Are Fiscal Multipliers Estimated with Proxy-SVARs Robust?*

Giovanni Angelini
University of Bologna

Giovanni Caggiano
Monash University
University of Padova

Efrem Castelnuovo
University of Melbourne
University of Padova

Luca Fanelli
University of Bologna

October 2019

Abstract

We estimate fiscal spending and tax multipliers for the US economy by employing different combinations of fiscal and non-fiscal instruments in a proxy-SVAR framework. We do so by working with a novel identification strategy which allows us to jointly estimate the multipliers and assess the overall validity of the SVAR specification. We provide robust evidence in favor of a fiscal spending multiplier larger than one. Turning to the tax multiplier, we show that the strikingly different estimates one finds in the literature may depend on the orthogonality assumption regarding the non-fiscal instrument (namely, total factor productivity shocks) and tax shocks. In particular, we show that assuming total factor productivity shocks to be orthogonal to tax shocks implies a tax multiplier close to one. However, if this orthogonality assumption is relaxed, the tax multiplier is estimated to be three times larger.

Keywords: Fiscal multipliers, fiscal policy, identification, instruments, structural vector autoregressions.

JEL codes: C52, E62.

* We thank Fabio Canova, Antti Ripatti, Pedro Gomis-Porqueras, Xuan Zhou, and seminar participants at the Universities of Helsinki, Adelaide, and Deakin University for useful comments. Giovanni Angelini thanks the University of Melbourne (where part of this research was developed) for its kind hospitality. Financial support by the Australian Research Council via the Discovery Grant DP160102281 is gratefully acknowledged.

1 Introduction

The empirical literature on fiscal multipliers has offered disparate indications on the absolute and relative sizes of the output effects of increases in fiscal spending and tax cuts. Part of this disagreement is due to the challenging issue of identifying variations in spending and tax revenues that are exogenous to the business cycle. Working with zero restrictions and institutional information about the US tax and transfer systems, Blanchard and Perotti (2002) find that the fiscal spending multplier to be larger or smaller than the tax multplier depending on details of the VAR specification. Differently, Mountford and Uhlig (2009) work with sign restrictions and find a large tax multiplier and a spending multiplier lower than one.

Recent contributions have tackled the above mentioned endogeneity issue by working with an instrumental variable "proxy-SVAR" (or "SVAR-IV") approach (see Stock and Watson (2012) and Mertens and Ravn (2013) for early contributions, and Stock and Watson (2018) for a review).[1] Such contributions, which are concerned with the size of the tax multiplier, point to values between 2 and 3 (Romer and Romer (2010), Mertens and Ravn (2011, 2012, 2013, 2014)).[2] However, a recent paper by Caldara and Kamps (2017) finds that the size of the fiscal multipliers is sensitive to the type of instruments one works with. By using non-fiscal instruments (chiefly, total factor productivity, TFP hereafter) to recover fiscal spending and tax shocks and the corresponding multipliers, they find a spending multiplier of about 1-1.3, and a tax multiplier of 0.5-0.7. The latter values are strikingly lower than those found via the proxy-SVAR approach by directly instrumenting the tax shocks. In light of policymakers' need of reliable estimates of the fiscal multipliers for the design of fiscal policy plans, the substantial difference in these estimates is obviously undesirable.

This paper estimates fiscal multipliers with multiple fiscal and non-fiscal instruments. It does so by employing the novel "augmented and constrained VAR" approach recently proposed by Angelini and Fanelli (2019). Such approach jointly models observables of interest and instruments, test for the latter's relevance, and test for the specification of the SVAR in one step only. Multiple instruments provide moment conditions that, combined with the information stemming from the covariance matrix,

[1] We will use the terms "instruments" and "proxies" interchangeably throughout the paper.

[2] Exceptions are Favero and Giavazzi (2012), who estimate a tax multiplier similar to Blanchard and Perotti's (2002), and Perotti (2012), who finds a tax multiplier larger than Blanchard and Perotti's (2002) but smaller that those documented in the text. For a discussion on the reasons behind the heterogeneity of these estimates, see Mertens and Ravn (2014).

enable us to jointly identify fiscal shocks and their effects.[3] Working with multiple fiscal and non-fiscal instruments, we compute fiscal multipliers and check for their robustness across different sets of proxies. Our exercises are conducted by using four different instruments: in our most general specification, the unanticipated tax spending shocks estimated by Mertens and Ravn (2011b); the fiscal spending shocks proposed by Gorodnichenko (2014) and identified as in Blanchard and Perotti (2002); the total factor productivity series produced by Fernald (2014); and the oil shocks series by Hamilton (2003) for inflation shocks. While the first two proxies are used to directly identify the fiscal shocks of interest, the latter two carry information for the identification of "output" and "inflation" shocks that, via the moments related to the covariance matrix of the fiscal VAR, is useful to identify the spending and tax innovations.

Our results are the following. We estimate a fiscal spending multiplier of about 1.4-1.6. This estimate, which is robust across different sets of instruments, is statistically in line with Caldara and Kamps' (2017), who work with non-fiscal instruments only, Canova and Pappa (2007), who work with sign restrictions in a panel VAR framework modeling US and EU data, and Leeper, Traum, and Walker (2017), who work with different micro-founded structural frameworks.[4] To our knowledge, ours is the first exercise in which a proxy for unexpected fiscal spending shocks is used to estimate the US fiscal spending multiplier in a VAR context. Our contribution complements the one by Ramey (2011), who focuses on the output response to anticipated fiscal spending shocks.[5]

Turning to the tax multiplier, our estimate is about 3. As pointed out above, this estimate is line with Romer and Romer's (2010) and Mertens and Ravn's (2011, 2012, 2013, 2014) papers, but it is much larger than the one documented by Caldara and Kamps (2017), who find it to be 0.5-0.7. One obvious difference between these two camps is the use of different instruments for the tax shock, i.e., fiscal in Mertens and Ravn's papers, and non fiscal (total factor productivity in first place) in Caldara and

[3]Most proxy-SVAR contributions in the literature pursue a "partial identification" approach. Differently, our methodology allows us to achieve full identification (i.e., the simultaneous identification of fiscal and non-fiscal shocks) provided an additional set of restrictions, other than those related to external instruments, is imposed. Given that our goal is to quantify fiscal multipliers, this paper will focus on the output effects of fiscal policy shocks.

[4]Ramey (2019) documents this multiplier to be in the 0.6-1 range. Auerbach and Gorodnichenko (2012), Caggiano, Castelnuovo, Colombo, and Nodari (2015), and Ghassibe and Zanetti (2019) find this multiplier to be larger in recessions. For contrasting evidence, see Ramey and Zubairy (2018).

[5]Ramey and Zubairy (2018) estimate the multiplier generated by anticipated fiscal spending shocks with a local projections approach. See Plagborg-Møller and Wolf (2018) on the mapping between local projections and proxy-SVARs.

Kamps'. Our analysis reconciles these two different positions on the tax multiplier as follows. First, we show that, using a proxy for tax shocks on the one hand, and a proxy for TFP shocks on the other hand, we are able to replicate Mertens and Ravn's estimate of the multiplier (about 3) as well as Caldara and Kamps' (about 0.7). Crucially, the latter estimate is obtained by imposing orthogonality between TFP and the tax shocks. This assumption is in line with the one entertained by Caldara and Kamps (2017), who recover the tax shocks and their output effects by estimating the tax policy function with an instrumental variable approach meant to identify the causality going from output to tax revenues. Assuming that TFP is correlated with output but not with tax revenues, Caldara and Kamps (2017) recover the output-tax elasticity and, via restrictions related to the covariance matrix of the VAR residuals, the tax multiplier. Digging deeper, we unveil a significant correlation between TFP shocks and tax residuals in our VAR. Such statistical evidence is in line with economic intuition: in a world featuring cyclical tax revenues, shocks hitting the business cycle generate an output-tax revenue positive comovement. This correlation suggests that TFP shocks can fruitfully be used to identify not only output shocks, but also tax shocks. Hence, we relax the orthogonality condition previously imposed when working with the TFP instrument and allow such instrument to proxy both output and tax shocks jointly. In this case, our SVAR estimates point to a tax multiplier around 3. Our evidence of a large tax multiplier is robust to working with many instruments (a proxy for fiscal spending shocks, one for exogenous changes in tax revenues, TFP, and oil shocks), as long as the above mentioned relaxation of the orthogonality condition is allowed.

Why does relaxing the orthogonality condition drive the multiplier upward? The rationale for this result is the impact of the correlation between TFP shocks and tax shocks on the estimate of the output-tax revenues elasticity. Our preferred model points to a tax elasticity around 3.3. This estimate is in line with the one (3.7) found by Mertens and Ravn (2011a), who estimate the response of the US tax revenues to a technology shock identified with long-run restrictions. When imposing orthogonality between TFP shocks and tax shocks, the estimate of the output-tax elasticity drops to 2.2. This latter figure is closer to the estimate employed by Blanchard and Perotti (2002) and provided by the OECD (Giorno, Richardson, Roseveare, and van den Noord (1995)), which is around 2. However, as pointed out by Mertens and Ravn (2014), such estimate is likely to be affected by endogeneity issues related to the estimation of the tax base-tax revenues and the output-tax base elasticities across different categories of tax revenues. Our estimates support Mertens and Ravn's (2014) reasoning. Also, our results confirm the link between output-tax elasticities and tax multiplier already unveiled by Mertens and Ravn (2014) (via counterfactual simulations) and Caldara and Kamps (2017) (via analytical derivations). Finally, our econometric investigation points to an output-spending elasticity close to zero, which supports the value often imposed to achieve identification in just identified fiscal SVARs (Blanchard and Perotti (2002), Auerbach and Gorodnichenko (2012)).

The paper closest to ours is Caldara and Kamps (2017). Their analysis of the fiscal multipliers features two parts. First, they show that the heterogeneity of estimates of the fiscal multipliers in the literature can be explained by the different fiscal elasticities implied by the different methodologies at work (zero restrictions, sign restrictions, point-identified proxy-SVARs). Then, they use non-fiscal instruments to estimate fiscal elasticities and work out the fiscal multipliers by exploiting the information coming from the covariance matrix of the VAR residuals. They find the fiscal spending multiplier to be larger than one and bigger than the tax multiplier. We reach a similar conclusion on the fiscal spending multiplier, but a strikingly different one on the tax multiplier. As explained above, this difference is due to the different assumption on the TFP instrument-tax shocks relationship, i.e., the imposition of orthogonality by Caldara and Kamps (2017) that we do not entertain. Several other elements separate their investigation and ours. First, we jointly employ fiscal and non-fiscal instruments to estimate the multipliers. Doing so enables us to show that, while the estimate of the fiscal spending multiplier is robust across different sets of proxies, that of the tax multiplier is not. A second, related point is that, for the estimation of the latter multiplier, we unveil that using the same instrument (TFP) to jointly identify two shocks (output shocks, tax shocks) is crucial for correctly estimating the output effects of tax cuts. Third, our methodology enables us to formally assess the validity of the instruments we use without appealing to information external to that of the original VAR and of the external instruments already used to identify the targeted shocks.[6] Differently, Caldara and Kamps (2017) need to appeal to fiscal instruments to test the exogeneity (orthogonality) of the non-fiscal instruments they use as proxies in their approach. Fourth, the use of multiple instruments enables us to work with over-identified models and formally test some of the restrictions imposed by the literature, e.g., the zero output-spending elasticity imposed by Blanchard and Perotti (2002) and Auerbach and Gorodnichenko

[6] Technically speaking, the proxy-SVAR specification in Caldara and Kamps (2017) is based on an "A-model", while ours is based on a "B-model". Detailed references on the "A-" and "B-" SVARs may also be found in Lütkepohl (2005).

(2012). Fifth, we cover the case of the estimation of the fiscal spending multiplier related to an unexpected fiscal spending shock, which they do not study.

The focus of this paper is on the output effects of unexpected variations in fiscal spending and taxes. Hence, this paper complements the analysis on the fiscal multipliers due to changes in announced future fiscal policies (see, among others, Fisher and Peters (2010), Ramey (2011), Leeper, Walker, and Yang (2013), Ricco (2016), Forni and Gambetti (2016), Ben Zeev and Pappa (2017)). It also complements the recent investigations on the output effects of debt consolidation plans, which are recently surveyed in Alesina, Favero, and Giavazzi (2018, 2019). In line with most of the literature, this paper deals with the output effects of shocks to federal tax revenues. Papers dealing with narrower definitions of tax shocks are Barro and Redlick (2011) and Mertens and Ravn (2013). Finally, our focus on the effects of fiscal shocks on aggregate output. Papers dealing with the distributional effects of fiscal shocks are Mertens and Montiel Olea (2018) and Zidar (2019).

This paper is structured as follows. Section 2 presents the methodology, the data, and the way in which we compute the multipliers. Section 3 documents our results. Section 4 documents some robustness checks. Section 5 concludes.

2 Methodology, data and multipliers

Proxy-SVAR: Identification. Consider the following reduced-form VAR system

$$\Pi(L)Y_t = u_t \tag{1}$$

where Y_t is a vector of n observables, $\Pi(L) \equiv I_n - \Pi_1 L - \Pi_2 L^2 - ... - \Pi_p L^p$ is the matrix polynomial collecting the coefficients associated with the p lags of the variables ($Y_{t-p} = L^p Y_t$), and u_t is the vector of innovations with covariance matrix $E(u_t u_t') = \Sigma_u$.[7]

Let the mapping between the vector of innovations u_t and that of structural shocks ε_t be

$$u_t = B\varepsilon_t \tag{2}$$

where it is assumed that $E(\varepsilon_t \varepsilon_t') = I_n$. We focus on the identification of a subset of $k \leq n$ structural shocks $\varepsilon_{1,t}$, where $\varepsilon_t = (\varepsilon_{1,t}', \varepsilon_{2,t}')'$. $\varepsilon_{1,t}$ collects the k shocks of primary interest of the analysis, which in our framework are the fiscal shocks (spending shock

[7]Constants and other determinist terms are omitted from the formulations that follow to save notation. The extension of our formal expressions to cases in which constants and deterministic trends are present is straightforward.

and tax shock) but possibly also non-fiscal shocks. $\varepsilon_{2,t}$ collects the remaining $n-k$ non-fiscal structural shocks of the system. Then, without loss of generality, we can re-write the mapping (2) in the form

$$u_t = B_1\varepsilon_{1,t} + B_2\varepsilon_{2,t} \tag{3}$$

where $B = \begin{pmatrix} B_1 & B_2 \end{pmatrix}$, B_1 contains the instantaneous impact coefficients associated with the shocks in $\varepsilon_{1,t}$, and B_2 pertains to the instantaneous impact coefficients associated with the shocks in $\varepsilon_{2,t}$. We have ordered the shocks $\varepsilon_{1,t}$ first for convenience: as it will be clear below, the ordering of the variables is irrelevant in our framework.

Assume that a vector of $r \geq k$ instruments $v_{z,t}$ is available. For such instruments to be valid, the following two conditions have to hold:

$$E(v_{z,t}\varepsilon'_{1,t}) = \Phi\ , \quad \text{rank}(\Phi) = k \tag{4}$$

$$E(v_{z,t}\varepsilon'_{2,t}) = 0_{r\times(n-k)}. \tag{5}$$

Condition (4) states that the instruments have to be relevant, i.e., significantly correlated with the shocks of interest. Φ is an $r \times k$ full column rank matrix containing "relevance" parameters, and the rank condition in (4) implies that each column of Φ is non-zero and carries important information on the shocks in $\varepsilon_{1,t}$. Condition (5) states that the instruments have to be orthogonal to the non-instrumented shocks. The conditions (4)-(5) can be conveniently summarized for our purposes with the expression

$$v_{z,t} = \Phi\varepsilon_{1,t} + \omega_t \tag{6}$$

which establishes that the instruments are connected to the instrumented structural shocks via the matrix Φ, up to the measurement error term ω_t. The measurement error is assumed to be independent on $\varepsilon_t = (\varepsilon'_{1,t}, \varepsilon'_{2,t})'$ and has covariance matrix Σ_ω.

Angelini and Fanelli (2019) propose a novel approach to the identification of proxy-SVARs. Their proposal is that of working with an augmented system that jointly accounts for the observables Y_t and the instruments $v_{z,t} \equiv Z_t - E(Z_t | \mathcal{F}_{t-1})$, where Z_t collect the "raw" variables the instruments are constructed upon, and $\mathcal{F}_{t-1}$ is the econometrician's information set at time $t-1$. They denote the resulting model with the acronym AC-SVAR, where "A" stands for "augmented" and "C" for "constrained" because of the constraints the model features. The AC-SVAR model reads as follows:[8]

[8] A detailed exposition of the properties of the AC-VAR approach can be found in Angelini and Fanelli (2019). We use their notation to facilitate the mapping between their derivations and our presentation of their framework and its properties.

$$\begin{pmatrix} \Pi(L) & 0_{n\times r} \\ \Gamma(L) & \Theta(L) \end{pmatrix} \begin{pmatrix} Y_t \\ Z_t \end{pmatrix} = \begin{pmatrix} u_t \\ v_{z,t} \end{pmatrix} \tag{7}$$

where $\Gamma(L)$ and $\Theta(L)$ are matrix polynomials likewise $\Pi(L)$ in the VAR (1), in particular $\Gamma(L) \equiv \Gamma_1 L + \Gamma_2 L^2 + ... + \Gamma_s L^s$ and $\Theta(L) \equiv I_r - \Theta_1 L - \Theta_2 L^2 - ... - \Theta_q L^q$. The AC-SVAR model allows the variables Z_t to be persistent (via $\Theta(L)$), and possibly the lags of Y_t to be predictors of Z_t (via $\Gamma(L)$). Obviously, $\Gamma(L) = 0_{r\times n}$ and $\Theta(L) = I_r$ when $v_{z,t} \equiv Z_t$, i.e., when the external instruments are already expressed in innovation form. Given the large number of coefficients featured by the system of equations (7), in the empirical analyses presented below we impose that $\Theta(L)$ be diagonal when $r > 1$, i.e., the instruments are assumed to be dynamically unrelated to each other. These restrictions are supported by the data, i.e., the (cross-)correlations among the instruments used throughout the analysis are statistically equal to zero. Furthermore, in all estimated models discussed below the lag order q of $\Theta(L)$ and s of $\Gamma(L)$ is set to four, in line with the VAR lag order p.

In the AC-SVAR model, the relationships between innovations, shocks, and instruments is obtained by coupling (3) with (6). The resulting system is the following:

$$\begin{pmatrix} u_t \\ v_{z,t} \end{pmatrix} = \underset{\widetilde{G}}{\begin{pmatrix} B_1 & B_2 & 0_{n\times r} \\ \Phi & 0_{r\times(n-k)} & \Sigma_\omega^{1/2} \end{pmatrix}} \begin{pmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \omega_t^o \end{pmatrix} \tag{8}$$

where ω_t^o denotes the measurement error term ω_t in (6) normalized to have unit variance.[9]

System (7)-(8) can be written in compact form. Consider the following definitions:

$$W_t \equiv \begin{pmatrix} Y_t \\ Z_t \end{pmatrix}, \; \eta_t \equiv \begin{pmatrix} u_t \\ v_{z,t} \end{pmatrix}, \; \widetilde{\Psi}(L) \equiv \begin{pmatrix} \Pi(L) & 0_{n\times r} \\ \Gamma(L) & \Theta(L) \end{pmatrix}, \; \widetilde{G} \equiv \begin{pmatrix} B_1 & B_2 & 0_{n\times r} \\ \Phi & 0_{r\times(n-k)} & \Sigma_u^{1/2} \end{pmatrix}$$

where W_t and η_t are $(n+r)$-dimensional, and "$\sim$" indicates that $\widetilde{\Psi}(L)$ and $\widetilde{G}$ incorporate by construction a set of zero restrictions. Then, system (7)-(8) can be expressed as:

$$\widetilde{\Psi}(L) W_t = \eta_t \tag{9}$$

$$\eta_t = \widetilde{G} \xi_t \tag{10}$$

[9] Formally, $\Sigma_\omega^{1/2}$ in (8) is a symmetric positive definite matrix such that the variance of the measurement error $\omega_t = \Sigma_\omega^{1/2} \omega_t^o$ is equal to Σ_ω. In our setup $\Sigma_\omega^{1/2}$ could also correspond to the Cholesky factor of Σ_ω, see Angelini and Fanelli (2019) for details.

where $E(\eta_t\eta_t') = \Sigma_\eta = \begin{pmatrix} \Sigma_u & \Sigma_{u,v_z}' \\ \Sigma_{u,v_z} & \Sigma_\omega \end{pmatrix}$, and $E(\xi_t\xi_t') = I_{n+r}$.

Importantly, system (10) imposes the orthogonality condition (5) (corresponding to the block of $r(n-k)$ zeros in the position (2,2) of $\widetilde{G}$), which is therefore met by construction. Moreover, it enables the econometrician to assess the relevance condition via the coefficients of the matrix Φ, which is one of the components of the matrix $\widetilde{G}$. Note that a crucial component of Σ_η is the covariance between the VAR reduced form innovations and the instruments, $E(u_t v_{z,t}') = \Sigma_{u,v_{z,t}}$. Formally, the AC-SVAR model in (9)-(10) reads as a structural "B-model" Lütkepohl (2005)) characterized by a certain number of zero restrictions in the autoregressive coefficients $\widetilde{\Psi}(L)$ and in the matrix of "structural parameters" $\widetilde{G}$.[10] From eq. (10), we can write the system of restrictions on the coefficients $\widetilde{G}$ coming from the data as

$$\Sigma_\eta = \widetilde{G}\widetilde{G}' \tag{11}$$

and it is easily seen that these generate the "core" covariance restrictions $\Sigma_{v_{z,t},u} = \Phi B_1'$ which are at the basis of the proxy-SVAR approach, see e.g. Stock and Watson (2012), Mertens and Ravn (2013), Stock and Watson (2018) and Angelini and Fanelli (2019).

Angelini and Fanelli (2019) derive the necessary and sufficient rank conditions and the necessary order conditions for the identification of the whole matrix $\widetilde{G}$ (namely, the identification of all n structural shocks in $\varepsilon_t = (\varepsilon_{1,t}', \varepsilon_{2,t}')'$) based on $r \geq k$ instruments for $\varepsilon_{1,t}$. They also show that: i) imposing a set of few "additional" restrictions on B_2 (i.e., on the non-instrumented structural shocks) is a necessary condition for identification; ii) in cases in which the restrictions on $\widetilde{G}$ are zero constraints separable across columns, a convenient way to study the identification of the proxy-SVAR is to check whether the sufficient conditions for global identification in Theorem 2 of Rubio-Ramírez, Waggoner, and Zha (2010) are met; iii) the matrix $\widetilde{G}$ (as well as the non-zero parameters in $\widetilde{\Psi}(L)$) can be estimated via maximum likelihood; iv) when the restrictions on $\widetilde{G}$ are overidentifying, likelihood ratio tests for the overidentification restrictions tend to reject the null when the exogeneity (orthogonality) condition (5) fails, i.e. when the instruments are not valid.

It is worth noting that given an identified matrix $\widetilde{G}$, the matrix of relevance parameters Φ generally incorporates some zero restrictions. For example, in the square case ($r = k$), Φ one might potentially be diagonal, meaning that each proxy instruments just one structural shock. But Φ might equally be non-diagonal, which is the case we face

[10] See Arias, Rubio-Ramírez, and Waggoner (2018) for a similar specification based on the "A-model" and a Bayesian approach.

empirically in the estimations presented below, meaning that at least one external instrument in the proxy-SVAR is correlated with more than one instrumented structural shock. Finally, we observe a key property of our methodology is that it covers the case $r = n$, namely we can potentially instrument all structural shocks featured by the fiscal SVAR.

Data and instruments. We model the following endogenous variables: gross domestic product, y_t, real per-capita federal tax revenue, tr_t, and government spending, g_t. The last series is defined as the sum of government consumption and investment. Following Caldara and Kamps (2017), these series are expressed in logs and detrended using a linear trend via OLS regressions. In some scenarios, we also include consumer price inflation π_t and the 3-month (nominal) Treasury bill rate i_t in the model. Thus, $Y_t = (y_t, tr_t, g_t)'$ is the vector of endogenous variables in our baseline specifications and $Y_t = (y_t, tr_t, g_t, \pi_t, i_t)'$ is the vector of endogenous variables of our "extended" model.

As anticipated in the Introduction, we include up to four proxies in the vector Z_t to achieve identification, two fiscal instruments and two non-fiscal ones. The two fiscal instruments are Mertens and Ravn's (2011) series of unanticipated tax shocks (denoted MR), which is a subset of and Romer and Romer's (2010) shocks identified by studying narrative records on tax policy decisions, and Blanchard and Perotti's (2002) series of unanticipated fiscal spending shocks (denoted BP). As regards BP, we use the instrument constructed by Gorodnichenko (2014) by estimating the part of the contemporaneous growth rate of fiscal spending which is orthogonal to a number of controls. This instrument is similar to the one used by Auerbach and Gorodnichenko (2012), who employ the one-quarter ahead prediction error computed as the difference between government spending at time t and forecasts formulated by professional forecasters at time $t-1$. We prefer to use this instrument to the Ramey (2011) news spending shock because the latter is likely to contain information on both unexpected and expected ("news") changes in fiscal spending. As stressed by Mertens and Ravn (2014), using instruments that confound unanticipated and news shocks may lead to a failure of the exogeneity assumption, and therefore invalidate our econometric analysis.

Turning to non-fiscal instruments, the instrument employed for the output shock is the total factor productivity series by Fernald (2014), denoted TFP, which is adjusted for changes in factor utilization. Further, as an instrument for inflation in the "extended" model we use Hamilton (2003) oil shocks series, denoted OIL, which is a nonlinear function of the changes in the nominal price of crude oil.[11]

[11] All series but Blanchard and Perotti's (2002) instrument are available in the repli-

Estimation and bootstrap inference. We estimate our model with quarterly US data, sample: 1950Q1-2006Q4. This sample choice helps us compare our results with those documented in the literature (see e.g. Caldara and Kamps (2017), Mertens and Ravn (2013)). The SVAR for Y_t includes $p = 4$ lags of the endogenous variables and a constant. The corresponding AC-SVAR specification is obtained by appending the external instrument(s) Z_t to form a larger SVAR model for W_t as in (9)-(10). Notice that, in some cases, instruments will not carry enough information to identify all the elements of the matrix $\widetilde{G}$ in (8) that are needed to compute the fiscal multipliers. In such cases, restrictions on the matrices B_1, Φ and B_2 will be employed to achieve (full) identification. These additional restrictions are discussed case-by-case in the next section. The model is estimated by maximum likelihood along the lines described in Angelini and Fanelli (2019).

Bootstrap inference on the impulse response functions computed from proxy-SVARs has recently been debated by Mertens and Montiel Olea (2018), Jentsch and Lunsford (2019b), Mertens and Ravn (2019) and Jentsch and Lunsford (2019a). Elaborating on results by Brüggemann, Jentsch, and Trenkler (2016), Jentsch and Lunsford (2019a) show that asymptotic inference in these models is still "standard" (i.e., based on the Gaussian distribution, albeit the expressions for the asymptotic covariance matrices of the estimators may be rather complex) under fairly general conditions on the VAR innovations u_t and the instruments $v_{z,t}$. These include situations in which the dynamics of the external instruments in (6) can be replaced by the special zero-censored model:

$$v_{z,t} = D_t(\Phi\varepsilon_{1,t} + \omega_t) \tag{12}$$

where D_t is a dummy variable that takes value 1 with probability p and value 0 with probability $1 - p$. In (12) the external instruments can be either zero (with probability $1 - p$) or can take both positive and negative values (with probability p). In the empirical analyses discussed in the next section, the Mertens and Ravn's (2011) series of unanticipated tax shocks MR_t is characterized by a type of dynamics consistent with (12). Jentsch and Lunsford (2019b) show that in these situations, the Moving Block Bootstrap (MBB) method is resampling scheme which correctly reconstructs

cation package of the Caldara and Kamps (2017) paper, which is available at Dario Caldara's webpage: https://sites.google.com/view/dariocaldara/publications . The Blanchard and Perotti (2002) instrument is available at Valerie Ramey's webpage under https://econweb.ucsd.edu/~vramey/research/Ramey_Zubairy_replication_codes.zip . The instrument, labeled "gregsag", is contained in the file "agtspdat.xls", which can be found under the folder "AGreplication\AGexperiments_TSP". The construction of this instrument is detailed in https://econweb.ucsd.edu/~vramey/research/Gorodnichenko_slides.pdf .

the variability of estimated impulse response functions (see also Jentsch and Lunsford (2019a)). Hence, we apply the MBB resampling scheme to build confidence bands for the estimated fiscal multipliers which are robust to the zero-censoring mechanisms as in (12)

Multipliers. As in Blanchard and Perotti (2002), Auerbach and Gorodnichenko (2012, 2013), and Caldara and Kamps (2017), we define the fiscal multiplier as the dollar response of output to a shock of size one dollar.

Let P be either the level of fiscal spending G or the level of taxes TR; Y be the level of ouptut; βy_h be the response of log-output at horizon h to a fiscal policy shock; and βp_0 be the impact of the fiscal policy shock to the corresponding fiscal variable expressed in logs. Then, the multiplier is defined as

$$\mathcal{M}p_h = (\beta y_h / \beta p_0)(Y/P)$$

where Y/P is a policy shock-specific scaling factor converting elasticities to dollars. As in Caldara and Kamps (2017), we set the scaling factors for the two shocks of interest (unexpected change in fiscal spending and tax revenues) to their sample means, i.e., $(Y/G)^{-1} = 0.20$ and $(Y/T)^{-1} = 0.18$. We consider positive fiscal spending shocks and negative tax shocks to compare multipliers related to shocks expected to have a positive effect on output.[12]

3 Results

Our results cover three scenarios. First, we document the empirical findings obtained by relying on fiscal instruments for the identification of fiscal spending and tax revenues shocks in our model. We then explore the polar opposite case, i.e., the one in which we use TFP shocks to identify output shocks in first place and, via the moments associated to the covariance matrix of the residuals, recover the effects of fiscal shocks. Here we show that different assumptions on the correlation between TFP shocks and tax revenues shocks lead to dramatically different estimates of the tax multiplier. Instead, the estimates related to the output effects of fiscal spending shocks are relatively robust. We then discuss the link between changes in the output-tax elasticity and variations in the tax multiplier. We also discuss how sensible a large output-tax elasticity is in light of other estimates in the literature. Finally, we show that our results are robust

[12] This definition of the fiscal multipliers enhances the comparability of our results with those documented by the literature. For a discussion on this vs. alternative definitions, see Ramey (2019).

to estimating fiscal shocks by working with all instruments mentioned so far in a joint fashion.

3.1 Fiscal instruments only approach

Fiscal spending shock: Blanchard and Perotti's (2002) instrument. We begin our analysis by instrumenting the fiscal spending shock with Blanchard and Perotti's (2002) unexpected changs in fiscal spending BP. In this case, $Y_t = (y_t, tr_t, g_t)'$, $Z_t = (BP_t)$, and $\varepsilon_{1,t} \equiv \varepsilon_t^g$, and we estimate an AC-SVAR model for $W_t = (Y_t', Z_t)' = (y_t, tr_t, g_t, BP_t)'$. We achieve just identification by assuming that fiscal spending does not instantaneously respond to output *shocks*.[13]. For brevity, the maximum likelihood estimates of the $\widetilde{G}$ matrix along with MBB standard errors for this and the cases we discuss below are confined in the Appendix. All tests documented below are conducted by relying on the MBB standard errors.

Figure 1 (left panel) plots the fiscal spending multiplier obtained from this specification. The on-impact multiplier ($\mathcal{M}g_0$ in our notation) is about 0.8, it increases to about 1.4 after two quarters, it stays at that level for about one year, than it gradually declines. While our just identified model cannot be offered formal statistical support (given the lack of overidentifying restrictions), the relevance of the BP instrument is formally supported by the data. The estimated coefficient $\widehat{\phi}_{BP} = 0.012$, which connects the BP_t instrument to the fiscal shock $\varepsilon_{g,t}$, is very precisely estimated (the associated t-statistic is 15.1). This result is in line with the findings in Gorodnichenko (2014) and Ramey and Zubairy (2018), who also document a strong predictive power of the BP instrument. The output-spending elasticity associated to the esimated spending multiplier is $\psi_y^g = -(\widetilde{GI}_{3,1}/\widetilde{GI}_{3,3})$, where $\widetilde{GI} \equiv \widetilde{G}^{-1}$, and $\widetilde{GI}_{i,j}$ is the element located in the i-th row and j-th column of the $\widetilde{GI}$ matrix. Caldara and Kamps (2017) show that the fiscal policy coefficient ψ_y^g is inversely correlated to the fiscal spending multiplier $\mathcal{M}g_0$ for positive values of ψ_y^g which are below 1.8. While this coefficient is often set to zero, our estimate is of such coefficient (conditional on the zero response of fiscal spending to output shocks $b_{g,y} = 0$) is $\hat{\psi}_y^g = 0.18$. Caldara and Kamps' (2017) analytical derivations associate this elasticity to an on-impact multiplier equal to 0.8, which is indeed what

[13]Blanchard and Perotti (2002) impose a zero contemporaneous response of fiscal spending to all shocks affecting output. The two restrictions are equivalent if output is not affected by fiscal shocks at time t. If it is, our restriction is less stringent than Blanchard and Perotti's (2002). The difference in these restrictions is due to the fact that they work with an "AB-model" which accounts also for the contemporaneous relationships among the variables. Differently, we work with a "B-model", which focuses directly on the mapping going from the structural shocks to the VAR innovations.

we find.

Tax shock: MR instrument. We now turn to the identification of the tax revenues shock. The instrument we use is the series of unanticipated tax shocks produced by Mertens and Ravn (2011b), which we label MR. Since $Y_t = (y_t, tr_t, g_t)'$, $Z_t = (MR_t)$ and $\varepsilon_{1,t} \equiv \varepsilon_t^{tr}$, we estimate an AC-SVAR model for $W_t = (Y_t', Z_t)' = (y_t, tr_t, g_t, MR_t)'$. Consistently with the case analyzed before, we impose the restriction that g_t does not respond contemporaneously to output shocks

The estimated relevance parameter for the MR instrument is $\widehat{\phi}_{MR} = 0.043$, and it has an associated t-statistic of 2.22. Figure 1 (right panel) plots the implied tax multiplier. As one can appreciate, this multiplier is large, takes the value of 2.1 on impact ($\mathcal{M}tr_0$) and a peak value of 3.1 after three quarters. The size of the multiplier is in line with the estimates by Mertens and Ravn (2014) and part of the literature cited therein. We recover the output-tax elasticity as $\psi_y^{tr} = -(\widetilde{GI}_{2,1}/\widetilde{GI}_{2,2})$. Conditional on our estimated model, $\widehat{\psi}_y^{tr} = 3.29$. This value is close to the estimate in Mertens and Ravn (2014), who find it to be equal to 3.13, and that of Mertens and Ravn (2011a), which is 3.7. Moreover, as shown by Caldara and Kamps (2017), it is close to the one implied by the sign restrictions approach by Mountford and Uhlig (2009), which is 3. However, our estimate is higher than the one used by Blanchard and Perotti (2002) (2.08), who rely on an application of the OECD methodology documented in Giorno, Richardson, Roseveare, and van den Noord (1995), and that produced by Follette and Lutz (2010) for the US economy (1.7).[14] We postpone the discussion on the plausibility of an output-tax elasticity around 3 to the following Section.

3.2 TFP only approach

Caldara and Kamps (2017) employ non-fiscal instruments to identify fiscal shocks. They do so by estimating fiscal policy rules first, and then recover the fiscal shocks of interest by combining the estimated elasticities with the information coming from the covariance matrix of the VAR residuals.[15] Following them, we then use the Fernald (2014) measure of total factor productivity adjusted for factor utilization, TFP_t, which we use as an

[14] As pointed out in Section 2, our approach enables us to achieve full identification. Hence, while our focus so far has been on the spending (tax) multiplier obtained with the BP (MR) instrument, our estimated systems are actually able to generate the tax (spending) multiplier conditional on the employment of the BP (MR) instrument. When using the BP (MR) instrument to identify a tax (spending) shock, we find elasticities and multipliers very similar to those documented in Table 1.

[15] For an early study on the connection between policy rules and policy shocks with an application to the identification of monetary policy shocks, see Leeper, Sims, and Zha (1996).

instrument for output shocks. While such shocks are not of direct interest for the computation of the fiscal multipliers, the information related to their impulse vector can be fruitfully combined with that of the covariance matrix of our VAR to achieve full identification and recover the output effects of fiscal spending and tax shocks. Thus, we have $Y_t = (y_t, tr_t, g_t)'$, $Z_t = (TFP_t)$ and $\varepsilon_{1,t} \equiv \varepsilon_t^y$, and we estimate an AC-SVAR model for $W_t = (Y_t', Z_t)' = (y_t, tr_t, g_t, TPF_t)'$. Consistently with the cases analyzed above, we impose that fiscal spending does not respond to output shocks contemporaneously ($b_{g,y} = 0$). For the necessary and sufficient rank condition for identification to be met, we also assume that fiscal spending does not contemporaneously respond to tax shocks ($b_{g,tr} = 0$). This further restriction, already adopted by the literature (e.g., see Caldara and Kamps (2017)), will be relaxed when working with multiple instruments.

Given that this model is overidentified, we test if this structure of the economy is formally supported by the data, and verify that it is (p-value: 0.41). Moreover, the relevance of the TFP instrument is very precisely estimated ($\widehat{\phi}_{TFP} = 1.86$, with associated t-statistic equal to 8.5). As shown by Figure 1, the point estimates of fiscal spending multiplier identified with TFP shocks turns out to be higher that the one computed with the BP instrument. The impact multiplier ($\mathcal{M}g_0$) is equal to 1.1, while the peak - which occurs after two quarters - is equal to 1.8. The identifying restrictions imposed to achieve full identification imply that the only shock responsible for the on-impact changes in g_t is the fiscal spending shock itself. Hence, by construction, $\psi_y^g = 0$. The fiscal spending multiplier is higher that the one we found when using the BP instrument. The negative correlation between ψ_y^g and $\mathcal{M}g_0$ one can appreciate when contrasting their values in this case vs. the BP case above is consistent with the one in Caldara and Kamp (2017).

A very different picture emerges when looking at the tax multiplier estimated with the TFP instrument. Such multiplier is estimated to be substantially lower that the one obtained with the MR instrument. On impact, the multiplier is estimated to be 0.4, and the peak value - 0.99 - realizes five quarters after the shock. What is the driver of this drastic change in the tax multiplier when moving from the MR case to the TFP one? Table 1 collects the estimated value of the tax policy coefficient ψ_y^{tr} in this scenario, which is, 2.11. This value is significantly lower that the one found when using the MR instrument only. The positive correlation between ψ_y^{tr} and $\mathcal{M}tr$ (conditional on the estimates reported in Table 1) is consistent with the theoretical predictions on the size of the tax multiplier put forth by Caldara and Kamps (2017).

3.3 TFP only approach: Relaxing the TFP-tax shocks orthogonality condition

Relaxing the TFP-tax shocks orthogonality condition: Evidence and implications for the multipliers. A crucial assumption behind the case entertained above is that of orthogonality of the TFP instrument with respect to the fiscal shocks. While such assumption can be somewhat defended on the basis of the delays characterizing fiscal spending decisions and implementations, it is much harder to think of changes in tax revenues as being uncorrelated to the business cycle. Quite naturally, tax revenues (one of the components behind the output-tax elasticity) are cyclical. Hence, one would expect TFP shocks affecting output to also be drivers of fluctuations in tax revenues. A look at the data confirms this intuition. Figure 2 plots the correlations between the VAR residuals of output, tax revenues, and public spending on the one hand, and TFP residuals on the other.[16] Such correlations, which are often used in the proxy-SVAR literature to assess the relevance of the instruments at hand, point to a significant (at a 1% level) comovement not only between output and TFP, but also between TFP and tax revenues. Differently, the correlation between TFP and spending residuals is not significantly different from zero.[17]

In light of these correlations, TPF can be jointly used as an instrument for tax shocks and output shocks. What this means is that additional moments can be generated by relaxing the orthogonality conditions imposed in the previous scenario by allowing TFP shocks to also instrument tax shocks. The implication is that extra information from the data can be used to identify tax shocks, output shocks, government spending shocks (this last one via the restrictions imposed by covariance matrix of the VAR residuals) and, eventually, the fiscal policy multipliers.

The findings related to this exercise are the following. First, while the model as a whole is just identified and cannot be formally tested, the relevance of the TFP instrument for the identification of both output and tax shocks is supported by the data. The estimated coefficient for the relevance of TFP as an instrument for the

[16] The correlations computed by using TFP as observable in place of its residuals are very close to those documented in Figure 2.

[17] Caldara and Kamps (2017) assess the exogeneity of the TFP instrument by regressing it over Mertens and Ravn's (2011) narrative measure of tax shocks and Ramey's (2011) narrative measure of expected exogenous changes in military spending. They document individually and jointly insignificant estimated coefficients, and conclude that the TFP instrument is exogenous. After replicating their estimates, we verified that, when computing HAC standard errors, the t-statistic of the estimated coefficient of the measure of tax shocks increases from 1.53 to 1.92, while the F-statistic goes from 1.44 up to 1.88.

former is $\widehat{\phi}_{tfp,y} = 1.63$ (t-statistic: 6.5), while the one for the relevance of TFP as an instrument for tax shocks is $\widehat{\phi}_{tfp,tr} = -0.89$ (t-statistic: 2.2). Second, the peak fiscal spending multiplier is estimated to be around 2, i.e., slightly larger but not statistically different than those found when imposing the TFP-tax shocks orthogonality condition. Third, the impact on the tax multiplier is dramatic, its peak value moving from 0.7 to 3.5. This latter figure is statistically in line with the tax multiplier around 3 estimated with the MR instrument.

Driver of the large tax multiplier. What is the driver of the substantial difference between the small tax multiplier found when imposing the TFP-tax shocks orthogonality and the one around 3 obtained by relaxing such restriction? Mertens and Ravn (2014) and Caldara and Kamps (2017) document the mapping between the output-tax elasticity and the tax multiplier. In particular, Caldara and Kamps (2017) derive an analytical expression for the tax multiplier and show that, if $\psi_y^{tr} \in [-1, 4]$ range, there is a positive correlation between the elasticity and the multiplier. Table 1 documents the substantial change in such elasticity when the TFP-tax shocks orthogonality is relaxed, with $\widehat{\psi}_y^{tr}$ moving from 2.1 (orthogonality imposed) to 3.8 (non orthogonality allowed). This latter number is pretty close to the 3.7 estimate provided by Mertens and Ravn (2011a). Moreover, the associated bootstrapped standard deviation suggests that estimates around 3 that are often found in the literature are statistically equivalent to ours.

How sensible an output-tax elasticity equal to 3 is? As stated above, Blanchard and Perotti (2002) rely on an output-tax elasticity equal to 2.08, which is the one estimated by the OECD (Giorno, Richardson, Roseveare, and van den Noord (1995)). Such elasticity is slightly larger than that estimated by Follette and Lutz (2010) on yearly data (1.7). Instead, our results rely upon output-tax elasticities equal to 3 or larger. Are such large elasticities sensible? Mertens and Ravn (2014) discuss how the before mentioned elasticities are obtained. In particular, the OECD one relies on a weighted average of the output elasticities for different tax revenue components (personal income taxes, social security contributions, indirect taxes and corporate income taxes). Each component-specific elasticity is a product of two elasticities, i.e., the tax base-tax revenues one and the output-tax base one. Mertens and Ravn (2014) point out that, while both elasticities are (somewhat necessarily) computed by relying on many somewhat questionable assumptions, the second one in particular is typically estimated via OLS regressions that do not tackle the obvious endogeneity issue affecting the output-tax relationship. Importantly, Mertens and Ravn (2014) show that such endogeneity issue is likely to induce a negative bias in the estimated output-tax elasticity. Mertens and Ravn (2011a) tackle this bias by estimating the response of the US federal tax revenues to a technology shock identified with long run restrictions, and find a value for the elasticity equal to 3.7. Caldara and Kamps (2017) derive the output-tax elasticity implied by the sign restriction approach pursued by Mountford and Uhlig (2009), and find a value equal to 3. Wrapping up, we believe a value of the output-tax elasticity equal to 3 or larger not to be at odds with the US data at hand.

3.4 Multiple instruments approach

As stressed in the Introduction, the AC-VAR methodology we work with allows to work with multiple instruments. We then combine all instruments used so far (both fiscal and non-fiscal) and re-estimate both multipliers. This way to proceed adds further moment conditions and, therefore, information (if the moment conditions are supported by the data). Formally, we work with $Y_t = (y_t, tr_t, g_t)'$, $Z_t = (BP_t, MR_t, TFP_t)$, and we estimate an AC-SVAR model for $W_t = (Y_t', Z_t')' = (y_t, tr_t, g_t, MR_t, BP_t, TPF_t)'$. To our knowledge, this is the first case in the proxy-SVAR literature in which the number of employed external instruments r is the same as the number of variables n the original SVAR comprises, i.e., all shocks in the VAR are instrumented.

Given the role played by the TFP-tax shocks orthogonality condition for the estimation of the tax multiplier, we analyze two cases: i) the one in which all instruments are put at work at the orthogonality condition is imposed; ii) the one in which all instruments are considered and the orthogonality condition is relaxed.

Fiscal shocks: BP & MR & TFP instruments - orthogonality condition. Figure 1 shows the fiscal spending and tax multipliers generated with this version of the AC-VAR. The fiscal spending multiplier peaks at a value equal to 1.6, which is relatively similar to those found in the previous investigated scenarios. The tax multiplier peaks at a value equal to 1.2. While being larger that the one estimated with the TFP instrument only under the assumption of TFP-tax shocks orthogonality, this values is three times smaller than the one obtained with the TFP instrument only when the orthogonality condition is relaxed. Hence, the two findings as far as the tax multiplier is concerned are: i) fiscal instruments positively affect the tax multiplier from a quantitative standpoint; ii) such multiplier is much lower than the one documented in the non orthogonality case. From a statistical standpoint, the model, this overidentified model - is supported by the data (p-value: 0.25).

Fiscal shocks: BP & MR & TFP instruments - non orthogonality. A natural question is what happens if we relax the TFP-tax shocks orthogonality condition when playing with multiple instruments. Figure 1 documents the spectacularly different implications for the two multipliers. The impact of relaxing the orthogonality condition on the estimated fiscal spending multiplier is basically zero, i.e., the multiplier is exactly the same as the one estimated when imposing such condition. Differently, the tax multiplier records a peak value of 3.1 vs. the 1.2 estimated when imposing the orthogonality condition. Figure 3, which reports the 68% bands bootstrapped by following the MBB by Jentsch and Lunsford (2019a), shows that the estimated tax multipliers are significantly different. As before, the driver for this dramatic increase in its value is the impact of the relaxation of the orthogonality condition on the estimated output-tax elasticity, which moves from 2.3 (orthogonality imposed) to 3.3 (orthogonality not imposed). Turning to the output-fiscal spending elasticity, our model allows us to avoid imposing the usual zero restriction (Blanchard and Perotti (2002)). Our point estimate - 0.15 - is significantly different from zero but quantitatively small. Finally, this AC-VAR model estimated with multiple instruments and the relaxation of the TFP-tax shocks orthogonality condition is overidentified and supported by the data (p-value: 0.32).

4 Robustness checks

Monetary policy. Our baseline model is a fiscal policy-only model. Research on the fiscal-monetary policy mix shows that the output effects of fiscal shocks are importantly affected by the systematic monetary policy in place (see Leeper (1991) for an early contribution, and Leeper and Leith (2016) for a recent review). To control for the role of monetary policy, we work with an enriched model featuring also CPI inflation and the 3-month Treasury bill rate. Hence, our vector of modeled variables becomes $Y_t = (y_t, tr_t, g_t, \pi_t, r_t)'$. We estimate this model by working with the three instruments employed so far (BP, MR, and TFP) plus the measure of oil shocks (OIL henceforth) proposed by Hamilton (2003) as an instrument for the inflation shock (as done by Caldara and Kamps (2017).[18] Consequenly, we estimate an AC-SVAR model for $W_t =$

[18] Caldara and Kamps (2017) also employ the measure of monetary policy shocks proposed by Romer and Romer (2004) to instrument the policy rate in their fiscal rules. We avoid using such instrument because it is available not before 1969. This would reduce our sample by about 20 years. We notice that the results we obtain with vs. without inflation and the policy rate are very similar. Caldara and Kamps (2017) reach the same conclusion. Evans (1992) find that TFP measures produced with the

$(Y_t', Z_t')' = (y_t, tr_t, g_t, \pi_t, r_t, MR_t, BP_t, TPF_t, OIL_t)'$.

As before, we study two different scenarios, one in which the TFP-tax shocks orthogonality condition is imposed, and one in which it is relaxed.

Figure 4 shows the estimated multipliers in these two scenarios. As before, the estimated fiscal spending multiplier is insensitive to the treatment of the orthogonality condition, and peaks at a value equal to 1.6. Quite differently, the peak of the tax multiplier is 1.2 when the condition is imposed, and 3.4 when it is not. It is important to stress that this latter model, which is overidentified, is supported by the data (p-value: 0.86), and that the relevance of the TFP instrument for both output and tax shocks is also supported by the data ($\widehat{\phi}_{tfp,y} = 1.69$, t-statistic: 7.89; $\widehat{\phi}_{tfp,tr} = -0.63$, t-statistic: 2.05).

Fiscal foresight. Anticipation effects are likely to be of great relevance for the identification and transmission of fiscal policy shocks. This phenomenon, often referred to as "fiscal foresight", makes SVAR analysis complicated. Standard VARs, which rely on current and past shocks to interpret the dynamics of the modeled variables, can be "non-fundamental", in that they do not embed the information related to "news shocks", i.e., future shocks anticipated by rational agents. Leeper, Walker, and Yang (2013) work with different fiscal models and show that the anticipation of tax policy shocks severely affects VAR exercises aiming at identifying fiscal shocks. Ramey (2011) shows that government spending shocks estimated with standard fiscal SVARs are predictable, i.e., they are non-fundamental. Forni and Gambetti (2014) propose a test for "sufficient information" to detect non-fundamentalness. In presence of non-fundamentalness, SVAR shocks can be predicted with information available at time $t-1$. If such predictive power is not detected, the VAR contains enough information for the identification of the shocks of interest to be achieved.

We test for information sufficiency of our estimated model by regressing the identified fiscal shocks against lagged realizations of the factors extracted from the large set of macroeconomic and financial variables put together by McCracken and Ng (2016).[19] We use two sets of regressors: i) the first estimated factor, which explains about 55% of the variance of the data; ii) the first four factors, which explain almost 90%. Table 2

Solow-Prescott residuals approach are Granger-caused by monetary measures. The correlation between TFP shocks and Romer and Romer's (2004) measure of monetary policy shocks is low (0.07) and not significant at conventional levels.

[19] To maximize the number of observations to compute the factors, we work with monthly data. We convert monthly factors in quarterly ones by taking the last realization of the factors in each quarter. Given that the factors are estimated with a sample starting in 1959, our regressions regard the sample 1959-2006.

collects the p-values of the F-tests for information sufficiency we run over all our models. For each shock or combination of shocks, we consider two scenarios: a) an univariate scenario in which each fiscal shock is regressed over a constant and the estimated factors (first two rows of each shock/combination of shocks); b) a multivariate one in which the vector of fiscal shocks is regressed over constants and the estimated factors (last row of each shock/combination of shocks). Clearly, all models pass the information sufficiency test.[20]

Specification of trends. As in Caldara and Kamps (2017), our analysis is performed by using data on g_t, tr_t, and y_t that are linearly detrended. We check the robustness of our results to modeling data in log-levels. We notice that modeling data in log-levels implies a non-stationary VAR reduced-form. We re-estimate all our models and compute the fiscal elasticities and multipliers. We find the following: i) the main results in this paper, i.e., the robustness of fiscal spending multiplier and the sensitivity of the tax multiplier to including non-fiscal instruments in the set of proxies used for identification, are robust; ii) the result on the relative size of the multipliers is less clear. This exercise returns tax multipliers larger than fiscal spending multipliers. However, the estimates of the multipliers are much more imprecise than those of our baseline case, and are not different from each other from a statistical standpoint. These results are documented in our Appendix for brevity.

5 Conclusions

This paper jointly exploits fiscal and non-fiscal instruments to estimate the US fiscal multipliers in proxy-SVARs. It does so with a novel methodology that allows to work with multiple instruments and assess the validity of the estimated proxy-SVARs in one step. We estimate the fiscal spending multiplier to be about 1.4-1.6 across different specifications characterized by different sets of interest. Differently, the tax multiplier is estimated to be about 3.3 when a tax instrument only is employed, while its value drops to 1-1.2 when the effects of the tax shocks are recovered via the covariance matrix of the residuals by exploiting total factor productivity as an instrument to estimate the effects of output shocks. We show that these different estimates, which replicate those obtained by key contributions in the literature, are due to the imposition of the TFP-tax

[20] Canova and Sahneh (2018) note that Granger-causality tests might over-reject fundamentalness because of aggregation issues affecting the variables modeled with the VAR. The Forni and Gambetti (2014) tests we conducted over the different specifications of our VARs never reject fundamentalness. Hence, our VARs are not subject to the Canova-Sahneh critique.

shocks orthogonality condition. When relaxing such condition, which is not supported by the data, we find a tax multiplier around 3. Finally, our estimates confirm the positive correlation between changes in the output-tax elasticity and variations in the tax multiplier previously detected via counterfactual simulations by Mertens and Ravn (2014) and analytically worked out by Caldara and Kamps (2017).

References

Alesina, A., C. A. Favero, and F. Giavazzi (2018): "What Do We Know About the Effects of Austerity?," *American Economic Association Paper & Proceedings*, 108, 524–530.

——— (2019): "Effects of Austerity: Expenditure- and Tax-based Approaches," *Journal of Economic Perpectives*, 33(2), 141–162.

Angelini, G., and L. Fanelli (2019): "Exogenous uncertainty and the identification of Structural Vector Autoregressions with external instruments," *Journal of Applied Econometrics*, forthcoming.

Arias, J. E., J. F. Rubio-Ramírez, and D. F. Waggoner (2018): "Inference Based on SVARs Identified with Sign and Zero Restrictions: Theory and Applications," *Econometrica*, 86(2), 685–720.

Auerbach, A., and Y. Gorodnichenko (2012): "Measuring the Output Responses to Fiscal Policy," *American Economic Journal: Economic Policy*, 4(2), 1–27.

Auerbach, A., and Y. Gorodnichenko (2013): "Output Spillovers from Fiscal Policy," *American Economic Review Papers and Proceedings*, 103(3), 141–146.

Barro, R. J., and C. J. Redlick (2011): "Macroeconomic Effects from Government Purchases and Taxes," *Quarterly Journal of Economics*, 126(1), 51–102.

Ben Zeev, N., and E. Pappa (2017): "Chronicle of a War Foretold: The Macroeconomic Effects of Anticipated Defense Spending Shocks," *Economic Journal*, 127, 1568–1597.

Blanchard, O., and R. Perotti (2002): "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output," *Quarterly Journal of Economics*, 117(4), 1329–1368.

Brüggemann, R., C. Jentsch, and C. Trenkler (2016): "Inference in VARs with conditional volatility of unknown form," *Journal of Econometrics*, 191, 69–85.

Caggiano, G., E. Castelnuovo, V. Colombo, and G. Nodari (2015): "Estimating Fiscal Multipliers: News From a Nonlinear World," *Economic Journal*, 125(584), 746–776.

Caldara, D., and C. Kamps (2017): "The Analytics of SVARs: A Unified Framework to Measure Fiscal Multipliers," *Review of Economic Studies*, 84, 1015–1040.

Canova, F., and E. Pappa (2007): “Price differentials in monetary unions: The roel of fiscal shocks,” *Economic Journal*, 117, 713–737.

Canova, F., and M. H. Sahneh (2018): “Are Small-Scale SVARs Useful for Business Cycle Analysis? Revisiting Nonfundamentalness,” *Journal of the European Economic Association*, 6(4), 1069–1093.

Evans, C. L. (1992): “Productivity Shocks and Real Business Cycles,” *Journal of Monetary Economics*, 29(2), 191–208.

Favero, C. A., and F. Giavazzi (2012): “Measuring Tax Multipliers: The Narrative Method in Fiscal VARs,” *American Economic Journal: Economic Policy*, 4(2), 69–94.

Fernald, J. (2014): “A Quarterly, Utilization-Adjusted Series on Total Factor Productivity,” Federal Reserve Bank of San Francisco Working Paper No. 2012-19.

Fisher, J. D. M., and R. Peters (2010): “Using Stock Returns to Identify Government Spending Shocks,” *Economic Journal*, 120(544), 414–436.

Follette, G., and B. F. Lutz (2010): “Fiscal Policy in the United States: Automatic Stabilizers, Discretionary Fiscal Policy Actions, and the Economy,” Board of Governors of the Federal Reserve System Finance and Economics Discussion Series 2010-43.

Forni, M., and L. Gambetti (2014): “Sufficient information in structural VARs,” *Journal of Monetary Economics*, 66, 124–136.

——— (2016): “Government Spending Shocks in Open Economy VARs,” *Journal of International Economics*, 99, 68–84.

Ghassibe, M., and F. Zanetti (2019): “State Dependence of Fiscal Multipliers: The Source of Fluctuations Matters,” University of Oxford, mimeo.

Giorno, C., P. Richardson, D. Roseveare, and P. van den Noord (1995): “Estimating Potential Output, Output Gaps, and Structural Budget Balances,” OECD Economics Department Working Paper No. 152.

Gorodnichenko, Y. (2014): “Discussion of: "Government Spending Multipliers in Good Times and Bad: Evidence from U.S. Historical Data", by V.A. Ramey and S. Zubairy,” NBER Economic Fluctuations and Growth Program, July 12.

Hamilton, J. D. (2003): “What Is an Oil Shock?,” *Journal of Econometrics*, 113, 363–398.

Jentsch, C., and C. K. Lunsford (2019a): “Asymptotically Valid Bootstrap Inference for Proxy SVARs,” Federal Reserve Bank of Cleveland Working Paper No. 19-08.

Jentsch, C., and K. G. Lunsford (2019b): “The dynamic effects of personal and corporate income tax changes in the United States: Comment,” *American Economic Review*, forthcoming.

Leeper, E. (1991): “Equilibria Under ’Active’ and ’Passive’ Monetary and Fiscal Policies,” *Journal of Monetary Economics*, 27, 129–147.

Leeper, E. M., and C. Leith (2016): "Understanding Inflation as a Joint Monetary-Fiscal Phenomenon," in: J.B. Taylor and H. Uhlig (Eds.): Handbook of Macroeconomics, Elsevier Science, forthcoming.

Leeper, E. M., C. Sims, and T. Zha (1996): "What Does Monetary Policy Do?," *Brookings Papers on Economic Activity*, 27, 1–78.

Leeper, E. M., N. Traum, and T. B. Walker (2017): "Clearing Up the Fiscal Multiplier Morass," *American Economic Review*, 107(8), 2409–2454.

Leeper, E. M., T. B. Walker, and S.-C. S. Yang (2013): "Fiscal Foresight and Information Flows," *Econometrica*, 81(3), 1115–1145.

Lütkepohl, H. (2005): "New Introduction to Multiple Time Series Analysis," Springer-Verlag, Berlin and Heidelberg.

McCracken, M. W., and S. Ng (2016): "FRED-MD: A Monthly Database for Macroeconomic Research," *Journal of Business and Economic Statistics*, 34(4), 574–589.

Mertens, K., and J. L. Montiel Olea (2018): "Marginal Tax Rates and Income: New Time Series Evidence," *Quarterly Journal of Economics*, 133(4), 1803–1884.

Mertens, K., and M. Ravn (2019): "The dynamic effects of personal and corporate income tax changes in the United States: Reply to Jentsch and Lunsford," *American Economic Review*, forthcoming.

Mertens, K., and M. O. Ravn (2011a): "TechnologyŮhours redux: Tax changes and the measurement of technology shocks," NBER International Seminar of Macroeconomics, 41–76.

——— (2011b): "Understanding the Aggregate Effects of Anticipated and Unanticipated Tax Policy Shocks," *Review of Economic Dynamics*, 14(1), 27–54.

——— (2012): "Empirical evidence on the aggregate effects of anticipated and unanticipated US tax policy shocks," *American Economic Journal: Economic Policy*, 4(2), 214–237.

——— (2013): "The Dynamic Effecs of Personal and Corporate Income Tax Changes in the United States," *American Economic Review*, 103(4), 1212–1247.

——— (2014): "A Reconciliation of SVAR and Narrative Estimates of Tax Multipliers," *Journal of Monetary Economics*, 68, S1–S19.

Mountford, A., and H. Uhlig (2009): "What Are the Effects of Fiscal Policy Shocks?," *Journal of Applied Econometrics*, 24, 960–992.

Perotti, R. (2012): "The effects of tax shocks on output: Not so large, but not so small either," *American Economic Journal: Economic Policy*, 4(2), 241–237.

Plagborg-Møller, M., and C. K. Wolf (2018): "Local Projections and VARs Estimate the Same Impulse Responses," Princeton University, mimeo.

Ramey, V. A. (2011): "Identifying Government Spending Shocks: It's All in the Timing," *Quarterly Journal of Economics*, 126(1), 1–50.

——— (2019): "Ten Years after the Financial Crisis: What Have We Learned from the Renaissance in Fiscal Research?," *Journal of Economic Perpectives*, 33(2), 89–114.

Ramey, V. A., and S. Zubairy (2018): "Government Spending Multipliers in Good Times and in Bad: Evidence from U.S. Historical Data," *Journal of Political Economy*, 126(2), 850–901.

Ricco, G. (2016): "A New Identification of Fiscal Shocks Based on the Information Flow," London Business School, mimeo.

Romer, C., and D. Romer (2004): "A New Measure of Monetary Policy Shocks: Derivation and Implications," *American Economic Review*, 94(4), 1055–1084.

Romer, C. D., and D. H. Romer (2010): "The Macroeconomic Effects of Tax Changes: Estimates Based on a New Measure of Fiscal Shocks," *American Economic Review*, 100(3), 763–801.

Rubio-Ramírez, J. F., D. F. Waggoner, and T. Zha (2010): "Structural Vector Autoregressions: Theory of Identification and Algorithms for Inference," *Review of Economic Studies*, 77, 665–696.

Stock, J., and M. W. Watson (2018): "Identification and Estimation of Dynamic Causal Effects in Macroeconomics Using External Instruments," *Economic Journal*, 128, 917–948.

Stock, J. H., and M. W. Watson (2012): "Disentangling the Channels of the 2007-2009 Recession," *Brookings Papers on Economic Activity*, Spring, 81–135.

Zidar, O. M. (2019): "Tax Cuts for Whom? Heterogeneous Effects of Income Tax Changes on Growth and Employment .," *Journal of Poltical Economy*, forthcoming.

Instruments	ψ_y^g	ψ_y^{tr}	$\mathcal{M}g$	$\mathcal{M}tr$
BP only	0.1756 0.0439	–	1.3940 0.4632	–
MR only	–	3.3615 1.0327	–	3.0863 1.4460
TFP only - orth.	−0.1434 0.1084	2.1142 0.2648	1.9134 0.4958	0.7583 0.4186
TFP only - non orth.	−0.3430 0.2471	3.8565 1.0423	2.1842 0.6179	3.5831 1.7672
TFP & MR & BP - orth.	0.1659 0.0449	2.3346 0.3105	1.6147 0.4383	1.2113 0.4800
TFP & MR & BP - non orth.	0.1656 0.0448	3.3639 1.0820	1.6165 0.4458	3.1354 2.7485
TFP & MR & BP & OIL - orth.	0.1557 0.0480	2.6363 1.6341	1.6294 0.3909	1.2248 0.9024
TFP & MR & BP & OIL - non orth.	0.1555 0.0463	3.6082 1.2282	1.6289 0.3987	3.4556 1.4848

Table 1: **Estimated elasticities and multipliers: Data in log-levels.** Bootstrapped standard errors (based on1,000 repetitions and the MBB method) below point estimates. Multipliers: Peak values.

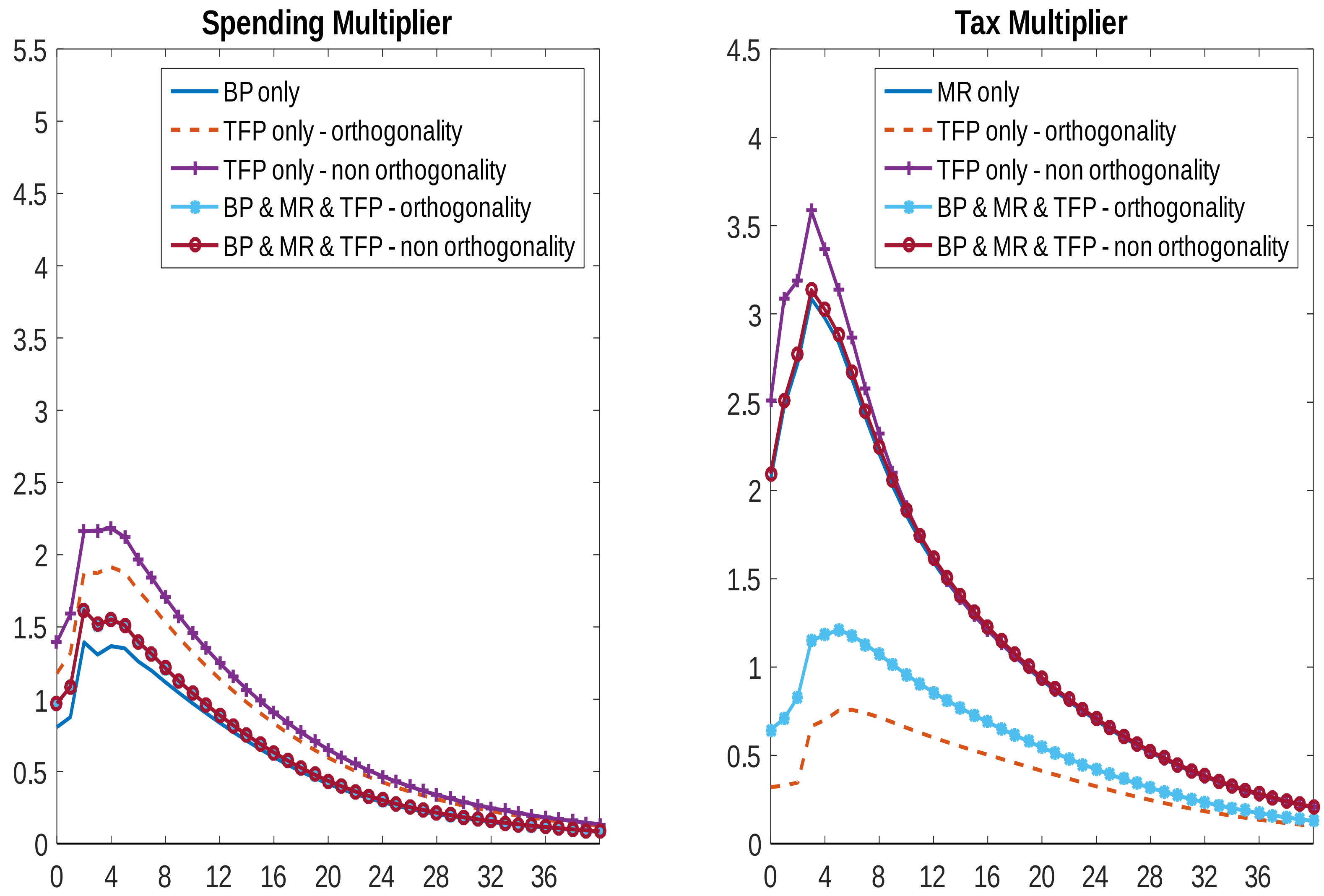

Figure 1: **Fiscal multipliers: Role of instruments.** Model with fiscal spending, taxes, output. BP: Blanchard and Perotti's (2002) fiscal spending instrument. MR: Mertens and Ravn's (2012) tax spending instrument. TFP: Fernald's (2014) TFP instrument.

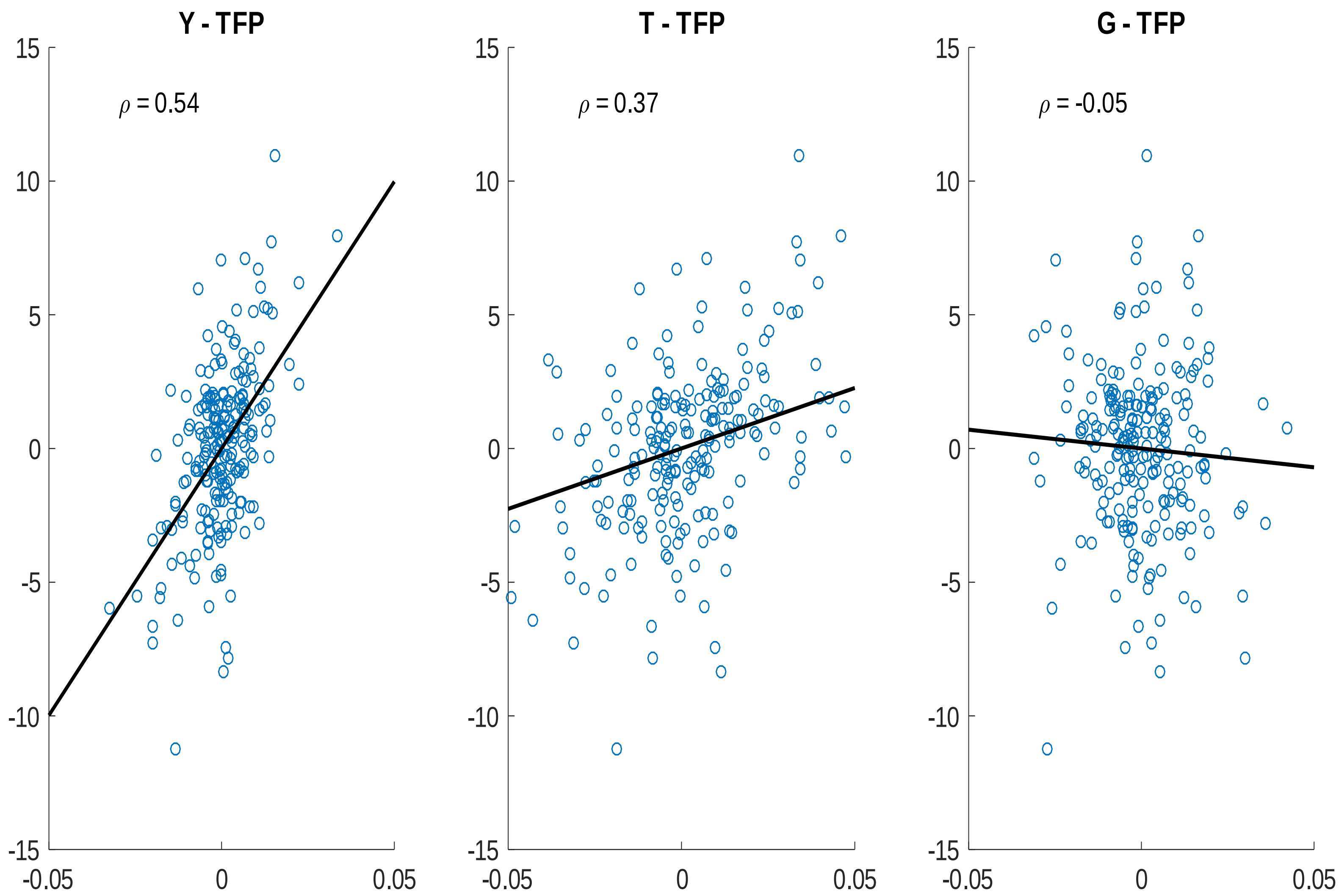

Figure 2: **Relevance of the TFP instrument: Correlation with output and tax revenues.** Scatter plots and correlations based on the residuals of our estimated AC-VAR with output, tax revenues, spending, and Fernald's (2014) TFP series.

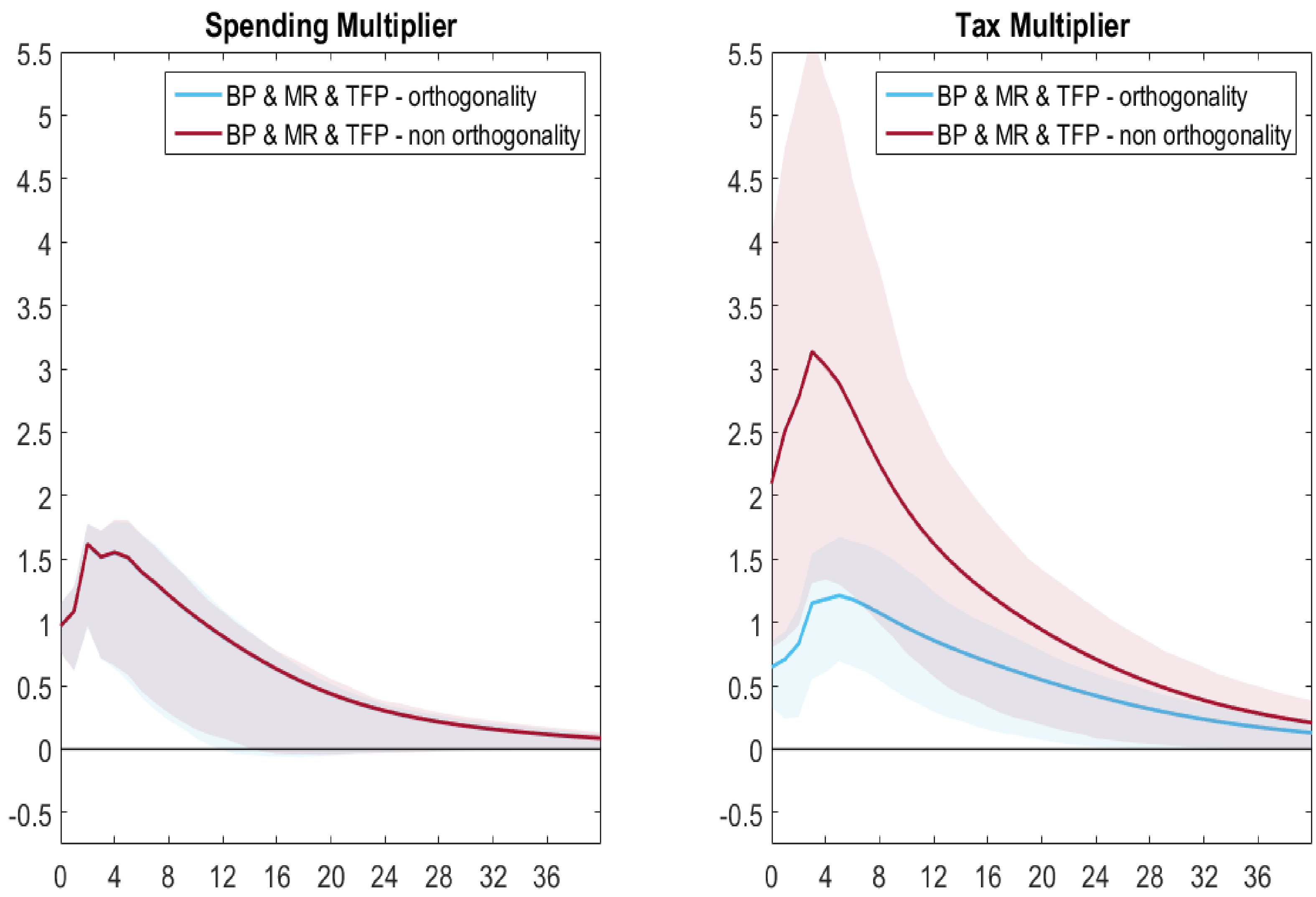

Figure 3: **Fiscal multipliers with alternative sets of instruments: Statistical difference.** Shaded areas: 68Moving Block Bootstrap algorithm by Jentsch and Lunsford (2019b). BP: Blanchard and Perotti's (2002) fiscal spending instrument. MR: Mertens and Ravn's (2012) tax spending instrument. TFP: Fernald's (2014) TFP instrument.

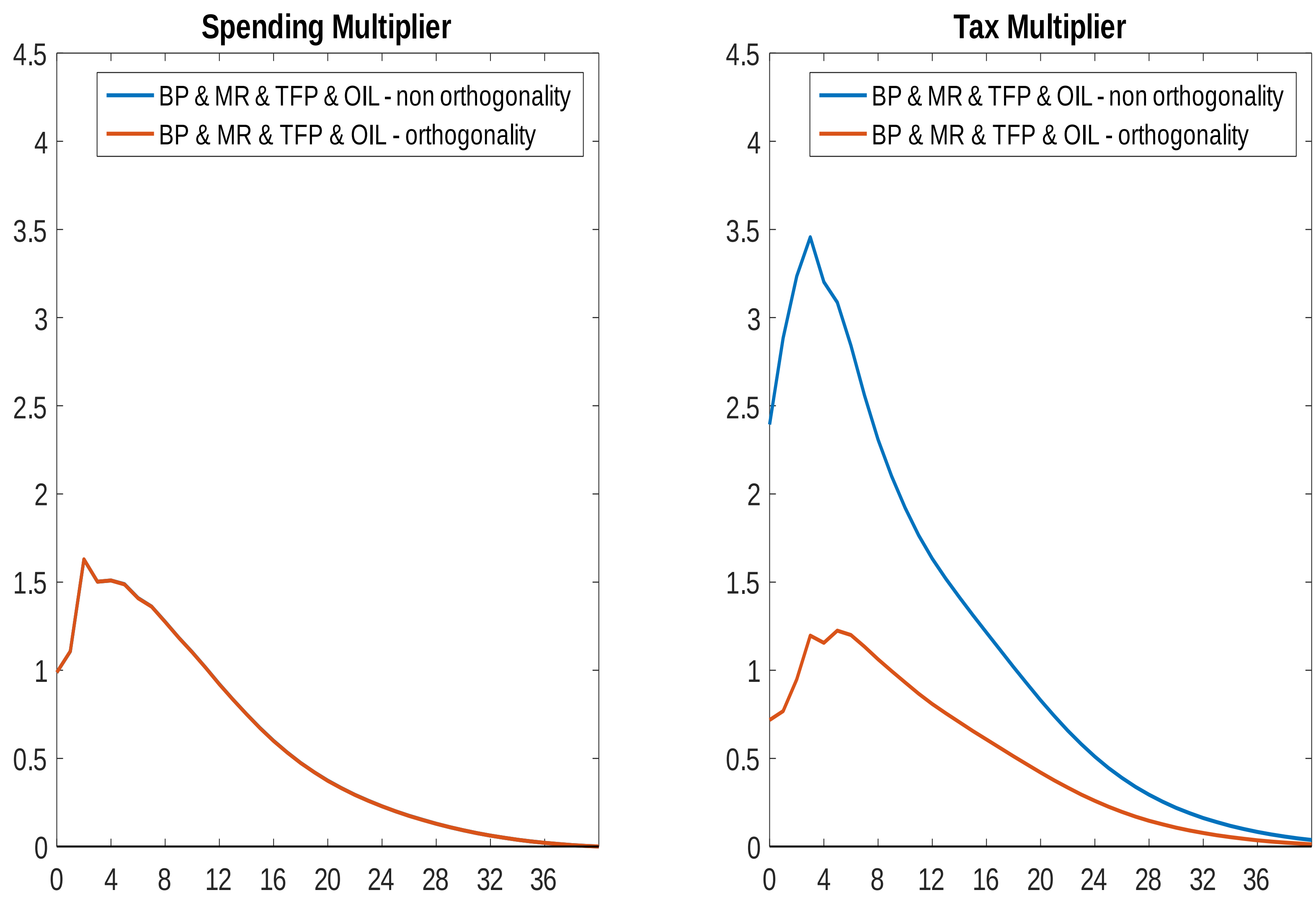

Figure 4: **Fiscal multipliers: Model with Monetary Policy.** Model with fiscal spending, taxes, output, inflation, 3-month Treasury bill rate. BP: Blanchard and Perotti's (2002) fiscal spending instrument. MR: Mertens and Ravn's (2012) tax spending instrument. TFP: Fernald's (2014) TFP instrument. OIL: Hamilton's (2003) instrument.

Instruments	Shocks	$F_t = (F_{1,t})$	$F_t = (F_{1,t}, F_{2,t}, F_{3,t}, F_{4,t})$
	$\hat{\varepsilon}_{Tax,t}$	0.1387	0.1263
BP only	$\hat{\varepsilon}_{g,t}$	0.7947	0.7823
	$\hat{\epsilon}_t$	0.3613	0.3205
	$\hat{\varepsilon}_{Tax,t}$	0.1414	0.1326
MR only	$\hat{\varepsilon}_{g,t}$	0.8028	0.7641
	$\hat{\epsilon}_t$	0.3719	0.3248
	$\hat{\varepsilon}_{Tax,t}$	0.3600	0.2697
TFP only - orthogonality	$\hat{\varepsilon}_{g,t}$	0.8942	0.5046
	$\hat{\epsilon}_t$	0.6843	0.4088
	$\hat{\varepsilon}_{Tax,t}$	0.0250	0.1128
TFP only - non orthogonality	$\hat{\varepsilon}_{g,t}$	0.6242	0.3856
	$\hat{\epsilon}_t$	0.1298	0.1983
	$\hat{\varepsilon}_{Tax,t}$	0.5020	0.2154
TFP & MR & BP- orthogonality	$\hat{\varepsilon}_{g,t}$	0.7911	0.7817
	$\hat{\epsilon}_t$	0.7457	0.4367
	$\hat{\varepsilon}_{Tax,t}$	0.1404	0.1323
TFP & MR & BP - non orthogonality	$\hat{\varepsilon}_{g,t}$	0.7913	0.7814
	$\hat{\epsilon}_t$	0.3746	0.3272

Table 2: **Informational sufficiency: Forni and Gambetti (2014) test.** P-values of F-tests reported in the Table. Per each shock or combination of shocks, we consider two scenarios: a) each fiscal shock regressed over a constant and the estimated factors (first two rows of each shock/combination of shocks); b) the vector of fiscal shocks regressed over constants and the estimated factors ((last row of each shock/combination of shocks). Two lags of the factors included in all cases.