed in Section 4.1 and in footnote 31, to control for potential cross-sectional dependence, we use robust Driscoll-Kraay errors in all of our baseline specifications. Given the large number of zeros in our dependent variable and following Romer and Romer (2010), the reported standard errors are computed by taking 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. As a robustness check, Fig. A.5.4 shows our basic results with an alternative structure of errors: two-way clustered robust standard errors.
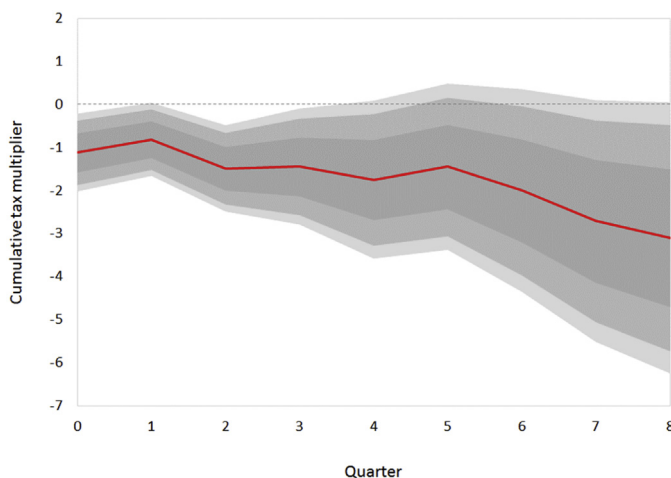

Fig. A.5.4. Two-way clustered robust standard errors. Notes: Country fixed-effects panel regression, with two-way clustered robust standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

5.5. Additional non-fiscal control variables

As described in Section 4.2, we use real GDP in our empirical specification (1) as a non-fiscal control variable. Since some VAT reforms might have reflected movements in consumption rather than GDP, what follows are the multipliers obtained if changes in consumption and consumer price index (CPI) were also included as controls, like Δg in specification (1).
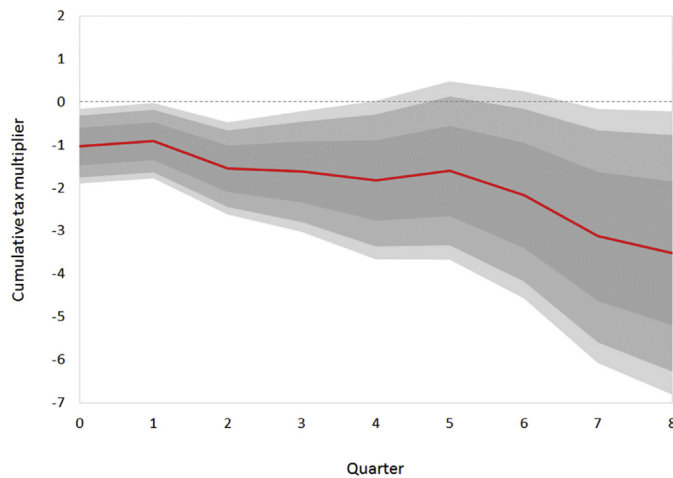
Fig. A.5.5. Cumulative tax multiplier: Using exogenous legislated tax rate changes and adding changes in consumption and CPI in specification (6). Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

The results are almost the same as before. The effect after two years of an exogenous tax change in Panel A of Fig. 2 is -2.7 ($t = -1.9$) compared to -3.1 ($t = -2.1$) in this case.

5.6. The role of expectations

As noted in footnote 34 of Section 4.3, if we compute the overall effect of news (i.e., using one single ΔNews resulting from the addition of ΔNews^1 and ΔNews^{2+}), output does not react much, as in Panel A in Fig. 4. This result is illustrated in Fig. A.5.6 based on the following specification:

$$\Delta y_{i,t+h} = \alpha_{i,h} + \beta_h \Delta\tau_{i,t}^{exog} + \varkappa_h \Delta\text{News}_{i,t} + \sum_{l=0}^{L} \lambda_{lh} \Delta y_{i,t-1-l} + \sum_{l=0}^{L} \psi_{lh} \Delta\tau_{i,t-1-l}^{all} + \sum_{l=0}^{h-1} \omega_{lh} \Delta\tau_{i,t+h-l}^{exog} + \sum_{l=0}^{L} \phi_{lh} \Delta g_{i,t-1-l} + \mu_{i,t+h}$$

where ΔNews indicates changes in exogenous tax rates in the quarter of the official passage of the law if the date of passage is at least one quarter before the shock.
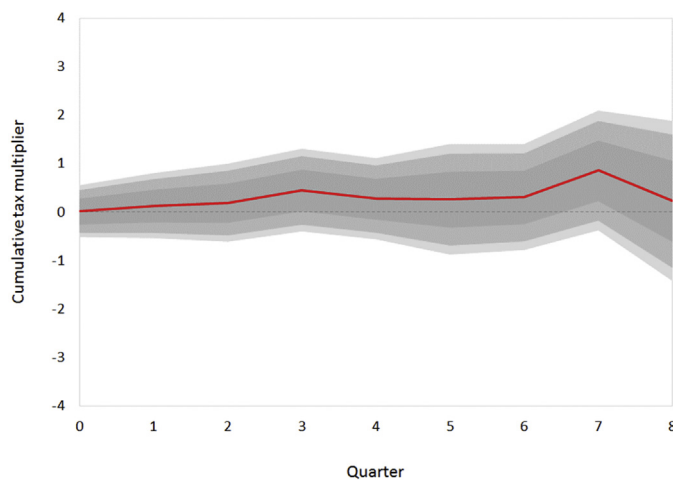

Fig. A.5.6. Cumulative multiplier after the official passage of the legislated tax rate change if passage occurred one quarter before the shock. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

This lack of anticipated response of output is not surprising considering the asymmetric response observed in Panels A and B in Fig. 4 and that only a third (or 5 out of 15) of anticipated exogenous tax rate changes are officially passed at least two quarters before the shock.

Table A.5.7
Other factors affecting the size of tax multipliers.

Panel A. Relationship between initial level of VAT rate and macroeconomic factors		
Variable	Coefficient of regression (1)	*p*-value (2)
Exchange rate regime	−1.32	0.13
Public debt (% of GDP)	0.005	0.81
Trade opennsess	−0.005	0.65
Capital account openess	−0.76	0.16

Panel B. Mean tests of macroeonomic factors inindustrial Europe and rest of countries in the sample.				
Variable	Mean industrial Europe (1)	Mean rest of the sample (2)	Mean difference = (2)–(1)	T-statistic (3)	p-value (4)
Exchange rate regime	1.97	2.20	0.23	0.82	0.41
Public debt (% of GDP)	51.84	48.56	−3.28	−0.32	0.75
Trade opennsess	66.08	76.37	10.28	0.53	0.60
Capital account openess	0.86	0.19	−0.67	−1.58	0.12

5.7. Other factors affecting the size of tax multipliers

Based on a cross-sectional regression (using averages of all variables involved), we first show that the initial level of the VAT rate is not related to the exchange rate regime, public debt as a percentage of GDP, and trade and capital account openness. In Table A.5.7, Columns 1 and 2 in Panel A show, for the cross sectional regression, the coefficient of each regression and the associated *p*-value, respectively.

Second, Panel B in Table A.5.7 shows that we cannot reject the null hypothesis that the existence of different type of exchange rate regimes, the size of public debt as a percentage of GDP, and trade and capital account openness is the same for tax changes in industrial European economies and the rest of the sample.

5.8. Alternative timing of initial tax rate level

As noted in footnote 40 of Section 5.1, the initial tax rate level interacting with the change in the tax rate in specification (6) is captured in $t − 1$ which, in turn, might be correlated with the past history of structural shocks. Even though tax rate changes are infrequent, and since it is not obvious that controlling for the lagged dependent variable and government spending is enough to rule this out, we now test the proposed non-linearity captured by specification (6) using a set of constant initial conditions fixed at the beginning of our sample. Fig. A.5.8 shows that our non-linear arguments continue to hold and that the results from this figure are virtually identical to those of Fig. 7.
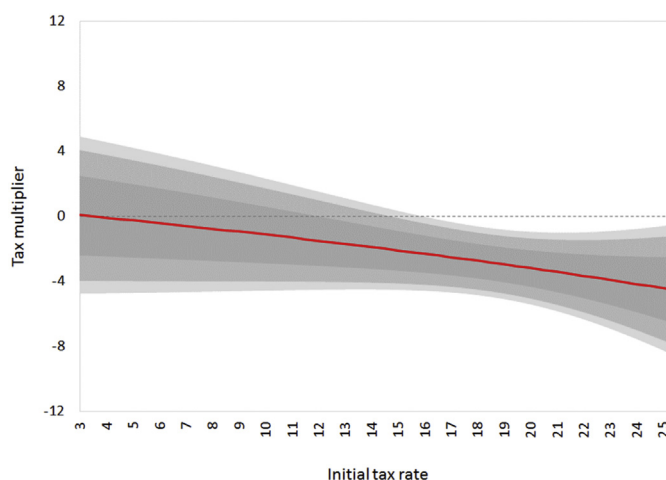

Fig. A.5.8. Non-linear cumulative tax multiplier after two years: The role of the initial tax rate level using an alternative timing of initial tax rate level. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

Even though tax rate changes are infrequent, and since it is not obvious that controlling for the lagged dependent variable and government spending is enough to rule this out, Appendix 5.8 tests the proposed non-linearity using a set of constant initial conditions fixed at the beginning of our sample.

5.9. Excluding anticipated shocks

As noted in the main text, the literature warns us against the use of anticipated shocks in an LP framework and about potential endogeneity. In our case, the number of anticipated shocks is very small an precludes a more careful study of their dynamics and specific effects on the multipliers. Thus, to ensure that those anticipated shocks are not driving our results, we ran the main regressions excluding any anticipated shocks in our sample and including only exogenous unanticipated shocks. As Figs. A.5.9.A and A.5.9.B show, excluding anticipated shocks has very small effects on the coefficients of our impulse response functions and does not change our main results.
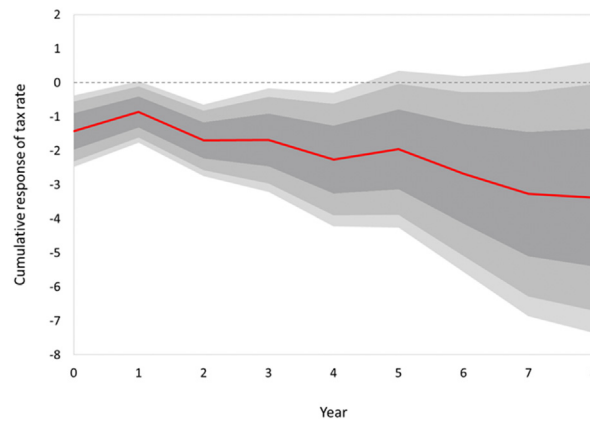

Fig. A.5.9.A. Cumulative tax multiplier: Exogenous legislated tax rate changes excluding anticipated shocks. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.
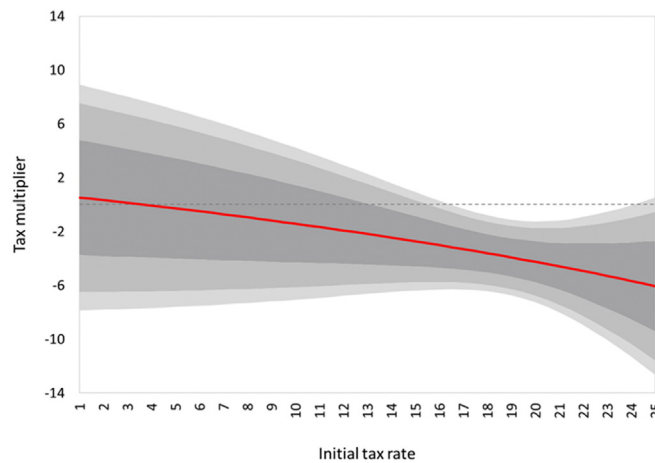

Fig. A.5.9.B. Non-linear cumulative tax multiplier after two years excluding anticipated shocks: The role of the initial tax rate level. Notes: Country fixed-effects panel regression, with Driscoll-Kraay standard errors. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

5.10. Country-specific elasticities in the derivation of the multiplier

As shown above, our derivation of the multiplier from the impulse response coefficients involves several country specific elasticities. In the main text, we use the country averages to present a single multiplier and show that the variance of the required country specific data is relatively small. Nevertheless, the concern of the averages widely misrepresenting the country specific multipliers may remain. To address this issue, Fig. A.5.10 depicts the median point estimate of the multiplier for exogenous shocks based on country specific elasticities jointly with the values for the top 90th percentile and bottom 10th percentile (see figure below). As shown in the figure, while dispersion grows with the size of the multiplier, its value is relatively small for the typical values of the multiplier found in the paper.
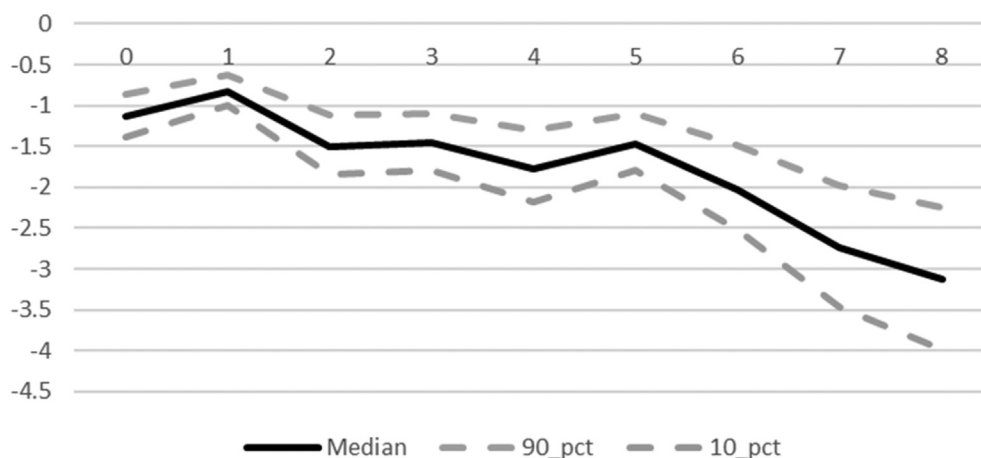

Fig. A.5.10. Distribution of the cumulative tax multiplier using country specific elasticities.

Appendix 6. Are non-linear distortion-based arguments also present when using RR's sample?

This appendix analyzes whether the same type of distortionary and disincentive-based non-linear arguments is present in RR's U.S. dataset. 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:

$$\Delta y_t = \alpha + \sum_{i=0}^{12} \beta_i \Delta \tau_{t-i}^{exog} + \sum_{j=1}^{12} \gamma_j \Delta y_{t-j} + \mu_t, \tag{19}$$

where y is the logarithm of real GDP (and thus Δy measures the real GDP growth rate) and $\Delta \tau^{exog}$ is RR's measure of exogenous legislated tax changes.

We proceed as in Subsections 5.1 and evaluate whether the effect of tax changes on output depends upon the initial tax level. Using the same type of interaction strategy proposed in specification (6), Fig. A.5.1 shows similar findings for the U.S. to those obtained in our global sample (Panel A for a linear specification and Panel B for a non-linear one). This evidence further supports the notion that the output effect of tax increases is, as theoretically argued, highly non-linear and becomes more negative with the initial tax level.
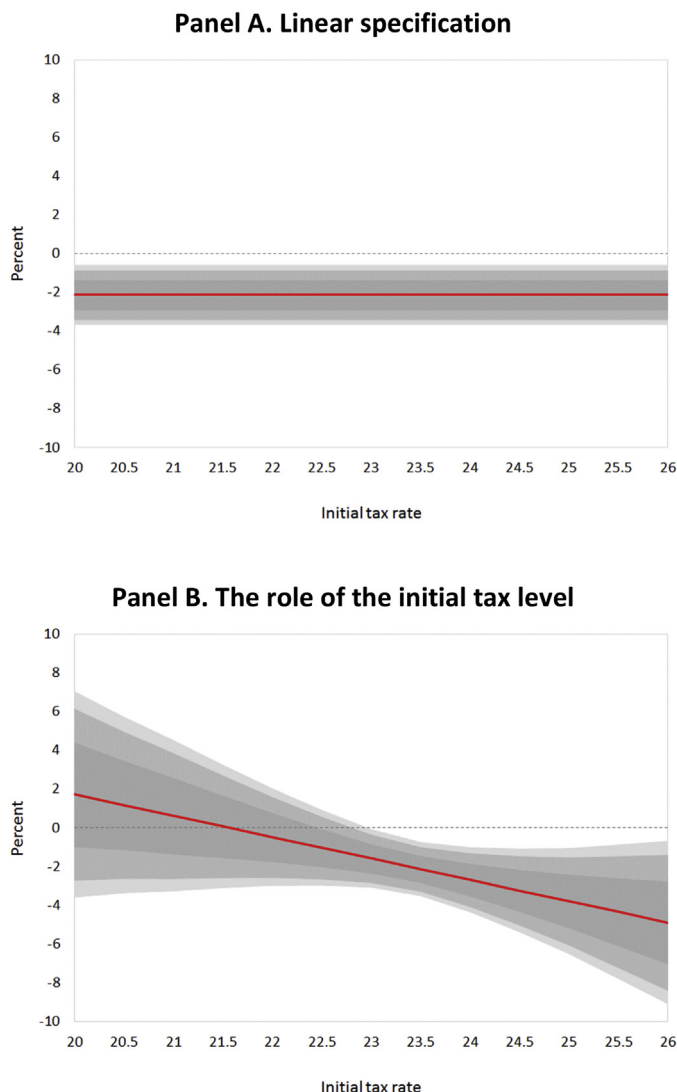
Panel A. Linear specification

Panel B. The role of the initial tax level

Fig. A.6.1. Non-linear cumulative effect of a tax change on GDP growth after two years using Romer and Romer (2010) dataset. Notes: Robust standard errors. Panel A and B exclude the top and bottom 10 percent of initial tax levels. Dark, medium, and light grey areas show 68, 90, and 95 percent confidence intervals, respectively.

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