# Questioning the puzzle: fiscal policy, real exchange rate and inflation*


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**Abstract**

The paper re-investigates the effects of government spending shocks on the real exchange rate and inflation, using US data. In opposition to some previous *puzzling* results, we find that an increase in government spending appreciates the real exchange rate and generates inflationary pressures. Positive spending shocks also induce a trade balance deficit and an increase in the nominal interest rate. The discrepancy with the existing literature lies in the identification of fiscal shocks: embedding a narrative instrument within a proxy-SVAR model is what makes the difference. Findings are robust and coherent with a standard open economy business cycle model. Our analysis suggests that proxy-SVAR models are more *immune* to structural changes in US fiscal policy.



*JEL classification*: E62, F41

*Keywords*: Fiscal shocks, real exchange rate, inflation, proxy-SVAR, narrative shocks.



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# 1 Introduction

Since the Great Recession, the debate on the role of fiscal policy has gained traction, as discretionary fiscal measures have started afresh to serve as policy tools in advanced economies. This renewed interest in fiscal policy, recently accentuated by the Covid-19 crisis, has spurred considerable academic research on its effects. However, despite the importance of the question, there is still no consensus on how inflation and the real exchange rate respond to fiscal shocks. The aim of this paper is to re-examine the implications of fiscal policy for domestic and international variables, starting from the responses of inflation and the real exchange rate.

According to standard theoretical frameworks, whether Real Business Cycle or old and new-Keynesian theories, inflation should increase and the real exchange rate should appreciate in response to an increase in government spending. However, the empirical literature finds mixed results. On inflation, while Edelberg et al. (1999), Zeev and Pappa (2017) and Caldara and Kamps (2017) find that a government spending shock is inflationary, Fatás and Mihov (2001b), Canzoneri et al. (2002), Mountford and Uhlig (2009a), Dupor and Li (2015), Ricco et al. (2016), Jorgensen and Ravn (2021) and D'Alessandro et al. (2019) find that the same shock generates deflationary pressures.

On the real exchange rate, Kim and Roubini (2008) found that fiscal expansions depreciate the real exchange rate. This result has then been confirmed by Monacelli and Perotti (2010), Enders, Muller and Scholl (2011), Ravn, Schmitt-Grohe and Uribe (2012) and Ilzetzki, Mendoza and Vegh (2013). However, Auerbach and Gorodnichenko (2016) show that military spending news shocks (i.e. unanticipated news to future spending) cause an appreciation of the U.S. dollar. Born et al. (2013) and Born et al. (2019) also point out that under a fixed exchange rate regime the real exchange rate appreciates and Ilzetzki and Jin (2013) found that the response of the real exchange rate depends on the sample considered. Then, in line with different conditional responses, Kim (2015), Forni and Gambetti (2016), Miyamoto, Nguyen and Sheremirov (2019), Boehm (2019) and Lambertini and Proebsting (2020) argue that the response of the exchange rate depends on country characteristics, like the stage of economic development, the timing of the fiscal shock (namely if it is anticipated or not) and the sign or type of fiscal instrument (government consumption or investment).

This paper re-examines and merges the closed and open economy debate by employing a different identification scheme to estimate the impact of fiscal spending shocks on inflation and the real exchange rate. The military narrative series constructed by Ramey (2011) and Ramey (2016a) is used into a Structural Vector Auto-Regression (SVAR) model, employing the proxy-SVAR methodology developed by Mertens and Ravn (2013) and Stock and Watson (2008). Using this identification technique, most *puzzling* results dissolve: government spending shocks are inflationary, appreciate the real exchange rate and worsen the trade balance. We also find that private consumption falls and that the nominal short-term interest rate (3-Month Treasury Bill) increases, as opposed to most of the empirical literature studying the domestic effects of fiscal policy (see Murphy and Walsh (2020) for a review of the literature). These dynamics are aligned with standard theoretical predictions and the responses of an estimated real business cycle open economy model match surprisingly well empirical impulse-responses.[1]

Specifically, the proxy-SVAR is estimated on quarterly United States data using a Bayesian approach over the 1964Q1-2015Q4 period. Two important aspects should be emphasised at the very outset. First, even though Ramey (2016a) has constructed the narrative series to instrument both contemporaneous and future government spending, we use it here to instrument only contemporaneous shocks, recovering standard surprise shock as opposed to news shock. We show that this series is indeed a valid instrument for contemporaneous government spending in the 1964-2015 period, satisfying both the relevance and the exclusion restrictions. Second, given the importance of the time-frame for fiscal estimates, we pick as a baseline the 1964Q1-2015Q4 period to use the official real effective exchange rate data from the Bank of International Settlement (BIS), available at the earliest from 1964.

Multiple robustness checks are also included in our empirical analysis. Theory-consistent responses to a positive government spending shock are also found when the estimation is carried out in the post-1973 sample (which excludes the Bretton-Wood's period, Kim et al., 2017) or when we exclude the Great Recession period (i.e. with sample ending in 2006). Using nominal exchange rates or using a different definition of inflation does not change the result. Moreover, using defense government investment, instead of Ramey (2016a)'s narrative series, as an instrument for government spending (as in Miyamoto et al. (2019)) also confirms our results (Section 5).

The contribution of the paper to the literature is twofold. First, we show that, by using a truly exogenous measure of unanticipated government spending shocks, we are able to recover responses of the main macroeconomic variables that are in line with the stan-

[1] Results from the estimated model are available in Appendix G. To keep the intuition of the model as clear as possible, we construct a standard two-good RBC small open economy model and estimate it to match the impulse-responses to a government spending shock. This exercise allows us to get an immediate feeling on how far we can go in explaining empirical results with a standard and frictionless framework. Impact responses, with the exception of GDP (not surprisingly), are impressively well described by a standard estimated open real business cycle model.

dard theory, solving a well-known puzzle in the international macro literature. For this purpose, we exploit previously unexplored properties of the military narrative series constructed in Ramey (2011). Second, we also show that the short-term interest rate increases following a spending shock. This is not only consistent with our results on inflation and the exchange rate, but also speaks to another puzzle concerning the domestic effects of fiscal policy, as the empirical literature tends to find negative responses of the short rate. Overall, we believe that our analysis contributes not only to the academic debate, but it can also be useful to think about the current environment in which a large stimulus package in the United States has just been passed by the Biden's administration. In this respect, our results inform on the reaction of variables like the US real exchange rate and trade balance, which are key in the international transmission of US fiscal shocks.

The rest of the paper is organized as follows. Section 2 discusses the relation of our paper with existing literature. Section 3 briefly describes the proxy-SVAR methodology, the identification strategy, the data and specification adopted in the paper. Section 4 presents the empirical results. Section 5 shows the robustness of the results to different specifications and Section 6.1 compares in details both recursive and proxy-SVAR shocks. Finally, Section 7 concludes.

## 2 Literature review

Our paper draws on different strands of the literature. First, it is closely related to the literature analyzing the empirical effects of fiscal policy on the real exchange rate and inflation. The seminal paper focusing on exchange rate responses is Kim and Roubini (2008), where the authors document a US real exchange rate depreciation following a positive US fiscal shock, at odds with what the theory predicts. They also document a counterintuitive reaction of the trade balance, which improves instead of deteriorating. Such puzzling results ignited a stream of the literature which mainly confirmed these empirical regularities. Monacelli and Perotti (2010) find that, in the US and other advanced economies, a rise in government spending induces a depreciation of the CPI real exchange rate and a trade balance deficit. They also find that private consumption rises in response to a government spending shock, in line with Blanchard and Perotti (2002) and Ravn, Schmitt-Grohé and Uribe (2006). Ravn et al. (2012) use a panel structural VAR analysis to document that an increase in government purchases raises output and private consumption, deteriorates the trade balance, and depreciates the real exchange rate, both in the US and in other four industrialized countries. Enders et al. (2011) find, using sign restrictions, that the exogenous expansions of government spending depreciates the real exchange rate and the terms of trade. Ilzetzki et al. (2013) concentrate on the output effect of fiscal policy, but it highlights the same puzzling response of the real exchange rate, using a panel of 44 countries. More recently, Kim (2015) investigated again the question, examining 19 OECD countries. The author finds that current account worsens and real exchange rate appreciates in the majority of the countries, but various country characteristics (e.g. trade openness, capital mobility, etc.) are driving the result. Similarly, Miyamoto et al. (2019) explore the response of the exchange rate to a government spending shock differentiating between advanced and emerging countries. They identify the shock using annual military expenditures and find an appreciating (depreciating) exchange rate in emerging (advanced) economies. Even if focusing on a different aspect, Boehm (2019) shows that a government investment shock, and not a government consumption shock, can slightly appreciate the real exchange rate when the country has a floating nominal exchange rate (based on Ilzetzki et al. (2017)). Born et al. (2013) and Born et al. (2019) confirm that real exchange rate responses is conditional on the exchange rate regime but also show an asymmetry due to the sign of the government spending shock. Finally, Lambertini and Proebsting (2020) find that government spending shock cause an appreciation of the exchange rate in a fixed exchange rate regime.

However, the two papers closest to our findings in terms of exchange rate responses are Auerbach and Gorodnichenko (2016) and Forni and Gambetti (2016). Auerbach and Gorodnichenko (2016) use daily data on U.S. defense spending and documents that the dollar immediately and strongly appreciates after announcements of future government spending. On the contrary, when actual payments are made, spending variations have no significant effects on the exchange rate. Forni and Gambetti (2016) use the Survey of Professional Forecasters to account for both government spending news and surprise shocks. They estimate the effects of both types of shocks using a quarterly VAR from the 80's, finding that anticipated shocks generate an appreciation of the real exchange rate, while unanticipated ones generate a depreciation.

Moving to the effects of fiscal policy on inflation, results are also mixed. Edelberg et al. (1999), Zeev and Pappa (2017) and Caldara and Kamps (2017) find that a government spending shock increases prices/inflation. Other studies, like Fatás and Mihov (2001a), Perotti (2005), Canova and Pappa (2007) and Nakamura and Steinsson (2014) find either a non-significant response or mixed evidence. However, a large set of papers (i.e. Fatás and Mihov (2001b), Canzoneri et al. (2002), Mountford and Uhlig (2009a), Dupor and Li (2015), Ricco et al. (2016), Jorgensen and Ravn (2021) and D'Alessandro et al. (2019)), find that a government spending shock is deflationary. In particular, Jorgensen and Ravn (2021), using data from the 80's and adopting various identification schemes, document that in response to an increase in government spending, inflation falls. They rationalize the negative behavior of inflation by showing that a fiscal shock increases domestic productivity, hence generating a supply side boost which more than compensate the increase in aggregate demand. Similar results are found by D'Alessandro et al. (2019), which develops a quarterly Bayesian VAR including fiscal and TFP variables for the period 1954Q3-2007Q4, finding that inflation turns negative after a positive fiscal shock.

Regarding the response of the interest rate, in a recent paper Murphy and Walsh (2020) discuss how most of the empirical literature obtains puzzling evidence also with this respect, as interest rates fall after positive spending shocks instead of increasing as standard theory would suggest. For example Mountford and Uhlig (2009a) find that deficit spending stimulates the economy but it crowds out private investment without causing interest rates to rise. Our methodology finds results more consistent with the interpretation of government spending shocks as a shift in aggregate demand, even for the behaviour of the interest rate, which increases on impact and remains significant for the first few quarters, consistently with the appreciation of the exchange rate and the inflationary pressures.

Clearly, our paper is also related to the literature on the estimation methods of fiscal policy shocks. One common feature over most of the aforementioned papers is the identification methods adopted in order to recover the structural fiscal shock. These are based on the Blanchard and Perotti (2002) restrictions on the variance-covariance matrix or on sign restrictions (Mountford and Uhlig, 2009a) or on narrative identification methods (Romer and Romer, 2010). In this paper we will differentiate ourselves by adopting the proxy-SVAR methodology, developed independently by Mertens and Ravn (2013) and Stock and Watson (2008), which combines the narrative series of Ramey (2011) and Ramey (2016a) with the SVAR structure, on a long sample.

It is important to mention that our focus on the real exchange rate, and consequently on net exports, interrelates our paper to the literature studying fiscal spillovers. Corsetti et al. (2009), Corsetti et al. (2011), Corsetti and Muller (2013), Auerbach and Gorodnichenko (2013) and Faccini et al. (2016) study the role of fiscal policy in a increasing globalized world, highlighting different transmission mechanisms. Here we simply show that a government spending shock appreciates the exchange rate and decreases net export, which will therefore have an impact (that we don't estimate) on other economies.

Last, our paper is related to the theoretical literature analyzing the economic effects of fiscal policies. A standard closed economy neo-classical model (Baxter and King, 1993) would suggest that an increase in unproductive government spending would generate a fall in private consumption (via a negative wealth effect due to the increase in the present value of taxes to be paid) and an increase in prices. Empirically, however, most of the evidence pointed towards an increase in private consumption and a fall in prices in response to a positive government spending shock. This mismatch between theory and empirics has been shaping theoretical studies, which tried to rationalize the empirical findings (see, for example, Basu and S. Kimball, 2003, Linnemann, 2006, Ravn et al., 2006, Galí et al., 2007 and more recently Jorgensen and Ravn, 2021 and D'Alessandro et al., 2019). A similar contrast between theoretical predictions and empirical evidence drove also the theoretical literature looking at the impact of fiscal policy in open economies. A benchmark general equilibrium open economy model featuring complete financial markets would imply that an increase in government spending would generate an appreciation of the exchange rate, a fall in the trade balance and a fall in consumption. Empirically, however, the evidence was pointing towards a depreciation of the real exchange rate, an increase in the trade balance and an increase in consumption. Monacelli and Perotti (2008) and Monacelli and Perotti (2010) describe well the empirical vs theoretical inconsistencies: benchmark open economy models including the wealth effect of government spending and perfect risk-sharing across countries cannot rationalize simultaneously the effects on quantities and relative prices, and even more so if government spending is intensive in non-traded goods. To solve these issues, two theoretical solutions have been proposed: first, counteract the negative wealth effect coming from government spending by assuming non-separable utility or equilibrium variable markups (Monacelli and Perotti, 2010); second, calibrate the model with a low trade elasticity (Enders et al., 2011). To relate our paper also to this debate, in Appendix G, we will set up a model accounting for the possibility of these features and we will estimate their relevance via an impulse-responses matching procedure.

# 3 Empirical model and identification strategy

In this Section we introduce our empirical model and the identification strategy. First, we briefly describe the proxy-SVAR methodology. Second, we present our set of target variables. Third, we discuss the use of the military narrative series as an instrument for unanticipated government spending shocks.

## 3.1 The proxy-SVAR framework

Consider the following Vector AutoRegressive (VAR) model:

$$X_t = c_0 + \sum_{k=1}^{P} A_k X_{t-k} + u_t \qquad u_t \sim N(0, \Sigma_u) \tag{1}$$

where $X_t$ is a vector of endogenous variables, $c_0$ is a constant vector, $A_k$ are the matrices containing the reduced-form parameters, $u_t$ is the vector of reduced-form residuals and $\Sigma_u$ is the covariance matrix of the reduced-form shocks. In order to identify structural shocks in the VAR, one needs to specify a matrix $P_0$ that pre-multiplying Equation (1) yields:

$$P_0 X_t = P_0 c_0 + P_0 \sum_{k=1}^{P} A_k X_{t-k} + \epsilon_t \tag{2}$$

where $\epsilon_t = P_0 u_t$ is the vector of structural shocks with mean zero and covariance matrix $\Sigma_\epsilon$. To construct the matrix $P_0$, to identify fiscal shocks in the United States, we use the proxy-SVAR methodology, developed by Mertens and Ravn (2013) and Stock and Watson (2008). Restrictions on $P_0$ are obtained by making use of a proxy of the true latent exogenous variable. We employ a narrative measure $m_t$ to proxy for the unobserved fiscal shock $\epsilon_{f,t}$, where we assume $E(m_t) = 0$; In addition, denoting the non-fiscal US shocks as $\epsilon_{nf,t}$, our narrative measure needs to satisfy the following two conditions:

$$E[m_t, \epsilon_{f,t}] = \gamma \tag{3}$$

$$E[m_t, \epsilon_{nf,t}] = 0 \tag{4}$$

This means that our proxy $m_t$ is correlated with the unobserved fiscal policy shock but it is orthogonal to the remaining shocks. This methodology provides the restrictions for the columns of the matrix $P_0$ related to the fiscal variable. To obtain them, we follow the standard two-step procedure for proxy-SVARs: first, we run a two-stage least squares (2SLS) estimation of all non-fiscal residuals in the US model ($u_{nf,t}$) on the fiscal ones, using $m_t$ as an instrument for $u_{f,t}$: the estimated coefficients represent each variables' restrictions up to a scale factor; second, we impose covariance restrictions to identify each element in the $l^{th}$ column of $P_0$. Details on the proxy SVAR procedure are reported in Mertens and Ravn (2013).

### 3.2 Data and specification

The baseline specification of our VAR model encompasses the following US variables: real government spending $G_t$, real GDP $y_t$, real tax revenues $tax_t$, real private consumption $c_t$, inflation $\pi_t$, total factor productivity (TFP) $tfp_t$, trade balance (in percent of GDP) $TB_t$, the stock price of Boeing (proxying the market value of the military firms sector) $s_t$, the narrow real effective exchange rate of the dollar $reer_t$ and the nominal short-term interest rate (3-Month Tbill Rate) $R$.[2] With the only exception of inflation, the trade balance-to-GDP ratio and the short rate, all other variables are taken in logs. Inflation is computed on an annual basis using the personal consumption expenditure (PCE) deflator. Real government spending, real GDP, real private consumption and real tax revenues are obtained by deflating nominal variables using the GDP deflator. To instrument exogenous variations in government spending, we use the military spending narrative series constructed by Ramey (2016a). Such series quantifies the amount of current and future military spending (i.e. surprise plus anticipated movements) reported in the news, extracting information from the Businessweek magazine. The series is taken in real terms, i.e. divided by lagged GDP deflator. Our variables come from different sources.[3] The TFP variable is taken from Fernald (2012). Nominal GDP, government spending and tax revenues are taken from Ramey and Zubairy (2018). Stock prices are taken from Yahoo!Finance. The real effective exchange rate, as well as the nominal effective exchange rate used in a robustness check, are taken from the BIS database. Data on nominal defense government investment, used in another robustness section, are deflated with defense consumption and investment deflators; both the defense and deflator variables are taken from the FRED database.

We estimate the model on quarterly data and, as it is standard in the literature, we include the constant and four lags of the endogenous variables. The baseline estimation sample ranges from 1964Q1 to 2015Q4.[4] Dummy variables from 2007Q4 to 2009Q2 are included to control for the exceptional fluctuations observed during the great financial crisis. The model is estimated using Bayesian techniques, performed via a block MCMC algorithm. We use the dummy method of Del Negro and Schorfheide (2011) and Caldara and Kamps (2017) and we impose a Minnesota prior on the reduced-form VAR parameters; in addition, we choose the hyper-parameters governing the prior distributions in order to impose relatively weak priors.[5]

[2]The broad effective exchange rate is only available since 1994.

[3]For more details, see Appendix A

[4]Such sample interval is the widest possible given the constraints on data availability: data on real effective exchange rate starts in 1964Q1 and the narrative military series ends in 2015Q4.

[5]Our codes are based on the Matlab programs provided by Caldara and Kamps (2017).

### 3.3 The narrative series in the proxy-SVAR framework

As already pointed out in the introduction, we use the Ramey (2016a) narrative series to recover spending surprise shocks. This means that, in the proxy-SVAR framework, we instrument contemporaneous government spending only, instead of the sum of contemporaneous *and* future spending as it is done in Ramey (2016a). For this purpose we prove that, in the post-1964 period when real effective exchange rates for the United States are available, the military narrative series appears to be a relevant instrument exactly for that purpose. We test this hypothesis by running a set of first-stage regressions, in which government spending is regressed on the military narrative series and lagged control variables. Following Ramey and Zubairy (2018), the estimate is repeated multiple times to assess the relevance of the instrument at different horizons, using cumulated spending up to 20 quarters ahead as dependent variable. Details of the testing procedure are reported in Appendix B.1.

Figure 1 displays the F-statistics related to each regression, in which horizon 0 refers to the regression of contemporaneous spending on the instrument. As critical values of the F-tests are not the same at each horizon, we report the *relative* F-statistics (i.e. the F-statistic minus its corresponding critical value), so the zero line represents the threshold for weak instrument.[6] The red dotted line shows F-statistics of regressions conducted on the 1947-2015 sample, while blue lines on the 1964-2015 sample with only tax revenue and real GDP as controls as in Ramey and Zubairy (2018) (straight line) and with the full set of controls (dotted line).

First, the figure confirms results in Ramey (2016a), i.e. that the narrative series is a valid instrument for future government spending – in particular, for cumulated spending from 4 to 12 quarters ahead. Second, and most importantly, in the 1964-2015 sample, the narrative series is still a valid instrument but only for *contemporaneous* government spending – the first data point of the dotted blue line is above the zero line. Note that this is true only for the specification that includes the full set of controls, which is exactly the one we adopt in our VAR. All in all, our results suggest that in the post-1964 period, the narrative series constructed in Ramey (2016a) is a relevant instrument for current government spending, as opposed to the 1947-2015 in which it is a good proxy only for future spending. This could be related to a decrease in the implementation lag of some types of military expenditures beyond the largest spending episodes of the twentieth century corresponding to major wars (which all happened before 1964).

Beside relevance, another potential issue in using narrative instruments is that of non-

[6] This is because residuals of regression at horizons greater than 0 are serially correlated, see Montiel Olea and Pflueger (2013) for a discussion.

*Relative* F-statistics with respect to the appropriate critical value

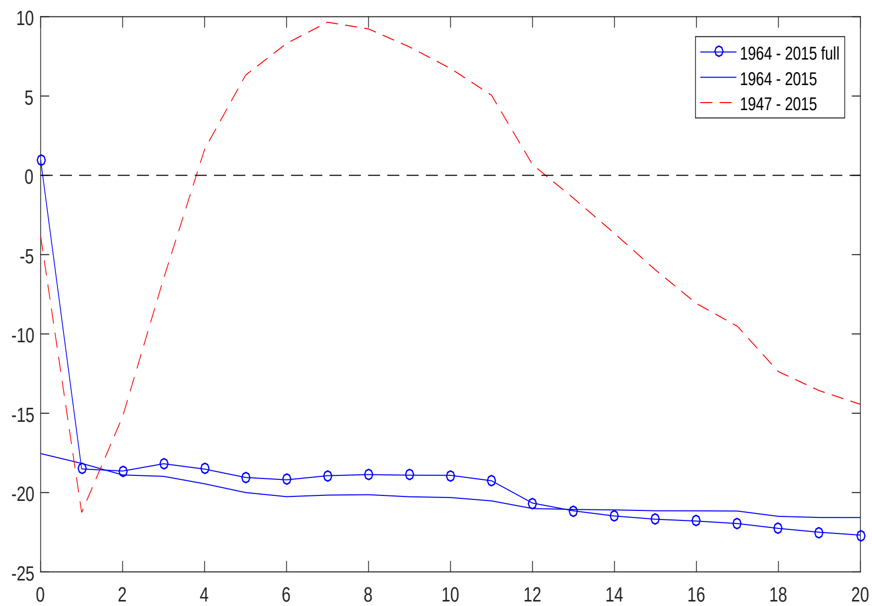



Figure 1: **F-statistics (in deviations from their critical values) over h-horizons**. First-stage F-statistics for government spending shocks. The F-statistics are based on the regression of the sum of government spending from $t$ to $t+h$ on the military narrative series at $t$, plus 4 lags of control variables (equation 5). Controls for the 1964-2015 and 1947-2015 specifications (blue and red dotted lines) are tax revenue and GDP, while the 1964-2015 full specification (blue solid line) has additional controls (inflation, TFP, consumption, short term interest rate, the stock price of defense military firms and the real exchange rate). The horizontal dashed line at zero is the weak instrument threshold. A value above zero indicates that the test accepts the instrument to be a valid one.

fundamentalness. We run the non-fundamentalness test using the method proposed in Forni and Gambetti (2014). The test fails to reject the null hypothesis of fundamentalness, confirming that the military series first proposed in Ramey (2011) is suitable for our purposes. Details are reported in Appendix B.2.

# 4 Empirical Results

This section presents the main results from the empirical analysis. Responses to a government spending shock identified through the proxy-SVAR methodology are compared with responses stemming from a standard Cholesky identification method. Then, in the following section, we provide empirical evidence on the robustness of our results.

## 4.1 Impulse response functions

We start by showing standard *puzzling* results. Figure 2 reports responses to a one standard deviation positive shock to US government spending, using the recursive Cholesky identification method on the 1964-2015 sample. The real exchange rate depreciates (here defined as number of foreign goods for domestic ones), inflation and the short-term rate fall, the trade balance improves and consumption increases.

Cholesky identification scheme (1964Q1-2015Q4)

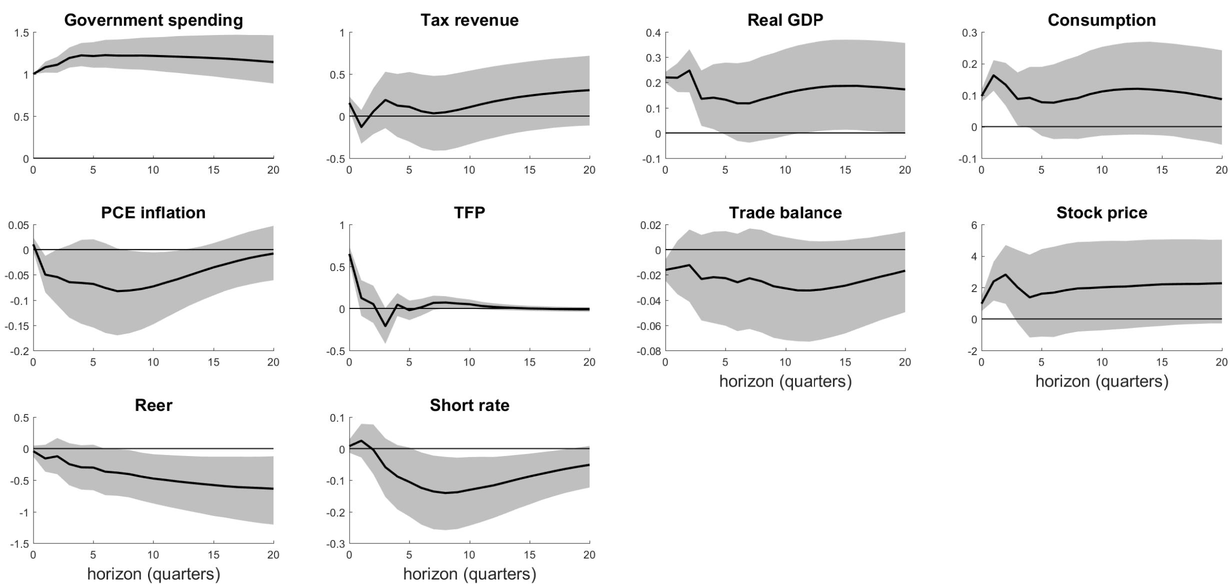



Figure 2: **Cholesky identification.** Impulse responses from a 1% government spending shock. Target variables are tax revenues, real GDP, real private consumption, PCE inflation, total factor productivity, trade balance, stock prices of military firms, real effective exchange rate and nominal interest rate. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: a decrease stands for a depreciation. The impulse responses are obtained in a VAR framework with the spending shock identified through the Cholesky scheme. Shaded bands denote the 68% pointwise credible sets.

Figure 3 displays instead the responses of the same variables (on the same sample) when the fiscal shock is identified using the military narrative series in a proxy-SVAR framework. We find that the real exchange rate appreciates, inflation and the short rate increase, the trade balance deteriorates and consumption falls.

Dissecting the result, the real exchange rate appreciation is driven both by the response of inflation and by the nominal effective exchange rate although the contribution of the former appears to be larger (see Figure 4). Inflation increases on impact and becomes not significant after few quarters. The fall in trade balance supports the twin deficit hypothesis, coherently with the appreciated real exchange rate and contrasts the alternative

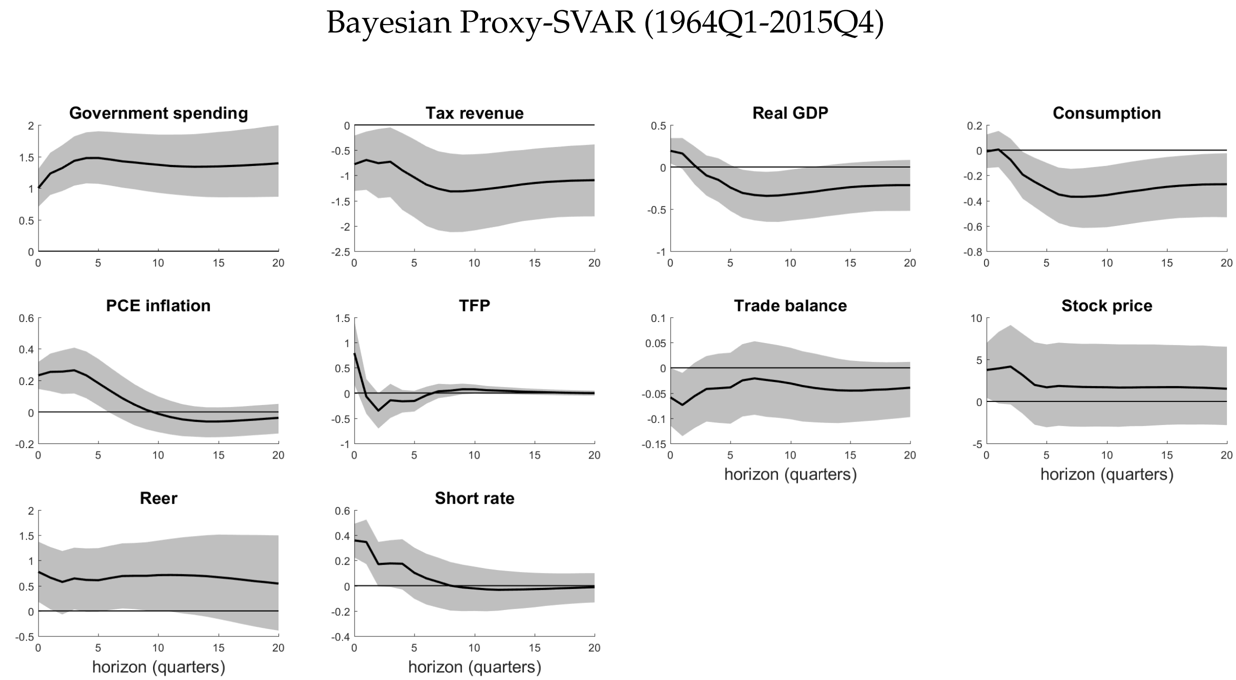



Figure 3: **Proxy-SVAR narrative identification.** Impulse responses from a 1% government spending shock. Target variables are tax revenues, real GDP, real private consumption, PCE inflation, total factor productivity, trade balance, stock prices of military firms, real effective exchange rate and nominal short-term interest rate. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: an increase stands for an appreciation. The impulse responses are obtained in a proxy-SVAR framework in which government spending is instrumented with the military narrative series of Ramey (2016a). Shaded bands denote the 68% pointwise credible sets.

twin divergence hypothesis (Kim and Roubini, 2008). The interest rate increases on impact, contributing to rationalize the appreciation of the real exchange rate and consistently with standard economic theory. Consumption decreases, in line with Ramey (2011), confirming the crowding-out effect due to the increase in the present value of taxes to be paid. This is true for both consumption of durables and consumption of non-durables and services (Figure D3 in Appendix D).[7] TFP, in line with Jorgensen and Ravn (2021), increases on impact. However, differently from them, the increase in supply, due to the TFP increase, does not overcome the positive increase in demand from government spending and therefore prices increase.

The remaining variables show a standard behavior. Economic activity increases on impact, implying a fiscal multiplier slightly below 1, and then becomes insignificant. The short-lived reaction in GDP squares well with the endogenous reaction of the interest rate and exchange rate, which dampen the expansionary effect of the fiscal stimulus. The stock

[7]In Appendix E we show that also private investment falls in response to the government spending shock.

price index of military firms also increases, confirming the non-anticipated component in the identified shock. Finally, tax revenues decrease. This response appears to be driven by the slightly negative response of the tax rate to the spending shock: in Appendix C we add more evidence regarding this behavior, distinguishing between the response of personal and corporate income taxation.

# 5 Robustness

This section reports additional evidence to support our baseline result, i.e. that the real exchange rate appreciates and inflation reacts positively after a spending shock. We propose two additional sets of impulse responses. The first one is constructed using the same identification scheme of the baseline model but changing samples length or variables specification (i.e. excluding the Bretton-Woods or the Great Recession, defining inflation as the consumer price index and focusing on the nominal exchange rate). The second one uses defense government investment, instead of the narrative military series of Ramey, 2016a, to instrument surprise government spending shocks. Overall, we get that our empirical results are robust to those changes.

## 5.1 Other VAR specifications

Figure 4 shows the impulse-responses of our proxy-SVAR model re-estimated against four different backgrounds: 1) excluding the Bretton-Woods period - 1973Q1-2015Q4, as this has the advantage of focusing on a sample with only floating exchange rates and of being directly comparable with Kim and Roubini (2008); 2) excluding the Great Recession - 1964Q1-2006Q4, as this allows us to exclude the financial crisis and its, maybe, specific behavior; 3) substituting the real effective exchange rate with the nominal one; and 4) replacing the personal consumption expenditure price index with the consumer price index to measure inflation. For conciseness, Figure 4 reports only the main variables of interest, i.e. the spending shock, the exchange rate, the trade balance, inflation and the short-term rate. All other variables are available upon request.

We observe that in all four specifications we get that the shock is inflationary, appreciates the real (or nominal) exchange rate, deteriorates the trade balance and increases the nominal interest rate.

Bayesian Proxy-SVAR - Robustness

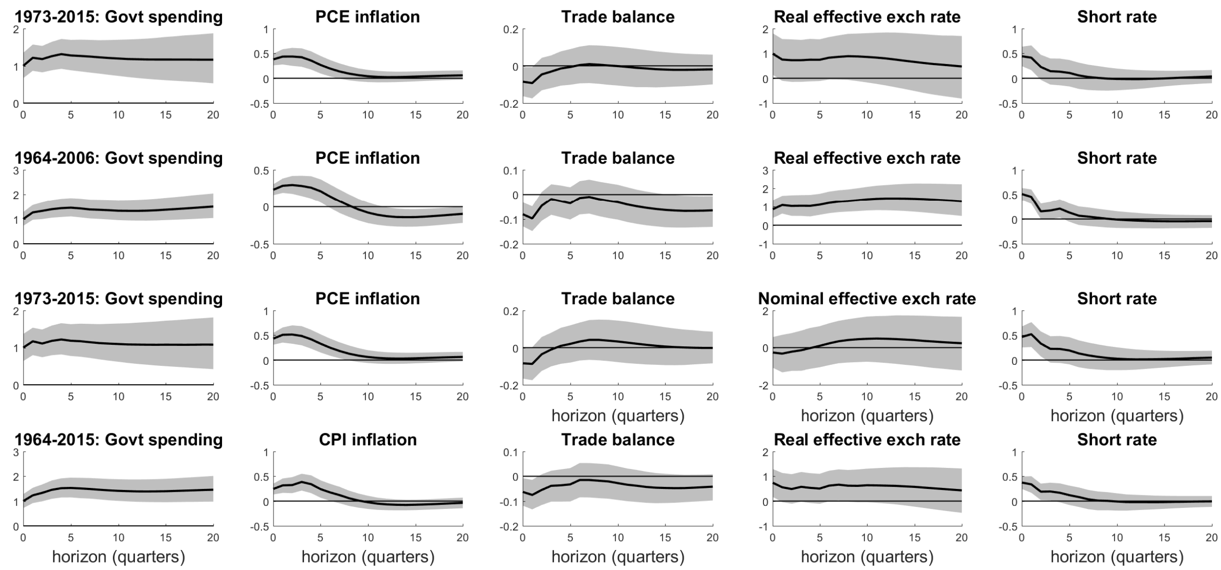



Figure 4: **Robustness using narrative shocks.** Impulse responses of government spending, inflation, trade balance, real effective exchange rate and nominal interest rate across different sample or variable specifications. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: an increase stands for an appreciation. Line 1: fully flexible exchange rate sample (1973Q1-2015Q4). Line 2: pre-crisis sample (1964Q1-2006Q4). Line 3: 1973Q1-2015Q4, nominal (instead of real) effective exchange rate. Line 4: full sample, CPI (instead of PCE) inflation. The estimation sample for line 3 and 4 is 1964Q1-2015Q4. Shaded bands denote the 68% pointwise credible sets.

Bayesian Proxy-SVAR - Government defense investment as an instrument

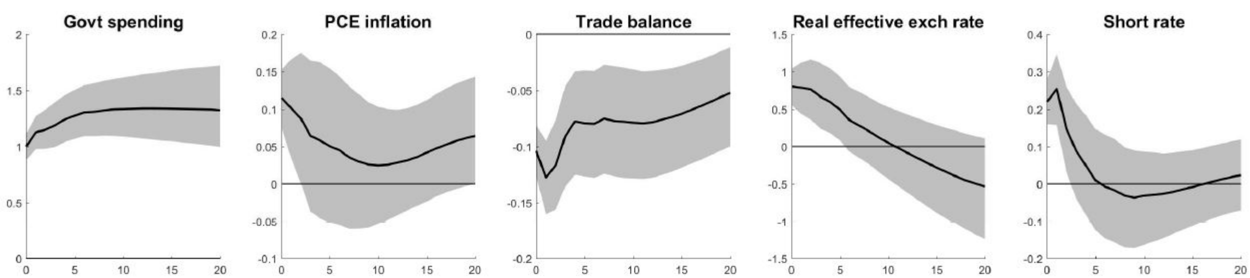



Figure 5: **Robustness using defense investment.** Impulse response functions constructed using defense investment as instrument for total government spending. The estimation sample is 1964Q1-2015Q4. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: an increase stands for an appreciation. Shaded bands denote the 68% pointwise credible sets.

## 5.2 Government defense investment as an instrument

Miyamoto et al. (2019) use defense spending to instrument exogenous variations in government spending for a panel of countries. The reason behind their choice is that defense spending is known to be less correlated than other types of government spending to business cycle fluctuations. However, as Ramey (2011) pointed out, defense spending in the United States could be exposed to fiscal foresight issues, possibly making it less exogenous. In any case, as we explained in Section 3.3, those issues seem less material in our sample.

For this reason, we can run a robustness exercise by re-estimating our proxy-SVAR model by replacing Ramey's instrument with quarterly changes in government defense spending. Within defense expenditures, we make only use of defense investment, as this part is usually considered as the most exogenous. Being aware that shocks in government consumption and investment might have different characteristics (see Boehm, 2019), we test the relevance of this series finding that is also a valid instrument for surprise government spending shocks.[8] The proxy-SVAR is re-estimated maintaining the same specification and estimation sample (1964Q1-2015Q4) of the baseline model. Figure 5 shows impulse responses. In response to a positive government spending shock, the real exchange rate appreciates, inflation and the short rate increase, while the trade balance deteriorates, confirming thus our key results in the baseline specification.[9]

# 6 Proxy-SVAR vs. other approaches

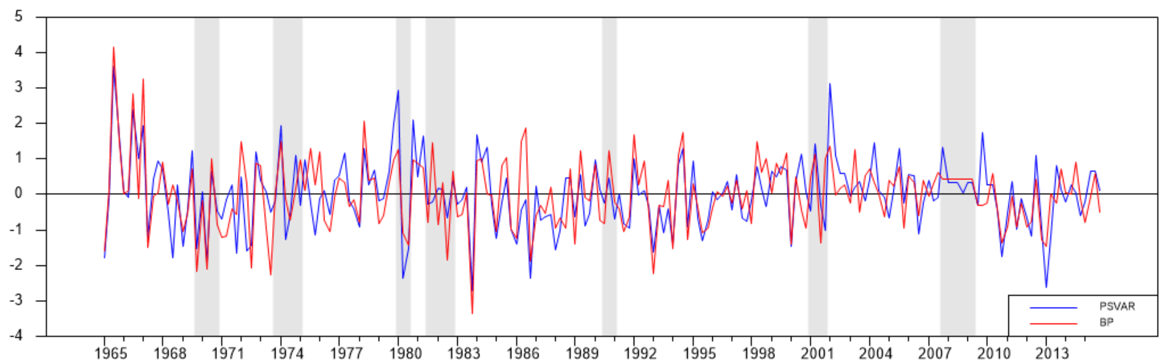
In this section we compare our estimation framework with other approaches adopted in the literature. We first make a closer look to what generates different results using our proxy-SVAR identification with respect to the recursively identified VAR. Then, we discuss whether other approaches, such as event studies using natural disasters or identification through regional variations, can also be used in our analysis.

## 6.1 Proxy-SVAR and Cholesky: inspecting the differences

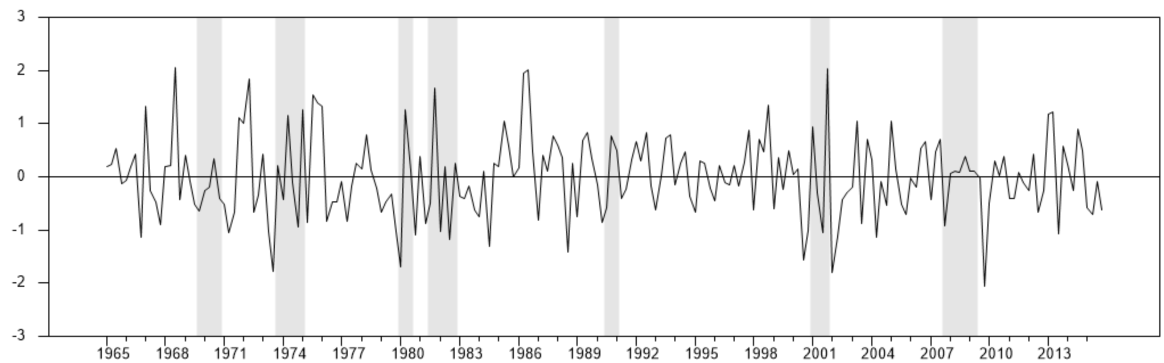
Proxy-SVAR models have a higher degree of flexibility than identifications based on variable orderings. Based on narrative instruments, they are able to capture exogenous variations in the target variable (government spending in this case) taking into account the economic context in which they materialize, such as time-varying economic characteris-

[8] Results are available upon request.

[9] In Appendix F we present the impulse responses of a recursively identified government spending shock using defense investment ordered first. If, as explained in Section 6.1, the problem of the Cholesky ordering lies in the presence of a structural break in fiscal strategy, using only defense investment should mitigate the problem. As shown in Figure F5, identifying government spending shock using only defense investment does a big step towards solving the problem.




(a) Cholesky and the proxy-SVAR identified shocks




(b) Difference between the Cholesky and the proxy-SVAR identified shocks

Figure 6: (a) shocks identified using the Cholesky and Proxy SVAR approach, reported at the median. Shadow areas are NBER Recessions. (b) Difference between the two shocks and NBER recessions. Linear difference between the shocks identified using the Cholesky and Proxy SVAR approach, reported at the median. Shadow areas are NBER Recessions.

tics or policy regimes. On the contrary, the recursive identification imposes rigid assumptions about the hierarchy among variables and the timing of their response, which may not hold in some part of the estimation sample. This makes the proxy-SVAR less subject to specification issues than a recursive approach, and this turns out to be crucial when analyzing fiscal policy. We show that the puzzling effects obtained using the recursive identification depend on the fact that it fails to capture the changing nature of government spending, which shifted from alternating tax- and debt- financing to be steadily debt-financed since the end of the 1990s.

While the difference between the two approaches is not easily detectable by comparing the obtained shocks, also because of the Bayesian framework, this clearly emerges when estimating the effect of government spending in different parts of the sample. Figure 6 plots the time series of the shocks retrieved by the Proxy-SVAR and recursive identification (panel a) and their difference over time (panel b), along with NBER recession bars.[10] By visual inspection, the two shocks are not particularly different. Differences in the responses to the shocks are instead visible when applying recursive identification in sub-samples, considering that an important structural change in the conduct of US fiscal policy had occurred at the end of 1990s.

Auerbach (2009) and McKay and Reis (2016), among others, noted that US governments moved, since 1998, to debt-financed spending policies. In particular, while the 1964-1997 period saw alternating phases of tax-financed measures (1964-1982, 1993-1997) and periods of debt-financed spending (1982-1993), between 1998 and 2015 government expenditures have been mostly debt-financed. This regime shift impacts substantially recursively identified impulse responses. Assumptions made by ordering government spending first and letting taxes react fits poorly in the first phase (in which taxes did move with spending in some periods but not in others), but correctly in the second one – in which the policy conduct has always been the same, i.e. non-budget neutral government spending.

Figure 7 shows results stemming from the Cholesky identification strategy for the 1964-1997 sub-sample, while Figure 8 presents those for the 1998-2015 period. In the first sub-sample (the one considered in Blanchard and Perotti, 2002), all the puzzles arise: following a spending shock, inflation and the interest rate fall, and the real exchange rate depreciates. Instead, impulse responses estimated in the 1998-2015 sub-sample are more in line with the theory and look closer to those of the proxy-SVAR: the spending shock is inflationary, appreciates the exchange rate, deteriorates the trade balance and increases the interest rate.

To sum up, if applied to the entire 1964–2015 period, the recursive approach would miss-classify a relevant part of the government spending shock in the sample, generating biased impulse responses. This highlights an additional limitation of the recursive approach, which was already challenged in the fiscal policy literature because of not properly taking into account fiscal foresight. On the contrary, impulse responses stemming from the proxy-SVAR, by relying on narrative restrictions, are able to generate impulse responses that are robust to that type of structural changes.

## 6.2 Other identification methods

To study the effects of fiscal policy, the literature proposed also different methodologies to identify government spending shocks. On top of more standard methods like sign re-

[10] Proxy-SVAR shocks are extracted following the procedure in Montiel Olea et al. (2020), are retrieved by each iteration of the Gibbs sampling and "representative shocks" are constructed by taking median shock values at each point in time.

Cholesky identification scheme (1964Q1-1997Q4)

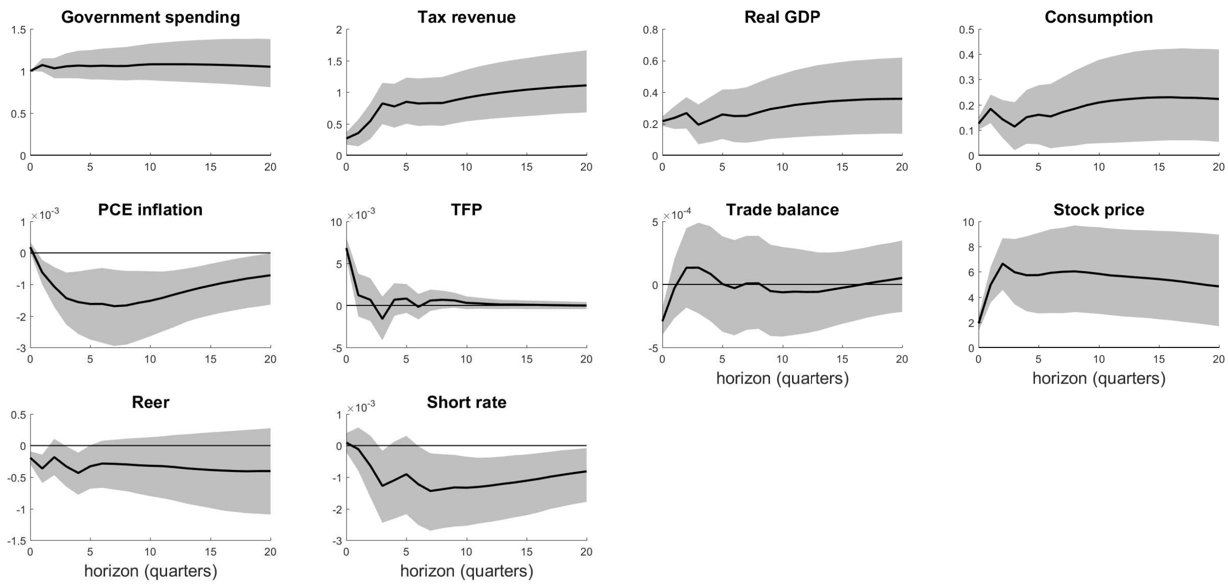



Figure 7: **Cholesky identification in the 1964-1997 subsample.** Impulse responses from a 1% government spending shock. Target variables are tax revenues, real GDP, real private consumption, PCE inflation, total factor productivity, trade balance, stock prices of military firms, real effective exchange rate and nominal interest rate. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: a decrease stands for a depreciation. The impulse responses are obtained in a VAR framework with the spending shock identified through the Cholesky scheme. Shaded bands denote the 68% pointwise credible sets.

strictions (e.g. Mountford and Uhlig, 2009b), which suffer from similar issues as those highlighted in previous section, recent papers relied on alternative approaches: quasi-experimental settings to identify exogenous variation of government spending (e.g. Acconcia et al., 2014), regional variation in policies (e.g. Nakamura and Steinsson, 2014) or natural disaster episodes (e.g. Acconcia et al., 2020).

These methods, which focus on the impact of fiscal policies at local level, are extremely useful to investigate specific direct effects (e.g. the impact of public programs on homeowners' consumption, or open economy relative multipliers) but less suitable to study economic implications at the aggregate level. Indeed, as explained in Ramey (2016b), estimates of the impact of government spending policies at local level do not take into account that taxation is levied at the national level, therefore ignoring part of the tax response to the identified shocks. This issue is particularly relevant when estimating the effect of government spending on inflation and on the real exchange rate, as shown in section 6.1. Therefore, the main advantage of using narrative identification methods is that the estimation of the impact of government spending is less sensitive to structural

Cholesky identification scheme (1998Q1-2015Q4)

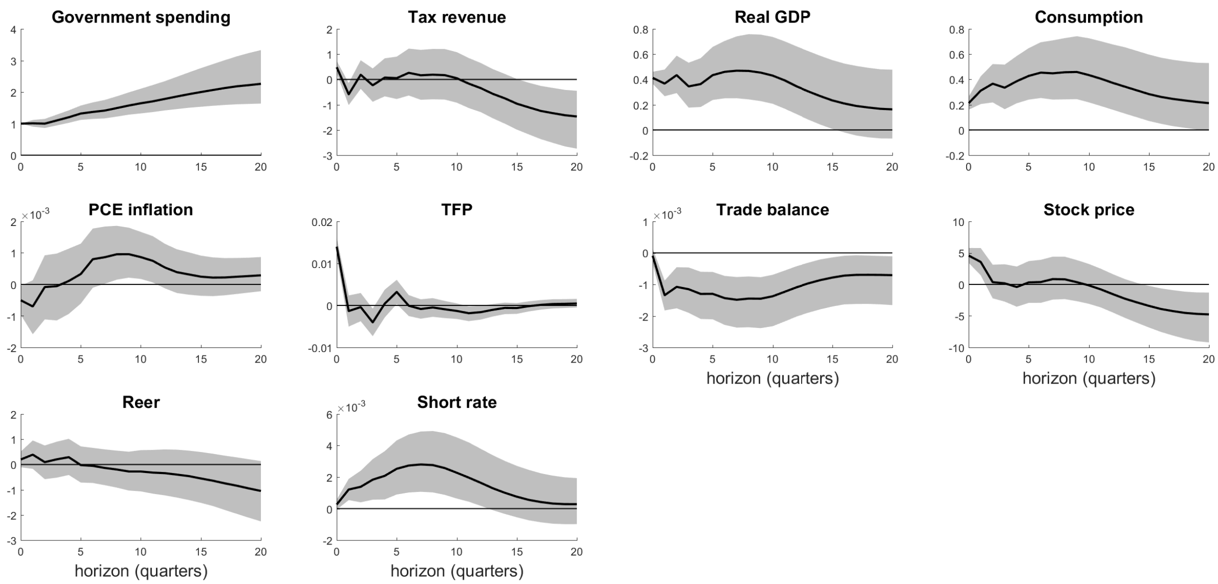



Figure 8: **Cholesky identification in the 1998-2015 subsample.** Impulse responses from a 1% government spending shock. Target variables are tax revenues, real GDP, real private consumption, PCE inflation, total factor productivity, trade balance, stock prices of military firms, real effective exchange rate and nominal interest rate. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: a decrease stands for a depreciation. The impulse responses are obtained in a VAR framework with the spending shock identified through the Cholesky scheme. Shaded bands denote the 68% pointwise credible sets.

breaks, also related to different tax policy regimes, and is better suited to estimate the national-level effect of government spending.

Finally, it is important to mention that narrative instruments are also employed within the local projection framework developed by Jorda (2005), which provides a more flexible environment to compute impulse responses than structural VAR models. According to Plagborg-Møller and Wolf (2021) and Montiel Olea and Plagborg-Möller (2021), results of local projections and VARs should be consistent in large samples; however this is not guaranteed in small ones, where there is a trade-off between bias and variance of the estimated impulse responses, as Li et al. (2021) clarify. In line with that, some papers show that local projections and VAR models can produce conflicting evidence when used to address central economic questions such as the effects of monetary or fiscal policies (e.g. Ramey, 2016b and Nakamura and Steinsson, 2018).

# 7 Conclusions

This paper empirically re-investigates the effects of government spending shocks on the real exchange rate and inflation, using US data. Starting from an extensive closed and open economy literature showing puzzling effects of government spending shocks on inflation and real exchange rate, we find that an increase in government spending appreciates the real exchange rate and generates inflationary pressures. We also get that such shocks induce a trade balance deficit, a fall in consumption and lead to a tightening of monetary policy. The discrepancy with the existing literature lies in the identification of fiscal shocks: embedding a narrative approach into a proxy-SVAR is what makes the difference.

All empirical findings are robust to various specifications, like changing samples length and variables (i.e. excluding the Bretton-Woods or the Great Recession, defining inflation as the consumer price index and focusing on the nominal exchange rate) or using defense government investment to instrument surprise government spending shocks. We also show that our results are in line with an estimated simple two-good standard small open economy RBC model.

Overall, our analysis suggests that a proxy-SVAR approach is more *immune* to structural changes in US fiscal policy, that went from alternating tax- and debt-financed policies from the sixties to a steadily debt-financed approach since the end of the nineties.

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# Appendix

## A Data source

The baseline specification of our VAR model encompasses the following US variables: real government spending, real GDP, real tax revenues, real private consumption, inflation, total factor productivity (TFP), trade balance (in percent of GDP), the stock price of Boeing (proxying the market value of the military firms sector), the narrow real effective exchange rate of the dollar and the nominal short-term interest rate (3-Month Tbill Rate). With the only exception of inflation, the trade balance-to-GDP ratio and the short rate, all other variables are taken in logs. Inflation is computed on an annual basis using the personal consumption expenditure (PCE) deflator. To instrument exogenous variations in government spending, we use the military spending narrative series constructed by Ramey (2016a). The series is taken in real terms, i.e. divided by lagged GDP deflator. Concerning the robustness tests, we utilize the following variables: real government defense investment, real durable and non durables consumption and personal and corporate income tax rate & base. Real government spending, real GDP, real private consumption and real tax revenues are obtained by deflating nominal variables using the contemporaneous GDP deflator. Table A below summarizes the time series used.

Table A: Data table

| Variable | Sample | Source | Transformation |
|---|---|---|---|
| Government Spending | 1964:Q1-2015:Q4 | Ramey and Zubairy (2018) | log level |
| Government Revenues | 1964:Q1-2015:Q4 | Ramey and Zubairy (2018) | log level |
| GDP | 1964:Q1-2015:Q4 | Ramey and Zubairy (2018) | log level |
| Consumption | 1964:Q1-2015:Q4 | Ramey and Zubairy (2018) | log level |
| Investment | 1964:Q1-2015:Q4 | Ramey and Zubairy (2018) | log level |
| GDP deflator | 1964:Q1-2015:Q4 | Ramey and Zubairy (2018) | (to produce real variables) |
| CPI price index | 1964:Q1-2015:Q4 | FRED [CPIAUCSL] | YoY change |
| PCE price index | 1964:Q1-2015:Q4 | FRED [PCEPI] | YoY change |
| TFP | 1964:Q1-2015:Q4 | Fernald (2012) | growth rate |
| Trade balance | 1964:Q1-2015:Q4 | FRED [IEABC] | % of GDP |
| T-bill rate | 1964:Q1-2015:Q4 | Ramey and Zubairy (2018) | p.p. |
| Stock price | 1964:Q1-2015:Q4 | Yahoo! Finance | QoQ change |
| Real effective exchange rate | 1964:Q1-2015:Q4 | BIS (narrow definition) | log level |
| Nominall effective exchange rate | 1964:Q1-2015:Q4 | BIS (narrow definition) | log level |
| Govt Defense Investment | 1964:Q1-2015:Q4 | FRED [DGI] | QoQ change |
| Durable consumption | 1964:Q1-2015:Q4 | FRED [PCEDG] | log level |
| Non-durable and serv. consumption | 1964:Q1-2015:Q4 | FRED: [PCEND] + [PCESV] | log level |
| Personal income tax rate | 1964:Q1-2015:Q4 | Mertens and Ravn (2013) + NIPA tables | p.p. |
| Corporatel income tax rate | 1964:Q1-2015:Q4 | Mertens and Ravn (2013) + NIPA tables | p.p |
| Personal income tax base | 1964:Q1-2015:Q4 | Mertens and Ravn (2013) + NIPA tables | log level |
| Corporatel income tax base | 1964:Q1-2015:Q4 | Mertens and Ravn (2013) + NIPA tables | log level |

# B Test the military narrative series as an instrument for government spending

## B.1 Relevance

In order to test the relevance of the narrative series proposed in Ramey (2011), we proceed as follow. We regress cumulated spending on the military narrative series at time $t$ and four lags of control variables. This regression can be written as

$$\sum_{j=0}^{h} g_{t+j} = \gamma_h + m_h \text{narrative}_{\,t} + \phi_h(L) z_{t-1} + \omega_{t+h} \tag{5}$$

where $\sum_{j=0}^{h} g_{t+j}$ is the sum of current and future government spending, narrative $_t$ is the military narrative series and $z_{t-1}$ is the set of lagged controls.[11] The test is computed against an alternative specification which excludes the narrative series from the set of regressors, i.e.

$$\sum_{j=0}^{h} g_{t+j} = \gamma_h + \phi_h(L) z_{t-1} + \omega_{t+h}. \tag{6}$$

We run three specifications of the F-test: first, on the 1947-2015 sample, using only tax revenue and GDP as controls (Ramey, 2016a and Ramey and Zubairy, 2018); second, employing the same specification but on the 1964-2015 period; third, on the same 1964-2015 sample but enriching the set of controls with all variables that are included in our baseline SVAR. Results of the F-tests, each of them conducted with $h = 20$ (i.e. from 0- to 20-quarter horizon), are displayed in Figure 1. The Figure reports the F-statistics minus the appropriate critical value threshold. This means that, according to whether residuals of Equation (5) should have a different critical values (i.e. because they are autocorrelated or not), each point of the F-test is plotted with respect to its appropriate critical value (see Montiel Olea and Pflueger, 2013).

To test for autocorrelation, we run the Ljung-Box Q-test on the three F-test specifications, one for each $h$ series of residuals $\omega_{t+h}$. Results, available upon request, show that residuals of h-quarter ahead predictive regressions (with $h > 0$) are all autocorrelated. This is the case by construction, as control variables do not include time $t + h - 1$ observations. Concerning contemporaneous regressions (i.e. $h = 0$), residuals are still autocorrelated in the 1964-2015 sample if we control for only tax revenues and GDP. They

[11] The findings from the F-tests are robust to the alternative specification of the dependent variable as $g_{t+j}$ instead of $\sum_{j=0}^{h} g_{t+j}$.

become *non*-autocorrelated only when inflation, real exchange rate and consumption are also included as control variables. Even though this set of variables might be sufficient to avoid autocorrelation, we include as controls all variables of our SVAR specification, following Stock and Watson (2018) reasoning that this improves test precision.[12] As a result, the (lower) critical value for serially uncorrelated error terms is considered only for impact F-statistics (i.e., $h = 0$) in the 1947-2015 and 1964-2015 specification with the full set of controls (third specification). In all other cases, the significance of the F-test is judged with respect to the threshold of autocorrelated error terms.[13]

To exclude the possibility that our proxy is an instrument also for variables other than government spending, we repeat our F-tests by substituting $g$ with one of the other variable at a time on the left hand side of Equations 5 and 6. Results, displayed in Figure B1, show that the F-test fails for all variables at all horizons but for contemporaneous government spending.

## B.2 Non-fundamentalness

Beside relevance, another potential issue is that of non-fundamentalness. Indeed, if a VAR model does not contain sufficient information, it is not possible to recover the true structural shocks. Forni and Gambetti (2014) show the necessary and sufficient conditions under which the VAR is invertible and propose a test to detect non-fundamentalness.[14] The idea of the test rests on the assumption that structural shocks $\epsilon_t$ cannot be Granger-caused by any other variable. In the spirit of Forni and Gambetti (2014) we project the recovered structural spending shock, estimated in the next section, on the lagged principal components extracted from a large dataset of macro variables (McCracken and Ng, 2016), which summarize the information set of the econometrician.[15]The obtained F-statistic is

[12]It is worth adding two things: first, results do not change when the F-test is performed on the only post Bretton-Woods period, which ensures that our instrument is a valid one also when considering the flexible exchange rate regime period; second, results hold also when we add among the set of controls the principal components extracted from the dataset of macroeconomic variables of McCracken and Ng (2016). Both these exercises improve F-test results.

[13]For the serially uncorrelated case, we apply the threshold of Montiel Olea et al. (2018) - i.e. 3.84. For the other cases we use the one proposed by Montiel Olea and Pflueger (2013), and used in Ramey and Zubairy (2018), which is 23.1085.

[14]Canova and Sahneh (2018) propose an alternative method to test for non-fundamentalness in small-scale SVAR.

[15]In order to assess fundamentalness in our environment we test whether the coefficients $\psi$ in the following regression are jointly significant:

$$\epsilon_t = \delta + m_h \sum_{j=1}^{nPC} \psi_j \mathrm{PC}_{j,t-1} + \phi_t \tag{7}$$

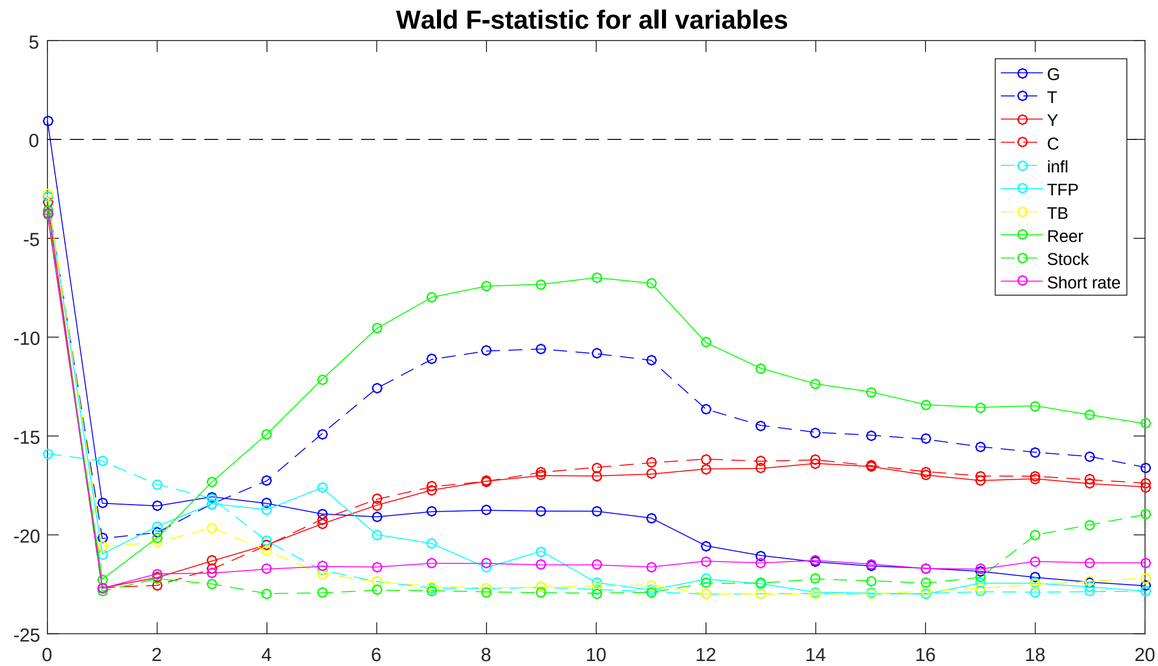


Figure B1: **F-statistics (relative to the appropriate threshold) of tests conducted on all variables of our VAR specification.** The F-statistics are based on equation 5. Controls are tax revenue, GDP, inflation, TFP, consumption, short term interest rate, the stock price of defense military firms and the real exchange rate. The horizontal dashed line at zero is the weak instrument threshold. A value above zero indicates that the test accepts the instrument to be a valid one.

0.92, failing to reject the null hypothesis of fundamentalness.

where $\delta$ is a constant, $PC$ stands for the principal components and $nPC$ is the number of $PC$ considered.

# C Tax rates and tax bases

Figure C2 displays impulse responses of the baseline specification where tax revenue is decomposed into its personal and corporate income tax components, looking specifically at the response of tax rates and tax bases. All remaining variables are the ones included in the baseline specification. IRFs are obtained using the proxy-SVAR methodology.

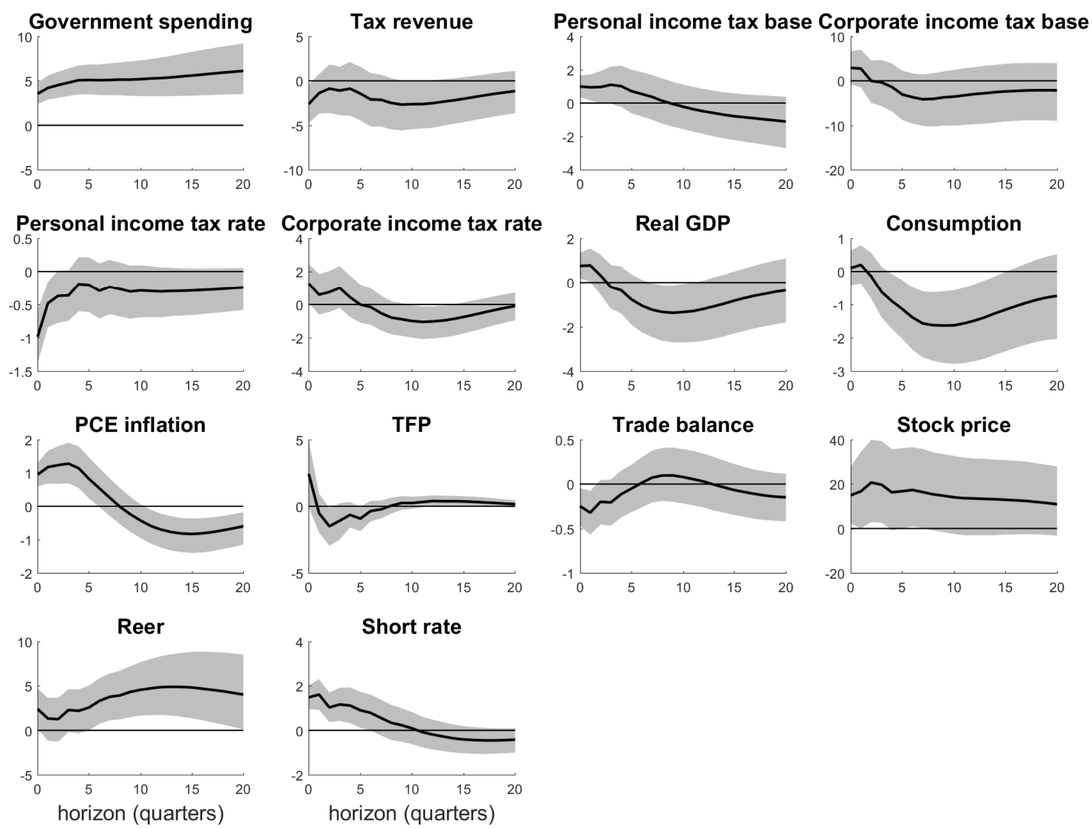


Figure C2: **Tax rates and tax bases.** Impulse responses from a 1% government spending shock on personal and corporate income tax rates and (nominal) tax bases. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: an increase stands for an appreciation. The impulse responses are obtained in a proxy-SVAR framework in which government spending is instrumented with the military narrative series of Ramey (2016a). Shaded bands denote the 68% pointwise credible sets.

# D Consumption

Figure D3 displays impulse-responses of the baseline specification where consumption is decomposed between non-durable + services and durable. All remaining variables are the ones included in the baseline specification. IRF are obtained using the proxy-SVAR methodology.

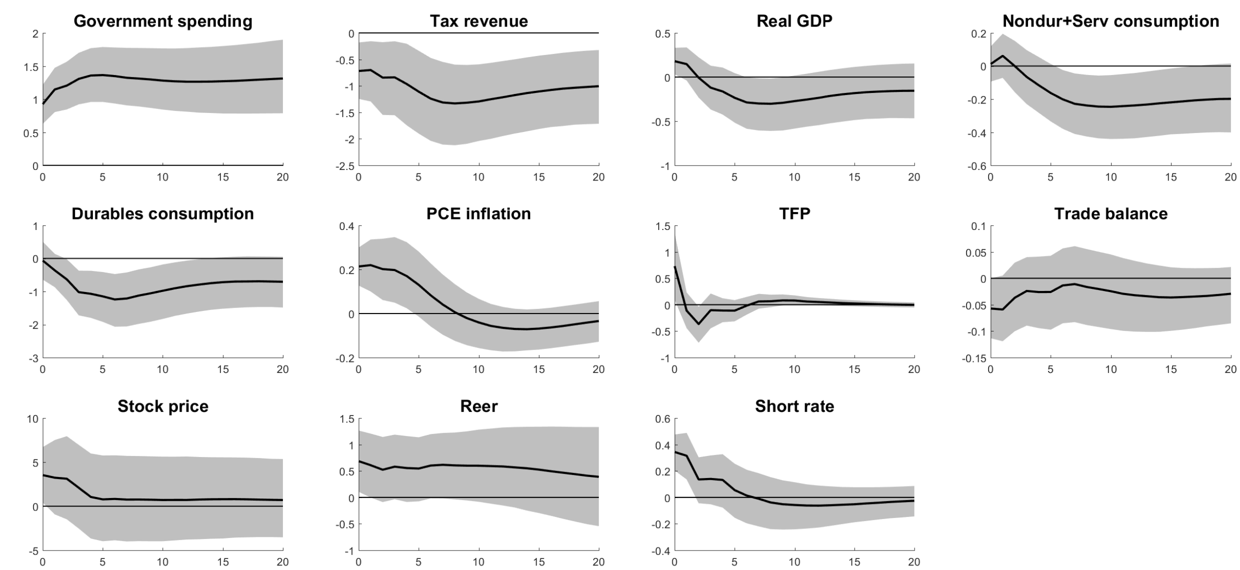


Figure D3: **Real private consumption decomposition.** Impulse responses from a 1% government spending shock decomposing consumption. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: an increase stands for an appreciation. The impulse responses are obtained in a proxy-SVAR framework in which government spending is instrumented with the military narrative series of Ramey (2016a). Shaded bands denote the 68% pointwise credible sets.

# E Investment

Figure F5 displays impulse-responses of tax revenues, real GDP, real investment, PCE inflation, total factor productivity, trade balance, short-term interest rate and real effective exchange rate to a government spending shock. IRF are obtained using the proxy-SVAR methodology. With respect to the baseline, consumption is here substituted with investment.

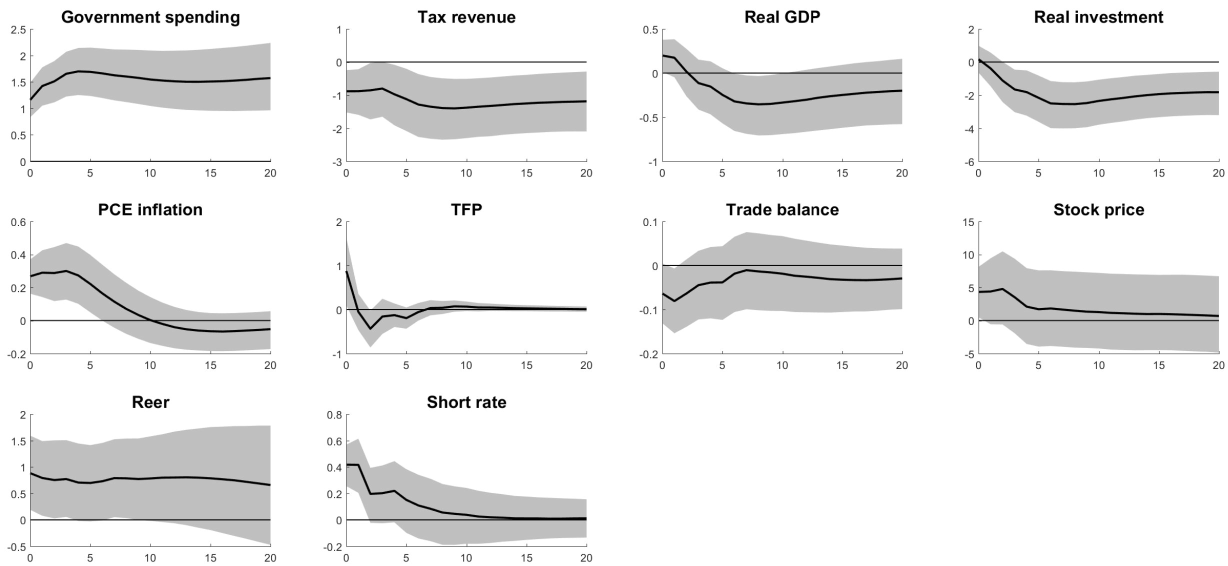


Figure E4: **Real investment.** Impulse responses from a 1% government spending shock including investment. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: an increase stands for an appreciation. The impulse responses are obtained in a proxy-SVAR framework in which government spending is instrumented with the military narrative series of Ramey (2016a). Shaded bands denote the 68% pointwise credible sets.

# F Defense Investment

Figure F5 displays impulse-responses of defense investment, other government spending, PCE inflation, trade balance, short-term interest rate and real effective exchange rate to a defense spending shock. IRF are obtained using the a recursive identification approach, ordering defense spending first. With respect to figure 2, now inflation raises, trade balance deteriorates, the real exchange rate appreciates on impact and the short rate rises.

Cholesky identification scheme (1964Q1-2015Q4)

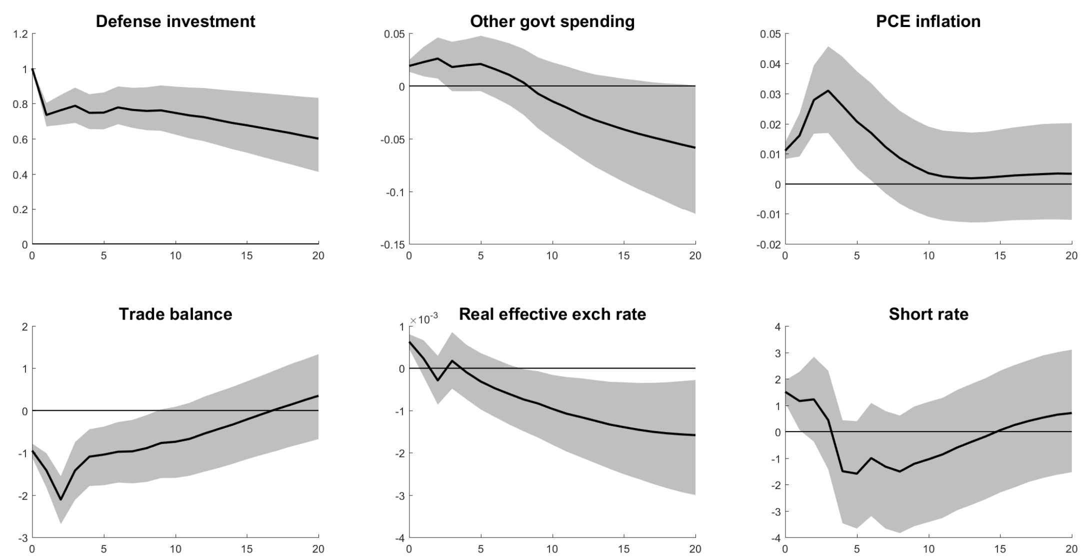


Figure F5: **Cholesky identification.** Impulse responses from a 1% defense spending shock. Target variables are PCE inflation, trade balance, real effective exchange rate and nominal interest rate. The real effective exchange rate is defined as the weighted basket of foreign goods to domestic goods: a decrease stands for a depreciation. The impulse responses are obtained in a VAR framework with the spending shock identified through the Cholesky scheme with defense spending ordered first. Shaded bands denote the 68% pointwise credible sets.

# G Theory and Empirical results - solving the puzzles

To check the theoretical coherence of our empirical results, we build a standard RBC small open economy model. We then estimate its parameters to see how far we can go with a simple model in matching our empirical estimates. The results are quite striking: the simple model does a fair job in accounting for a broad range of macroeconomic responses to a government spending shock.

The model is the standard Small Open Economy Real Business Cycle model (see Mendoza, 1991 and Schmitt-Grohé and Uribe, 2017) enriched with multiple goods, as in Galí and Monacelli (2005), and a utility specification accounting for different degrees of wealth effects of government spending (Jaimovich and Rebelo, 2009). The economy is small, does not affect world prices and takes the world interest rate as given. This simplification, considering the focus on the U.S., is done to make our results comparable to Monacelli and Perotti (2010). However, as in Monacelli and Perotti (2010), results are not driven by the assumption of a small open economy. The model has three agents: household, firms and the government. International financial markets are incomplete and there are no nominal frictions. Households consume a composite of domestic and foreign goods, supply labor and save/borrow using a single internationally traded asset. They own the physical capital, rent it to firms and take investment decisions, which is subject to adjustment costs. Domestic firms produce a tradable good using capital and labor, selling it domestically and abroad. Movements in the terms of trade determine the competitiveness of the domestic sector, taking world demand as given. The government purchases domestic goods raising funds through taxes, running a balanced fiscal budget (Monacelli and Perotti, 2010). The independence of the non-stochastic steady state from initial conditions is ensured through an endogenous discount factor, as in Schmitt-Grohé and Uribe (2003).

## G.1 A sketch of the model

### Household

The household side of the economic is a simplified version of Siena (2021), where domestic representative household maximizes the present value of expected lifetime utility:

$$E_t \sum_{s=0}^{\infty} \chi_{t+s} U(C_{t+s}, L_{t+s}). \tag{8}$$

$E_t$ denotes the conditional expectation at date $t$ and $U$ is the instantaneous utility which is a function of final goods' consumption, C, and hours worked, L. $\chi$ denotes the household's endogenous discount factor. Agents become more impatient when average consumption, $\overline{C_t}$, increases:[16]

$$\chi_t = 1 \quad \text{and} \quad \forall s \geq 0 \quad \chi_{t+s} = \beta_{t+s-1}\chi_{t+s-1} \quad \text{where} \quad \beta_{t+s} \equiv \frac{1}{1+\overline{C}_{t+s}-h\overline{C}_{t+s-1}-\psi^L L_{t+s}^{1+\nu} X_{t+s}} \tag{9}$$

Preferences of the household are represented by the following utility function:

$$U(C_t, L_t) = \frac{\left\{(C_t - h\overline{C}_{t-1}) - \psi^L L_t^{1+\nu}\Omega_t\right\}^{1-\sigma} - 1}{1-\sigma}, \tag{10}$$

where

$$\Omega_t = (C_t - h\overline{C}_{t-1})^{\mu}\Omega_{t-1}^{1-\mu}. \tag{11}$$

where $h$ is the degree of habit persistence in consumption, $\sigma$ controls the curvature of the utility function and $\psi^L$ is a labor supply preference parameter. Utility depends on consumption at time $t$, $C_t$, a portion of average past consumption, $h^B\overline{C}_{t-1}$, and hours worked $L_t$. Past average consumption is perceived by the maximizing household as independent from his/her own choices. $\Omega_t$ controls the wealth effect on labor supply through the parameter $\mu \in [0,1]$. As $\mu$ rises, the wealth elasticity of labor supply increases. This preference specification is due to Jaimovich and Rebelo (2009). By changing $\mu$ we can account for two important classes of utility functions used in the business cycle literature: King et al. (1988) types of preferences when $\mu = 1$ and Greenwood et al. (1988) when $\mu = 0$.

The representative household faces the following budget constraint:

$$P_tC_t + P_tI_t + E_tB_{t+1} = R_{t-1}^*B_t + W_tL_t + Z_tK_{t-1} + P_tT_t \tag{12}$$

$B_t$ is an internationally traded asset, $W_t$ is the nominal wage in terms of the final good price and $K_t$ is the stock of physical capital owned by the household which accumulates according to

$$K_t = (1-\delta)K_{t-1} + \left[1 - \phi\left(\frac{I_t}{K_t}\right)\right]\frac{K_t}{I_t}. \tag{13}$$

where $I_t$ is investment in physical capital, $\delta$ is the depreciation rate and $\phi(\cdot)$ is an adjustment cost function. $Z_t^k$ is the return on capital.

There is full insurance within but not across countries, as only the domestic financial

[16]This feature of the model ensures the presence of a stable non-stochastic steady state independent from initial conditions with incomplete financial markets. See Schmitt-Grohé and Uribe (2003) for a detailed discussion on the topic. The average consumption will be treated as exogenous by the representative household.

market is complete. The small open economy assumption is such that our economy takes the return on the bond as exogenous $\log R_t^* = (1-\rho_r)\log R^* + \rho_r \log R_{t-1}^* + \zeta_t^{R^*}$.

Consumption is an Armington aggregator of domestic and foreign consumption:

$$C_t \equiv [\gamma_h^{\frac{1}{\epsilon}}(C_{h,t})^{\frac{\epsilon-1}{\epsilon}} + (1-\gamma_h)^{\frac{1}{\epsilon}}(C_{f,t})^{\frac{\epsilon-1}{\epsilon}}]^{\frac{\epsilon}{\epsilon-1}}.$$

where $\epsilon > 0$ is the elasticity of substitution between domestic and imported goods (trade elasticity). $\gamma_{h,t}$ and $(1-\gamma_{j,t})$ are respectively the preference shares for domestic and foreign goods, determining the size of home bias. Consequently, also the dynamic of consumption prices will be influenced by the behavior of the terms of trade (the price of imported over exported goods $S_t \equiv \frac{P_{f,t}}{P_{h,t}}$). Following Faia and Monacelli (2008) the price index over the price of the domestic good can be written as a function of the terms of trade and parameters only

$$\frac{P_t}{P_{h,t}} = g(S_t) = [\gamma_h + (1-\gamma_h)S_t^{1-\epsilon}]^{\frac{1}{1-\epsilon}}$$

with $\frac{\partial g(S_t)}{\partial S_t} > 0$. We assume that the law of one price holds $P_{f,t} = P_{f,t}^*$ but the purchasing power parity (PPP) will not be satisfied given the presence of home bias in consumption.

The real exchange rate is defined as $Q_t = \frac{P_t^*}{P_t}$ and it can be rewritten as a function of $S_t$ and the exogenous foreign prices:

$$Q_t = \frac{S_t}{g(S_t)} \tag{14}$$

**Government and Production**

We make two important assumptions in modeling government spending. First government purchases only domestic goods (full home biased) and second it runs a balanced fiscal budget each period:

$$P_{H,t}G_t = T_t$$

Government spending is exogenous and follows an AR2 process: $\log G_t = (1-\rho_G)\log G + \rho_{1,G}\log G_{t-1} + \rho_{2,G}\log G_{t-2} + \zeta_t^{G^*}$, where $\zeta_t^{G^*}$ is i.i.d. with mean zero.

The production side is kept identical to the standard RBC model with perfect competition. The firm produces the home variety combining capital and labor in a standard Cobb-Douglas production function, to maximize profits.

$$Y_{H,t} = A_t K_{t-1}^{\alpha} L_t^{1-\alpha}$$

**Market clearing**

All markets clear in equilibrium. Wages and the return on capital will clear respectively the labor and capital markets. The goods market equilibrium implies that

$$Y_{H,t} = C_{H,t} + I_{H,t} + G_t$$

## G.2 IRF Matching

To relate our results to the existing literature reconciling theory and empirical findings and to see how far a simple framework can account for our findings, we estimate seven crucial parameters: (1) the trade elasticity - governing (often together with the persistency of shocks) the response of households' demand (Corsetti et al. (2008); (2) capital adjustment cost - hindering the evolution of capital, affecting the correlation of macro variables' responses and the trade balance; (3) wealth elasticity of the labor supply - controlling the elasticity of the labor supply to wealth movements, setting the crowding out of government spending shocks; (4-5) Second order autoregressive process - shaping the response of government spending to its shock; (6) Inter-temporal elasticity of substitution - defining the inter-temporal behavior of consumption; (7) home bias in consumption - setting the share of domestic goods consumed in the basket of households.[17]

Table 1. Estimated parameter values

| Parameter | Value | Standard Error |
|---|---|---|
| Trade elasticity $\epsilon$ | 0.694 | 0.096 |
| Capital adjustment cost $\phi$ | 0.714 | 0.032 |
| Wealth Elasticity $\mu$ | 0.894 | 0.1 |
| AR 1 $\rho_{1,G}$ | 1.41 | 0.081 |
| AR 2 $\rho_{2,G}$ | -0.416 | 0.1 |
| Inter-temporal elasticity of substitution $\sigma$ | 0.644 | 0.042 |
| Home bias in consumption $\gamma_{h,t}$ | 0.798 | 0.012 |

Parameters are estimated by matching the impulse-responses of six variables over twelve quarters: government spending, GDP, inflation, real exchange rate, trade balance and consumption. The estimated values of the parameters and their standard errors are reported in Table G.2.[18]

[17] We tried also to estimate the inverse of the Frisch elasticity and habits in consumption but these parameters are not identified using the IRF-matching procedure.

[18] Standard errors are computed using Altig et al. (2011) procedure.

Model and empirical responses to a 1% increase in government spending (% deviations)

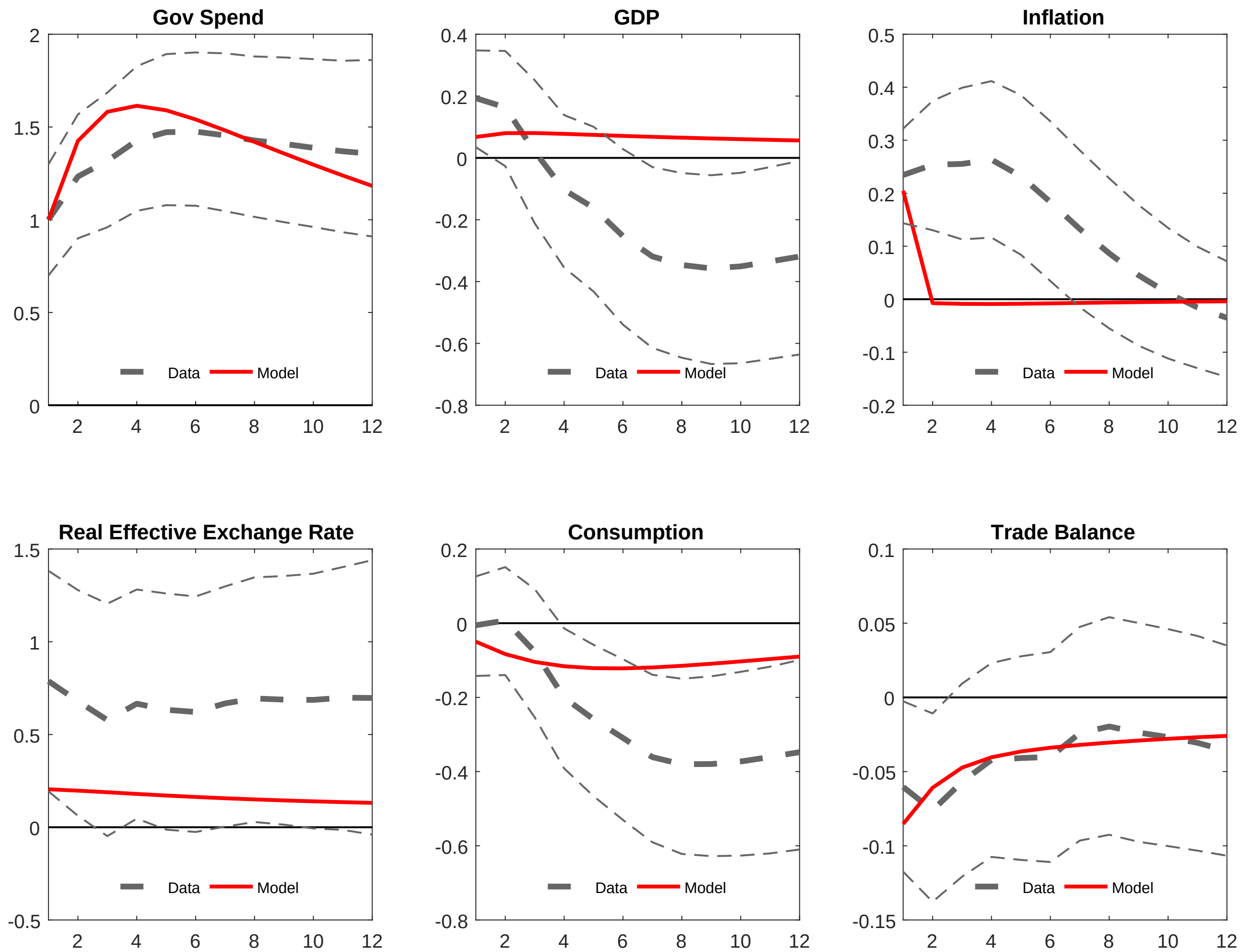


Figure G6: **Impulse-response matching.** Empirical (with lower and upper bound) vs. theoretical impulse-responses to one standard deviation shock to an unanticipated (unproductive) government spending shock.

Three are the main findings of the impulse-matching procedure. First, the trade elasticity is lower then one, consistently with most of theoretical international macro literature using simplified frameworks. Second, households' preferences display a quite large wealth effect in order to be consistent with the crowding out of consumption. Third, the labor elasticity, habits in consumption and the home bias are not extremely well identified using these responses to a government spending shock.

Figure G6 compares the impulse-responses of the estimated model with empirical ones. The model matches, on impact, all signs of the responses and for all, with the exception of inflation and GDP, quite well also the dynamics. An increase in government spending is inflationary, appreciates the real exchange rate and, while increasing aggregate output, generates a fall in aggregate consumption. Focusing on inflation, the model is unable to explain the persistent inflation dynamics. However this is a feature of flexible prices, as, in absence of nominal rigidities, prices adjust immediately. As for GDP, given the almost frictionless model, the multiplier would be larger only in the presence of a quite high inter-temporal elasticity of substitution, a low trade elasticity and high capital adjustment costs.