

Restrepo-Ángel, Sergio; Rincón Castro, Hernán; Ospina-Tejeiro, Juan J.

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Multipliers of taxes and public spending in Colombia: SVAR and local projections approaches

Sergio Restrepo-Ángel^{1,*}, Hernán Rincón-Castro¹, Juan J. Ospina-Tejeiro¹

Banco de la República, Carrera 7 No. 14 -78 piso 11, Bogotá, Colombia

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ABSTRACT

This paper estimates and analyzes multipliers for tax revenue and public spending for Colombia using structural autoregressive vectors and local projections models. Quarterly series of the central national government between 2000Q1 and 2018Q4 are used. The results show fiscal multipliers that are less than unity when the state of the economy is not considered and a spending multiplier around unity when the economy is in an expansionary phase. The spending multiplier is greater and bigger than one during a contractionary phase, supporting the case for conducting countercyclical fiscal policy in this state. The tax revenue multiplier is negative and much smaller in magnitude than the spending multiplier. The results are robust to different identification schemes and estimation methodologies.

1. Introduction

Generally, authorities in advanced economies and emerging countries tend to increase public spending or reduce taxes when they face periods of economic slowdown or recessions. Questions arise about the sign and magnitude of the effects and the channels through which those decisions impact GDP, employment, and investment. Theoretically, there is no agreement on this. However, the Keynesian view illustrates the multiplier concept well: an increase in public spending increases aggregate demand, which leads to higher demand for labor and, therefore, higher wages and employment. Higher labor income stimulates consumption, which leads to even higher aggregate demand and, consequently, to a higher level of investment and employment, higher incomes, more consumption, and thus a virtuous spiral that multiplies. As Lopez-Vera et al. (2018) point out, “The factors mentioned above not only justify the importance of the workability of fiscal policy but also create the need to quantify the fiscal policy in order to provide information about its impact when performing an intervention.” Thus, the fiscal multipliers are known in the literature as the resulting sum of impacts on aggregate demand and GDP after a shock on government spending or tax revenue. This article aims to estimate the multipliers for Colombia, which will be useful, first, in creating economic analysis models and, second, to provide some elements to guide judgment fiscal and macroeconomic policy decision-making.

* Corresponding author.

E-mail addresses: srestran@banrep.gov.co (S. Restrepo-Ángel), hrincoca@banrep.gov.co (H. Rincón-Castro), jospinte@banrep.gov.co (J.J. Ospina-Tejeiro).

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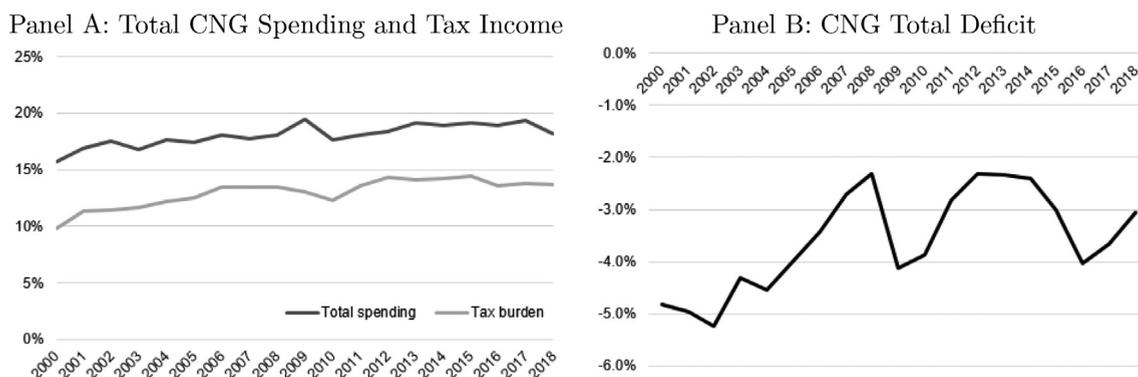


Fig. 1. Tax Burden, CNG Spending and Total Fiscal Deficit. Note: all series are presented as a percentage of nominal GDP. Source: Ministry of Finance; author's calculations.

Colombia is a small open economy in which the government and the short-term fiscal policy play a stabilizing role in the economic cycle. Therefore, knowing how much the movements of its instruments (taxes and expenses) impact economic activity, that is, having a measure of fiscal multipliers, becomes a central objective for fiscal policy decision-making. From the point of view of its role in the economy, the government's tax burden is around 14% of GDP, despite continuous reforms throughout the study sample. It is well below the average tax burden of the countries in the region (around 18% of GDP) and even lower than the average for OECD countries (around 20% of GDP). The size of the government, as measured by total central national government (CNG) spending as a share of GDP, is relatively small and has remained below 19% of GDP in recent years, with most of it going to cover the functioning of the state. The imbalance between taxes and expenditures has generated a government fiscal deficit maintained throughout the sample, with downward and upward trends (Fig. 1).

In recent years, international literature has explored whether the estimates of government tax or spending multipliers vary depending on the state of the economy. One branch of this literature analyzes the possibility that multipliers are different during low parts of the business cycle and recessions (for example, Auerbach and Gorodnichenko, 2012b; Bachmann and Eric, 2012; Baum and Weber, 2012, Auerbach 2013, Fazzari 2013, Riera-Crichton 2015, Lopez-Vera et al., 2018). In line with this literature, in a recent paper, Bournakis et al. (2022) identify low and high uncertainty regimes (associated with periods of high and low economic growth) within which the nature of the relationship between fiscal policy and capital intensity differs substantially. They show that, in a low uncertainty regime, fiscal tightening is either irrelevant or has a relatively small negative economic effect on the evolution of capital intensity. On the other hand, in a high uncertainty regime, the negative effect of fiscal tightening on capital intensity can be three times bigger in comparison to the effect in a low uncertainty regime. Another branch considers that monetary policy affects the size of multipliers. In this direction, new keynesian dynamic stochastic general equilibrium (DSGE) models show that, when interest rates remain close to the zero lower bound (ZLB), multipliers can be higher than in normal conditions (Christiano et al., 2011; Coenen and Günter, 2012; Cogan et al., 2010).

In Colombia, the study by Rincón et al. (2014) uses a DSGE model. It shows that the CNG multiplier on taxes is small and negative (-0.02, on impact). For spending, the authors distinguish two channels, depending on whether the cut is via reducing operating costs or investment costs. In the first case, the multiplier is 0.3, and in the second, it is -0.1. The study concludes that "shocks to fiscal policy are counteracted to a certain degree by monetary policy, but shocks to the latter come from fiscal policy" (Rincón et al., 2014), page 1).

In this document, we estimate point and cumulative multipliers for both taxes and spending at one and two years for Colombia. Their dynamics using impulse-response functions. The CNG's quarterly fiscal series for the period 2000Q1 to 2018Q4 are used. The econometric methodologies used are an SVAR identified by Blanchard and Roberto (2002), hereinafter referred to as the BP, and local projections (LP) and smoothed local projections (SLP), with and without transition variable. In accordance with Ramey and Zubairy (2018), the cumulative multipliers are calculated as described in detail in Section 2.3.

In this article, we follow Blanchard and Roberto (2002); Fisher et al. (2010); Mountford et al. (2009); Uhlig and Harald (2010), and, more recently, Ramey and Zubairy (2018), who assert that multipliers should be calculated as the integral (or cumulative sum) of the output response divided by the integral of the public expenditure response. Multipliers measured in this way effectively solve the relevant fiscal policy question, as they measure the cumulative gain in GDP relative to cumulative public spending over a given period. The SLP method was developed by Barnichon and Brownlees (2019). They use base B-spline functions to smooth the impulse response functions generated by the LP method, improving the estimators' efficiency and their interpretation.

The LP method was initially developed by Jordà (2005) and has been used in the literature that estimates fiscal multipliers (see Auerbach and Gorodnichenko, 2012a; Ramey and Zubairy, 2018; Vargas-Herrera et al., 2015), as well as in studies that evaluate the macroeconomic impacts of shocks to the prices of commodities such as oil (see Francis and Restrepo-Ángel, 2018). In the case of Vargas-Herrera et al. (2015), a series of public spending multipliers are estimated, taking the maximum of the output response and the initial public spending shock, following Blanchard and Roberto (2002).

As the LP method allows for the direct and explicit inclusion of fiscal shocks, we conducted two exercises: first, we used the series of structural spending and taxes shocks extracted from the SVAR according to the BP method. As we will see shortly, this

identification method assumes that spending and taxes do not respond contemporaneously to movements in GDP. In the second exercise, the series of structural shocks is derived from a narrative approach based on the behavior of CNG spending. In the latter case, we follow the methodology used by Vargas-Herrera et al. (2015). The expenditure shock is the difference between the spending projected in the CNG financial plans and the ex-post observed expenditure. Hereinafter, the shock identification methodology based on Vargas-Herrera et al. (2015) we will refer to VGL (which stands for the authors last names initials). The results of both exercises are similar, although they present some differences in magnitude, as will be seen and discussed in Section 4.

Additionally, we extend the LP methodology to estimate multipliers that depend on whether the economy is in a state of expansion or contraction. To achieve this, we follow the changes introduced by Auerbach and Gorodnichenko (2012a). This exercise shows that fiscal policy in Colombia has a considerable larger multiplier effect in contractionary than in expansionary phases.

The BP methodology was first applied to Colombian data by Restrepo and Rincón (2006), who used quarterly statistics of the non-financial public sector between 1990 and 2005. Subsequently, it was used by Campo Robledo (2007), who, like Lozano 2012, found that the GDP response to the spending shock is positive, although close to zero, and that the tax shock is also positive, which is counterintuitive. Ultimately, the methodology was applied by Restrepo (2020), who used quarterly statistics of the CNG between 1995 and 2017. Regarding the LP method, as far as we are aware, the only article that employs it to estimate fiscal multipliers in Colombia is that of Vargas-Herrera et al. (2015), although with the differences noted above. In Section 4, we will compare our results with those of the literature mentioned above.

Our main contributions consist of the identification of tax and spending shocks through two different methods (BP and VGL-narrative approach) applied to a single database in terms of public sector coverage and study period. Also, we provide estimates using three alternative econometric techniques (SVAR, LP, and SLP), which enables us to gauge the robustness of the results. The referenced literature uses one or another identification or estimation method for non-unified periods, which makes comparability difficult.

After this introduction, the article contains four additional sections. The second section describes the standard and smoothed LP and BP methodologies and presents the econometric models used to estimate the multipliers; the third details the data series used; the fourth presents and analyzes the results; the last section concludes and summarizes the main findings.

2. Econometric Methodology

2.1. Blanchard and Perotti

This subsection describes the methodology proposed by Blanchard and Roberto (2002) to identify and estimate the multipliers of CNG taxes and spending on GDP for Colombia. The estimates use a structural vector autoregressive (SVAR) model. As an extension of the BP methodology, the cumulative multipliers proposed by Ramey and Zubairy (2018) are also estimated. Quarterly information is used for the period 2000 to 2018.

Government spending and taxes impact GDP, except when it is assumed that agents are fully Ricardian. At the same time, they are correlated with themselves and with GDP. Therefore, to analyze the individual dynamic effects of taxes and spending on GDP, it is necessary to identify the structural changes individually. This is the first task that BP undertakes.

BP proposes a structural model for taxes and spending based on a reduced-form VAR model:

$$Y_t = A(L, q)Y_{t-1} + U_t, \quad (1)$$

where $Y_t = [T_t, G_t, GDP_t]'$, the three-dimensional vector of the logarithms of quarterly per capita taxes, spending, and real GDP, respectively. "Taxes" refer to total income net of interest on debt and transfers for both the CNG and the general government (GG). "Spending" corresponds to the sum of CNGs personal services, general expenses, and investment. The three-dimensional vector $U_t = [u_t^T, u_t^G, u_t^{GDP}]'$ contains the corresponding reduced-form errors. $A(L, q)$ is a polynomial of distributed lags of order $q = 4$ (four quarters) of the reduced-form endogenous variables of the model. A crucial element of this BP formulation is that it allows the coefficients in each lag to depend on the particular quarter q that the dependent variable indexes. According to BP, the reason for allowing the "quarterly dependence" of the coefficients is the presence of seasonal patterns in the response of taxes to GDP. Thus, for example, indirect taxes such as VAT or withholding taxes, in the case of Colombia, are paid with minimal or no delay in relation to the time of the transaction. However, other taxes, such as income or corporate, are paid with a significant lag with respect to the timing of their generation; furthermore, if payment is made in one or two specific quarters of the year (generally between the first and second quarters of the year in Colombia), the lag varies depending on the quarter. As an example, let us review the timing of the accrual and payment of corporate tax in Colombia: the tax is paid in the first two quarters of each year for profits that were accrued during the previous year. Thus, in the first two quarters of the year, income collections of the companies will depend on the previous years GDP, but in the final two quarters, there will be no collections, and therefore there will be no dependence between taxes and GDP in that period.

The BP method assumes that there is a linear relationship between the reduced-form errors and the structural model innovations (not observable) $\varepsilon_t = [\varepsilon_t^T, \varepsilon_t^G, \varepsilon_t^{GDP}]'$ such that:

$$u_t^T = a_1 u_t^{GDP} + a_2 \varepsilon_t^G + \varepsilon_t^T \quad (2)$$

$$u_t^G = b_1 u_t^{GDP} + b_2 \varepsilon_t^T + \varepsilon_t^G \quad (3)$$

$$u_t^{GDP} = c_1 u_t^T + c_2 u_t^G + \varepsilon_t^{GDP} \tag{4}$$

The first equation establishes that the tax forecast errors in quarter t (u_t^T) are contemporaneously related to errors in GDP forecast (u_t^{GDP}), the structural disturbances in spending (ε_t^G), and the structural disturbances of the taxes themselves (ε_t^T). A similar interpretation applies to the spending forecast errors, u_t^G , in the second equation. The third establishes that the forecast errors of GDP in quarter t (u_t^{GDP}) are explained by the forecast errors of spending (u_t^G) and taxes (u_t^T) and by the quarter's own structural disturbances (ε_t^{GDP}). The coefficients measure the degree of impact of the shocks on the respective forecast errors.

The system defined by equation (1), together with the identification strategy defined by equations (2) to (4), can be expressed in matrix form (as in Restrepo and Rincón (2006) and Restrepo (2020), with slight changes in the order and notation of the system):

$$\begin{bmatrix} u_t^T \\ u_t^G \\ u_t^{GDP} \end{bmatrix} = \begin{bmatrix} 1 & 0 & -a_1 \\ 0 & 1 & -b_1 \\ -c_1 & -c_2 & 1 \end{bmatrix}^{-1} \begin{bmatrix} 1 & a_2 & 0 \\ b_2 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^T \\ \varepsilon_t^G \\ \varepsilon_t^{GDP} \end{bmatrix} \tag{5}$$

Note that the first two matrices on the right-hand side of equation (5) make it possible to obtain the estimators of the structural parameters of the model and constitute the input for constructing the impulse response functions to tax and spending disturbances. Also, as in Restrepo and Rincón (2006), notice that the elements of the main diagonal of matrix B are equal to 1. This means that the variances of the structural shocks are assumed to be equal to 1.

Now, as the SVAR system defined by equation (5) contains more parameters than the reduced-form VAR system in equation (1), it is required to impose restrictions on some of the structural parameters in order to identify the system and estimate the remaining coefficients. Thus, the central question is how to identify the structural innovations of taxes and spending. The answer to this question is the main contribution of BP's proposal. In order to achieve this objective, the restrictions that will be imposed come from the arrangements of particular fiscal institutions of the country under study. Therefore, the identification methodology of the system defined by equations (1) to (5) and formulated by BP follows three steps.

First, the parameters a_1 and b_1 are estimated. These are, the elasticities of taxes and spending to changes in economic activity (measured by GDP) using auxiliary regressions. With respect to a_1 , it is clear that GDP impacts tax collections because most move along with its behavior through the so-called "automatic stabilizers." The same does not happen with spending since, in Colombia, there are not unemployment subsidies that depend on economic activity. The regression to estimate a_1 specifies taxes as a dependent variable and, as explanatory variables, the GDP, lags of GDP (which control for the lag in some tax collection such as corporate income tax), lags of taxes, qualitative seasonal variables due to seasonality of the quarter to which the dependent variable is indexed ("quarterly dependence"), and a measure of the terms of trade, which controls for the effects of external shocks that impact local economic activity. The dependence of spending on GDP is ruled out first, because of what was mentioned above, and second, because this is predetermined by the financial budgets approved in past quarters. Therefore, it is assumed that $b_1 = 0$. Furthermore, Colombian tax authorities have treated spending as "structural" since the beginning of the implementation of the fiscal rule in 2012 and, in particular, since 2014, the year in which compliance with a specific deficit target was required.

It should be noted that the coefficients a_1 and b_1 also capture the effect of economic activity on taxes and spending by means of discretionary adjustments of the tax authority in the face of unexpected events that occurred in quarter t . However, BP discards this transmission channel, as do we given how institutionality functions in the United States (as studied by BP) and in Colombia, which generally prevents both fiscal and legislative authorities from being able to observe current period shocks in economic activity, make decisions, and implement them during the same quarter.

Second, parameters c_1 and c_2 are estimated in three steps. In the first, the reduced-form system is estimated in (1), and forecast errors are obtained for each of the endogenous variables (the \hat{u}_t^s , $s = T, G, GDP$). In this step, the terms of trade are included as an exogenous variable. In the second, forecast errors of taxes and spending are adjusted for the GDP, that is, $u_t^T = \hat{u}_t^T - \hat{a}_1 \hat{u}_t^{GDP}$ and $u_t^G = \hat{u}_t^G - b_1 \hat{u}_t^{GDP} = \hat{u}_t^G$ (remember that it is assumed that $b_1 = 0$). In the last step, and since u_t^T and u_t^G could still be correlated with each other but are no longer correlated with ε_t^{GDP} , they are used as instruments in equation (4) to estimate the parameters c_1 and c_2 . This step includes other instruments, such as the lags of the dependent variable and lags of the tax and expense instruments.

Third and last, it is necessary to know the values of the parameters a_2 and b_2 . A priori, and as BP points out, their identification is unclear if the fiscal authority changes taxes and spending discretionally and simultaneously. Are expenditures responding to the change in taxes ($b_2 \neq 0$ and $a_2 = 0$) or the opposite ($a_2 \neq 0$ and $b_2 = 0$)? Note that, if the frequency of the data were annual, this question could be answered directly. For Colombia since 2012, the structural fiscal rule for the CNG first establishes the goal of "structural income" and then the spending budget that is consistent with it. That is, we are restricted to the first situation. Of course, if one looks at the fiscal situation of the last three decades, the upward trend of public spending, and the continuous tax reforms, it could also be said that we have been restricted to the second situation. Now, as the information is quarterly, one could lean towards the latter scenario since spending might have been adjusted in some quarters due to an unexpected shock in economic activity. All of the above might not apply to taxes due to the institutional rigidities discussed above, which apply to Colombia and the United States. Faced with these possible scenarios, BP identified the model using two alternative assumptions. First, BP assumes that tax decisions are made first, in which $a_2 = 0$ and b_2 is estimated. Conversely, BP assumes that spending decisions are made first, such that $b_2 = 0$ and a_2 is estimated. Our exercises estimate the first alternative, based on the discussion above.

Before proceeding further, it should be noted that BP's methodology has been subject to various criticisms. First, the methodology assumes that the model parameters are state and shock independent, an assumption that the literature has reevaluated (Auerbach

and Gorodnichenko, 2012a; Christiano et al., 2011; Ramey and Shapiro; Ramey, 2011; Romer and Romer, 2010), Auerbach 2013, (Coenen and Günter, 2012; Fazzari et al., 2015; Ramey and Zubairy, 2018). Second, Ramey and Zubairy (2018) argue that taking logarithms of the variables of interest and using a conversion factor ex-post to transform elasticity into a multiplier, as BP does, biases its value upward. Therefore, the authors propose using the Gordon and Robert (2010) transformation, which directly divides the levels of endogenous variables by trend GDP, which makes it possible to obtain variables in the same units. To avoid this bias, when we estimate multipliers with local projections, the adjustments suggested by Barro and Redlick (2011); Hall (2009) and Ramey and Zubairy (2018), explained later on, will be incorporated. Third, both the BP methodology and the one proposed by Ramey and Zubairy (2018) assume a linear world. However, non-linearities on both magnitude and direction of fiscal shocks can be of relevance when analyzing the impact of fiscal policy on economic activity. Fourth, neither BP nor Ramey and Zubairy (2018) nor the literature on Colombia reported in the introduction take into account that the impact of fiscal disturbances on economic activity depends on the type of taxes or spending that is changing, as shown by Auerbach and Gorodnichenko (2012a) for the United States and Rincón et al. (2014) for Colombia. In other words, they do not consider the different channels through which shocks to fiscal policy are transmitted throughout the economy. Finally, they do not consider the effects of uncertainty about fiscal policy on economic activity and hence on multipliers, which as shown by Fernández-Villaverde et al. (2015) for the United States and Delgado-Rojas and Rincón-Castro (2017) for Colombia, are not negligible.

Given the pitfalls mentioned above and criticisms of BP's methodology, we use alternative methodologies that address the first two issues in the following subsection. These alternative methodologies will enable us to calculate alternative multipliers, compare them with those obtained with the BP method and contrast the differences. In any case, BP is a good benchmark to start with.

2.2. Local Projections

This subsection describes and analyzes Jordà (2005) LP method for estimating impulse response functions and cumulative fiscal multipliers to address some of the criticisms of the BP method mentioned above. Gorodnichenko (2012) was the first to use this technique to estimate multipliers for OECD member countries. It was recently used by Ramey and Zubairy (2018) to investigate whether the multipliers of US government spending are higher during periods of low economic activity or during periods when interest rates are close to the “zero lower bound.” According to Jordà (2005), the standard local projections regression model, which we call LP, can be estimated by ordinary least squares. They provide an appropriate inference (individual or joint) that does not require asymptotic approximations or numerical techniques for its calculation. It is robust to a wrong specification of the data generating process and adapts easily to non-linear specifications, which are often impractical or not viable in a multivariate context. Since LP models can be estimated using univariate equations methods, they can be easily calculated with available standard regression packages and thus become a natural alternative for estimating impulse response functions of VAR models. LP requires the estimation of a series of regressions for each horizon h and each variable. Following the notation of Ramey and Zubairy (2018), the linear model is as follows:

$$x_{t+h} = \alpha_h + \psi_h(L)z_{t-1} + \beta_h shock_t + \gamma t + \varepsilon_{t+h} \text{ for } h = 0, 1, 2, \dots, 8 \quad (6)$$

where x corresponds to the variable of interest between $\{GDP, G, T\}$, z is a vector of control variables, $\psi_h(L)$ is a polynomial of order 4 in the lag operator, and the shock $shock_t$ corresponds to the fiscal shocks identified and described in Appendix 7.2 and by the methodology of BP, ε_t^G and ε_t^T . Our vector of control variables, z , includes deviations with respect to the trend value of real GDP (seasonally adjusted and adjusted for calendar effects) and CNG spending. Additionally, lags of the identified fiscal shock are included to control for any serial correlation. The coefficient β_h gives the response of x in the period $t+h$ to the shock at t . We construct the impulse-response functions as the sequence of β_h estimated in a series of regressions for each horizon. The only complication associated with Jord's method is the serial correlation of the error terms induced by the successive advance of the dependent variable. Therefore, to address this, we use the correction proposed by Newey et al. (1987).

LPs are easily adapted to the estimation of a state-dependent model. For this, we estimate a set of regressions for each horizon h as follows:

$$x_{t+h} = G(z_t) [\alpha_{A,h} + \psi_{A,h}(L)z_{t-1} + \beta_{A,h} shock_t] + (1 - G(z_t)) [\alpha_{B,h} + \psi_{B,h}(L)z_{t-1} + \beta_{B,h} shock_t] + \gamma t + \varepsilon_{t+h} \quad (7)$$

where $G(z_t)$ is a transition function that takes values between zero and one and indicates which state the economy is in when the shock occurs. We allow the model coefficients, except the deterministic trend, to vary according to $G(z_t)$. The function $G(z_t)$ corresponds to the transition variable defined according to Auerbach and Gorodnichenko (2012a). It corresponds to the normalized centered average of order seven (three forward-looking and four backward-looking quarters) of real GDP in deviations of its trend value. Therefore, once the shock occurs, the forecast of x_{t+h} might differ according to the state of the economy. In addition to the specific advantages for estimating multipliers in the state-dependent exercise that we will analyze later, Jord's method does not restrict the shape of the impulse-response function, making it less sensitive to an incorrect specification (as could be the case with an SVAR). It also does not require all variables to go into all equations, so a more parsimonious specification can be used. A third advantage is that the variables in the regression model do not need to have the same order of integration (or be co-integrated) as the variables on the right-hand side. As we will explain later, this is a significant advantage over a standard SVAR in this particular context.

It is worth noting that the LP method is not necessarily superior to the standard SVAR method for calculating impulse response functions. First, because LP does not impose any constraints linking impulse responses at h and $h+1$, responses are often erratic due to loss of statistical efficiency. Second, as the horizon increases, the end-of-sample observations are lost. Finally, LP impulse

responses sometimes show abrupt oscillations over very long horizons. Ramey (2011) compares the estimated impulse response functions using Jordà’s method versus a standard VAR and a dynamic simulation, such as the one used by Romer and Romer (2010), that is based on fiscal shocks originated in the news about military spending in the economy of the United States. The results are qualitatively similar for the first 16 quarters, although LP responses tend to be more erratic. However, over longer horizons, LPs tend to produce statistically significant oscillations that are not observed with the other two methods. Since the interest of this article lies in shorter-term responses (eight quarters), long-term estimates do not represent a significant concern.

2.2.1. Smooth Local Projections

The non-parametric nature of LP generates efficiency costs. In practice, the LP estimator can suffer from significant variability, which is manifested in erratic behavior of the impulse response functions. To solve these drawbacks, we follow the work of Barnichon and Brownlees (2019). They introduce B-spline smoothing functions to implement the methodology of smoothed local projections, which we will refer to as SLPs. This method preserves the flexibility of local projections, substantially increases accuracy, and is simple to implement.

According to Barnichon and Brownlees (2019), the coefficient β_h of equation (6) is approximated by a B-spline linear basis function for the forecast horizon h . Thus:

$$\beta_h \approx \sum_{k=1}^K b_k B_k(h) \tag{8}$$

where $B_k : \mathbb{R} \rightarrow \mathbb{R}$ for $k = 1, \dots, K$ is a set of base B-spline functions and b_k for $k = 1, \dots, K$ is a set of scalar parameters. Generally, a relatively high K value is used to ensure that the bias that could be caused by the approximation is minimized. In a similar way, we proceed to do the same with α_h and ψ_h , with which equation (6) would be approximated by:

$$x_{t+h} \approx \sum_{k=1}^K \alpha_k B_k(h) + \sum_{i=1}^p \sum_{k=1}^K \psi_{ik} B_k(h) z_{it} + \sum_{k=1}^K \beta_k B_k(h) shock_t + \gamma t + \varepsilon_{(h)t+h} \text{ where } h = 0, 1, 2, \dots, 8 \tag{9}$$

Following the definition of Barnichon and Brownlees (2019), the B-spline functions are basis functions with a “hump” shape, indexed by a set of nodes.² A B-spline basis function is composed of $q + 1$ polynomial components of order q . These polynomials join in a set of $q + 2$ internal nodes and are calibrated so that the derivatives up to order $q - 1$ are continuous at the internal nodes. The B-spline basis function is nonzero over the domain spanned by the $q + 2$ internal nodes and zero elsewhere. The leftmost internal node is used to index the B-spline function, and the order of the polynomials determines the order of the basis (if the polynomial components are of order q , the basis B-spline is said to be of order q). In this document, cubic B-splines are used with equidistant nodes between -2 and 7, with unit increments.³

Equation (9) can be compactly expressed as the following linear model:⁴

$$\mathcal{Y}_t = \mathcal{X}_t \beta + \mathcal{U}_t \tag{10}$$

where \mathcal{U}_t denotes the regression prediction error vector $d \times 1$. The estimation of smooth local projections is carried out through the generalized ridge estimation:

$$\begin{aligned} \hat{\theta} &= \arg \min_{\theta} \left\{ \|\mathcal{Y} - \mathcal{X}\beta\|^2 + \lambda \theta' \mathbf{P} \theta \right\} \\ &= (\mathcal{X}' \mathcal{X} + \lambda \mathbf{P})^{-1} \mathcal{X}' \mathcal{Y} \end{aligned} \tag{11}$$

where \mathbf{P} is a positive semi-defined penalty matrix and λ is a contraction parameter that determines the trade-off between bias and variance of the estimator $\hat{\theta}$: when λ is 0, the estimator coincides with the least squares (without bias but potentially large variance), whereas when $\lambda > 0$, $\hat{\theta}$ is biased but has a smaller variance than the least squares estimator. Like in Barnichon and Brownlees (2019), λ is selected using a k-fold cross validation.

2.3. Considerations for the calculation of multipliers

In this subsection, we highlight two potential problems that directly affect multipliers calculated from non-linear VARs and all standard linear SVARs used in the literature, such as the one estimated by BP, which we discussed previously in Section 2.1. The first problem concerns the conversion of elasticities to multipliers. The usual practice in the literature is to use the logarithm of variables such as real GDP, public spending, and taxes. However, the estimated impulse response functions do not directly reveal the multiplier because they are elasticities. Generally, what the literature does is convert the estimated elasticities into a monetary equivalent, using an ex-post conversion factor based on the sample average of the relationship between GDP and public spending (G) or taxes (T): GDP/G or GDP/T . The problem with this methodology is that the multiplier will possibly be biased, and its degree will depend on the historical behavior of the GDP/G or GDP/T (Ramey and Zubairy, 2018).

To avoid this bias, we estimate the multipliers using the BP methodology and calculate the cumulative ones as in Ramey and Zubairy (2018). When the LP are used, we incorporate the adjustments suggested by Barro and Redlick (2011); Hall (2009), and

² See Boor (1978) for an explanation of B-splines and Eilers and Marx (1996) for a summary of their properties.

³ It is derived from $h_{min} - 2$ to $h_{max} - 1$ where $h = 0, 1, 2, \dots, 8$.

⁴ See Barnichon and Brownlees (2019) for a more detailed mathematical derivation.

those recently introduced by Ramey and Zubairy (2018). In this case, we convert changes in both GDP and public spending to the same units before calculating. In particular, we define the variables Y on the left side of equation (1) as $gdp_t = \frac{GDP_t}{\overline{GDP}_t}$ and $g_t = \frac{G_t}{\overline{GDP}_t}$, where GDP_t corresponds to real GDP (seasonally adjusted and adjusted for calendar effects) and \overline{GDP}_t to trend GDP, obtained by applying a Hodrick-Prescott filter to GDP_t .

The second problem is the definition of the multiplier in a dynamic environment. The original document by Blanchard and Roberto (2002) defined the multiplier as the relationship between the maximum of the product response and the initial shock of public spending. Several articles have used this same definition, or variations, as the average GDP response to the initial shock to government spending (Auerbach and Gorodnichenko, 2012a) Auerbach 2013. According to Mountford et al. (2009); Uhlig and Harald (2010), and Fisher et al. (2010), the multipliers must be calculated as the integral of the GDP response divided by the integral of the public expenditure response. The multipliers measured in this way effectively solve the relevant fiscal policy question, as we do later because they measure the cumulative gain in GDP relative to cumulative public spending over a given period. For the case of local projections, the cumulative multiplier is easy to calculate using instrumental variables (IV) in one step. For the linear case, the following equation is estimated:

$$\sum_{j=0}^h gdp_{t+j} = \gamma_h + \phi_h(L)z_{t-1} + m_h \sum_{j=0}^h g_{t+j} + \omega_{t+h} \text{ for } h = 0, 1, 2, \dots, 7 \tag{12}$$

using $shock_t$ as an instrument for $\sum_{j=0}^h g_{t+j}$. Here, $\sum_{j=0}^h gdp_{t+j}$ is the sum of GDP from t to $t+h$ and $\sum_{j=0}^h g_{t+j}$ is the sum of government spending from t to $t+h$. This estimate is equivalent to (i) estimating equation (6) for GDP for each horizon j to h and then adding the β_j ; (ii) estimating equation (6) for G for each horizon j to h and then adding the β_j ; (iii) calculating the multiplier as the division of the result in (i) by the result (ii), $m_h = \frac{\sum_{j=0}^7 \beta_{j,h}^{GDP}}{\sum_{j=0}^7 \beta_{j,h}^G}$.

Additionally, performing the IV estimation as described above entails the following additional advantages: First, the standard error for m_h is estimated directly and second, coefficient estimates for both $shock_t$ and G are unbiased despite possibly having measurement error (as long as they are not correlated).

Similarly, for the state-dependent case, we estimate the following equation:

$$\sum_{j=0}^h gdp_{t+j} = G(z_{t-1}) \left[\gamma_{A,h} + \phi_{A,h}(L)z_{t-1} + m_{A,h} \sum_{j=0}^h g_{t+j} \right] + (1 - G(z_{t-1})) \left[\gamma_{B,h} + \phi_{B,h}(L)z_{t-1} + m_{B,h} \sum_{j=0}^h g_{t+j} \right] + \omega_{t+h} \text{ for } h = 0, 1, 2, \dots, 7 \tag{13}$$

where $G(z_{t-1}) \times shock_t$ and $(1 - G(z_{t-1})) \times shock_t$ are used as instruments for the respective interactions of cumulative government spending with the two state indicators. The resulting multipliers $m_{A,h}$ and $m_{B,h}$ are the same as those calculated following the three steps described above.

3. Data

This study uses the Colombian CNG’s quarterly series of income and expenses from 2000 to 2018 taken from the Ministry of Finance and Public Credit and Banco de la República. During this period Colombia adopted an inflation targeting regime for monetary policy with a flexible exchange rate. We calculated all estimations with quarterly data instead of annual data to employ the BP methodology and capture the reactions of economic agents to news of the fiscal and macroeconomic environment in a timely manner.

In Appendix 7.1 we show the figures of the series used in both BP and LP methodologies. In Appendix 7.4 we show the unit root tests. The GDP and the fiscal series were seasonally adjusted using the Census X-12 method. The series are listed below.

- **GDP:** Real and seasonally adjusted gross domestic product expressed as a deviation from the trend component extracted by applying a Hodrick-Prescott filter.⁵ Source: National Administrative Department of Statistics (DANE).
- **CNG Spending:** The sum of CNG’s personal services, general expenses, and investments. It is expressed in real terms using the GDP deflator and as a percentage of the real GDP trend. Source: Colombia’s Ministry of Finance and Public Credit and Banco de la República.
- **Taxes:** Total CNG’s income net of interest for debt and transfers⁶ expressed as a percentage of the real GDP trend. This variable was chosen from the available data, emphasizing that there may be limitations in the analysis due to changes in the tax base or tax rates. Source: Colombia’s Ministry of Finance and Public Credit.

⁵ With $\lambda = 1,600$ corresponding to quarterly data.

⁶ The motivation behind constructing the “taxes” in this way is to capture the net income that the government obtains from the economy, including it taxes and rents and returns interest and transfers. Unlike the US tax statistics used by BP, whose government does not own companies and therefore does not receive dividends and only considers tax income in its calculations, we include both tax and non-tax income. Among them are dividends received from national public companies. The justification is that it is income extracted from the economy that otherwise would be used to finance the expenses of such companies.

Table 1
Estimated parameters of the SVAR model.

Dependent Variable: T	Coefficient	Sample: 2001:I-2018:IV
Y	$a_1 = 3.5656$	Elasticity of net taxes to changes in GDP
u_t^T	$c_1 = -0.0014$	Elasticity of GDP to changes in net taxes
u_t^G	$c_2 = 0.0175$	Elasticity of GDP to changes in spending

- **GDP Deflator:** Used to express all nominal variables in real terms. Source: National Administrative Department of Statistics (DANE).
- **Dif COL-USA:** Differences in policy interest rates between Colombia and the United States. Source: US Federal Reserve and Banco de la República.
- **Terms of Trade:** The specification used in this document corresponds to the Terms of Trade Index (2000=100) according to the Producer Price Index (PPI) methodology. It is calculated as the quotient between the price index of exported goods and the price index of imported goods. According to ISIC Rev. 4, these indices are obtained by adding the price indices of different economic activities, weighted by foreign trade figures.⁷ The unit root tests indicate that the series is $I(1)$ (see Appendix 7.4) and that the first difference is taken and used in both LP and BP methodologies. Source: Banco de la República.
- **EMBI:** Corresponds to the Emerging Markets Bond Index (EMBI) for Colombia. Source: *mbÁito* magazine.

In order to control for the effects of external shocks on internal economic activity and fiscal variables, the VAR and SVAR systems of the BP methodology include exogenous dummy variables that control for the tax reforms made in Colombia throughout the study period. Those variables are constructed from [Delgado-Rojas and Rincón-Castro \(2017\)](#) compilation reported in Appendix 1 of their study based on atypical series observations.

Both the LP and SLP methodologies require definitions of exogenous public spending shock ($shock_t$), that meets the criteria of non-anticipation and no contemporaneous correlation with the GDP. The shock is calculated as the difference between real spending executed by the CNG (total expenses excluding payment of interest on public debt) and the forecast for this variable in the Ministry of Finance's financial plans. Appendix 7.2 specifies the details of its construction, which follows [Vargas-Herrera et al. \(2015\)](#) methodology.

4. Results

4.1. Blanchard and Perotti

As highlighted by BP, one of the implications of quarterly dependency is that the effects of fiscal policy vary depending on the quarter in which the shock occurs. This implies that impulse response functions should be obtained for each quarter in which the shock occurred. Therefore, the authors use a more straightforward calculation that consists of estimating a quarter-dependent VAR of the system of equations provided by equations (2) to (4) and obtaining the variance-covariance matrix and the coefficients (elasticities). Notably, instead of directly presenting the elasticities, BP defines and calculates the contemporaneous multipliers as the response of GDP (in dollars) to a change of \$ 1 in the fiscal variable, evaluated at the average value of the respective variables. In other words, to convert the elasticities into multipliers, they ex-post use the sample average of the ratio of GDP to each of the fiscal variables: $G\bar{D}P/\bar{T}$ or $G\bar{D}P/\bar{G}$. The multiplier is expressed in dollar terms. Alternatively, BP carries out the previous exercise with no quarterly dependence in order to characterize the response of USD GDP to a fiscal shock of one dollar over time. The multiplier is defined as the ratio of the highest GDP response to the initial unitary fiscal shock.

4.1.1. System Parameters

[Table 1](#) shows the results of the estimated elasticities or parameters of the SVAR system. In contrast to our results, [Restrepo and Rincón \(2006\)](#) estimated that in Colombia the elasticities of net taxes to GDP were 1.87, GDP to net taxes was -0.002, and spending was 0.025, respectively. The most significant difference between our parameters and the ones estimated by [Restrepo and Rincón \(2006\)](#) is in the elasticity of taxes to changes in GDP. Our estimates show that CNG taxes are more sensitive to output changes than the non-financial public sector (NFPS). This result was expected because some of the most regional territorial taxes, which are part of the NFPS income, depend on the behavior of taxes on assets (household property and vehicles) and not on flows (GDP), as it is the case for national taxes (VAT and income). For Chile, [Restrepo and Rincón \(2006\)](#) estimated elasticities of 3.03, -0.034, and 0.165, respectively. BP's results for the United States from 1947 to 1997 were estimated as 2.08, -0.0014, and 0.0175, respectively.

4.1.2. Impulse Response Functions

The impulse response functions (IRFs) are shown in [Figures 2 and 3](#). [Fig. 2](#) represents the Colombian pesos, (COP) response of net taxes, CNG Spending, and GDP to a non-anticipated \$1 increase in net taxes and CNG spending. [Fig. 3](#) shows the cumulative

⁷ For more details, see the methodology of calculation at https://www.banrep.gov.co/sites/default/files/paginas/Nota_metodologica_terminos_intercambio_IPP.pdf.

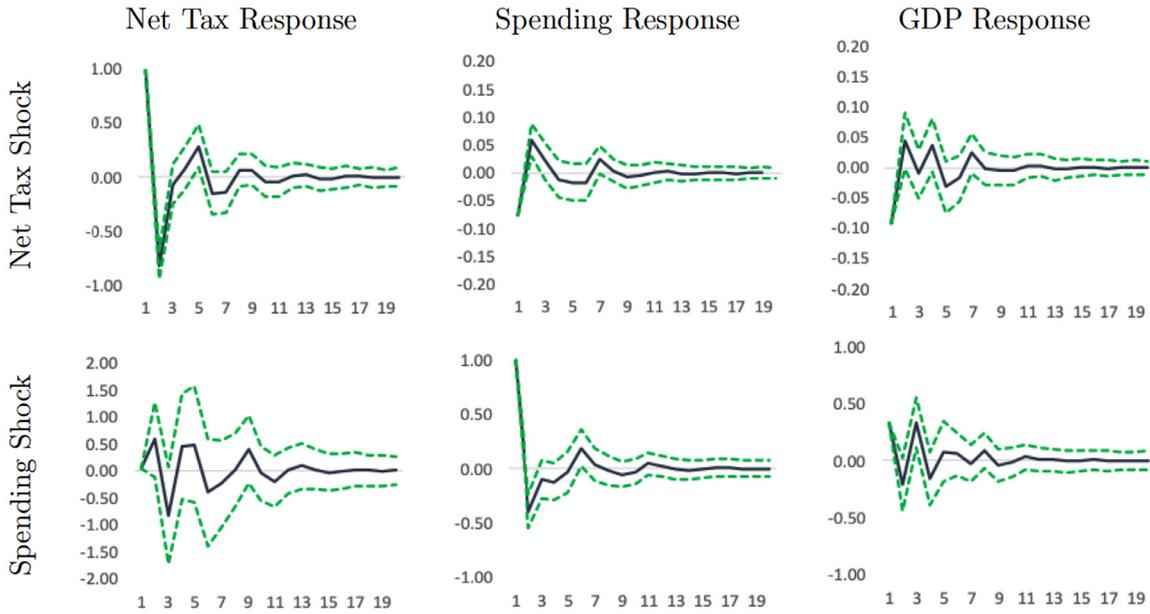


Fig. 2. IRF of SVAR Variables in first differences. Note: The IRFs in this graph directly report the evolution of the multipliers after the estimated elasticities were converted into an equivalent in COP using a conversion factor consisting of the sample average of the relationship between GDP and taxes (or the GDP and spending), as in BP. The IRF reports multipliers in COP to a change of \$1 in the fiscal variable. The latter is then evaluated using the sample average.

Table 2
Tax and Spending Multipliers.

GDP response to COP \$1 shock in T			GDP response to COP \$1 shock in G		
BP	Cumulative (equation (6))		BP	Cumulative (equation (6))	
Lowest	1 year	2 years	Highest	1 year	2 years
-0.09	-0.10	-0.16	0.33	0.75	0.89

Note: The BP multiplier has the lowest response in magnitude (negative values) of GDP before a tax shock. For CNG spending, the BP multiplier corresponds to the highest GDP response in the face of a spending shock. The cumulative multipliers expressed by equation (12) correspond to the definition introduced by Ramey and Zubairy (2018).

responses; solid lines represent the responses, and dotted lines represent the 90% confidence intervals. Fig. 2 indicates that, in the face of a tax shock, CNG spending and output are reduced immediately and up to the second quarter, as shown by the confidence intervals; after this, the responses become statistically insignificant. Fig. 3 shows that the cumulative responses for CNG spending stabilize around zero and GDP stabilizes at 5 cents; both become statistically insignificant after the second or third quarter.

Fig. 2 reports that in the face of a spending shock of \$1, taxes do not react, but GDP increases significantly by 45 cents immediately and in the third quarter. Fig. 3 indicates that the GDP response stabilizes around 45 cents but is only statistically significant in the first and third quarters. These results might indicate that the GDP response to the CNG spending shock is transitory.

We performed two additional exercises. The first consisted of alternatively assuming that $b_2 = 0$ and a_2 are estimated and making spending and tax decisions based on these estimates. Similar to BP, the results showed that the taxes multiplier is reduced by 2 cents and the cumulative multiplier is reduced by 12 cents on average. The spending multiplier increases by about 10 cents for both impact and cumulative. The second exercise consisted of directly using the definition of net taxes similar to BP for the United States and Restrepo and Rincón (2006) for Colombia. The tax income is added to the financial returns and then subtracted from the debt interest and transfers. Then the models are estimated again. In this case, the tax multiplier becomes more positive and is reduced by 8 cents in absolute value. On average, the cumulative tax multiplier was reduced by 6 cents in absolute value. The spending multipliers increased by 13 cents and the cumulative multipliers increased by 40 cents on average.

4.1.3. Multipliers

Table 2 reports the multipliers estimated and expressed in COP. The general conclusion derived from the estimates is that the multipliers are less than one, particularly for taxes, which are modest.

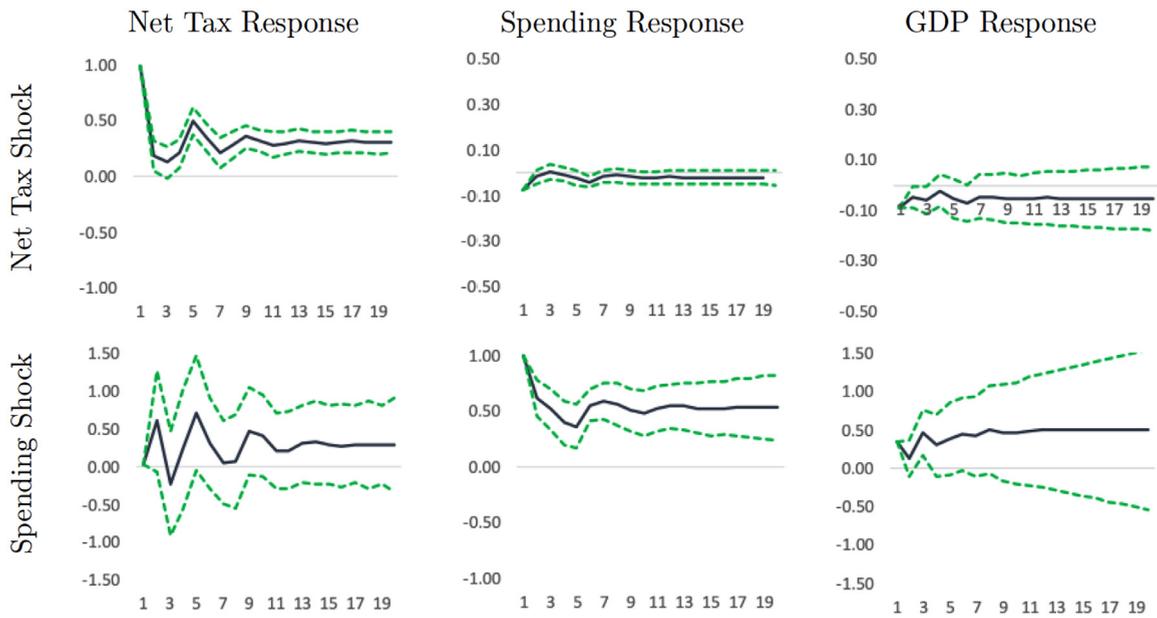


Fig. 3. Accumulated IRF from SVAR Variables in first differences. Note: The IRFs in this graph directly report the evolution of the multipliers after the estimated elasticities were converted into an equivalent in COP using a conversion factor consisting of the sample average of the relationship between GDP and taxes (or the GDP and spending), as in BP. The IRF reports multipliers in COP to a change of \$1 in the fiscal variable. The latter is then evaluated using the sample average.

The BP multiplier for taxes is -0.09, implying that a tax increase of \$1 decreases GDP by about 10 cents. Restrepo and Rincón (2006) found that this multiplier was equal to zero, whereas Lozano and Rodríguez (2011) estimated it as positive and equal to 0.6, contrary to expectations. For Chile 2006 estimated the tax multiplier at -0.4; however, Restrepo (2020) estimated it at -0.75. For the United States, BP estimates the multiplier at -0.78 or -1.33, depending on whether the SVAR model is estimated with a deterministic or stochastic trend. The cumulative multipliers estimated in Ramey and Zubairy (2018), reported in Table 2, and defined in equation (6) indicate that a \$1 tax increase reduces GDP between 10 and 16 cents in one and two years, respectively. On the other hand, Restrepo (2020) estimates the cumulative multiplier of taxes for Colombia at -3.03 in the eighth quarter and highlights that the multipliers for Colombia are the highest out of the study's sample of Latin American countries (Brazil, Chile, Colombia, Mexico, Paraguay, Peru, the Dominican Republic, and Uruguay).

The spending multiplier that uses BP's methodology is 0.33, which implies that an increase in spending of \$1 increases GDP by 33 cents. Restrepo and Rincón (2006) estimated it at 0.15, Lozano and Rodríguez (2011) at 0.76, and Restrepo (2020) at 1.01. The cumulative multipliers reported in Table 2 indicate that a \$1 increase in spending increases GDP between 75 and 89 cents in the fourth quarter (1 year) and the eighth quarter (2 years). Restrepo (2020) estimated the cumulative spending multiplier for Colombia at 1.89 after two years. Notably, our estimated BP spending multiplier is lower than the cumulative multiplier (contrary to Ramey and Zubairy, 2018) but in line with Restrepo, 2020. One can argue that the differences in our results could be explained by different definitions of the variables "taxes" and "spending" that were used. We strictly followed BP's definitions.

4.2. Local Projections

4.2.1. Standard Local Projections

In this subsection, we describe the results of the LP multiplier estimates. First, we consider the linear model results shown in equation (12), assuming that the multipliers are invariant to the state of the economy. Second, we show the results for the state-dependent model described by equation (13), which discriminates if the economy is in an expansionary or contractionary state. Both models (linear and state-dependent) are estimated for disturbances in the structural spending and tax shocks identified with the BP method (see equation (5)) and for the spending shock constructed by Vargas-Herrera et al. (2015), referred to as VGL and updated for this study. All of the results displayed 90 percent confidence intervals and were corrected for serial autocorrelations using the Newey-West methodology. The states are defined according to the transition variable proposed by Auerbach and Gorodnichenko (2012a) (see Section 2.2). For control variables, we used a time trend, four lags of GDP, CNG's spending, the terms of trade index, the EMBI Colombia, and the difference between Colombia's policy interest rate and the Fed funds rate.

In general terms, both CNG spending and GDP react positively and significantly to a 1% shock from the CNG spending shock to GDP's trend, as shown in Figures 4 and 5. The first column of the graphs corresponds to the response of GDP and the second column to CNG spending, using the shocks from BP's methodology (Fig. 3) and VGL (Fig. 4). The first, second, and third rows display the IRFs for the linear, expansionary, and contractionary models, respectively.

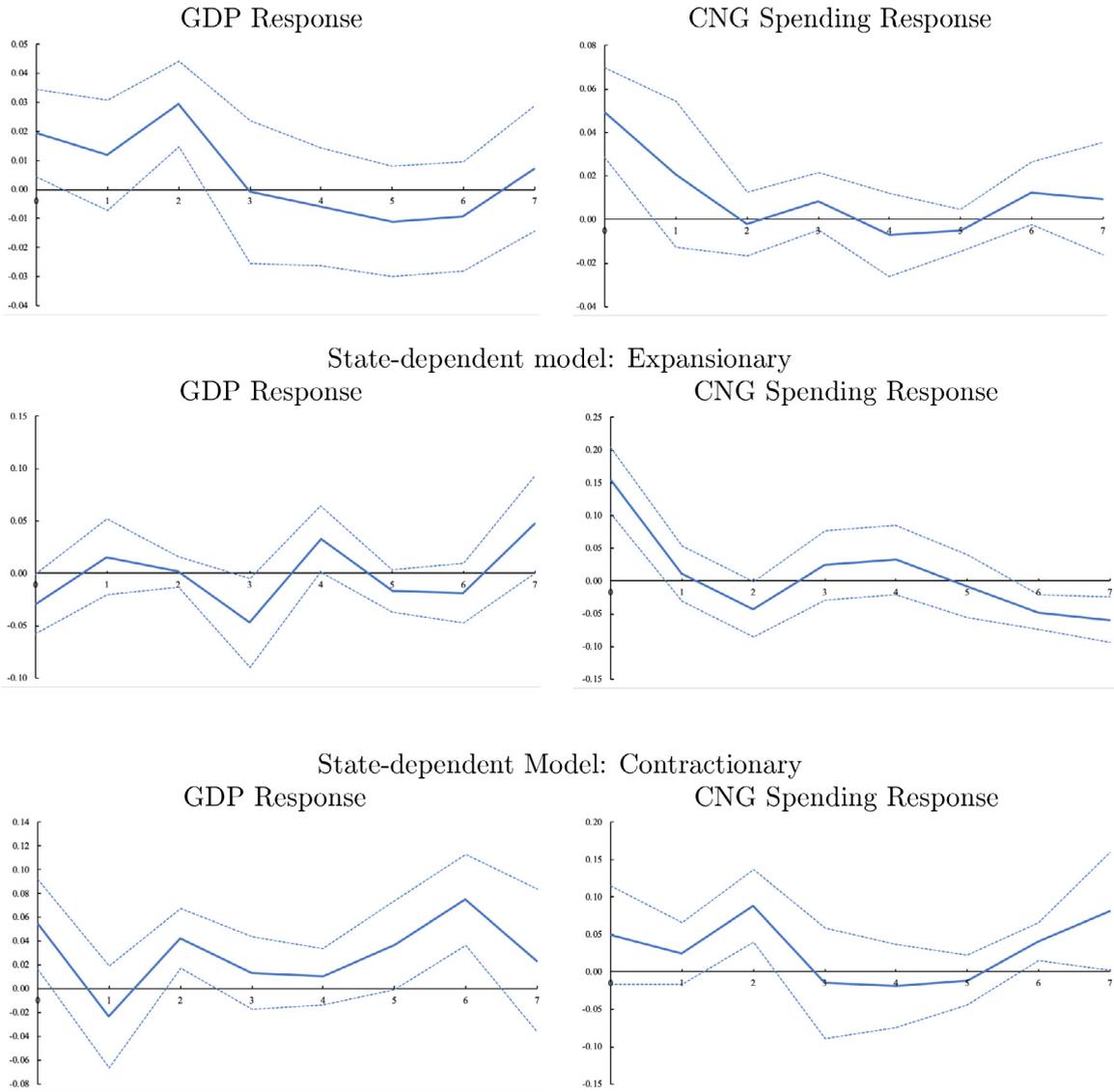


Fig. 4. IRF in the face of a 1% spending shock (BP shock) Note: The linear model corresponds to the specification of equation (6) and the state-dependent model (expansionary and contractionary) corresponds to the specification of equation (7). Dashed lines correspond to 90% confidence intervals.

The IRF in the state-dependent model is derived from the estimated parameters of $\beta_{A,h}$ and $\beta_{B,h}$ for GDP and G in equation (7). In line with other studies [Auerbach and Gorodnichenko, 2012a](#); [Ramey and Zubairy, 2018](#), we found that GDP responds on impact to a greater extent during a state of low economic performance as is the case for the BP shock. The opposite happens when the VGL’s shock is used since the impact is greater when the cycle phase is expansionary, contrary to expectations. On the other hand, government spending has a moderate response during these contractionary periods.

[Fig. 6](#) shows the estimated path of the spending multiplier for the two types of shocks (BP and VGL). [Table 3](#) summarizes the estimates of the multipliers with the methodology of local projections and shocks derived from both BP and VGL. Remember that they should be interpreted as the response of GDP in COP to a public spending shock of \$1. With the first type of shock (BP), the linear model reports a cumulative multiplier of 0.74 in the first year and 0.51 in the second. If the economy experiences an expansion phase, the multiplier reduces to 0.18 in the first year and increases to 1.1 in the second. In contrast, if the economy is in a contraction phase, the multiplier increases to 0.84 in the first year and 1.48 in the second. In the case of the multipliers estimated with the BP shock, except for the cumulative one in the fourth quarter (one year) in the expansionary phase, they are statistically significant at 5% confidence. Note that statistically, there is no difference between the multiplier value in both states of the economy, as indicated by the p-value of the difference between the states ([Table 3](#), column 4, BP shock).

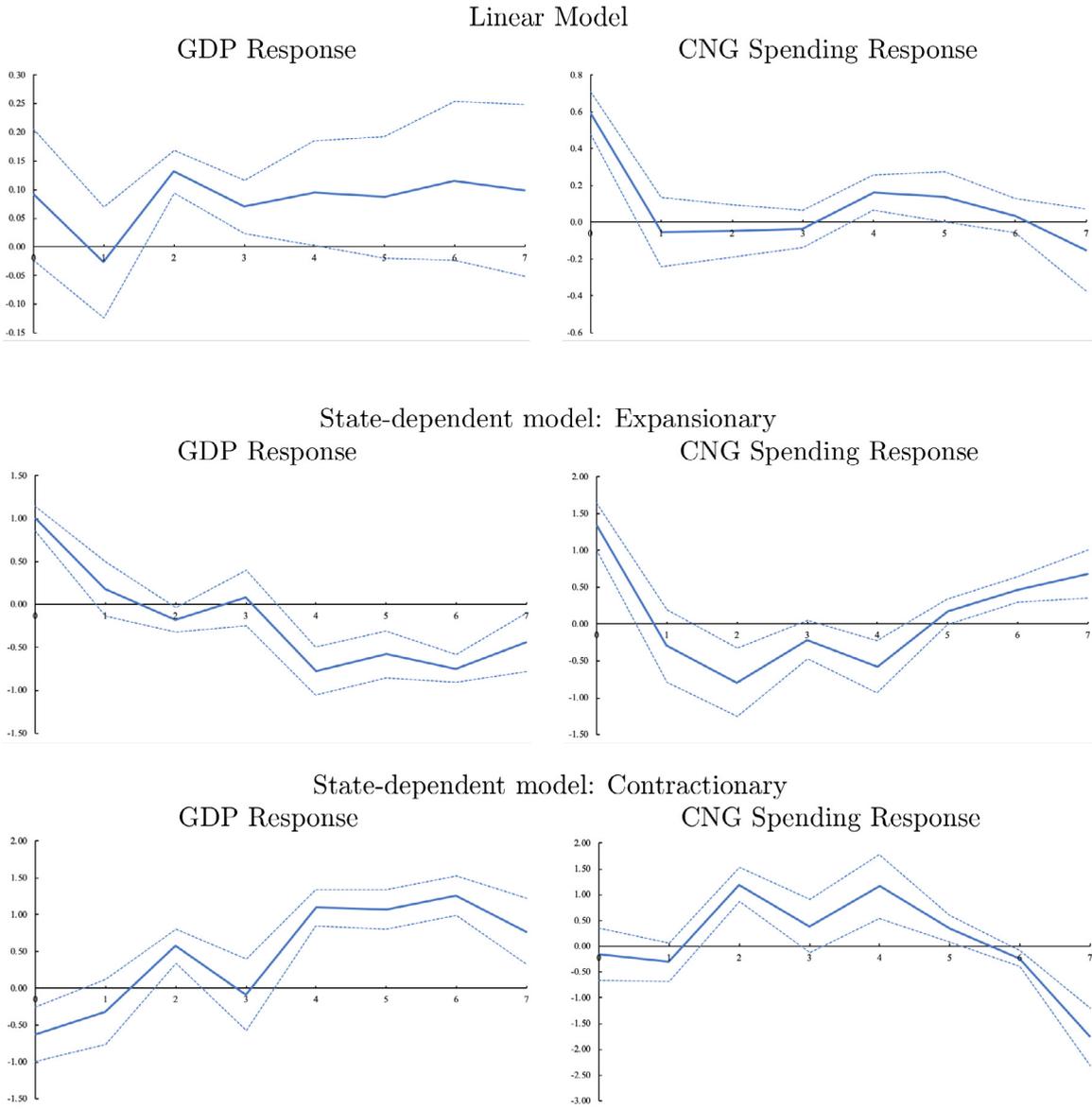


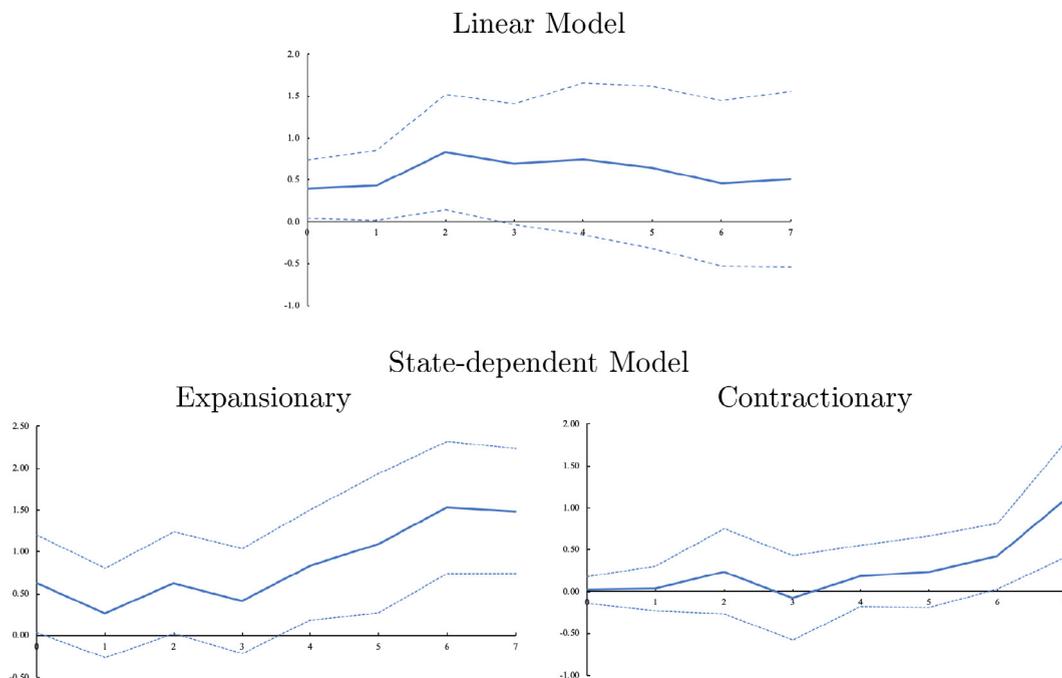
Fig. 5. IRF in the face of a 1% spending shock (VGL shock). Note: The linear model corresponds to the specification of equation (6) and the state-dependent model (expansionary and contractionary) corresponds to the specification of equation (7). Dashed lines correspond to 90% confidence intervals.

When the VGL shock is used, the linear model reports a cumulative multiplier of 0.48 in the first year and 0.84 in the second. The multiplier increases to 1.03 in the first year and 1.21 in the second in an expansion phase. If the economy is contracting, the multiplier increases further to 1.16 in the first year and 2.2 in the second. The multipliers for the cumulative two years are statistically significant and different between states with the VGL shock. The multipliers are statistically significant for the cumulative year at a 5% confidence level. Statistically, there is a difference between the multiplier value in both states of the economy, at least in the cumulative two years (Table 3, Column 4, VGL shock). It is important to remember that the differences in signs and magnitudes between the IRFs in Fig. 5 and the multipliers shown in Fig. 6 correspond to how the latter is constructed. Thus, the multiplier corresponds to the quotient of the sum of the GDP’s IRF on the sum of the CNG spending IRFs.

In summary, and according to most of the literature (Canzoneri et al., 2016; Christiano et al., 2011; Ilzetzi et al., 2013), the spending multiplier is higher when the economy experiences a contractionary phase. This result differs, for example, from that of Alloza (2014) and Ramey and Zubairy (2018), who argue that spending shocks have a greater impact in periods of expansion due to both investor and consumer confidence.

Regarding the response of GDP to a 1% shock to Net taxes, we have that the shock has a significant and negative impact at the contemporary level but of a very small magnitude ($-1,56 \times 10^{-3}$). The cumulative multiplier is significant only on impact, and its

Linear Model and State-Dependent Multipliers with BP Shock



Linear Model and State-Dependent Multipliers with VGL Shock

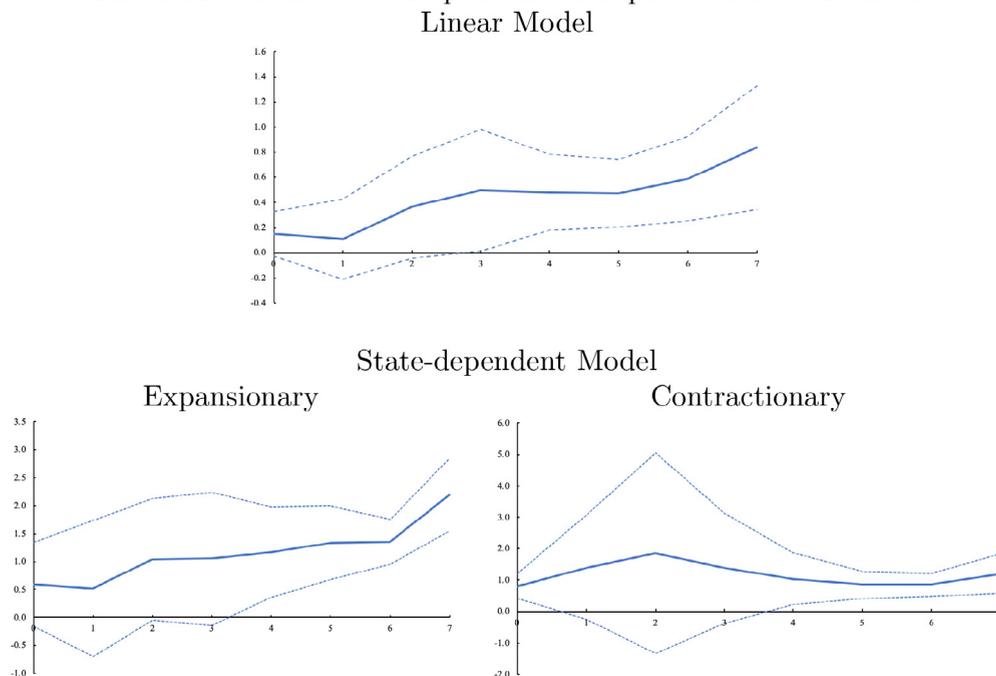


Fig. 6. Fiscal Multipliers Linear Model and State-Dependent Multipliers with BP Shock. Note: The multipliers of the linear model are calculated following equation 12. The multipliers of the state-dependent (expansionary and contractionary) are calculated according to equation 13. Dashed lines correspond to the 90% confidence intervals. The graph panels located in the first and second rows report the multipliers for the linear and state-dependent models with the BP shock. The graph panels located in the third and fourth rows report the multipliers with the VGL shock. The panels on the left side of the second and fourth rows correspond to the case in which the economy is in an expansionary state, those on the right to the case in which the economy is in a contractionary state.

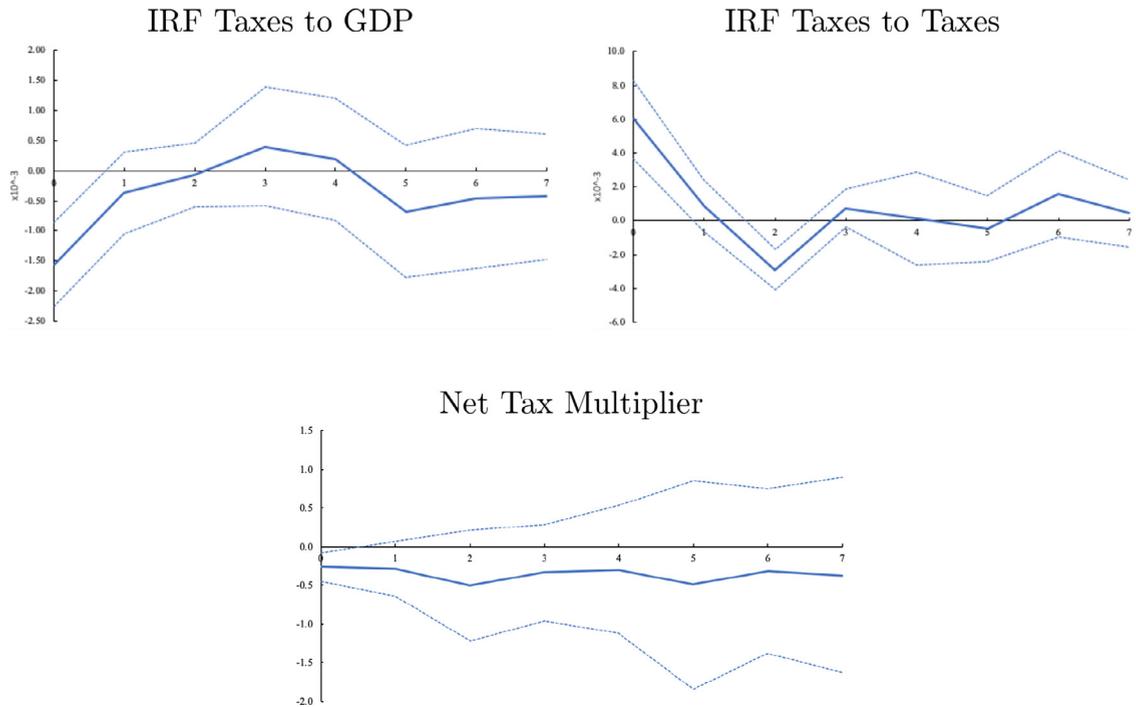


Fig. 7. IRF and Multiplier by LP in the face of a 1% BP Tax Shock. Note: The shock used corresponds to ε_t^T in equation (2). The multiplier was calculated using the equation $m_h = \frac{\sum_{j=0}^h \beta_{j,h}^{GDP}}{\sum_{j=0}^h \beta_{j,h}^T}$. Dashed lines correspond to 90% confidence intervals.

Table 3
Fiscal Multipliers with LP method and VGL and BP shocks.

VGL Shock:	Linear Model	Expansionary	Contractionary	p-value Difference Between States
Impact ($t = 0$)	0.15 (0.010)	0.81* (0.248)	0.59 (0.461)	0.006
Cumulative 1 year	0.48*** (0.010)	1.03** (0.041)	1.16** (0.018)	0.191
Cumulative 2 years	0.84*** (0.005)	1.21*** (0.002)	2.20*** (0.000)	0.000
BP Shock:				
Impact ($t = 0$)	0.39 (0.178)	0.02 (0.099)	0.62 (0.357)	0.208
Cumulative 1 year	0.74 (0.178)	0.18 (0.416)	0.84** (0.036)	0.818
Cumulative 2 years	0.51 (0.428)	1.10*** (0.009)	1.48*** (0.001)	0.338

Note: the values in parentheses correspond to the z-value. The symbols *, **, and *** signify statistical significance levels of 10%, 5%, and 1%, respectively.

magnitude is -0.26. This magnitude, in absolute value, is lower than the CNG’s spending multipliers (see Table 3) but higher than that estimated in Section 4.1 with the BP methodology, which oscillates around -0.10. Despite differing in magnitude, with both methodologies (BP and LP), the multiplier is negative for the entire IRF horizon and significant only on impact ($t = 0$). These results are expected and consistent with the literature (Zubairy, 2014). For the exact tax multiplier values and significance, see Appendix 7.5.

4.2.2. Smooth Local Projections

In this subsection, we describe the results of the model estimates by SLP. First, we use the BP shocks and, as control variables, the time trend and four GDP lags, CNG’s spending, the Terms of Trade index, the EMBI Colombia, and the difference between Colombia’s policy interest rate and the Fed funds rate. Second, we use the VGL shock and the same controls mentioned previously. Fig. 8 plots the IRF of GDP and CNG spending to a 1% shock from the spending BP shock. The left panels plot the IRF obtained from the LP, while

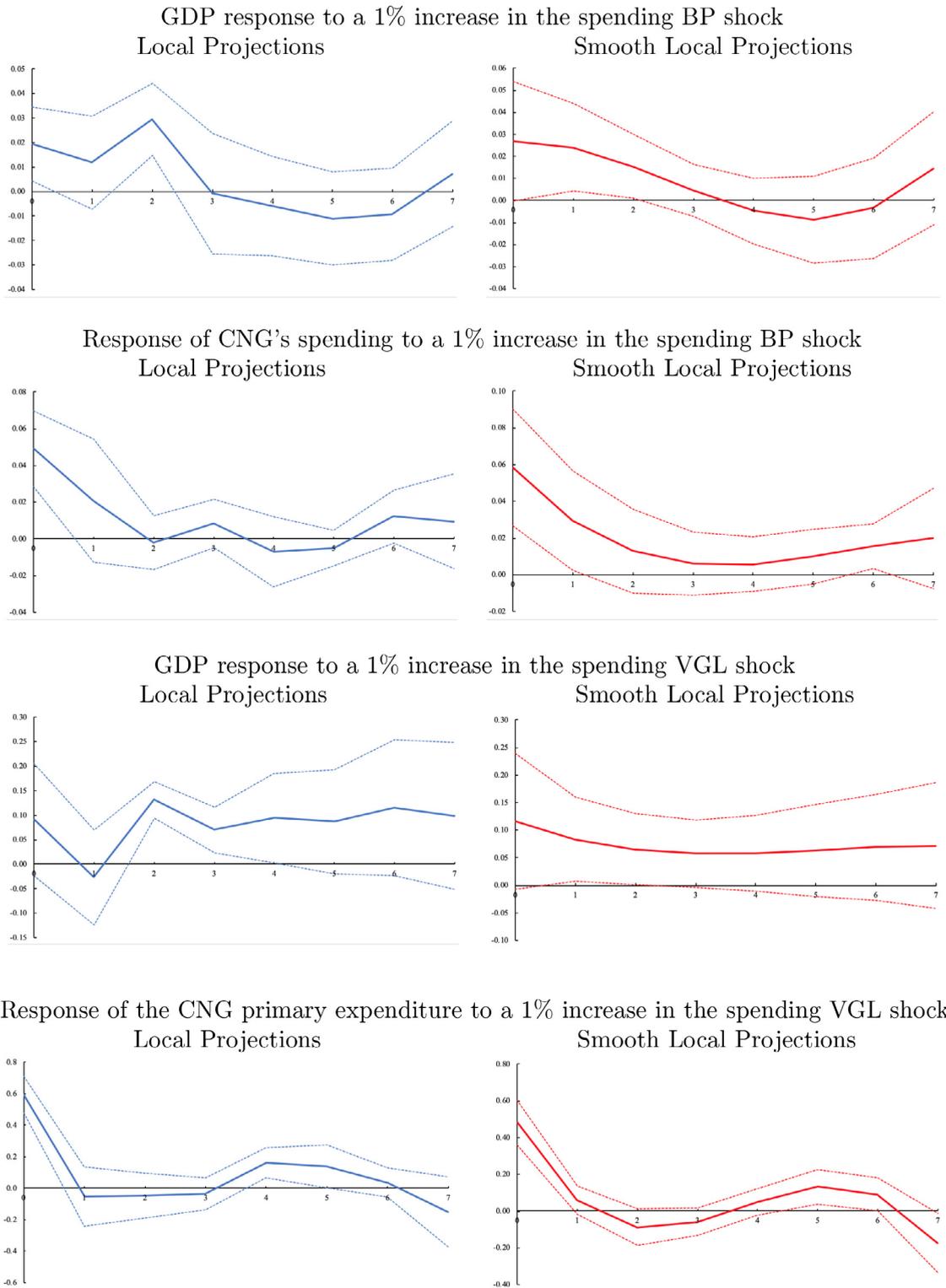


Fig. 8. Impulse Response Functions with LP and SLP. Note: Dashed lines correspond to 90% confidence intervals.

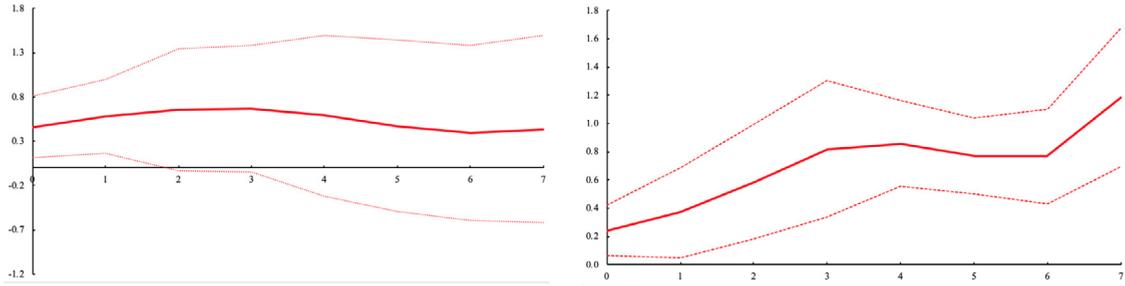


Fig. 9. Cumulative multipliers with SLP. Note: The left panel corresponds to the estimates with the BP shock and the right with the VGL. Dashed lines correspond to 90% confidence intervals.

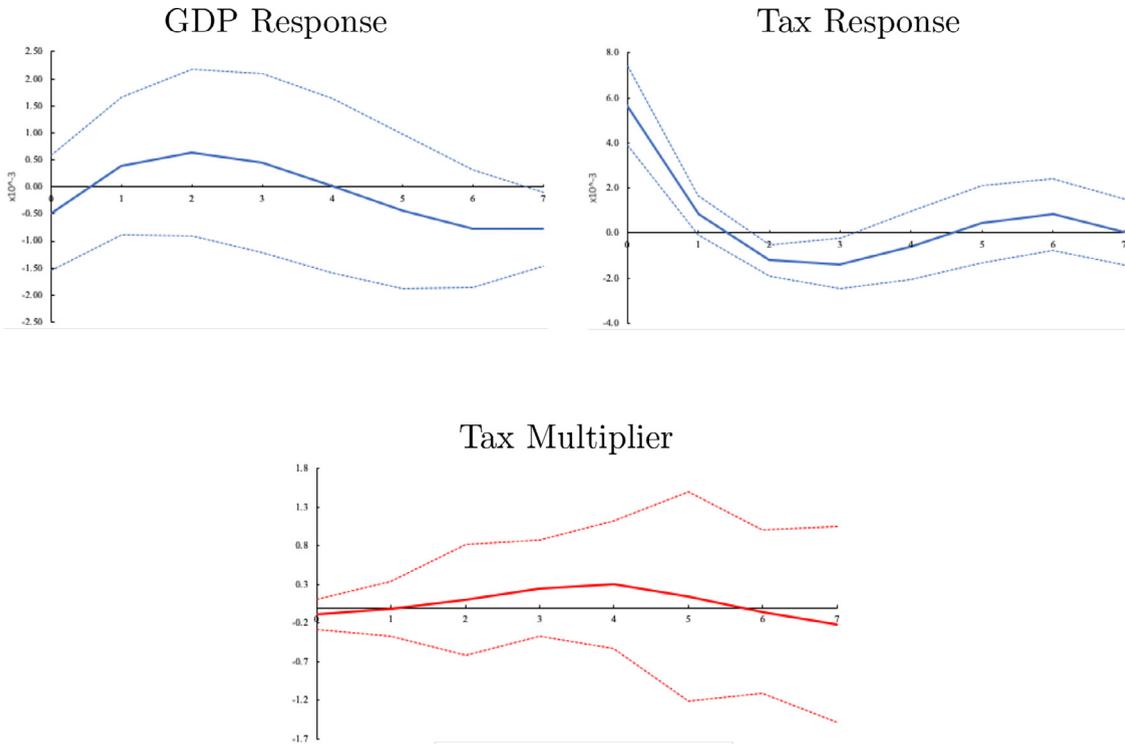


Fig. 10. IRF and Multiplier by SLP in the face of a 1% BP Tax Shock. Note: The shock used corresponds to ϵ_t^T of equation 2. The multiplier was calculated using the equation $m_h = \frac{\sum_{j=0}^h \beta_{j,h}^{GDP}}{\sum_{j=0}^h \beta_{j,h}^T}$. Dashed lines correspond to 90% confidence intervals.

the right panel plots the IRF obtained from the SLP. As mentioned, the IRF obtained from the LPs is more erratic, with occasional sharp fluctuations from one quarter to the next, making it more difficult to interpret them. Thanks to the smoothing, the IRF of the SLP is easier to interpret.

For example, the right panel of the third row of Fig. 8 shows that in the event of a 1% VGL shock, the GDP response oscillates around its average of 0.07%. However, it is only statistically significant for the first and second quarters. In the case of LP, the average is slightly higher (0.08%), and the second, third and fourth quarters are statistically significant.

The fourth row of Fig. 8 shows the IRF for the CNG expenditure that uses the VGL shock. Here, the SLP IRF has its highest peak on impact (around 0.5%) and then in the fifth and sixth quarters (0.13% and 0.09%, respectively).

As mentioned in section 3.3, the cumulative multipliers should be calculated as the cumulative sum of the GDP response divided by the cumulative sum of the government spending response. The multipliers measured in this way effectively solve the relevant policy question because they measure the cumulative gain in GDP relative to cumulative public spending over a given period. Therefore, the multipliers reported in Graph 8 result from the estimation of equation 12 using $shock_t$ as an instrument for $\sum_{j=0}^h g_{t+j}$. $shock_t$ takes two series: one from the BP shock (ϵ_t^G from equation (3)) and one from the VGL shock. Here, $\sum_{j=0}^h y_{t+j}$ is the sum of GDP from t to $t+h$, and $\sum_{j=0}^h g_{t+j}$ is the sum of CNG spending from t to $t+h$. As mentioned above, this estimate is equivalent to estimating

Table 4
Fiscal multipliers with LP and SLP. VGL and BP Shocks.

VGL Shock:	Spending Multipliers	
	LP	SLP
Impact ($t = 0$)	0.15 (0.010)	0.24*** (0.109)
cumulative 1 year	0.48*** (0.010)	0.82*** (0.294)
cumulative 2 years	0.84*** (0.005)	1.19*** (0.298)
BP Shock:	LP	SLP
Impact ($t = 0$)	0.39 (0.178)	0.46* (0.211)
cumulative 1 year	0.75 (0.178)	0.67 (0.436)
cumulative 2 years	0.51 (0.428)	0.44 (0.642)

Note: The values in parentheses correspond to standard errors. The symbols *, **, and *** signify statistical significance levels of 10%, 5%, and 1%, respectively.

equation (6) for the GDP of each horizon j to h and adding the β_j^{GDP} ; estimate the equation (6) for the G of each horizon j up to h and add the β_j^G , and calculate the multiplier as the ratio of the cumulative sum, $m_h = \frac{\sum_{j=0}^7 \beta_{j,h}^{GDP}}{\sum_{j=0}^7 \beta_{j,h}^G}$.

The fiscal multiplier with the BP shock is 0.46 on $t = 0$, 0.67, and 0.44 at the end of the first and second years, respectively. The multiplier calculated with the VGL shock shows, on average, higher values: 0.24 on $t = 0$, 0.82 at the end of the first year, and 1.19 at the end of the second year (Table 4).

Regarding the response of GDP to a 1% shock to taxes on trend GDP, we obtain non-significant impacts except for the eighth quarter after the shock, which is negative and very small in magnitude (-0.78×10^{-3}). The cumulative multiplier is not significant for the entire IRF horizon.

In Appendix 7.5, we present a table summary with all the multipliers and shocks from all exercises presented in this section.

5. Conclusions

Colombia is a small open economy in which the government and the short-term fiscal policy play a stabilizing role in the economic cycle. Therefore, knowing how much the movements of its instruments (taxes and expenses) impact economic activity, that is, having a measure of fiscal multipliers, becomes a central objective for fiscal policy decision-making. This paper provides estimates for the multipliers.

In this paper, we estimated the point and cumulative fiscal multipliers (CNG spending and taxes) for Colombia, as well as the Impulse Response Functions of CNG's spending and GDP to shocks to the same variables.

Summarizing our results, the point BP CNG spending multiplier is 0.33, while the cumulative at one and two years lies between 0.75 and 0.89. Using smoothed local projections and BP shock, it yields a cumulative multiplier at one and two years of 0.59 and 0.44, respectively. With the VGL-narrative spending shock, the multipliers are higher: 0.82 at the end of the first year and 1.19 at the end of the second year. When conditioned by the state of economic activity, the cumulative spending multiplier estimated by local projections at one and two years (using either BP or VGL shocks) is estimated between 0.18 and 1.21 when the economy is expanding, and between 0.84 and 2.20 when it is contracting.

According to BP's methodology, the tax multiplier is -0.09, and the cumulative ones are -0.10 and -0.16 at one and two years, respectively. With the local projections methodology, the multiplier for one and two years lies between -0.29 and -0.36, respectively, although they are not statistically significant. With smoothed local projections, the cumulative multiplier is not statistically different from zero for the entire horizon.

In summary, the results show that fiscal policy in Colombia has a greater multiplier effect when the economy is in a contractionary phase. This result is consistent with most of the literature (Bournakis et al., 2022; Canzoneri et al., 2016; Christiano et al., 2011; Ilzetzi et al., 2013) but different from that obtained by Ramey and Zubairy (2018) and Alloza (2014), who argue that spending shocks have a greater impact in periods of expansion due to both investor and consumer confidence.

As mentioned, BP's methodology has faced various criticisms, some of which we address in this article. Some other extensions are possible: the first is to use non-linear techniques as in Bournakis et al. (2022), to assess the dependence of the value of multipliers on the magnitude and direction of fiscal shocks (positive versus negative). The second is to consider various types of taxes or spending that could affect the magnitude of the multipliers, as shown by Auerbach and Gorodnichenko (2012a) for the United States and Rincón et al. (2014) for Colombia. Finally, as Fernández-Villaverde et al. (2015) and Delgado-Rojas and Rincón-Castro (2017) show, controlling for the not minor uncertainty effects on fiscal policy and economic activity (and hence on multipliers).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A

A1. Series used for estimation in BP and LP methods

A2. Construction of the CNG Spending Shock

The LP and SLP methodologies require the definition of an exogenous public spending shock, $shock_t$, which meets the criteria of non-anticipation and no contemporaneous correlation with GDP. In this way, the shock is defined as the difference between the actual spending executed by the CNG (total spending excluding interest payments on the public debt) and the forecast made for this variable in the financial plans announced by the Ministry of Finance. In these, the general balance budgeted for $t + 1$ of the CNG is anticipated, with a lag of half a year. Thus, the shock is defined as the following forecast error:

$$G_{t+1} - E[G_{t+1} | \Omega_t]$$

where G_{t+1} corresponds to spending executed by the CNG in period $t + 1$, and $E[G_{t+1} | \Omega_t]$ is its expected value conditional on the information available in t , denoted as Ω_t . The fiscal shocks calculated are unanticipated by construction and are not correlated with the level of GDP in t due to the delay in the information with which production and other data on real activity are available and the lag with which the operations are executed.

To build the CNG spending forecast, we replicate the steps followed by Vargas-Herrera et al. (2015):

- Annual spending announcements made by the government in the middle of each year in its Financial Plans (FP) and, more recently, in the Long-Term Fiscal Framework (MFMP, by its acronym in Spanish), are considered as the forecast of annual spending.
- The FP execution rate for each quarter in a year is obtained from the observed annual and quarterly historical data for spending.
- Based on (a) and (b), the spending for each quarter of each year is forecast by multiplying the 4th-order moving average execution rate ($MA(4)$) by annual expense announcements. Order 4 is chosen to capture a recent quarterly trend in spending execution.
- At the end of the second quarter, information is available on the expenses executed in the first quarter. Therefore, an adjustment is added to the forecast for the third and fourth quarters that results from the assumption of compliance with the annual FP. The forecast error for the first quarter is uniformly distributed between the second, third, and fourth quarters. The assumption that the annual spending plan is fulfilled is valid, on average, for the sample. The average annual forecast error is COP 372 trillion in 2015 real prices, representing 0.38 percent of public spending.
- At the end of the third quarter, information on the expense executed in the second quarter is available. Therefore, an adjustment is added to the forecast for the fourth quarter that results from the assumption of compliance with the annual FP and that the forecast error for the second quarter is uniformly distributed between the third and fourth quarters.
- The series of forecast errors (calculated with respect to the adjusted forecasts for the third and fourth quarters) is the spending shock for each quarter. Table A7.2.1 illustrates its construction. Fig. A7.3.1 in Appendix 7.3 shows no significant correlation between the fiscal shock and the cyclical component of GDP, which is expected because there are no automatic stabilizers related to public spending in Colombia.

A3. CNG Spending Shock and Cross-Correlation with the GDP Gap

Table A7.2.1
Construction of the Spending Forecast.

Quarter	Forecast			
	I	II	III	IV
I	$\delta_1 \cdot ASA$	$\delta_2 \cdot ASA$	$\delta_3 \cdot ASA$	$\delta_4 \cdot ASA$
II	$\delta_1 \cdot ASA$	$\delta_2 \cdot ASA$	$\delta_3 \cdot ASA$	$\delta_4 \cdot ASA$
III	$G_1(obs)$	$(\delta_2 \cdot ASA) - \left(\frac{EP_1}{3}\right)$	$(\delta_3 \cdot ASA) - \left(\frac{EP_1}{3}\right)$	$(\delta_4 \cdot ASA) - \left(\frac{EP_1}{3}\right)$
IV	$G_1(obs)$	$G_2(obs)$	$(\delta_3 \cdot ASA) - \left(\frac{EP_1}{3}\right) - \left(\frac{EP_2}{2}\right)$	$(\delta_4 \cdot ASA) - \left(\frac{EP_1}{3}\right) - \left(\frac{EP_2}{2}\right)$

δ_i : $MA(4)$ execution rate for quarter i . ASA : Annual Spending Announcement. $G_i(obs)$: Spending observed in quarter i . EP_1 : Predicted error in the first quarter, $EP_1 = G_1(obs) - (\delta_1 \cdot ASA)$. EP_2 : Predicted error in the second quarter, $EP_2 = G_2(obs) - (\delta_2 \cdot ASA) - (EP_1/3)$. Source: Table taken from Vargas et al. (2015).

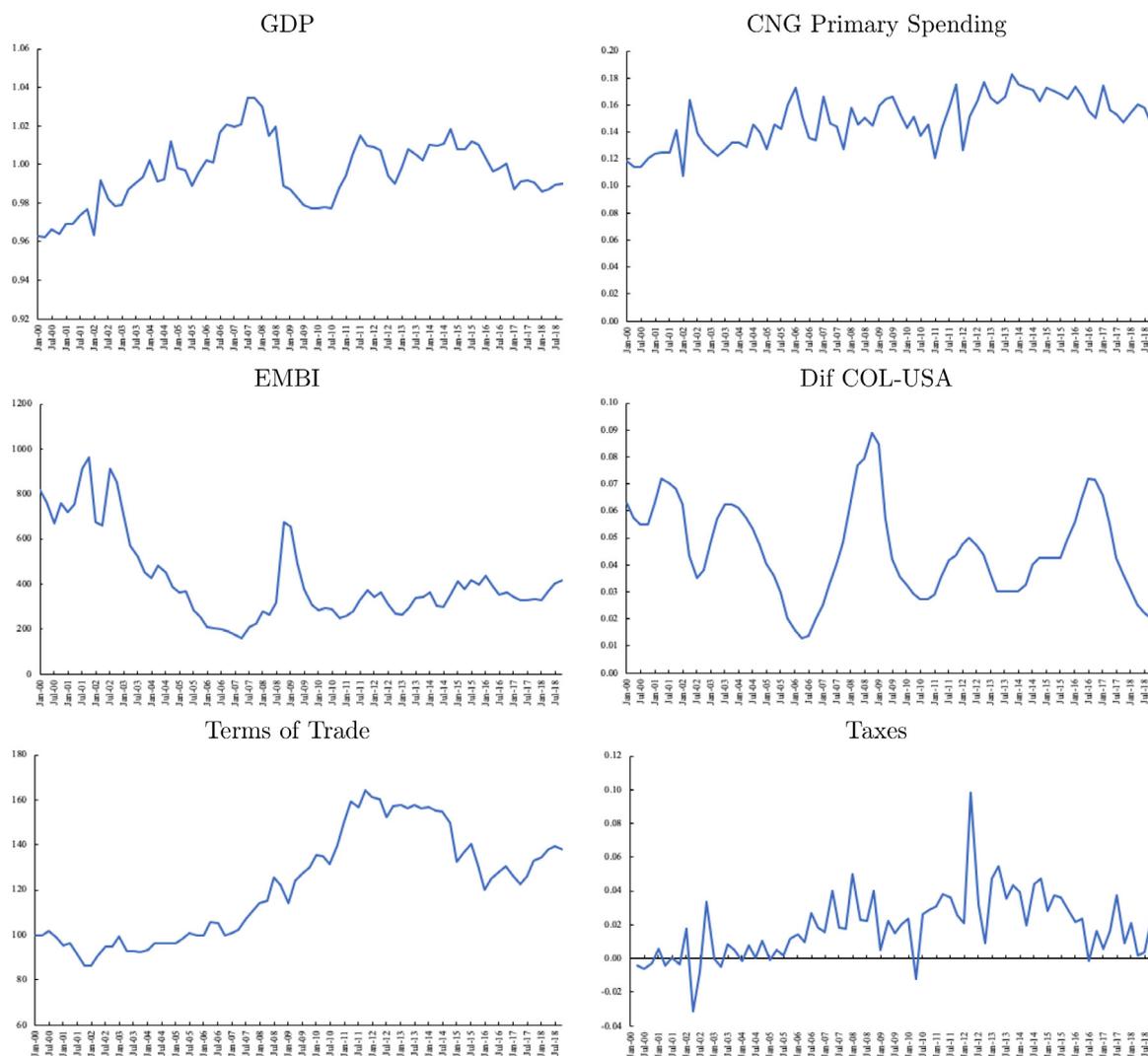


Fig. A7.1.11. Sources: Banco de la Republica, Ministry of Finance, Bloomberg, National Administrative Department of Statistics (DANE) and the National Directorate of Taxes and Customs (DIAN).

A4. Unit Root Tests

Table A7.4.1 reports the Dickey-Fuller stationarity or unit root tests over the transformed series in levels and in first differences. The results indicate that net taxes, spending and GDP are stationary in levels and in first differences, while the terms of trade are not stationary in levels, but stationary in first differences.

1/ The null hypothesis is that the series is non-stationary and behaves as an integrated process of order 1 or $I(1)$.

Table A7.4.1
Unit Root Tests¹.

Series ²	τ^3	ADF ⁴	
		Levels	First Differences
<i>T</i>	τ_μ	-5.64***	-13.51***
<i>G</i>	τ_μ	-4.31***	-13.36***
<i>GDP</i>	τ_μ	-2.64*	-9.84***
<i>Terms of Trade</i>	τ_μ	-0.99	-7.73***
<i>EMBI</i>	τ_μ	-2.45	-7.40***

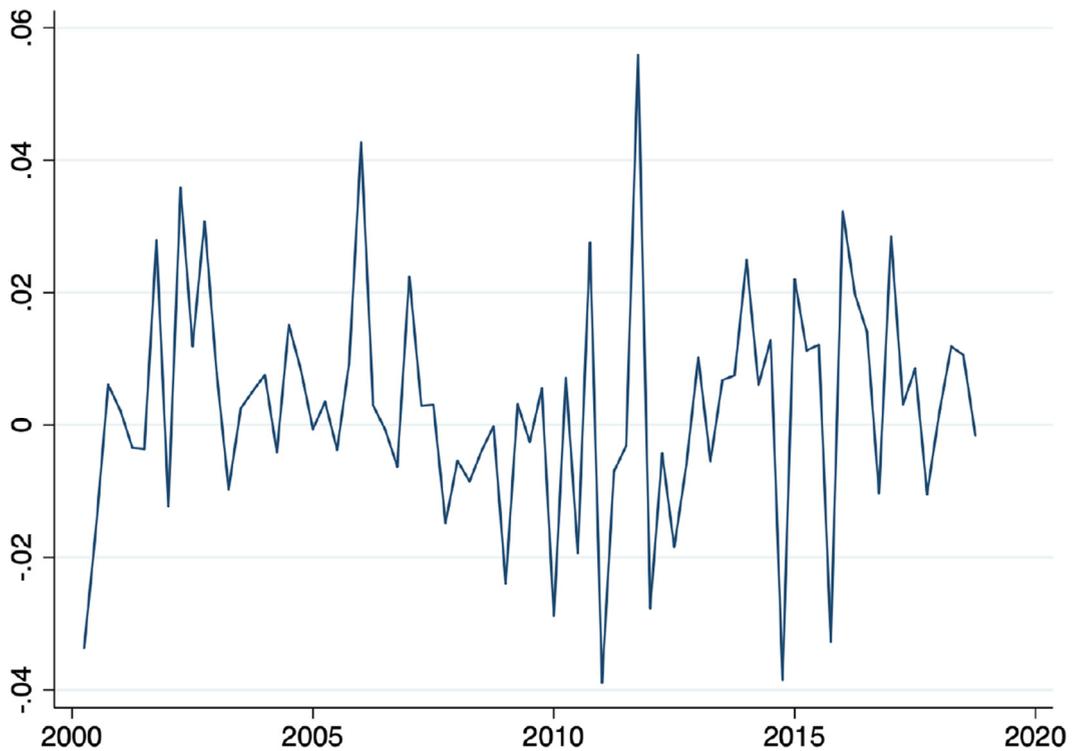


Fig. A7.3.1. Spending Shock as a percentage of Trend GDP. Source: Ministry of Finance; Authors' calculations.

GAP_GDP,SHOCK(-i)	GAP_GDP,SHOCK(+i)	i	lag	lead
		0	-0.0558	-0.0558
		1	-0.0605	0.0145
		2	-0.1463	0.0435
		3	-0.0799	0.0849
		4	-0.0383	0.1242
		5	-0.1079	0.0979
		6	-0.1593	0.1722
		7	-0.1111	0.0715
		8	-0.0287	0.0810
		9	-0.0856	-0.0154
		10	-0.0931	0.1165
		11	0.0308	0.0463
		12	0.0442	0.0783

Fig. A7.3.2. Cross Correlation between the Fiscal Shock and the GDP Gap.

2/ T are real net taxes as a percentage of the real GDP trend, G is real and seasonally adjusted CNG spending as a percentage of the real GDP trend, GDP is real and seasonally adjusted gross domestic product expressed as a deviation from its trend component, $Terms\ of\ Trade$ is the real terms of trade index deflated by PPI, and $EMBI$ is the Emerging Markets Bond Index for Colombia. See Section 3 for more details.

3/ The test τ_μ is the τ statistic of a regression that includes an intercept. The symbols *, ** and *** indicate a statistical significance at 10%, 5% and 1%, respectively.

Table A7.5.1**Panel A: SVAR methodology - Blanchard and Perotti (2002)**

GDP response to COP \$1 shock in T			GDP response to COP \$1 shock in G		
BP	cumulative (equation (6))		BP	cumulative (equation (6))	
Lowest	1 year	2 years	Highest	1 year	2 years
-0,09	-0.10	-0.16	0.33	0.75	0.89

Panel B: Local projections (LP) and Smoothed Local Projections (SLP)

CNG's primary spending Multipliers				
VGL Shock	LP-Linear	LP-Expansion	LP-Contraction	SLP-Linear
Impact ($t = 0$)	0.15 (0.010)	0.81* (0.248)	0.59 (0.461)	0.24*** (0.109)
cumulative 1 year	0.48*** (0.010)	1.03** (0.041)	1.16** (0.018)	0.82*** (0.294)
cumulative 2 years	0.84*** (0.005)	1.21*** (0.002)	2.20*** (0.000)	1.19*** (0.298)
BP Shock	LP-Linear	LP-Expansion	LP-Contraction	SLP-Linear
Impact ($t = 0$)	0.39 (0.178)	0.02 (0.099)	0.62 (0.357)	0.46* (0.211)
cumulative 1 year	0.75 (0.178)	0.18 (0.416)	0.84** (0.036)	0.59 (0.436)
cumulative 2 years	0.51 (0.428)	1.10*** (0.009)	1.48*** (0.001)	0.44 (0.642)
Tax multipliers				
BP Shock	LP-Linear			SLP-Linear
Impact ($t = 0$)	-0.26* (0.117)			-0.08 (0.117)
cumulative 1 year	-0.29 (0.505)			0.30 (0.505)
cumulative 2 years	-0.36 (0.770)			-0.22 (0.770)

Note: The values in parentheses correspond to standard errors. The symbols *, **, and *** signify statistical significance levels of 10%, 5%, and 1%, respectively. In Panel A, the BP multiplier is the lowest response in magnitude (negative values) of GDP before a tax shock. For CNG spending, the BP multiplier corresponds to the highest response of GDP in the face of a spending shock. The cumulative multipliers correspond to the definition introduced by Ramey and Zubairy (2018), expressed by equation(12).

4/ The Q statistic was used to evaluate the presence of serial correlation and the information criterion of Schwartz and Hannan-Quinn to choose the optimal lag structure.

A5. Multiplier Results Summary

Table A7.5.1 reports all multipliers derived from all methodologies (SVAR, LP, and SLP) and from BP and VGL shocks.

References

- Alloza, M., 2014. "is fiscal policy more effective in uncertain times or during recessions?". Working paper. Univ. Coll. London.
- Auerbach, A.J., Gorodnichenko, Y., 2012. Fiscal multipliers in recession and expansion. *Fiscal policy after the financial crisis* 63, 98.
- Auerbach, A.J., Gorodnichenko, Y., 2012. "measuring the output responses to fiscal policy.". *American Econ. J.: Econ. Policy* 4 (2), 1–27. 2012
- Bachmann, R., Eric, R.S., 2012. "confidence and the transmission of government spending shocks.". *J. Monetary Econ.* 59, 235–249.
- Barnichon, R., Brownlees, C., 2019. "impulse response estimation by smooth local projections.". *Review of Economics and Statistics* 101 (3), 522–530.
- Barro, R.J., Redlick, C.J., 2011. "macroeconomic effects from government purchases and taxes.". *Q.J.E.* 126 (1), 51–102.
- Baum Anja, M.P.-R., Weber, A., 2012. "fiscal multipliers and the state of the economy.". Manuscript. Internat. Monetary Fund, Washington, DC..
- Blanchard, O., Roberto, P., 2002. "an empirical characterization of the dynamic effects of changes in government spending and taxes on output.". *Q.J.E.* 117 (4), 1229–1268.
- Boor, C.D., 1978. *A Practical Guide to Splines*. Berlin, Springer.
- Bournakis, I., Ramírez-Rondán, Nelson, R., 2022. "does uncertainty matter for the fiscal consolidation and capital intensity nexus?". MPRA Paper 111592. University Library of Munich, Germany.
- Campo Robledo, J., 2007. Efecto de los cambios en el gasto y en los ingresos del gobierno sobre el PIB: Una caracterización empírica para Colombia. Borradores de Economía. No. 475. Banco de la Republica
- Canzoneri, Matthew, Collard, F., Dellas, H., Diba, B., 2016. "fiscal multipliers in recessions.". *Econ. J.* 126 (590), 75–108.
- Christiano, Lawrence, Eichenbaum, M., Rebelo, S., 2011. "when is the government spending multiplier large?". *J.P.E.* 119 (1), 78–121.
- Coenen, Günter, 2012. "effects of fiscal stimulus in structural models.". *American Econ. J.: Macroeconomics* 4 (1), 22–68.

- Cogan, John, F., Cwik, T., Taylor, J.B., Wieland, V., 2010. "new keynesian versus old keynesian government spending multipliers." *J. Econ. Dynamics and Control* 34, 281–295.
- Eilers, P.H.C., Marx, B.D., 1996. "flexible smoothing with b-splines and penalties." *Statistical Science* 11, 89–102.
- Fazzari, Steven, M., Morley, J., Panovska, I., 2015. "state-dependent effects of fiscal policy." *Studies Nonlinear Dynamics and Econometrics* 19 (3), 285–315.
- Fernández-Villaverde, J., Kuester, K., Guerrón-Quintana, p., Rubio-Ramírez, J., 2015. *Fiscal Volatility Shocks and Economic Activity*. American Economic Review 105 (1), 3352–3384.
- Fisher, Jonas, D.M., Peters, R., 2010. "using stock returns to identify government spending shocks." *Econ. J.* 120, 414–436.
- Delgado-Rojas, M.E., Rincón-Castro, H., 2017. *Incertidumbre acerca de la política fiscal y ciclo económico*. Borradores de Economía, No.1008, Banco de la República.
- Gordon, R.J., Robert, K., 2010. "the end of the great depression: VAR insight on the roles of monetary and fiscal policy." Working Paper no. 16380. NBER, Cambridge, MA.
- Hall, R.E., 2009. "by how much does GDP rise if the government buys more output?" *brookings papers econ. Activity* (Fall): 183–236.
- Ilzetzki, Mendoza, E., Enrique, G., Végh, C.A., 2013. "how big (small?) are fiscal multipliers?." *Journal of Monetary Economics*, Elsevier 60 (2), 239–254.
- Jordà, Óscar, 2005. "estimation and inference of impulse responses by local projections." *A.E.R.* 95 (1), 161–182.
- López-Vera, A., Pinchao-Rosero, A., Rodríguez-Niño, N., 2018. *Non-Linear Fiscal Multipliers for Public Expenditure and Tax Revenue in Colombia*. *Revista Ensayos Sobre Política Económica* 36 (85), 48–64. Edición especial. 2018
- Lozano, I., Rodríguez, K., 2011. *Assessing the macroeconomic effects of fiscal policy in colombia*. *Journal of Financial Economic Policy* 3 (3).
- Mountford, Andrew, Uhlig, H., 2009. "what are the effects of fiscal policy shocks?." *J. Appl. Econometrics* 24, 960–992.
- Newey, Whitney, K., West, K.D., 1987. "a simple, positive semidefinite, heteroskedasticity and autocorrelation consistent covariance matrix." *Econometrica* 55 (3), 703–708.
- Ramey, V., Shapiro, M., 1998. *Costly capital reallocation and the effects of government spending*. *Carnegie-Rochester Conference Series on Public Policy* 48 (1), 145–194.
- Ramey, V.A., 2011. *Identifying government spending shocks: It's all in the timing*. *The Quarterly Journal of Economics* 126 (1), 1–50.
- Ramey, V.A., Zubairy, S., 2018. *Government spending multipliers in good times and in bad: evidence from US historical data*. *Journal of political economy* 126 (2), 850–901.
- Francis, N., Restrepo-Ángel, S., 2018. *Sectoral and aggregate response to oil price shocks in the colombian economy: SVAR and local projections approach*. *borradores de economía* 1055. Banco de la República de Colombia.
- Restrepo, J., 2020. *How big are fiscal multipliers in latin america?* IMF Working Papers, WP No. 20/17.
- Restrepo, J., Rincón, H., 2006. *Identifying fiscal policy shocks in chile and colombia*. Working Papers, No. 370. Banco Central de Chile.
- Riera-Crichton, Daniel, Végh, C.A., Vuletin, G., 2015. "procyclical and countercyclical fiscal multipliers: Evidence from OECD countries." *J. Internat. Money and Finance* 52, 15–31.
- Rincón, H., Rodríguez, D., Toro, J., Téllez, S., 2014. *FISCO: Modelo fiscal para colombia*. *Ensayos Sobre Política Económica* 35 (83). Banco de la República.
- Romer, C., Romer, D., 2010. *The macroeconomic effects of tax changes: Estimates based on a new measure of fiscal shocks*. *American Economic Review* 100, 763–801.
- Uhlig, Harald, 2010. "some fiscal calculus." *A.E.R.* 100 (2), 30–34.
- Vargas-Herrera, H., Gonzalez, A., Lozano-Espitia, L.I., 2015. *Macroeconomic gains from structural fiscal policy adjustments: The case of colombia*. *Economía* 15 (2), 39–81.
- Zubairy, Sarah, 2014. "on fiscal multipliers: Estimates from a medium scale DSGE model". *International Economic Review* 169–195. February 2014. Vol 55, Iss. 1