Dynamic effects of the Costa Rican fiscal policy: the case of a small and open economy

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Abstract

To determine the effectiveness of fiscal policy on the Costa Rica’s economy, we use a structural autoregressive vector model, and to characterize its dynamics we implement a smooth transition autoregressive vector model, with quarterly data from 1991 to 2018. From the results, it is concluded that higher expenditure flexibility improves fiscal policy effectiveness, and that there are negative effects for tax increases which are highly time persistent. Furthermore, increases in government consumption and capital expenditures have a different impact given the economic cycle; they are beneficial during recessions, but harmful at expansions. The latter result can be explained mainly by a high fiscal deficit, which channels the transmission mechanism through negative expectations and crowding-out effects which increase interest rates. The results of this research support Neokeynesian theory in recessions, but resembles Neoclassical theory in expansions. Finally, given our estimations, there is a clear and intuitive fiscal policy recommendation: expansionary fiscal policy through increases in government consumption or capital expenditures could help overcome a crisis, but special attention must be given to its funding process and time of validity.

Key words: Public Spending, Government Revenues, Ricardian Equivalence, VAR, SVAR, STVAR, Structural Change, Macroeconometrics, Tax Structure.

JEL codes: C32, E62, H20, H50.

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Resumen

Para determinar la efectividad de la política fiscal sobre la economía costarricense, se usa un modelo de vectores autorregresivos estructurales y para caracterizar sus dinámicas, se implementa un modelo de vectores autorregresivos de transición suave, con datos trimestrales desde 1991 hasta 2018. De los resultados se concluye que mayor flexibilidad del gasto mejora la efectividad de la política fiscal y que el efecto negativo de incrementos en impuestos es altamente persistente en el tiempo. Además, incrementos en el gasto de consumo o de capital tienen diferente impacto según el ciclo económico; son beneficiosos en recesiones, pero dañinos en expansiones. El último resultado puede ser explicado principalmente por un alto déficit fiscal, que canaliza el mecanismo de transmisión a través de expectativas negativas y el efecto expulsión que incrementa las tasas de interés. Los resultados de esta investigación dan soporte a la teoría Neokeynesiana en recesiones, pero se asemejan a la teoría Neoclásica en expansiones. Finalmente, dadas nuestras estimaciones, existe un claro e intuitivo consejo a la política fiscal: política fiscal expansiva mediante incrementos en el gasto de consumo o de capital podrían ayudar a salir de crisis, pero se debe dar especial atención a su proceso de financiamiento y a la validez temporal.

Palabras clave: finanzas públicas, mecanismos de transmisión, multiplicador fiscal, política fiscal, VARE, VAR-TS, macroeconometría, estructura tributaria.

Clasificación JEL.: C32, E62, H20, H50.
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1. Introduction

After the 2008 financial crisis, the debate among economists started up again on the impact of fiscal policy on the economic growth as many governments decided to implement stimulus programs, even when there was no consensus in the literature about its effectiveness. Theoretically, the discussion circles around the two main streams of the economic thought: the Neoclassic and Neokeynesian.

Under the latter, the expenditure multiplier is expected to be positive given that the government expenditure will result in an increase of the aggregated demand, boosting local production. While within Neoclassical view, a negative result is expected as the increase in the public expenditure is perceived as an action to be financed in the future with more taxes.

In general, the income multiplier is expected to be negative, as the impact of more taxes on disposable income lowers consumption. But still, there are some cases were the results point to a positive outcome which although might seem unusual, has been interpreted within high public debt contexts, as a positive signal. Therefore, an increase in taxes is perceived by economic agents as positive for public finances, diminishing uncertainty and promoting economic activity.

Given this context, empirically, the magnitude and sign of the impact of fiscal policy on production has been the center of debate when evaluating the actions policymakers could take in order to affect the economy. Therefore, the relevance of quantifying such effect is of critical importance; specifically, for the actual fiscal context of Costa Rica and the
international conditions, it seems urgent. We have to consider the increase in interest rates above the zero lower bound, the possible negative effects of the implemented actions in international commerce, adjusted financial conditions, geopolitical tensions, higher bills for oil imports, and a lower forecast for the international economy dynamics (IMF, 2018).

Under this scenery the main objective is to estimate the direction and magnitude of the fiscal multipliers in general, and particularly, their behaviour conditional on the state of the economy. Multiple countries had used fiscal policy as an instrument to stabilize the economic activity but, is the dynamic effect of fiscal policy invariant to the state of the economy?

This research looks to bring evidence on this regard. It intends to characterize the effects of fiscal policy in a developing and open economy, by estimating its fiscal multipliers, which are understood as the response (in magnitude and direction) of growth to exogenous shocks on government expenditure and/or income. As these multipliers signal a measure of the effectiveness of fiscal policy, they are valuable inputs for public policy. For example, in a recession they would determine if a fiscal stimulus will have the expected outcome on economic growth and for how long.

For these estimations, other studies have included Costa Rica in a panel of countries, but this is the first time series study with quarterly data from 1991 until 2018. Methodologically, we follow the seminal paper of Blanchard and Perotti (2002), which involves a structural autoregressive model and the use of impulse-response functions to measure the impact of shocks from a particular variable on the dynamics of other variables. There are two main reasons for its use. Firstly, changes in fiscal variables rarely obey to production stabilization, and secondly, decision making and implementation of fiscal policy is done with substantial lags, implying there is little space for discretionary policy changes with high frequency data.

In order to have a complete analysis of the effectiveness of fiscal policy, we additionally extend the model by including prices, interest rates, and the nominal exchange rate, following Perotti (2002). And also, we use the estimation method performed by Auerbach and Gorodnichenko (2012) in order to differentiate the responsiveness of fiscal policy conditional

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1In the fiscal data, there was a methodological change between 2006 and 2009, when they changed from cash based to accrued. For research, this has implied a major limitation as the time series were not overlapped. Even though, we were able to join the series obtaining the longest fiscal data series for Costa Rica at this time.
on the economic cycle.

The results obtained indicate that in Costa Rica, a change on government consumption, or what will be called flexible expenditure, measured by the multiplier, has a positive and statistical significant impact on growth. Hence, an increase of 1% in flexible expenditure can be associated with an accumulated increment of 0.2% in production one year after the shock.

Even though, when differentiating this impact by the economic cycle, we see that for recessions it maintains a positive effect but it is negative in expansions. This may be explained by arguing that expenditure increases in expansions are perceived as an increment in the total debt level or in future taxes, which imply either a crowding out effect and less credit availability, or a drop of the agent’s expected disposable income. Both which have a negative effect on production.

The tax income multiplier turned to be negative and statistically significant. Therefore, an addition of 1% in tax income is associated with an accumulated decline of 0.08% in the production one year later. When considering the economic cycle, the response of growth is positive in expansions and negative during recessions. The recessions’ effect is intuitive: reductions in the disposable income and business’ profits lessens the aggregated demand. But, the positive result for expansions should be taken with caution. Two hypothesis arise as explanations. In terms of methodology, it is not possible to separate the reverse causality problem between economic activity and tax income (issue that seems to not be present in the linear SVAR model). Or we may have found evidence of what has been named in the literature as an ”expansionary fiscal contraction or consolidation”, which relies on the argument that economies with high public debt levels could experience a boost if agents’ expectations consider the tax change to be linked with an improvement of public finances, and future macroeconomic stability.

The methodology and these results will be explained in detail in section four and five, and will be preceded by a review of the theoretical and empirical literature on the topic, and by a characterization of the Costa Rican fiscal context, in order to have a comprehensive framework before the discussion of the results and robustness checks, which are presented

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2Public expenditure in Costa Rica is highly inflexible, as more than 90% relative to tax income is determined by law or constitution. What we will call flexible expenditure is what is considered as government consumption in other contexts. Therefore, flexible expenditure will be the percentage of total expenditure for which the incumbent has some degree of freedom, as it is not determined by law or constitution.
in section six. The seventh section expands on the characterization of the dynamics of fiscal policy as it presents additional results. Specifically, it includes specifications with private consumption and investment, and the effect of current and capital public expenditure. The eighth and last section concludes summarizing the results, comparing the results with the empirical evidence from other countries, establishing the limitations of the presented estimations and mentioning areas for further research on the topic.

2. Literature Review

Empirical studies, within this topic, have shown divergent conclusions based in a wide spectrum of assumptions, and are inconclusive on the effect fiscal policy may have on growth in the short, medium, and long run. In general, the effects in the short run have been described through aggregate demand, while the medium and long term effects through the supply side. Therefore, it seems that effectiveness of fiscal policy will depend on the temporal horizon considered, the assumptions about the agents’ behavior, and the credibility of the decisions taken by the government.

The conclusions of the theoretical models on this matter are also divergent. The Keynesians and Neokeynesians would forecast a consumption, and hence, a demand response in the same direction with a fiscal policy expansion. While Neoclassicals would predict a zero or even negative effect. For the former, the aggregate demand is composed by consumption, investment, public expenditure, and net exports. Therefore, its variations generate an impact on employment and real GDP, before that on the price level. An increase in each of its components (one at the time), ceteris paribus, would generate an increase in production of the same amount. Under the assumption of price rigidities, economic policy measures on the demand side will provoke variations in the level of production and employment. However once full employment is achieved, increments in the aggregate demand will only generate inflation (UPV/EHU, 2015). The traditional Neokeynesian theory assumes a medium term horizon, with myopic agents that do not consider the government’s intertemporal budget constraint when making decisions. Under this context it is expected a positive equal multiplier in the short run.

On the other side, Neoclassical theory assumes rational agents, an infinite temporal horizon, an intertemporal budget constraint which considers the government’s constraint, and
decision making with long run perspectives. Under their scope, an increase in the government expenditure today will be translated into an increase of tomorrow’s taxes, therefore the disposable income would not change inter-temporally. As the agent could forecast this scenario, there are no changes in consumption. In other words, fiscal policy would be neutral (Ricardian equivalence); independently on how the expenditure is financed, it does not have an impact on consumption and hence neither on production. Within this line of thought, the markets of productive factors are highly flexible, which allow a quick convergence to equilibrium implying it is the aggregate supply the major component in the economic activity. At the same time, if it exists an inflation goal, there will exist pressure on prices which turns into interest rates increments with crowding out effects on private investments.

There exists other type of models that considers non-linear behavior, Sutherland (1997) is one of them. In the author’s study, the agent behaves under the guidelines of the Keynesian theory when the public debt stock is low, but in a different way if the debt levels are excessive and considered as threat of insolvency for the future generations. In other words, the non-linearity is provoked by the insolvency probabilities of the public sector: if it is low, the individuals will not consider increases in short run taxes, but if the probability is high, then the agents save because increases in taxes would be imminent.

When looking at the empirical literature, there are also divergent results, which seem as context dependant. In general, positive short run expenditure multipliers due to expansionary fiscal policies have been the outcome of macro structural models and VAR analysis, but they differ in magnitude and duration.

For the United States case, Blanchard and Perotti (2002) were the first to estimate in a convincing way fiscal policy effect, as methodologically they were able to isolate the reverse causality problems involved in the production’s and fiscal variables’ interactions. They found that expansive fiscal policy shocks increase output. From a direct expenditure shock, the private consumption responds positively and the private investment negatively. The identification method proposed was also adopted by Perotti (2002) for a sample of five OECD countries. The five equation system created included the gross domestic product, GDP, the GDP deflator, government expenditures, net government income, and the interest rate; but different results were obtained when comparing to those of Blanchard and Perotti.

These are based on Modigliani’s life cycle theory, and Friedman’s permanent income theory.
(2002). The author concludes that fiscal policy effects on GDP and its components became weaker as time passed because he found that both income and expenditure multipliers, had negative effects.

As part of the varied results, Romer and Romer (2010) estimated for the United States that a 1% change in fiscal policy increases GDP around 1%, but it could raise to 2 or 3% when the effect is on its peak some years later. Also, Corsetti and Müller (2006) studied the fiscal shocks for the United States, Canada, United Kingdom, and Australia, and presented evidence of the twin deficit phenomena: it is more restricted in relatively closed economies, and the fiscal shocks are less persistent.

For open economies, Monacelli and Perotti (2006) used SVAR techniques, for a sample of OECD countries, to estimate the government expenditure shocks effects on the real exchange rate, the trade balance and their co-movements with GDP and private consumption. First, they found that in all the countries an increase in government expenditure lead to a depreciation of the real exchange rate, and a trade balance deficit. Second, in all the countries, private consumption increased in response to the same fiscal shock, and hence it co-moves positively with the real exchange rate. They argue that these results are in clear contrast with virtually all the complete financial market models and separable utility functions, including a Neokeynesian open economy model with rigid prices and capital accumulation. But that there exists an extension of the model, which includes non-separable preferences in consumption and leisure, that would support their results as it is capable of replicating (at least qualitatively) the consumption and real exchange rate responses they found in the data. Additionally, if the substitution elasticity between foreign and domestic products is sufficiently small, the model is also successful in showing the correct co-movement between the real exchange rate and trade balance.

As mentioned, Corsetti and Müller (2006) focused on the international transmission mechanism of fiscal policy shocks through terms of trade, and showed that the probability and magnitude of the twin deficit increases in accordance to the economy’s openness degree, and decreases with the persistence of fiscal shocks. They also found that, for a given fiscal shock persistence, the crowding out effect on investment is stronger in a relatively closer economy, meaning that its trade balance deterioration is not very sharp. Hence, given a greater openness degree, the crowding out effect on investment is stronger when the fiscal shock is persistent. The mechanism behind these results emphasizes an important macroe-
conomic trade for economic policy: fiscal expansions reduce the domestic capital or the trade balance.

There are also differences in fiscal policy effectiveness when conditioning on the economic cycle. Since the Auerbach and Gorodnichenko (2012) paper, more attention has been given to the fact that fiscal policy’s impact will depend on the state of the economy. These authors, with changing regime models, found significant differences in the size of expenditure multipliers for expansions and recessions, with fiscal policy being considerably more effective in recessions than in expansions in the United States. Even when controlling for the fiscal shocks’ expected components, the size of the multipliers tends to increase in recessions.

In contrast Owyang et al. (2013) with data from the United States and Canada examined if the government expenditure multipliers are bigger during slowdown periods. Particularly they looked to exploit information of the two World Wars and the Great Depression. They did not find larger multipliers in recession periods for the United States, but they did for Canada. Similarly for the United States, Caggiano et al. (2015) used a non-linear VAR model with expectation revisions on fiscal expenses to control for the private agents’ fiscal prevision. The anticipated fiscal shocks measurements turned to be valuable information about the future public expenditure dynamics. With generalized impulse responses, the authors suggest that fiscal multipliers in recessions are larger than one, but are not statistically different from those in expansions. Subsequently, they argue that non-linearities emerge when considering extreme events, i.e. strong recessions against strong expansions.

For other countries, Baum et al. (2012) with a sample of G7 countries (excluding Italy) showed that fiscal multipliers are diverse between countries, and also dependant on the business cycle. They suggest that, on average, expenditure and income multipliers tend to be greater (in absolute value) in recessions than in expansions.

For the Turkish case, Cebi (2016) used local projection methods to estimate the fiscal multiplier variation in high and low growth, given the potential level. They found that fiscal policy is stronger in periods of low economic growth in comparison with times of high growth. For France, Cléaud et al. (2017) studied the impact with a SVAR time-varying model, emphasizing the government expenditure in goods and services. They found that the multiplier does not evolve significantly for any temporal horizon and that there is no evidence of a larger multiplier when in recessions.
When comparing, there is much more literature for the developed countries, than for developing countries, and even more than for Latin American economies. But among all, there is a wide variability of results. The last set of countries is no exception, as results are diverse in magnitude, duration and even direction; moreover, fiscal policy effectiveness research conditional on the state of the economy is more scarce.

Restrepo and Rincón (2006), estimated SVAR and SVEC models for Chile and Colombia between 1990 and 2005. The authors looked to identify fiscal policy shocks and measure the peso by peso impact that has an increase in taxes or in central government expenditure on GDP. They performed the Johansen cointegration test where Colombia presented evidence of one cointegrating vector, while the Chilean evidence was not conclusive towards the existence of cointegrating relationships among the variables. In order to achieve a complete analysis, they carried out the SVAR and SVEC estimations for both countries without important differences in the results. They found that, when the public finances are under strict control, the Chilean case, fiscal policy seems to be more effective than when there is lack of stability and credibility, the Colombian case since the mid 90’s. Specifically for Chile an increase in one Chilean peso of the tax income has a transitory negative effect on GDP of 40 cents, while the equivalent increase in the government expenditure has a transitory positive effect of 1.9 pesos on GDP, which is stabilized in 1.37 pesos. For Colombia, an increase in public expenditure in 1 peso has an impact of 12 cents in GDP, and income changes do not seem to impact GDP. Meanwhile, in another literature example, the research for Chile of Cerda et al. (2005) contradicts the keynesian theory with a negative expenditure multiplier. The authors argue the evidence found supports the permanent income theory: individuals decrease their consumption due to the expected increase in future taxes.

The IMF (2018) performed an impact analysis for the fiscal consolidation in Latin America and the Caribbean through the use of fiscal multipliers. The multipliers computation was made with diverse econometric identification methods: i) narrative approach; ii) forecast errors; iii) SVAR models for individual countries, all of which estimate the impacts through local projections based on Jordà (2005). The study found shock due to the narrative approach had a lower range and variability that shocks identified by the SVAR and forecast errors methods. Th fiscal multipliers for the region were estimated to be between 0.5 and 1.1, where the lower multipliers is associated with higher sovereign risk.

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4Given the data availability, Costa Rica was excluded from the SVAR analysis
Estevão and Samaké (2013) found lower income countries, contrary to advanced economies, after an public expenditure shock, experience a temporal negative effect on growth, while the output increases in the medium run. Ilzetzki et al. (2013) consider the economies heterogeneity and found the government expenditure impact depends on the key country characteristics as the level of development, the exchange regime, the trade openness degree, and the public debt level. With information for 44 countries they found the effect on GDP is greater for developed economies that developing ones, the multipliers is relatively higher for economies with predetermined exchange rates and zero for the ones with flexible exchange regime, they are lower for open economies compared with closed ones, and even the expenditure multipliers are negative in countries with high public debt levels.

An example of developing countries treated as open economies was made by Gualu (2013). The author used SVAR where identification is obtained from sign restrictions. The identification framework applies the restriction to obtain the government expenditures shocks are the only one that increase the government expenditure, the GDP, the deficit, and the tax income in the impact period. With 9 countries data, the author’s results showed an increase in the government expenditure would lead to a short expansion in output and consumption, an immediate deterioration of net exports, and an appreciation or zero effect on the exchange rate. The product multipliers resulted greater than unity for all except on country in the impact period. Also the author considered the procyclicalty of developing countries fiscal policy. A procyclical fiscal policy is due to a lack in financial integration with the global economy, or weak institutions inside the country. With a 109 countries panel, the author considers the different states of the economy, the financial openness role, and the institutional quality on the countries’ ability to perform countercyclical fiscal policy. The analysis showed under good times the institutional quality has a dominant role on fiscal policy cyclicality, and in bad times both the financial integration and institutions are important in the countries’ ability to perform countercyclical fiscal policy.

Several authors had found fiscal policy is procyclical in developing countries ((Gavin, 1997); (Kaminsky et al., 2004); (Talvi and Végh, 2000); (Ilzetzki and Végh, 2008); (Gualu, 2013)). Despite both neoclassical and neokeynesian models had shown a procyclical fiscal policy is not optimal. The optimal fiscal policy in Neoclassical models is acyclical ((Barro, 1979)) or countercyclical ((Baxter and King, 1993)), while for Neokeynesian models the optimal fiscal policy is essentially countercyclical due to the presence of rigid prices and wages ((Christiano et al., 2011)).
The previous evidence jointly with that showed by Estevão and Samaké (2013) and Ilzetzi et al. (2013) delimit fiscal policy analysis should be country specific. Nevertheless, within the developing countries’ evidence, the one from Latin America is scarce. In fact, Costa Rica had been studied in few cases. Among them, the doctoral thesis of Mouhamadou (2011) developed a panel SVAR and concluded the government expenditure shock is persistent, with its output impact quasi-simultaneous, positive, and of long duration. The working paper from Contreras and Battelle (2014) used the GMM method to estimate the fiscal multipliers, with the lags of the dependent variable as instruments for the SVAR model. They found a expenditure fiscal multipliers of higher magnitude in developing countries (including Costa Rica) than those of high income countries.

Estevão and Samaké (2013) declare are the first to estimate fiscal multipliers of short and medium run for Central American countries. They took as a starting point the study of Blanchard and Perotti (2002), but due to the data base limitations (annual data), they used cointegration techniques to determine the key factors of the VAR’s variance-covariance matrix; more specifically, they estimated a structural error correction model. Their estimations suggest fiscal consolidation affects output in the short run (one year). Their expenditure fiscal multipliers result in a range of -0.01 for Nicaragua to -0.44 for Panama. The output impact response due to a current expenditure shock for Costa Rica resulted in -0.04, and the accumulated multiplier in 0.76. One of the most recent studies, where the fiscal multipliers magnitude is analyzed for Costa Rica is the macroeconomic report made by the Inter-American Development Bank (IADB (2017)), which found an increase in two percentage points for the aggregated value tax’s proportion generates a negative multiplier effect of 1.5% on output. Reaffirming the non-linearity theory, which follows the assumption that under tax changes in countries where the initial level of taxes is low,\(^5\) (13% for the Costa Rican case) these changes would have a low or even null impact on tax income. The contrary would apply to countries where the initial tax proportion is high ((Gunter et al., 2018)). On the other side, Garry and Rivas Valdivia (2017) estimated with a SVAR the public expenditure multipliers for Central America, Dominican Republic, and Mexico. The authors found the current and capital expenditure multipliers sum up to a long run one of 2.6 for Costa Rica.

In this paper we start with the three variables model proposed by Blanchard and Perotti (2002) which includes real output, government expenditures, and public income net of

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\(^5\)For more details see Gunter et al. (2018)
transfers. This methodology is widely used in the literature given it was the first one in solving the identification problem associated with the stylized facts between the joint movement of expenditures, tax income, and output ((Kuckuck and Westermann, 2014)), which also requires a minimum number of assumptions.

Blanchard and Perotti (2002) used quarterly data and assumed the government expenditure do not respond to the economic cycle. Also they estimated in advanced the tax income elasticity in order to consider the response to the economic cycle. As expressed by Borg et al. (2014), this methodology has been used for specific studies on countries, and has been accepted as the start up point for the fiscal multipliers estimation in countries where the literature on the topic is beginning, which is the Costa Rican case.

Nevertheless, it is important to note the used methodology is not infallible. Garry and Rivas Valdivia (2017) point out the critics of VAR and SVAR approach, for multipliers estimation, which says those models usually fails to capture exogenous changes in public policy (see annex 8.1.). There also exists an inherent risk to omit relevant variables from the model, due the the limited information for the identification and the elasticities used in the computation. Other challenges lie in the availability of appropriate data, especially in developing countries, as quarterly frequency series are relatively short, and the aggregated variable components are not available in most cases. Lastly, the greater limitation in the SVAR models is the assumption the identified shocks are unexpected by the economic agents who, in the case of expected fiscal policy changes, could vary their behavior in advanced implying the observed results are not accurate and could be wrongly interpreted.

As mention previously, the narrative approach based on government actions, which uses budget documents and forecasts, are used as alternatives to identified exogenous fiscal shocks. Equally, dynamic stochastic general equilibrium models or macroeconomic neokeynesian models present methodological difficulties; among them the struggle to model fiscal policies and non-linearities. As a matter of fact, there is no fiscal rule widely accepted to be included in this kind of models. These models moreover show sensitivity to the parameters size, as example the price and wage rigidity degree, habit formation, investment adjustment costs, and structural settings.
3. Costa Rican context

It is necessary to understand the context on which fiscal policy is performed to determine the identification of the structural model. Thus this section characterizes the fiscal variables, public income and expenditures and the debt level. The evolution of other relevant variables as output and its components, prices, interest rates, exchange rate, and others is shown in annex 8.2..

![Figure 1: Costa Rica: Central government income by type](image)

The public income is composed of taxes, current transfers, no tax entries, and capital income. Its behavior has maintained a growth trend through time, however, the financial crisis and its repercussions had a great impact in its level (figure 1).

During 2009 the government income decreased 2.1 percentage points as GDP percentage with respect to 2008, mainly due to tax income, when it represented 15,5% of GDP. After this period, despite the income has maintained an increasing trend, it has not reached the
proportions before the crisis, when in the 2018 represented 14.3% of GDP.

Through this research period, 1991 to 2018, there has been two tax reforms to the general tax to sales. In 1991 its rate increased 3%, from 10% to 13% to later diminish gradually 1% during the next three years. In 1995 the rate increased from 10% to 15% for 18 months, and then positioned itself in the current 13%. Another change in collection was the decision taken in 1992, where it includes the profits tax contribution by the Banco Popular y de Desarrollo Comunal (BPDC) as a taxpayer with 15% tax rate.

About tax avoidance, tax evasion, and tax default, Costa Rica got a tax non-compliance of 8.22% of GDP in 2013, percentage similar to the 2010’s one (8.21%), according to the data available by MH (2015). Only in the income tax there was tax avoidance of more than 5% of GDP for the period 2010-2013. This is more than the double of the non-compliance presented in the general tax on sales.

Recently, Ueda (2018) made a tax gap analysis for Costa Rica with 2012-2016 data, where they estimated the non-compliance gap between 1.7% and 2% of GDP.\(^6\) As a response, in December 2016 was approved the law N° 9416 to improve the fight against the fiscal fraud, which includes improvements in collection and inspection of the collection process. Also it points out the tax expenses, which are defined as the income not perceived as a result of exoneration or special regimes to a taxable sector,\(^7\) that represented in 2016 5.34% of GDP, the highest rate since 2009.

Through legislative means there has been initiatives to implement structural fiscal reforms, however they were not approved in the process. In 2004 it was presented a law project “Ley de Pacto Fiscal”, which proposal contemplated to make a total reform, including a general tax on sales transformation into an aggregated value one, and also transform the schedular system of the tax on income to a global one. Following this proposal The administration Chinchilla Miranda, 2010-2014, promoted the project named “Proyecto de Solidaridad Tributaria” that posed the passive rents and the capital gains to be uniformly taxable at 15%; also the transformation of the general tax on sales into an aggregated value one.

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\(^6\)For the estimation of the tax gap, the authors use the RA-GAP methodology. This consists in estimate the potential tax income, through the application of the in force normative framework to the aggregated value of each economic sector, to quantify the tax base. The model works through the supply and use tables bring by the Central Bank. The gap is computed as the difference between this potential income and the income effectively collected.

\(^7\)Includes import taxes, the “Depósito Libre de Golfito”, and fuels.
one. However, besides this project was approved in the legislature process (“Asamblea Legislativa”) it was rejected by the court (“Sala Constitucional”) being invalid.

It was until December 2018 that finally the “Asamblea Legislativa” approved the project “Ley para el Fortalecimiento de las Finanzas Públicas” (N° 20.580), which modifies the tax on income, the general tax on sales (law N° 6826), it includes a fiscal rule that allows to sustain the economic growth and the public investment, and also considers a reform to the salaries of the public sector (law N° 2166).

As it could be appreciated in figure 2, the tax income is the principal source of public income, it is equivalent to 90% of the total perceived. The two principal taxes are the general tax on sales and the tax on income. Both have increased the collection in time, which is 2017 represented 9% of GDP. The other components together sum to near 1% of GDP in each year.

With respect to public expenditure, during the last 27 years its real growth had been steady. The current expenditures are more than 90% of total expenses as it could be seen in 3.\textsuperscript{8} These includes the wage a salaries payment, public debt interest, and current transfers to the public, private, and external sectors.

The expenditure behavior in the 1994 year presented around a 32% increase relative to the previous year, corresponding to the closure of the Anglo Bank (“Banco Anglo”). It is from the 2009 year -because of the financial crisis- that we could observe a considerable increment due to the implemented government policies, namely the "Plan Escudo". This actions included an increase of 15% in the non-contributing retirement regime of the “Caja Costarricense del Seguro Social” (Costa Rican social security), and the destination of 5% of GDP to investment in order to stimulate the economy. Moreover it incorporated a 50 percentile policy with the goal to equalize the wages of the central government professionals to the ones of the non-financial autonomous public sector, who perceived higher remunerations. But all those changes were formalized as permanents, so once the crisis was overcome, the public expenditure happened to represent 14.9% of GDP previous the crisis to 20% of GDP in 2015, being the largest percentage in the last two decades. The figure 4 shows the relative weight of the expenditure components. As it was mentioned previously, we should put attention to the considerable upward trend in the wages and salaries and the current transfers components.

\textsuperscript{8}Except 1997, 2008, and 2010 where it was 89%, 86% and 88% respectively.
The Ministerio de Hacienda decision to increase the capital expenditure, encouraging the betterment of production activities, as well as the generation of new physical and financial goods, was impulse by the economic growth presented in 2006, 2007, and 2008 of 7%, 8%, and 5% respectively, joined with the fiscal surplus of 0.6% and 0.2% for the 2007 and 2008 years, as it could be observed in figure 5.

Nevertheless, the fiscal deficits are a constant in the Costa Rican economy, which had been financed with public debt. In the figure 6, the debt presented a decrease from 2004 owing to the government actions in debt renegotiation, but, after the international crisis there was an increases of 7% with respect to the 2008 levels. During the last observed years, because of the crowding out effect, the high debt levels has pressured up the interest rates, diminished the the credit availability and limit the disposable resources; additional to the decrease in the private investment due to speculative reasons.
Finally, despite that in the fiscal multipliers literature there is no consensus on the size of the multipliers for developing or low income economies as Costa Rica, there exists evidence on certain patterns that affect it. The IMF (2014) technical note highlights the effect of factors as the increase in the liquidity restrictions in the financial markets, the little effectiveness in the response to monetary policy, and the low debt levels as determinants of the increase in the multipliers’ size. On the other side, it determines the inefficiency in the public expenditure and the openness degree contributes to the diminishing multiplier’s size.

The report from CEPAL (2017) additional to include the debt level, the openness degree, and the country’s development level highlights a less rigid labor market, and the flexible exchange rate regimes as factors that contribute to low multipliers. Therefore, this section includes the characterization of those variables as part of the Costa Rican context, as well as a beforehand for the interpretation, evaluation, and comparison of the obtained
results. This characteristics are the following: i) increase in the liquidity restrictions in the financial market (+); ii) little effectiveness in the response to monetary policy (+); iii) low debt level (+); iv) public expenditure inefficiency (-); v) trade openness (-); vi) less labor market rigidity (-); and vii) more flexibility in the exchange rate regime (-). For Costa Rica the available evidence on this topics is:

- With respect to liquidity restriction in the Costa Rican financial market, Deléchat et al. (2014) did a liquidity analysis for Central America, Panama, and Dominican Republic with 2006 to 2010 data. According to the liquidity assets to deposits coefficient of the financial system, the result is close to 22%, with an excess liquidity (above the regulatory requirement) near 7% which could be considered high. Moreover, they found the liquidity preventive demand of the banks is positively related with the deposit’s dollarization degree, present aspect of Costa Rica’s financial system. This liquidity excess improves financial stability, but lessens the financial deepening and
the transmission of the monetary and fiscal policy.

- In Costa Rica the monetary policy rate (TPM) is the principal tool of the Central Bank (BCCR) for policy. Romero and Guerrero (2015) the TPM’s pass-through effect to the bank system rates lasts in average eight to twelve months.

- Another factor highlighted by IMF (2014) is the debt level that has increased in time (figure 6). In 2018 the total public debt was 54% of GDP, an increase close to 100% in comparison with the decade’s beginnings (28% in 2010).

- The last six government national budgets determine the constitutional and legal items established, alongside the unavoidable obligations cover near 67.8% of the total budget (without the debt service) and 95% of the tax income in 2018, leaving an action margin for expenditures below 5% for reallocation (CGR (2018)).
The trade openness index according to Beverinotti et al. (2014) was 74% in 2014, similar to the one found in 1991 (71%). The BCCR in the 2018 inflation report (BCCR, 2018) took into consideration multiple external sector aspects in its forecasting and risk balance, which implies the trade openness is really important for the Costa Rican economy. Thus, in accordance with IMF (2018) with lower the multiplier size. When using the ratio of exports plus imports over GDP, the openness degree is above 60% for all the sample period.

Ibarra (2010) performed a comparative analysis of the labor market flexibility in Ibero-America. For this the author uses a synthetic index of labor rigidity, using the OECD methodology of factor analysis. The specific value for Costa Rica was 1.34, a medium-low position of labor rigidity, given the median value for the country sample was 1.68. We could interpret Costa Rica has a labor market not much rigid, but also not much flexible.
• Costa Rica has an exchange rate regime of floating administration since 2015. Costa Rica’s exchange rate regime had changed two times in the last 26 years. The first change was in 2005 when it migrates from a "crawling parity regime" to a system of exchange rate intervals. In February 2015, the BCCR board of directors decides to migrate to a floating administration regime.

Once the Costa Rica’s context is determined and the diverse factors that could affect the fiscal multipliers size are exposed, we could have an idea of the possible effect that fiscal policy shocks could have on output. Even so, the quantification of the dynamic effects goes beyond the study of the Costa Rica’s economy characteristics. Thus, the next section defines and explains in detail the econometric strategy used, in order to estimate the dynamic effects of unexpected shocks in fiscal policy and the fiscal multipliers computation.

4. Empirical Methodology

This paper is based on the three equations model proposed by Blanchard and Perotti (2002) with production, the government "flexible" expenditure, and the net tax income (i.e. without transfers). Blanchard and Perotti (2002) used quarterly data and assumed the government expenditures do not react to the economic cycle. Also they estimated the tax income to GDP elasticities beforehand, to consider their response to the outcome cycle. These elasticities estimation for the Costa Rican case are shown in annex 8.3.

Additionally, knowing Costa Rica is a small open economy, we include the terms of trade to control for external demand factors, all of which could affect the relationship between output and fiscal variables. As expressed by Borg et al. (2014), this methodology had been used for countries’ specific studies and it has been accepted as the starting point for the fiscal multiplier studies in countries where the literature is beginning. This is definitely the Costa Rica’s case.

As an additional result and robustness check, we follow the model proposed by Perotti

---

9 Exchange rate regime of fixed exchange rate at the beginning and then an adjusted parity one (BCCR, 2018). It resembles a fixed exchange rate with a upward trend.

10 An allowed lower and upper bound between which the exchange rate could move freely, outside the interval, the Central Bank will intervene the currency markets to put the exchange rate back inside the interval.

11 The exchange rate is free to move, but the Central Bank could intervene in a discretionary way in order to avoid abrupt changes in the exchange rate that could result in macroeconomic instability.
that here uses GDP, government flexible expenditure, and net tax income, the price level measure by the consumer price index (CPI), the interest rate, and the exchange rate. Perotti (2007) following Blanchard and Perotti (2002) used quarterly data and also assumed the government expenditure does not respond to the economic cycle. Also he estimated the income to GDP elasticities in advanced. We extend his model in two aspects: i) we include the external sector with an explicit equation for the exchange rate, and control for the trade openness degree and terms of trade; and ii) we include the contemporaneous effects of prices, interest rates, and the exchange rate on the fiscal variables and output. The latter to clean out the effect of the fiscal variables on GDP from any influence of the economic activity.

Finally, we apply the methodology used by Auerbach and Gorodnichenko (2012). This involves to fundamental aspects: i) we use the VAR model with smooth regime changes, from now on denoted STVAR, for the three variable specification previously described; and ii) the regime changes are based on an empirical measure of the economic cycle, namely the difference between the real GDP growth and the potential GDP growth. With that we study the dynamics of fiscal policy conditional on the state of the economy for the first time in Costa Rica, contribution to the literature on developing, small, and open economies.

Now we summarize the series used and their characteristics. Later we present the econometric approximation and the estimation method for the 3 equation SVAR (the 6 equation SVAR could be consulted in annex 8.4.). Next we define the fiscal multipliers computation with some comments on their pros and cons. Finally we present the non-linear methodology, with the estimation method details in the annex 8.5.

4.1. Analysis of the series

The data base used is composed of government income, expenditures, and GDP, with quarterly frequency from the first quarter of 1991 to the forth quarter of 2018. The data is from the Ministerio de Hacienda and the Central Bank of Costa Rica, all in accrual basis. Additionally we include the GDP deflator, and the population quantity to transform the series to real per capita values. Finally, we use some GDP components, specifically the final consumption of households (proxy of private consumption) and the brute fixed capital formation (proxy for private investment), to assess the impact of fiscal policy of these
components. We complement the analysis with basic passive rate\textsuperscript{12} as an approximation of the behavior for the relevant interest rates,\textsuperscript{13} the nominal exchange rate as the average between the one for sell and buy, the terms of trade, the openness degree measure as the proportion between exports plus imports over GDP, and the consumer price index.

For the estimates made, we defined the central government income as the sum of all the tax income including direct taxes to people’s income and firm’s profits, indirect and specific taxes.\textsuperscript{14} From now on we will name this variable as tax income. On the other side, for the central government expenditure we consider the sum of wages and salaries expenditures, social security expenditure, goods and services expenditure, and investment on non-financial assets, which we name “flexible” expenditure. This definition is important given the high inflexibility of Costa Rica’s public expenditure, so that this is an expenditure measure that requires minimum legislative effort to be changed. As mentioned earlier we also consider the current and capital expenditure for further results.

The annex 8.2. shows the time evolution for the principal series used: flexible expenditure, tax income, and GDP all at quarterly frequency and real per capita terms. All have an upward trend with a strong seasonal component specially important in the fourth quarter of each year, with some particular events. Primarily the expenditure has a peak in the fourth quarter of 1994 due to the Anglo Bank closure, and an upward slope change after 2008 by the “Plan Escudo” in the Arias administration. On the tax income side there is an important fall from 2008 owing to the international financial crisis.

Another important aspect in the series analysis is their statistical behavior. First, we need to know if the series are stationary or not. We performed the usual unit root tests with the results summarized in annex 8.8.. The unit root test are not conclusive. The evidence is according to the nonstationarity of the series, but all also could present a deterministic trend, i.e. after controlling for a deterministic trend the real per capita series tend to reject the nonstationarity hypothesis. Also most of the series in real per capita terms present evidence of stationarity when diverse structural breaks are taken into account. These allow

\textsuperscript{12}It is a weighted average of deposit rates computed weekly by the BCCR, the current methodology could be seen, in spanish, here https://gee.bccr.fi.cr/indicadoreseconomicos/Documentos/DocumentosMetodologiasNotasTecnicas/Artículo %208%20del%20acta%20de%20la%20sesión%205703-2015.pdf.

\textsuperscript{13}Due to data availability we use the basic passive rate. The time evolution of this rate and the weighted average public debt rates given by Hacienda is similar, and also there is evidence of a cointegration relationship. For more details see annex 8.2. and annex 8.6..

\textsuperscript{14}As coffee and banana exports. For more details on the fiscal series composition see annex 8.7..
us to model with greater confidence the dynamic fiscal shocks through VAR models, as long as we control for a deterministic trend and the adequate structural breaks. Moreover there is an informal model stability test given by the impulse responses convergence to a long run value, result obtained in this paper.

4.2. Econometric approach: Structural VAR (SVAR)

The formulation of the reduced form VAR is the following

\[ X_t = A(L, q)X_{t-1} + U_t \]  

Where \( X_t \equiv \begin{bmatrix} g_t, it_t, y_t \end{bmatrix} \) represents the endogenous variables (flexible expenditure, tax income and GDP), \( A(L, q) \) is a lag polynomial that shows the coefficient’s relationship for each quarter, and \( U_t \equiv \begin{bmatrix} u^g_t, u^{it}_t, u^y_t \end{bmatrix} \) is the set of reduced form VAR residuals. The model is estimated with logarithms, quarterly frequency, and real per capita terms data.

The reduced form residuals for the flexible expenditure and tax income equations \( (u^g_t \text{ and } u^{it}_t) \) could be thought as linear combinations from three types of shocks. First, the automatic response in taxes and expenditures to GDP, prices, and interest rates innovations. Second, the discretionary systematic response of the policy makers to output, prices and interest rates innovations. Third random discretionary shocks to fiscal policy; which are the fiscal structural shocks -in the econometric sense-, and contrary to the reduced form residuals, those are not correlated among them.

\(^{15}\text{Blanchard and Perotti (2002) obtained similar results. After using the Dickey-Fuller and Phillips-Perron unit root test with deterministic trend, they did not find strong evidence for the use of stochastic or deterministic trend in each variable (tax income, expenditure, and output). Given this, they worked out the SVAR estimation with two alternative assumptions. In the first one, they used the deterministic trend assumption for each variable with the use of a linear and quadratic trend in each reduced form VAR equation. In the second, they assumed stochastic trends through using the variable first differences in the reduced form VAR. To consider the drift term, they subtracted a changing average built as the geometric average of the pas first differences, with a 2.5% decay parameter per quarter. The results they obtained with both methods were similar. For Costa Rica we preferred to use the deterministic trend assumption and control for the adequate structural breaks for each particular variable.}\)

\(^{16}\text{In this work with use in an equivalent form the concepts tax income, income, and taxes to refer to the central government income obtain through taxes. In a general form taxes could refer to the marginal tax rate. The same applies to expenditures which resembles the flexible expenditure measure built here. Later on we also use current and capital expenditures and we will name those explicitly.}\)
From $U_t$ we have three equations that allow us to estimate the dynamic fiscal policy effects stated in the following system:

\begin{align*}
    u_t^g &= \alpha_{gy} u_t^y + \beta_{git} e_t^{it} + e_t^g \\
    u_t^{it} &= \alpha_{ity} u_t^y + \beta_{itg} e_t^g + e_t^{it} \\
    u_t^y &= \gamma_{git} u_t^{it} + \gamma_{gy} u_t^g + e_t^y
\end{align*}

where $e_t^g$, $e_t^{it}$, and $e_t^y$ represent the structural shock for expenditure, taxes, and GDP respectively, and they are uncorrelated among them; $u_t^{it}$ and $u_t^g$ represent the unexpected movements in taxes and expenditure respectively; $\alpha_{gy} u_t^y$ and $\alpha_{ity} u_t^y$ recover the fiscal variables’ responses to unexpected movements on GDP; and $\beta_{git} e_t^{it}$ and $\beta_{itg} e_t^g$ capture the expenditure and taxes responses to the structural shocks on the other respective fiscal variable. Finally, $\gamma_{git} u_t^{it}$ and $\gamma_{gy} u_t^g$ represent the GDP response to expenditure and taxes shocks.

### 4.3. Coefficients estimation

The followed approach is based on two observations. First it takes more than a quarter to observe, decide, and implement a discretionary change in fiscal policy in response to output observed innovations. As a consequence, in quarterly data the systematic discretionary component of $u_t^{it}$ and $u_t^g$ (the second component defined previously) is zero: the coefficients $\alpha_{jk}$ in equation 2 and equation 3 reflect only the first component: the automatic response to the economic activity.

Second, this could be of little help if we need to estimate the parameters $\alpha_{jk}$, because $e_t^g$ and $e_t^{it}$ are correlated with the reduced form of the residuals in the right hand side of equations equation 2 and equation 3. Nevertheless, we have independent information about the $\alpha_{jk}$, which construction and estimation is presented in annex 8.2.. With those elasticities, we could defined the cyclically adjusted fiscal shocks as:
\[ u_{t,CA}^i \equiv u_t^i - \alpha_{ity}y_t^i = \beta_{ity}e_t^i + e_t^i \quad (5) \]
\[ u_{t,CA}^g \equiv u_t^g - \alpha_{gy}y_t^g = \beta_{gy}e_t^g + e_t^g \quad (6) \]

This is the first identification step. In the second step, the structural shocks \( e_t^g \) and \( e_t^i \) must be identified. For this we need to decide the relative order of the two cyclically adjusted fiscal shocks. We can assume the expenditure shocks go first; in this case \( \beta_{gy} = 0 \) in equation 2 and equation 6 and \( \beta_{ity} \) could be estimated in equation 3 and equation 5 with OLS of the cyclically adjusted tax residual \( u_{t,CA}^i \) on the cyclically adjusted expenditure residual \( u_{t,CA}^g \). The procedure is symmetric if the income shocks go first.17

Under any order, the result of this two step procedure are estimated series for \( e_t^g \) and \( e_t^i \). Both are orthogonal to the other structural shocks of the economy. Instead with annual data there is a whole budget cycle and policy adjustments are possible making the parameter identification harder to achieve. Either the use of monthly data leads to identification problems, as the with monthly data the fiscal variables do not have enough time to react.

With the previous argument, the use of quarterly data implies \( \alpha_{gy} = 0 \), then it is necessary to estimate \( \alpha_{ity} \) only. The within quarter elasticity of net taxes with respect to output is built as:

\[ \alpha_{ity} = \sum_i \eta_{T_i,B_i} \eta_{B_i,y} \frac{T_i}{\bar{T}} \quad (7) \]

where \( \eta_{T_i,B_i} \) is the elasticity of type \( i \) taxes with respect to its respective tax base; \( \eta_{B_i,y} \) is the elasticity of the tax base \( i \) with respect to GDP; and \( \frac{T_i}{\bar{T}} \) is the proportion of tax \( i \) on the total of taxes. We estimate the respective long run elasticities and built the \( \alpha_{ity} \) parameter for Costa Rica in the annex 8.3..

17Blanchard and Perotti (2002) argued that while the correlation between the two reduced form fiscal shocks is sufficiently low, the order of the shocks does not affect the results. Here this is the case. The robustness check of changing the expenditure shocks after the tax shocks bring the same results.
To identify the parameters $\beta_{git}$ and $\beta_{itg}$ we assume the expenditure decisions come first, implying $\beta_{git} = 0$ and then estimate $\beta_{itg}$. Thus the parameters $\beta_{itg}$, $\gamma_{yit}$ and $\gamma_{yg}$ are estimated using the information of the given SVAR model system, with restrictions on the respective matrices with the parameter values commented previously.\textsuperscript{18} We estimate multiple specifications including different lags of the endogenous variables (the optimal lag given the statistical tests is four lags, i.e. a year), linear trend, dummy variables to control for seasonality (the base specification uses the seasonally adjusted variables with the TRAMO-SEATS routine), other dummies for structural breaks (as example the 2008 financial crisis and the ”Plan Escudo”), and specific relevant events (closure of Anglo Bank). Additionally the corresponding statistical tests show the used SVAR model is stable. A summary of the models characteristics could be seeing in annex 8.9..

### 4.4. Multipliers estimation

After the coefficients estimation we proceed to the multipliers computation. Both the impact and cumulative fiscal multipliers are computed as follows:

- **Immediate impact**: this multipliers reflects the GDP variation at the moment of the fiscal variable shock. Thus it uses the contemporaneous coefficients, in other words those coefficients estimated in the equation system 2, 3, and 4. In previous studies this computation is:\textsuperscript{19}

\[
\frac{\Delta Y_t}{\Delta X_t} \tag{8}
\]

- **Cumulative impact**: contrary to the previous multiplier, the computation is done through the recollection of taxes and expenses and their impact on production for a given period. These multipliers uses the impulse response functions and is widely

\textsuperscript{18}We choose to estimate the parameters $\beta_{itg}$, $\gamma_{yit}$ and $\gamma_{yg}$ through the whole system to impose the less quantity of restriction as possible. However, Blanchard and Perotti (2002) used an alternative method. With the $\alpha_{ity}$ and $\alpha_{gy}$ estimates they built the cyclically adjusted reduced form residuals for income and expenditure, commented previously, namely $u_t^i - \alpha_{ity} u_t^y$ and $u_t^g - \alpha_{gy} u_t^y$. Those were taken as the unexpected movements in the fiscal variables, which could be correlated among them, but not with the $e_t^y$ term. Therefore those variables were used as instruments to estimate $\gamma_{yit}$ and $\gamma_{yg}$ in a linear regression. Later the respective parameters were imposed as additional restrictions in the system and $\beta_{git}$ (as tax decisions were first for them) was estimated. As a robustness check, both estimation methods are used in this paper and they are equivalent.

\textsuperscript{19}For example Puig (2014), Estevão and Samaké (2013), Cebi (2016), and Mitra and Poghosyan (2015).
used in the study of fiscal policy impacts:\(^{20}\)

\[
\sum_{j=0}^{n} \Delta Y_{t+j} / \sum_{j=0}^{n} \Delta X_{t+j}
\]

(9)

In both cases \(\Delta X_t\) represents variations in expenditures or taxes in a given time, and \(\Delta X_{t+j}\) in a given period.

Recall the impulse response functions use the impulse as shocks of an standard deviation to the respective structural error. In order to interpret the multipliers as usual elasticities, we divide equation 9 with the standard deviation of the structural form error in the variable \(X\) equation, \(\sigma_{ex}\), hence standardizing the impulse responses and obtaining elasticity measures. The fact the structural shocks \(e^g_t, e^t_t, e^y_t\) are not correlated allows a direct interpretation: a shock to \(e^X\) is equivalent to a shock in variable \(X\). Thus the computed multipliers refer exclusively to the impact of variable \(X\), holding everything else constant.

Besides the simplicity of this computation, the multiplier’s calculation is not free from critics, even more as there is not a standardized form for such calculation in the empirical literature. As expressed by Ramey (2016), a lot of researchers had followed the methodology of Blanchard and Perotti (2002), computing multipliers with the comparison of the peak output response with the initial fiscal variable impact. Ramey (2016) says that is a useful to compare impulse responses but not a good one for multipliers estimation. As argued by Mountford and Uhlig (2009), Uhlig (2010), and Fisher and Peters (2010) the multipliers should be computed as an integral (or at present value) of the output response over the integral of the respective fiscal variable response. The integral multipliers succeed in measure the cumulative GDP gain relative to the cumulative gain in the fiscal variable during a determine period.

Ramey (2016) mentions the majority of researchers who estimate VAR models use the log variables, thus to convert the estimated multipliers, they usually multiply those estimates times the average sample ratio of GDP to fiscal variable. Owyang et al. (2013) argue this could lead to biases in samples with trends in the GDP fiscal variable ratio. In particular, they found this method generally produce multipliers higher than unity.

In this paper we use the cumulative response of production to the fiscal variables shocks,

as an approximation to the integral computation mentioned. Despite the multipliers are obtained as an elasticity, to facilitate their interpretation and use by the policy makers we divide them by the ratio fiscal variable to GDP.\textsuperscript{21} That allows us to interpret the multipliers as the 1% change in the fiscal variable as proportion to GDP and its impact on GDP in percentage. We consider the bias magnitude is minimized as the multipliers are below unity and converge to a long run value, main characteristic of the stable (stationary) VAR models.

4.5. Econometric approach: Smooth Transition VAR (STVAR)

Consider the VAR model presented in equation 1. We want to compute different responses in expansions and recessions of the economic activity to the fiscal shocks. For this goal we allow the VAR model to change regime as proposed by Auerbach and Gorodnichenko (2012), in a smooth transition VAR model (STVAR).

It is preferred to the autoregressive models with thresholds (STAR) because they allow to obtain not only different responses, but also contemporaneous different responses to the structural shocks. The economic dynamics in general do not have sharp changes but instead smooth transitions, so the STVAR model is intuitively appealing for the fiscal effects study. Moreover the model is advantageous relative to SVAR models for each regime, because the latter could have relatively few observations in one particular regime resulting in unstable and inaccurate estimates. A lot of the unexpected changes in taxes could be the result not of policy changes, but in the aggregate activity and tax income relationship; at the same time it is expected the tax policy acts through the tax structure, i.e. the marginal tax rates, not through the level of tax income. At last, the tax shocks identification would depend on the ability to clean the income innovations from the automatic responses to output, where the key aspect is the income elasticity with respect to GDP. Nevertheless this elasticity tends to vary with the economic cycle, which introduces a bias of unknown magnitude and direction for the specific estimates in each regime. All these could be minimized with the STVAR model, that admits the regime be choosen endogenously.

\textsuperscript{21}This interpretation is taken from Hamer-Adams (2018), the footnote 19, adapted to the Costa Rican case: Suppose we have a flexible expenditure shock of 1% size. Since the share of this government expenditure to GDP is 6%, the 1% flexible government shock corresponds to 0.06 percent of GDP. After this shock assume the output increases by 0.01%. The corresponding multiplier, the increase in percent of GDP due to a 1% of flexible expenditure as GDP proportion would be 0.2% ($\frac{0.01}{0.06} \approx 0.2$).
The specification is the following:

\[
X_t = (1 - F(z_{t-1}))\Pi_E(L)X_{t-1} + F(z_{t-1})\Pi_R(L)X_{t-1} + u_t
\]  
(10)

\[
u_t \sim N(0, \Omega_t)
\]
(11)

\[
\Omega_t = \Omega_E(1 - F(z_{t-1})) + \Omega_R F(z_{t-1})
\]
(12)

\[
F(z_t) = \frac{\exp(-\gamma z_t)}{1 + \exp(-\gamma z_t)}, \gamma > 0
\]
(13)

\[
var(z_t) = 1, E(z_t) = 0
\]
(14)

where \(X_t \equiv [g_t, it_t, y_t]'\) and \(u_t \equiv [u^g_t, u^i_t, u^y_t]'\). \(\gamma\) is known as the smoothing parameter.

The order of \(X_t\) implies shocks to income and output do not have a contemporaneous effect on expenditures. The linear model application justify our ordering for \(X_t\) and helps to obtain a correct econometric identification.

The STVAR allows the propagation of the structural shocks in two ways: i) a contemporaneous one through the different error covariance matrices \(\Omega_R\) and \(\Omega_E\); and ii) dynamically with the different lag polynomials \(\Pi_E(L)\) and \(\Pi_R(L)\). The variable \(z\) in our base specification is an index (normalized to obtain unit variance and zero mean so that \(\gamma\) is invariant to the scale) of economic conditions, with a positive \(z\) indicating an expansion. From the convention \(\gamma > 0\), the system’s behavior in a sufficiently strong recession \((F(z_t) \approx 1)\) can be described with \(\Omega_R\) and \(\Pi_R(L)\), while \(\Omega_E\) and \(\Pi_E(L)\) describe the behavior in a sufficiently strong expansion \((1 - F(z_t) \approx 1)\). We consider the \(z\) index in \(t - 1\) to avoid contemporaneous feedback of fiscal policy conditional of the state of the economy, in other words, the policy actions today do not depend on today’s state of the economy, so the government authorities know the state of the economy and implement the respective actions with a lag.

As signalled by Auerbach and Gorodnichenko (2012), the index \(z\) selection is not a trivial
one. Here we use the quarterly potential real GDP computation as in Álvarez (2017) and its
growth is compared with the inter-annual quarterly real GDP growth rate. Thus negative
values signal a recession and positive ones an expansion. This measure is intuitive as it is
an empirical indicator for the economic cycle.

Due to the quarterly frequency of the data, we could exploit the advantages commented by
Auerbach and Gorodnichenko (2012) with the \( z \) use: i) we can use the complete sample for
estimation, with the resulting accuracy and robustness of the estimates; and ii) we could
consider easily the dynamic feedback of policy changes to the state of each regime, namely
we can incorporate the fact the policy shocks could alter the regime.

With respect to the estimation, to avoid the sensitivity of \( \gamma \) in small samples, we follow
the suggestion of Granger et al. (1993) to impose different fixed values for \( \gamma \), until finding
the estimates of \( \Pi_R(L), \Pi_E(L), \Omega_R, \Omega_E \) are not sensible to changes in \( \gamma \). We calibrate the
economy to \( \gamma = 1 \) so the economy is near 25% of the time in the recession regime, that is
\( P(F(z_t) > 0.75 \approx 0.25) \), where the economy is defined to be in a recession if \( F(z_t) > 0.75 \).
At the same time this allows to construct the dates to which we could consider the Costa
Rican economy to be in recession and expansion.

Given the system highly non-linear nature describe in the equations 10-14, we use the Monte
Carlo Markov Chain (MCMC) developed by Chernozhukov and Hong (2003) for estimation
and inference (see annex 8.5. for more details). In summary, under standard conditions
this approach finds a global optima in fitting terms, including the parameter estimates and
the standard errors could be computed directly from the generated chains.

For the impulse response computation, we ignore initially any feedback of changes in \( z \)
inside the dynamics of the macroeconomic variables. That is, we assume the system could
stay in a particular regime for long time. The advantage is that, once the regime has been
fixed, the model is linear and the impulse responses are not functions of history (see Koop
et al. (1996) and Potter 1996 for more details). As Auerbach and Gorodnichenko (2012)
the impulse responses are based on local projections from Jordà (2005).
Table 1: Contemporaneous coefficients 3 equations SVAR

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Probability</th>
</tr>
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<tbody>
<tr>
<td>$y_{yg}$</td>
<td>0.05</td>
<td>0.05</td>
<td>0.37</td>
</tr>
<tr>
<td>$y_{yt}$</td>
<td>-0.09</td>
<td>0.03</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note: The coefficient $y_{yg}$ refers to the flexible expenditure contemporaneous impact, $y_{yt}$ the respective of the tax income. Source: Own elaboration.

5. Results

This section shows the results of the flexible expenditure and tax income effects on production. First, the corresponding ones to the baseline 3 equation SVAR. Second, the effects when we model the open economy explicitly with the 6 equations SVAR. Finally, we present the differences in fiscal policy effects conditional on the economic cycle. It is important to note all the dynamic cumulative responses where computed for 16 of more quarters after the shock, the former corresponding to the electoral cycle in Costa Rica, which in principle could affect the evolution of the fiscal variables, mainly the expenditure, but as the results showed this cycle does not seem to bias them.

5.1. Short run dynamics and fiscal multipliers: 3 equations SVAR

Table 1 shows the contemporaneous coefficients results. These measures, as an usual elasticity, the production response at the same time the tax income and expenditure shocks occur. They are respectively 0.05 and -0.09 for the flexible expenditure and the tax income,
the first one not statistically significant, but the second one is. Both coefficients $\gamma_{yg}$ and $\gamma_{yit}$ are according to the economic intuition: expenditure increases have a positive impact on output and increases in tax a negative one. However, these are not the dynamic short term effects, only the impact effects. To obtain the short run response, for example in a year, it is necessary the estimation of the impulse response functions, of widely use in the VAR models. Here, as a difference with the simple VAR models the reduced form residuals for computation, we use the structural form residuals, i.e we shock the structural residual series obtained. Because the structural errors are uncorrelated, there is a direct interpretation: a shock to $e^g_t$ (respectively to $e^it_t$) is equivalent to an exogenous shock to the flexible expenditure (income tax) and the consequent output response. In other words, the impulse responses are clean from the influence of third variables, so the output evolution is entirely explained by the fiscal shock at issue.

Figure 7: Cumulative GDP response to a structural shock in flexible expenditure

In the figure 7 and figure 8 we can observe the cumulative responses have the expected
impact on production. Specifically, an unexpected structural shock to the flexible expenditure would lead to a positive GDP response, which is statistically significant from the third quarter after the shock to the tenth. The unexpected structural shock on taxes would be associated with a negative GDP response, with statistical significance from the first quarter to the to the fourteenth quarter, that is three years and a half, after which the effect would dissipate.

The validity of the impulse responses depends on the model characteristics. The annex 8.9. shows the diverse statistical tests and their results for the three equations model. In summary the model not only is stable, but also does not reject the no serial correlation and homoscedasticity hypothesis for its residuals, neither their normality at 5% of significance. The model was estimated with the optimal lag of four periods. Additionally, as the informal stability test and validity of the results, the 32 periods impulse responses converge (not shown here).
Often it is necessary an direct interpretation for the dynamics between output and fiscal variables in monetary terms. For that, as it is usual in the literature, we compute the fiscal multipliers. This are obtained from the impulse responses from figures 7 and 8. The responses are divided by the standard deviation of the respective structural error, in order to measure the impact of 1% changes in fiscal policy (expenditures or income) on GDP in percentage (i.e an usual elasticity). Moreover, we divide this value by the ratio fiscal variable to GDP, for the multipliers to be interpreted as percentage GDP change due to a 1% change in the fiscal variables to GDP ratio. Table 2 shows the cumulative multipliers by quarter.

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Flexible Expenditure</th>
<th>Tax Income</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.20</td>
<td>-0.08</td>
</tr>
<tr>
<td>6</td>
<td>0.34</td>
<td>-0.14</td>
</tr>
<tr>
<td>8</td>
<td>0.46</td>
<td>-0.20</td>
</tr>
<tr>
<td>10</td>
<td>0.53</td>
<td>-0.24</td>
</tr>
<tr>
<td>14</td>
<td><strong>0.53</strong></td>
<td>-0.32</td>
</tr>
</tbody>
</table>

Note: A 1% increase in the fiscal variable as GDP proportion is associated with the presented GDP cumulative percentage change, by quarter. Red values are not statistically significant.
Source: Own elaboration.

An increase in 1% of the flexible expenditure to GDP ratio is associated with a cumulative increase of 0.2% in production in one year, 0.46% in two years, and 0.53% in two years and a half, after which the effect would dissipate. Putting in other words, if we expect output to growth at 3% for the next year, the mentioned increase in expenditure would imply the output will growth at 3.2% next year. Analogously a 1% increase in the taxes to GDP ratio would lead to a decrease in output of 0.08% in a year, which would accumulate to 0.2% in two years, and 0.32% in three years and a half.

This estimated multipliers are an additional reference to define the direction and magnitude of fiscal policy impact. However, these results should be taken with caution mainly for two motives. First, fiscal policy shocks modelled here are, by definition, unexpected to the private sector. This is a key implicit assumption important in the context of recent fiscal reform approval in Costa Rica, that has been clearly anticipated by the private sector with enough time (at least one quarter). From this, the use of the results for forecasting scenarios
under the fiscal reform must take into account this limitation. Second, there exists multiple forms to compute the multipliers, the majority look for a monetary interpretation. Those are based on the impulse response functions use that at the same time use logarithm form, with the corresponding debate on its correct formulation (some mentioned earlier). In other to minimized the possible bias sources in the multipliers computation, we used the simple calculation detailed previously. This one allows us to interpret the multipliers as elasticities and in monetary terms, in what is called the integral approach.

5.2. Short run dynamics and fiscal multipliers: 6 equations SVAR

In order to model the open economy explicitly we include additional equation corresponding to the price level, interest rate, and the nominal exchange rate. This allows the interactions among all the variables through the lag polynomial in the reduced form, which implies not only possible changes in the coefficient’s values, but also the existence of new relationships; for example increases of the exchange or interest rates and their effect on output, and how the fiscal variables affect the exchange rate, interest rates and prices. The results for the open economy are obtained with the estimation of the system in matrix form presented in equation 3 of annex 8.4. This model assumes the expenditure decisions come first. Table 3 shows the contemporaneous coefficient results for the flexible expenditure and tax income on GDP.

In general this models results are similar to the previous one. The contemporaneous effects are according to the economic intuition. Increases in the flexible expenditure and the tax income of 1% would lead to contemporaneous GDP changes of 0.08% and -0.07 respectively. This effect is statistically significant for both variables (at 10% for expenditure).

23The literature had mentioned the existence of lags in fiscal policy, key assumption for the SVAR econometric specification. The existing lags in fiscal policy are of two kinds: decision lags imply some time is necessary for the policy to change in response to shocks; and implementation lags imply some time passes for the decided policy changes to be implemented. The first type helps with the identification assumption. The second one involves an ignored problem in the paper, particularly what the econometrician identifies as fiscal shocks could be the result of previous policy changes, and thus those are anticipated by the private sector. Blanchard and Perotti (2002) bring more details in the econometric domain.

To have an idea why in the empirical domain the anticipated fiscal policy is a problem for modelling, let us assume the agents behave as in Neoclassical basic model. An anticipated increase today in public expenditure would lead to a diminish in private consumption today, because the agents increase savings to tackle the future increases in taxes. With that, although the policy change is not present in the data, the private consumption has already reacted.
Table 3: Contemporaneous coefficients 6 equations SVAR

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>Standard error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_{gg}$</td>
<td>0.08</td>
<td>0.04</td>
<td>0.06</td>
</tr>
<tr>
<td>$\gamma_{git}$</td>
<td>-0.07</td>
<td>0.03</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Note: The coefficients refer to elasticities. As an example $\gamma_{gg}$ is interpreted as follows: an increase in 1% of the flexible expenditure is associated with an increase of 0.08% on output at the impact period (contemporaneous effect).

Source: Own elaboration.

Again we point out this coefficients are not the short run dynamics, only refer to the impact effect of the fiscal variables. The impulse response graphs for quarter up to eight years show the respective short run dynamics.

The same as in the 3 equation case, the validity of the impulse responses depends on the model’s characteristics. The annex 8.4. shows the statistical tests used and their results for the open economy. Again as a summary the model is stable, there is no strong evidence against the hypothesis of no serial correlation, homoscedasticity, and normality of the residuals a 5%. The model is estimated with the optimal lag of five periods, which helped with the serial correlation correction. Moreover, the informal stability and validity test show the impulse responses to 32 periods converge for the open economy model.

The fiscal variables effects is as expected. In figure 9 we observe the output response to flexible expenditure increases. It remains to be positive, but now it is not statistically significant for any quarter, which could suggest effects on production of fiscal policy through expenditure is diluted across the price variables in the economy, namely the inclusion of prices, interest rate, and exchange rate; as well as the influence of the external sector, in accordance with the literature for developing, small, and highly open economies (Ilzetzki et al., 2013). On its part, increases in tax income affect negatively the output, with a significant effect from the first quarter to the quarter sixteen after the shock, i.e. with four years of persistence, as shows figure 10.

Again we compute the fiscal multipliers for the six equations model. As observed in table 4, the signs and magnitudes are really similar to the previous model. However, there is not
5.3. Short run dynamics in expansions and recessions: STVAR

We estimate a regime switching VAR specification to answer the question: ¿Is the dynamic fiscal policy effect invariant to the Costa Rica’s state of the economy, or is it different if the economy is in recession or expansion? That allows to observe if the output response to unexpected expenditure and tax changes are different according to the economic cycle. In that case, it is possible fiscal policy to be more effective during recessions, common result in the literature, so that expansive fiscal policies would be an useful tool to move out of a crisis in Costa Rica.

Although this specification is based on the considerations and uses the same variables as the 3 equation model, it is not directly comparable with those results for three reasons.
First, despite both specifications possess contemporaneous responses according with the unexpected and exogenous impact in fiscal policy, in the SVAR model a part of those effects are obtained outside the system, with the tax income elasticities, while the STVAR model estimate them inside the system for both regimes through the allocation of probabilities with a bayesian method. Second, the SVAR model, with the use of tax income elasticities accomplish to eliminate the reverse causality problem between taxes and output, namely tax increases are associated with GDP increases. By not doing it the direct way, this problem could persists in the STVAR model. Third, the use of the tax income elasticity assumes a strong supposition on production and taxes dynamics: the tax income elasticities are constant and independent of the economic cycle. This is a point in favor of the STVAR over the SVAR model, in the sense it allows to estimate the tax-output relationship conditional on the state of the economy.

Even so both models usefulness is obvious. On one side, the SVAR allows to have an
approximation of fiscal policy effect in a neutral setting (without economic cycle). On the other side, the STVAR allow to obtain evidence of a diverse effect given by the economic cycle.

Figure 11 presents a clear history: expenditures have a positive effect in recessions, but a negative one in expansions. Thus, the expenditure could be used as a tool to stabilize the economy in recession times, with the major example the "Plan Escudo" in the 2008 crisis. However the fact expenditures have a negative impact on expansions seems to indicate the economic agents’ expectations play against it. Increases in expenditures in expansions could be perceived as increases in public debt or in future taxes, where the first aspect tend to increase the interest rates and diminish the credit availability, whereas the second acts directly on the agents’ expected disposable income. Both could explain the negative effect of production.

Increases in tax income show a different history. In figure 12 we could see the output response is positive in expansions and negative in recessions. The recessions effect is intuitive: decreases in the disposable income and the business profits lessen aggregate demand and economic activity. But the positive effect on expansions must be taken with caution. Three points emerge as possible interpretations for this effect. First, it is definitive increases in taxes are less harmful for economic activity in expansions, which is intuitive. Second, the effect could be due to the reverse causality bounded previously, the positive output response to increases in taxes in reality are due to the fact tax income depends on economic activity, positive correlation that could be stronger in expansions and it is reflected here. Third, the positive effect of taxes on production could be explained by what is known in the

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Flexible expenditure</th>
<th>Tax income</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td>4</td>
<td>0.15</td>
<td>-0.12</td>
</tr>
<tr>
<td>8</td>
<td>0.32</td>
<td>-0.29</td>
</tr>
<tr>
<td>12</td>
<td>0.19</td>
<td>-0.40</td>
</tr>
<tr>
<td>16</td>
<td>0.11</td>
<td>-0.41</td>
</tr>
</tbody>
</table>

Note: values in red are not statistically significant. Changes in flexible expenditure and tax income refer to 1% as GDP proportion. The multipliers’ response are interpreted in GDP cumulative percentage change at the given quarter.
Figure 11: Cumulative GDP response to flexible expenditure

Note: GDP responses to a 1% change in flexible expenditure. Blue signal expansions, red recessions. Discontinuous lines are the respective confidence intervals.

literature as the "expansionary fiscal contraction" (for some examples see Hjelm (2006), Hjelm (2002), Afonso (2010), and Hogan (2004)). This argument states economies with high debt levels (as it is the Costa Rica’s case) could experience improvements in economic agents’ expectations to increases in taxes, as well as the agents consider the new tax income would be used for the public finances betterment and hence it will lead to a greater future macroeconomic stability, which in the end is translated into a greater economic growth.

5.4. Robustness checks: 3 equations SVAR

The results do not vary when considering the tax income ($\beta_{itg} = 0$) or expenditure ($\beta_{git} = 0$) come first. Also the results do not vary importantly when we take different values of the effect of production on tax income ($\alpha_{ity}$). Changing the value of this elasticity to its lower bound (0.64) or upper one (1.46) does not result in perceptible changes of the taxes
Another interesting robustness check is to corroborate the results from the instrumental variables approach. As mentioned earlier, the parameters $\beta_{itg}$, $\gamma_{yg}$, and $\gamma_{yit}$ are estimated using the system’s information as a whole, with restrictions on the matrix given by the diverse parameter values. This approach is far from the one used by Blanchard and Perotti (2002), who with estimates for $\alpha_{ity}$ and $\alpha_{gy}$ built the cyclically adjusted reduced form residuals for tax income and expenditures,

$$u_{it,CA}^t = u_{it}^t - \alpha_{ity}u_{yt}^t = \beta_{ity}e_{it}^q + e_{it}^t$$

and

$$u_{g,CA}^t = u_{gt}^t - \alpha_{gy}u_{yt}^t = \beta_{gy}e_{it}^q + e_{it}^q.$$ Later they took those as the unexpected movements in the fiscal variables and were used as instruments to estimate $\gamma_{yg}$ and $\gamma_{yit}$ in a linear regression with the GDP reduced form error, $u_{yt}^q$. Finally, those parameters are imposed as additional constraints to estimate $\beta_{itg}$.

Table 5 shows the results from the system estimation with this alternative approach. As

Figure 12: Cumulative GDP responses to tax income

Note: GDP responses to a 1% change in tax income. Blue signal expansions, red recessions. Discontinuous lines are the respective confidence intervals. Source: Own elaboration.
Table 5: Contemporaneous coefficients 3 equations SVAR, instrumental variables approach

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Estimate</th>
<th>Standard Error</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\gamma_{yy}$</td>
<td>0.05</td>
<td>0.05</td>
<td>0.42</td>
</tr>
<tr>
<td>$\gamma_{yt}$</td>
<td>-0.09</td>
<td>0.03</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Note: the coefficient $\gamma_{yy}$ refers to flexible expenditure contemporaneous impact, $\gamma_{yt}$ to the respective one for tax income.
Source: Own elaboration.

it could be appreciated the contemporaneous coefficients, and hence the impulse responses are the same to our method. This does not only provide confidence about the obtained results, but also shows the equivalence in the estimation through the whole system instead of the two step instrumental variables method.

In the literature, the temporal robustness with respect to the fiscal multipliers results had been an open issue without a concrete answer. Blanchard and Perotti (2002) analyzed the sub-sample stability with the estimates of the GDP responses when a different decade is dismissed in each new estimation. They found the exclusion of the 80’s cause a substantial fall in the income multiplier size; while the expenditure multiplier when excluding the 80’s is three times higher that when the 70’s are excluded. Both authors mentioned they did not possess a convincing explanation on the impulse response changes through time.

This peculiarity is also present in the Costa Rican output responses, where, given the sample limitations, we use as temporal robustness check an estimation with data from 1991 to 2005, and another from 2006 to 2018. Table 6 summarize the contemporaneous coefficients results, while figures 13, 14, 15, and 16 show the respective GDP responses.

From the 1991 to 2005 sample the GDP response for the flexible expenditure is not statistically significant (figure 13), while the tax income effect is still significant and negative on economic activity (figure 14). Despite that, in the 2006 to 2018 sample, the expenditure continues to have a non-significant effect on economic activity (figure 15), but the tax income impact now is null (figure 16). During this sample period (2006-2018), the Costa Rican economy presented several abrupt changes with respect to economic policy. First
since 2006, the exchange rate regime migrated from an adjusted parity to an exchange rate
interval regime, and later to floating administration of the exchange rate since 2015. This
greater exchange rate flexibility has been documented as a potential factor for low mul-
tipliers in developing countries (Ilzetzki et al., 2013). Second, in 2016 public debt comes
to represent 45% of GDP, an increase of almost 100% in comparison with the decade’s
beginning, an indicative of poor public finance management that could lessen fiscal policy
effectiveness.

Even there is more evidence like this one. In the literature, economies with higher debt
levels tend to have low or even negative expenditure multipliers (Ilzetzki et al., 2013).
Including Perotti (2007) who concluded fiscal policy effects on GDP and its components
had become substantially weaker in the last 2 years, with negative multipliers both for
income and expenditures in OECD countries.

6. Other results

This section will show a summary of multiple relevant results of fiscal policy impact, which
will focus on the impulse responses from different specifications. First, we will observe the
effect on output of two types of expenditures: current and capital expenditures; with the
interest rate channel for the current expenditure effect on output, and a little discussion
on the expenditure’s flexibility. Second, we will have the effect of flexible expenditure and
tax income on private consumption, and private investment.
6.1. Current and capital expenditure

In a wide range of research about fiscal policy impact on economic activity, there has been used diverse public expenditure measures under the statement their productivity, and spillover to the rest of the economy depends on the specific expenditure type. It is well known one of the most effective expenditures for economic growth is in infrastructure, while expenditures for debt services and interest should not have any direct importance by definition (it is not a productive activity). With the goal to determine if there is a different effect by the type of expenditure, we estimate the GDP response to changes in the current (excluding debt related expenses) and capital expenditures.\textsuperscript{24}

\textsuperscript{24}The capital expenditure is defined as investment in non-financial assets and capital transfers to the public, private, and external sectors. Sadly it was not possible to determine if this data includes infrastructure investment or if it was possible to extract it from the data.
In figure 17, the current expenditure shows a significant effect from the tenth quarter to the twenty-four quarter after the shock. However, the effect is negative on output. Multiple explanations emerge for this negative impact. First, the national government budget is highly inflexible. Unavoidable obligations cover near the 95% of the total tax income (67.8% of total budget without the debt service). This tiny action margin implies fiscal policy through expenditures could not only be anticipated by the private sector, who could adjust downward consumption to tackle future tax increases; but also the changes in expenditures could obey, endogenously, to budget needs and political process instead to an output stabilization tool. Second, as mentioned previously and also said by Ilzetzki et al. (2013), the exchange rate flexibility jointly with high debt levels could lead to low or even negative expenditure multipliers as in this case. The positive effects of expenditure increases are diluted by exchange rate movements, while put upward pressure to the fiscal deficit and thus in public debt, with the corresponding upward pressures on interest.
rates and the posterior negative effect on the economic activity, hence the large lag of production’s response.

On its part, increases in capital expenditure have an almost null and non-statistically significant effect on output (figure 18). Although counter-intuitive, it could be due to the low size for the kind of expenditure which represents, on average, only 9% of total public expenditures, and 1.6% of GDP.

The significant results under the flexible expenditure definition used (figure 7), against the other expenditures definition, posed an important conclusion. Greater public expenditure flexibility would have a significant effect as a tool for economic activity stabilization. Recall the flexible expenditure was built with wages and salaries, social charges, goods and services expenditures, and investment in non-financial assets, all of which could be argued are the best representation of flexible expenditures in Costa Rica and together have provided a
positive effect on output. The "Plan Escudo" implemented in the Arias administration in 2009 meant a change (maybe unexpected) in the expenditure’s trend in order to stabilize the economy, that isolated from the funding method, could have considerable explanatory power in the results obtained.

Nevertheless, it is necessary to bound this results for the flexible expenditure do not take into account the funding method. If it is through taxes, the result show taxes have a negative impact on economic activity. If it is through debt, an informal and incomplete test would be given by the results in the 2006-2018 sub-sample, where the flexible expenditure losses the statistically significant impact on GDP, and there is also a considerable increase in public debt (figure 6) mostly due to the "Plan Escudo" permanent changes. It is important to note that for increases in the flexible expenditure to be beneficial for the economic activity, these must be done with full consciousness and an exhaustive analysis for the
funding effects on the economic activity.  

The figures 19 and 20 bring greater details on the impact of both types of expenditures. When conditioning on the state of the economy, we observe the current expenditure has no effect in expansions, in accordance with previous explanations; but even we could see here the expenditure inflexibility affects its effectiveness to help the economy in recessions. Instead current expenditure increases harm the economic activity which, as said previously, generate negative expectations on the economic agents due to possible increases in debt (hence in interest rates), and in taxes (hence diminishing the disposable income and  

\footnote{Sadly the main example for the Costa Rican economy seems to be the "Plan Escudo". It helped the economy to overcome the 2008 financial crisis, but as the changes were permanent, now it has become into a public debt issue with the corresponding problems in terms of higher interest rates, bad private agent’s expectations, and others. We hope the recent approval of the tax reform (which came with several strikes from different economic sector) could help to tackle all those problems and in some years could serve as evidence for interesting research.}
Capital expenditure in the linear model does not have a statistical significant impact, but now it is in both expansions and recessions. The history remains the same in expansions, increases in capital expenditures are perceived by the economic agents as something negative for the economic prospects, and thus the negative impact on production in this regime. Instead, now the output response is clearly positive in recessions, where it seems the economic agents left behind the negative expectations on expenditure increases and it is successful to impact positively the economic activity, in contrast with current expenditures that had a null effect. A intuitive policy implication is suggested by this results: capital expenditures are effective to help recover the Costa Rican economy during crisis, but it is not true for the current expenditure.

Inside the public debate there is always statements on the government expenditures crowding-
out effects on private consumption and investments. Specifically, that increases in the current expenditure are associated with increases in debt, as mentioned previously, implying the channel for the negative impact of current expenditures on output is through the increases debt provokes on the interest rates.\footnote{The other channel argued is the expectations on future tax increases, it is more difficult to measure this impact in a convincing way. Blanchard and Perotti (2002) and Auerbach and Gorodnichenko (2012) searched as an additional exercise to control for agent’s expectations, aspect mentioned as the principal limitation in this kind of models. However, as there is not a systematic and convincing way for this issue, we preferred to omit controlling for expectations and leave it for future research on the Costa Rican fiscal policy dynamics.} The figure 17 shows increases in current expenditure, far from increase production, have a negative effect with a substantial lag. This is not only in accordance with previous results in the literature, specifically in Ilzetzki et al. (2013) mentioned earlier. When the Costa Rica’s current expenditure increases indeed there is an upward pressure on the interest rates (figure 21), which is statistically significant for the first year, and between the third and fourth year after the shock. This
pressure emerge from the fact the current expenditure is funded with public debt, so the government competes for the raising of liquid funds increasing the interest rates, all produced with certain lag when the net savers observe the sovereign debt increases, due to a higher debt level, and demand higher risk premiums. This effect on interest rates could be the transmission channel for the debacle in production, as the impact of the former on the latter is negative and statistically significant from the first quarter to the seventh one after the chock (figure 22).

6.2. Private consumption and investment responses

We have determined the effect of increases in flexible expenditure are positive on GDP, whereas increases in tax income have a negative effect. But, what happens with the components in the private sphere? An analysis of fiscal policy impact on private consumption
and investment is always relevant. This allows us to obtain an overall impression on the economic theory behind the economic agent’s behavior in Costa Rica for changes in fiscal policy. As an example, besides variants to Neoclassical and Neokeynesian models forecast positive output responses to expenditure increases and negative ones to tax increases, the private consumption and investment responses are far away between both theories. Neokeynesian expect public expenditure increases to be translated into private consumption increases, while tax increases will have the contrary effect. The neoclassics would forecast a null or negative effect on private consumption for increases in both expenditures and/or taxes. With respect to investments, for the neoclassics there is also a decrease in private investment to both increases in expenditures as well as taxes. Whereas Neokeynesian consider increases in public expenditure could increase or decrease investment depending on the relative strength of the output and interest rates increases; for these theorists, increases
in taxes will be totally the opposites to the expenditure ones.

The consumption dynamic response to a flexible expenditure shock is positive and statistically significant only in the first year (figure 23). While the consumption response to a tax income shock is not only negative, but is also statistically significant from the first quarter to the 32 quarters after the shock, i.e. eight years after the impact (figure 24).

When the flexible expenditure increases the investment response is not statistically significant (figure 25). But the investment responds negatively to tax income shocks, with a statistically significant effect from the first quarter also to the 32 quarters after the shock (figure 26).

This results signal private consumption seems to behave as in Neokeynesian theory, but there is some ambiguity in the investment behavior, due to the statistically null effect of expenditures. Relying only in the impulse response direction, the investment behavior will
Figure 23: Cumulative response of private consumption to a structural shock in flexible expenditure

be in accordance also with Neokeynesian theory. It is important to note the negative effects of tax increases are highly persistent for both private components.

What takes place when we observe the dynamics in recessions and expansions? The figure 27 indicates in expansions the final households’ consumption does not vary with the public expenditure, while there is a positive and significant relation in recessions, although the response is only statistically different as the expansions one only for the first year. On the other side, the tax income still have a negative impact on private consumption both in expansions and recessions. However in the figure 28 we observe this response to be stronger and more persistent contrary to the observed one for output in figure 12. It seems the private consumption, when faced to fiscal policy changes and conditional on the state of the economy, behaves as stated by Neokeynesian predictions in recessions, but as Neoclassical theory forecasts in expansions.
Instead the response of the brute fixed capital formation is similar in sign to the output’s ones, which suggests fiscal policy has more impact in production through its effect on private investment when conditioning on the state of the economy. In figure 29 we appreciate increases in the flexible expenditure have a negative effect on private investments during expansions, mainly in accordance with Neoclassical view (although it is possible to have neokeynesian models with this prediction as mentioned previously), but its response is positive in recessions according to Neokeynesian approach. As with the output and capital expenditure cases, this suggests the public expenditure directed to capital formation in the Costa Rican economy is really effective and suitable during recession times as a measure for economic activity stabilization.

The effect of tax income increases on investment is also according with the ones it has on output (figure 30). The investment response is clearly negative in recessions and appears as positive in expansions. The recessions effect is intuitive and according to both neoclassical
and neokeynesian views. But as in the production’s case, the positive effect in expansions is difficult to reconcile with both neoclassical and neokeynesian models, so it should be taken with caution due to the possible reverse causality issue. Maybe some explanation could be brought from the expansionary fiscal contraction approach.

7. Conclusions

fiscal policy impact on output has been the center of the debate about the actions the government authorities can do to reactivate the economy. Quantify these effects is a great importance in a Costa Rican context with weak public finances, recent fiscal reform approval, and slowdown economy. For this goal we estimate SVAR models base on Blanchard and Perotti (2002) and Perotti (2007), in addition to a STVAR model as in Auerbach and
Gorodnichenko (2012). This is one of the few estimates done for Costa Rica, and to our knowledge, the first one with quarterly data since 1991.

According to the results obtained, the flexible expenditure effect on output, measured by the multiplier is positive and statistically significant. An increase of 1% in the ratio of flexible expenditure to GDP is associated with an increase of 0.20% in production one year later. Moreover, this expenditure has a positive effect in recessions, so it could be used as a tool to stabilize the economy during slowdown periods. However, in expansions its impact is negative, where it seems agent’s expectations play against it. Expenditure increases in expansions could be perceived as increases in public debt or future taxes, the former increasing interest rates and credit availability through the crowding-out effect, and the latter diminishing the expected disposable income of agents. Both effects could explain the negative impact on production. Thought it is difficult to measure the expectations channel, it was possible to find evidence in favor of the interest rate channel, as current expenditure
Figure 27: Cumulative response of private consumption to flexible expenditure

increases put upward pressures on interest rates and this have a negative effect on output, evidence in favor of the crowding-out effect of the public sector.

The results for the tax income multiplier show a negative and statistically significant effect on GDP. An increase of 1% in the ratio tax income to GDP is associated with a reduction of 0.08% in output a year later. This effect is highly persistent through time, more than the flexible expenditure. When observing the effect conditional on the state of the economy, we found the response of output is positive in expansions and negative in recessions. The recessions effect is in accordance with economic intuition: decreases in disposable income and business profits lessens aggregate demand and thus the economic activity. Instead, the positive effect in expansions must be taken with caution. Three points arise as possible interpretations. First, it is definitely the case increases in taxes are less harmful for the economic activity in expansions than in recessions. Second, this effect could be due to a reverse causality problem given the positive correlation between economic activity and tax
income (which seems to be isolated effectively in the SVAR model). Third, the positive effect of tax increases on production could be explain by what is known in the literature as the "expansionary fiscal contraction". This approach states economies with high public debt levels, the Costa Rican case, could experience improvements in the agents’ expectations due to the tax increases, as long as those are considered to be used for the public finances betterment, leading to a greater future macroeconomic stability, and hence to a higher economic growth.

By expenditure type, the current expenditure shows a negative effect on output. Multiple explanations emerge for the effect. First, the government budget is highly inflexible. The unavoidable obligations cover near 95% of tax income (67.8% of the total budget without the debt service). This tiny action margin implies fiscal policy through expenditures could be not only anticipated by the private sector, who could adjust downwards their consumption to tackle future taxes, but also the expenditure changes could be endogenous to budget
needs and the political process, not used as an stabilization tool for the economic activity. Second, as argued by Ilzetzki et al. (2013), the exchange rate flexibility and the high debt levels, both Costa Rican aspects, could lead to low or even negative expenditure multipliers. The possible positive effects of increases in the current expenditure are diluted by the exchange rate movements, while the pressure on the fiscal deficit and hence on public debt tends to increase the interest rates, and thus it has a negative effect on output, an explanation for the large lag in the output’s negative response.

The significance of the results under the flexible expenditure definition, in contrast to the current expenditure, brings an important conclusion. Higher public expenditures flexibility could have a positive and statistically significance effect as a tool to stabilize the economic activity. Even when conditioning on the state of the economy the current expenditure increases are harmful for output both in recessions and expansions, implying the expenditures inflexibility diminish the expenditure effectiveness even in recessions.
When there is a shock in the government capital expenditure, the output response in the linear model is almost null. Although this is counter-intuitive, it could be due to the low size in this kind of expenditure, it represents only 9% of total expenditures and 1.6% of GDP. Even thought, the capital expenditure has statistically significant effects both in recessions and expansions. The history is similar in the expansions case, increases in the capital expenditures are perceived as something negative by the economic agents and thus the negative impact on output in this regime. Instead the output response is clearly positive in recessions, where it seems the economic agents leave behind the negative expectations about government capital expenditures, and this one achieves a positive impact on output, in contrast to the current expenditure and its null effect in this regime. An intuitive policy implication is: capital expenditures are effective to help the Costa Rican economy overcome a crisis, but it is not true for the current expenditure.

The responses of the private components to changes in fiscal policy are also relevant.
Private consumption is negatively and persistently affected by taxes (even 8 years after the shock), while the flexible expenditure effect is positive only in the first year. Conditioning on the state of the economy, in expansions private consumption does not vary with public expenditures, whereas it has a positive and significant response in recessions, though it is statistically different from the expansions one only in the first year. On the other side, tax income maintains the negative impact on private consumption, both in recessions and expansions.

On the private investment side we have an equivalent situation: taxes effect is negative, statistically significant, and highly persistent (until 8 years after the shock); and the expenditure shocks have a positive impact, but not statistically significant in the linear model. Instead, when considering economic cycles, the investment response is similar to the output responses, which suggests fiscal policy has more impact on production through its effect on private investment. Increases in the flexible government expenditure have a negative impact on investments in expansions, according to Neoclassical theory, but the response is positive in recessions in line with neokeynesian theory. As in the case of output and public capital expenditure, this suggests public expenditures directed to investments in Costa Rica is really effective and suitable in slowdown periods as a stabilization tool of the economic activity. On the same line, the tax income effects on private investments are similar to the ones on output. The response is clearly negative in recessions and it turns positive in expansions. As with output, the latter effect must be taken with caution due to possible reverse causality problems.

We conclude fiscal policy through higher expenditure flexibility and on capital investment is effective to stabilize the economic activity in recessions. Nevertheless, this expenditure funding requires special attention. On the tax income side, the multipliers showed to be consistently negative and with a highly persistent effect on GDP, private consumption and mainly on investment. Additionally, the debt level could provoke negative effects on production, as observed with the negative GDP response to current expenditure shocks, and the crowding-out effect evidence. Thus, the debate on the optimal use of public resources is still open, and requires an exhaustive revision.

The evidence on low multipliers, as the ones in this Costa Rica’s study, are not an empirical rarity. Several are the results of this kind for the fiscal multipliers in income and expenditure, both in the theoretical and empirical domains. In the theory side, Sutherland (1997)
pointed out a high default probability of the public sector leads to negative multipliers, as the economic agents save because they perceive tax increases are imminent, implicit result for Costa Rica.

In fact, the linear (SVAR) model results suggest the economic agents in Costa Rica behave under Neokeynesian theory, when using the flexible expenditure, and the tax effects are negative and highly persistent. Besides that, the high expenditure inflexibility and the high debt level, as proxy of high default probability, proved to be harmful for the effectiveness of fiscal policy.

The model with changing regime goes beyond. It allows to suggest the Costa Rica’s economic agents behave under Neoclassical theory in expansions, where the expectations of tax and interest rates increases (the latter due to public debt) make expenditure policy harmful. But in recessions, it is Neokeynesian theory what seems to rule, which opens the possibility expenditure policies, well designed, well implemented, and well financed stabilize the economic activity in recessions times.

Looking at the size and direction of the fiscal multipliers proposed here, other studies that include Costa Rica, also found similar results. For Estevão and Samaké (2013), the output impact response to a current expenditure shock in Costa Rica resulted in -0.044, and a cumulative multiplier of 0.7626. Likewise one of the most recent studies is the macroeconomic report made by the Inter-American Development Bank (IADB). In this report IADB (2017) a increase of two percentage points in the marginal tax rate on the taxes on sales generates a multiplier effect of -1.5 on production. Reaffirming the non-linearity theory, which assumes tax changes in countries with a low initial marginal tax rate (13% in Costa Rica) have a low or null reaction. The figures 31 and 32 show the obtained multipliers for expenditure and tax income respectively, to make a comparison with multiple studies for developing countries, some including Costa Rica.

Given the Costa Rica’s context and the different aspects described by CEPAL (2017) and IMF (2014) as factors for the multipliers size, the low Costa Rica’s fiscal multipliers size is not unexpected. Despite the low liquidity restrictions in the financial market (in part due to the degree of deposits dollarization), and a reasonable response to monetary policy (the pass-through effect of the monetary policy rate to the other interest rates in the bank system last on average eight to twelve months), it has an increasing public debt level, a high inflexible expenditure (unavoidable obligations are near 95% of tax income),
a high openness degree (above 60%), little labour inflexibilty (Ibarra, 2010), and a flexible exchange rate (floating administrations).

Figure 31: Expenditure cumulative multipliers for several countries

![Cumulative expenditure multipliers for several countries](image)

Even so, the results must be taken with caution as there are multiple limitations in the analysis. Fiscal policy changes could not be completely unexpected. As argued through the paper, theoretically the agents could change their behavior when anticipating government policy changes (Yang, 2005). For that the estimation of fiscal policy effects on output usually requires the policy changes to be unexpected. However, in the recent tax reform approval in Costa Rica, it is truly expected by the economic agents. As further research it is relevant to estimate fiscal policy dynamic effects when we relax this assumption. Finally, the definition and calibration of DSGE models could bring a more holistic and complete comparison for the jointly economic activity dynamics and the transmission channels.
Figure 32: Tax income cumulative multipliers for several countries

Note: multipliers up to one year. In red this paper’s multiplier.
Source: Own elaboration with results from several studies (Estevao y Samake, 2013; IMF, 2018; Contreras y Batelle, 2014).
Bibliography


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UPV/EHU (2015), *Introducción a los modelos macroeconómicos*, Universidad del País Vasco.

Yang, S.-C. S. (2005), ‘Quantifying tax effects under policy foresight’, *Journal of Monetary Economics* 52(8), 1557–1568.
8. Annex

8.1. Annex 1: Comparison of strengths and limitations of fiscal multipliers estimation techniques

<table>
<thead>
<tr>
<th>Summary</th>
<th>SVAR models</th>
<th>DSGE models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables of interest (tax income, expenditures, output, interest rates, and inflation) are interrelated and there are multiple potential causal relationships.</td>
<td>It uses elasticities of tax income and expenditures with respect to output to rule out the effects of the automatic stabilizers.</td>
<td>It is based on the current economic characteristics.</td>
</tr>
<tr>
<td>It isolates exogenous fiscal shocks and estimate its impact on GDP using diverse identification assumptions.</td>
<td>Commonly available for the United States and G20 countries.</td>
<td>It describes the economic system as a whole through the analysis of multiple microeconomic decisions.</td>
</tr>
<tr>
<td>SVAR as a linear model does not capture the multipliers could be conditional on the respective state.</td>
<td>Uses specific country data for few macroeconomic variables.</td>
<td>They use the general government instead of the central government.</td>
</tr>
<tr>
<td>Limitations</td>
<td>SVAR models</td>
<td>DSGE models</td>
</tr>
<tr>
<td>Fail to measure purely exogenous fiscal shocks.</td>
<td>No consensus about fiscal policy modeling (i.e. fiscal rules).</td>
<td>The majority of studies includes the OECD countries.</td>
</tr>
<tr>
<td>If there had existed a structural change for a determine country, the average output response to an exogenous fiscal shock would not capture the effect it could have today, as the method uses historical information.</td>
<td>Linear equations, there could not be obtained state dependent fiscal multipliers.</td>
<td></td>
</tr>
<tr>
<td>SVAR as a linear model does not capture the multipliers could be conditional on the respective state.</td>
<td>Multipliers depend on model assumptions (calibration versus estimation).</td>
<td></td>
</tr>
<tr>
<td>It do not consider when the interest rate is near the zero lower bound.</td>
<td>Results are sensible to the selection of certain parameters.</td>
<td></td>
</tr>
</tbody>
</table>

Source: Taken from Garry and Rivas Valdivia (2017)
8.2. Annex 2: Series used

Figure 33: Costa Rica: GDP, flexible expenditure, and tax income

Figure 34: Costa Rica: Interest rates
Figure 35: Costa Rica: Exports and imports

Figure 36: Costa Rica: Openness degree

Figure 37: Costa Rica: Nominal exchange rate
Figure 38: Costa Rica: Terms of trade

Note: It refers to export prices relative to import prices. Increases would mean exports are becoming more expensive relative to imports.
Source: Own elaboration with data from Central Bank of Costa Rica.

Figure 39: Costa Rica: Real output gap

Note: It is measured by first seasonally adjust real GDP, then by the Hodrick-Prescott filter we obtain its trend, finally we subtract the trend's growth to the seasonally adjusted real GDP growth, and divide by the latter. It is a common measure for the state of the economy.
Source: Own elaboration with data from Central Bank of Costa Rica.

Figure 40: Costa Rica: Probability of recession regime

Note: It refers to the probability of being in a recession regime in that particular period. It is computed with the SVAR model.
Source: Own elaboration.
8.3. Annex 3: Tax income elasticity estimation

The quarterly income taxes elasticity with respect to output is constructed as:

\[ \alpha_{it} = \sum_i \eta_{T_i,B_i} \eta_{B_i,y} \tilde{T}_i \tilde{T} \]  

where \( \eta_{T_i,B_i} \) is the elasticity of type \( i \) taxes with respect to its respective tax base; \( \eta_{B_i,y} \) is the elasticity of the tax base \( i \) with respect to GDP; and \( \tilde{T}_i \) is the proportion of tax \( i \) on the total of taxes.

The computation of the income tax elasticities to GDP requires several estimations: i) the income tax elasticity with respect to its tax base; ii) the tax base’s elasticity with respect to GDP; and in case of not having an approximation of the tax base; iii) the elasticity of the tax income with respect to GDP (the latter has been used as a robustness check). Due to the cointegration evidence between the variables, we estimate the long-run elasticities. Multiple specifications were used including lags of the variables and possible structural changes (obtained through CUSUM and squared CUSUM tests), such that we selected the estimations with highest fit and that passed all the statistical tests. Table 7 shows the 12 relevant elasticities for the present paper. In all cases the standard errors were corrected by the HAC estimator, and they all also passed the Ramsey test of the existence of a linear relationship. With respect to the residual normality, in all cases there is no evidence to reject they are normally distributed, so the estimate obtained is the minimum variance one.

In the estimations we took proxies of the tax bases for each type of tax in the following way:

- Final consumption expenditure of the households (GDP component) for the selective taxes on production and goods consumption.
- Exports for export taxes.
- Imports for import taxes.
- GDP for income and profit taxes.
- Final consumption expenditure of the households (GDP component) for the general
tax on sales.

We also estimate the elasticities of each type of tax with respect to GDP as a robustness check. This allows us to obtain an estimation interval of the parameter $\alpha_{ity}$, although the different values do not lead to different results of the fiscal multipliers for the Costa Rican case.

The estimations bring the following results. First related to the respective tax bases the selective tax on production and goods consumption, just as export and import taxes are elastic (1.82, 2.26, and 1.19 respectively), while the income and profits taxes seem to have unitary elasticity, and the general tax on sales is inelastic (0.99 and 0.55 respectively). Second, the three tax bases considered are inelastic with respect to GDP (0.75 for final consumption expenditure of households, 0.87 for exports, and 0.97 for imports). Third, the imports taxes and the general tax on sales are elastic with respect to GDP (1.77 and 2.37 respectively), while the selective taxes on production and goods consumption and the exports taxes are inelastic with respect to GDP (0.97 and 0.73).

From the results from table 7 and equation A1 the coefficient $\alpha_{ity}$ is built. As argued by Blanchard and Perotti (2002), the $\alpha_{ity}$’s value vary through time due to two reasons: i) the proportion of the tax types with respect to total varies in time; and ii) the tax elasticities with respect to their tax base, the term $\eta_{T_i,B_i}$ in equation A1 vary through time. Like the mentioned authors, we assume the relationships between the diverse tax bases and the GDP is invariant to the type of shock that affects output. Therefore, the coefficient $\alpha_{ity}$ is obtained with the quarterly average. The average with the direct GDP elasticity is 1.46, while with the tax bases is 0.64. The SVAR estimations are robust for both tax elasticity values.
Table 7: Tax income elasticities used for $\alpha_{ity}$

<table>
<thead>
<tr>
<th>Variables</th>
<th>Long-run elasticity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selective taxes on production and goods consumption with respect to the households’ final consumption</td>
<td>$1.82^{***}$</td>
</tr>
<tr>
<td>Households’ final consumption with respect to GDP</td>
<td>$(0.28)$</td>
</tr>
<tr>
<td>Selective taxes on production and goods consumption with respect to GDP</td>
<td>$0.97^{***}$</td>
</tr>
<tr>
<td>Taxes on exports with respect to exports</td>
<td>$2.26^{**}$</td>
</tr>
<tr>
<td>Exports with respect to GDP</td>
<td>$(0.57)$</td>
</tr>
<tr>
<td>Taxes on exports with respect to GDP</td>
<td>$0.73^{***}$</td>
</tr>
<tr>
<td>Taxes on imports with respect to imports</td>
<td>$1.19^{***}$</td>
</tr>
<tr>
<td>Imports with respect to GDP</td>
<td>$(0.26)$</td>
</tr>
<tr>
<td>Taxes on imports with respect to GDP</td>
<td>$1.77^{***}$</td>
</tr>
<tr>
<td>Taxes on income and profits with respect to GDP</td>
<td>$0.99$</td>
</tr>
<tr>
<td>General tax on sales with respect to household’s final consumption</td>
<td>$0.55^{***}$</td>
</tr>
<tr>
<td>General tax on sales with respect to GDP</td>
<td>$(0.08)$</td>
</tr>
</tbody>
</table>

Note: Elasticity refers to 1% in the regressor and the associated percentage change in the dependent variable. *, **, *** significant at 10%, 5% y 1% respectively. Standard errors in parenthesis. All coefficients are long-run elasticities.

Source: Own elaboration with data from the Central Bank of Costa Rica and the Ministerio de Hacienda.

8.4. Annex 4: 6 equations SVAR estimation method

The six equations economy modelling use the same exogenous variables and assumptions as the three equations model (expenditure decisions come first). The system has the following form (excluding exogenous variables for simplicity):

\[
\begin{align*}
\dot{u}_t^g &= \alpha_{gy} u_t^y + \alpha_{gyc} u_t^{yc} + \alpha_{gyp} u_t^p + \alpha_{gyi} u_t^i + \beta_{gpi} \epsilon_t^i + \epsilon_t^g \\
\dot{u}_t^i &= \alpha_{ity} u_t^y + \alpha_{itc} u_t^{yc} + \alpha_{itp} u_t^p + \alpha_{iti} u_t^i + \beta_{iti} \epsilon_t^i + \epsilon_t^i \\
\dot{u}_t^y &= \gamma_{gg} u_t^g + \gamma_{gity} u_t^i + \alpha_{gyc} u_t^{yc} + \alpha_{gyp} u_t^p + \alpha_{gyi} u_t^i + \epsilon_t^y \\
\dot{u}_t^{yc} &= \gamma_{ycy} u_t^y + \gamma_{ycy} u_t^{yc} + \gamma_{icy} u_t^i + \alpha_{itc} u_t^{yc} + \alpha_{icy} u_t^i + \epsilon_t^{yc} \\
\dot{u}_t^p &= \gamma_{py} u_t^y + \gamma_{pgy} u_t^g + \gamma_{pity} u_t^i + \gamma_{ptc} u_t^{yc} + \alpha_{ipi} u_t^i + \epsilon_t^p \\
\dot{u}_t^i &= \gamma_{iy} u_t^y + \gamma_{icy} u_t^{yc} + \gamma_{ipi} u_t^i + \gamma_{ig} \epsilon_t^i + \gamma_{iti} \epsilon_t^i + \epsilon_t^i
\end{align*}
\]
which could be rewritten in matrix form as:

\[
\begin{pmatrix}
1 & 0 & -\alpha_{gy} & -\alpha_{gtc} & -\alpha_{gp} & -\alpha_{gi} \\
0 & 1 & -\alpha_{ity} & -\alpha_{ittc} & -\alpha_{itp} & -\alpha_{iti} \\
-\gamma_{yg} & -\gamma_{yit} & 1 & 0 & -\alpha_{ytc} & -\alpha_{yp} & -\alpha_{yi} \\
-\gamma_{tcy} & -\gamma_{tcg} & -\gamma_{itct} & 1 & 0 & -\alpha_{tcr} & -\alpha_{tc} \\
-\gamma_{py} & -\gamma_{pty} & -\gamma_{ptc} & 1 & 0 & 0 & 0 & 0 \\
-\gamma_{iy} & -\gamma_{itc} & -\gamma_{ipt} & -\gamma_{ipt} & -\gamma_{itc} & -\gamma_{iy} & -\gamma_{iti} & 1
\end{pmatrix}
\begin{pmatrix}
u_{t}^g \\
u_{t}^i \\
u_{t}^y \\
u_{t}^p \\
u_{t}^p \\
u_{t}^i \\
\end{pmatrix}
= 
\begin{pmatrix} 
se_1 & \beta_{gt} & 0 & 0 & 0 & 0 \\
\beta_{ty} & se_2 & 0 & 0 & 0 & 0 \\
0 & 0 & se_3 & 0 & 0 & 0 \\
0 & 0 & 0 & se_4 & 0 & 0 \\
0 & 0 & 0 & 0 & se_5 & 0 \\
0 & 0 & 0 & 0 & 0 & se_6 \\
\end{pmatrix}
\begin{pmatrix}
u_{t}^g \\
u_{t}^i \\
u_{t}^y \\
u_{t}^p \\
u_{t}^p \\
u_{t}^i \\
\end{pmatrix}
\]

(A2)

The different \(\alpha_{jk}\) parameters were estimated beforehand in the same way as the income elasticities described in annex 8.3., and with the assumptions of the three equations model. Only the contemporaneous coefficients between the exchange rate, the interest rate, and the price level were managed according to the Cholesky decomposition with the exchange rate first and the interest rate last. We obtained the complete system A2 and estimate the rest of the coefficients, the structural errors, and the respective impulse responses. The whole system A2 is as follows:

\[
\begin{pmatrix}
1 & 0 & 0 & 0 & 0 & 0.97 & 0.003 \\
0 & 1 & -1.46 & -0.22 & 0.57 & 0.11 & \\
-\gamma_{yg} & -\gamma_{yit} & 1 & 0 & 0 & 0.06 & 0.06 & \\
-\gamma_{tcy} & -\gamma_{tcg} & -\gamma_{itct} & 1 & 0 & 0 & \\
-\gamma_{py} & -\gamma_{pty} & -\gamma_{ptc} & 1 & 0 & 0 & \\
-\gamma_{iy} & -\gamma_{itc} & -\gamma_{ipt} & -\gamma_{ipt} & -\gamma_{itc} & -\gamma_{iy} & -\gamma_{iti} & 1
\end{pmatrix}
\begin{pmatrix}
u_{t}^g \\
u_{t}^i \\
u_{t}^y \\
u_{t}^p \\
u_{t}^p \\
u_{t}^i \\
\end{pmatrix}
= 
\begin{pmatrix} 
se_1 & \beta_{gt} & 0 & 0 & 0 & 0 \\
\beta_{ty} & se_2 & 0 & 0 & 0 & 0 \\
0 & 0 & se_3 & 0 & 0 & 0 \\
0 & 0 & 0 & se_4 & 0 & 0 \\
0 & 0 & 0 & 0 & se_5 & 0 \\
0 & 0 & 0 & 0 & 0 & se_6 \\
\end{pmatrix}
\begin{pmatrix}
u_{t}^g \\
u_{t}^i \\
u_{t}^y \\
u_{t}^p \\
u_{t}^p \\
u_{t}^i \\
\end{pmatrix}
\]

(A3)

8.5. Annex 5: STVAR model estimation procedure

The model is estimated with Maximum Likelihood, given the procedure followed by Auerbach and Gorodnichenko (2012). The logarithm likelihood for the model 10-14 is given by:

\[
\log(L) = const - \frac{1}{2} \sum_{t=1}^{T} \log|\Omega_{t}| - \frac{1}{2} \sum_{t=1}^{T} u_{t}'\Omega_{t}^{-1}u_{t},
\]

(A4)
Where \( u_t = X_t - (1 - F(z_{t-1}))\Pi_E(L)X_{t-1} - F(z_{t-1})\Pi_R(L)X_{t-1} \). Because the model is highly non-linear a has several parameters \( \Psi = \gamma, \Omega_R, \Omega_E, \Pi_R(L), \Pi_E(L) \), the use of standard optimization methods is problematic, so we use the following procedure.

We can see that conditional on \( \gamma, \Omega_R, \Omega_E \) the model is linear in the lag polynomial \( \Pi_R(L), \Pi_E(L) \). Hence, for a given conjecture \( \gamma, \Omega_R, \Omega_E \), we could estimate by weighted least squares where the weights are given by \( \Omega_t^{-1} \) and the estimators of \( \Pi_R(L), \Pi_E(L) \) must minimize \[ \frac{1}{2} \sum_{t=1}^{T} u_t' \Omega_t^{-1} u_t. \]

Define

\[ W_t = [(1 - F(z_{t-1}))X_{t-1}F(z_{t-1})X_{t-1}...(1 - F(z_{t-1}))X_{t-p}F(z_{t-1})X_{t-p}] \]

be the extended vector of regressors and \( \Pi = [\Pi_R \Pi_E] \), such that \( u_t = X_t - \Pi W_t' \). The objective function is

\[ \frac{1}{2} \sum_{t=1}^{T} (X_t - \Pi W_t')\Omega_t^{-1}(X_t - \Pi W_t') \]

(A5)

Note that A5 can be rewritten as

\[ \frac{1}{2} \sum_{t=1}^{T} (X_t - \Pi W_t')\Omega_t^{-1}(X_t - \Pi W_t') = \frac{1}{2} \sum_{t=1}^{T} \text{trace}[(X_t - \Pi W_t')\Omega_t^{-1}(X_t - \Pi W_t')] = \frac{1}{2} \sum_{t=1}^{T} \text{trace}[(X_t - \Pi W_t')]\Omega_t^{-1}(X_t - \Pi W_t'). \]

The first order condition with respect to \( \Pi \) is

\[ \sum_{t=1}^{T} (W_t'X_t\Omega_t^{-1} - W_t'W_t\Pi\Omega_t^{-1}) = 0. \]

Now using the vector operator \( \text{vec} \) we have

\[ \text{vec} \left( \sum_{t=1}^{T} W_t'X_t\Omega_t^{-1} \right) = \text{vec} \left[ \sum_{t=1}^{T} W_t'W_t\Pi\Omega_t^{-1} \right] = \sum_{t=1}^{T} \text{vec} W_t'W_t\Pi\Omega_t^{-1} = \sum_{t=1}^{T} [\text{vec} \Pi'] [\Omega_t^{-1} \otimes W_t] = \text{vec} \Pi' \sum_{t=1}^{T} [\Omega_t^{-1} \otimes W_t], \]

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which results in

\[ \text{vec}\Pi' = \left( \sum_{t=1}^{T} [\Omega_t^{-1} \otimes W_t^{-1}W_t^t] \right)^{-1} \text{vec} \left( \sum_{t=1}^{T} W_t^tX_t\Omega_t' \right). \]  

(A6)

The procedure iterates in \( \gamma, \Omega_R, \Omega_E \), which bring \( \Pi \) and the likelihood until the optimum is achieved. If the errors were homoscedastic (\( \Omega_t = \text{const} \)) we would obtain the standard VAR estimators.

As the model is highly non-linear in its parameters, it is possible to have multiple local optima meaning we must try different starting values for \( \gamma, \Omega_R, \Omega_E \). In order to be sure \( \Omega_R \) and \( \Omega_E \) are both positive definite, we use \( \Psi = \gamma, \text{chol}(\Omega_R), \text{chol}(\Omega_E), \Pi_E, \Pi_R \), where \( \text{chol} \) is the operator for the Cholesky decomposition. Additionally, due to the problem’s non-linearity, it is difficult to construct analytically the confidence intervals for the estimated parameters as well as the respective impulse responses. As a solution we use the Markov Chain with Monte Carlo method (MCMC) developed by Chernozhukov and Hong (2003) from now on denoted CH. The method does not only bring a global optima but also distributions for the estimated parameters.

We use the Hasting-Metropolis algorithm to implement the CH’s estimation method. This procedure to construct chains of size \( N \) could be summarize as follows:

**Step 1:** Take \( \Theta^{(n)} \) as a candidate for the vector of parameter values for the chain in the \( n + 1 \) state. As \( \Theta^{(n)} = \Psi^{(n)} + \psi^{(n)} \) where \( \Psi^{(n)} \) is the actual state \( n \) of the parameter values in the chain, \( \psi^{(n)} \) is the vector of \( i.i.d. \) shocks taken from \( N(0, \Omega_\Psi) \) and \( \Omega_\Psi \) is a diagonal matrix.  

**Step 2:** Take the \( n + 1 \) state of the chain as

\[
\Psi^{(n+1)} = \begin{cases} 
\Theta^{(n)} & \text{with probability min } 1, \exp[\log L(\Theta^{(n)}) - \log L(\Psi^{(n)})], \\
\Psi^{(n)} & \text{if not}
\end{cases}
\]

Where \( L(\Psi^{(n)}) \) is the value of the objective function in the actual state of the chain and \( L(\Theta^{(n)}) \) is the value of the objective function with the candidate vector of parameter values.

The initial value \( P_{si}^{(0)} \) is computed as follows. We approximate the model \( ??-?? \) such as the model could be rewritten as the regression of \( X_t \) on the lags of \( X_t, X_t z_t, X_t z_t^2 \). Then we
take this regression residuals and adjust equation ?? with Maximum Likelihood to estimate \( \Omega_R \) and \( \Omega_E \). This estimators are used as initial values. Given \( \Omega_R \) and \( \Omega_E \) and the fact the model is linear conditional on \( \Omega_R \) and \( \Omega_E \), we construct the initial values for the lag polynomial \( \Pi_R(L), \Pi_E(L) \) using equation A3.

The initial matrix \( \Omega_\Psi \) is calibrated around one percent of the parameter value and then it is adjusted on the fly for the first 20,000 iterations to generate an acceptance rate of 0.3 for the candidates in each iteration, as proposed by Gelman et al. (2013). We used 100,000 iterations for the base model and the different analysis, and drop the first 20,000 iterations which will count as the "burn-in" period. We performed diagnostics checks about the properties of the generated chain resulting distributions. We found the simulated chains converge to stationary distributions and the simulated parameter values are consistent with a good parameter identification.

CH showed that \( \bar{\Psi} = \frac{1}{N} \sum_{n=1}^{N} \Psi^{(n)} \) is a consistent estimator for \( \Psi \) under the standard regularity assumptions of the maximum likelihood estimators. CH also showed the estimator covariance matrix of \( \Psi \) is given by \( V = \frac{1}{N} \sum_{n=1}^{N} (\Psi^{(n)} - \bar{\Psi})^2 = var(\Psi^{(n)}) \) is an estimator matrix of the generated chain.

Additionally we can use the generated chain of the parameter values \( \Psi^{(n)}_{n=1} \) to construct confidence intervals for the impulse responses. Specifically, we run 1,000 iterations of \( \Psi^{(n)}_{n=1} \) with replacement, and for each iteration we compute the impulse response. As the columns of \( \text{chol}(\Omega_R) \) and \( \text{chol}(\Omega_E) \) in \( \Psi^{(n)}_{n=1} \) are identified except their sign, the generated chains for \( \text{chol}(\Omega_R) \) and \( \text{chol}(\Omega_E) \) could change signs. Besides this sign changes are not a problem for estimation, they could be sometimes a problem for impulse response analysis. In particular, when there is a sign change in the entries of \( \text{chol}(\Omega_R) \) and \( \text{chol}(\Omega_E) \) that correspond to the variance of the government expenditure shocks, these entries could be really close to zero. Given we compute responses to an unitary government expenditure shock, and the respective entries of \( \text{chol}(\Omega_R) \) and \( \text{chol}(\Omega_E) \) must be divided by the respective standard deviation, the obtained confidence intervals could be really wide. To attack this numerical problem, when we construct the impulse responses, we take \( \Pi_R(L), \Pi_E(L) \) directly from \( \Psi^{(n)}_{n=1} \) while the covariance matrix of the residuals in the regime \( s \) is taken from \( N(\text{vec}(\Omega_s), \Sigma_s) \), where

\[
\Sigma_s = 2[(D_n' D_n)^{-1} D_n] var(\text{vec}(\Omega_s)) \otimes var(\text{vec}(\Omega_s))([(D_n' D_n)^{-1} D_n]' ,
\]

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$D_n$ is the duplication matrix and $\text{var}(\text{vec}(\Omega_n))$ is computed from $\Psi(n)_{n=1}^{N}$ (see Hamilton (1994) for more details). The confidence 90 percent interval is computed with the 5 and 95 percentiles of the generated impulse responses.

8.6. **Annex 6: Cointegration rates for interest rates**

Table 8: Interest rates cointegration tests

<table>
<thead>
<tr>
<th>Series*</th>
<th>Data trend:</th>
<th>Test’s type</th>
<th>Without intercept</th>
<th>Linear</th>
<th>Quadratic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None</td>
<td>With intercept</td>
<td>Without trend</td>
<td>With intercept</td>
<td>With intercept</td>
</tr>
<tr>
<td>TBP-TPPDIGC</td>
<td>Trace</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Max-Eig</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>TBP-TPPDEGC</td>
<td>Trace</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Max-Eig</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>TBP-TPPDGC</td>
<td>Trace</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Max-Eig</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Quarterly data. We use Johansen’s cointegration tests of the basic passive rate with each of the debt interest rates individually. The optimal lag were 2 periods for all rates. The debt rates refer to the weighted average given by Hacienda, with monthly frequency, we obtained the quarterly average. 0: zero cointegration relationships; 1: one cointegration relationship; 2: stationary relationship.

*TBP: basic passive rate; TPPDIGC: Central government domestic debt rate; TPPDEGC: Central government foreign debt rate; TPPDPGC: Central government total public debt rate.

Source: Ministerio de Hacienda.

8.7. **Annex 7: Fiscal series composition**

The tax income variables included in the data base are the following:

- Total income
- Current income
  - Income and profits taxes
- Imports taxes
- Exports taxes
- General taxes on sales
- Selected taxes on production and goods consumption

• Non-tax income

• Transfers

The expenditure variables are:

• Total expenditure

• Current expenditure
  - Remunerations
  - Wages and salaries
  - Social charges
  - Expenditure on goods and services
  - Interests: Domestic and foreign debt
  - Current transfers: private sector, public sector, external sector, with external resources.

• Capital expenditures
  - Investment in non-financial assets
  - Capital transfers: public sector, private sector, external sector, with external resources
### 8.8. Annex 8: Unit root tests

Table 9: Unit root tests’ results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Evidence of unit root existence</th>
<th>With structural break</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real per capita Without intercept nor trend</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goods and services exports</td>
<td>Yes</td>
<td>No, 1993Q4</td>
</tr>
<tr>
<td>Tax on exports</td>
<td>No</td>
<td>No, 1999Q4</td>
</tr>
<tr>
<td>Final households’ consumption</td>
<td>Yes</td>
<td>No, 1993Q4</td>
</tr>
<tr>
<td>Brute fixed capital formation</td>
<td>Yes</td>
<td>No, 2005Q3</td>
</tr>
<tr>
<td>Current expenditure</td>
<td>Yes</td>
<td>No, 1993Q4</td>
</tr>
<tr>
<td>Tax on income and profits</td>
<td>Yes</td>
<td>No, 2001Q4</td>
</tr>
<tr>
<td>Goods and services imports</td>
<td>Yes</td>
<td>No, 2008Q3</td>
</tr>
<tr>
<td>Tax on imports</td>
<td>Yes</td>
<td>No, 1998Q4</td>
</tr>
<tr>
<td>Consumer Price Index</td>
<td>Yes</td>
<td>Without break</td>
</tr>
<tr>
<td>General tax on sales Product</td>
<td>Yes</td>
<td>No, 2006Q3</td>
</tr>
<tr>
<td>Capital expenditure</td>
<td>Yes</td>
<td>No, 1994Q1</td>
</tr>
<tr>
<td>Tax income</td>
<td>Yes</td>
<td>No, 1994Q2</td>
</tr>
<tr>
<td>Primary expenditure</td>
<td>Yes</td>
<td>No, 1994Q2</td>
</tr>
<tr>
<td>Basic passive rate</td>
<td>No</td>
<td>No, 1995Q2</td>
</tr>
<tr>
<td>GDP deflator</td>
<td>Yes</td>
<td>Without break</td>
</tr>
<tr>
<td>Nominal Exchange rate</td>
<td>Yes</td>
<td>No, 2009Q3</td>
</tr>
</tbody>
</table>

Source: Own elaboration. Note: XXXXQX represents the year and quarter of the structural break.
### 8.9. Annex 9: SVAR models characteristics

Table 10: Three equations SVAR

<table>
<thead>
<tr>
<th>Test (null hypothesis) Rejected</th>
<th>Type of test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>No serial correlation of residuals (until two lags)</td>
<td>No</td>
<td>LM with two lags</td>
</tr>
<tr>
<td>Homoscedastic residuals</td>
<td>No</td>
<td>White</td>
</tr>
<tr>
<td>Model is stable</td>
<td>No</td>
<td>Roots of characteristic polynomial</td>
</tr>
<tr>
<td>Residuals are normally distributed</td>
<td>No</td>
<td>Cholesky</td>
</tr>
<tr>
<td>Optimal lag length is four periods</td>
<td>No</td>
<td>AIC criteria</td>
</tr>
</tbody>
</table>

Table 11: Six equations SVAR

<table>
<thead>
<tr>
<th>Test (null hypothesis) Rejected</th>
<th>Type of test</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>No serial correlation of residuals (until two lags)</td>
<td>No</td>
<td>LM with two lags</td>
</tr>
<tr>
<td>Homoscedastic residuals</td>
<td>No</td>
<td>White</td>
</tr>
<tr>
<td>Model is stable</td>
<td>No</td>
<td>Roots of characteristic polynomial</td>
</tr>
<tr>
<td>Residuals are normally distributed</td>
<td>No</td>
<td>Cholesky</td>
</tr>
<tr>
<td>Optimal lag length is five periods</td>
<td>No</td>
<td>AIC criteria</td>
</tr>
</tbody>
</table>