in tax revenues. For example, on average, a 1 percent of GDP spending hike in a major advanced economy can raise output in recipient countries by 0.15 percent over the first year, against 0.05 percent for a tax cut of equal size.

- *Relatively weak cyclical positions imply larger spillovers.* This is true for source countries—suggesting that slack in the source may increase spillovers through a larger *domestic* impact of the fiscal impetus—as well as for recipient countries, suggesting stronger *transmission* in the presence of slack. When economies have little or no slack, estimated spillovers are small.
- *Monetary policy constraints can also increase spillovers.* When monetary policy in either the source or recipient country is unable or unwilling to counteract the fiscal shocks, spillovers can be amplified. For example, compared to average baseline results, spillovers from spending shocks under monetary policy constraints in source (recipient) countries can reach 0.25 percent (0.30 percent) over the first year, while those from tax cuts can reach 0.1 percent (0.15 percent).
- *Currency pegs between source and recipient countries may amplify fiscal spillovers*. The note suggests that fiscal spending shocks from the United States have somewhat larger spillovers on recipient economies whose currencies are pegged to the US dollar compared to those with flexible exchange rates, although this does not seem to be the case for tax revenue shocks.
- Finally, while fiscal actions in the United States have farther-reaching spillovers, those in European countries and Japan have a more regional impact. Fiscal shocks in the United States can entail larger cross-border impact than shocks in other countries—especially onto Canada and Latin America. The global impact of euro area shocks is more modest but particularly relevant for countries in Europe.

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Annex 1. Data for Shock Identification

Quarterly fiscal data used in shock identification for five shock-emitting (source) countries (France, Germany, Japan, United Kingdom, United States) are collected from respective national statistical bureaus, either directly or via Haver Analytics. The following sections describe the data, their limitations, and calculations underlying identified fiscal shocks.

Data Description

Quarterly real government spending and tax revenue data used in constructing fiscal shocks are all expressed in local currency units, seasonally adjusted, and annualized for the sample period, which covers the first quarter of 2000 through the second quarter of 2016. Government spending is calculated as the sum of quarterly general government consumption and general government gross fixed capital formation from the national accounts. For tax revenue, quarterly general government total tax income is used, except in the case of Japan. Annex Table 1.1 provides detail on data sources for each country.

Data Limitations

For Japan, quarterly government total revenue is used instead of tax revenue because of data limitations. Government total revenue data are estimated using both monthly Treasury receipts data from Japan's Ministry of Finance and annual general government revenue data from the IMF's *World Economic Outlook*. Higher-frequency fiscal data cannot be used directly for our analysis owing to definitional differences. Treasury data cover receipts and payments of the private sector only, while official government budget data cover all receipts and payments (Ministry of Finance, *Japan Statistical Yearbook*). To reconcile this difference, we extrapolate quarterly data from the annual government revenue using information from Treasury receipts using the Denton proportional benchmarking method (Di Fonzo and Marini 2014). This method both preserves the seasonality observed from higher-frequency Treasury receipts data and matches the data published in the *World Economic Outlook* when converted to an annual basis.

Annex 2. Data for Spillover Analysis

The quarterly database of 55 recipient countries for the sample period (first quarter of 2000 to second quarter of 2016) includes series on real output, external demand, short-term interest rate, output gap, and exchange rate regime, collected from multiple data sources. The following sections explain how each data series is estimated. Annex Table 2.1 provides details on data sources for each series, and Annex Table 2.2 lists countries in our sample.

Data Description

- *Real GDP.* Quarterly real output levels are rebased to 2010 prices, expressed in local currency units, seasonally adjusted, and annualized.
- *Bilateral goods exports/imports.* Bilateral weights are calculated using the ratio of bilateral exports to imports of goods between 55 countries in the sample and 5 source countries (55 × 5 = 275 pairs). For each country pair, the average between reported values for both countries is taken.

Annex Table 1.1. Sources for Quarterly Fiscal Data for Source Countries

Country	Fiscal Data	Data Source	Seasonal Adjustment	Note
France	Government spending	Eurostat[1]	SWDA by source	Sum of government final consumption and GFCF
	Tax revenue	Eurostat[1]	SWDA by source	Current taxes on income and wealth, excluding social contributions
Germany	Government spending	Bundesbank	SWDA by source	Sum of government final consumption and GFCF
	Tax revenue	Eurostat[1]		
Japan	Government spending	Cabinet Office	SAAR by source	Sum of government final consumption and GFCF
	Government total revenue	Ministry of Finance and Cabinet Office	X-12-ARIMA by IMF staff	Extrapolated using Denton method (Di Fonzo and Marini 2014)
United Kingdom	Government spending	Office for National Statistics	Seasonally adjusted by source	Sum of government final consumption and GFCF
	Tax revenue	Eurostat[1]	X-12-ARIMA by IMF staff	
United States	Government spending	Bureau of Economic Analysis	Seasonally adjusted by source	Sum of government final consumption and GFCF
	Tax revenue	Bureau of Economic Analysis	Seasonally adjusted by source	

Source: IMF staff compilation.

Note: For government spending, nominal levels are deflated using GDP deflator if real levels are not directly available from the source. For tax revenue (total revenue for Japan), real levels are calculated by deflating nominal levels using GDP deflator for each country, respectively. ARIMA = autoregressive integrated moving average; GFCF = gross fixed capital formation; SAAR = seasonally adjusted and annualized data; SWDA = seasonally and working days–adjusted data.

[1]Quarterly nonfinancial accounts for general government database.

Annex Table 2.1. Data Sources for Recipient Countries

Series	Data Sources	Estimation	Countries Missing Data	Note
Real Output	Haver Analytics; IMF, *World Economic Outlook*	Rebased to 2010; deflated using GDP deflator	None in our sample	Seasonally adjusted, annualized, in national currency
Bilateral Goods Exports/Imports	IMF, *Direction of Trade Statistics*	Average between values reported by the reporter and partner countries	None in our sample	Original data in monthly frequency, aggregated by sum
External Demand	Haver Analytics; IMF, *Direction of Trade Statistics*; IMF, *World Economic Outlook*;	Export-weighted sum of partner countries' real GDP growth	None in our sample	Seasonally adjusted, quarter-over quarter growth, in percent
Short-Term Monetary Policy Rate	Bloomberg Finance L.P.; Haver Analytics	Three-Month London interbank offered rate (LIBOR), three-month Treasury bill rate where available	Cyprus, Estonia, Luxembourg, Slovak Republic, Uruguay	Policy rate, deposit rate, target rate used where LIBOR and Treasury bill rate are not available
Output Gap	Haver Analytics; IMF, *World Economic Outlook*	Gap between real output and potential output estimated by Hodrick-Prescott filter	None in our sample	Denton method (Di Fonzo and Marini 2014) used to match annual output gap numbers in *World Economic Outlook*

Source: IMF staff compilation.

Annex Table 2.2. Recipient Countries in Sample

Region	Countries (55 total)
Africa	South Africa
Americas	Argentina, Brazil, Canada, Chile, Colombia, Costa Rica, Mexico, Peru, *United States*, Uruguay
Asia	Australia, China, India, Indonesia, *Japan*, Korea, Malaysia, New Zealand, Philippines, Thailand, Vietnam
Europe	Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, *France*, *Germany*, Greece, Hungary, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russia, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, *United Kingdom*

Source: IMF staff compilation.

Note: Shock-emitting (source) countries are shown in italics.

- *External demand.* This is calculated as a weighted sum of partner countries' real growth based on bilateral export weights.
- *Short-term interest rate.* The three-month London interbank offered rate (LIBOR) and three-month Treasury bill rate are used. For better country coverage and historical coverage, policy, deposit, and target rates are used where three-month LIBOR and Treasury bill data are not available.
- *Output gap.* The quarterly output gap is first calculated as the gap between real output and potential output, estimated by the Hodrick-Prescott (HP) filter. Then, to reconcile any potential difference between our estimated output gap and the annual output gap numbers published in IMF's *World Economic Outlook* (WEO), the Denton proportional benchmarking method is used. This method both preserves the seasonality observed from quarterly estimated output gap series and matches the WEO data when converted to an annual basis.

Before entering the regressions, variables with notable trends over the sample period are detrended using country-specific linear trends. In addition, outliers—that is, observations showing quarter-over-quarter GDP growth rates above 10 percent or below –10 percent in any given quarter—are removed (there are very few of these observations).

Exchange Rate Regime Classification

We construct a measure of bilateral exchange rate arrangement with respect to the US dollar to estimate spillovers for different exchange rate regimes.

For the Reinhart-Rogoff classification, the exchange rate regime is expressed as a time-varying index based on the annual coarse de facto classification from Ilzetzki, Reinhart, and Rogoff (2017a, 2017b), ranging from 1 (most rigid) to 6 (most flexible). For each period, if a country is assigned a value of 1 (de facto peg) or 2 (de facto crawling peg), it is deemed a "fixed regime." The quarterly index is interpolated from annual data, assigning the same value for all four quarters within a year. For example, in 2015, this classification yields 7 "fixed"-rate countries out of the sample of 55 countries (Argentina, China, Costa Rica, India, Peru, Philippines, Vietnam).[31]

For the IMF classification, the pre-2008 (coarse) scheme consists of six categories, with 1 being most rigid and 6 being most flexible. Data for regime classification before 2008 are obtained from Carmen Reinhart's website.[32] The classification changed in 2008, and post-2008 data are obtained from the IMF's website.[33] Similarly to the Reinhart-Rogoff classification, a country is generally classified as having a "fixed" exchange rate with respect to the US dollar if it is assigned a value of 1 (de facto peg) or 2 (de facto crawling peg or crawling band that is narrower than or equal to +/–2 percent). Again, the quarterly index is interpolated from annual data. For example, in 2015, this classification yields two "fixed"-rate countries out of the sample of 55 countries (China, Vietnam), although there are more "fixed"-rate countries in earlier periods.

Annex 3. Blanchard and Perotti Methodology

This annex provides a brief overview of the SVAR shock identification methodology of Blanchard and Perotti (2002) as applied in this note.

VAR Specification

The identification of shocks under this methodology involves estimating the following VAR specification:

$$\mathbf{Y}_t = A(L,q)\mathbf{Y}_{t-1} + \mathbf{U}_t, \tag{A.3.1}$$

in which $\mathbf{Y}_t \equiv [T_t, G_t, X_t]'$ is a vector containing the values of quarterly taxes, spending, and GDP (all in logs of real, per capita terms), $A(L,q)$ is a four-quarter distributed lag polynomial, and $\mathbf{U}_t \equiv [t_t, g_t, x_t]'$ is the corresponding vector of reduced-form residuals. We can write

$$t_t = a_1 x_t + a_2 e^g_t + e^t_t, \tag{A.3.2}$$

$$g_t = b_1 x_t + b_2 e^t_t + e^g_t, \tag{A.3.3}$$

$$x_t = c_1 t_t + c_2 g_t + e^x_t, \tag{A.3.4}$$

in which e^t_t, e^g_t, e^x_t are the mutually uncorrelated structural shocks that we want to recover. For example, equation (A.3.2) says that unexpected movements in taxes can be due to a response to unexpected movements in GDP and a response to structural shocks to spending or taxes.

[31]The numbers of countries classified as having "fixed"-rate regimes can generally vary over time, since the exchange rate regime classification is time varying.

[32]http://www.carmenreinhart.com/data/browse-by-topic/topics/12/

[33]http://www.elibrary-areaer.imf.org/Pages/Home.aspx

Identification

The identification follows three steps:

- The effects of activity on taxes and government spending—captured by the coefficients a_1 and b_1—consist of two channels: (1) the *automatic* responses of these fiscal variables to activity under existing fiscal policy rules and (2) *discretionary* policy changes in response to unexpected shocks to activity. The key identifying assumption is that the second channel does not operate with the use of quarterly data because of decision lags (that is, it takes time for policymakers to realize a shock to GDP and make spending/tax decisions in response). In addition, there is no evidence of any automatic response of spending to activity, and thus $b_1 = 0$. For taxes, the automatic response of tax revenues to activity can be calibrated using the empirically estimated elasticity of tax revenues with respect to output (or "tax elasticity"; see discussion later in the annex), pinning down the a_1 coefficient.
- With a_1 and b_1 pinned down, the cyclically adjusted reduced-form tax and spending residuals, $t'_t \equiv t_t - a_1 x_t$ and $g'_t \equiv g_t - b_1 x_t = g_t$, can be constructed and can then be used as instruments to estimate c_1 and c_2 in a regression of x_t on t_t and g_t since they are not correlated with e^x_t.
- The remaining parameters, a_2 and b_2, can be estimated under two alternative assumptions: (1) assuming $a_2 = 0$ (taxes do not respond to spending) and estimating b_2, or (2) assuming $b_2 = 0$ (spending does not respond to taxes) and estimating a_2. Both assumptions give similar results.

While the identified structural shocks are not very sensitive to the value of tax elasticity used, the domestic tax multiplier is. Blanchard and Perotti (2002) use data on institutional characteristics of the US tax system to estimate the elasticity at quarterly frequency, obtaining the number 2.08. Their estimate of the domestic tax multiplier after eight quarters is 0.72 or 1.32 depending on the VAR specification. Caldara and Kamps (2012) show that the size of the fiscal multiplier increases in the size of the elasticity, suggesting that careful calibration of this value is important to correctly estimate the size of the multiplier. Mertens and Ravn (2014) propose a new methodology—proxy SVAR, which integrates shocks identified from a narrative approach, such as, for example, those of Romer and Romer (2010), into the standard SVAR framework—that allows estimating the size of the elasticity rather than directly assuming it, and find that the underlying value of the elasticity is 3.13 rather than 2.08 for the United States. This higher elasticity value reconciles the size of the domestic multiplier typically obtained from SVARs with the estimates obtained using narrative shocks, the latter of which are typically higher.

To estimate the tax elasticities in the five source countries, we follow Mertens and Ravn (2014) and use information on other measures of tax shocks:

- *United States*. We use the value of 3.13, which comes from Mertens and Ravn's (2014) analysis based on Romer and Romer's (2010) shocks and quarterly data.
- *United Kingdom*. Cloyne (2013) estimates this elasticity for the United Kingdom using a new quarterly data set of narrative tax shocks and arrives at the value of 1.61, which we use in our analysis.
- *Germany, France, Japan*. Elasticity estimates for these countries are not readily available from the literature; therefore, we estimate the elasticity values ourselves. Data on narrative shocks, which could be used in a proxy SVAR, for these countries are scarce. The only available narrative data set, that of DeVries and others (2011), has annual frequency and includes only fiscal consolidations, thus not fully capturing all possible tax shocks. Instead, we use forecast error shocks[34] to complement the SVAR and recover the elasticity estimates. These shocks capture unanticipated tax changes based on OECD forecasts.[35] The sample for each country is based on availability of forecast error shocks. The resulting values of elasticities vary depending on the exact VAR specification (trend, dummies), and we choose a specific value within the obtained range: 0.7 for Germany, 1.8 for France, and 1.3 for Japan.

[34]See Annex 5 for details on how the forecast error shocks are constructed.

[35]One potential drawback of using these shocks is that they are available only at annual frequency, meaning that the elasticity should be recovered from a VAR specified on annual data and might not be a good measure for quarterly elasticity. Another potential problem is that forecast error shocks can capture only unanticipated changes in fiscal variables, while anticipated changes can play an important role as well. However, there is no quarterly measure of shocks available for these three countries, nor is there a measure of anticipated shocks, that we could use in the estimation.

Annex 4. Domestic Fiscal Multipliers

This annex discusses the results in regard to domestic multipliers and how they relate to the literature. We find that spending multipliers tend to be larger than tax multipliers in all source countries, except the United States. These results are broadly in line with the findings in the vast empirical literature on the size of domestic fiscal multipliers.

Since changes in a source country's demand for recipient country exports is an important channel through which spillovers are propagated, a brief discussion of domestic (that is, source country) fiscal multipliers is warranted.

The "Baseline Results" section in the note text shows that government spending shocks have larger spillovers onto recipient country output than tax shocks. If trade is the main channel for international transmission of fiscal shocks, one would expect that domestic fiscal multipliers are also larger for government spending shocks. Indeed, we find this is almost universally the case. Annex Table 4.1 shows our estimated domestic fiscal multipliers for tax and expenditure shocks for our set of five source countries. Government spending multipliers tend to be slightly above 1 and are relatively tightly grouped between values of 1.12 (France) and 1.49 (United States). By comparison, tax multipliers are generally well below 1, with the notable exception of the United States, which is discussed later in this annex.

The finding that government spending shocks have larger spillovers is consistent with traditional Keynesian theory. Consider two changes to fiscal policy: an increase in government spending and a cut in taxes, each with a budgetary cost of a dollar. The increase in government spending immediately contributes a dollar to aggregate demand, but the tax cut could contribute less than a dollar because it can be either spent or saved, since the marginal propensity to consume is typically less than 1. There is also considerable empirical evidence that suggests multipliers are larger for spending than for tax shocks: based on a survey of 41 studies, Mineshima, Poplawski-Ribeiro, and Weber (2014) show that first-year multipliers amount on average to 0.75 for government spending and 0.25 for government revenue in advanced economies.

The heterogeneity in domestic tax multipliers across the United States and Europe presents an apparent puzzle. One possible explanation for this result may rely on the differences between the tax systems in the United States and in Europe. The US tax system relies more on personal and corporate income taxes and less on consumption taxes relative to the European system. The literature using dynamic stochastic general equilibrium models (for example, Coenen, Straub, and Trabandt 2012; Kilponen and others 2015) tends to find that multipliers for personal and corporate income taxes are higher than those for consumption taxes, reflecting their more distortionary effects on labor supply and investment decisions. These findings suggest a higher tax multiplier in the United States, given its tax system structure.

The empirical literature on this topic also tends to find larger tax multipliers for the United States than for countries in Europe. For example, Romer and Romer (2010) find that the output response to a narrative-based tax shock peaks at –2.93 after 10 quarters in the United States. Similarly, Mertens and Ravn (2014) find a large multiplier (–2.5 after three quarters) from narrative-based personal income tax changes for the United States. By contrast, most estimates of tax multipliers for European countries lie below 1 (Kilponen and others 2015).

Annex Table 4.1. Domestive Fiscal Multipliers

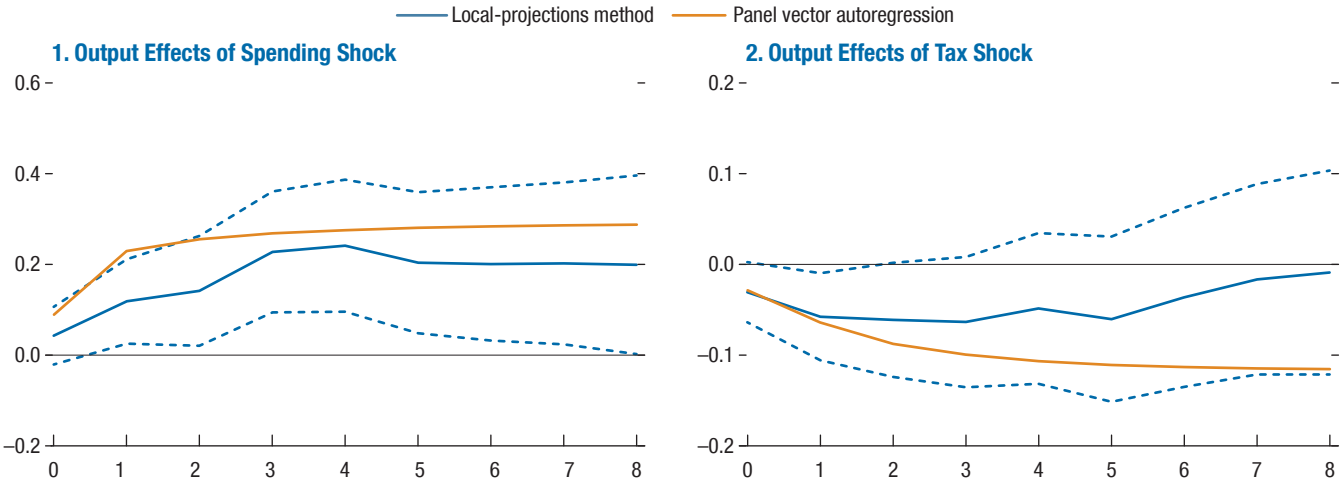
Country	Estimated Multiplier[1]		Sample
	Spending Shock	Tax Shock	
France	1.12*	–0.33*	2000:Q1–2016:Q2
Germany	1.47*	–0.73*	2000:Q1–2016:Q3
Japan	1.18*	–0.56*	1995:Q1–2016:Q3
United Kingdom	1.14	–0.24*	2000:Q1–2016:Q3
United States	1.49*	–2.24*	1980:Q1–2016:Q3

Source: IMF staff estimates.
Note: Table shows effect of one-dollar increase in spending/tax on real GDP level.
[1]Peak impact or largest significant impact, Blanchard-Perotti methodology.
* $p < 0.1$.

Annex 5. Robustness Tests

To ensure that our baseline results are not solely a function of our shock identification scheme, estimation approach, or various assumptions made during the analysis, in this annex we conduct numerous robustness checks. We find that our findings are robust to (1) estimation of spillovers in a panel VAR environment, which accounts for the endogenous response of exchange rates and monetary policy in recipient countries, (2) the use of alternative fiscal shocks based on both forecast error and narrative approaches, and (3) controlling for additional recipient country variables. These are explored in turn.

Annex Figure 5.1. Effects of Spending and Tax Shocks on Recipient Countries' Output: Comparison with Panel Vector Autoregression
(Percent)



Source: IMF staff calculations.
Note: Numbers on horizontal axes represent quarters; $t = 0$ is the quarter of the respective shocks. Solid blue lines denote the baseline response to respective shocks using local-projections method; dashed lines denote 90 percent confidence bands; and solid orange lines represent the response to respective shocks using panel vector autoregressions. Shocks are normalized to an average 1 percent of GDP across the source countries.

Spillover Estimates Using a Panel VAR

We conduct our spillover analysis in the context of a panel VAR (PVAR) to ensure that our results are not driven by the use of the local-projections method. The main goal here is to explicitly take into account the endogenous response of key macro variables when estimating spillovers to a fiscal shock. Consistent with this goal, we specify a six-variable PVAR, according to the following equation:

$$\mathbf{Y}_{i,t} = \mathbf{c}_i + \sum_{p=0}^{1} \mathbf{A}_p \mathbf{Y}_{i,t-p} + \mu_{i,t}, \qquad \text{(A.5.1)}$$

in which $\mathbf{c}_i$ is a vector of country-specific fixed effects, $\mathbf{A}_p$ is a reduced-form coefficient matrix, $\mu_{i,t}$ is a vector of shock terms, and $\mathbf{Y}_{i,t}$ is a vector of six endogenous variables:

$$\mathbf{Y} = \{\frac{Shock^{G}_{it}}{Y_{i,t-1}}; \frac{Shock^{T}_{it}}{Y_{i,t-1}}; \textit{effective external demand}; \textit{GDP growth}; \textit{interest rate}; \textit{REER}\},$$

in which *REER* is the real effective exchange rate.

With the exceptions of $\frac{Shock^{G}_{it}}{Y_{i,t-1}}$ and $\frac{Shock^{T}_{it}}{Y_{i,t-1}}$, which are identical to the government spending and tax shocks used in the baseline analysis (see "Fiscal Spillovers: Baseline Analysis"), each variable is in (detrended) quarter-over-quarter growth rates and relates to recipient country *i*'s domestic economy.[36] The analysis is conducted for the same sample period as the baseline local-projections analysis.

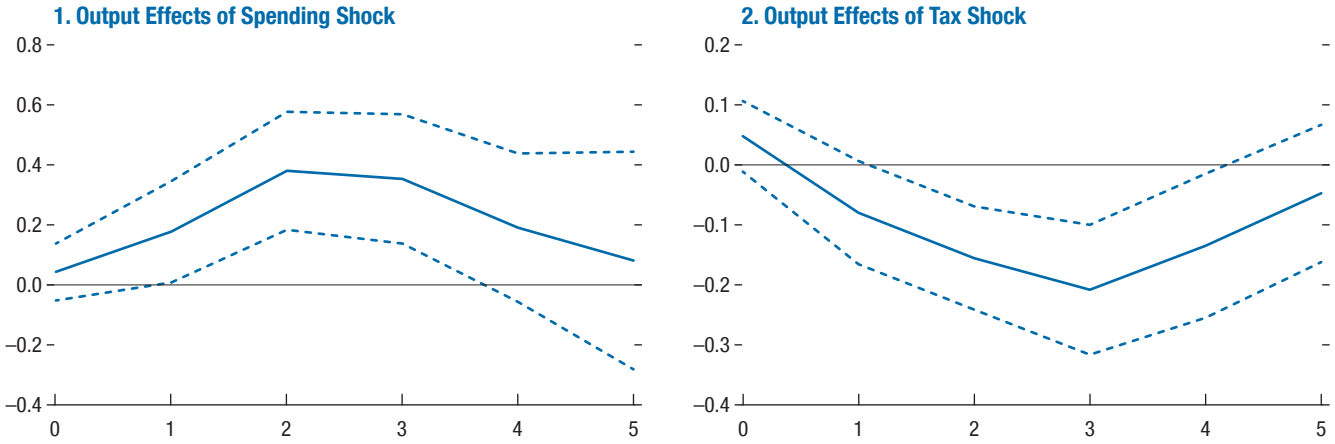
The results from the PVAR analysis are closely aligned with the findings from the baseline local-projections model. Shown in Annex Figure 5.1, the spillover effects from a shock to government spending in source countries are larger than those for identically sized shocks to tax revenues. These results, shown by the orange lines in the figure—expressed in terms of the cumulative impulse-response functions from the PVAR following a 1 percent of source country GDP shock to government spending or tax revenues—are different from zero at the 5 percent level of statistical significance, according to simulations conducted using standard (Monte Carlo) resampling methods.

Robustness to Identification Using Forecast Errors

The second robustness check focuses on the identification of fiscal shocks as forecast errors in the growth rates of government spending or tax revenues.

[36]Results from the PVAR are robust to several alternative specifications, including not detrending the data.

Annex Figure 5.2. Effects of Spending and Tax Shocks on Recipient Countries' Output: Forecast Errors
(Percent)



Source: IMF staff calculations.
Note: Numbers on horizontal axes represent years; $t = 0$ is the year of the respective shocks. Solid lines denote the response to respective shocks, and dashed lines denote 90 percent confidence bands. Effects are estimated based on shocks derived from forecast errors. Shocks are normalized to an average 1 percent of GDP across the source countries.

The method has been previously used in the literature (Auerbach and Gorodnichenko 2013; Ramey 2011) and identifies fiscal shocks by exploiting the difference between actual government purchases (tax revenues) and their forecast from the previous period. This approach captures only unanticipated changes in spending and revenues, as opposed to SVAR shocks, which are based on actual changes in fiscal variables and can be anticipated by agents if they have been announced earlier. The presence of such anticipated shocks in theory could bias the estimates, because the econometrician's information set is different from the agents' information set. Since forecast errors capture unexpected changes, this approach reduces the problem with fiscal foresight, as the econometrician's and agents' information sets are more aligned.

We rely on real-time OECD fiscal projections to construct the forecast error shocks. The data are at annual frequency, and the sample covers the period from 2000 to 2012 (after 2012, the forecasts data are not continuous). The forecast errors are constructed based on real-time information about expectations and actual data. The forecast error for each variable $X = \{G, T, Y\}$ is constructed as

$$FE_t^X = X_t - X_{t|t-1}^f, \qquad \text{(A.5.2)}$$

in which X_t is the growth rate of the variable from contemporaneous data release and $X_{t|t-1}^f$ is the forecast made one period earlier. A positive forecast error therefore implies an expansionary spending and a contractionary tax shock. Following Auerbach and Gorodnichenko (2013), we regress the forecast errors of spending and taxes on the forecast errors of output to take into account any changes due to surprises in the business cycle and also on lagged macroeconomic variables growth (GDP, deflator, investment, government spending or tax revenues) to account for the part of the innovation that can be predicted from past observations. The forecast error shocks are then constructed as residuals from this regression, converted to levels using base year (2010) levels of expenditures or revenues, and substituted in the baseline regression equation instead of the SVAR shocks.

Spillover analysis using forecast error shocks confirms the baseline results—that spending shocks have larger spillovers than tax shocks—and provides a strong robustness check (Annex Figure 5.2). These shocks are constructed using a very different methodology, which relies on a different database, and they are estimated at a different frequency than the shocks used in our baseline specification. Obtaining similar spillovers using forecast error shocks is reassuring and suggests that problems related to fiscal foresight seem not to affect our main results. The size of the spillovers is somewhat larger than that of those obtained using structural shocks. In part this can be explained by a

larger response of government spending and tax revenue to forecast error shocks than to structural shocks, especially for the United States (although in the former case, these impulse responses are imprecisely estimated because of the small sample).

Robustness to Identification with Narrative Approach

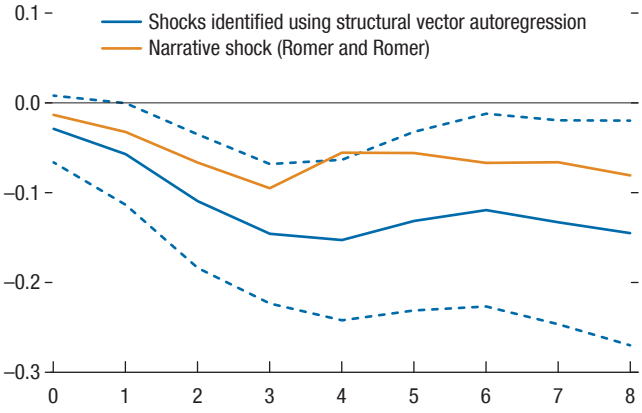
To further establish the robustness of our results, we consider spillovers from tax shocks given by the narrative shock of Romer and Romer (2010). Although some other studies construct narrative fiscal shocks (for example, DeVries and others 2011), the data set of Romer and Romer (2010) is the most suitable for our purposes, since it covers both expansion and consolidation episodes, making it most comparable to our baseline shock specification.[37] To obtain spillover results using this type of shock, we simply replace each source country shock (*sjt*) from equation (2) with the narrative shock; this analysis is performed over the period from the first quarter of 1995 to the fourth quarter of 2007.[38] A more comparable set of baseline results using our SVAR shocks is then constructed by restricting our baseline analysis to the same time period.

Analysis using narrative tax shocks for the United States shows similar spillovers onto partner countries. Despite their being derived from a very different identification scheme, the broad similarity between the estimated US tax shock spillovers from the narrative approach and those from our (time-sample-modified) baseline approach is notable. Results presented in Annex Figure 5.3 indicate that although spillovers identified by the narrative approach are somewhat smaller than those in our baseline, they are similar and fall comfortably within the confidence bands of our baseline estimates.

Robustness to Additional Control Variables

Baseline results are also robust to the inclusion of additional control variables. First, we use the short-term interest rate to control for the stance of recipient country monetary policy and the output gap and unemployment rate as measures of slack in recipients. Dynamic responses are presented in Annex Figures 5.4–5.6 and confirm that additional control variables do not materially change the baseline results. Controlling for domestic fiscal policies in the baseline specification is another important robustness check, however, estimating fiscal shocks for 55 recipient economies at quarterly frequency is infeasible, because quarterly fiscal data are unavailable for many countries. Since Eurostat provides fiscal data at quarterly frequency for European countries, we conduct a robustness check for this subsample in which we control for changes in primary balances (as a percent of GDP) to proxy for the stance of recipient country fiscal policy. Since this robustness check is conducted on a limited sample (European Union), we select Germany and France as source countries for this exercise, since shocks from these countries are most relevant for Europe. We find that the results of this robustness check are almost identical to those in the regression that omits the stance of recipient country fiscal policy (Annex Figure 5.7).

Annex Figure 5.3. Effects of US Tax Shock on Recipient Countries' Output: Comparison with US Narrative Tax Shock, 1995–2007
(Percent)

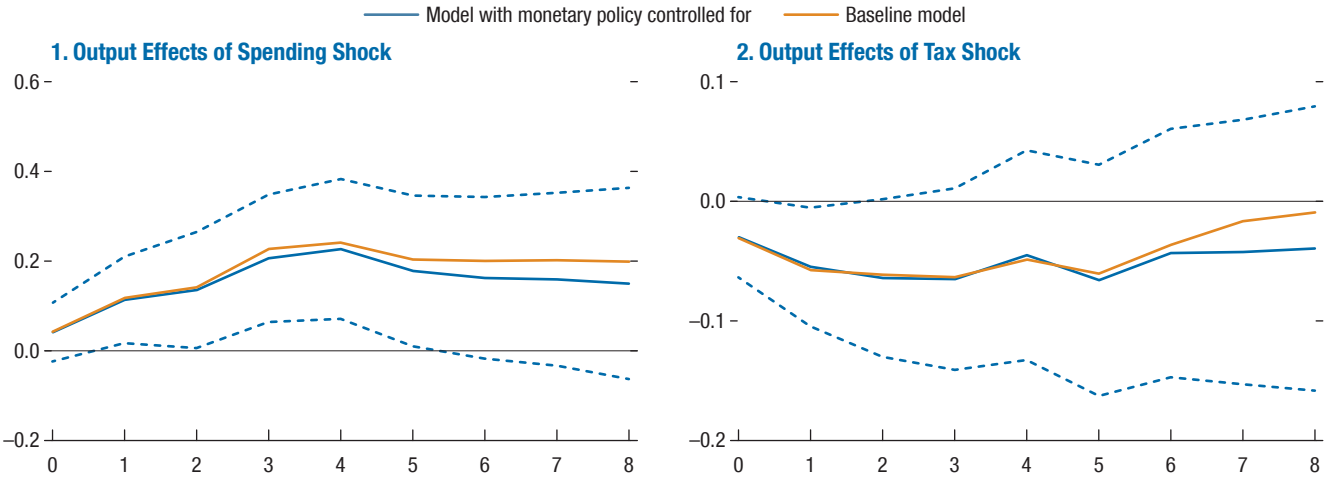


Sources: Romer and Romer (2010); and IMF staff calculations.
Note: Numbers on horizontal axes represent quarters; t = 0 is the quarter of the US tax shock. Solid blue line denotes the response to US tax shock using structural vector autoregression; dashed blue lines denote 90 percent confidence bands; and solid orange line represents the response to US narrative tax shock based on Romer and Romer (2010). Shocks are normalized to an average 1 percent of GDP across the source countries (note that this will represent a less than 1 percent of US GDP shock).

[37]Narrative shock databases for government spending are much less common in the literature, which precludes a robustness check of spillovers from spending shocks based on narrative shocks.

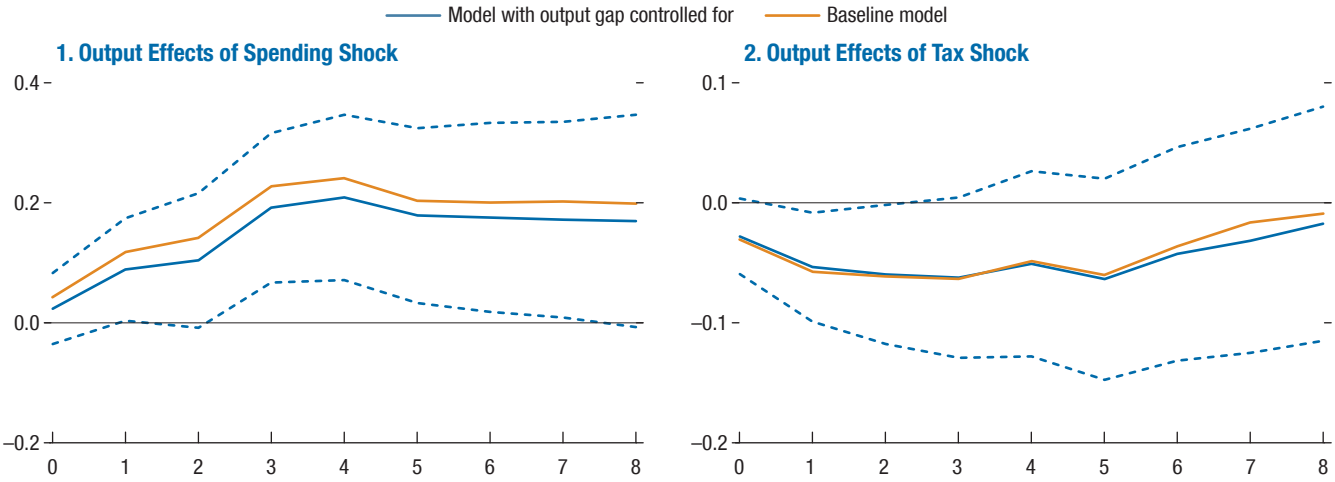
[38]The fourth quarter of 2007 is the last period for which data on these shocks are available.

Annex Figure 5.4. Dynamic Responses of Recipient Output to Fiscal Shocks, with Monetary Policy Controlled For
(Percent)



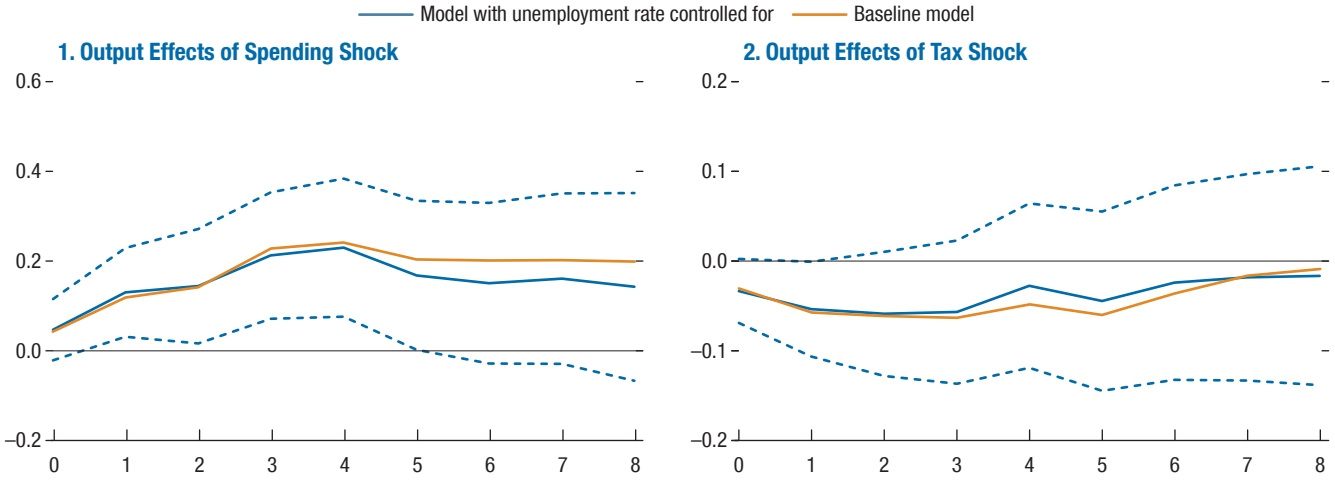
Source: IMF staff estimates.
Note: Numbers on horizontal axes represent quarters; $t = 0$ is the quarter of respective shocks. Solid blue lines denote the response to respective shocks, controlling for monetary policy; dashed blue lines denote 90 percent confidence bands; and solid orange lines represent the baseline response to respective shocks. Shocks are normalized to an average 1 percent of GDP across the source countries.

Annex Figure 5.5. Dynamic Responses of Recipient Output to Fiscal Shocks, with Output Gap Controlled For
(Percent)



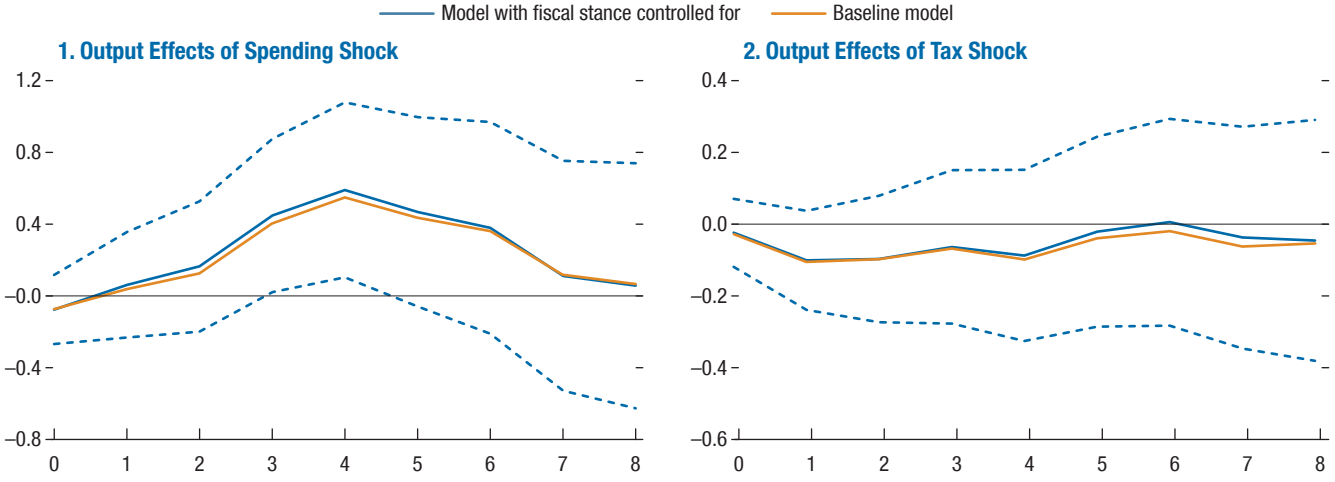
Source: IMF staff estimates.
Note: Numbers on horizontal axes represent quarters; $t = 0$ is the quarter of respective shocks. Solid blue lines denote the response to respective shocks, controlling for output gap; dashed blue lines denote 90 percent confidence bands; and solid orange lines represent the baseline response to respective shocks. Shocks are normalized to an average 1 percent of GDP across the source countries.

Annex Figure 5.6. Dynamic Responses of Recipient Output to Fiscal Shocks, with Unemployment Rate Controlled For
(Percent)



Source: IMF staff estimates.
Note: Numbers on horizontal axes represent quarters; $t = 0$ is the quarter of respective shocks. Solid blue lines denote the response to respective shocks, controlling for unemployment rate; dashed blue lines denote 90 percent confidence bands; and solid orange lines represent the baseline response to respective shocks. Shocks are normalized to an average 1 percent of GDP across the source countries.

Annex Figure 5.7. Dynamic Responses of Recipient Countries' Output to France and Germany Fiscal Shocks, with Recipient Countries' Fiscal Stance Controlled For
(Percent)



Source: IMF staff estimates.
Note: Numbers on horizontal axes represent quarters; $t = 0$ is the quarter of respective shocks. Solid blue lines denote the response to respective shocks, controlling for recipients' primary balance estimated on a (time-varying) European Union sample; dashed blue lines denote 90 percent confidence bands; and solid orange lines represent the response to respective shocks from the baseline model estimated on a (time-varying) European Union sample. Shocks are normalized to an average 1 percent of GDP across the source countries.

Annex Table 6.1. Comparison to Empirical Literature: Response of Recipient Country GDP
(Percent)

	Impact	Average One-Year	Average Three-Year
Government Spending Shock			
Local Projections with SVAR–Blanchard-Perotti Shocks (baseline)	0.30	1.05**	1.35**
PVAR with SVAR–Blanchard-Perotti Shocks	0.62**	1.55**	1.82**
Local Projections with Forecast Error Shocks[1]	—	0.78	1.65***
Auerbach and Gorodnichenko (2013)[1]	—	—	1.94*
Goujard (2017)[1]	—	—	1.98
Tax Revenue Shock			
Local Projections with SVAR–Blanchard-Perotti Shocks (baseline)	–0.21	–0.37*	0.04
PVAR with SVAR–Blanchard-Perotti Shock	–0.20**	–0.54**	–0.70**
Local Projections with Forecast Error Shocks[1]	—	–0.10	–0.68**
Goujard (2017)[1]	—	—	0.63

Source: IMF staff calculations.
Note: Table shows response to a shock normalized to 1 percent of recipient country GDP.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

Annex 6. Comparison of Spillover Estimates with Previous Literature

While we choose to present results in terms of source country GDP shocks for ease of interpretation, several previous studies on fiscal spillovers normalize shocks to recipient country GDP. Key among these studies are Auerbach and Gorodnichenko 2013 and Goujard 2017. Auerbach and Gorodnichenko (2013) estimate spillovers from shocks to government spending for a set of 30 OECD countries, using forecast error shocks constructed from the OECD's Economic Outlook: Statistics and Projections database. Goujard (2017) considers spillovers on 34 recipient countries from both spending and tax shocks in 17 OECD countries using annual data for 1978–2011; shocks are taken from the narrative database of DeVries and others (2011) and pertain only to consolidation episodes.

Our estimates of fiscal spillovers are broadly similar to those obtained in these studies. Annex Table 6.1 compares the results from our baseline and alternative specifications—that is, panel VAR using structural shocks and local projections using forecast error shocks—to estimates reported in Auerbach and Gorodnichenko 2013 and Goujard 2017, focusing on separate estimates for spending and tax shocks. The comparison shows that

- For government spending shocks, our average spillovers over the first three years are comparable to those in both studies and are statistically significant. The average first-year effects, which are not reported in comparable studies, are also statistically significant.
- For tax revenue shocks, our estimates of spillovers are statistically significant over the first year, with more mixed results over the longer horizon. Meanwhile, Goujard (2017) finds no statistically significant effect from tax shocks.

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