The International Transmission of US Tax Shocks: A Proxy-SVAR Approach

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Abstract

We investigate the international propagation of tax rate shocks originating in the USA using a global vector error correction model. We identify shocks to corporate and personal income tax rates by using narrative series as external instruments, following the proxy-SVAR methodology. The main results are the following: (1) In terms of fiscal multiplier, domestic effects of corporate tax shocks are stronger than those of personal income tax shock; (2) spillovers are in most cases positive and significant, albeit of small size; (3) the boost to exports in recipient economies, stimulated both by stronger US demand and, to a lesser extent, by real exchange rate depreciation, is the main transmission channel; and financial channels (through long-term interest rates) also play a role.

Keywords International fiscal spillovers · Proxy SVAR · GVAR

JEL Classification C22 · E62 · F42

1 Introduction

Since the Great Recession, the discussion on the role of fiscal policy has gained traction, as discretionary fiscal measures have started afresh to serve as policy tools in advanced economies. During the global financial crisis, the US administration implemented a sizable fiscal stimulus, which supported the recovery in the USA; in contrast, during the Euro area debt crisis many countries in Europe introduced tax increases and spending cuts as a way to restore confidence in the sustainability of public debt. More recently, the US Congress has adopted a major overhaul of the tax

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code, embracing tax cuts and increases in military spending. Finally, in response to the ongoing Covid-19 crisis, most advanced economies around the world are making major fiscal policy interventions to limit the economic impact of the pandemic.

The renewed interest in fiscal policy has spurred considerable academic research on its effects on economic activity. However, with much of the debate concentrated on the domestic effects, much less has been said on the international dimension of fiscal policy and its spillovers. We take up this issue by focusing on spillovers from tax policy that, differently than spillovers from government spending, have been mostly disregarded in the fiscal policy literature. We evaluate the domestic and spillover effects of an expansionary tax rate shock in the USA, focusing on the international channels of transmission. Our analysis provides answers to some relevant policy questions, such as: does a fiscal expansion in the US increase output abroad? Is there heterogeneity in the transmission across recipient countries? Are spillovers driven by real or financial channels? Also, we provide evidence on how the impact of fiscal policy depends on the specific instrument adopted, comparing specific components of tax policies. Are corporate and personal income tax shocks both effective? Are their effects equally persistent? Do they propagate through the same channels?

We answer these questions within a global vector error correction model (GVAR), the framework developed by Pesaran et al. (2004), in which each country model features domestic and foreign variables. Target variables are real GDP, inflation, real equity prices, interest rates, real exchange rates and exports. In the US model, we also include fiscal variables and identify tax rate shocks following the proxy-SVAR methodology. For this purpose, we use the narrative series of Mertens and Ravn (2013) as instruments for personal and corporate income tax rate shocks. The main results of the paper are the following. First, the domestic effects of tax rate shocks are strong, with multipliers consistently above unity 1 year after the shock. This result is in line with Ramey (2019), showing that tax shocks have an impact on output that is even stronger than that of a spending shock.¹ Moreover, personal income tax rate shocks seem to activate demand-side effects, while corporate income tax rate shocks trigger supply-side ones, at the domestic level. Second, spillovers are positive and, in most cases, statistically significant, albeit of a small size. Third, in terms of geographical distribution, US tax shocks have a stronger impact on advanced than emerging countries; moreover, economies that are geographically close to the USA are not impacted in the same way, with Mexico benefiting less than Canada from the US fiscal expansion.

This paper also sheds some light on the international transmission mechanism of US fiscal policy. The main channel through which fiscal shocks propagate is international trade. Independently of the type of shock, following a fiscal expansion the USA increases its imports from the rest of the world, stimulating output in foreign countries. This occurs via both a price and a quantity effect. Indeed, for some countries real exchange rates depreciate vis-à-vis the US dollar, improving their price competitiveness (expenditure switching or price effect); for other countries, higher

¹ This result is not uncontroversial. For a different point of view, see Caldara and Kamps (2017).

US output stimulates demand for imports without significant exchange rate variations (expenditure boosting or quantity effect). In our results, this latter propagation mechanism seems to dominate quantitatively on the former. Moreover, financial channels (through interest rates and equity prices) also play a role in the international transmission, although a smaller one than the trade channel. Foreign long-term interest rates generally increase following the US fiscal shocks, acting as a drag on economic growth; only in a few cases, they fall on impact reinforcing expansionary effects. Concerning equity markets, a US fiscal expansion may lead to an increase in foreign equity prices, generating positive wealth effects which, in principle, could support consumption and investment; in our framework, we find equity prices reacting significantly to fiscal shocks only in some cases, suggesting that wealth effects are of minor importance in channeling fiscal shocks across the board.

This paper contributes to the recently growing literature on fiscal spillovers in several ways. First, it is one of the first studying empirically the international transmission of fiscal shocks originating in the USA, in particular for what concerns tax shocks. As we model the world economy in a single framework, we are able to take into account the indirect effect of shocks arising from the economic linkages among recipient countries (third-party effects) and obtain more accurate spillover estimates than those delivered by widely used bilateral models (such as two-country VARs or local projections à la Jorda 2005), as highlighted by Georgiadis (2017). Second, the paper highlights the differences in the international propagation among the implemented tax policy tools, i.e., personal and corporate income tax policies. Third, it is the first paper quantifying spillovers in terms of fiscal multipliers for each type of tax shocks and at different points in time. Fourth, fiscal policy shocks in the US are identified using narrative series, which allow for the identification of tax rate shocks, as opposed to the more endogenous measure of tax revenues usually adopted in the literature on fiscal spillovers. As far as we know, this is also the first time that a proxy-SVAR identification strategy is employed in a GVAR framework.

2 Literature Review

The paper draws on different strands of literature. First, it relates to the literature analyzing international fiscal spillovers, in particular to the very scant literature analyzing tax spillovers. The closest papers to ours are Blagrove et al. (2018) and Christofzik and Elstner (2018). Blagrove et al. (2018) investigate spillovers stemming from a global fiscal shock (both spending shock and tax revenue shock), aggregated across five advanced economies; by running the local projection estimates of Jorda (2005) on the GDP of each recipient economy separately, the paper finds that spillovers depend on the monetary policy response (in particular at the zero lower bound) and on the degree of economic slack in source and recipient countries. Although it addresses the relevant issue of the state dependency of fiscal policy effectiveness, Blagrove et al. (2018) focus on the more endogenous variable tax revenues instead of tax rate shocks. Moreover, they do not concentrate on the transmission mechanism of fiscal shocks, which is instead our focus. Christofzik and Elstner (2018) analyze the spillover effect of tax rate shocks, identified as in our case through the

methodology of Mertens and Ravn (2013). They find positive but small spillovers on German output, also considering the reaction of the German fiscal variables. This study, contemporaneous to ours, is also the closest. However, it focuses only on the German economy, neglecting the whole international dimension. Aside from these two papers, most of the literature on fiscal spillovers concentrates on government spending. Auerbach and Gorodnichenko (2013) estimate government spending spillovers in a panel of OECD countries; they find, in line with Blagrove et al. (2018), positive effects on foreign output. Bussiere et al. (2017) use a three-country specification of the Global Integrated Monetary and Fiscal (GIMF) model of the IMF to simulate different types of budget-neutral spending policies in the USA; they find positive domestic and spillover effects that can be amplified in case of a coordinated action across countries, and a trade-off between growth and distributional consequences. Faccini et al. (2016) estimate spillovers from a US government spending shock in a factor model, finding positive and sizable effects on foreign output operating mainly through a financial channel, i.e., a reduction of real interest rates abroad. This paper follows some theoretical and empirical papers claiming that expectations of future spending reversals, triggered by fiscal rules on debt, are such that the effect of expansionary shocks on domestic interest rates, positive in standard models, is instead negative and acts as the main driver of fiscal expansion in the medium run.² According to this literature, spillovers are mainly determined by the evolution of the foreign interest rates determined by international financial linkages (Corsetti et al. 2010, 2012; Corsetti and Muller 2013; Ong 2018). While we find some negative impacts on long rates in the case of corporate tax shocks, in our paper the international transmission goes mainly through the trade channel. In this respect, our results are more in line with those of papers that investigate fiscal spillovers indirectly, i.e., by studying the reaction of those domestic variables that can influence foreign output dynamics, such as the exchange rate (e.g., Auerbach and Gorodnichenko 2016; Forni and Gambetti 2016), the trade balance (e.g., Kim and Roubini 2008), or the terms of trade (Monacelli and Perotti 2010; Enders et al. 2011). In general, the literature on fiscal spillovers is not particularly large; it focuses only on specific country groups and mainly on spending shocks, neglecting the tax side.³

Second, our paper is related to the strand of the literature analyzing the domestic effects of fiscal policy, specifically for the USA (e.g., Blanchard and Perotti 2002; Ramey 2011; Romer and Romer 2010; Mountford and Uhlig 2009; Mertens and Ravn 2013; Ilzetzi et al. 2013). We are closer to those empirical studies using proxy-SVAR methods and the narrative approach as identification scheme, in particular Mertens and Ravn (2013). The latter is one of the papers that develops the proxy-SVAR methodology, together with Stock and Watson (2008);⁴ also, Mertens

² As also noted in Blagrove et al. (2018), in a standard Mundell–Fleming–Dornbusch framework a fiscal expansion puts upward pressure on interest rates, appreciates the nominal exchange rate and increases domestic prices.

³ A set of papers investigate fiscal spillovers within the Euro area, see, for instance, Beetsma et al. (2008), Beetsma and Giuliodori (2011) and, more recently, Dabla-Norris et al. (2017).

⁴ Indeed, the methodology of Mertens and Ravn (2013) builds on the precedent work by Stock and Watson (2008) presented in a 2008 NBER summer school, and later applied in Stock and Watson (2012).

and Ravn (2013) construct the exogenous narrative tax rate series that we use in the estimation, both for the corporate tax and the personal income tax. They moreover quantify the effects of tax rate shocks, finding a large multiplier in the case of personal income tax rate shocks, while they cannot provide such estimate for the corporate tax measure, as the response of tax revenues in this case is not significant. In our paper, we follow the Mertens and Ravn (2013) methodology and we embody it in the GVAR. As in Mertens and Ravn (2013), we find quantitatively similar effects on US output but, differently from them, also significant effects on tax revenues following both tax shocks. This allows us to calculate fiscal multipliers in both cases finding that, in the post-1980 sample, corporate income tax cuts are more output enhancing than cuts in personal income tax rates.

Finally, our paper draws on the GVAR methodology, introduced in the two seminal papers by Pesaran et al. (2004) and Di Mauro et al. (2007). The GVAR framework has been widely used to assess the international transmission of shocks; however, also in the GVAR literature, the topic of fiscal spillovers has been under-investigated. Caporale and Girardi (2013) and Hebous and Zimmermann (2013) study the propagation of non-identified fiscal disturbances originated in the Euro area, while Favero et al. (2011) investigate the effects of contemporaneous fiscal policy shocks at the global level.⁵ None of these studies aims at quantifying the output effect of an identified fiscal shock stemming from the USA on the rest of the world. In our paper, we aim at filling this gap. The rest of the paper is organized as follows. Section 2 describes the GVAR methodology, the proxy-SVAR methodology and the identification strategy, while Sect. 3 discusses the data and the specification adopted in the paper, focusing also on the cross-border transmission mechanism of fiscal shocks. Section 4 reports the results obtained. Finally, Sect. 5 concludes.

3 Model and Identification Strategy

3.1 The GVAR Model

The GVAR model is a multi-country framework which explicitly allows for interdependencies among countries and markets. The model is particularly useful to investigate the transmission channels of shocks across countries and to quantify the magnitude of such spillovers. The GVAR modeling strategy consists of two steps. In the first step, each country i is modeled separately in a single-country VAR model augmented with exogenous variables (VARX). In each VARX, the endogenous variables are domestic only ($X_{i,t}$), while country-specific foreign variables $X_{i,t}^*$, constructed as averages of all other countries' variables, serve as a proxy for common unobserved factors. In this way, each country is affected by its domestic developments and by the rest of the world. Each country model is estimated separately, conditional on the

⁵ Other studies which employ the GVAR methodology to investigate fiscal shocks among Euro area countries are Ricci-Risquete and Ramajo-Hernandez (2015) and Dragomirescu-Gaina and Philipapas (2015).

foreign variables, in error correction form. In the second step, the country-specific VARX's are stacked together and linked using a matrix of cross-country linkages W , building in this way the global model.

3.2 First Step

Consider $N+1$ countries, indexed by $i = 0, 1, 2, \dots, N$. Each country is modeled through a VARX(K_i, P_i) of the following form:

$$X_{i,t} = a_{i,0} + a_{i,1}t + \sum_{k=1}^{K_i} \phi_{i,k} X_{i,t-k} + \sum_{p=0}^{P_i} \Lambda_{i,p} X_{i,t-p}^* + u_{i,t} \quad (2.1)$$

where $X_{i,t}$ is the vector of country i 's domestic variables and $\sum_{k=1}^{K_i} \phi_{i,k}$ are the corresponding lagged coefficients; $X_{i,t-p}^*$ is the vector of country i 's foreign variables and $\sum_{p=0}^P \Lambda_{i,p}$ the associated coefficients; $a_{i,0}$ and $a_{i,1}$ are, respectively, the vector of intercepts and the vector of the coefficients of the deterministic time trend. $u_{i,t}$ is the vector of country-specific residuals, which is assumed to be distributed as a white noise process, i.e., $u_{i,t} \sim i.i.d.(0, \Sigma_i^u)$. The vector $X_{i,t}^*$ plays a crucial role in the GVAR framework, and it is defined in the following way:

$$X_{i,t}^* = \sum_{j=0}^N w_{i,j} X_{j,t} \quad (2.2)$$

where $w_{i,j}$ represents the trade share of country j for country i , i.e., the country-specific weight of country j in the total trade of country i . Moreover, $w_{i,i} = 0$ and $\sum_{j=0}^N w_{i,j} = 1$. Equation (2.1) can be consistently estimated assuming that $X_{i,t}^*$ is weakly exogenous with respect to the other variables in the system. In words, this means that each country is considered as a small open economy with respect to the rest of the world and therefore that Eq. (2.1) can be estimated on a country-by-country basis.⁶

Di Mauro et al. (2007) show that Eq. (2.1) can be rewritten in error correction (EC) form, thus allowing for cointegration both within $X_{i,t}$ and between $X_{i,t}$ and $X_{i,t}^*$; the model in EC form can be estimated with the Johansen procedure, modified to take into account the exogenous variables (Harbo (1998); Pesaran et al. (2000)).

3.3 Second Step

After the estimation of each country-specific VARX, these are combined and stacked in order to form the global model. For the ease of exposition, we assume that a VARX(1,1) is estimated for each country:

⁶ In "Appendix 1" of the paper, we test such exogeneity assumption, reporting the results of the test in Table 8.

$$X_{i,t} = a_{i,0} + a_{i,1}t + \phi_{i,1}X_{i,t-1} + \Lambda_{i,0}X_{i,t}^* + \Lambda_{i,1}X_{i,t-1}^* + u_{i,t}, \quad (2.3)$$

Defining

$$z_{i,t} = \begin{pmatrix} X_{i,t} \\ X_{i,t}^* \end{pmatrix}, \quad (2.4)$$

Equation (2.3) can be written as:

$$A_{i,0}z_{i,t} = a_i + a_{i,1}t + A_{i,1}z_{i,t-1} + u_{i,t} \quad (2.5)$$

where

$$A_{i,0} = (I, -\Lambda_{i,0}), A_{i,1} = (\phi_{i,1}, \Lambda_{i,1}) \quad (2.6)$$

The trade weights w_{ij} are then used to define the link matrix W_i and obtain the identity:

$$z_{i,t} = W_i X_t \quad (2.7)$$

with $X_t = [X'_{0,t}, X'_{1,t}, \dots, X'_{N,t}]'$, i.e., the vector collecting all the country-specific endogenous variables of the model. Substituting 2.7 in Eq. (2.5), we obtain:

$$A_{i,0}W_iX_t = a_{i,0} + a_{i,1}t + A_{i,1}W_iX_{t-1} + u_{i,t} \quad (2.8)$$

Now, the country-specific models given by Eq. 2.8 are stacked to generate the global model for X_t :

$$G_0X_t = a_0 + a_1t + G_1X_{t-1} + u_t \quad (2.9)$$

where

$$G_0 = \begin{pmatrix} A_{00}W_0 \\ A_{10}W_1 \\ \vdots \\ A_{N0}W_N \end{pmatrix}, G_1 = \begin{pmatrix} A_{01}W_0 \\ A_{11}W_1 \\ \vdots \\ A_{N1}W_N \end{pmatrix},$$

$$a_0 = \begin{pmatrix} a_{00} \\ a_{10} \\ \vdots \\ a_{N0} \end{pmatrix}, a_1 = \begin{pmatrix} a_{01} \\ a_{11} \\ \vdots \\ a_{N1} \end{pmatrix}, u_t = \begin{pmatrix} u_{0t} \\ a_{1t} \\ \vdots \\ a_{Nt} \end{pmatrix}$$

With G_0 non-singular matrix, depending on the trade weights and the estimated parameters, we obtain:

$$X_t = b_0 + b_1t + F_1X_{t-1} + v_t \quad (2.10)$$

where

$$F_1 = G_0^{-1}G_1, \quad b_0 = G_0^{-1}a_0, \quad b_1 = G_0^{-1}a_1, \quad v_t = G_0^{-1}u_t \quad (2.11)$$

Equation (2.10) represents the GVAR model and can be solved recursively. The variance–covariance matrix of the global model is computed directly from the country-specific reduced form residuals $v_{i,t}$ and is represented by the following:

$$\Sigma_v = \begin{bmatrix} \Sigma_{v_0} & \Sigma_{v_0,v_1} & \cdots & \Sigma_{v_0,v_N} \\ \Sigma_{v_1,v_0} & \Sigma_{v_1} & \cdots & \Sigma_{v_1,v_N} \\ \cdots & \cdots & \cdots & \cdots \\ \Sigma_{v_N,v_0} & \Sigma_{v_N,v_1} & \cdots & \Sigma_{v_N} \end{bmatrix} \quad (2.12)$$

where Σ_{v_i,v_j} is the sample covariance matrix between country i and country j and Σ_{v_i} is the covariance matrix of country i .

3.4 Identification Approach

In order to identify shocks in the GVAR, one needs to specify a matrix P_0 that pre-multiplies Eq. (2.10) yielding

$$P_0 X_t = P_0 b_0 + P_0 b_1 t + P_0 F_1 X_{t-1} + \epsilon_t \quad (2.13)$$

where P_0 is

$$P_0 = \begin{bmatrix} P_{0,0} & P_{0,1} & \cdots & P_{0,N} \\ P_{0,1} & P_{1,1} & \cdots & P_{1,N} \\ \cdots & \cdots & \cdots & \cdots \\ P_{N,0} & P_{N,1} & \cdots & P_{N,N} \end{bmatrix} \quad (2.14)$$

and

$$\epsilon_t = P_0 v_t \quad (2.15)$$

is the vector of identified structural shocks, with covariance matrix Σ_ϵ :

$$\Sigma_\epsilon = \begin{bmatrix} \Sigma_{\epsilon_0} & \Sigma_{\epsilon_0,v_1} & \cdots & \Sigma_{\epsilon_0,v_N} \\ \Sigma_{v_1,\epsilon_0} & \Sigma_{v_1} & \cdots & \Sigma_{v_1,v_N} \\ \cdots & \cdots & \cdots & \cdots \\ \Sigma_{v_N,\epsilon_0} & \Sigma_{v_N,v_1} & \cdots & \Sigma_{v_N} \end{bmatrix} \quad (2.16)$$

We are interested in identifying shocks originating from the USA only, chosen on $i = 0$; therefore, we need to make specific assumptions on $P_{0,0}$ (to identify the US model) and then on the other matrices within P_0 . We take up these issues in the following two paragraphs.

Identifying US fiscal shocks using external instruments In order to identify fiscal shocks in the US model, we rely on the proxy-SVAR methodology. Restrictions on the $P_{0,0}$ matrix are obtained by using proxies for the latent shocks. In each of the two GVAR models we estimate, following Mertens and Ravn (2013), we assume that a narrative measure, denoted by m_t , is a proxy for the unobserved structural fiscal shock of interest $\epsilon_{f,t}$, with $E(m_t) = 0$; in addition, denoting the other non-fiscal US

shocks as $\epsilon_{nf,t}$, the methodology assumes that the defined proxy satisfies the following conditions

$$E[m_t, \epsilon_{f,t}] = \gamma \neq 0 \quad (2.17)$$

$$E[m_t, \epsilon_{nf,t}] = 0 \quad (2.18)$$

In other words, m_t is correlated with the unobserved fiscal policy shock of interest and orthogonal with the remaining shocks. Assuming that the fiscal variable is ordered l th in the US model, the proxy-SVAR method provides the restrictions to be placed on the l th column of the matrix $P_{0,0}$. To obtain those restrictions, one must follow a two-step procedure:

- Run two-stage least squares (2SLS) estimates of all non-fiscal residuals in the US model, $v_{nf,t}$, on the fiscal residual $v_{f,t}$, using each time m_t as an instrument for $v_{f,t}$; the estimated coefficients represent each variables' restrictions up to a scale factor;
- Impose covariance restrictions to identify each element in the l th column of $P_{0,0}$.

Details on the proxy-SVAR procedure are reported in Mertens and Ravn (2013). Narrative measures of fiscal policy changes are constructed from historical sources, and as suggested by Mertens and Ravn (2013), they can be viewed as imperfectly correlated with linear combinations of the latent structural policy shocks.⁷ In order to validate the use of narrative series as instruments for the latent shocks, one should test the relevance of the proxy by constructing the reliability test statistic of Mertens and Ravn (2013) that is based on the hypothesis of linear random measurement errors. The reliability test statistic represents the fraction of the variance of the measured variable that is explained by the latent variable; it lies between 0 and 1, with large values indicating a high correlation between the proxy and the true underlying tax shock.

Imposing cross-country restrictions After having imposed restrictions on $P_{0,0}$, we have to impose restrictions on the other elements of P_0 . Provided that we are not interested in identifying shocks in other countries, we assume that all the other matrices on the diagonal of P_0 are identity matrices. Concerning off-diagonal matrices, we impose all cross-country correlations between model residuals to be zero. Indeed, correlations between the residuals of the GVAR may occur both within countries (i.e., among variables of a country-specific model) but also across countries (i.e., among variables in different countries). While the first type of correlations is taken care of through the identification procedure described in the previous paragraph, residuals can still be contemporaneously correlated across countries, creating concerns about reverse spillover effects. Although, having conditioned domestic models on foreign variables, cross-country correlations are generally very small, the

⁷ Indeed, measurement errors may arise both from the fact that historical records sometimes contradict each other, because narrative series typically disregard minor policy changes that are censored to zero.

case of significant correlations with specific foreign variables cannot be ruled out, giving rise to possible identification issues. Given the central role of the US economy, it is reasonable to assume that it does not react within the quarter to foreign developments. This restriction is crucial to complete identification in GVAR models, although it is not always stressed in the GVAR literature.

By imposing such correlations to be zero, we obtain a block-diagonal P_0 matrix. Therefore, the resulting P_0 matrix is

$$P_0 = \begin{bmatrix} P_{0,0} & 0 & 0 & \dots & 0 \\ 0 & I & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & I \end{bmatrix} \quad (2.19)$$

3.5 Impulse Response Functions

For the dynamic analysis of shocks, the GVAR literature largely relies on generalized impulse response functions (GIRFs) (Koop et al. 1996; Pesaran and Shin 1997) that in our case take the form of structural GIRFs (SGIRFs) as our model is identified. The response of variable j at time $t + n$ to a one standard error shock at time t given to variable l is given by the j th element of:

$$SGIRF(x_t; \epsilon_{lt}, n) = \frac{\epsilon'_j A_n (P_0 G_0)^{-1} \Sigma_\epsilon e_l}{\sqrt{e'_l \Sigma_\epsilon e_l}} \quad (2.20)$$

where $e_l = (0; 0; \dots; 0; 1; 0; \dots; 0)$ is a selection vector with unity as the l th element; G_0 is defined as in Eq. (2.9); A_n is

$$A_n = \sum_{i=1}^p F_i A_{n-i}, \quad A_0 = I, \quad n = 1 \dots p \quad (2.21)$$

4 Data and Transmission Channels

We specify two GVAR models using quarterly data.⁸ Each model encompasses 25 economy-specific VARX models, where the included economies account for about 90 percent of world GDP.⁹ Subject to data availability, we consider the same set

⁸ We use the GVAR toolbox developed by Smith and Galesi (2014).

⁹ The countries included are Argentina, Australia, Brazil, Canada, China, Chile, Euro Area, India, Indonesia, Japan, Korea, Mexico, Norway, New Zealand, Peru, Philippines, South Africa, Saudi Arabia, Singapore, Sweden, Switzerland, Thailand, Turkey, the UK and the USA. The Euro area is constructed as the aggregation of eight countries: Austria, Belgium, Finland, France, Germany, Italy, Netherlands and Spain.

of variables for each economy except for the USA. For non-US economies, domestic variables are real GDP $y_{i,t}$, consumer price inflation $\pi_{i,t}$, real exchange rate $r_{i,t}$ (defined as the nominal exchange rate $e_{i,t}$ minus domestic CPI, following Di Mauro et al. 2007), the 3-month interest rate $i_{i,t}^s$, the 10-year government bond yield $i_{i,t}^l$, the real equity price index $q_{i,t}$ (the equity index deflated by domestic CPI) and real exports of goods and services $x_{i,t}$.^{10,11} Foreign variables, constructed as trade-weighted averages of variables in all other economies, are the following: foreign real GDP $y_{i,t}^*$, foreign consumer price inflation $\pi_{i,t}^*$, foreign real equity price $q_{i,t}^*$ and the foreign 3-month short-rate $i_{i,t}^{*s}$. The real exchange rate is not included in the set of foreign variables of non-US models to avoid multicollinearity.

The US model is slightly different for a number of reasons. First, as our aim is to study the effect of a fiscal policy expansion in the USA on the rest of the world, we include, as domestic variables, US fiscal variables, both on the spending and on the tax side. Government spending and tax variables are constructed following previous works on US fiscal shocks (Blanchard and Perotti 2002; Mertens and Ravn 2013, among others). On the spending side, we include real government expenditure to take into account the possible reaction of spending variables following the tax shock; on the tax side, we include the average personal income and corporate tax rates, together with their respective tax bases (net of transfers and interest payments).¹² Second, we include real imports among the domestic variables in the USA for a more in-depth study of the trade channel of fiscal policy, as we explain in Sect. 4. Concerning the instruments for personal and corporate tax rate shocks, we rely on the legislated tax liability changes categorized by Mertens and Ravn (2013) from the total tax liabilities changes recorded by Romer and Romer (2010). Regarding foreign variables, we only include the real exchange rate in the US model. This implies that the USA is considered as a closed economy in our framework. Table 1 summarizes the domestic and foreign variables included in the US and non-US models.

We estimate two GVAR models: one to study the effects of personal income tax shocks and one for corporate income tax shocks¹³

- In GVAR #1, the US model is augmented with the personal income tax rate, the personal income tax base and government expenditure;

¹⁰ All variables except the 3-month and 10-year rates are set equal to 100 in 2000Q1 and expressed in natural logarithms.

¹¹ The nominal exchange rate $e_{i,t}$ is defined as the exchange rate vis-à-vis the US dollar. For this reason, the real exchange rate is not included in the US model, as $e_{US,t} = 1$ for all t .

¹² We do not include fiscal variables in non-US models because series of government spending and taxes are not available on a quarterly frequency for all countries; for countries in which series are available, we choose not to increase model size further.

¹³ We also estimated one single model featuring both personal income tax rate and base together with corporate income tax rate and base. Impulse responses derived from such model are reported in “Appendix 3” of the paper (Figs. 14, 15 and 16). Such model, although generating similar results, is large and in some cases, the IRFs show wider confidence bands; for this reason, we preferred to proceed with the more parsimonious approach of two distinct GVAR models.

- In GVAR #2, the US model is augmented with the corporate income tax rate, the corporate income tax base and government expenditure;

The GVAR models are estimated over the period 1979 Q2–2006 Q4 because of data availability issues: observations before 1979 Q2 are not available for all countries, while the available tax instruments data end in 2006 Q4. “Appendixes A1.1 and A1.2” contain more details regarding the data sources and the specifications chosen, in particular for what concerns the selection of lag length and the number of cointegrating relationships in each country model.

4.1 Transmission Channels

Before describing the results of the paper, it is useful to summarize the main transmission channels through which fiscal policy shocks in the USA may affect real variables in the rest of the world. The first channel operates through trade, in particular through the so-called *expenditure boosting* effect. Following a fiscal expansion that increases US output, US demand for imports increases as well, to an extent depending on the marginal propensity to import, both of the public and of the private sector. Output in foreign countries can thus rise through higher export demand. This direct channel can be reinforced via third-party effects, i.e., through the aforementioned mechanism working in all the foreign countries experiencing a boost in output. The second channel is represented by the real exchange rate. The US fiscal expansion is expected to increase domestic interest rates and to appreciate the US dollar, improving price competitiveness for all goods and services produced abroad and stimulating foreign exports and output (*expenditure switching* effect).

A fiscal shock can also impact foreign GDP through the financial channel. A loose fiscal policy stance in the USA affects domestic interest rates, which in turn can impact foreign financial variables through financial linkages. The direction in which variables can be affected is not straightforward. On the one hand, in a standard portfolio balance model, the financial channel should cause both domestic and foreign interest rates to rise, putting a drag on the magnitude of spillovers on foreign output. On the other hand, an expansionary fiscal policy in the USA might generate the opposite effect, putting downward pressure on domestic and foreign interest rates. Faccini et al. (2016) and Corsetti and Muller (2013) obtain falling interest rates by making the assumption of a subsequent reversal of the fiscal shock; alternative explanations suggest that lower taxes may either expand aggregate supply or increase firms’ savings more than investments, in both cases putting downward pressures on prices and interest rates. Fiscal spillovers might also be transmitted by an equity price channel: Expected profits of foreign exporting firms may rise, and depending on whether there is no offset from discount rates (which rise due to foreign central bank reactions), they put upward pressure on equity prices. This produces wealth effects for portfolio investors that could support consumption and investment.

Overall, the magnitude of fiscal spillovers is an empirical question. The relative importance of the aforementioned channels depends on the strength of trade and

Table 1 Summary of the variables included in the GVAR

	Non-US model		US model	
	Domestic	Foreign	Domestic	Foreign
All GVARs:	y_i	y_i^*	y_{US}	—
	π_i	π_i^*	π_{US}	—
	r_i	—	—	r_{US}^*
	i_i^s	i_i^{s*}	i_{US}^s	—
	i_i^l	—	i_{US}^l	—
	q_i	q_i^*	q_{US}	—
	x_i	—	x_{US}	—
			m_{US}	
GVAR 1:	—	—	$pitr_{US}$	—
	—	—	$pitb_{US}$	—
	—	—	$gcgi_{US}$	—
GVAR 2:	—	—	$citr_{US}$	—
	—	—	$citb_{US}$	—
	—	—	$gcgi_{US}$	—

Table reports the variables included in the non-US models (for each country i) and in the US model. Variables are: real GDP y_i , consumer price inflation π_i , real exchange rate r_i (defined as the nominal exchange rate e_i minus domestic CPI), the 3-month interest rate i_i^s , the 10-year government bond yield i_i^l , the real equity price index q_i (the equity index deflated by domestic CPI), real exports of goods and services x_i and real imports for the US m_{US} . $gcgi_{US}$ is government spending, $taxrev_{US}$ are net tax revenues, $pitr_{US}$ ($citr_{US}$) is personal (corporate) income tax rate, and $pitb_{US}$ ($citb_{US}$) is personal (corporate) income tax base

financial linkages among the source and recipient countries, and to a smaller extent, among recipient countries themselves. Finally, it might also depend on the composition of the fiscal shock, i.e., whether the fiscal expansion is implemented through spending increases or tax reductions, and also on the particular type of spending or tax instrument.

5 Results

In this section, we describe our main results. In order to compare the effects of the two shocks, we comment on the results of the two GVAR models together, divided between domestic and spillovers effects; then, we construct domestic and international fiscal multipliers. The shocks of interest are: shock to average personal income tax rate (PITR henceforth) and shock to corporate income tax rate (CITR henceforth). Last, we discuss the main transmission channels.

Reliability tests ensure the relevance of the chosen tax instruments in our settings. In GVAR #1, the reliability test on the adopted instrument shows a statistic

of 0.8, and in GVAR #2, of 0.6. These values are in the good-quality range for tax models reported in Mertens and Ravn (2013) and Mertens and Ravn (2014), validating the adopted identification procedures. Impulse response functions (IRFs), standardized to obtain comparable results, are shown in Figs. 1, 2, 3, 4, 5, 6, 7, 8 and 9. Regarding their interpretation, we highlight the following points. First of all, all impulse responses can be interpreted as reactions to a shock of -1 percentage point size in the tax rate. Second, the impulse response functions show a permanent behavior, both for the shocked and the response variables. Such behavior is driven by the fact that the model is estimated in error correction form and, therefore, takes into account the existing cointegrating relationships among variables, as outlined in Sect. 2. Finally, the IRFs display the median estimates along one standard deviation confidence bands, calculated through the bootstrap procedure.^{14,15}

5.1 Domestic Effects

Figure 1 displays the domestic response to a -1 p.p. shock to US PITR and CITR. In both cases, the output response is positive and significant, showing a persistent behavior that is similar to that of the shocked variable, i.e., the tax rate. The timing of the response is slightly different across the two shocks, with GDP increasing on impact following the PITR shock, while reacting with a lag to the CITR shocks. In terms of magnitudes, GDP in percentage changes increases more in the case of PITR shocks than CITR shocks, similarly to what Mertens and Ravn (2013) find. However, in order to correctly quantify the impact on output, we rely on fiscal multipliers, as we clarify later. Short- and long-term interest rates react significantly, despite following opposite dynamics. Indeed, they increase in response to the personal income tax shock, while they fall after the corporate tax shock.¹⁶ A similar pattern can also be noted for inflation. Such results suggest a different propagation mechanism for the two types of shocks. In the case of personal income tax shock, demand-side effects seem to dominate, with the central bank reacting to higher demand and inflation raising interest rates and dampening the positive effect of the tax cut on growth. At the opposite, in the case of corporate tax rate shock supply-side effects prevail, reinforcing the positive impact given by the fiscal expansion.

In order to properly compare the quantitative effects of the two different shocks, we report the results in terms of their implied multipliers, i.e., the dollar increase

¹⁴ In order to bootstrap the GVAR model as in 2.10, we need to resample the estimated residuals, to obtain:

$$X_t^{\text{boot}} = \hat{b}_0 + \hat{b}_1 t + \hat{F}_1 X_{t-1} + v_t^{\text{boot}} \quad (4.1)$$

The resampling procedure is carried out by making random draws with replacement from the residual vector $[v_1, v_1, \dots, v_T,]$, and impulse responses are recomputed at each draw.

¹⁵ We adopt one standard deviation confidence bands as uncertainty surrounding international spillover effects is considered higher than that around domestic effects. Other papers in the GVAR literature adopting one-standard deviation bands are, for example, Caporale and Girardi (2013) and Inoue et al. (2015).

¹⁶ Murphy and Walsh (2020) noted a similar behavior after government spending shocks.

in GDP following a one dollar decrease in tax revenues, see Table 2.¹⁷ One year after the shock, both tax rate shocks yield multipliers greater than one, with the one related to the personal income tax equal to 1.4 and the multiplier related to the corporate income tax equal to 3.9. The high value of the corporate tax multiplier partly relates to the negative response of the long-term interest rate, which reinforces the effect of fiscal policy on output, instead of dragging down growth. Two years after the shock, tax multiplier reaches 2.5 in case of a personal income tax shock while cannot be calculated in case of corporate tax rate shock, as tax revenues become not significant.¹⁸ While we cannot directly compare our multipliers with Mertens and Ravn (2013), as they can calculate such statistics only for personal income tax rate shocks¹⁹, our results are in line with tax revenues multipliers reported in Mountford and Uhlig (2009).

5.2 Spillover Effects

Tax rate shocks have positive and statistically significant, albeit relatively small, international output spillovers. For the sake of brevity, we focus on the main economic partners of the USA, i.e., the Euro area, China, Japan, the UK and Canada, for which we detail the main transmission channels; for other emerging economies, we only discuss the overall effect of shocks on economic growth.

Effects on GDP Spillovers on foreign GDP are reported in Figs 3, 4 and 5. Output spillovers are significant in most of the main advanced economies. In particular, they are strongest in Canada and of comparable size in the Euro area, China and the UK. The shapes of foreign GDP responses follow those of US GDP: Spillovers from PITR shocks are slightly more front-loaded, while those from CITR shocks are more gradual. The effect of fiscal policy on emerging countries is on average less significant than that on advanced economies (Fig. 5). Among EMEs, they are stronger in Mexico and South East Asia than in Latin America, and never significant in India.²⁰

International fiscal multipliers Tables 3 and 4 quantify the effect of fiscal shocks on GDP in recipient economies in terms of fiscal multipliers. International fiscal multipliers are here defined as the dollar increase in foreign GDP following a one

¹⁷ The response of tax revenues t periods after the shock ($t = 0, \dots, n$) is constructed by combining the dynamics of the shock with the response of the tax base, following Mertens and Ravn (2013)

$$\hat{r}_t = \hat{T}^i / \bar{T}^i + \hat{b}_t^i$$

where T is the tax rate of type $i = \text{PITR}, \text{CITR}$, $\bar{T}^i$ is the mean average tax rate, and b is the appropriate tax base; hats denote impulse responses, and lower case letters denote logged variables.

¹⁸ After the 2-year horizon, it is not possible to calculate anymore the fiscal multiplier in neither case, as tax revenues become all insignificant.

¹⁹ The main difference between our results and those of Mertens and Ravn (2013) is that, in the latter, the response of tax revenues following a CITR shock is never significant. In fact, such difference is explained by the different sample we adopt, i.e., 1979:Q2–2006:Q4 instead of 1955Q1–2006Q4. Indeed, when re-estimating Mertens and Ravn's model in the sample 1979:Q2 - 2006:Q4, we find that tax revenues are in line with the domestic responses we obtain in our GVAR framework.

²⁰ South East Asia is the GDP-weighted aggregation of Indonesia, Philippines and Thailand, while Latin America is the aggregation of Argentina, Brazil, Chile and Peru.

Table 2 Domestic fiscal multipliers

	Impact	1-year	2-year
Personal income tax rate (PITR)	0.2	1.4	2.5
Corporate income tax rate (CITR)	n.s.	3.9	n.s.

Table reports fiscal multipliers for the USA in case of negative PITR and CITR shocks. GDP elasticities are scaled by average GDP ratios over the 1979–2006 sample. All reported multipliers are significant; n.s. stands for not significant

Fig. 1 US tax rate shocks, domestic effects. Impulse responses from a -1 percentage point shock to US personal income tax rate (PITR). IRFs are in percent for all variables, except for inflation and interest rates, which are in percentage points. Bootstrap median estimates with 68% confidence bands

dollar decrease in US tax revenues. The fiscal multiplier of country i , M^i , observed t periods after the shock ($t = 0, \dots, N$) and referred to a US fiscal instrument FI^{us} , is given by the following:

$$M_{FI,t}^i = \frac{\Delta Y_t^i}{\Delta FI_t^{us}} \quad (4.2)$$

ΔFI^{us} is the response of the fiscal instrument and ΔY^i that of GDP in country i .²¹ Empirically, international multipliers are computed as follows. Defining the elasticity of GDP to the fiscal instrument at period t as the ratio of the impulse response of GDP over that of the fiscal instrument, i.e.,

²¹ The fiscal instrument is the tax revenue, obtained by combining the tax rate shock and the response of tax base as detailed in footnote 17.

$$\epsilon_{FI,t}^i = \frac{\Delta Y_t^i}{Y_t^i} \bigg/ \frac{\Delta FI_t^{us}}{FI_t^{us}}, \quad (4.3)$$

fiscal multipliers are obtained by weighting the elasticities by the ratio of the fiscal instrument to real GDP at some point in time

$$M_{FI,t}^i = \epsilon_{FI,t}^i \frac{FI^{us}}{Y^i} \quad (4.4)$$

Following Ramey (2016), we report cumulated multipliers given by

$$M_{FI,t}^i = \frac{\sum_{s=0}^t \frac{\Delta Y_s^i}{Y_s^i}}{\sum_{s=0}^t \frac{\Delta FI_s^{us}}{FI_s^{us}}} \quad (4.5)$$

In order to compute international multipliers, we calculate the ratio FI/Y in Eq. (4.4) as the average FI/Y ratios throughout the estimation period for each economy.²²

The tables below summarize the estimates of the international fiscal multipliers for the two types of tax rate shocks, both in terms of the 1-year and 2-year multipliers (Tables 3 and 4). In general, international fiscal multipliers are small, ranging between 0 and 0.4. There is substantial variation across countries: multipliers are small in China, while strongest in the Euro area and the UK. Moreover, multipliers are larger in case of CITR shocks than PITR shocks, consistently with the stronger domestic effect of corporate tax cuts. All in all, the aforementioned results suggest that US fiscal policy does affect economic activity in foreign economies, but its impact is limited.

Transmission channels Figs. 6, 7, 8 and 9 are illustrative in order to shed some light on the international transmission channels of the US fiscal shocks. Although such results are mainly suggestive, we believe they provide useful information on the propagation mechanism. The trade channel appears to be the dominant propagation mechanism. This result is partly driven by the fact that, in the model, international financial markets are also linked by trade weights, so the pure financial spillovers from the USA to the rest of the world may be underestimated. However, other estimates we made with our GVAR assigning higher weights to US financial variables in foreign economies confirm the dominance of the trade channel.²³ The two propagation mechanisms lying behind the trade channel, i.e., the *expenditure switching* and the *expenditure boosting* effects, affect the various economies in different ways. As Fig. 6 shows, following a personal income tax cut in the USA, real exchange

²² This procedure can lead to a bias when significant trends in this ratio are present (Ramey 2016). We also computed the ratio using end-of-sample values, and multipliers do not change significantly.

²³ In order to evaluate whether financial spillovers are able to fully counteract trade spillovers, in a robustness analysis we make the extreme assumption that US short-term rates, long-term rates and equity prices influence foreign financial variables with unitary weights, leaving third-party financial spillovers equal to zero. We simulate a new GVAR with mixture of trade and (unitary) financial weights for PITR shocks, for which a stronger, positive reaction of foreign interest rates could, in principle, mute the positive trade effects on foreign output. Estimates, available upon request, show that spillovers are still positive, confirming the dominance of the trade channel on the financial channel.

rates vis-à-vis the US dollar depreciate for China, Japan, UK and Canada, making their exports cheaper. However, as the responses are barely or even not significant, it is difficult to imagine that these countries benefit from a large expenditure switching effect. Regarding CITR shocks, the picture is specular. Real exchange rates appreciate in foreign countries, but also in this case the responses are mainly not significant. Such opposite behavior of the real exchange rate following PITR and CITR shocks is consistent with the domestic effects of the two shocks in the US, which generate opposite reactions in interest rates and prices, as already commented in the previous section. As real exchange rate responses are subdued, the *expenditure switching* channel does not seem to play a prominent role. On the other hand, Fig. 7 reports the response of real exports, which rise even when the real exchange rate does not depreciate. This fact suggests that exports receive a boost from stronger import demand in the USA, confirmed by the behavior of US real imports in Figs. 1 and 2, hinting at the presence of a powerful *expenditure boosting* mechanism.

An important transmission mechanism is also represented by financial channels. Such channels point to the response of long-term interest rates and equity prices as vehicles for the transmission of fiscal shocks abroad, as explained in Sect. 3.²⁴ Overall, the effect of financial channels on growth is ambiguous. As regards long-term rates, they increase following the two types of US shocks (Fig. 8).²⁵ However, such increase is more relevant in the case of PITR shocks, while in the case of CITR shocks the response is generally less significant and pronounced and, in some cases, even negative. For what concerns equity prices, Fig. 9 reports the results. In the case of PITR shocks, they do not seem to play a major role, as their response is basically null, both at the domestic and foreign levels.²⁶ In case of CITR shocks, the effects are positive and significant, representing a possible amplification mechanism. Although it is difficult to evaluate the quantitative relevance of financial channels, it seems plausible that, in the case of corporate income tax shocks, such channels do not significantly contribute to dampen the real effects of fiscal policy across the board. For personal income tax shocks, instead, the responses of interest rates and equity prices seem to represent a drag on GDP growth.

6 Conclusions

In this paper, we investigate the international dimension of fiscal policy, analyzing the spillover effects of tax rate shocks originating in the USA. We study different subcategories of tax shocks, focusing on the international propagation mechanisms

²⁴ For the sake of completeness, we report the response of foreign short-term interest rate and inflation in Figs. 10 and 11 of “Appendix 2”.

²⁵ This is particularly interesting for the case of CITR shocks, as in such case interest rates fall in the USA. Our interpretation of this finding is that, while CITR shocks can be thought as supply shocks domestically, this is not the case for their cross-border transmission. Indeed, output and prices abroad increase, pushing interest rates up.

²⁶ It is likely that the increase in interest rates (highly elastic to PITR shocks) counter balance a possible rise in firms’ expected profits.

and quantifying the size of multipliers. The main finding is that fiscal spillovers are positive and statistically significant, albeit of a relatively small size.

This result suggests some relevant policy insights. First, the potential benefits of a fiscal expansion in the US, from the point of view of recipient countries, are generated via the trade channel, which includes an expenditure boosting and, to a lesser extent, an expenditure switching effect. Second, the international spillovers of US fiscal policy seem to be more relevant for advanced countries than for emerging ones. This is in contrast with the effects of US monetary policy, which is considered as a driver of international capital flows and a source of major concern for developing countries. In this paper, we do not address the question of nonlinearity of fiscal policy spillovers, which still deserves further research.

Appendix 1: Estimation Specification and Data Source

A1.1: Data Source

The set of variables common to all GVAR models are taken from Mohaddes and Raissi (2018). The database contains data for real GDP y_i , consumer price inflation π_i , real exchange rate r_i (defined as the nominal exchange rate e_i minus domestic CPI), the 3-month interest rate i_i^s , the 10-year government bond yield i_i^l , the real equity price index q_i (the equity index deflated by domestic CPI). Exports and imports are taken from the IMF IFS database. For what concerns the fiscal variables in the USA, we used the following sources. Nominal government spending ($gcgi$) is taken from the NIPA tables of the Bureau of Economic Analysis and consists of both government consumption and investment. Nominal variables are then deflated using the CPI index. The personal income tax rate and tax base, as well as corporate income tax rate and tax base, are taken from the dataset provided by Mertens and Ravn (2013). The narrative series used to identify tax shocks are taken from Mertens and Ravn (2013).

A1.2: Estimation Specification

Here, we summarize our model specification in terms of the number of cointegrating relationships and lags chosen. First of all, we conducted the augmented Dickey–Fuller (ADF) test to check for the presence of unit root for the variables included in the GVAR. At the 5% significance level, we find that most of the domestic variables are integrated of order 1, i.e., $I(1)$, with the exception of some variables, mainly interest rate variables, being $I(0)$ or near $I(1)$. The fact that almost all variables show a unit root behavior motivated our choice to proceed in the estimation of the $N + 1$ single-country models using the error correction form. In order to recover the cointegrating relationships among variables, we followed the standard Johansen cointegrating procedure (see Table 5 for the results); in some cases, we had to reduce the number of cointegrating relationships found by the Johansen test to guarantee the stability of the model,

Fig. 2 US tax rate shocks, domestic effects. Impulse responses from a -1 percentage point shock to US corporate income tax rate (CITR). IRFs are in percent for all variables, except for inflation and interest rates, which are in percentage points. Bootstrap median estimates with 68% confidence bands

Fig. 3 Personal tax rate shock, spillover effects. Impulse responses of real GDP rate from a -1 percentage point shock to US personal income tax rate (PITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

as in Cesa-Bianchi (2013). Concerning the choice of lags in each country model, we followed the Schwarz criterion for the domestic variables, while we impose one lag only for the foreign variables. Table 6 reports the results. We also calculated the optimal number of lags following the Akaike criterion, which is less parsimonious. Table 7 reports the number of lags chosen by this criterion, while Figs. 12 and 13 in “Appendix 3” plot the IRFs calculated using such

Fig. 4 Corporate tax rate shock, spillover effects. Impulse responses of real GDP rate from a -1 percentage point shock to US corporate income tax rate (CITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

Fig. 5 Spillovers to EMEs. Impulse responses of real GDP from a -1 p.p. shock to US personal income tax rate (PITR) and US corporate income tax rate (CITR). IRFs are in percent. Latin America is the GDP-weighted aggregation of Argentina, Brazil, Chile and Peru. South East Asia is the GDP-weighted aggregation of Indonesia, Philippines and Thailand. Bootstrap median estimates with 68% confidence bands

specification. Finally, in Table 8 we also report the results of the weak-exogeneity test, along the lines of Harbo (1998). Results show that the economies included in our GVAR can be considered weakly exogenous with respect to the rest of the world, at least in the long run, validating the estimation framework given by Eq. 2.1 (See Tables 5, 6, 7 and 8).

Table 3 International fiscal multipliers, one year after the shock

	Euro area	China	Japan	UK	Canada
Personal income tax rate (PITR)	0.12	0.07	0.04	0.13	0.11
Corporate income tax rate (CITR)	0.30	n.s.	0.23	0.40	0.19

Table reports the fiscal multipliers, both for PITR and CITS shocks, for the Euro area, China, Japan, the UK and Canada. All reported multipliers are statistically significant

Table 4 International fiscal multipliers, 2 years after the shock

	Euro area	China	Japan	UK	Canada
Personal income tax rate (PITR)	0.23	0.14	0.07	0.22	0.22
Corporate income tax rate (CITR)	n.s.	n.s.	n.s.	n.s.	n.s.

Table reports the fiscal multipliers 2 years after the shock, both for PITR and CITS shocks, for the Euro area, China, Japan, the UK and Canada. All reported multipliers are statistically significant

Fig. 6 Trade channel-exchange rates. Impulse responses of real foreign exchange rate from a -1 percent point shock to US personal income tax rate (PITR) and US corporate income tax rate (CITR). IRFs are in percent. Values above zero mean appreciation of foreign currencies towards the US dollar. Bootstrap median estimates with 68% confidence bands

Fig. 7 Trade channel-real exports. Impulse responses of real exports from a 1 percentage point (p.p.) shock to a -1 p.p. shock to US personal income tax rate (PITR) and US corporate income tax rate (CITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

Fig. 8 Financial channel-long rates. Impulse responses of nominal long-term interest rates from a 1 percentage point (p.p.) shock to a -1 p.p. shock to US personal income tax rate (PITR) and US corporate income tax rate (CITR). IRFs are in percentage points. Bootstrap median estimates with 68% confidence bands

Fig. 9 Financial –equity prices. Impulse responses of real equity prices from a 1 percentage point (p.p.) shock to a –1 p.p. shock to US personal income tax rate (PITR) and US corporate income tax rate (CITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

Table 5 Cointegration test results

		Rank	Rank
Argentina	2	New Zealand	4
Australia	3	Peru	3
Brazil	2	Philippines	3
Canada	3	South Africa	2
China	2	Saudi Arabia	2
Chile	2	Singapore	2
Euro area	1	Sweden	3
India	1	Switzerland	2
Indonesia	3	Thailand	1
Japan	2	Turkey	1
Korea	4	UK	1
Mexico	1	USA	4
Norway	2		

Table reports the rank number chosen by the Johansen cointegration test. For the case of UK and Canada, the number of ranks has been reduced by one. Results are unchanged irrespective of considering the model with PITR shocks or CITR shocks

Table 6 Lag-order selection test: Schwarz criterion

Lag number		Lag number	
Argentina	2	New Zealand	1
Australia	1	Peru	2
Brazil	1	Philippines	1
Canada	1	South Africa	1
China	1	Saudi Arabia	2
Chile	1	Singapore	1
Euro area	1	Sweden	1
India	1	Switzerland	1
Indonesia	1	Thailand	1
Japan	1	Turkey	1
Korea	1	UK	1
Mexico	1	USA	1
Norway	1		

Table reports the number of domestic lags chosen by the Schwarz criterion, for each country model. Results are unchanged irrespective of the model featuring PITR shocks or CITR shocks

Table 7 Lag-order selection test: Akaike criterion

Lag number		Lag number	
Argentina	4	New Zealand	2
Australia	1	Peru	4
Brazil	4	Philippines	4
Canada	3	South Africa	2
China	1	Saudi Arabia	3
Chile	4	Singapore	4
Euro area	2	Sweden	2
India	4	Switzerland	4
Indonesia	3	Thailand	4
Japan	3	Turkey	3
Korea	4	UK	1
Mexico	3	USA	4
Norway	2		

Table reports the number of domestic lags chosen by the Akaike criterion, for each country model. Results are unchanged irrespective of the model featuring PITR shocks or CITR shocks

Table 8 Weak-exogeneity test results

Country	F test	Crit. value	y_s	π_s	eq_s	r_s	e_s
Argentina	F(2,88)	3.10	1.28	1.23	0.90	3.48	–
Australia	F(3,91)	2.70	0.15	1.40	1.16	0.55	–
Brazil	F(2,94)	3.09	0.64	0.39	0.59	0.48	–
Canada	F(3,91)	2.79	1.30	2.99	0.45	0.38	–
China	F(2,94)	3.09	0.05	0.18	1.49	1.27	–
Chile	F(2,94)	3.09	1.87	3.81	2.92	3.21	–
Euro area	F(1,93)	3.94	3.85	0.22	0.15	0.05	–
India	F(1,94)	3.9	0.02	0.55	0.32	0.26	–
Indonesia	F(3,93)	2.7	0.78	0.34	0.54	1.39	–
Japan	F(2,92)	3.1	0.42	1.08	2.57	0.39	–
Korea	F(4,90)	2.47	1.27	1.74	0.26	2.30	–
Mexico	F(1,95)	3.94	0.07	0.30	0.28	2.36	–
Norway	F(2,92)	3.1	7.98	0.61	0.15	0.12	–
New Zealand	F(4,90)	2.47	1.50	2.42	0.57	1.70	–
Peru	F(3,94)	2.7	1.02	0.30	0.59	1.35	–
Philippines	F(3,93)	2.70	1.23	1.24	0.22	0.72	–
South Africa	F(2,92)	3.1	1.50	1.74	0.91	0.63	–
Saudi Arabia	F(2,96)	3.09	1.38	0.69	1.47	2.75	–
Singapore	F(2,93)	3.09	0.95	0.04	2.55	1.57	–
Sweden	F(3,91)	2.7	1.26	1.99	0.84	1	–
Switzerland	F(2,92)	3.1	0.11	0.57	1.32	0.06	–
Thailand	F(1,94)	3.94	2.02	0.07	1.29	2.17	–
Turkey	F(1,95)	3.9	0.01	1.39	0.02	0.67	–
UK	F(1,93)	3.94	0.42	0.88	0.43	0.02	–
USA	F(4,85)	2.48					2.51

Table reports results of the weak-exogeneity test for the CITR shocks. Results are unchanged irrespective of the model featuring PITR shocks or CITR shocks

Appendix 2: Additional Spillover Effects

See Figs. 10 and 11.

Fig. 10 Spillovers to short-term rates, baseline estimate. Impulse responses of nominal short-term interest rates from a -1 p.p. shock to US personal income tax rate (PITR) and a -1 p.p. shock to US corporate income tax rate (CITR). IRFs are in percentage points. Bootstrap median estimates with 68% confidence bands

Fig. 11 Spillovers to CPI inflation, baseline estimate. Impulse responses of foreign inflation from a -1 p.p. shock to US personal income tax rate (PITR) and a -1 p.p. shock to US corporate income tax rate (CITR). IRFs are in percentage points. Bootstrap median estimates with 68% confidence bands

Appendix 3: Robustness Estimates

C3.1: Lags Selected with Akaike Information Criterion

See Figs. 12 and 13.

Fig. 12 PITR shock spillovers, lag robustness. Impulse responses of foreign real GDP from a -1 p.p. shock to US personal income tax rate (PITR) and a -1 p.p. shock to US corporate income tax rate (CITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

Fig. 13 CITR shock spillovers, lag robustness. Impulse responses of foreign real GDP from a -1 p.p. shock to US personal income tax rate (PITR) and a -1 p.p. shock to US corporate income tax rate (CITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

C3.2: US Model Including Both Types of Taxes

See Figs. 14, 15 and 16.

Fig. 14 Domestic effects, model with both types of taxes. Impulse responses from a -1 p.p. shock to US personal income tax rate (PITR) and a -1 p.p. shock to US corporate income tax rate (CITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

Fig. 15 PITR spillovers, model with both types of taxes. Impulse responses of foreign real GDP from a -1 p.p. shock to US personal income tax rate (PITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

Fig. 16 CITR spillovers, model with both types of taxes. Impulse responses of foreign real GDP from a -1 p.p. shock to US corporate income tax rate (CITR). IRFs are in percent. Bootstrap median estimates with 68% confidence bands

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