The Impact of r-g on Euro-Area Government Spending Multipliers*

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Abstract

We compute government spending multipliers for the Euro Area contingent on the interest-growth differential, the so-called r-g. Whether the fiscal shock occurs when r-g is positive or negative matters for the size of the multiplier. Median estimates vary conditional on the specification, but the difference between multipliers in the negative and positive r-g regimes differs systematically from zero with very high probability. Over the medium run (5 years), median cumulated multipliers range between 1.13 and 1.77 when r-g is negative, and between 0.54 and 1.26 when r-g is positive. We show that the results are not driven by the state of the business cycle, the monetary policy stance, or the level of government debt, and that the multiplier is inversely correlated with r-g. The calculations are based on the estimates of a factor-augmented interacted panel vector-autoregressive model. The econometric approach deals with several technical problems highlighted in the empirical macroeconomic literature, including the issues of fiscal foresight and limited information.

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1 Introduction

In academic and policy circles, the interest rate-growth differential ($r - g$) has been under close scrutiny in the past few years. With interest rates persistently low, $r - g$ has turned negative in many countries after the Global Financial Crisis (GFC), providing arguments for fiscal stimuli to boost economic activity (Blanchard, 2019). At the same time, government debt has risen to historically high levels, casting doubts on debt sustainability, given that a negative $r - g$ may turn positive in response to adverse shocks (Rogoff, 2020). This debate could not be more central in the context of the economic fallout of the COVID-19 pandemic, because countries have increased, and will likely continue to increase, government expenditures to face the health emergency, mitigate the economic collapse, and accelerate the recovery.

Whether fiscal expansions will deliver the intended objectives boils down to the extent to which they are able to boost GDP, the relationship captured by the concept of fiscal multiplier. High fiscal multipliers would benefit also debt sustainability through the negative effect that GDP growth has on $r - g$. The literature has investigated the size of fiscal multipliers from many different angles, focusing recently on the state dependency of multipliers on a variety of macroeconomic indicators (the business cycle, effective lower bound (ELB) regimes, the level of public debt, among others). However, to our knowledge, there is no contribution linking the size of the fiscal multiplier to $r - g$. This paper deals with this matter from an empirical viewpoint by posing the following research question: does the level of $r - g$ affect the size of the government spending multiplier?

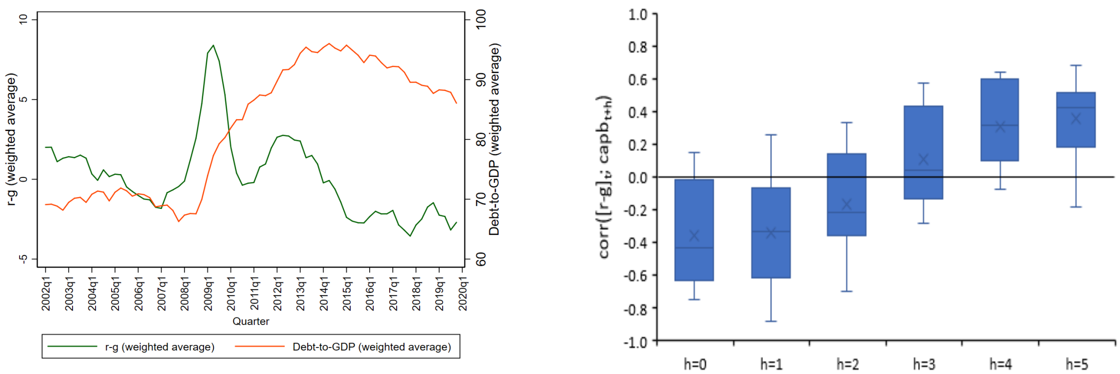
According to textbook macroeconomics, at every point in time, the debt stock will grow by the existing debt stock multiplied by $r - g$, net of the primary budget balance (with debt and the primary balance expressed as fractions of GDP). Therefore, government debt will tend to grow when $r - g$ is positive, and it will tend to fall when $r - g$ is negative. In addition, the higher $r - g$, the higher the primary budget balance a government will need to run in the future to stabilize its debt. Forward-looking private agents will incorporate this mechanism in their expectations and increase their savings. We conjecture that this behavior should curb the size of the fiscal multiplier.

We use data from ten Euro Area (EA) countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain) that were part of the European Monetary Union (EMU) since its inception.[1] This choice yields a balanced panel dataset with quarterly observations on countries that experienced a wide variety of discretionary

[1] In line with Auerbach and Gorodnichenko (2013), we exclude Luxembourg being it a small economy with large and volatile changes in government spending series.

Figure 1: Government Debt, $r-g$, and Cyclically-Adjusted Primary Balances (CAPB) in the Euro Area

(a) Government debt-to-GDP ratio and $r-g$ (b) Correlations between $r-g$ and CAPB



Sources: Datastream, IMF and authors' calculations.
Notes: In panel (a), $r-g$ is computed as explained in Section 2.2, and both lines represent weighted averages of 10 EA countries (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain), using national GDPs as weights. Panel (b) reports dynamic correlations between $r-g$ at time t and the IMF's cyclically adjusted primary balance (fraction to potential GDP) at time $t+h$, with $h = 0, 1, ..., 5$. In each box, the horizontal line (x) represents the median (average) correlation across the same 10 EA countries; the upper and lower edges of each box represent the top and bottom quartiles of the correlations, respectively; and the top and bottom markers denote the maximum and minimum correlation, respectively.

fiscal shocks over a period of time in which they were exposed to the same monetary policy stance. In line with other advanced economies, the EA exhibits an increase in the debt ratio and a fall in $r-g$ after the GFC (Figure 1, Panel a). Moreover, the theoretical prediction of higher $r-g$ being associated with higher future primary balances is consistent with EA data. Figure 1 (Panel b) reports the distributions of dynamic correlations between $r-g$ and the cyclically-adjusted primary balance (CAPB), a common indicator of the discretionary fiscal policy stance. While the two variables tend to display a negative contemporaneous correlation,[2] the correlation tends to turn positive over the medium term (five years). In other words, a higher $r-g$ at time t tend to be associated with a stronger discretionary fiscal adjustment down the road.[3]

Our empirical findings are consistent with the abovementioned theoretical considerations and can be summarized as follows: (i) the size of the average cumulated multiplier depends on the $r-g$ regime, with the difference between the size of the multiplier in the negative and positive $r-g$ regimes being economically important and different from zero with high

[2] The negative contemporaneous correlation captures the countercyclical nature of fiscal policy in advanced economies. When the economy is growing (large g), the fiscal stance tends to be tight (large CAPB) and $r-g$ tends to be low.

[3] Note that a higher CAPB represents higher taxes and/or lower non-interest expenditures, once the business cycle has been taken into account.

probability; (ii) this difference increases at time horizons beyond the first year; (iii) median estimates of the multipliers vary conditional on the specification: over the medium run (5 years), median cumulated multipliers range between 1.13 and 1.77 when $r-g$ is negative, and between 0.54 and 1.26 when $r-g$ is positive; (iv) more generally, the multiplier is inversely correlated with the level of $r-g$. These results survive a number of robustness checks, while placebo-like tests confirm that the findings are not driven by the state of the business cycle, the monetary policy stance, or the level of government debt.

The estimates are derived from a factor-augmented interacted panel vector-autoregressive model purified of expectations (FAIPVAR-X). This setup is an extension of the I-VAR model by Caggiano et al. (2017), which we recently used to estimate fiscal multipliers at the ELB for the EA (Amendola et al., 2020). Using this framework has four advantages. First, the panel dimension allows exploiting quarterly data of the abovementioned ten EA countries. Second, the presence of an interaction term allows capturing nonlinearities and estimating the reaction of the variables of interest to a government spending shock conditional on $r-g$, which we endogenize in our econometric model. Third, augmenting the specification with factors extracted from a large number of macroeconomic variables mitigates limited information concerns. In fact, there is likely important information that we do not explicitly include in our model, but that might have been used by economic agents in making their choices (see Bernanke et al., 2005; Stock and Watson, 2005; Fragetta and Gasteiger, 2014). Fourth, including forecasts of government spending formed over the past year as an exogenous variable purges government spending shocks from a considerable fraction of its anticipated component and mitigates the issue of fiscal foresight (see, e.g., Forni and Gambetti (2010), among others).

Our paper is related to two strands of the literature. The first strand comprises the contributions analyzing the relationship between $r-g$ and debt sustainability. Blanchard (2019) shows that, in countries such as the U.S., with safe interest rates expected to remain below growth rates for a long time, debt rollovers without a later increase in taxes may be feasible. The evidence on advanced economies hints that a negative $r-g$ may persist in the long run (Barrett, 2018). However, there is no guarantee, given that $r-g$ may quickly turn positive due to large adverse shocks (Rogoff, 2020), especially if government debt is high (Lian et al., 2020). Moreover, the historical experience of advanced and emerging economies suggests that a negative $r-g$ is not a sufficient condition for debt sustainability (Mauro and Zhou, 2020). The second strand of the literature encompasses studies on the state dependency of fiscal multipliers on a variety of macroeconomic indicators. Common conditioning variables are the state of the business cycle (Auerbach and Gorodnichenko, 2012; Batini et al., 2012; Caggiano et al., 2015; Ramey and Zubairy, 2018; Ghassibe and

Zanetti, 2020, among others); monetary policy regimes, with a focus on the ELB (Miyamoto et al., 2018; Amendola et al., 2020; Bonam et al., 2020; Liu et al., 2019, among others); and the level of government debt (Kirchner et al., 2010; Nickel and Tudyka, 2014, among others). Our paper bridges these two strands of the literature for the first time, by linking the size of the government spending multiplier to $r - g$.

The remainder of the paper is structured as follows. Section 2 explains the empirical methodology and the econometric specification. Section 3 reports the results. Section 4 presents robustness checks. Finally, Section 5 concludes. Data sources and technical details are appended to the paper.

2 Methodology

2.1 Empirical Model

The empirical model is an extension of the factor-augmented interacted panel vector-autoregressive model purified of expectations (FAIPVAR-X) of Amendola et al. (2020), which in turn builds on the Interacted Vector Auto-Regressive (I-VAR) framework developed by Caggiano et al. (2017). To allow for as much heterogeneity as possible, we utilize a panel model with fixed effects and heterogeneous slopes, which we estimate using the mean group estimator. This estimator has been shown to perform better than alternative estimators in dynamic panels (see, e.g., Pesaran and Smith, 1995 and Canova and Ciccarelli, 2013, among others).

The model specification takes the following reduced form:

$$\begin{aligned} Y_{i,t} &= \sum_{i=1}^{N} C_i D_{i,j} + \sum_{i=1}^{N}\sum_{k=1}^{L} A_{i,k} D_{i,j} Y_{i,t-k} + \left[\sum_{i=1}^{N}\sum_{k=1}^{L} A^1_{i,k} D_{i,j} G_{i,t-k} \times (r-g)_{i,t-k}\right] \\ &+ \sum_{i=1}^{N} V_i D_{i,j} f_{(t|t-1:t-4)} + V^1 z_{t-1} + u_{i,t}, \end{aligned} \quad (1)$$

where $t = 1, ..., T$ denotes the time dimension; $i = 1, ..., N$ denotes the country dimension; and $k = 1, ..., L$ represents the lag structure. The vector of endogenous variables is denoted by $Y_{i,t}$; the interaction term is represented by $G_{i,t-k} \times (r-g)_{i,t-k}$; while the vectors of two sets of exogenous variables are denoted by $f_{(t-1:t-4)}$ (discussed in Subsection 2.2) and z_{t-1} (foreign exogenous variables, also discussed in Subsection 2.2). Furthermore, coefficient C_i is the country-specific intercept of country i; $A_{i,k}$ is the matrix of autoregressive coefficients attached to the endogenous variables; $A^1_{i,k}$ is the matrix of country-specific coefficients of the interaction term; V_i is the matrix of country-specific coefficients attached to the first set of exogenous variables; V^1 represents the pooled estimated coefficients of the another set of exogenous variables;[4] $D_{i,j}$ is an indicator variable for each country (equal to 1 if $i = j$, and 0 otherwise); and, lastly, $u_{i,t}$ is a vector of normally distributed residuals with mean zero and covariance matrix Σ_i.

Given that the model requires the estimation of a large number of parameters, for the sake of parsimony, we produce the results with a uniform lag structure of one quarter ($L = 1$). This model is well suited to our purposes for the presence of an interaction term which involves two endogenous variables. The first variable is a proxy for government spending, G, the exogenous variation of which we aim at identifying. The second variable is a proxy of the interest-growth differential used as a conditioning variable, $(r - g)$.[5]

It is worth clarifying that the panel interacted VAR approach differs from other methods to study regime dependency (such as threshold VAR), in which separate sets of coefficients must be estimated for separate regimes. With the panel interacted VAR, one set of coefficients is estimated, but the presence of an interaction term allows gauging how the level of a given endogenous variable impacts the propagation of a shock of interest. Unlike binary approaches, this methodology allows conditioning the propagation of a certain shock on a continuum of regimes. In our case, the interaction term is given by the product of government spending by $r - g$, and it is designed to capture how the level of $r - g$ influences the effect of government spending shocks on all endogenous variables. Once the model has been estimated, impulse responses can be derived for initial conditions corresponding to all quarters in the sample (see Appendix B for technical details). In the following empirical analysis, we trace conditional impulse responses (and compute associated fiscal multipliers) distinguishing between quarters characterized by negative versus positive values of $r - g$, given the importance of this issue in the theory of debt sustainability (Subsection 3.1 and first part of Subsection 3.2). Additionally, we report fiscal multipliers with initial conditions corresponding to all quarters in the sample, to investigate how these evolved over time and how they correlate with $r - g$ (second part of Subsection 3.2).

2.2 Baseline Specification, Data and Computation of Cumulated Government Spending Multipliers

The vector of endogenous variables reads as follows:

[4] Due to data availability constraints, we estimate homogeneous slopes of foreign exogenous variables, z_{t-1}.

[5] We limit the analysis to one interaction term given that, as argued by Caggiano et al. (2017), pervasive instability of the estimates are found when working with additional interaction terms.

$$Y_{i,t} = [G_{i,t}, GDP_{i,t}, T_{i,t}, SR_t, (r-g)_{i,t}, F_t]' \quad (2)$$

where SR_t, and F_t are vectors common to all countries, but that may have a different impact in each country.

Variables $G_{i,t}, GDP_{i,t}$ and $T_{i,t}$ are the three variables traditionally used in the fiscal-VAR literature and represent real government purchases (the sum of government gross fixed capital formation and government consumption), real gross domestic product and real net taxes (the sum of government receipts of direct and indirect taxes minus transfers to businesses and individuals), respectively.

Common variable SR_t is the European Central Bank's shadow monetary policy rate developed by Wu and Xia (2017), which allows us to control for the overall (conventional and unconventional) monetary policy stance in the eurozone.[6]

The addition of $(r-g)_{i,t}$ among the endogenous variables allows us to take the dynamic response of the variable into account when shocking government spending, and ultimately influencing the size of the fiscal multiplier. While we produce the baseline results with an $r-g$ computed as the difference between the ten-year government bond yield and nominal GDP growth relative to the quarter of the previous year, we also conduct robustness checks by replacing the ten-year yield with the average cost of financing the debt (Section 4).

Lastly, F_t is a 1×5 vector of common factors extracted from a large number of macroeconomic times series via principal components. Extracting information from a large set of macroeconomic variables mitigates the limited information problem because the principal components proxy the unobserved factors affecting most macroeconomic variables (see Forni et al., 2009 and Fragetta and Gasteiger, 2014 for further details).[7]

Among the exogenous variables, we add the $f_{(t|t-1:t-4)}$ series. This represents the forecast of time-t government spending over the past 12 months (four quarters), published by the Economist Intelligence Unit. The addition of this variable represents a way to purge our structural government spending shocks from the change in government spending already anticipated by economic agents in the past year, mitigating the problem known in the literature as *fiscal foresight*.[8] Although this device does not control for anticipated movements

[6]Since this rate is available from 2004Q3 onward, for the very beginning of the sample, we complement it with the Main Refinancing Operations (MRO) rate, given that the two, until 2008, are virtually indistinguishable.

[7]Similar to Bernanke et al. (2005), we implement a two-step estimation procedure. As a first step, we extract five common factors, as established by the Bai and Ng (2007) IC_{p2} information criterion. The second step is adding the five factors to our vector of endogenous variables.

[8]Fiscal foresight is the phenomenon by which private agents, mainly due to legislative and implementation lags, can anticipate future movements in government spending. Failing to account for them in the identification of what are meant to be unanticipated government spending shocks may give rise to endogeneity

Table 1: Fraction of Observations in the $r - g > 0$ and the $r - g < 0$ Regimes

Country	Percent of observations			
	Full sample		Excluding 2008-2009	
	$r - g > 0$	$r - g < 0$	$r - g > 0$	$r - g < 0$
Austria	31.9	68.1	25.0	75.0
Belgium	38.9	61.1	31.3	68.8
Finland	37.5	62.5	32.8	67.2
France	44.4	55.6	39.1	60.9
Germany	36.1	63.9	28.1	71.9
Ireland	33.3	66.7	25.0	75.0
Italy	76.4	23.6	73.4	26.6
Netherlands	45.8	54.2	43.8	56.3
Portugal	47.2	52.8	40.6	59.4
Spain	36.1	63.9	29.7	70.3
Average	42.8	57.2	36.9	63.1

in government spending beyond the one-year horizon, it alleviates the issue of anticipation insofar as a considerable share of variation of government spending is attributable to expectations formed over the past year. In Section 4, we conduct a robustness check controlling for expectations formed over two years.[9] We add as exogenous variables also a set of U.S. variables, z_{t-1}, including the U.S. output gap, U.S. inflation and the U.S. shadow monetary policy rate developed by Wu and Xia (2016), to account for international factors which may influence our variables of interest.

Our dataset comprises quarterly data and covers the period from 2002Q1 to 2019Q4.[10] We consider ten of the eleven countries that first joined the EA: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal and Spain. In line with Auerbach and Gorodnichenko (2013), we exclude Luxembourg being a small economy, which exhibits large and volatile changes in government spending series. For details on the construction of the dataset, see Appendix A.

In the full sample, the fraction of quarters in the $r - g > 0$ regime varies from 32 percent (Austria) to 76 percent (Italy), with a cross-country average of 43 percent of quarters with $r - g > 0$ and 57 percent of quarters with $r - g < 0$ (Table 1). If we exclude 2008 and 2009 (approximately coinciding with the banking crisis in the EA), the average fraction of

and bias the results (see, e.g., Forni and Gambetti, 2010 and Leeper et al., 2013 among others for further details).

[9]Using an estimated DSGE model of the U.S., Schmitt-Grohé and Uribe (2012) attribute 37 percent of the variation of government spending to unexpected shocks, 35 percent to shocks anticipated over the past year, 23 percent to shocks anticipated two years before, and 5 percent to non-fiscal shocks.

[10]The beginning of our sample is dictated by the availability of the Economist Intelligence Unit forecasts of government spending.

observations in the $r-g>0$ regime drops to 37 percent and remains above 30 percent in most countries in the sample. Therefore, even without the 2008-2009 period, there is a considerable fraction of quarters with $r-g>0$.

To simplify the procedure related to the computation of government spending multipliers, we divide government spending, GDP and net taxes by the real potential GDP of the corresponding country. This way there is no need to take the logarithm of the variables and perform *ex-post* conversions of the estimated elasticities to euro equivalents, avoiding potential biases. In fact, *ex-post* conversion requires the use of constant sample averages of the ratios of fiscal variables to GDP, which may instead vary over time, potentially biasing the size of the multipliers. This problem is even more acute in nonlinear models, such as that adopted in this paper (for more details on this issue see, e.g., Gordon and Krenn, 2010 and Ramey and Zubairy, 2018, among others). We compute real potential GDP using the filter recently proposed by Hamilton (2018), but also check whether results are robust to the use of the traditional HP filter (Section 4).

We estimate the model presented in equation (1) using a Bayesian strategy for inference and compute cumulated multipliers as the ratio of discrete approximations of the integral of the median generalized impulse response functions (GIRFs) of real output and government purchases over a given time horizon $h=0,1,\dots,H$:

$$\mathcal{M}_H = \frac{\sum_{h=0}^{H} d\text{GDP}(h)}{\sum_{h=0}^{H} d\text{G}(h)}. \tag{3}$$

For the technical details on inference and identification, see Appendix B.

3 Results

This section reports all our baseline results. We start by showing, in Subsection 3.1, impulse responses of important macroeconomic variables to an unexpected shock to government spending, conditional on two regimes: negative and positive *r-g*. Based on these impulse responses, in Subsection 3.2, we compute the associated cumulated government spending multipliers at various time horizons. In Subsection 3.3, we investigate whether the results are driven by the state of the business cycle, the monetary policy stance or the level of public debt.

Table 2: Estimated Interaction Term Coefficients

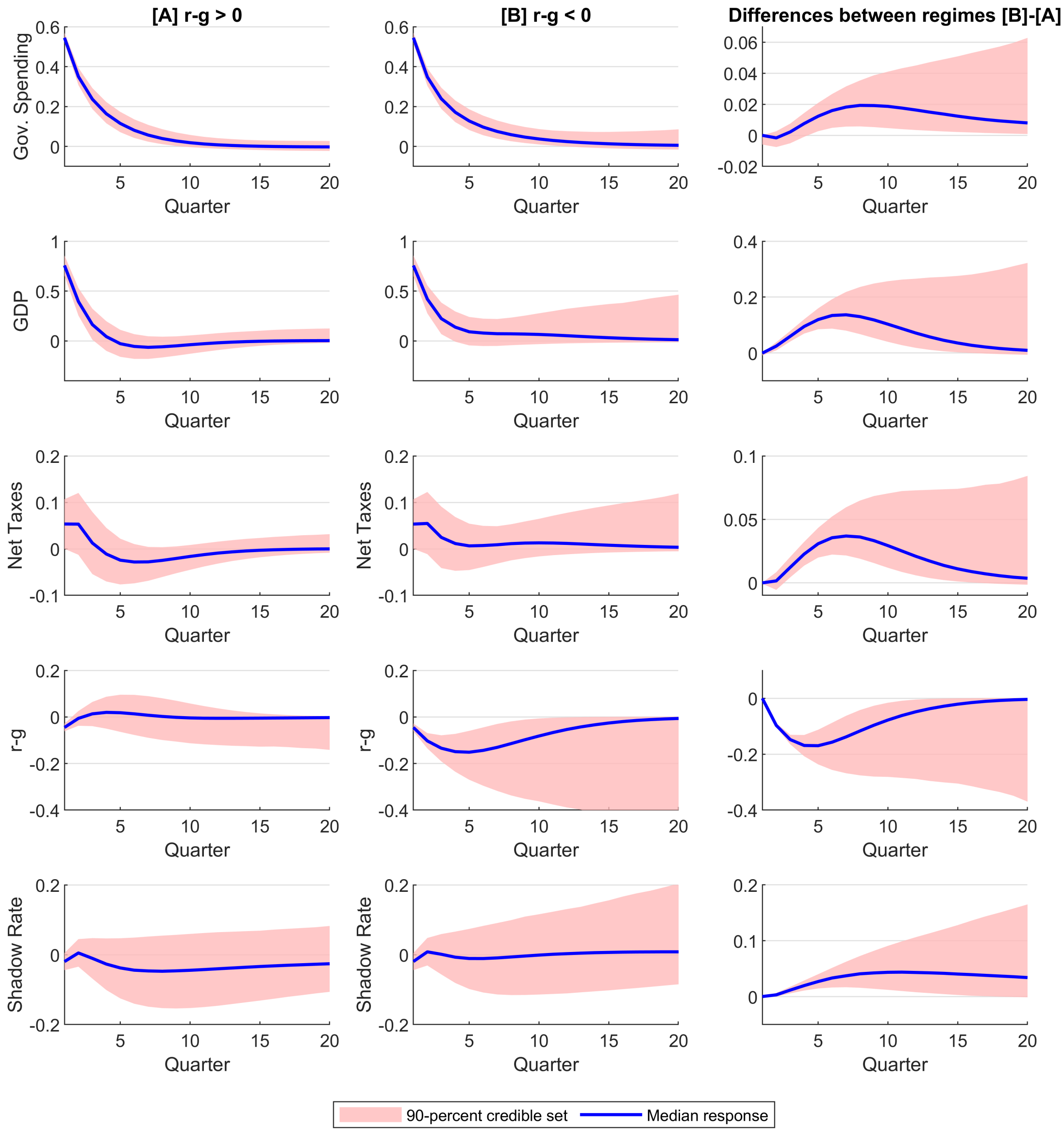
	Equation				
	Government spending	GDP	Net taxes	$r-g$	Shadow rate
Coefficient	-0.0005	-0.0158	-0.0074	0.0083	-0.0004
P-value	0.0000	0.0000	0.0000	0.0000	0.0000

3.1 Impulse Responses

In this subsection we report impulse response functions (IRFs) of government spending, output, net taxes (all in real terms), and of $r-g$ and the shadow monetary policy rate to an unexpected shock to government spending. One of the advantages of the FAIPVAR-X model is that it allows conditioning the IRFs on specific initial conditions. For the purpose of this analysis, the initial condition is represented by the shock occurring in quarters characterized by negative or positive $r-g$.

The left and middle columns of Figure 2 report the IRFs for positive and negative $r-g$ regimes, while the right column reports the difference in the IRFs across the two regimes. A few remarks are in order. First, in both cases a shock to government spending keeps spending itself persistently above baseline and it takes about ten quarters to die out. Second, output and net taxes respond positively to the shock, although the credible set of the responses of net taxes often includes zero. Third, $r-g$ responds positively on impact in both regimes. Afterwards, it increases (albeit not in a statistically significant manner) if the fiscal shock occurs when $r-g>0$, and it falls (to a statistically significant extent) when $r-g<0$. The 90-percent credible set of the difference in the median response of output, net taxes, $r-g$, and the shadow rate, between the negative and positive $r-g$ regimes, excludes zero up to a horizon of 2.5 years or more; it includes zero in the case of government spending, in the first year after the occurrence of the shock. The differences in the responses of the endogenous variables to a government spending shock across the two regimes is driven by the presence of the interaction term in each equation of the FAIPVAR-X model (reported in square bracket in equation 1). The estimated coefficients attached to the interaction terms, reported in Table 2, are statistically significant and have signs consistent with the difference between IRFs in the negative and positive $r-g$ regimes. For example, the interaction term in the equation of GDP is negative, meaning that the higher (lower) $r-g$ the smaller (larger) the impact of the government spending shock on GDP.

Figure 2: Impulse Responses to a Government Spending Shock



Notes: Impulse responses in percent to a shock of size one standard deviation. Bold lines represent median responses. Shadowed areas represent 90 percent credible sets.

3.2 Cumulated Government Spending Multipliers

Based on these impulse responses, we can compute the cumulated government spending multipliers at several time horizons, as explained in Subsection 2.2. Results are reported in Table 3. Both in the short and the medium term the multiplier is systematically higher if the fiscal shock occurs when $r - g < 0$, relative to the case when $r - g > 0$. At a one-year

Table 3: Cumulated Government Spending Multipliers

Horizon	H	$r - g > 0$	$r - g < 0$
1 year	4	0.95	1.14
2 years	8	0.69	1.13
3 years	12	0.61	1.18
4 years	16	0.60	1.21
5 years	20	0.61	1.23

Notes: Multipliers are computed as in Equation (3) for the positive and negative $r - g$ regimes. The table reports median values. H identifies the number of quarters after the shock.

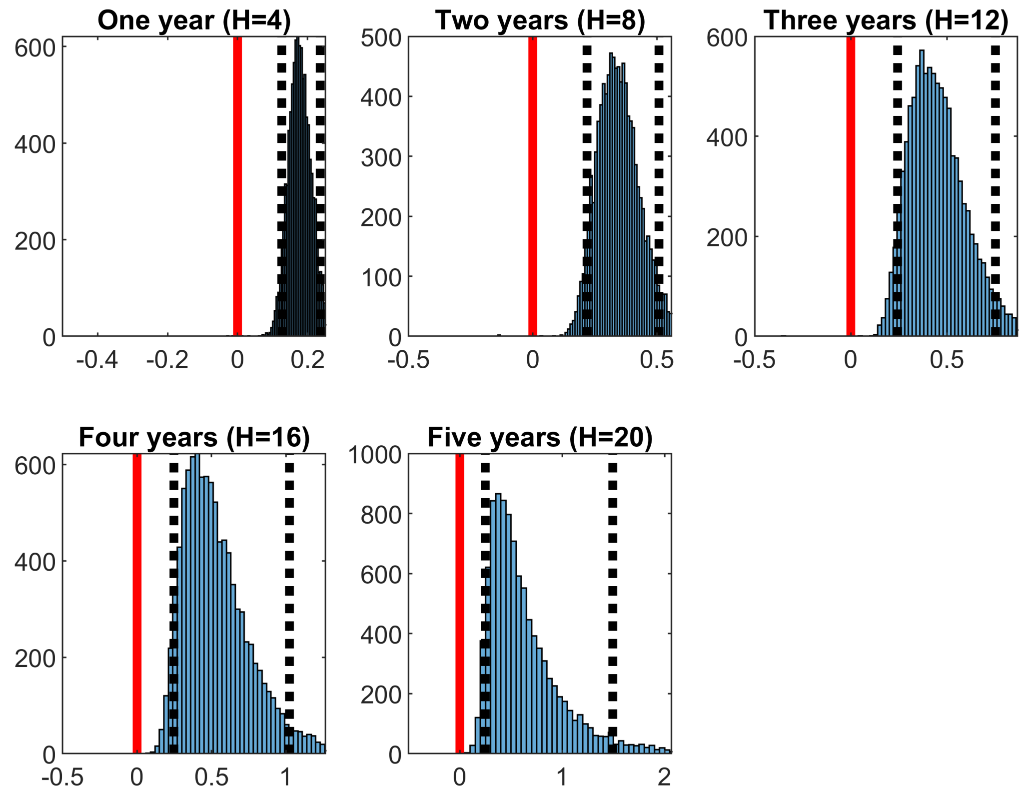
horizon, the point estimate is 0.95 in the positive $r-g$ regime and 1.14 in the negative $r-g$ regime. Beyond the one-year horizon, the difference between the two regimes becomes larger with a multiplier of about 0.6 when $r - g > 0$ and 1.2 when $r - g < 0$.

A fair question is whether the difference between the two sets of multiplier is statistically significant. Bayesian inference does not allow us to construct a test as in the frequentist approach. Therefore, we follow an approach compatible to Bayesian inference. Analogously to Caggiano et al. (2015) and Amendola et al. (2020), we compute empirical distributions of the differences computed as multipliers conditional on the economy being in the negative $r-g$ regime minus multipliers conditional on the economy being in the positive $r-g$ regime, and verify whether a very large part of the distributions include zero or not. In particular, for each of the 10,000 parameter draws from the posterior distribution, we compute the multipliers as in Equation (3), evaluate them for the two regimes, and compute the difference between the two. Figure 3 plots the distributions of the difference between the two multipliers cumulated at various time horizons together with 90 percent credible sets. It turns out that, at all horizons, at least 90 percent of each distribution is located above zero, indicating that the difference between the two multipliers is positive with very high probability.

Given that, with the FAIPVAR-X model, IRFs are computed conditional on initial conditions corresponding to specific quarters in the sample, we can compute time series of the cumulated government spending multipliers, at various time horizons, over the entire history of the EMU. Figure 4 reports these time series for the whole estimation sample and five times horizons. In line with the average results for the two regimes, these charts highlight an inverse correlation between $r-g$ and the size of the government spending multiplier (the correlation coefficient is 0.92, on average, across the horizons of cumulated multipliers).

Taken together, these results suggest that in the EA (i) the difference between the size of the government spending multiplier in the negative and positive $r-g$ regimes is different from zero with high probability and economically important; (ii) this difference increases at time horizons beyond the first year; (iii) in the medium-term (5 years), while the multiplier

Figure 3: Distributions of Differences in Cumulated Government Spending Multipliers between Negative and Positive $r - g$ regimes

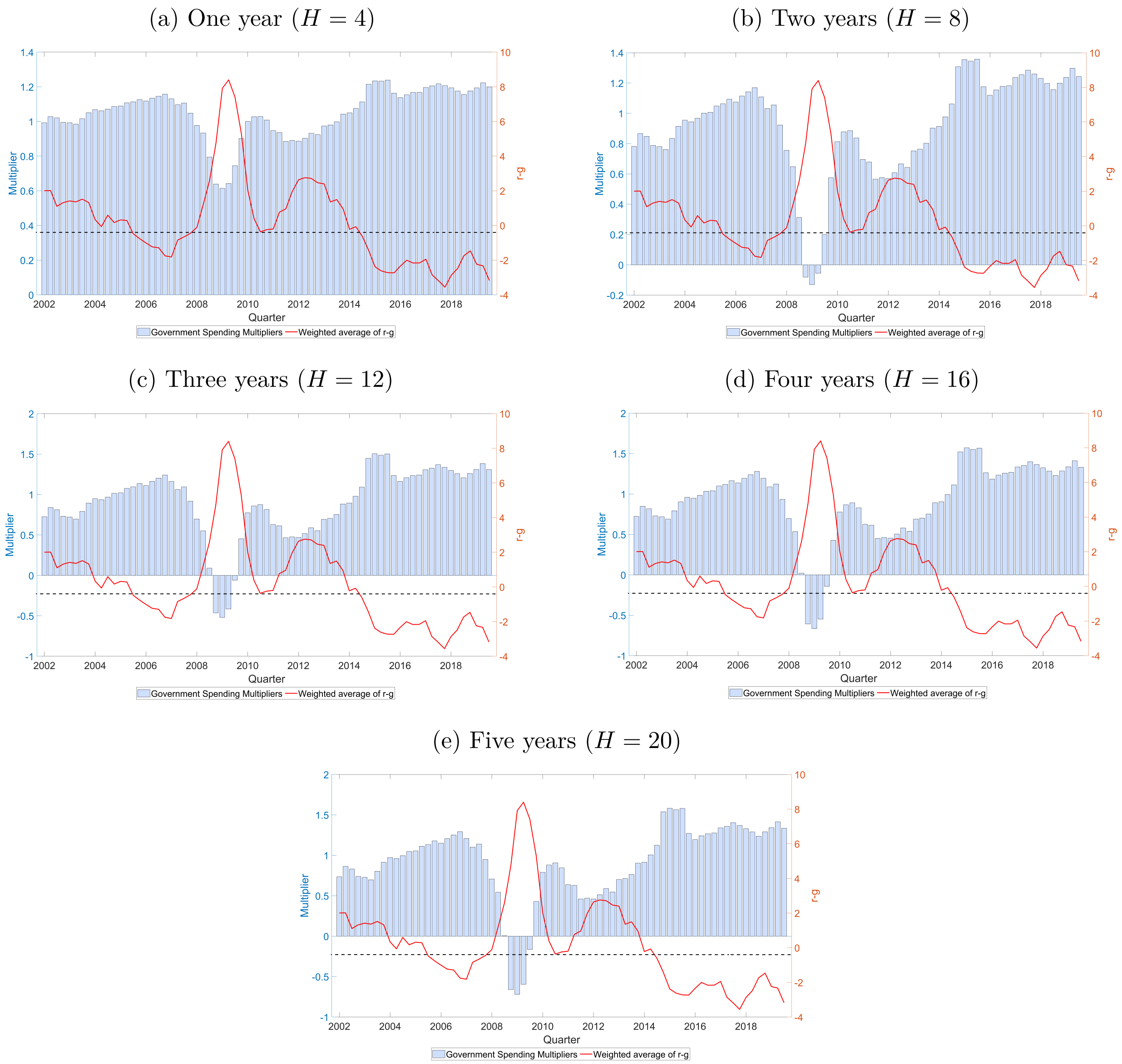


Notes: Empirical distributions of the differences are computed as multipliers conditional on the economy being in the negative $r - g$ regime minus multipliers conditional on the economy being in the positive $r - g$ regime. Multipliers are computed as in Equation (3) for each of the 10,000 parameter draws from the posterior distribution. Vertical dotted lines represent the 5th and the 95th percentiles of the distribution of differences. H identifies the number of quarters after the shock.

in the positive $r - g$ regime is about 0.6, in the negative $r - g$ regime it is about 1.2. More generally, the multiplier is inversely correlated with $r - g$.

These findings are compatible with theories of forward-looking private agents who expect governments to run larger primary budget balances in the future, if $r - g$ is high at the time of a government spending expansion. Anticipating a fiscal tightening (e.g. higher taxes) agents will save a larger fraction of the increase in income generated by the increase in government expenditures, leading to a smaller fiscal multiplier.

Figure 4: Historical Evolution of Cumulated Government Spending Multipliers



Notes: Multipliers are computed as in Equation (3) conditional on the economy being in a given quarter at the time of the government spending shock. H identifies the number of quarters after the shock.

3.3 Impact of the State of the Business Cycle, the Monetary Policy Stance, and the Level of Public Debt

Given that the literature points at several other determinants of the size of the fiscal multipliers, in this subsection we verify whether the results exaggerate the role of $r - g$, due to the impact of other channels related to $r - g$. We focus on three issues that dominate the literature on state-dependent fiscal multipliers.

1. *State of the business cycle.* There is a strand of the literature investigating whether government spending multipliers are dependent on the business cycle in advanced economies, and in particular whether they are higher in recessions relative to expansions (see Auerbach and Gorodnichenko, 2012, 2013; Batini et al., 2012; Caggiano et al., 2015; Ramey and Zubairy, 2018; Ghassibe and Zanetti, 2020, among others). Given that $r - g$ is inversely related to the business cycle via the impact of GDP growth, it seems natural to check whether our empirical results are driven by the state of the business cycle through its effect on $r - g$.

2. *Monetary policy stance.* Since the Great Recession, with many advanced economies hitting the zero lower bound (ZLB) of the monetary policy rate, several studies have investigated the role of the monetary policy stance on the size of the fiscal multiplier. Both single-country analyses (see, e.g., Crafts and Mills, 2013; Miyamoto et al., 2018; Ramey and Zubairy, 2018; Di Serio et al., 2020; and Liu et al., 2019, among others), and panel investigations (see, e.g., Almunia et al., 2010, Bonam et al., 2020, Klein and Winkler, 2018, among others) find higher multipliers at the ZLB. In the context of the EA, Amendola et al. (2020) find similar results and establish an inverse association between the shadow monetary policy rate—capturing the overall (conventional and unconventional) monetary policy stance—and the government spending multiplier. Since $r - g$ is affected by monetary policy through its effects on yields, it is appropriate to verify whether the results are dominated by this channel.

3. *Level of public debt.* The level of public debt is also one of the channels the literature consider important for the size of the fiscal multiplier, with high levels of debt generally associated with smaller multipliers (Kirchner et al., 2010; Nickel and Tudyka, 2014, among others). Higher indebtedness generally requires higher yields for government debt issuance, which may lead to a positive correlation between the government debt ratio and $r - g$. On average, in EA data this relationship seems weak (Figure 1, Panel a) with small or even negative correlation coefficients at the country level. However, we still see merit in checking whether the public debt level may be behind the relationship between the multiplier and $r - g$.

Given the existence of these three important channels documented by the empirical literature, one may argue that the results documented above could be assigning an excessive role to $r - g$, because other channels might have been contemporaneously at play. We tackle this identification issue using the strategy that Caggiano et al. (2017) employ in the context of uncertainty shocks, and Amendola et al. (2020) use for fiscal multipliers. The approach entails estimating three alternative versions of the FAIPVAR-X model. These specifications differ from the baseline specification in that in the interaction term—presented in square brackets in equation (1)—$r - g$ is replaced by alternative endogenous variables proxying the three channels mentioned in this subsection, one at a time, while the vector of endogenous variables continues to include $r-g$. We estimate each alternative model over the same sample period used for the baseline analysis, and compute GIRFs and associated fiscal multipliers, conditional on the same quarters with positive and negative $r - g$ as in the rest of the paper. If the effect of $r - g$ on the multipliers could not be disentangled from the alternative three channels listed above, we would find very similar multipliers to those reported in Table 3. In contrast, if the alternative multipliers turned out to be different, we would then conclude that the baseline multipliers are not "observationally equivalent" to those produced with the alternative models. In other words, the effect of $r - g$ on the size of the multipliers would be autonomous from any other of the three alternative channels.

To proxy the stance of the business cycle, we use the output gap measure already present among the endogenous variables of the model.[11] To capture the monetary policy stance, we use the shadow monetary policy rate, which is also an endogenous variable. Finally, we proxy public indebtedness with the ratio of public debt to GDP, which we add to the vector of endogenous variables (while excluding it from the set of data used to extract the common factors).

As reported in Table 4, it turns out that the multipliers obtained with the alternative three models are rather different from those obtained with the baseline model and, more importantly, the 90-percent credible sets of the difference between the multipliers in the two regimes systematically include zero. In addition, the credible sets widen at longer horizons. These results provide evidence that the alternative sets of multipliers are not observationally equivalent to those computed by using $r - g$ in the interaction term of the empirical model. The interest-growth differential has an autonomous role in affecting the size of the EA government spending multiplier.

It is worth stressing that the regimes employed to conduct what is essentially a placebo test, are still $r - g$ regimes and are not dictated by the state of the business cycle, the monetary policy stance or the level of public debt. Therefore, our results should not be interpreted as a contradiction, but rather as a complement to the literature linking the magnitude of fiscal multipliers to other important channels.

[11] Note that, as explained in Subsection 2.2, in our specification we divide real GDP by the real potential GDP of the corresponding country. Therefore, endogenous variable $GDP_{i,t}$ represents a measure of the output gap.

Table 4: Cumulated Government Spending Multipliers: Alternative Variables in the Interaction Term

State of the business cycle					
Horizon	H	[A] $r-g>0$	[B] $r-g<0$	Distrib. of diff. [B]-[A]	
				5th pctl	95th pctl
1 year	4	0.25	0.43	-0.20	0.47
2 years	8	0.25	0.42	-0.28	0.61
3 years	12	0.34	0.50	-0.71	0.69
4 years	16	0.40	0.56	-1.40	1.06
5 years	20	0.45	0.60	-1.97	1.86
Monetary policy stance					
Horizon	H	[A] $r-g>0$	[B] $r-g<0$	Distrib. of diff. [B]-[A]	
				5th pctl	95th pctl
1 year	4	1.54	1.84	-0.10	0.71
2 years	8	1.69	2.09	-0.16	0.99
3 years	12	1.86	2.31	-0.21	1.20
4 years	16	1.98	2.48	-0.32	1.47
5 years	20	2.06	2.59	-0.45	1.86
Level of public debt					
Horizon	H	[A] $r-g>0$	[B] $r-g<0$	Distrib. of diff. [B]-[A]	
				5th pctl	95th pctl
1 year	4	1.95	1.90	-0.14	0
2 years	8	1.39	1.33	-0.33	0.06
3 years	12	1.17	1.14	-0.55	0.17
4 years	16	1.23	1.23	-0.69	0.31
5 years	20	1.43	1.47	-0.67	0.53

Notes: Multipliers are computed as in Equation (3) for the positive and negative $r-g$ regimes. Multipliers in columns [A] and [B] are median values. Differences between multipliers are computed as multipliers conditional on $r-g<0$ minus multipliers conditional on $r-g>0$. Distributions are obtained by computing these differences for each of the 10,000 parameter draws from the posterior distribution. H identifies the number of quarters after the shock.

4 Robustness Checks

In this section we present the results of a number of robustness checks addressing issues commonly discussed in the literature, which may be applicable also to the analysis presented in this paper.

1. *Public debt in the specification.* In Section 3.3 we report results obtained by including the public-debt-to-GDP ratio among the endogenous variables *and* replacing $r-g$ with the debt ratio in the interaction term. The rationale for that experiment was to check whether the debt ratio, rather than $r-g$, was the driver of the results. Here,

we check whether results are robust to the inclusion of the public debt ratio among the endogenous variables, while keeping $r - g$ in the interaction term (and excluding public debt from the set of data used to extract the common factors). This alternative estimation is motivated by some contributions in the literature that argue in favor of the inclusion of the level of public indebtedness in the specification (e.g. Favero and Giavazzi, 2007).

2. *Alternative measure of potential GDP.* To facilitate the computation of the multipliers, we divide all government spending, GDP and net taxes by the real potential GDP of the corresponding country. This avoids potential biases that could arise from using constant sample averages of the ratios of fiscal variables to GDP in the *ex-post* conversion of the estimated elasticities to euro equivalents (see, e.g., Gordon and Krenn, 2010; and Ramey and Zubairy, 2018). In our baseline estimates, we compute real potential GDP using the filter recently proposed by Hamilton (2018). Hodrick (2020) shows that, while Hamilton's filter performs better at identifying the cyclical components in time series environments where the first-differenced series is stationary, the standard HP filter (Hodrick and Prescott, 1997) performs better when the time series is generated from a model with unobserved components. Given that the nature of the series under scrutiny may not be easy to ascertain, we check whether results are robust to the use of a standard HP filter.

3. *Alternative measure of r.* Throughout the paper we proxy $r - g$ as the difference between the ten-year government bond yield minus nominal GDP growth computed relative to the quarter of the previous year. Given that several contributions in the literature (e.g. Mauro and Zhou, 2020) use the average cost of financing the public debt in the computation of $r - g$, it seems appropriate to check whether results are robust to this alternative measure. The average cost of financing the public debt is calculated as the ratio between net interest payments and the public debt stock outstanding in the previous quarter.[12]

4. *Alternative threshold for $r - g$ regimes.* Given the intuitive implications of a positive versus negative $r - g$ for public debt dynamics in macroeconomic theory, we use zero as the threshold to distinguish between the two $r - g$ regimes. However, it is worth checking whether the results are robust to adopting an alternative threshold, which we

[12] Mauro and Zhou (2020) adjust r also for exchange rate depreciation, given that their dataset includes countries that issue debt denominated in foreign currency. This is not an issue in the case of the EA countries in our sample.

set equal to the median value of $r - g$ in the sample, -0.11. Choosing the mean of 0.19 leads to very similar results.

5. *Alternative measure of* $r - g$. In the theory of debt sustainability, $r - g$ is defined as the difference between the real interest rate and the real GDP growth rate. In most of the empirical analysis, we proxy $r - g$ as the difference between the ten-year nominal government bond yield minus nominal GDP growth. Given that real interest rates are typically defined as differences between nominal yields and expected inflation, our definition of $r - g$ implicitly assumes that actual inflation equals expected inflation. To make sure that our findings are not driven by this assumption, we verify whether results are robust to an alternative measure of $r - g$ in which the real interest rate is calculated as the difference between the annual yield of 10-year government bonds and the average expected inflation rate over ten years, in line with vintages of Consensus Economics forecasts. From the resulting real interest rate, we subtract the real GDP growth rate computed using the series of GDP at constant prices available in the Eurostat database. Given that 10-year inflation forecasts for Finland and Portugal start from 2006, only for this estimation, we drop these two countries from the sample.

6. *Two-year-ahead government spending forecasts.* To mitigate the fiscal foresight problem in our baseline specification we added, among the exogenous variables, the forecast of time-t government spending over the past 12 months published by the Economist Intelligence Unit with monthly frequency. Given that, due to data availability, this device does not allow controlling for anticipated movements in government spending beyond the one-year horizon, we consider appropriate to check whether our results are robust to the inclusion of two-year rolling forecasts, resorting to the Stability Programs that each EA member country must submit to the European Commission every year. We limit the analysis to a two-year horizon because of a considerable number of missing values that would arise if we adopted a longer horizon. Therefore, the variable is constructed as a moving average of spending forecasts made for the current year during the two previous years.

7. *Wider definition of government spending.* In line with most contributions in the fiscal VAR literature, our measure of real government purchases is the sum of government gross fixed capital formation and government consumption (which in turn includes compensation of employees and social transfers in kind via market producers). Given the importance of transfers in many EA countries, we check whether results are robust to the inclusion of other current transfers in the definition of the government spending variable.

As shown in Table 5, subjecting our estimates to these robustness checks changes the median estimates of the multiplier, but does not change the bottom line of the analysis: EA government spending multipliers are systematically larger in the negative $r - g$ regime relative to the positive $r - g$ regime (or in the regime below the median threshold versus the regime above it), with the credible sets of the differences between the two sets of multipliers located largely above zero. While the specifications with public debt, the alternative measure of $r - g$ and the two-year-ahead government spending forecasts yield somewhat larger multipliers in both regimes, the other specifications deliver multipliers with similar magnitudes to the baseline specification.

In sum, across all estimation variants (including the baseline reported in Subsection 3.2), median estimates of the multipliers vary conditional on the specification, but the difference between the multiplier in the negative and positive $r - g$ regimes is economically important and different from zero with high probability. Over the medium run (5 years), median cumulated multipliers range between 0.54 and 1.26 in the positive $r - g$ regime, and between 1.13 and 1.77 in the negative $r - g$ regime.

5 Conclusions

Academic studies and policy analyses contributed to a lively debate on potential fiscal stimuli that dates back to well before the COVID-19 pandemic. The arguments in favor of more ambitious stimuli often gravitated around the negative $r - g$ recorded in many countries, while opposing views were rooted in the historically high public debt levels.

The pandemic made fiscal expansions a necessity, as governments had to tackle not only the health emergency per se, but also the economic fallout triggered by lockdowns and other mitigation measures. Despite unprecedented government interventions, there is a risk that COVID-19 may leave deep economic scars. Therefore, policymakers around the globe committed to accelerate the recovery with programs that will ultimately increase government expenditures and may bring debt to even higher levels. Whether government spending programs will be successful depends on the size of fiscal multipliers, not only due to their first-round implications for GDP, but also due to the effect that GDP growth has on debt sustainability through $r - g$.

Exploiting data on ten EA countries, this paper shows that a higher $r - g$ is associated with a lower government spending multiplier and viceversa. This empirical finding is in line with economic theories assuming forward-looking agents who anticipate that the higher $r - g$, the higher the primary budget balance a government needs to run to stabilize its debt.

Table 5: Robustness Checks on the Cumulated Government Spending Multipliers

Horizon	H	[A] $r-g>0$	[B] $r-g<0$	Distrib. of diff. [B]-[A]	
				5th pctl	95th pctl
Public debt in the specification					
1 year	4	1.24	1.41	0.13	0.24
2 years	8	1.10	1.43	0.22	0.51
3 years	12	1.08	1.50	0.24	0.75
4 years	16	1.09	1.57	0.25	1.02
5 years	20	1.11	1.62	0.25	1.49
Alternative measure of potential GDP					
1 year	4	0.62	0.75	0.06	0.19
2 years	8	0.79	1.10	0.15	0.49
3 years	12	0.95	1.37	0.19	0.85
4 years	16	1.11	1.59	0.18	1.28
5 years	20	1.26	1.77	0.17	2.19
Alternative measure of r					
1 year	4	0.97	1.10	0.11	0.18
2 years	8	0.83	1.14	0.21	0.46
3 years	12	0.84	1.24	0.23	0.73
4 years	16	0.88	1.31	0.22	0.95
5 years	20	0.91	1.33	0.20	1.13
Alternative threshold for $r-g$ regimes					
Horizon	H	[A] $r-g>-0.11$	[B] $r-g<-0.11$	5th pctl	95th pctl
1 year	4	0.95	1.15	0.15	0.26
2 years	8	0.70	1.15	0.30	0.67
3 years	12	0.63	1.21	0.34	1.06
4 years	16	0.63	1.24	0.33	1.38
5 years	20	0.64	1.25	0.32	1.59
Alternative measure of $r-g$					
1 year	4	1.55	1.78	0.17	0.31
2 years	8	1.07	1.58	0.32	0.82
3 years	12	0.82	1.50	0.38	1.37
4 years	16	0.69	1.47	0.40	1.91
5 years	20	0.62	1.45	0.41	2.35
Two-year-ahead government spending forecasts					
1 year	4	1.10	1.27	0.06	0.25
2 years	8	0.97	1.37	0.20	0.72
3 years	12	0.96	1.51	0.24	1.48
4 years	16	0.98	1.61	0.23	2.81
5 years	20	1.01	1.68	0.20	4.77
Wider definition of government spending					
1 year	4	0.71	0.91	0.15	0.25
2 years	8	0.57	0.99	0.29	0.61
3 years	12	0.54	1.07	0.34	0.89
4 years	16	0.54	1.11	0.34	1.07
5 years	20	0.54	1.13	0.34	1.20

Notes: Multipliers are computed as in Equation (3) for the positive and negative $r-g$ regimes. Multipliers in columns [A] and [B] are median values. Differences between multipliers are computed as multipliers conditional on $r-g<0$ minus multipliers conditional on $r-g>0$. Distributions are obtained by computing these differences for each of the 10,000 parameter draws from the posterior distribution. H identifies the number of quarters after the shock.

We find the difference between the size of the multiplier in the negative and positive $r - g$ regimes to be systematically different from zero with high probability, and to increase at time horizons beyond the first year. Median cumulated multipliers range between 1.13 and 1.77 when $r - g$ is negative, and between 0.54 and 1.26 when $r - g$ is positive, depending on the specification.

These calculations are based on the estimates of a factor-augmented interacted panel vector-autoregressive model. The econometric approach deals with several technical problems highlighted in the empirical macroeconomic literature, including the issues of fiscal foresight and limited information. Placebo-like tests confirm that the findings are not driven by the state of the business cycle, the monetary policy stance, or the level of government debt, and they survive a number of other robustness checks.

The results carry important policy implications especially in the context of the usage of the EU Recovery Fund, which will lead to ambitious government spending programs in member countries. With GDP growth expected to resume, insofar as interest rates remain low, the resulting $r - g$ should be conducive of relatively high government spending multipliers. However, this scenario may be reversed, and multipliers may become significantly more modest, if adverse shocks keep $r - g$ significantly above zero in member countries.

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Appendix

A Data

A.1 Endogenous Variables

Our variables of interest are gross domestic product, net taxes, government spending, the European Central Bank's shadow rate and the interest-growth differential. As standard in the literature we construct net taxes as the sum of government receipts of direct and indirect taxes minus transfers to businesses and individuals. The government spending series is constructed as the sum of government gross fixed capital formation and government consumption. The interest-growth differential $(r - g)$, which is present also in our interaction term, is constructed as the difference between the 10-year Government Bond Yield and year-on-year GDP growth. In our robustness analysis, we also employ an alternative measure of r, computed as the ratio between net interest payments and the public debt stock outstanding in the previous quarter. All the variables are downloaded from the Eurostat database available on the Thomson Reuters Datastream Economics database. Gross domestic product, net taxes and government spending are transformed in real terms using the implicit GDP price deflator. Then they are normalized by diving by real potential GDP. The European Central Bank's shadow rate, is that developed by Wu and Xia (2017).

A.2 Exogenous Variables

We use as exogenous variables the forecast of the annualized growth rate of total government expenditure over GDP produced by the Economist Intelligence Unit. In particular, we create a series where in each quarter we compute the average forecast for the current year over the past 12 months. The other exogenous variables are the U.S. output gap, and the U.S. inflation downloaded from the Federal Reserve Bank of St. Louis database, and the U.S. Shadow Rate developed by Wu and Xia (2016).

A.3 Informational Dataset

The informational dataset we used to extract common factors is composed by 250 series downloaded from the Eurostat database available on the Thomson Reuters Datastream

Economics database. Specifically we downloaded the following variables for each country considered:

- *National Account:* Domestic Demand; Export of Goods and Services; Imports of Goods and Services; Gross Capital Formation; Final Consumption Expenditure of Households.
- *Government Statistics:* Government Consolidated Gross Debt: Central Govt.
- *Output and income:* Industrial Production Index (Mining and Quarrying; Manufacturing; Electricity, Gas, Steam and Air Conditioning Supply); Nominal Unit Labor Cost based on persons; Production - Total Industry Excl. Construction; Production of Total Construction; Wages and Salaries; Change in Inventories.
- *Employment and hours:* Early Estimates of Labor Productivity - Total Economy; Employees Domestic Concept; Unemployment: Total.
- *Stock prices:* S&P BMI - Price Index.
- *Exchange rates:* REER: 19 trading partners EA; NEER: 37 Trading Partners.
- *Money and credit quantity aggregates:* Money Supply: M1 - Contribution to Euro M1; Money Supply: M2 - Contribution to Euro M2; Money Supply: M3 - Contribution to Euro M3; Official Reserve Assets.
- *Interest Rate:* Harmonized Government 10-Year Bond Yield.

Where appropriate we transform variables to guarantee stationarity tested by the Dickey and Fuller (1979) and Kwiatkowski et al. (1992) tests.

B Inference and Identification

We estimate the FAIPVAR-X model presented in equation (1), adopting the following three steps.

1. Estimate the reduced-form model adopting a Bayesian strategy for inference with an uninformative independent Normal–Wishart prior, which in turn uses a Montecarlo simulation to recover the posterior distribution of the parameters.[13] More precisely, adopt a Direct Monte Carlo Sampling to draw the variance-covariance matrix of the residuals after averaging coefficients across countries, $\Sigma^{(s)}$, from an inverse Wishart

[13] As in Cogley and Sargent (2005); Sá et al. (2014), we discard any explosive draws from the unrestricted posterior.

distribution $IW(\hat{S}, T \times N - f)$—where $\hat{S}$ is the sum of the squared residuals and f is the number of coefficients in a single equation of the VAR—for drawing $\Phi^{(s)}$ from the conditional multivariate normal distribution $MN\left(\hat{\Phi}, \Sigma^{(s)} \otimes \left(X'X\right)^{-1}\right)$, where $\hat{\Phi}$ are the estimated reduced-form parameters and X is the matrix of regressors in the panel VAR.[14]

2. Make a draw of the posterior distribution and derive Generalized Impulse Response Functions (GIRFs) following the methodology of Koop et al. (1996) and Caggiano et al. (2017). This approach allows endogenizing the variables in the interaction term and, consequently, conditioning the response of the other endogenous variables on their evolution. Specifically, GIRFs are derived as the following difference:

$$GIRF_{i,y}(h, \delta, \omega_{i,t-1}) = E\left[y_{i,t+h}|\delta, \omega_{i,t-1}\right] - E\left[y_{i,t+h}|\omega_{i,t-1}\right], \qquad \text{(B.1)}$$

where, for each country i, $E\left[y_{i,t+h}|\delta, \omega_{i,t-1}\right]$ represents the expected value of the response of the endogenous variables y to a shock of size δ, at horizon $t+h$, conditional on an initial history ω_{t-1}; and $E\left[y_{t+h}|\omega_{i,t-1}\right]$ represents the expected value of the endogenous variable y at horizon $t+h$ conditional on an initial history ω_{t-1}. It is worth emphasizing that the vector of endogenous variables y also includes the variables in the interaction term, and that the choice of the initial condition $\omega_{i,t-1} = \{y_{t-1}, \ldots, y_{t-k}\}$ allows discerning among different levels of $r - g$. Thus, for each country and each regime:

   (a) pick an initial condition $\omega_{t-1,j}$;

   (b) simulate the residuals series starting from its empirical distribution $\tilde{u}^r_{t+h} \sim d(0, \widehat{\Sigma})$;

   (c) for each simulation of residuals r, recover the path $E\left[y_{t+h,j}|\omega_{t-1,j}\right]^r$;

   (d) simulate the path $E\left[y_{t+h,j}|\delta, \omega_{t-1,j}\right]^r$starting from the residuals obtained in substep (b) perturbated by a government spending shock identified using a Cholesky decomposition (as in Kilian and Vigfusson, 2011 and Caggiano et al., 2017);[15]

   (e) compute the GIRF as in equation B.1;

   (f) compute the average GIRF across $R = 500$ simulations in order to obtain consistent estimates;[16]

[14]For further details see Algorithm 2.1 described in Del Negro and Schorfheide (2011).

[15]Following Blanchard and Perotti (2002), we order government spending as the first endogenous variables. The assumption behind this choice is that, due to implementation and legislation lags, government spending does not respond contemporaneously to other endogenous variables within the same quarter.

[16]As in Caggiano et al. (2017), if a given initial condition produce an explosive response, we discard it.

(g) average across countries once the average GIRF for each initial condition belonging to different regimes has been collected.

3. Repeat step 2 for 10,000 draws from the posterior distribution. Then consider the median IRFs across the 10,000 parameter draws. Parameter uncertainty is accounted for by saving the 5th and 95th percentile of the distribution as error bands.