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## NONLINEAR EFFECTS OF THE CHILEAN FISCAL POLICY\*

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### I. INTRODUCTION

In recent years a relatively new strand of literature has questioned whether the state of the economy is a determinant of the effects of fiscal policy on output and the size and sign of fiscal multipliers (Afonso et al., 2011; Baum and Koester, 2011; Auerbach and Gorodnichenko, 2012; Batini et al., 2012; Baum et al., 2012; International Monetary Fund, 2012; Auerbach and Gorodnichenko, 2013; Riera-Crichton et al., 2014; among others). This literature, focusing mostly on developed economies (Germany: Baum and Koester, 2011; the United States: Auerbach and Gordonichenko, 2012; a group of G-7 countries: Batini et al., 2012; Baum et al., 2012; International Monetary Fund, 2012; and Auerbach and Gordonichenko, 2013), has found that the effects of fiscal policy on output are likely nonlinear with fiscal multipliers being larger in recession than in expansion periods.<sup>1</sup> A contribution studying both developed economies and emerging markets (a sample of thirty OECD countries including developing economies such as Chile, Hungary, Mexico, Poland, and Turkey) by Riera-Crichton et al. (2014) also finds evidence of fiscal policy being more effective to boost the output during recessions than in expansions. Other recent papers studying developing economies and specifically Latin American countries, are Vargas et al. (2015) and Carrillo (2017), for Colombia and Ecuador, respectively. They find similar results to those for developed economies. In this paper, we focus in the case of Chile, an emerging market that possesses several interesting economic characteristics, and for which no evidence exists of the effects of fiscal policy on output and the size and sign of fiscal multipliers (hereafter, fiscal policy and fiscal multipliers) considering the state of the economy.

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1 G-7 is a group of countries consisting of Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.

Chile is a very open economy to the world markets. Its deep financial integration into foreign markets and its orientation to commodity exports have made it historically affected by shocks coming from international sources. On the one hand, such economic integration has dramatically benefited the Chilean economy by increasing its exports and capital inflows. On the other hand, however, it also has brought essential risks such as greater domestic macroeconomic instability. As a policy response, during the last decades, the Chilean economic authorities have progressively built a sound and effective macroeconomic policy framework comparable to those in place in commodity-exporting developed economies, such as Australia, New Zealand, and Norway. Nevertheless, despite its sound macroeconomic policy framework, the Chilean economy is still very exposed to shocks coming from abroad. Thus, to guarantee its macroeconomic stability, the country's fiscal policy is a crucial tool, with the effects of fiscal policy and fiscal multipliers being a relevant subject.<sup>2</sup>

This paper seeks to contribute to the literature by studying the effects of fiscal policy and fiscal multipliers in emerging markets. It considers a nonlinear approach to study Chile's fiscal policy effectiveness. It estimates fiscal multipliers depending on the state of the economy, either low economic growth ("tight" regime) or when the economy is growing at a more reasonable rate ("normal" regime). Also, by building on a nonlinear approach, it questions the influence of the short-term (monetary policy) interest rate on the size and sign of fiscal multipliers.

To respond if the state of the economy, "tight" or "normal", matters in the effects of Chile's fiscal policy and fiscal multipliers, we apply a nonlinear time series analysis, concretely Threshold Vector Autoregression (TVAR) models. Using the definition of government spending and taxes in the seminal paper by Blanchard and Perotti (2002) and closely following the contribution by Batini et al. (2012), we estimate a TVAR model we called "baseline model". To obtain the impulse-response functions, we determine the state of the economy—"tight" or "normal"—depending on the real GDP growth, to then calculate fiscal multipliers of government spending and taxes.<sup>3</sup> The period of study comprises from the first quarter of 1990 to the fourth quarter of 2017.

We find that fiscal multipliers independent of the state of the economy do not differ much at impact, but in the long term, government spending multipliers

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<sup>2</sup> *The Chilean macroeconomic policy framework includes: (i) A Central Bank utterly independent of the government in office decisions, responsible for monetary and exchange rate policies; (ii) A flexible exchange rate regime aiming at working as the first defensive line against foreign shocks; (iii) An inflation targeting regime to anchor prices and give certainty to the economic agents; (iv) A structural balance fiscal rule guiding short-term government spending depending on the economy's medium-term fundamentals, notably output and copper prices, allowing to isolate government spending from politically populist driven pressures; (v) Sovereign wealth funds successfully used under exceptional cases; and (vi) Low public debt to GDP ratio, both compared to OECD and Latin American peer economies, allowing the country access to credit in convenient conditions.*

<sup>3</sup> *Other papers, such as Baum and Koester (2011), Baum et al. (2012), and International Monetary Fund (2012) define the state of the economy using the output gap. Further extensions of this paper could include this measure instead of the real GDP growth as we do.*



are positive and above the unit in the “tight” regime, and negative and about -0.5 in the “normal” regime. Tax multipliers are about 0.2 in the long term when the economy is in the “tight” regime.

Next, we study the interaction between fiscal and monetary policies, depending on the state of the economy. Building on the baseline model and including the short-term (monetary policy) interest rate, we estimate a TVAR model we called “extended model.” We find that when including the short-term (monetary policy) interest rate, fiscal multipliers are slightly smaller compared to when it is not the case.

The remaining of this paper is structured as follows. Section II reviews the international literature studying the effects of fiscal policy and fiscal multipliers using nonlinear vector autoregression models and discusses the literature studying the case of Chile. Section III presents the data, discusses the analytical approach we use (TVAR models), and explains how we compute fiscal multipliers. Then section IV presents the results of the baseline model, finding that Chile’s fiscal multipliers, and therefore fiscal policy effectiveness, differ depending on the state of the economy (“tight” or “normal”), with government spending multipliers above the unit in the “tight” regime and around -0.5 in the “normal” regime. Tax multipliers do not statistically differ from zero in both regimes (“tight” and “normal”). Section V provides the results of the extended model, finding that government spending multipliers are slightly smaller compared to those not considering the monetary policy stance. Last, section VI concludes.

## II. LITERATURE REVIEW

In this section, we review the international literature studying the effects of fiscal policy and fiscal multipliers using nonlinear vector autoregression models, and we discuss the literature examining the case of Chile.

Most of the literature estimating the effects of fiscal policy and fiscal multipliers using vector autoregression models follows the seminal contribution of Blanchard and Perotti (2002). These authors, developing a Structural Vector Autoregression (SVAR) model with data for the United States, find that government spending has a positive impact on output, and the opposite happening when raising taxes. Since Blanchard and Perotti (2002), a vast literature using linear vector autoregression models has studied the effects of fiscal policy and fiscal multipliers (Perotti, 2005; Caldara and Kamps, 2008; Ilzetzki and Végh, 2008; González-García et al., 2013; Ilzetzki et al., 2013; among others).

A significant literature review by Spilimbergo et al. (2009) argues that: (i) the size of fiscal multipliers is far from being homogenous among countries; (ii) fiscal multipliers are bigger if a small part of the stimulus is spent on imports or saved by the private sector, the interest rate does not increase as a result of the fiscal expansion, and the country’s fiscal position is perceived as sustainable

by private agents; (iii) a rule of thumb government spending multiplier (assuming a constant interest rate) is of 1.5 to one for large countries, one to 0.5 for medium-sized countries and 0.5 or less for small open economies, with tax multipliers being about the half of government spending multipliers; (iv) The risk of “simultaneity biased” is reduced when using data with a frequency quarterly or higher.

As the global financial crisis proved the inaccuracy and ineffectiveness of vector autoregression linear models in predicting the effects of fiscal policy and the size and sign of fiscal multipliers, a new strand of literature developed nonlinear vector autoregression models able to capture the effectiveness of fiscal policy depending on the state of the economy. This literature includes contributions by Afonso et al. (2011), Baum and Koester (2011), Auerbach and Gorodnichenko (2012), Batini et al. (2012), Baum et al. (2012), International Monetary Fund (2012), Auerbach and Gorodnichenko (2013), for developed economies, and by Vargas et al. (2015) and Carrillo (2017), for developing countries, among others. In general, this new strand of literature finds substantial differences in the size of fiscal multipliers, with fiscal policy being more effective during periods of recession or slow economic growth, or “tight” regime, compared to periods of economic growth, or “normal” regime.

Among single-country studies, two early contributions are Baum and Koester (2011) and Auerbach and Gordnichenko (2012). Baum and Koester (2011), using a TVAR model, compute fiscal multipliers for Germany, finding that government spending multipliers are much more significant in the case of a negative output gap, and tax policy having a limited effect. Meanwhile, Auerbach and Gordnichenko (2012), for the United States, compute fiscal multipliers from a Markov switching vector autoregression (MSVAR) model, finding that the government spending multiplier at impact is similar during “tight” and “normal” regimes (about 0.5), but presents substantial differences in the long term (25 quarters), over 2.5 in the “tight” regime and about zero in the “normal” regime.

Alternatively, papers studying a group of countries and estimating TVAR models include studies by Afonso et al. (2011), Batini et al. (2012), Baum et al. (2012), and International Monetary Fund (2012), among others. Afonso et al. (2011), using a financial stress indicator proposed by Cardarelli et al. (2011) as the threshold variable, and quarterly data for Germany, Italy, the United Kingdom, and the United States, study whether the effects of fiscal policy differ depending on the financial conditions. They find a nonlinear response of output to a fiscal shock associated with different behaviors across regimes. Batini et al. (2012), using a TVAR model, estimate the impact of fiscal adjustments in the United States, Europe, and Japan, finding government spending multipliers much larger in downturns than in upturns. Baum et al. (2012), using the output gap as the threshold variable and quarterly government spending and tax data for Canada, France, Germany, Japan, the United Kingdom, and the United States, find that fiscal policy shocks on output depend not only on the state of the economy (with government spending and tax multipliers being more significant in “tight” regimes than in “normal” regimes) but also on their



size and direction. Similarly, the International Monetary Fund (2012), for the G-7 countries except Italy, finds evidence suggesting that the impact of fiscal policy on output varies with the business cycle, that the average fiscal multipliers are much more significant in times of negative output gaps, with government spending multipliers being more significant in absolute value than tax multipliers.

Subsequently, for a group of thirty OECD countries, including both developed economies and emerging markets, Riera-Crichton et al. (2014) explore whether the effects of fiscal policy and fiscal multipliers depend on the state of the business cycle or not. They find not only that government spending multipliers are higher during a “tight” regime than in a “normal” regime, but also that government spending multipliers are even higher during a “tight” regime and when government spending is increasing.

Country-specific contributions focusing on Latin America include Vargas et al. (2015) for Colombia and Carrillo (2017) for Ecuador. Both studies, in line with the literature focusing on developed economies, find that fiscal policy is more effective in “tight” regimes than in “normal” regimes, with government spending being more efficient to boost output than tax cuts.

In the case of Chile, the literature studying the effects of fiscal policy and fiscal multipliers has mostly used linear models, then not considering the effectiveness of the fiscal policy depending on the state of the economy.

The literature studying the effects of Chile’s fiscal policy and fiscal multipliers, using quarterly frequency data, to the best of our knowledge, includes four main contributions (Cerdeña et al., 2005; Restrepo and Rincón, 2006; Céspedes et al., 2011; Fornero et al., 2019) with very different results, leaving the question about the effects of fiscal policy and fiscal multipliers far from being conclusive.<sup>4</sup>

Cerdeña et al. (2005) made the first attempt to estimate the effects of Chile’s fiscal policy using quarterly data. These authors, using an SVAR model and data for the period 1986.I-2001.IV, find that a positive shock to government spending reduces output at impact and then dies out and that a positive shock to taxes has a negative and minimal effect on output at impact.<sup>5</sup> Thus, according to Cerdeña et al. (2005), fiscal policy in Chile has a null and even slightly adverse effect on output.

Later, Restrepo and Rincón (2006) also using an SVAR model, for the period 1989.I-2005.II find that one Chilean peso spent by the government generates about USD 1.9 at impact that stabilizes at about USD 1.4 in the long term and

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<sup>4</sup> Alternatively, Correa et al. (2014) employ a “narrative approach.”

<sup>5</sup> In Cerdeña et al. (2005), government spending corresponds to the total spending, including transfers, social security, financial investment, public debt services, and other fiscal spending. Taxes include all taxes net of subsidies, i.e., income taxes, value-added tax, trade taxes, excise taxes, juridical acts taxes, and other taxes.

that an increase in taxes of one Chilean peso reduces GDP by about USD 0.4 at impact, being not much different from zero in the long term.<sup>6</sup> Hence, Restrepo and Rincón (2006) conclude that in Chile, while government spending might have a positive effect on output, taxes do the opposite.

Céspedes et al. (2011), using a Vector Autoregression (VAR) model, estimate government spending multipliers for the period 1990.I-2010.I, finding a government spending multiplier of 0.7 at impact and a cumulative multiplier of 2.8 after eight quarters.<sup>7</sup> The results of Céspedes et al. (2011) suggest that government spending multipliers are high and positive, with fiscal policy being quite useful to boost the Chilean economy.

In a recent paper, Fornero et al. (2019) estimate government spending multipliers and specific multipliers for government consumption, public transfers, and government investment using an SVAR for the period 1996.I-2015.IV, they find a government spending multiplier of 0.2 at impact and about 0.6 in the long term.

Summing up, the results in the literature using linear vector autoregression models to estimate the effects of fiscal policy and fiscal multipliers in Chile are far from conclusive. Cerda et al. (2005) conclude that the Chilean fiscal policy has a null or even adverse effect on economic activity (both government spending and taxes). Restrepo and Rincón (2006) suggest that government spending might be useful, but taxes not. Céspedes et al. (2011) find that government spending is quite capable of boosting the Chilean economy. Fornero et al. (2019) suggest that government spending has a positive effect on the economy, but with government spending and investment being particularly useful. We guess that the methodological choices might explain the differences in the results, i.e., the period of study, the alternative models used, the variables included, the number of lags the models have, and the government spending and tax definitions considered. Appendix A presents a summary.

### III. METHODOLOGY

In this section, we present the data, describe the variables and their arrangements, list the statistical tests we apply to them, and the number of lags selected and included in our estimations. Then we describe the analytical approach we use (TVAR model) discussing its strengths and weaknesses. Last, we describe how we calculate the fiscal multipliers (at impact, after a year, after two years, and in the long term) presented later in sections IV and V.

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<sup>6</sup> Restrepo and Rincón (2006) define government spending as wages and salaries, goods and services, and investment, and taxes as total taxes net of subsidies and grants, interest payments, social security payments, and capital transfers.

<sup>7</sup> Céspedes et al. (2011) understand government spending as the sum of government consumption and government investment.



## 1. Data

This paper covers the period 1990.I-2017.IV. The data have a quarterly frequency, which means one hundred and twelve observations, sourced by the Chilean Budget Office (Dipres), the National Institute of Statistics (INE), the Central Bank of Chile (BCCh) and the OECD. The nominal government spending and taxes data come from Dipres; the BCCh and the OECD provide the nominal GDP, consumer price index (of all items), and the short-term (monetary policy) interest rate; the population comes from the INE.<sup>8</sup>

The variables included in the baseline model of section IV are the log of real per capita GDP in differences  $d\log Y_t$ , the log of real per capita government spending in differences  $d\log G_t$ , and the log of real per capita taxes in differences  $T_t$ . In section V, the extended model builds on the baseline model by adding the short-term (monetary policy) interest rate in percentage and differences  $di_t$ . To get these variables, except the short-term (monetary policy) interest rate, we deflate the nominal time series by the consumer price index (of all items), divided by the population, transformed into logarithms, seasonally adjusted using the Census X-12 seasonally adjustment method, and set their differences to achieve stationarity.<sup>9</sup>

Following, to check stationarity, we implement the standard Augmented Dickey-Fuller, Elliot-Rothemberg-Stock, and the Phillips-Perron unit root tests. Meanwhile, the time series in logarithms show non-stationarity, i.e., unit root, the series in percentages observes mixed results meaning stationarity and non-stationarity depending on the specific test, and the data in differences are stationary in almost all cases. Appendix B reports these unit root tests.

It is well-known that the lag choice has important quantitative implications for the accuracy of the vector autoregression models and their impulse-response functions (Ivanov and Kilian, 2005). At the same time, however, the number of lags chosen by the existent criteria (Schwarz Information Criterion (SIC), Hannan-Quinn Information Criterion (HQC), and Akaike Information Criterion (AIC), among others) can be somewhat contradictory. In the related literature using quarterly data, four lags are usually chosen (see for instance: Balke, 2000; Blanchard and Perotti, 2002; Caldara and Kamps, 2008; Ilzetzki et al., 2013; González-García et al., 2013; and Karagyozyova-Markova et al., 2013; among others); however, such practice does not consider the specificities of the data used.

In this paper, we follow a more “statistical” approach for choosing the number of lags included in our models. This approach starts by selecting the maximum number of lags, depending on the data frequency. As we use quarterly data, the maximum number of lags is four. Then, we choose the number of lags using the

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<sup>8</sup> We use the data built on the “accrual principle,” meaning government spending and taxes recorded at the time the activity that generates the obligation to pay them occurs.

<sup>9</sup> This procedure follows what has been extensively implemented in the literature (see, for example; Cerda et al., 2005; Restrepo and Rincón, 2006; Baum and Koester, 2011; Céspedes et al., 2011).

existent information criteria, but these give different answers to this question. Hence, we follow Ivanov and Kilian (2005), who recommend when using semi-structural vector autoregression models based on quarterly data, as we do, use the number of lags suggested by the HQC.

## 2. Analytical approach

The empirical literature studying the effects of fiscal policy and fiscal multipliers uses three main approaches: (i) the estimations based on vector autoregression models; (ii) structural model-based evaluations as dynamic stochastic general equilibrium models (DSGE); and (iii) case studies based on well-documented changes in government spending and taxes. Among the vector autoregression models, four strands stand out (Jemec et al., 2011): (i) short-term restrictions as the recursive Cholesky decomposition of the variance-covariance matrix of the model's residuals (Fatás and Mihov, 2001); (ii) SVAR models based on institutional information coming out of the model (Blanchard and Perotti, 2002); (iii) sign restrictions on the variables in the model (Mountford and Uhlig, 2009) and (iv) "event studies" requiring long data series of well-established exogenous shocks (Ramey and Shapiro, 1998).

We estimate TVAR models, with Cholesky decomposition as the identification strategy, because these models allow incorporating the state of the economy ("tight" and "normal" regimes) to study the effects of fiscal policy and fiscal multipliers. Also, TVAR models are now considered a standard tool in modern applied macroeconomics (Afonso et al., 2011; Baum and Koester, 2011; Batini et al., 2012; Baum et al., 2012; among others), scarcely implemented in emerging markets such as Chile.

TVAR models are nonlinear vector autoregression models capable of separating observations into different regimes depending on a threshold, where the models are linear within each regime (International Monetary Fund, 2012). In these models, parameters can switch depending on whether the "threshold variable" crosses or not an estimated threshold. In recent years TVAR models have become increasingly popular as these models can overcome the problem of nonlinearity among variables that traditional linear vector autoregression models cannot deal with.<sup>10</sup> Nevertheless, despite their advantage over linear vector autoregression models, TVAR models have the drawback of potential arbitrariness in the threshold selection (Riera-Crichton et al., 2014).

TVAR models can be expressed as follows:

$$W_t = I_{\{c_{t-d} < \gamma\}} \left[ B^1 Z_t + F^1(L) Z_{t-1} \right] + I_{\{c_{t-d} \geq \gamma\}} \left[ B^2 Z_t + F^2(L) Z_{t-1} \right] + \varepsilon_t \quad (1)$$

where  $Z_t$  is a vector of endogenous variables. In this paper, meanwhile, the baseline model of section IV includes  $\text{dlog } G_t$ ,  $\text{dlog } Y_t$ , and  $\text{dlog } T_t$ , the extended model of section V, building on the baseline model, includes  $\text{dit}$  as well. Also,

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<sup>10</sup> Alternative approaches modeling nonlinear dynamic relationships are MSVAR models.

as in Batini et al. (2012), the GDP growth,  $\text{dlog } Y_t$ , is both an endogenous and the “threshold variable.”

Consequently,  $B^1$  and  $B^2$  represent the contemporaneous structural relationships in the two regimes we study, “tight” and “normal”,  $F^1(L)$  and  $F^2(L)$  are lag polynomial matrices, and  $\varepsilon_t$  are the structural disturbances.  $c_{t-d}$  represents the threshold determining in which regime the system  $\mathbb{1}_{\{c_{t-d} \geq \gamma\}}$  is an indicator function that equals one when  $c_{t-d} \geq \gamma$  and zero otherwise. Following Balke (2000), Afonso et al. (2011) and Batini et al. (2012), among others, we set the parameter  $d = 1$  because we need at least one lag of the threshold variable to feed the TVAR models recursively and because our interest is in response to fiscal shocks when a regime switch has just occurred (Batini et al., 2012).

We achieve identification through Cholesky decomposition. The variables ordering in the baseline model of section IV consider  $\text{dlog } G_t$  first,  $\text{dlog } Y_t$  second, and  $\text{dlog } T_t$  last, following early contributions using Cholesky decomposition for identification (Fatás and Mihov (2001), Caldara and Kamps (2008), among others). The extended model of section V follows the ordering of the variables in the baseline model with the exception that  $\text{dlog } T_t$  goes third and dit is placed last, as in Caldara and Kamps (2008) and Batini et al. (2012). To allow comparability with the results in section IV, the number of lags included in the extended model is also two.

### 3. Fiscal multipliers

To check the effects of fiscal policy on output, we estimate TVAR models, obtaining impulse-response functions and computing fiscal multipliers of government spending and taxes.

Aware of the existence of alternative ways to compute fiscal multipliers, in this paper we follow the definition in Spilimbergo et al. (2009), meaning the ratio of a change in output to an exogenous change in government spending or taxes, with respect to their respective baselines (as Batini et al. (2012), González-García et al. (2013), and Ilzetzki et al. (2013), among others).

Hence, we compute two alternative multipliers, the impact multiplier (IM) and the cumulative multiplier (CM). While the IM considers the effects of fiscal policy on output in the very short-term, the CM summarizes the total effect that a fiscal policy shock has on output over a specified period. The IMs of government spending (equation 2) and taxes (equation 3) are defined as follows:

$$IM \text{ spending} = \frac{dY_t}{dG_t} \quad (2)$$

$$IM \text{ taxes} = \frac{dY_t}{dT_t} \quad (3)$$

where  $dY_t$  is the change in output followed by a change in government spending,  $dG_t$ , or taxes,  $dT_t$ , in the very short-term (at impact).

Subsequently, the CMs represent the sum effects of government spending and taxes on output at a specified time horizon after impact. These are defined as following:

$$CM \text{ spending} = \frac{\sum_{j=1}^N dY_{t+j}}{\sum_{j=1}^N dG_{t+j}} \quad (4)$$

$$CM \text{ taxes} = \frac{\sum_{j=1}^N dY_{t+j}}{\sum_{j=1}^N dT_{t+j}} \quad (5)$$

where  $dY_{t+j}$  is the change in output concerning the baseline  $j$  periods after the fiscal shock, and  $dG_{t+j}$  and  $dT_{t+j}$  are the changes in government spending and taxes  $j$  periods after the fiscal shock (Spilimbergo et al., 2009; Batini et al., 2012). The fiscal shock we study corresponds to a positive one-standard-deviation shock to government spending and taxes.

Then, in addition to the IMs of government spending and taxes, we also compute the CMs of government spending and taxes after ten quarters as Céspedes et al. (2011) and Fornero et al. (2019), contributions using the same type of data we use in this paper. In the following sections, we alternatively report impact and cumulative government spending and tax multipliers. We define the long term cumulative multiplier when it reaches ten quarters.<sup>11</sup>

To compute the IMs and the CMs from the impulse-response functions, we use the following standard transformations (Céspedes et al., 2011; González-García et al., 2013):

$$IM \text{ spending} = \frac{dY_t}{dG_t} = \frac{d \log Y_t}{d \log G_t} * \frac{\bar{Y}}{\bar{G}} \quad (6)$$

$$IM \text{ taxes} = \frac{dY_t}{dT_t} = \frac{d \log Y_t}{d \log T_t} * \frac{\bar{Y}}{\bar{T}} \quad (7)$$

$$IM \text{ spending} = \frac{\sum_{j=1}^N dY_{t+j}}{\sum_{j=1}^N dG_{t+j}} = \frac{\sum_{j=1}^N d \log Y_{t+j}}{\sum_{j=1}^N d \log G_{t+j}} * \frac{\bar{Y}}{\bar{G}} \quad (8)$$

$$CM \text{ taxes} = \frac{\sum_{j=1}^N dY_{t+j}}{\sum_{j=1}^N dT_{t+j}} = \frac{\sum_{j=1}^N d \log Y_{t+j}}{\sum_{j=1}^N d \log T_{t+j}} * \frac{\bar{Y}}{\bar{T}} \quad (9)$$

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<sup>11</sup> The long term multiplier corresponds to the multiplier when  $N \rightarrow \infty$ , but in practice, after a sufficiently large number of periods the CM reaches a constant level.

where  $d\log Y_t$ ,  $d\log G_t$ , and  $d\log T_t$  come from the impulse-response function estimates by the TVAR models and approximate  $[Y_t - Y_{t-1}]/Y_{t-1}$ ,  $[G_t - G_{t-1}]/G_{t-1}$  and  $[T_t - T_{t-1}]/T_{t-1}$ , respectively. Finally,  $\bar{Y}$ ,  $\bar{T}$  and  $\bar{G}$  are respectively the average output, average government spending, and average taxes, in the period of study.

#### IV. BASELINE MODEL

In this section, we present and discuss the results of estimating the baseline model. To do so we closely follow the paper by Batini et al. (2012), using the method developed initially by Balke (2000), and estimating a TVAR model that changes its structure according to the GDP growth (our threshold variable), to obtain regime dependent impulse-response functions and hence fiscal multipliers in the “tight” and “normal” regimes. The baseline model includes the three endogenous variables defined in section III, meaning  $d\log G_t$ ,  $d\log Y_t$  and  $d\log T_t$ . Identification is achieved through Cholesky decomposition, with  $d\log G_t$  ordered first, followed by  $d\log Y_t$ , and last  $d\log T_t$ .<sup>12</sup>

The baseline model includes a constant and two lags, as discussed in the previous sections following the HQC. We set the parameter describing the delay of the threshold variable, “ $d$ ”, equal to one as our interest is in the response to fiscal shocks when a regime switch has just occurred, same as Balke (2000), Calza and Souza (2006), Afonso et al. (2011), and Batini et al. (2012).

The threshold value, endogenously estimated from our data, sets a value for the GDP growth rate equal to 1.13%. It means that when the Chilean economy is growing below 1.13%, it is in the “tight” regime, and if it is growing above 1.13%, it is in the “normal” regime.

Figure 1 presents the baseline model results. As expected, both fiscal multipliers (government spending and taxes) differ depending on whether the Chilean economy is in the “tight” or the “normal” regime. Meanwhile, the government spending multiplier at impact is positive, and about 0.35 in the “tight” regime and 0.22 in the “normal” regime, the cumulative multiplier differs substantially, being above the unit (1.23) when the economy is in the “tight” regime and negative (-0.56) when the economy is in the “normal” regime.

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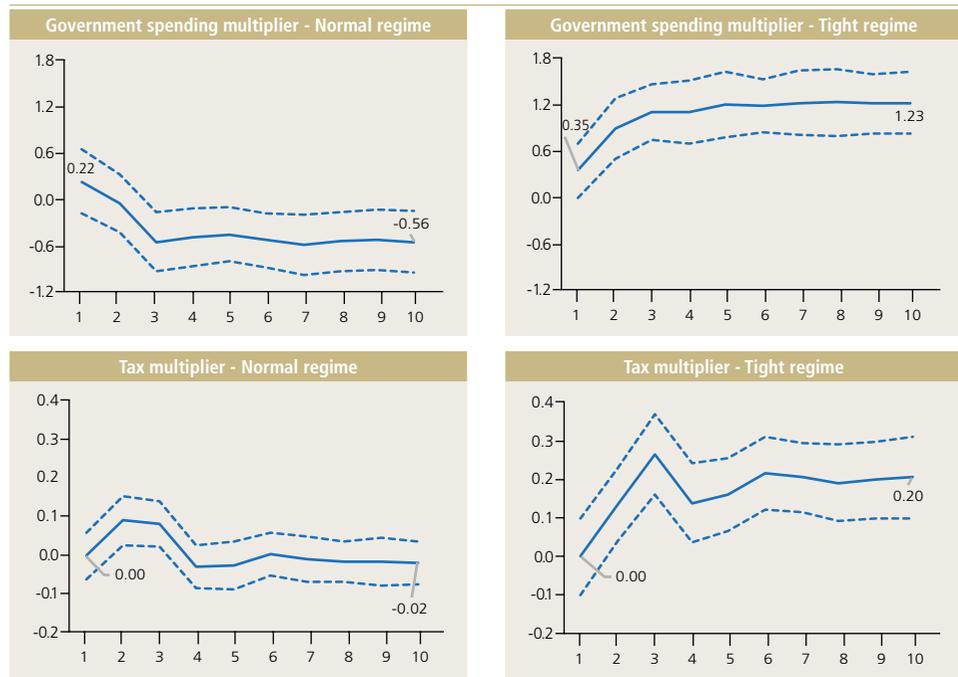
<sup>12</sup> Appendix C presents alternative estimations with  $d\log T_t$  ordered first, followed by  $d\log G_t$ , and last  $d\log Y_t$  (see Baum and Koester, 2011; Baum et al, 2012; IMF, 2012; among others). In this case, while the government spending multiplier is slightly bigger in the “normal” regime and less negative in the “tight” regime, tax multipliers are bigger in both regimes.

These results suggest, on the one hand, that government spending seems capable of boosting the Chilean economy when the GDP growth rate is below 1.13% and ineffective when the opposite occurs. That linear models underestimate the effects of a government spending shock during a period of slow growth and overestimate its effects in periods of more robust growth. On the other hand, tax multipliers in the “tight” and the “normal” regimes are zero at impact, as we assume that tax multipliers affect neither government spending nor output contemporaneously, though in the long term cumulative tax multipliers differ, being slightly positive in the “tight” regime (0.20) and statistically not different than zero in the “normal” regime (-0.02).

**Figure 1**

**Baseline model: Government spending and tax multipliers**

(threshold GDP growth = 1.13%)



Source: Authors' calculations.

Note: The vertical axis represents the size of the fiscal multipliers, the horizontal axis represents the number of quarters since the shock, and the dotted lines represent the confidence intervals at 95% of statistical significance based on bootstrap simulations (500 repetitions).



Consequently, figure 1 shows that: (i) fiscal multipliers and therefore the effectiveness of the Chilean fiscal policy differ depending if the economy is in the “tight” or the “normal” regime, in line with the international literature where fiscal policy seems to have different effects depending on the state of the economy; (ii) the results confirm that the effects of Chile’s fiscal policy are nonlinear, with fiscal multipliers, particularly government spending multipliers, being positive and above the unit in the “tight” regime and negative and about -0.5 in the “normal” regime; and (iii) tax multipliers are slightly effective in the “tight” regime.

## V. EXTENDED MODEL

The literature studying the dynamic effects of fiscal policy and fiscal multipliers on occasions includes variables other than government spending, taxes, and output, to investigate possible interactions between fiscal and other macroeconomic variables. In this sense, evidence on the interaction between fiscal and monetary policies, as a determinant of the effects of fiscal policy on output (Ahrend et al., 2006; Spilimbergo et al., 2009; Canova and Pappa, 2011; Batini et al., 2012; Ilzetzki et al., 2013; Fornero et al., 2019), relates the monetary policy stance with the size and sign of fiscal multipliers.

Building on the baseline model of section IV, this section estimates a model that also includes the short-term (monetary policy) interest rate to consider possible interactions between the Chilean fiscal and monetary policies, and to study if short-term (monetary policy) interest rate has had a role on the size and sign of fiscal multipliers. We include the short-term (monetary policy) interest rate because of the notion that monetary accommodation plays a crucial role in the expansionary effect of fiscal policy, that turns out to be related to those studies showing that fiscal multipliers are larger when central banks’ policy interest rate is at the zero-lower bound. We called this model the extended model. It includes four variables: government spending, taxes, output, and the short-term (monetary policy) interest rate.

The model changes its structure depending on the GDP growth rate (our threshold variable) into two regimes, “tight” and “normal”. The ordering of the variables included in the model is the following: first  $d\log G_t$ , then  $d\log Y_t$ ,  $d\log T_t$ , and  $dit$  last.<sup>13</sup> This ordering follows Batini et al. (2012), and identification is achieved through Cholesky decomposition. In this case the threshold value, endogenously estimated for the GDP growth rate, is equal to 1.07%. Then if the Chilean economy grows below 1.07%, it is in the “tight” regime, and if it grows above 1.07%, it is in the “normal” regime. Finally, the extended model includes a constant and two lags to allow comparability with the fiscal multipliers presented in figure 1.

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<sup>13</sup> Alternatively, table C2 in appendix C presents estimates with the ordering with  $d\log T_t$  ordered first, followed by  $d\log G_t$ ,  $d\log Y_t$ , and  $dit$ . In this case, government spending multipliers are slightly bigger in the “normal” regime and less negative in the tight regime, and tax multipliers are bigger in both regimes.

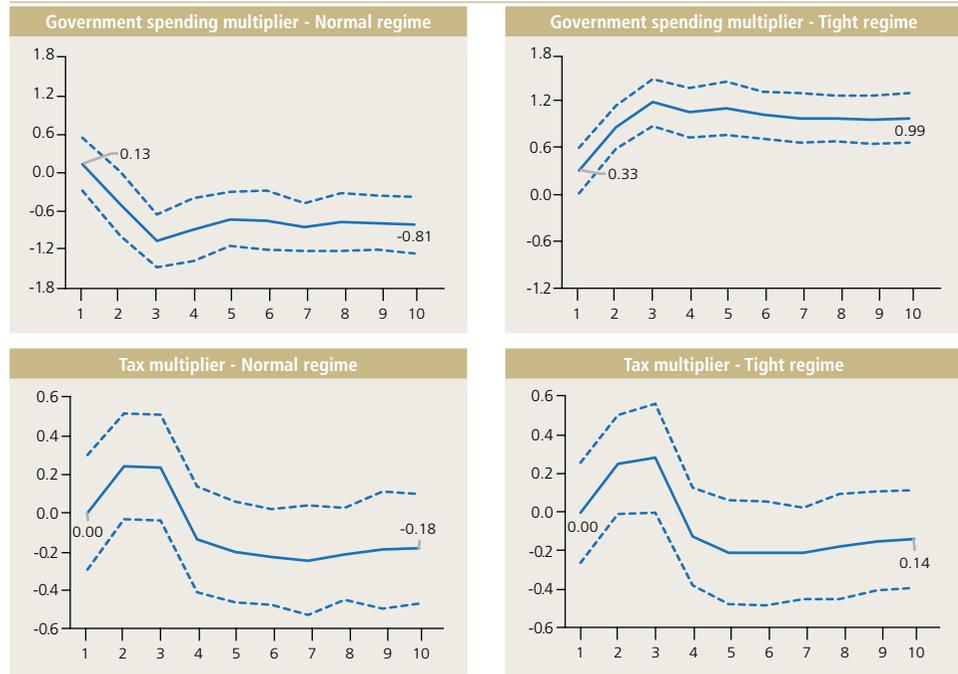
Figure 2 presents the extended model’s fiscal multipliers. The results show that government spending multipliers at impact are similar, 0.33 in the “tight” regime, and about 0.13 in the “normal” regime, nevertheless statistically not significant in this latter case. Subsequently, in the long term, while the government spending multiplier in the “tight” regime is about the unit (0.99), it is negative and about -0.81 in the “normal” regime. Regarding the tax multiplier, it is zero at impact (Cholesky decomposition assumption to achieve identification) and about -0.2 in the long term in both regimes, but statistically not significant. In brief, from comparing the baseline model (figure 1) and extended model (figure 2) fiscal multipliers, we observe that when including the short-term (monetary policy) interest rate we obtain slightly smaller fiscal multipliers compared to those not including it, with long term government spending multipliers remaining statistically significant.

Figures 1 and 2 display the fiscal multipliers in the baseline and extended models, respectively. We find that independently of the regime in which the economy is in, the government spending multipliers are slightly smaller when the short-term (monetary policy) interest rate is considered (extended model) compared to when it is not included (baseline model). Meanwhile, tax multipliers are zero at impact and slightly smaller when estimated using the extended model vis-à-vis using the baseline model. However, these multipliers are statistically not significant except for the tax multiplier in the “tight” regime using the baseline model.

Figure 2

**Extended model: government spending and tax multipliers**

(threshold GDP growth = 1.07%)



Source: Authors’ calculations.

Note: The vertical axis represents the size of the fiscal multipliers, the horizontal axis represents the number of quarters since the shock, and the dashed lines represent the confidence intervals at 95% of statistical significance based on bootstrap simulations (500 repetitions).



## VI. CONCLUSIONS

In this paper, we estimate nonlinear vector autoregression models (TVAR) using quarterly data and calculating fiscal multipliers of government spending and taxes, depending on the state of the Chilean economy, with GDP growth as our “threshold variable”.

The “baseline model,” which includes the government spending, GDP and taxes, as endogenous variables, find that in the long term the government spending multiplier is above the unit when the economy is in the “tight” regime, and it is about -0.5 in the “normal” regime. Furthermore, in the long term, the tax multiplier is slightly positive only in the “tight” regime. The “extended model” finds government spending multipliers a bit smaller when the short-term (monetary policy) interest rate is considered.

Possible avenues for future research might include the estimation of fiscal multipliers using alternative nonlinear models such as MSVAR and the use of different threshold variables, for instance, the output gap.

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## APPENDIX A

### DATA, APPROACHES, VARIABLES, AND RESULTS IN THE LITERATURE STUDYING THE CASE OF CHILE

	Cerda et al. (2005)	Restrepo and Rincón (2006)	Céspedes et al. (2011)	Fornero et al. (2019)
Period of study	1986.I-2001.IV	1989.I-2005.II	1990.I-2010.I	1996.I-2015.IV
Frequency	Quarterly	Quarterly	Quarterly	Quarterly
Approach	SVAR	SVAR	VAR	SVAR
Number of lags included in the vector autoregression model	8 (Akaike information criterion)	Not mentioned	4 (Criterion not mentioned)	2 (Akaike and Hannan-Quinn information criteria)
Variables included	Government spending, taxes and GDP	Government spending, taxes and GDP	Government spending, private consumption, public deficit and GDP	Government spending, GDP, short-term (monetary policy) interest rate, real exchange rate
Government spending definition	Total spending less transfers, social security, financial investment, debt interests and other fiscal expenditure	Wages and salaries, goods and services, and investment; i.e. government spending net of transfers	Government consumption and investment	Government consumption and investment
Taxes definition	Income taxes, value added tax, trade taxes, taxes to specific products, taxes to juridical actions, and other taxes net of subsidies	Taxes are net of subsidies and grants, interest payments, social security payments and capital transfers	Not studied. Instead they study the dynamic effects of government transfers	Not studied. Instead they study the dynamic effects of government consumption, public transfers, and government investment
Results of a positive government spending shock	Small and negative effect on output	Positive effect on output	High and positive effect on output	Positive effect on output
Results of a positive tax shock	Small and negative effect on output	Small and negative effect on output	Not studied	Not studied

Source: Authors' calculations.

Note: Céspedes et al. (2011) use GDP data, excluding copper and other natural resources. Regarding the fiscal data sources, Cerda et al. (2005) use data collected under the "cash principle" (government spending and taxes recorded at the time the transaction occurs), sourced by the government's payment office (Tesorería General de la República). Whereas Restrepo and Rincón (2006), Céspedes et al. (2011) and Fornero et al. (2019) use data provided by the Chilean Budget Office (Dipres) built on the "accrual principle" (government spending and taxes recorded at the time of the activity that generates the obligation to pay them).

## APPENDIX B

### UNIT ROOT TESTS

Table B1

#### Variables in levels

		Augmented Dickey-Fuller	Phillips-Perron	Elliot-Rothenberg-Stock
GDP	Evidence of unit root	Yes	Yes	Yes
	t-statistic	-2.21	-1.99	-2.24
	critical value 1%	-4.05	-4.04	-3.57
	critical value 5%	-3.45	-3.45	-3.02
	critical value 10%	-3.15	-3.15	-2.73
Government spending	Evidence of unit root	Yes	Yes	Yes
	t-statistic	-2.26	-3.18	-2.25
	critical value 1%	-4.05	-4.04	-3.57
	critical value 5%	-3.45	-3.45	-3.02
	critical value 10%	-3.15	-3.15	-2.73
Taxes	Evidence of unit root	No	No	No
	t-statistic	-3.64	-3.60	-3.20
	critical value 1%	-4.04	-4.04	-3.57
	critical value 5%	-3.45	-3.45	-3.02
	critical value 10%	-3.15	-3.15	-2.73

Source: Authors' calculations.

Note: "No" indicates the absence of evidence of unit root at a 5% critical value; "Yes" means the opposite. After data inspection, we decided to apply the unit root tests with intercept and trend to the variables in levels and with neither intercept nor trend to the variables in differences.

**Table B2****Variables in differences**

		Augmented Dickey-Fuller	Phillips-Perron	Elliot-Rothenberg-Stock
GDP	Evidence of unit root	No	No	No
	t-statistic	-5.56	-5.63	-4.69
	critical value 1%	-2.59	-2.59	-2.59
	critical value 5%	-1.94	-1.94	-1.94
	critical value 10%	-1.61	-1.61	-1.61
Government spending	Evidence of unit root	Yes	No	Yes
	t-statistic	-1.51	-13.05	-1.37
	critical value 1%	-2.59	-2.59	-2.59
	critical value 5%	-1.94	-1.94	-1.94
	critical value 10%	-1.61	-1.61	-1.61
Taxes	Evidence of unit root	No	No	No
	t-statistic	-12.50	-12.49	-3.04
	critical value 1%	-2.59	-2.59	-2.59
	critical value 5%	-1.94	-1.94	-1.94
	critical value 10%	-1.61	-1.61	-1.61

Source: Authors' calculations.

Note: "No" indicates the absence of evidence of unit root at a 5% critical value; "Yes" means the opposite. After data inspection, we decided to apply the unit root tests with intercept and trend to the variables in levels and with neither intercept nor trend to the variables in differences."

**Table B3****Variables in percentages**

		Augmented Dickey-Fuller	Phillips-Perron	Elliot-Rothenberg-Stock
Short-term interest rate	Evidence of unit root	No	Yes	Yes
	t-statistic	-3.72	-2.85	-1.37
	critical value 1%	-3.49	-3.49	-2.59
	critical value 5%	-2.89	-2.89	-1.944
	critical value 10%	-2.58	-2.58	-1.615
D (Short-term interest rate)	Evidence of unit root	No	No	No
	t-statistic	-6.84	-5.60	-6.87
	critical value 1%	-2.59	-2.59	-2.59
	critical value 5%	-1.94	-1.94	-1.94
	critical value 10%	-1.61	-1.61	-1.61

Source: Authors' calculations.

Note: "No" indicates an absence of evidence of unit root at a 5% critical value; "Yes" means the opposite. D(Short-term interest rate) denotes the short-term interest rate in differences.

## APPENDIX C

### GOVERNMENT SPENDING AND TAX MULTIPLIERS

Table C1

#### Baseline model: Government spending and tax multipliers

(threshold GDP growth = 1.13 percent)

	Regime	IM	CM (4th quarter)	CM (8th quarter)	CM (10th quarter)
Government spending	Tight	0.48	1.60	1.73	1.71
	Normal	0.31	-0.29	-0.28	-0.29
Taxes	Tight	0.23	0.68	0.75	0.76
	Normal	0.15	0.46	0.50	0.51

Source: Authors' calculations.

Note: The baseline model includes a constant and the number of lags suggested by the HQC, i.e.: two lags. IM denotes the impact multiplier and CM the cumulative multiplier.

Table C2

#### Extended model: Government spending and tax multipliers

(threshold GDP growth = 1.07 percent)

	Regime	IM	CM (4th quarter)	CM (8th quarter)	CM (10th quarter)
Government spending	Tight	0.43	1.39	1.21	1.25
	Normal	0.31	-0.37	-0.22	-0.16
Taxes	Tight	0.31	0.78	0.74	0.78
	Normal	0.16	0.33	0.29	0.33

Source: Authors' calculations.

Note: The extended model includes a constant and the number of lags suggested by the HQC, i.e.: two lags. IM denotes the impact multiplier and CM the cumulative multiplier.