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Abstract

We investigate the international propagation of fiscal policy shocks originated in the United States using a Global VAR framework. We identify shocks to US tax rates and government spending by using narrative series as external instruments, following the proxy SVAR methodology. The main results of the paper are the following: (1) the domestic effects of tax shocks are stronger than those of a government spending 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 by real exchange rate depreciation vis-à-vis the US dollar, is the main transmission channel; financial channels (through long-term interest rates and equity prices) also play a role.

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Keywords: international fiscal spillovers, proxy SVAR, GVAR

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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 sizeable fiscal stimulus, which supported the recovery in the United States; 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. The US Congress has recently adopted a major overhaul of the tax code, embracing tax cuts and also accompanied by increases in military spending.

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. This is the focus of this paper. First, we evaluate the domestic and spillover effects of an expansionary fiscal shock in the United States, 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? Second, we provide evidence on how the impact of fiscal policy depends on the specific instrument adopted, comparing not only tax versus spending, but also the specific components of tax and spending 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 VAR (GVAR), the framework developed by Pesaran et al. (2004), in which each country model features domestic and foreign variables such as real GDP, inflation, real equity prices, interest rates, real exchange rates and exports. In the US model, we also include fiscal variables, and identify spending and tax rate shocks following the proxy-SVAR methodology, using the narrative series of Ramey and Zubairy (2017) as instruments for general spending and government investment shocks, and those of Mertens and Ravn (2013) 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 stronger than those of general spending shocks: while the former delivers multipliers consistently above unity, only the government investment shock, which represents a small fraction of total government spending, has a multiplier larger than 1. This result is in line with the most recent evidence showing that tax shocks have a stronger impact on

output, and that spending shocks have multipliers on average below one ((Ramey, 2017)). Second, spillovers are positive and statistically significant, albeit of a small size except in the case of Canada; in particular, the size of spillovers is directly related to the domestic effect of the shock, without any inherent difference between spending and tax shocks. Third, in terms of geographical distribution, advanced countries are always impacted by US shocks, while spillovers are not always significant in emerging ones; moreover, economies that are geographically close to the US are not impacted in the same way, with Mexico benefiting less than Canada from the US fiscal expansion.

The paper also investigates 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 United States 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, in most cases foreign countries real exchange rates depreciate vis-à-vis the US dollar, improving their price competitiveness (expenditure switching or price effect); in other cases, higher US output stimulates demand for imports without significant exchange rate variations (expenditure boosting or quantity effect). Financial channels (i.e., through interest rates and equity prices) also play a role in the international transmission, although a smaller one than the trade channel, also because they involve effects of opposite signs. In most cases, foreign long-term interest rates 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, as suggested by the literature focusing on fiscal policy reversals as the key driver of domestic and international responses (see *Literature Review*). Concerning equity markets, a US fiscal expansion entails equity price increases in some economies, generating positive wealth effects which could support consumption and investment; however, financial wealth being generally highly concentrated (especially in developing countries), wealth effects due to equity portfolios 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 channels of a fiscal shock originating in the US. As we model the world economy in a single framework, we are able to study the transmission mechanism and take into account third party effects among the countries included in the model.[1] Second, the paper highlights the differences in the international propagation among the implemented fiscal policy tools, i.e. general

[1] Spillovers among recipient economies are particularly relevant for some partners and cannot be captured within simpler source-recipient models.

spending and government investment, as well as personal and corporate income tax policies; in particular, tax policy spillovers are mostly disregarded in the fiscal spillover literature. Third, it is the first paper quantifying spillovers in terms of fiscal multipliers for each type of spending and tax shocks and at different points in time. Finally, fiscal policy shocks in the US are identified using narrative series (not plagued by foresight problems (Ramey, 2016a)); in the case of taxes, the narrative series 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 the first time a proxy-SVAR identification strategy is employed in a GVAR framework.

Literature review

The paper draws on different strands of literature. First, it relates to the literature analyzing international fiscal spillovers. The closest paper to ours is IMF (2017b), which analyzes spillovers stemming from a global fiscal 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, IMF (2017b) does not focus on the transmission mechanism of fiscal shocks, which is instead our focus. Auerbach and Gorodnichenko (2013) estimate government spending spillovers in a panel of OECD countries; they find, in line with our paper and IMF (2017b), 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 US; 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 lower foreign interest rates determined by international financial linkages

[2] As also noted in IMF (2017b), 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.

(Corsetti et al. (2009), Corsetti et al. (2012), Corsetti and Muller (2013)). While we find some negative effects 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)), 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 literature analyzing the domestic effects of fiscal policy, specifically for the United States (e.g. Blanchard and Perotti (2002), Ramey (2011), Romer and Romer (2010), Mountford and Uhlig (2009), Mertens and Ravn (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 the paper that develops the proxy-SVAR methodology and construct the exogenous narrative tax rate series that we use in the estimation, both for the corporate tax and the personal income tax.[4] They also quantify the effects of tax rate shocks, finding large multipliers in the case of personal income tax rate shocks but smaller effects for the corporate tax shock, although they do not provide explicitly an estimate of the corporate tax multiplier. In our paper we follow the Mertens and Ravn (2013) methodology and we embody it in the GVAR. Despite the different sample period, we find tax multipliers for the US of similar magnitudes. Our paper is also closely related to Ramey (2016b) and Ramey and Zubairy (2017), which provide an historical series of exogenous defense spending news, generated by analyzing spending announcements and government balance sheets. We use that series as an instrument to identify our spending shocks. Ramey and Zubairy (2017) is also among the first papers investigating empirically the effects of fiscal policy when the economy is at the zero lower bound; in our large-scale multi-country framework, constrained by data availability, we abstract from this issue and results need to be interpreted as average responses over the estimation period.[5]

Finally, our paper draws on the GVAR methodology, introduced in the two seminal

[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, IMF (2017a).

[4] Contemporaneously, also Stock and Watson (2012) presented a similar methodology.

[5] Since our estimation period (1979 – 2006) is one where the US economy was not at the zero lower bound, the results can be interpreted, as a first approximation, as applying to a situation where US interest rates are not constrained by it. The same does not apply to all the other economies in our GVAR (e.g. Japan).

papers by Pesaran et al. (2004) and 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 largely 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.[6] None of these studies aims at quantifying the output effect of an identified fiscal shock stemming from the US 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 Section 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, Section 5 concludes.

2. Model and identification strategy

2.1. 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 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.

[6]Other studies which employ the GVAR methodology to investigate fiscal shocks among Euro area countries are Ricci-Risquete and Ramajo-Hernndez (2015) and Dragomirescu-Gaina and Philippas (2015).

First step

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

$$X_{i,t} = a_{i,0} + a_{i,1}t + \sum_{k=1}^{K} \phi_{i,k} X_{i,t-k} + \sum_{p=0}^{P} \Lambda_{i,p} X^*_{i,t-p} + u_{i,t} \tag{1}$$

where $X_{i,t}$ is the vector of country i's domestic variables and $\sum_{k=1}^{K} \phi_{i,k}$ are the relative 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. $u_{i,t} \sim i.i.d.(0, \Sigma^u_i)$. The vector $X^*_{i,t}$ plays a crucial role in the GVAR framework and it is defined in the following way:

$$X^*_{i,t} = \sum_{j=1}^{N} w_{i,j} X_{j,t} \tag{2}$$

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, $w_{i,j=i} = 0$ and $\sum_{j=1}^{N} w_{i,j} = 1$. Equation 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 a small open economy with respect to the rest of the world and therefore that Equation 1 can be estimated on a country-by-country basis.

Mauro et al. (2007) show that Equation 1 can be re-written in Error Correction (EC) form, thus allowing for cointegration both within $X_{i,t}$ and between $X_{i,t}$ and $X^*_{i,t}$, and estimated with the Johansen procedure, modified to take into account the exogenous variables (Harbo (1998), Pesaran et al. (2000)). The number of long-run relations is given by the rank of the matrix $\Pi_i = \alpha_i \beta'_i$. In the case where the rank of such matrix is $k > 0$, the model exhibits k cointegrating relationships. The coefficients α_i represents the speed of adjustment in the process of reaching the long-run equilibrium, β_i are the cointegrating vectors. The values of the parameters α_i and β_i are estimated through the Johansen procedure, assuming the foreign variables as weakly exogenous.[7]

[7]In order to avoid introducing quadratic trends in the levels of the variables when Π_i is not full rank, some form of restriction can be imposed on the parameter γ_i.

Second step

After the estimation of the country-specific VARX, these are combined and stacked in order to form the global model. Without loss of generality, we assume that a VARX(1,1) is estimated for each country:

$$X_{i,t} = a_{i,0} + a_{i,1}t + \phi_{i,1}X_{i,t-1} + \Lambda_{i,0}X^*_{i,t} + \Lambda_{i,1}X^*_{i,t-1} + u_{i,t}, \tag{3}$$

Defining

$$z_{i,t} = \begin{pmatrix} X_{i,t} \\ X^*_{i,t} \end{pmatrix}, \tag{4}$$

Equation 3 can be written as:

$$A_{i,0}z_{i,t} = a_i + a_{i,1}t + A_{i,1}z_{i,t-1} + u_{i,t} \tag{5}$$

where

$$A_{i.0} = (I, -\Lambda_{i,0}), A_{i.1} = (\phi_{i,1}, \Lambda_{i,1}) \tag{6}$$

The trade weights $w_{i,j}$ are then used to define the link matrix W_i and obtain the identity:

$$z_{i,t} = W_i X_t \tag{7}$$

with $X_t = [X_{1,t}, X_{2,t}, ...X_{N,t}]$, i.e. the vector collecting all the country specific endogenous variables of the model. Substituting 7 in Equation 5, we obtain:

$$A_{i,0}W_iX_t = a_{i,0} + a_{i,1}t + A_{i,1}W_iX_{t-1} + u_{i,t} \tag{8}$$

Now the country-specific models given by Equation 8 are stacked to generate the global model for X_t:

$$G_0X_t = a_0 + a_1t + G_1X_{t-1} + u_t \tag{9}$$

where

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

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

Since G_0 is a non-singular matrix that depends on the trade weights and the estimated parameters, we obtain

$$X_t = b_0 + b_1 t + F_1 X_{t-1} + v_t \tag{10}$$

where

$$F_1 = G_0^{-1} G_1, \quad b_0 = G_0^{-1} a_0, \quad b_1 = G_0^{-1} a_1, \quad v_t = G_0^{-1} u_t \tag{11}$$

Equation 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:

$$\Sigma^v = \begin{bmatrix} \Sigma_0^v & \Sigma_{0,1}^v & \dots & \Sigma_{0,N}^v \\ \Sigma_{1,0}^v & \Sigma_1^v & \dots & \Sigma_{1,N}^v \\ \dots & \dots & \dots & \dots \\ \Sigma_{N,0}^v & \Sigma_{N,1}^v & \dots & \Sigma_N^v \end{bmatrix} \tag{12}$$

where $\Sigma_{i,j}^v$ is the sample covariance matrix between country i and country j and Σ_i^v is the covariance matrix of country i.

2.2. Identification approach

In order to identify shocks in the GVAR, one needs to specify a matrix P_0 that pre-multiplies Equation 10 yielding

$$P_0 X_t = P_0 b_0 + P_0 b_1 t + P_0 F_1 X_{t-1} + \epsilon_t \tag{13}$$

where P_0 is

$$P_0 = \begin{bmatrix} P_{0,0} & P_{0,1} & \dots & P_{0,N} \\ P_{0,1} & P_{1,1} & \dots & P_{1,N} \\ \dots & \dots & \dots & \dots \\ P_{N,0} & P_{N,1} & \dots & P_{N,N} \end{bmatrix} \tag{14}$$

and

$$\epsilon_t = P_0 v_t \tag{15}$$

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

$$\Sigma_\epsilon = \begin{bmatrix} \Sigma_{\epsilon_0} & \Sigma_{\epsilon_0,v_1} & \dots & \Sigma_{\epsilon_0,v_N} \\ \Sigma_{v_1,\epsilon_0} & \Sigma_{v_1} & \dots & \Sigma_{v_1,v_N} \\ \dots & \dots & \dots & \dots \\ \Sigma_{v_N,\epsilon_0} & \Sigma_{v_N,v_1} & \dots & \Sigma_{v_N} \end{bmatrix} \tag{16}$$

We are interested in identifying shocks originating from the US 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 $N^2 + 2N$ P-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 four 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

$$E[m_t, \epsilon_{f,t}] = \gamma \tag{17}$$

$$E[m_t, \epsilon_{nf,t}] = 0 \tag{18}$$

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.[8] In order to validate the use of narrative

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

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 case of significant correlations with specific foreign variables can not 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

$$P_0 = \begin{bmatrix} P_{0,0} & 0 & 0 & \dots & 0 \\ 0 & I & 0 & \dots & 0 \\ \dots & \dots & \dots & \dots & \dots \\ 0 & 0 & 0 & \dots & I \end{bmatrix} \tag{19}$$

2.3. Impulse response functions

For the dynamic analysis of shocks, the GVAR literature largely relies on Generalized Impulse Response Functions (GIRFs) (Koop et al. (1996) and Pesaran and Shin (1997)), that in our case take the form of Structural GIRFs (SGIRFs) as our model is fully 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:

$$SGIRF(x_t; \epsilon_{lt}, n) = \frac{\epsilon_j' A_n (P_0 G_0)^{-1} \Sigma_\epsilon e_l}{\sqrt{e_l' \Sigma_\epsilon e_l}} \tag{20}$$

where $e_l = (0; 0; \ldots; 0; 1; 0; \ldots; 0)$ is a selection vector with unity as the l^{th} element and A_n is

$$A_n = \sum_{i=1}^{p} F_i A_{n-i}, \qquad A_0 = I, \qquad n = 1 \ldots p \tag{21}$$

3. Data and transmission channels

We specify four GVAR models using quarterly data. 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 of variables for each economy except for the US. 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 Mauro et al. (2007)), the 3-month interest rate $i^s_{i,t}$, the 10-year government bond yield $i^l_{i,t}$, the real equity price index $q_{i,t}$ (the equity index deflated by domestic CPI), real exports of goods and services $exp_{i,t}$.[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 $i^{s*}_{i,t}$.[12]

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 US on the rest of the world, we include 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) and Mertens and Ravn (2013), among others). On the spending side, we consider real government expenditure and real government investment; on the tax side, we include the average personal income and corporate tax rates, together with their respective tax bases

[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, United Kingdom and USA. The Euro area is constructed as the aggregation of eight countries: Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain.

[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. Therefore $e_{US,t} = 1$ for all t. For this reason the real exchange rate is not included in the US model.

[12] The real exchange rate is not included in the set of foreign variables of non-US models to avoid multicollinearity.

(net of transfers and interest payments).[13] Second, we do not include US exports and equity prices in order to reduce the number of parameters to be estimated and make the identification as neat as possible. As the instrument for both government spending and investment shocks, we use the military news series constructed in Ramey (2011) and updated in Ramey and Zubairy (2017), i.e. series of estimated changes in the expected present value of government purchases caused by military events; 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).

Table 1 summarizes the domestic and foreign variables included in the US and non-US models. Fiscal variables are included one at a time in each of the four models:

- In GVAR #1, the US model is augmented with the government expenditure variable;
- In GVAR #2, the US model is augmented with government investment;
- In GVAR #3, the US model is augmented with the personal income tax rate, the personal income tax base and government expenditure;
- In GVAR #4, the US model is augmented with the corporate income tax rate, the corporate income tax base and government expenditure;

Our tax models feature also personal and corporate income tax bases in order to be able to calculate fiscal multipliers, and general government spending to control for the endogenous response of fiscal policy. The GVAR model is estimated over the period 1979 Q2 – 2006 Q4 because of data availability issues: observations before 1979 Q2 are not available for all countries, and for some instruments in our set the data is limited to 2006 Q4.

3.1. 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 US 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,

[13] We do not include fiscal variables in non-US models also because only few economies feature fiscal data on a quarterly frequency.

Table 1: Summary of the variables included in the GVAR.

Non-US model		**US model**	
Domestic	Foreign	Domestic	Foreign
y_i	y_i^*	y_{US}	y_{US}^*
π_i	π_i^*	π_{US}	π_{US}^*
r_i	-	-	r_{US}^*
i_i^s	i_i^{s*}	i_{US}^s	i_{US}^{s*}
i_i^l	-	i_{US}^l	i_{US}^{l*}
q_i	q_i^*	G_{US}	-
exp_i	-	T_{US}	-

Table 1 reports the variables included in the non-US and US models. 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), 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), real exports of goods and services $exp_{i,t}$. G_{US} can be either government spending or government investment. T_{US} includes both tax rate and tax base variables, both for personal income and for corporate income.

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 US 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 US 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 ad-hoc 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 channeled by portfolio valuation effects: the equity values of foreign exporting firms might rise, producing 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 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.

4. Results

In this section we describe the results of our estimations. In order to compare the effects of the four shocks, we first comment on the results of the four GVAR models together, divided between domestic and spillovers effects; then, we construct domestic and international fiscal multipliers. The shocks of interest are: shock to total government spending (GCGI henceforth), shock to public investment alone (GI henceforth), shock to average personal income tax rate (PITR henceforth) and shock to corporate income tax rate (CITR henceforth). Second, we discuss the main transmission channels.

As already mentioned, four separate GVAR models are estimated. The employed narrative series (both on the tax and spending side) display reliability test statistics between 0,5 and 0,9, in line with values reported for tax models in Mertens and Ravn (2013) and Mertens and Ravn (2014), validating the adopted identification procedures.[14] Impulse responses, standardized to obtain comparable results, are shown in Figures 1 to 11. All impulse responses can be interpreted as percentage point reactions to a shock of 1 percentage point (or -1 percentage point) size.

4.1. Domestic effects

Figure 1 and 2 display the response of US real GDP to a 1 percentage point (p.p.) shock to US GCGI and GI and to a -1 p.p. shock to US PITR and CITR. In all the cases, the output response is positive and significant; moreover, the effects are persistent, i.e. variables moves gradually to their new steady state level. The timing of the response is differentiated across the four shocks, with GDP increasing on impact following the GI and PITR shocks, while reacting only with a lag to the GCGI and CITR shocks. Short and long-term interest rates do not react significantly to spending shocks. On the contrary, they increase in response to the personal income tax shock while they fall after the corporate tax shock.

In order to compare the quantitative effect of the four different shocks, we report the results in terms of their implied multipliers, i.e. the dollar increase in GDP following a one

[14] In particular, the reliability test statistic equals 0,4 in GVAR model #1, 0,5 in GVAR model #2, 0,7 in GVAR model #3 and 0,9 in GVAR model #4.

dollar increase in spending or tax revenues, see Table 2.[15] The multiplier of GCGI, the usual proxy of spending shocks in the fiscal policy literature, is equal to 0.5 on impact and remains below 1 later on, as already documented in the literature for the post-1980 period (e.g. Perotti (2005)).[16] Only shocks to government investment, whose share in total government spending is much lower than that of government consumption, give sizable multipliers (2.0 after one year). By contrast, both tax rate shocks yield multipliers greater than 1: the effect of personal income taxes is stronger and front-loaded, significant already one quarter after the shock, while corporate taxes have a multiplier of 1.2 one year after. Our results are in line with the recent evidence pointing to a lower multiplier for spending with respect to tax shocks (Ramey (2017)).

Table 2: Domestic fiscal multipliers.

	Impact	**One year**	**Five years**
Government spending (GCGI)	0.5	0.9	1.2
Government investment (GI)	1.6	2.0	2.3
Personal income tax rate (PITR)	0.3	1.3	2.0
Corporate income tax rate (CITR)	n.s.	1.8	5.0

Table 2 reports fiscal multipliers for the United States in case of positive GCGI and GI shocks and 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.

4.2. Spillover effects

Spending and 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 United States, i.e. the Euro area, China, Japan, the United Kingdom 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.

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

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

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

[16] The stronger effect of spending shocks on output for the 1960-1980 period is mainly due to the huge defense spending programs to finance Korea and Vietnam wars.

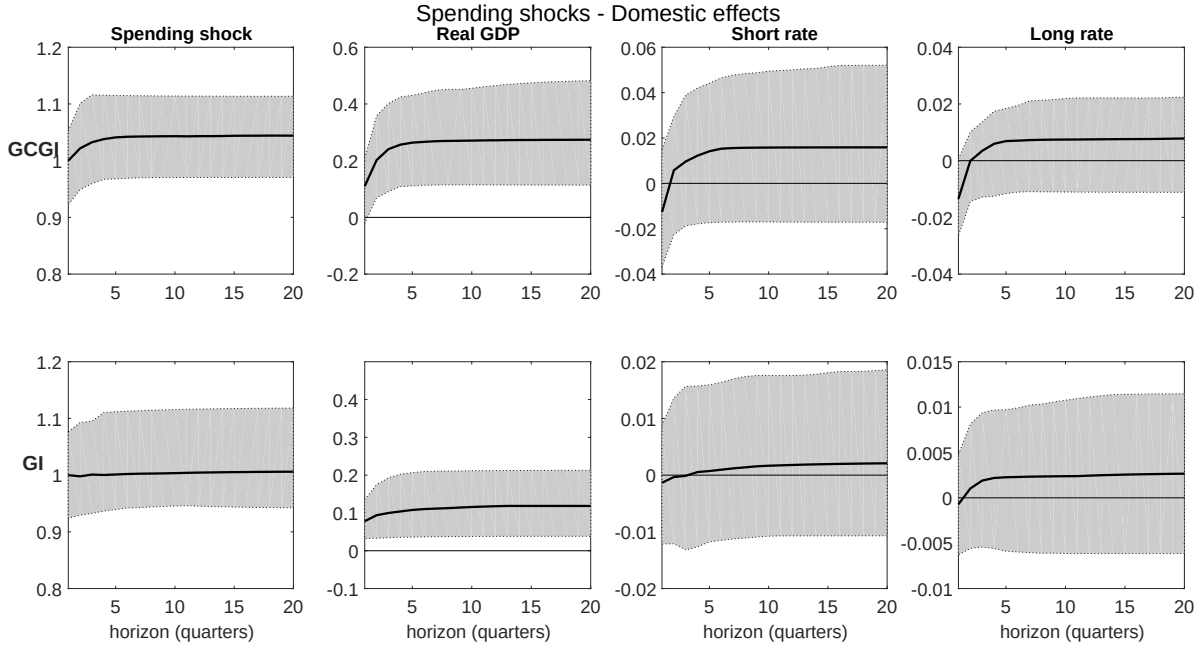

Figure 1. **US government spending shocks, domestic effects.** Impulse responses of real GDP from a 1 percentage point shock to US Government consumption and investment (GCGI) and to US Government investment (GI). Bootstrap median estimates with 68% confidence bands.

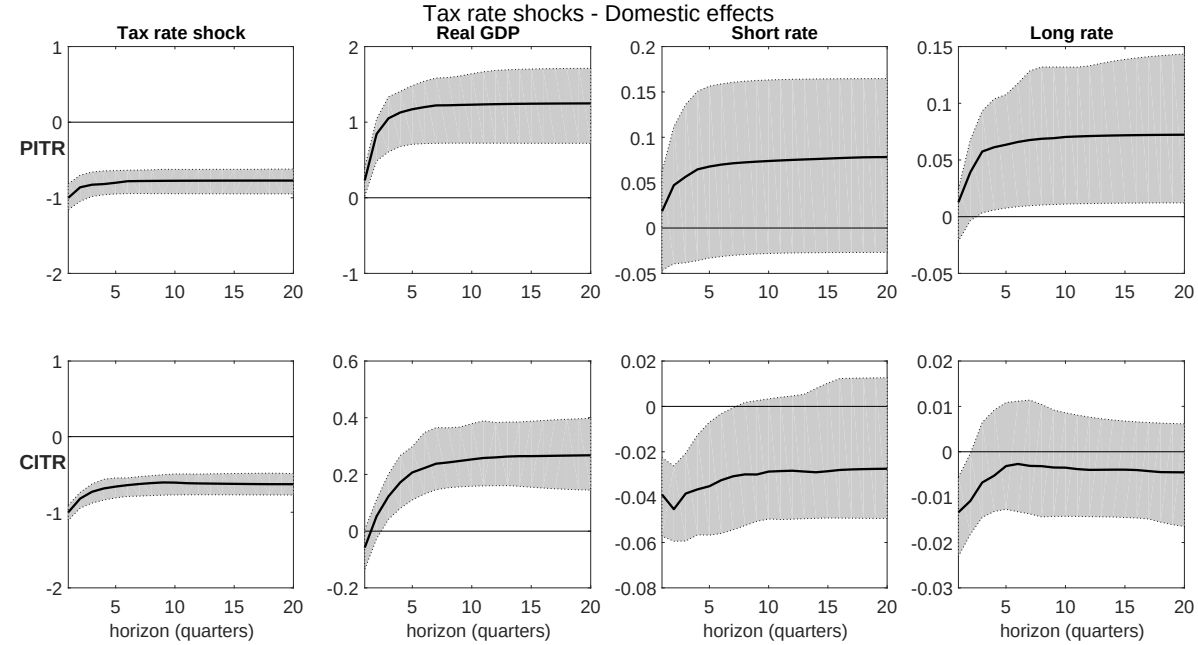

Figure 2. **US tax rate shocks, domestic effects.** Impulse responses of real GDP from a -1 percentage point shock to US Personal income tax rate (PITR) and to US Corporate income tax rate (CITR). Bootstrap median estimates with 68% confidence bands.

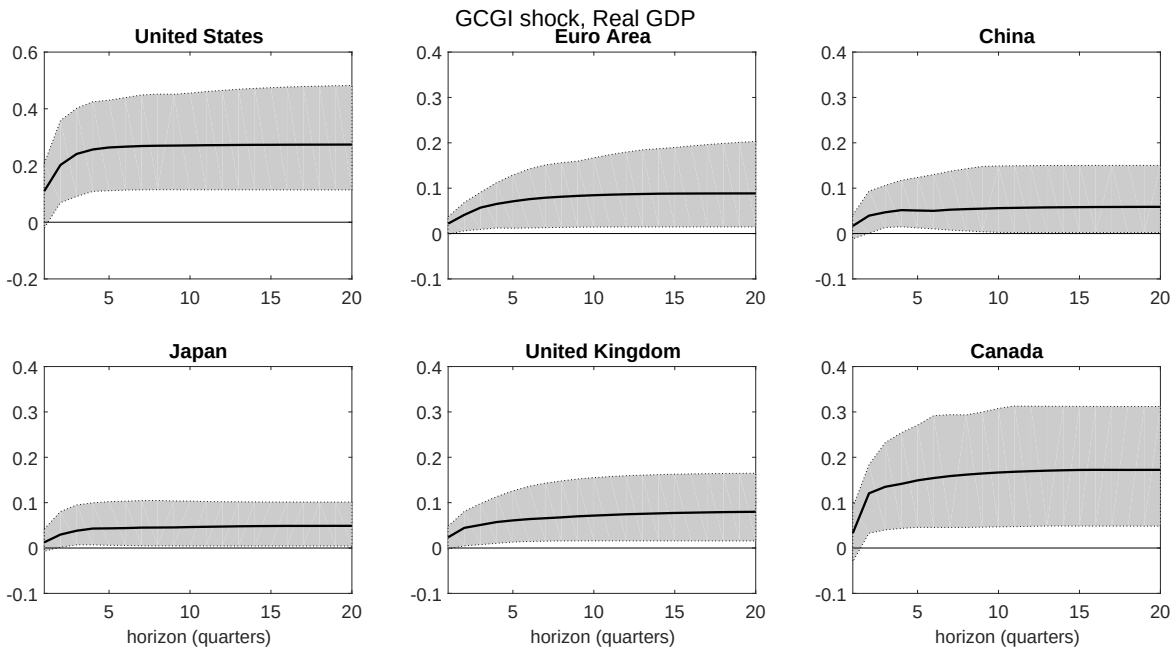

Figure 3. **Government spending shock, spillover effects.** Impulse responses of real GDP from a 1 percentage point shock to US Government consumption and investment (GCGI). Bootstrap median estimates with 68% confidence bands.

Effects on GDP Spillover effects on real GDP are reported in Figures 3 to 7. Overall, spillovers are significant in all of the main advanced economies. In particular, they are strongest in Canada; among the other economies, the impact is slightly higher in the Euro Area and the UK. On the other hand, the effects are not sizable in China. The shapes of foreign GDP responses follow those of US GDP. Therefore, spillovers from PITR shocks are front-loaded while those from GCGI, GI and CITR shocks are more gradual. Concerning the differences between the effects of tax and spending shocks, spillovers from tax shocks have tighter confidence bands, while those from spending shocks are not always significant. The effect of fiscal policy on emerging countries is on average lower than that on advanced economies (Figure 7). Among EMEs, they are stronger in Mexico and South East Asia[17] than in South America[18], and never significant in India.

International fiscal multipliers Tables 3, 4 and 5 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 dollar increase in US spending or tax revenues. The fiscal multiplier of country i, M^i, observed t periods after the

[17]South East Asia is given by the GDP-weighted aggregation of Indonesia, Philippines and Thailand
[18]South America is given by aggregating Argentina, Brazil, Chile and Peru

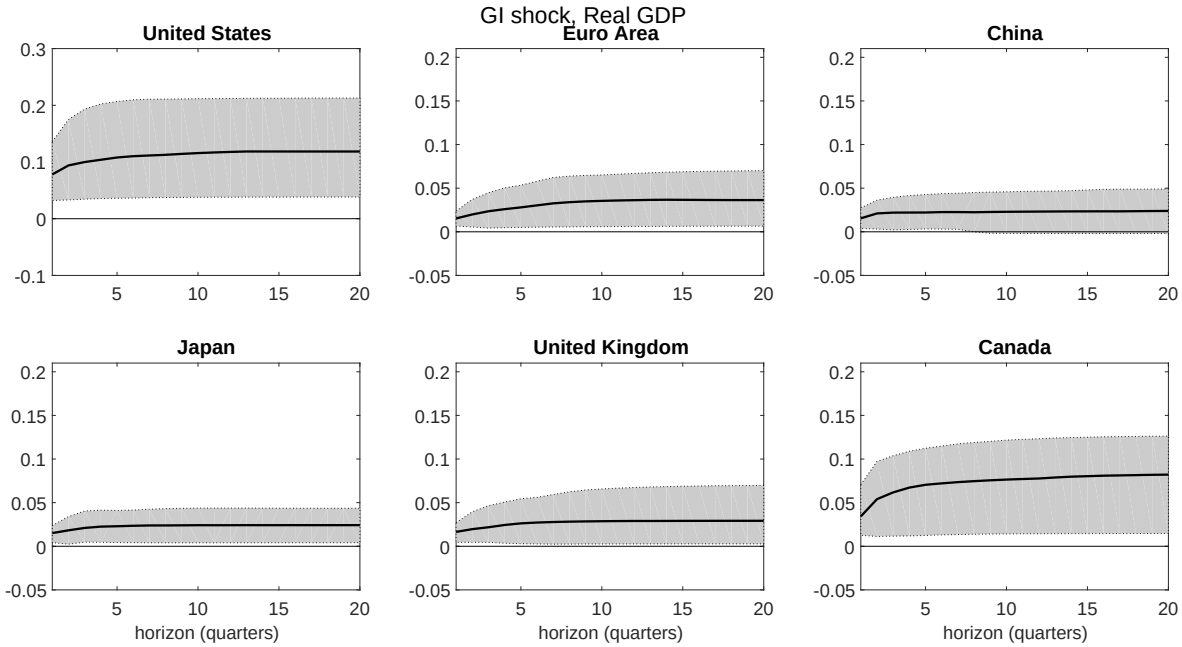

Figure 4. **Government investment shock, spillover effects.** Impulse responses of real GDP from a 1 percentage point shock to US Government investment (GI). Bootstrap median estimates with 68% confidence bands.

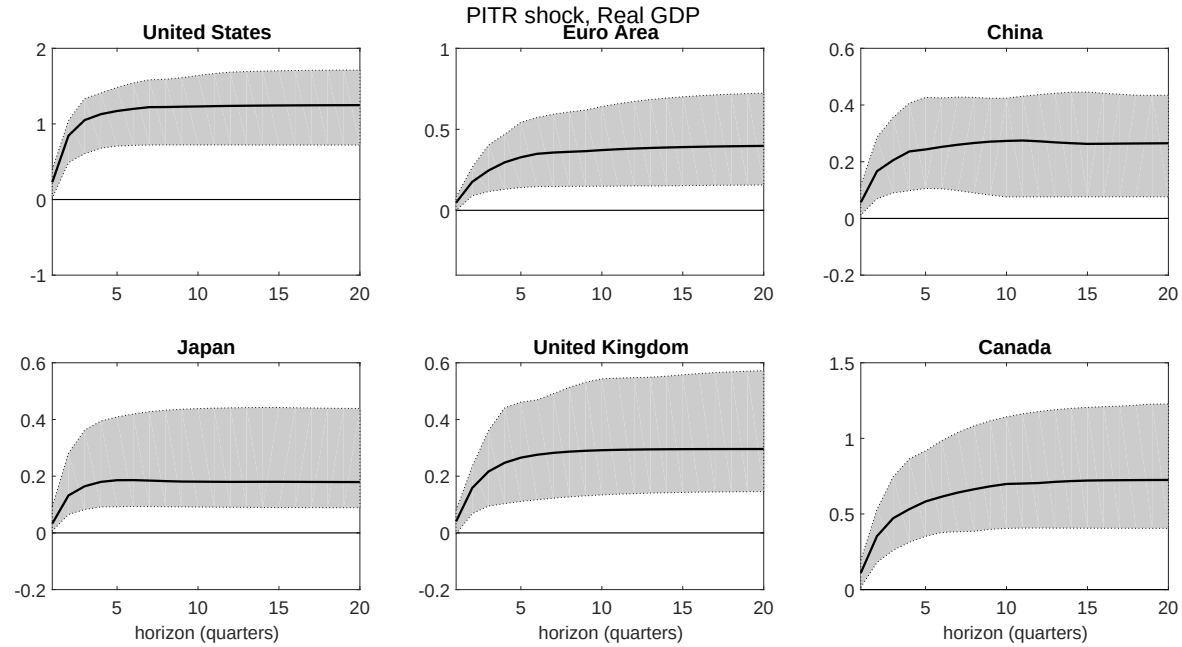

Figure 5. **Personal tax rate shock, spillover effects.** Impulse responses of real GDP rate from a -1 percentage point shock to US Personal income tax rate (PITR). Bootstrap median estimates with 68% confidence bands.

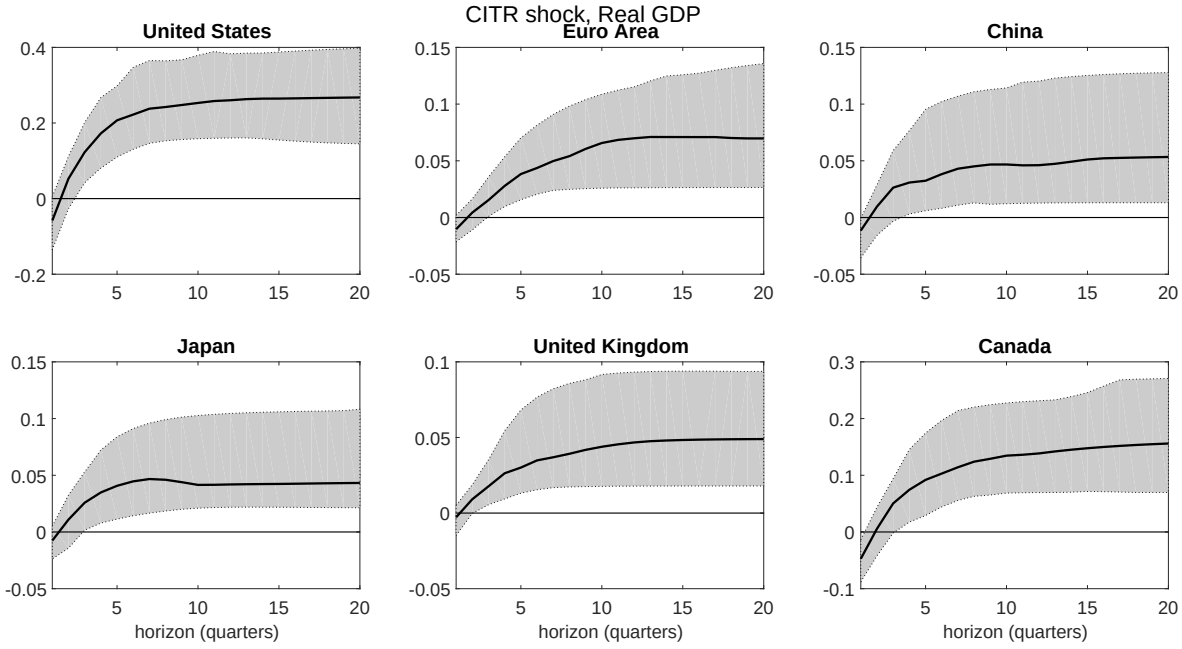

Figure 6. **Corporate tax rate shock, spillover effects.** Impulse responses of real GDP rate from a -1 percentage point shock to US Corporate income tax rate (CITR). Bootstrap median estimates with 68% confidence bands.

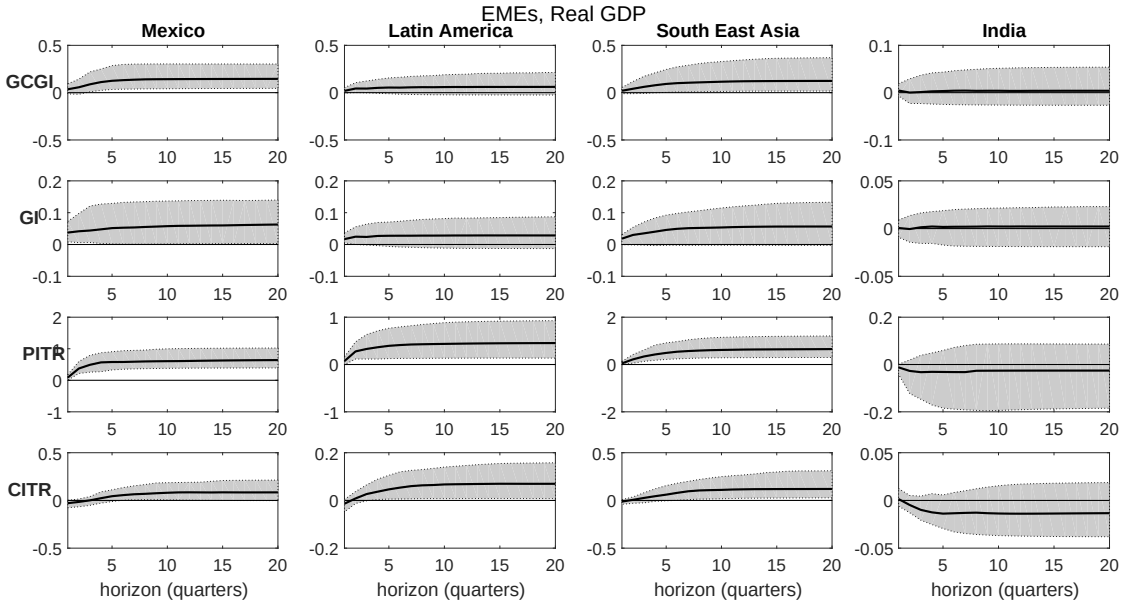

Figure 7. **Spillovers to EMEs.** Impulse responses of real GDP from a 1 percentage point (p.p.) shock to US Government consumption and investment (GCGI) and to US Government investment (GI), lines one and two, and a -1 p.p. shock to US Personal income tax rate (PITR) and US Corporate income tax rate (CITR), lines 3 and 4. 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.

shock ($t = 0, \ldots, N$) and referred to a US fiscal instrument FI^{us}, is given by the following:

$$M^i_{FI,t} = \frac{\Delta Y^i_t}{\Delta FI^{us}_t} \tag{22}$$

ΔFI^{us} is the response of the fiscal instrument and ΔY^i that of GDP in country i.[19] 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.

$$\epsilon^i_{FI,t} = \frac{\Delta Y^i_t}{Y^i_t} \Bigg/ \frac{\Delta FI^{us}_t}{FI^{us}_t}, \tag{23}$$

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

$$M^i_{FI,t} = \epsilon^i_{FI,t} \frac{FI^{us}}{Y^i} \tag{24}$$

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

$$M^i_{FI,t} = \frac{\sum_{s=0}^{t} \Delta Y^i_s}{\sum_{s=0}^{t} \Delta FI^{us}_s} \tag{25}$$

In order to compute international multipliers, we calculate the ratio FI/Y in Equation 24 as the average FI/Y ratios throughout the estimation period for each economy.[20]

The tables below summarize the estimates of the international fiscal multipliers, on impact, after one year and after five years, both for spending and for tax rate shocks. On the five year horizon, multipliers are higher for public investment and for the corporate tax shock, while they are lowest in the case of general government spending shocks. In general, international fiscal multipliers range between 0 and 0.4 but they lie, in most cases, in the 0.1–0.2 interval. There is variation across countries: multipliers are basically null in China and strongest in Canada and Japan. The aforementioned results suggest that US fiscal policy does affect economic activity in foreign economies, but its impact is limited.

[19] The fiscal instrument is government spending/investment – the shocked variables – in case of spending shocks, and tax revenues in case of tax rate shocks, obtained by combining the tax rate shock and the response of tax base as detailed in footnote 15.

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

Table 3: International fiscal multipliers, impact.

	Euro area	**China**	**Japan**	**UK**	**Canada**
Government spending (GCGI)	0	0	0	0	0
Government investment (GI)	0.1	0	0.1	0.1	0.1
Personal income tax rate (PITR)	0	0	0	0	0
Corporate income tax rate (CITR)	0	0	0	0	0.1

Table 3 reports the fiscal multipliers for the subcategories of spending and tax revenues, for the Euro area, China, Japan, UK and Canada. All reported multipliers are statistically significant; values equal to zero indicate multipliers between 0 and 0.1.

Table 4: International fiscal multipliers, one year after the shock.

	Euro area	**China**	**Japan**	**UK**	**Canada**
Government spending (GCGI)	0	0	0.1	0	0.1
Government investment (GI)	0.1	0	0.2	0.1	0.1
Personal income tax rate (PITR)	0.1	0	0	0	0.1
Corporate income tax rate (CITR)	0	0	0.2	0.1	0.1

Table 4 reports the fiscal multipliers for the subcategories of spending and tax revenues, for the Euro area, China, Japan, UK and Canada. All reported multipliers are statistically significant; values equal to zero indicate multipliers between 0 and 0.1.

Table 5: International fiscal multipliers, five years after the shock.

	Euro area	**China**	**Japan**	**UK**	**Canada**
Government spending (GCGI)	0.1	0	0.1	0.1	0.1
Government investment (GI)	0.1	0	0.2	0.1	0.2
Personal income tax rate (PITR)	0.1	0	0	0.1	0.1
Corporate income tax rate (CITR)	0.2	0.1	0.4	0.2	0.3

Table 5 reports the fiscal multipliers five years after the shock for the subcategories of spending and tax revenues, for the Euro area, China, Japan, UK and Canada. All reported multipliers are statistically significant; values equal to zero indicate multipliers between 0 and 0.1.

Transmission channels Figures 8 to 11 document the international transmission channels of the US fiscal shocks. The trade channel appears to be the dominant propagation mechanism. Two different mechanisms lie behind the trade channel, i.e. the *expenditure switching* and the *expenditure boosting* effects, and affect the various economies in different ways. As Figure 8 shows, following a fiscal policy expansion in the United States (both on the spending and on the tax side), real exchange rates vis-à-vis the US dollar depreciate for the Euro Area, and, more persistently, for Japan and the United Kingdom, making their exports cheaper: these countries benefit from an expenditure switching effect. However, exports rise even in cases where the real exchange rate does not depreciate (see Figure 9), as for Canada and China.[21] Indeed, notwithstanding the behavior of the real exchange rate, exports receive a boost from the stronger import demand in the US (in particular in Canada), suggesting 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 Section 3. Overall, the effect of financial channels on growth is ambiguous. As regards long-term rates, in most cases they increase following the US shocks while only in few cases they fall. Indeed, in the United States, long-term interest rates increase in the cases of GCGI, GI and PITR shocks, putting a drag on economic activity both domestically and abroad. On the contrary, they fall significantly only in the case of a CITR shock, reinforcing its expansionary effects. Possibly, the response of interest rates abroad depends on the balance between foreign monetary policy reactions and expectations of a policy reversal in the United States, acting as a drag on economic growth in the first case (as in the Euro Area and the UK) and stimulating investment and consumption in the second one (as in Japan).

Finally, Figure 11 reports impulse responses of stock prices, which are a possible source of wealth effects. Effects on equity prices are stronger for spending than tax shocks, and these are particularly relevant for the Euro Area and Japan. In developing countries the effects are mostly not significant, independently on the fiscal instrument, probably because of the lower responsiveness of emerging countries financial markets to real developments in the US. However, for the reasons described in Section 3, we do not expect equity prices to be the key transmission channel of fiscal policy across the board.

[21] The real exchange rate is not significant in China and works in the opposite direction for Canada

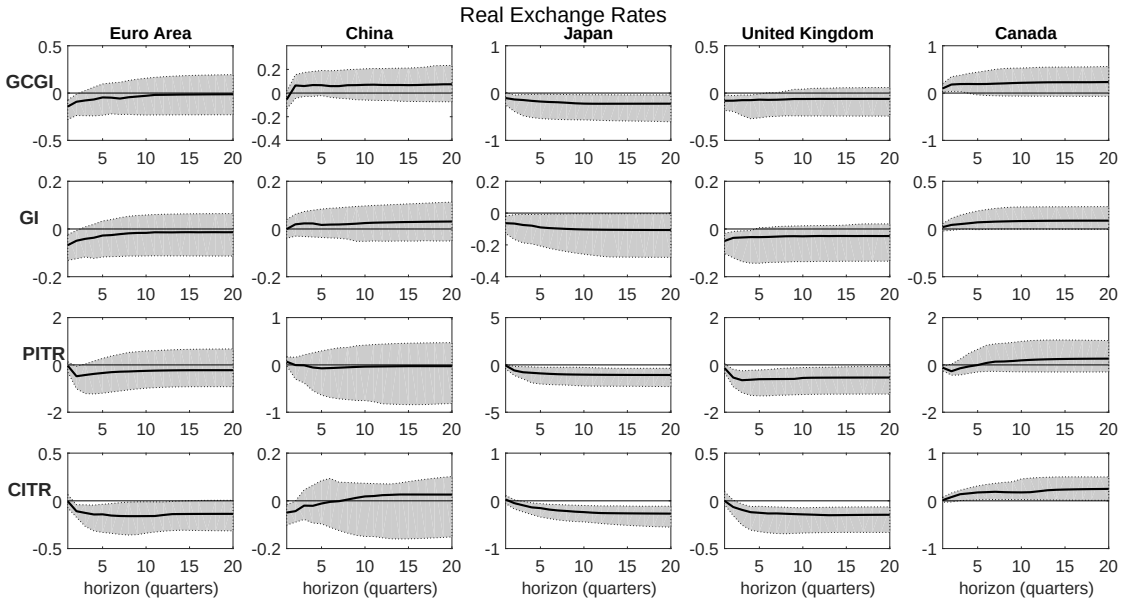

Figure 8. **Trade channel – exchange rates.** Impulse responses of real foreign exchange rate from a 1 percentage point (p.p.) shock to US Government consumption and investment (GCGI) and to US Government investment (GI), lines one and two, and a -1 p.p. shock to US Personal income tax rate (PITR) and US Corporate income tax rate (CITR), lines 3 and 4. Bootstrap median estimates with 68% confidence bands.

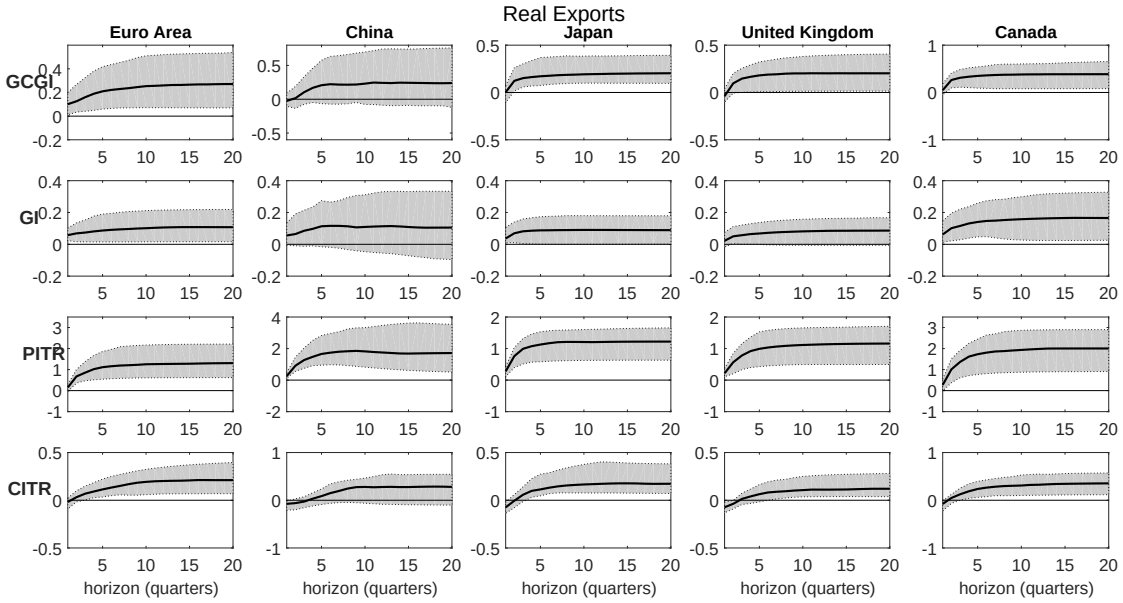

Figure 9. **Trade channel – real exports.** Impulse responses of real exports from a 1 percentage point (p.p.) shock to US Government consumption and investment (GCGI) and to US Government investment (GI), lines one and two, and a -1 p.p. shock to US Personal income tax rate (PITR) and US Corporate income tax rate (CITR), lines 3 and 4. Bootstrap median estimates with 68% confidence bands.

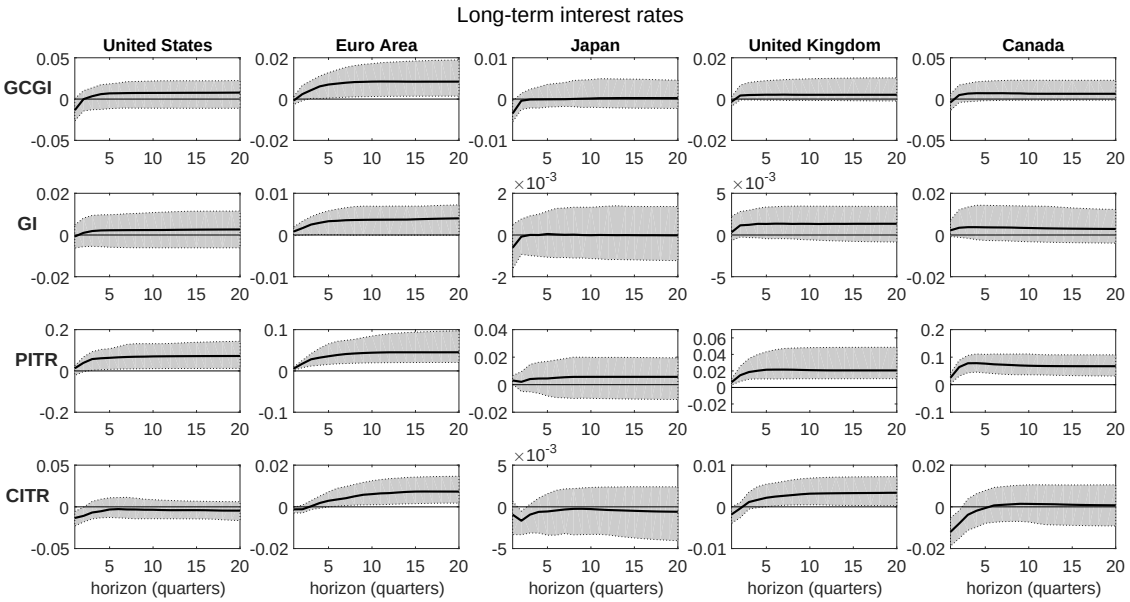

Figure 10. **Financial channel – long rates.** Impulse responses of nominal long-term interest rates from a 1 percentage point (p.p.) shock to US Government consumption and investment (GCGI) and to US Government investment (GI), lines one and two, and a -1 p.p. shock to US Personal income tax rate (PITR) and US Corporate income tax rate (CITR), lines 3 and 4. Bootstrap median estimates with 68% confidence bands.

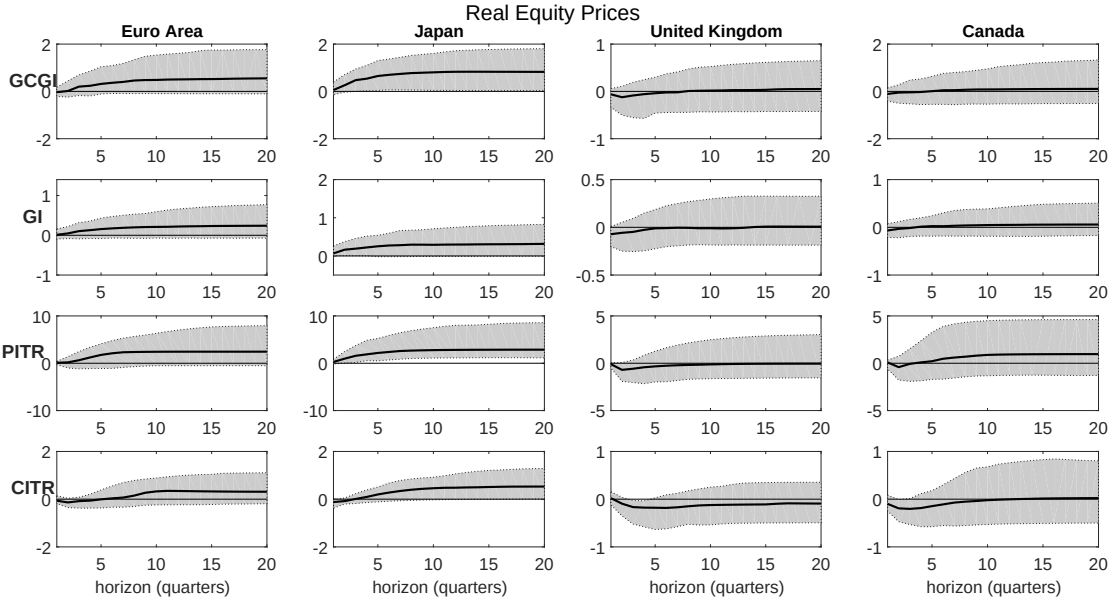

Figure 11. **Financial channel – equity prices.** Impulse responses of real equity prices from a 1 percentage point (p.p.) shock to US Government consumption and investment (GCGI) and to US Government investment (GI), lines one and two, and a -1 p.p. shock to US Personal income tax rate (PITR) and US Corporate income tax rate (CITR), lines 3 and 4. Bootstrap median estimates with 68% confidence bands.

5. Conclusions

In this paper we have investigated the international dimension of fiscal policy, analyzing the spillover effects of fiscal shocks originating in the US. We study different subcategories of tax rate and spending shocks, focusing on the international propagation mechanisms and quantifying the size of the external spillover multipliers of fiscal policies. The main finding is that fiscal spillovers are positive and statistically significant, albeit of a relatively small size, except in the case of Canada.

This result suggests some relevant policy insights. First, the potential benefits of a fiscal expansion the US, from the point of view of recipient countries, are generated via the trade channel, which includes both an expenditure boosting and an expenditure switching effect. Second, the international spillovers of US fiscal policy seem to be more relevant for advanced countries than for the developing ones. This is in contrast with the effects of US monetary policy, which is considered a driver for international capital flows and a source of major concern for developing countries. Third, coordination among developed countries for a combined fiscal stimulus would dampen one important channel through which spillovers are transmitted, i.e. real exchange rate movements. As our results showed, the international spillover effects are transmitted also through a real exchange rate depreciation in the recipient countries, a channel that would be muted if the fiscal stimulus were internationally coordinated. In this paper we did not address the question of non-linearities of fiscal policy, which we believe is an important one and we plan to study in the future.

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