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INTERNAL AND EXTERNAL SHOCKS AND ECONOMIC POLICY INNOVATIONS IN BOLIVIA: A GENERAL APPROACH

Roger Alejandro Banegas Rivero[1]
Marco Alberto Nunez Ramirez[2+]
Jorge Salas Vargas[3]
Luis Fernando Escobar Caba[4]
Irma Guadalupe Esparza Garcia[5]

[1,3,4]*Universidad Autonoma Gabriel Rene Moreno, Department of Economics, Ciudad Universitaria, Bolivia.*
[2]*Email: aleconomista@gmail.com Tel: +591 3-3556755*
[2,5]*Instituto Tecnologico de Sonora, Department of Management, Sonora, Mexico.*


(+ Corresponding author)

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ABSTRACT

This paper contributes to quantifying the severity of various types of shocks for one small open economy. The role of fiscal policy was evaluated along with monetary and exchange rate innovations and the findings reflect the relevance of domestic and external shocks. These estimates show that productivity shocks explain about 90% of real variables in the economy. Regarding external shocks, the presence of oil perturbance affects approximately one-third of the fiscal balance behavior. Finally, the main instrument of economic policy is related to public investment innovations that cause more than the 50% of the real variables, especially as an instrument for economic crisis.

Contribution/Originality: The paper's primary contribution is finding and demonstrating the impacts of economic stimulus of monetary policy, exchange rate and fiscal policy instruments in three additional contexts: when there are no domestic disturbances, in the presence of external shocks, and in the presence of domestic disturbances.

1. INTRODUCTION

The use of fiscal, monetary and exchange rate policy in Latin America has been considered the most widely used economic policy instruments to cushion recessions or economic downturns (Banegas, Salas, & Escobar, 2019; Sauma & Sánchez, 2011). However, there is a dearth of studies indicating the type of policies that offer greater effectiveness over the real economy from a dynamic perspective in the presence of domestic and external disturbances. The great debate focuses on the effectiveness of fiscal and monetary policy behavior, especially in response to the current economic downturn, imposing stimulus of low interest rates and high public spending, even though the space is limited with restricted results (Sims, 2016).

In previous studies (e.g., Cerezo, 2010; Guerra-Salas, Kirchner, & Tranamil-Vidal, 2020; Jemio & Wiebelt, 2003), evidence was shown that a small and open economy (in the case of Bolivia) was vulnerable to external shocks and foreign aid, such as international export prices, terms of trade, capital inflows and foreign debt relief, and economic policy innovations, such as devaluation and fiscal expansion, could become anti-shock measures. Other studies have shown that external shocks generate about one-third of output fluctuations in individual economies (e.g., Fernández, Schmitt-Grohé, & Uribe, 2017).

Similarly, it was argued that during the 1990s and early 2000s, fiscal policy in Bolivia was constrained; however, from the first decade of the 21st century, fiscal shocks had a greater impact on economic activity than monetary and external shocks (Palermo, 2014). Nevertheless, the question of the sensitivity or severity of internal shocks (also called domestic shocks), external disturbances and economic policy innovations, the role of fiscal, monetary and exchange rate policy in a small and open economy has not been resolved.

The objective of this research is to evaluate dynamic effects on the real economy of economic policy instruments for which the following simulations are provided: economic policy shocks (fiscal, exchange rate and monetary, *experiment* 1); exogenous shocks (oil prices and external sector) and economic policy innovations (*experiment 2*); domestic innovations (productivity, intertemporal consumption and domestic savings), exogenous innovations and economic policy innovations (*experiment 3*).

Our paper contributes to emerging literature focused on instruments needed for the recovery of macroeconomic effects and to quantify the stimulus impacts of economic policy in the presence of external and domestic shocks.

Research on the sources of variation, magnitude and contribution to macroeconomic aggregates is not yet complete. These findings of the simulations will make it possible to evaluate the impacts from domestic and external shocks and from various economic policy instruments in the real sector. In addition, fiscal, price level and social welfare policies are evaluated in order to appreciate the suggestions and implications of public policies.

Consequently, the document is structured in five sections; the first is regarding the state of public policies, dealing with the presence of internal and external shocks; the second contemplates a dynamic and stochastic general equilibrium model for Bolivia; the third section comprises the data and the calibration of the model; the fourth section shows the results of the research; and the final section presents the discussion of the main findings.

2. PUBLIC POLICIES DEALING WITH INTERNAL AND EXTERNAL SHOCKS

In the context of economic downturn or crisis most literature is related to the presence of domestic, fiscal and exchange rate as economic stimulus or policy response (Elgin, Basbug, & Yalaman, 2020). The most likely negative shocks that can affect the economy are domestic shocks such as supply and demand, and external demand that is reflected in export and commodity prices (Baldwin & Weder, 2020).

When dealing with the internal and external shocks, the related literature provides reference to the establishment of public policies that allows the cushioning of the influence of negative shocks, such as international prices for countries that export natural resources. Consequently, previous works have evaluated the effectiveness of monetary, exchange, fiscal and trade policies as anti-shock measures based on public debt and fiscal deficit restrictions (Canavire-Bacarreza & Mariscal, 2010; Jemio & Wiebelt, 2003).

In the presence of a big international crisis (such as COVID-19), the International Monetary Fund (IMF) has implemented a policy tracker in relation to 196 countries reflecting the fiscal packages and changes in monetary policy actions in order to provide information about strategies during contractive GDP episodes (Deb, Furceri, Ostry, & Tawk, 2020). This reflects the dominant paradigm for policymakers due to monetary and fiscal instruments.

According to Datancurt (2009), the exchange rate regime is a relevant element when combining monetary and fiscal policies as measures to absorb negative fluctuations in output, price levels and exogenous shocks. On the other

hand, empirical evidence indicates that three types of economic policy have been applied in Latin America since the early 1990s: fiscal policy, monetary policy and exchange rate policy (Banegas, 2014; Sauma & Sánchez, 2011).

The fiscal policy was based on prudential margins of the fiscal position: controlled fiscal deficits and restrictive public debt with the purpose of providing a counter-cyclical role in the recessive phases; the application of monetary policy instruments aimed at maintaining monetary aggregates according to the national and international economic situation; and the tendency of having flexible exchange systems (most Latin American countries) and directed exchange rates (Nicaragua and Bolivia).

The Bolivian context related to the vulnerability of external shocks, especially on oil prices, has proposed adjustments to the non-oil fiscal balance or implementation of fiscal rules that reduce the government's opportunism in conditions of fiscal sustainability (Banegas & Vergara, 2015; Zambrano & Aguilera, 2010).

Previously, it was concluded that the use of the expansive fiscal policy negatively affected the fiscal balance and produced deficit in the current account (increase in external saving) (Jemio & Wiebelt, 2003) with preference given to the use of the exchange policy oriented towards increasing economic growth.

3. DYNAMIC STOCHASTIC GENERAL EQUILIBRIUM MODEL (DSGE) FOR BOLIVIA

Dynamic stochastic general equilibrium (DSGE) models are instruments used in different Latin American countries for the analysis of economic policies through the simulation of multiple external, monetary and fiscal shocks that affect the economy as a whole. Similarly, these models have been used to assess shocks in financial markets and at sector levels (Ortiz, 2013).

Mora (2013a) and Mora (2013b) have presented the impacts of different shocks—real domestic (an increase in public spending, a decrease in taxes, a favorable shift in consumption towards domestically produced goods as well as an increase in investment), monetary (increase in the amount of money), external (economic expansion of its main trading partner and increase in the price of exportable goods) and domestic productivity for a small economy with two productive sectors under two exchange rate regimes (fixed and flexible).

The results generally point to the fact that the effect of the expansive monetary policy under a fixed exchange rate regime is ineffective; in contrast, under a flexible exchange rate regime, the monetary policy becomes a very important instrument of economic policy. In addition, from the point of view of domestic shocks, it can be seen that the economic policy options (fiscal and monetary) can be used to stabilize or stimulate the economy, but the costs of doing it result in a higher price level.

The difference in the application of economic policy lies in the magnitude of the impacts. These tend to be much higher when monetary policy is applied than when fiscal policy is applied. In the case of Bolivia, work done focuses on three combinations—monetary and external, monetary and fiscal, fiscal and external.

In this regard, Cerezo (2010) used a DSGE model for the Bolivian economy in the presence of different exogenous shocks (monetary, external and productive), for which he presented monetary policy transmission channels through the interest rate, economic agents' expectations and the exchange rate. The results indicated that the shocks that affect productivity and the external sector have a persistent effect on the economy and, unlike the monetary shocks; their effect dissipates in the short term.

Secondly, Vargas (2010) estimated a DSGE model for which he considered four internal shocks (technological change, the growth rate of money, the tax rate and government spending). His results showed that productive shock strongly and persistently affect product, consumption and investment, and that the other shocks do not affect the product but do affect consumption and investment.

Finally, Machicado and Estrada (2012) examined the impact of fiscal policy on product, consumption, investment and foreign trade using a DSGE model for Bolivia, including five sectors and a particular characteristic—companies from different sectors using public capital as a factor of production. It is worth mentioning that they used different scenarios, modifying each of the different instruments available for fiscal policy.

In general, their results indicated that fiscal policy alone is not capable of generating high rates of economic growth; it must be accompanied by an efficient provision of public capital (infrastructure) and increases in the productivity of economic sectors.

In summary, the aforementioned literature is characterized by the inclusion of internal and external stochastic processes and economic policy, so the developed model (DSGE) is directed towards small and open economies with consumers and representative firms, a government and monetary policy. Similarly, conditions of equilibrium and generation of stochastic processes are included with alternative specifications, also called experiments.[1]

3.1. Consumers

3.1.1. Consumers' Intertemporal Utility Function

For representative consumers, the central objective is to maximize their intertemporal utility function when making decisions with regard to consumption(C_t), investment and leisure (1). In the case of savings and investment, two alternatives are presented: physical investment (I_t)(tangible assets) and government bonds (B_t)(assets with intrinsic value) (2).

$$\max E_t \sum_{t=0}^{\infty} \beta^t S_t^c \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{l_t^{1+\psi}}{1+\psi}\right] (1)$$

In (1), there are disturbances to intertemporal consumption (S_t^c) in addition to the following budget restriction:

$$P_t(1+\tau_c)(C_t + I_t) + B_{t+1}/R_t^B = W_t l_t(1-\tau_p) + R_t K_t(1-\tau_k) + B_t \ (2),$$

and the dynamic relationship of the capital stock (3):

$$K_{t+1} = (1+\delta)K_t + Ifp_t * S_t^{ipr} + Ifg_t * S_t^{igob} \ (3).$$

In (3) the fixed investment is composed of private investment (Ifp_t) and government investment (Ifg_t), respectively, accompanied by their respective disturbances.

From (1) to (3), E_t corresponds to an expectation operator; $\beta \in (0,1)$ and is the intertemporal discount factor; C_t represents the consumption of representative families; S_t^c is an intertemporal consumption *shock*; Ifp_t and Ifg_t symbolize investment in private (tangible) and public physical assets, respectively; S_t^{sp} and S_t^{gob} correspond to private and public domestic savings and investment shocks; R_t is the return on capital stock; R_t^B corresponds to the return on government bonds (B_t). Other variables and parameters of interest are P_t, which is price level, W_t is wages, l_t is labor factor, ψ is labor disutility factor and σ is risk aversion parameter. By dynamic optimization the

[1]A frequent criticism of the DSGE models is directed towards the number of included stochastic processes, whose results can alter the conclusions substantially according to the incorporation of new disturbances.

Euler condition is also presented according to decisions of consumers in relation to their future consumption, expected inflation and return of capital stocks and bonds respectively.

3.2. Firms

3.2.1. Producing Companies of Intermediate Products

The aggregate production of the economy depends on the level of production for intermediate goods and substation elasticity for intermediate goods (4):

$$y_t = \left(\int_0^1 y_{j,t}^{\frac{\varphi-1}{\varphi}} dj\right)^{\frac{\varphi}{\varphi-1}} (4),$$

in which it is assumed that the price level of the economy depends on the price sensitivity of intermediate goods (5):

$$P_t = \left(\int_0^1 P_{j,t}^{\frac{\varphi-1}{\varphi}} dj\right)^{\frac{\varphi}{\varphi-1}} (5).$$

3.2.2 Final Goods Production Companies

For the level of aggregate production, we assumed a set of representative firms that operate by a Cobb–Douglas production function with two types—the productive factors of capital and labor, respectively (6 and 7):

$$y_t = A_t K_t^{\alpha} l_t^{\alpha} (6),$$

$$\text{subject to: } W_t * l_t + R_t K_t (1 - \tau_k) (7).$$

The optimization problem focuses on maximizing (6), subject to a budget constraint (7). Alternatively, an optimization strategy is to minimize (7), subject to a production function (6), where τ_k represents the direct wealth tax (Calvo, 1983).

The price-setting rule (Calvo, 1983) established that the current price level is a composition between the rigidity in probabilistic terms θ, with the possibility of maintaining the same price from the previous period and the remaining probability $(1 - \theta)$ with a transition to an optimal price:

$$P_t = \left[\theta P_{t-1}^{1-\varphi} + (1-\theta) P_t^{*1-\varphi}\right]^{\frac{1}{1-\varphi}} (8)$$

From (8), there is the need to specify a Phillips curve function in its Neo-Keynesian version (9):

$$\pi_t = \beta \pi_{t+1} + \frac{(1-\theta)(1-\theta\beta)}{\theta}(1-\alpha) W_t - A_t + \alpha R_t (9).$$

3.3. Government

Regarding government investment, the fiscal authority collects taxes, has oil tax revenues and carries out current public spending and fixed government investment.

In (11), current consumption expenditure and government fixed investment are considered to be factors dependent on their own innovations by virtue of the absence of a fiscal rule.

Tax collection is endogenous to the following behavior (10) and fiscal balance (11):

$$Tax_t = P_t(\tau_c)(C_t + Ifp_t) + \tau_k R_t K_t + + e_t \tau_m M_t \text{ (10)}$$

$$BALP_t = Tax_t + Oil_t - P_t * \left(G_t + Ifg_t * S_t^{igob}\right) \text{ (11)}.$$

The dynamics of public debt is a function of (12):

$$\frac{Bd_{t+1}}{R_{t+1}^{bd}} + \frac{Be_{t+1}}{R_{t+1}^{be}} - (Bd_t + Be_t) = P_t(G_t + Ifg_t * S_t^{igob}) - BALP_t - Tax_t \text{ (12)}$$

3.4. Monetary Policy

The main objective of monetary policy is based on a Taylor rule using the interest rate as a function of the output and the inflation gap (13):

$$R_t^B = \gamma_a(y_t - y^*) + \gamma_b(\pi_t - \pi^*) + \varepsilon_{sm} \text{ (13)},$$

where inflation is defined by (14):

$$\pi_t = P_t / P_{t-1} - 1 \text{ (14)}.$$

3.5 External Sector

Net exports are understood by the difference between initial exports and imports plus export growth with the consideration of real exchange rate elasticity (η), whose estimate corresponds to the Marshall–Lerner coefficient (15):

$$xn_t * S_t^{xn} = \eta * S_t^{tcr} \text{ (15)}.$$

3.6 Market Balance Conditions

Aggregate production is made up of families, companies, the government and the external sector (16):

$$y_t = cp_t + ifp_t + cg_t + ifg_t + xn_t \text{ (16)}.$$

Similarly, within the external sector is the current balance as the accounting difference between aggregate investment and domestic savings (17 and 18):

$$S_{e,t} = S_{d,t} - ifp_t * S_t^{ipr} - Ifg_t * S_t^{igob} + xn_t \text{ (17)}$$

$$S_{d,t} = Pmg_c * y_t + e_t * S_{e,t} + Ifg_t * S_t^{igob} \text{ (18)}.$$

3.7 Generation of Endogenous Stochastic Process

Ten endogenous stochastic processes are generated:

A) Domestic shocks (19-21):

$$A_t = \rho_a A_{t-1} + \varepsilon_A \text{ (19) Technological change,}$$

$$S_t^c = \rho_c S_{t-1}^c + \varepsilon_c \text{ (20) Private intertemporal consumption,}$$

$$S_t^{ipr} = \rho_c S_{t-1}^{ipr} + \varepsilon_{sav} \text{ (21) Savings domestic investment.}$$

B) Economic policy innovations

B.1) *Fiscal for public expenditure* (22-23):

$$g_t = \rho_g g_{t-1} + \varepsilon_g \quad (22)$$ Current expenditure,

$$ifg_t = \rho_{ifg} ifg_{t-1} + \varepsilon_{ifg} \quad (23)$$ Fixed investment by the government.

B.2) *Exchange rate* (24):

$$\Delta \log tcr = \rho_{tcr} \Delta \log tcr_{t-1} + \varepsilon_{tcr} \quad (24)$$ At the real exchange rate.

B.3) *Monetary* (25):

$$Sm_t = \rho_m sm_{t-1} + \varepsilon_m \quad (25)$$ At the interest rate.

C) External shocks (26-28):

$$oil_t = \rho_o oil_{t-1} + \varepsilon_{oil} \quad (26)$$ Oil prices,

$$xn_t = \rho_{xn} xn_{t-1} + \varepsilon_{xn} \quad (27)$$ Net exports,

$$M_t = \rho_M M_{t-1} + \varepsilon_{xn} \quad (28)$$ Imports.

Table 1. Representation of the dynamic stochastic general equilibrium (DSGE) model.

No.	Description	Log-linearized Model Equations
1	Dynamics of the capital stock	$K_{ss}\widetilde{K}_{t+1} = (1-\delta)K_{ss}\widetilde{K}_t + I_{ss}S_{ss}^{ipr}\left(\widetilde{I}_t + S_t^{\widetilde{ipr}}\right) + Ifg_{ss}S_{ss}^{ipr}\left(\widetilde{Ifg}_t + S_t^{\widetilde{ifg}}\right)$
2	Labor supply	$\left(C_{ss}{}^{\sigma}L_{ss}{}^{\psi}\right)(1+\tau_c)\left(\sigma\widetilde{C}_t + \psi\widetilde{L}_t\right) = W_{ss}/P_{ss}\left(\widetilde{W}_t - \widetilde{P}_t\right)$
3	Euler I	$\left(\frac{1}{\beta}\right)\left(\widetilde{S}_t^{\widetilde{c}} - \sigma\widetilde{C}_t\right) = (1-\delta)\left(S_{t+1}^{\widetilde{c}} - \sigma\widetilde{C_{t+1}}\right) + \frac{R_{ss}}{P_{ss}(1+\tau_c)}\left(S_{t+1}^{\widetilde{c}} - \sigma\widetilde{C_{t+1}} + \widetilde{R_{t+1}} - \widetilde{P_{t+1}}\right)(1-$
4	Euler II	$\widetilde{R_t^B} + S_{t+1}^{\widetilde{c}} - \widetilde{S_t^c} = \sigma\left(\widetilde{C_{t+1}} - \widetilde{C_t}\right) + \widetilde{\pi_{t+1}}$
5	Production function	$\widetilde{Y_t} = \widetilde{A_t} + \alpha\widetilde{K_t} + (1-\alpha)\widetilde{L_t}$
6	Actual wage level	$\widetilde{W_t} - \widetilde{P_t} = \widetilde{Y_t} - \widetilde{L_t}$
7	Level of return on capital	$\widetilde{R_t} - \widetilde{P_t} = \widetilde{Y_t} - \widetilde{K_t}$
8	Phillips Neo-Keynesian curve	$\widetilde{\pi_t} = \beta\widetilde{\pi_{t+1}} + \frac{(1-\theta)(1-\theta\beta)}{\theta}\left[(1-\alpha)\widetilde{W_t} - \widetilde{A_t} + \alpha\widetilde{R_t}\right]$
9	Dynamics of public debt	$\beta\left[\widetilde{B_{t+1}} - \widetilde{R_{b,t}}\right] - \widetilde{B_t} = P_{ss}G_{ss}\left(\widetilde{P_t} + \widetilde{G_t}\right) + P_{ss}Ifg_{ss}S_{ss}^{ifg}\left(\widetilde{P_t} + \widetilde{Ifg_t} + S_t^{\widetilde{ifg}}\right) + BAL_{ss}\widetilde{BAL_t}$
10	Tax income	$TAX_{ss}\widetilde{TAX_t} = P_{ss}\tau_c\left(C_{ss}\left(\widetilde{P_t} + \widetilde{C_t}\right) + I_{ss}S_{ss}^{ipr}\left(\widetilde{P_t} + \widetilde{I_t} + S_t^{\widetilde{ipr}}\right)\right) + e\,\tau_m M_{ss}\widetilde{M_t} + R_{ss}K_{ss}\tau_y\left(\widetilde{R_t} + \widetilde{K_t}\right)$
11	Fiscal balance	$BAL_{ss}\widetilde{BAL_t} = TAX_{ss}\widetilde{TAX_t} - OIL_{ss}\widetilde{OIL_t} - P_{ss}G_{ss}\left(\widetilde{P_t} + \widetilde{G_t}\right) - P_{ss}\,Ifg_{ss}S_{ss}^{ifg}\left(\widetilde{P_t} + \widetilde{Ifg_t} + S_t^{\widetilde{ifg}}\right)$

12	Taylor's rule for monetary policy	$R_{ss}^{\bar{B}} S_{ss}^{pm} \left(\widehat{R_t^{\bar{B}}} + S_t^{\widehat{pm}}\right) = aY_{ss}\widehat{Y_t} + b\pi_{ss}\widehat{\pi_t}$
13	Balance of the goods market	$Y_{ss}\widehat{Y_t} = C_{ss}\widehat{C_t} + I_{ss}\widehat{I_t} + Ifg_{ss}\widehat{Ifg_t} + G_{ss}\widehat{G_t} + XN_{ss}\widehat{XN_t}$
14	Social welfare	$BS = \left(C_{ss}{}^{1-\sigma}\widehat{C_t} + L_{ss}{}^{1+\psi}\widehat{L_t}\right)$
15	Marshall–Lerner condition	$XN_{ss}\widehat{XN_t} = \eta\, S_{ss}^{tcr}\widehat{S_t^{tcr}}$
16	External savings I	$S_{e,ss}\widehat{S_{e,t}} = S_{d,ss}\widehat{S_{d,t}} - I_{ss}\widehat{I_t} - Ifg_{ss}\widehat{Ifg_t}$
17	External savings II	$XN_{ss}\widehat{XN_t} + f_t + re_t = S_{e,ss}\widehat{S_{e,t}}$
18	Domestic Saving	$S_{d,ss}\widehat{S_{d,t}} = PmgC\ Y_{ss}\widehat{Y_t} + e_t\, S_{e,ss}\widehat{S_{e,t}} + S_{gob,ss}\widehat{S_{gob,t}}$
19-21	Domestic Shocks	$\widehat{A_t} = \rho_{tec}\widehat{A_{t-1}} + \varepsilon_A$ $\widehat{S_t^c} = \rho_c S_{t-1}^{\widehat{c}} + \varepsilon_c$ $S_t^{\widehat{ipr}} = \rho_{invp} S_{t-1}^{\widehat{ipr}} + \varepsilon_{invp}$
22-25	Economic policy innovations	$\widehat{G_t} = \rho_g\widehat{G_{t-1}} + \varepsilon_g$ $S_t^{\widehat{Ifg}} = \rho_{ifg} S_{t-1}^{\widehat{Ifg}} + \varepsilon_{ifg}$ $S_t^{\widehat{pm}} = \rho_{pm} S_{t-1}^{\widehat{pm}} + \varepsilon_{pm}$ $S_t^{\widehat{tcr}} = \rho_{tcr} S_{t-1}^{\widehat{tcr}} + \varepsilon_{tcr}$
26-28	External Shocks	$\widehat{OIL_t} = \rho_{oil}\widehat{OIL_{t-1}} + \varepsilon_{oil}$ $S_t^{\widehat{xn}} = \rho_{xn} S_{t-1}^{\widehat{xn}} + \varepsilon_{xn}$ $\widehat{M_t} = \rho_M\widehat{M_{t-1}} + \varepsilon_M$

4. DATA AND CALIBRATION

In the model for Bolivia, parameters from previous studies on this country were utilized (Banegas & Salas, 2016; Banegas, 2016; Cerezo, 2010) as well as standard parameters in dynamic and stochastic models (DSGE) (Duncan, 2004; Taylor, 1993).

On the other hand, real, quarterly and seasonally adjusted variables from 1990 to 2015 related to GDP at basic prices were used (Devarajan, Go, Lewis, Robinson, & Sinko, 1997). Table 2 presents the considered information.

5. RESULTS

5.1. Associations between Shocks and Macroaggregate Variables

According to estimates of the dynamic stochastic model (DSGE), simple correlations (ρ) were obtained between the generated shocks and the endogenous variables of the model, finding strong associations ($\rho \geq 0.70$) – in a positive and negative way, respectively, as well as a weak relationship ($\rho < 0.50$) (Mejía, 2013).

In strong and positive associations as a first point, the association between productivity shocks and fixed government investment stands out; other positive relationships are presented between the level of economic activity, private consumption, capital stock and social welfare. The second element in strong and negative associations is the association between productivity shocks in relation to the remuneration of capital, interest rates, prices and tax collection; likewise, the level of public debt is negatively related to the level of production, private consumption, capital stock and labor factor. Finally, as a third element, the weak associations are presented, which

are linked to the shocks of intertemporal consumption, oil price shock, real exchange rate shocks (exchange rate policy) and public expenditure shock (see Appendix A3).

Table 2. DSGE model calibration.

Calibration			
Product–capital elasticity	α	0.6967	Banegas and Salas (2016)
Capital depreciation rate	δ	0.0300	Banegas and Salas (2016)
Labor factor disutility parameter	ψ	0.5000	Duncan (2004); Cerezo (2010)
Discount factor	β	0.9800	Vargas (2010); Cerezo (2010)
Risk aversion	σ	2.0000	Cavalcanti and Vereda (2011)
Subst. elasticity of domestic goods and imports	ηc	1.0100	Duncan (2004); Cerezo (2010)
Substitution elasticity of domestic goods and exports	ηc^*	1.0100	Duncan (2004); Cerezo (2010)
CET (production)	ϕ	6.0000	Lim and McNelis (2008); Cerezo (2010)
Probability of price rigidity	θ	0.3900	Cerezo (2010)
Response to the product gap (monetary policy)	γa	0.5000	Taylor (1993)
Response to the inflationary gap (monetary policy)	γb	1.5000	Taylor (1993)
Net exports sensibility to the RER	η	0.4800	Banegas (2016)
Stochastic Processes			
Response parameter to oil shock	$\rho\ oil$	-0.06	Meenagh, Minford, and Oyekola (2015)
Response parameter to external shocks	$\rho\ xn$	0.73	Estimated with AR(1) to net exports
Response parameter to consumption shock	$\rho\ c$	0.74	Estimated with AR(1) to private consumption
Response parameter to technological shock	$\rho\ a$	0.40	Estimated with AR(1) to residue of Solow-Swan
Response parameter to public expenditure shock	$\mu\ g$	0.12	Estimated with a constant stochastic average
Response parameter to private investment shock	$\rho\ s$	0.92	Estimated with AR(1) to private investment
Response parameter to fixed government investment	$\rho\ gob$	0.84	Estimated with AR(1) to the public investment
Response parameter to monetary policy shock	$\rho\ m$	-0.44	Estimated with ARIMA(1,1,0); IGARCH (1,1) to the interest rate
Response parameter to exchange policy shock	$\rho\ tcr$	0.43	Estimated with ARIMA(1,1,0)
Response parameter the imports shock	$\rho\ M$	-0.31	Estimated with ARIMA(1,1,0)
Standard Deviation			
Oil shock	$\sigma\ oil$	0.2086	
External shock	$\sigma\ xn$	0.0277	
Consumption shock	$\sigma\ c$	0.0117	
Technological shock	$\sigma\ a$	0.0255	
Public expenditure shock	$\sigma\ g$	0.0056	
Private investment shock	$\sigma\ s$	0.1113	
Fixed government investment shock	$\sigma\ s$	0.0845	
Monetary policy shock	$\sigma\ m$	0.1503	
Exchange policy shock	$\sigma\ tcr$	0.0252	
Import shock	$\sigma\ M$	0.0775	

5.2. Macroaggregate Variance Decomposition

In order to quantify the magnitudes of the various domestic, external and economic policy shocks, variance decomposition was applied for endogenous variables in the three DSGE specification experiments (see Table 3). As a consequence, disturbances in the government's fixed investment exerted 52% of the variability on real macroaggregates (production, private consumption, investment and capital stock) as well as on the labor factor

through a simulation of stochastic processes in economic policy instruments (*experiment 1*)[2]. Comparatively, the relevance of the real exchange rate corresponds to 48% in the real variables.

On the other hand, the relevance of the monetary policy is focused on the major source of variability on capital retribution, interest rates, inflation levels and the fiscal sector (tax collection and fiscal balance).

The role of government fixed investment and exchange rate policy remains consistent with previous results (see Table 4, *experiment 2*)[3] as it assumes external stochastic processes (oil prices, net exports and import shocks). The greatest external disturbance is centered on oil shock, which explains 31% of the variability of the fiscal balance. In summary, in the presence of external shocks and economic policy innovations, the role of fixed government investment prevails over other economic policy instruments.

Nevertheless, in the presence of domestic shocks (see Table 5, *experiment 3*)[4], the role of economic policy is limited (between 3% and 5% of the real variables) either on the fiscal side or on the exchange rate side; the shocks in productivity or technological change are the most relevant with a share of between 89% and 92% of real product, private consumption and private investment. Likewise, productivity innovations exert greater variability on wages, prices and social welfare (89%). The most severe external shock is centered on oil prices with 12% variability on the fiscal balance.

Table 3. Variance Decomposition.

***Experiment 1*:** Economic Policy Innovations.

		Shocks			
Endogenous variables		**Monetary Policy**	**Real Exchange Rate**	**Fixed Government Investment**	**Current Expenditure**
Production	Y	0	48	52	0
Consumption	C	0	45	55	0
Private fixed investment	I	0	48	52	0
Government fixed investment	*Igob*	0	57	43	0
Current expenditure	G	0	0	0	100
Capital assets	K	0	48	52	0
Work	L	0	48	52	0
Capital remuneration	R	72	15	13	0
Interest rate	*R_b*	99	1	1	0
Wages	W	72	15	13	0
Bonds (public debt)	B	0	43	56	0
Taxes	*TAX*	72	15	13	0
Fiscal balance	*BAL*	74	11	16	0
Domestic prices	P	72	15	13	0
Inflation	*PI*	54	24	21	0
Social welfare	*Welfare*	0	45	55	0
Public savings	*S_pub*	0	0	100	0
Domestic savings	*domsav*	0	27	72	0
Monetary shock	*S_pm*	100	0	0	0
Net exports	*XN*	0	100	0	0
Exchange rate shock	*S_tcr*	0	100	0	0
External savings (current expenditure)	*Cab*	0	100	0	0

[2]Only positive innovations are introduced in current spending, fixed government investment, exchange rate policy (devaluation) and interest rates (exchange rate policy).

[3]In addition to economic policy innovations (fiscal, monetary and exchange rate), three external shocks are incorporated: oil prices, net exports and imports.

[4] *Experiment 3* incorporates three domestic shocks: productivity shock, intertemporal consumption and domestic savings; likewise, there are external shocks and economic policy innovations.

Table 4. Variance Decomposition.

Experiment 2: External shocks + economic policy innovations

	Variance							(percent)
		External shocks			Economic policy shocks			
Endogenous Variables		**Oil**	**Net Exports**	**Imports**	**Monetary Policy**	**Exchange Rate Policy**	**Gov. Fix. Investment**	**Current Exp.**
Production	Y	0	0	0	0	48	52	0
Consumption	C	0	0	0	0	45	55	0
Private fixed investment	I	0	0	0	0	48	52	0
Government fixed investment	Igob	0	0	0	0	57	43	0
Current expenditure	G	0	0	0	0	0	0	100
Capital assets	K	0	0	0	0	48	52	0
Work	L	0	0	0	0	48	52	0
Capital remuneration	R	1	0	0	71	15	13	0
Interest rate	R_b	0	0	0	99	1	1	0
Wages	W	1	0	0	71	15	13	0
Bonds (public debt)	B	0	0	0	0	43	56	0
Taxes	TAX	1	0	0	71	15	13	0
Fiscal balance	BAL	31	0	0	51	7	11	0
Prices	P	1	0	0	71	15	13	0
Inflation	PI	1	0	0	54	24	21	0
Social welfare	Welfare	0	0	0	0	45	55	0
Intertemporal cons. shock	S_c	0	0	0	0	0	0	0
Productivity	A	0	0	0	0	0	0	0
Private savings	S_sav	0	0	0	0	0	0	0
Imports	M	0	0	100	0	0	0	0
Public savings	S_pub	0	0	0	0	0	100	0
Domestic savings	domsav	0	0	0	0	27	72	0
Monetary shock	S_pm	0	0	0	100	0	0	0
Oil shock	OIL	100	0	0	0	0	0	0
Net exports	XN	0	0	0	0	100	0	0
Exchange rate shock	S_tcr	0	0	0	0	100	0	0
External savings (current expenditure)	cab	0	0	0	0	100	0	0
Net exports shock	S_xn	0	100	0	0	0	0	0

Table-5. Variance Decomposition *Experiment 3*: Internal shocks + External disturbances + Economic policy innovations.

		Internal Shocks			***External Shocks***			***Economic Policy Shocks***			
		Productivity	**Intertemporal Consumption**	**Sav. Priv. Dom. Inv.**	**Oil**	**Net Exports**	**Imports**	**Monetary Policy**	**Exchange Rate Policy**	**Government Fixed Investment**	**Current Expend.**
Production	*Y*	92	2	0	0	0	0	0	3	3	0
Consumption	*C*	89	2	0	0	0	0	0	4	5	0
Private fixed investment	*I*	9	0	90	0	0	0	0	0	0	0
Government fixed investment	*Igob*	91	1	0	0	0	0	0	4	3	0
Current expenditure	*G*	0	0	0	0	0	0	0	0	0	100
Capital assets	*K*	90	2	0	0	0	0	0	4	4	0
Work	*L*	92	2	0	0	0	0	0	3	3	0
Capital remuneration	*R*	78	2	0	0	0	0	14	3	3	0
Interest rate	*R_b*	17	0	0	0	0	0	81	1	1	0
Wages	*W*	79	2	0	0	0	0	14	3	2	0
Bonds (public debt)	*B*	89	3	0	0	0	0	0	4	5	0
Taxes	*TAX*	79	2	0	0	0	0	14	3	2	0
Fiscal balance	*BAL*	60	2	0	12	0	0	19	3	4	0
Prices	*P*	79	2	0	0	0	0	13	3	2	0
Inflation	*PI*	85	2	0	0	0	0	7	3	3	0
Social welfare	*Welfare*	89	2	0	0	0	0	0	4	5	0
Intertemporal consumption shock	*S_c*	0	100	0	0	0	0	0	0	0	0
Productivity	*A*	100	0	0	0	0	0	0	0	0	0
Private savings	*S_sav*	0	0	100	0	0	0	0	0	0	0
Imports	*M*	0	0	0	0	0	100	0	0	0	0
Public savings	*S_pub*	0	0	0	0	0	0	0	0	100	0
Domestic savings	*domsav*	95	1	0	0	0	0	0	1	3	0
Monetary shock	*S_pm*	0	0	0	0	0	0	100	0	0	0
Oil shock	*OIL*	0	0	0	100	0	0	0	0	0	0
Net exports	*XN*	0	0	0	0	0	0	0	100	0	0
Exchange rate shock	*S_tcr*	0	0	0	0	0	0	0	100	0	0
External savings (current expenditure)	*Cab*	0	0	0	0	0	0	0	100	0	0
Net exports shock	*S_xn*	0	0	0	0	100	0	0	0	0	0

5.3. Dynamic Impacts of Domestic, External and Economic Policy Shocks

5.3.1. Impulse Response Analysis

In order to complement the previous analysis, the impulse response functions are presented in a dynamic manner for the interest variables in *experiment 3*: a general specification of the national economy in the presence of domestic, external and economic policy disturbances that allows complementing the analysis of variance decomposition.

5.3.2. Domestic Disturbances Shocks

In general, productivity shocks are formed in the disturbance that has the most positive impact on the level of production, private fixed investment, domestic savings and social welfare when comparing domestic, external and economic policy innovations. The dynamic implications of a positive productivity shock produce a permanent negative effect on public debt and a temporary negative effect on real wages and inflation (see Figure 1). On the other hand, fixed government investment and domestic savings respond positively and temporarily.

In the presence of a positive disturbance in the intertemporal consumption (see Figure 2), public debt responds positively and permanently to a private internal consumption shock and temporarily to inflation and wages; on the other hand, domestic savings respond in a temporary negative manner to the fixed government investment and the fiscal balance (only in the first quarter, then until the eighth quarter in a positive manner and from there in a negative manner again) (see Figure 3).

5.3.3. External Shock

In the presence of a positive oil shock (see Figure 4), the fiscal balance, inflation and wages respond positively and temporarily. Similarly, the effects of a positive shock in imports have positive and temporary implications on the fiscal balance (tax collection), inflation (imported) and wages (see Figure 5).

5.3.4. Economic Policy Innovations

In Figure 6, a positive shock in the current spending has the following implications: public debt responds positively and permanently; conversely, the fiscal balance responds negatively. The impact on the other real variables is close to zero (no effect).

In Figure 7, in the presence of a positive shock in the government's fixed investment, the public debt responds in a negative and permanent manner, affecting the domestic savings in a negative and temporary way and the government's future investment and the fiscal balance in the short term.

In the presence of a monetary policy shock (see Figure 8), inflation and wages respond positively and temporarily, while the interest rate and fiscal balance respond negatively and temporarily.

Finally, when faced with an exchange rate policy shock (see Figure 9), public debt responds positively and temporarily, while other variables—the fiscal balance, inflation (*pass-through effect*) and wages—respond positively and temporarily. The orientation towards real devaluation (exchange shock) leads to negative and temporary effects on the government's fixed investment and foreign savings.

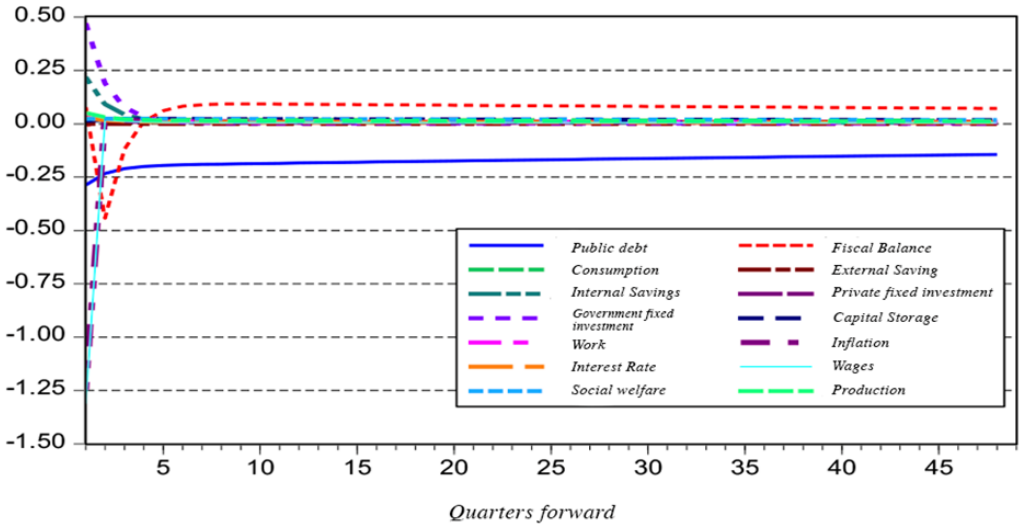

Figure 1. Responses to impulses from productivity shocks.

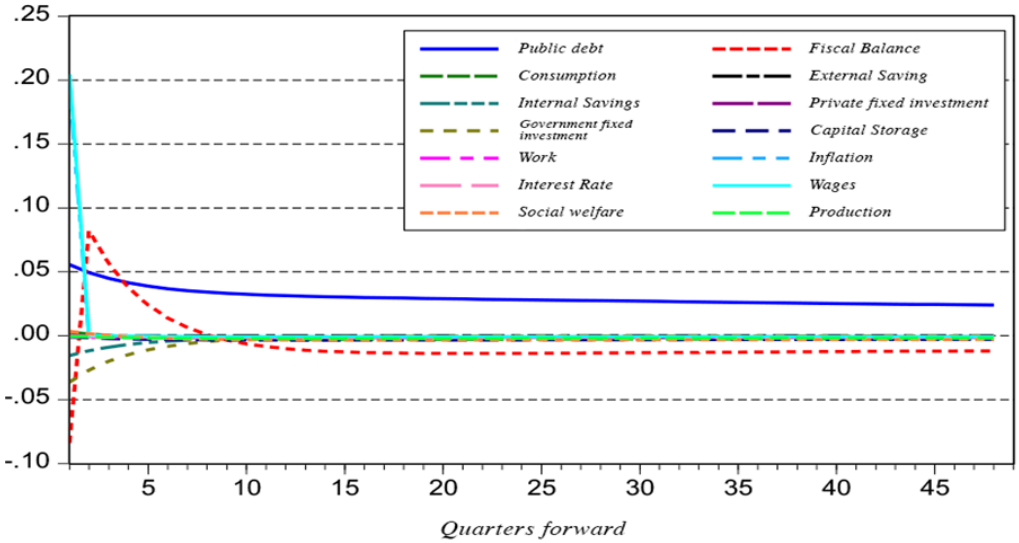

Figure 2. Responses to impulses from an intertemporal consumption shock.

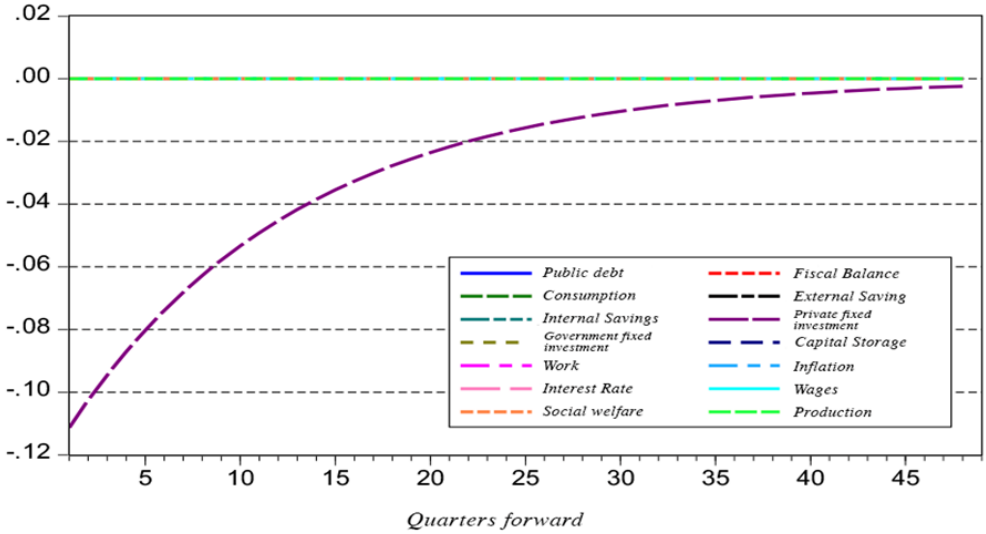

Figure 3. Responses to impulses from a domestic saving shock.

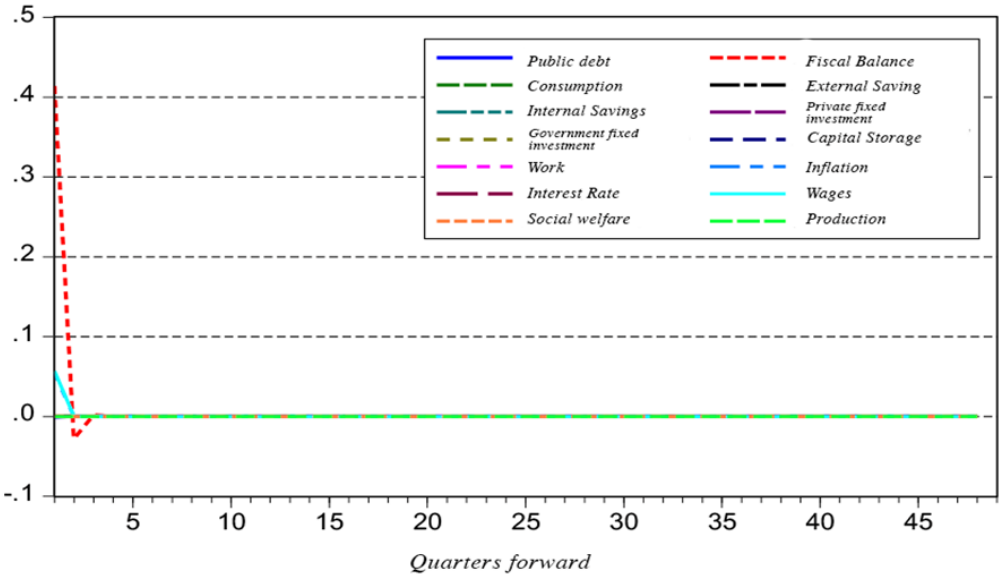

Figure 4. Response to impulses from a positive oil shock.

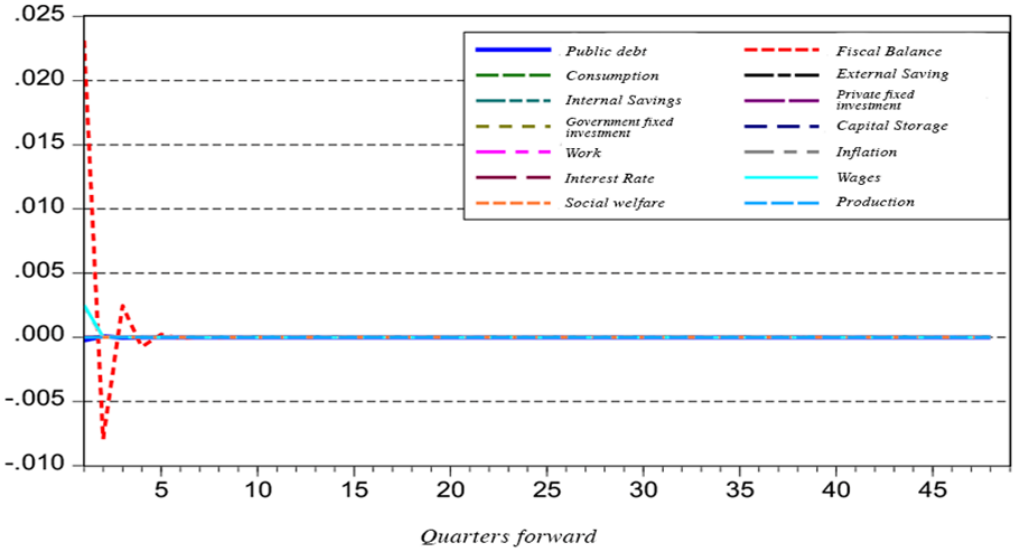

Figure 5. Responses to impulses from an import shock.

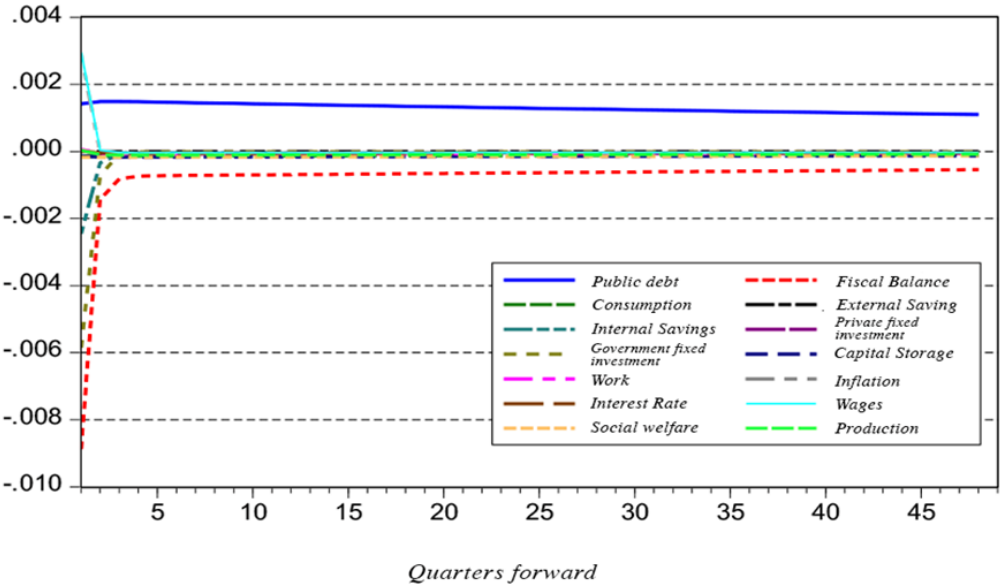

Figure 6. Responses to impulses from a positive shock of current expenditure.

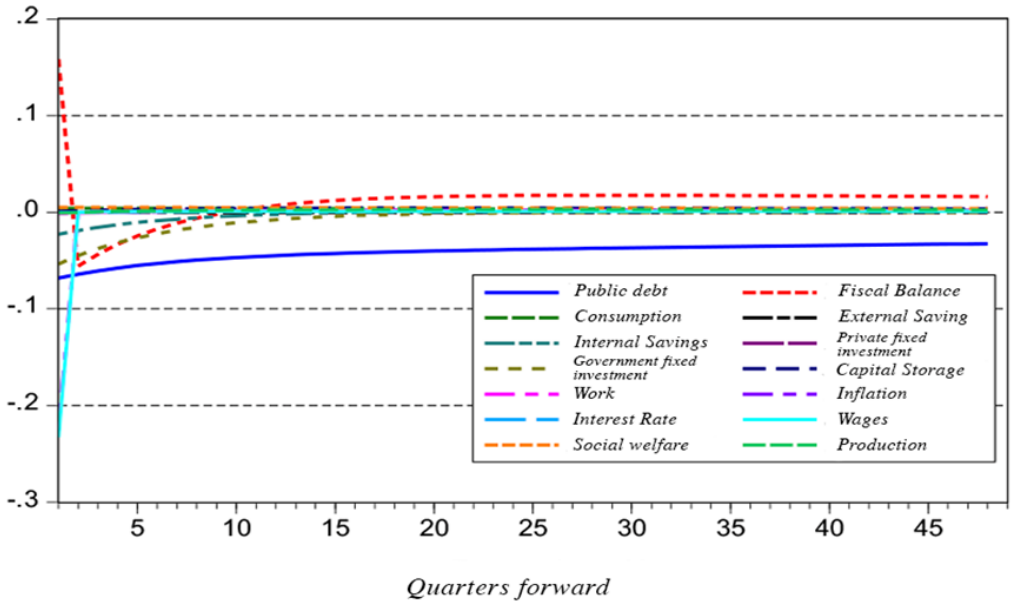

Figure 7. Responses to impulses from a positive shock of fixed government investment.

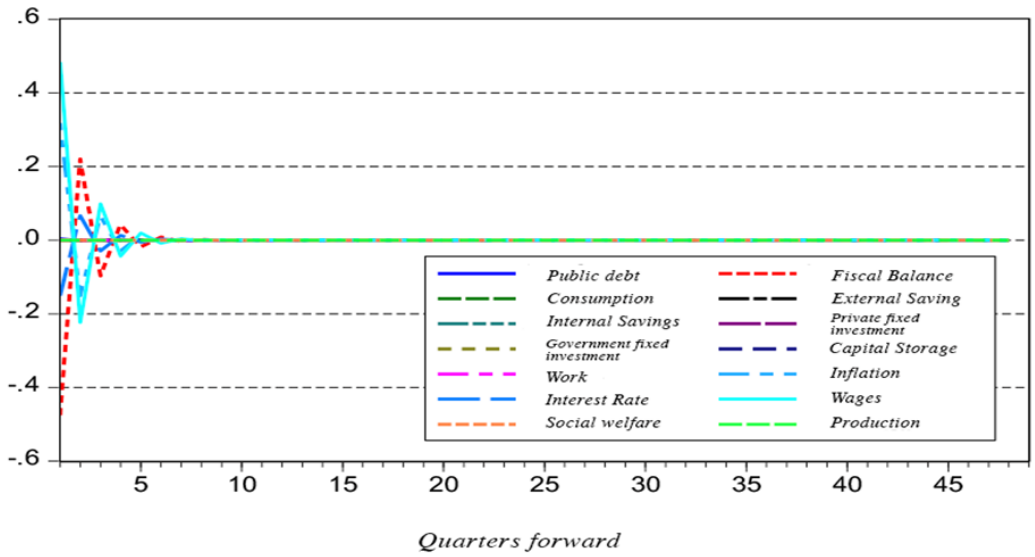

Figure 8. Responses to impulses from a monetary policy shock.

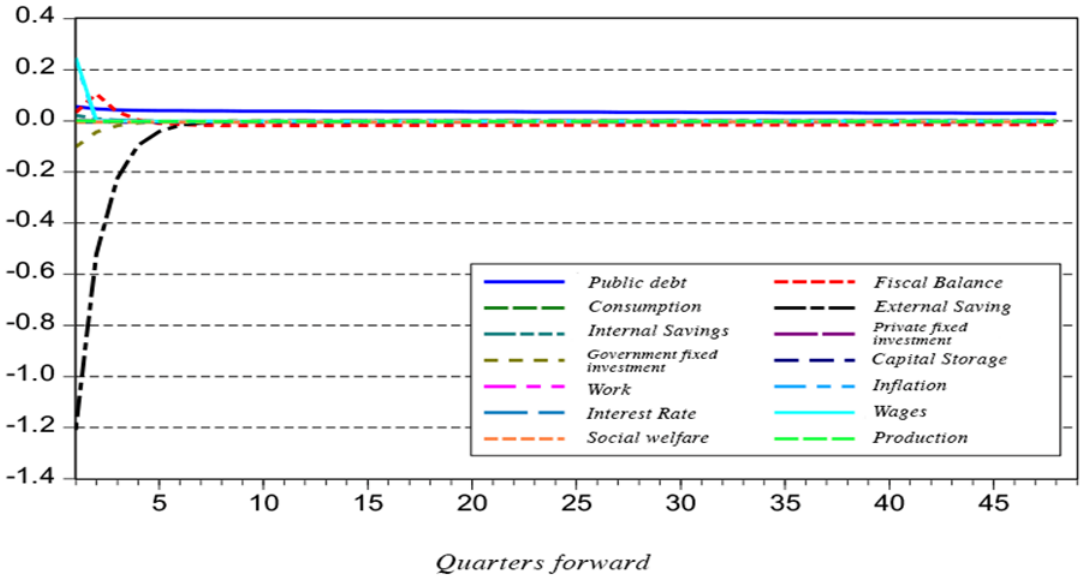

Figure 9. Responses to impulses from an exchange rate policy shock.

6. DISCUSSION AND PUBLIC POLICY IMPLICATIONS

This section aims to compare the results found in previous studies as well as point out the contributions of quantifying shocks for a small and open economy (in the case of Bolivia). Similarly, it discusses the implications and transmission channels of internal and external shocks and their effects within the economy for economic policy makers.

6.1. Implications of Domestic Shocks

Productivity shocks are the main innovations that mostly affect the economy as a whole. The transmission mechanism is mainly through production (supply shock), which is interrelated with the balance of the goods market and spreads to the entire system. Unlike findings by Cerezo (2010), there are temporary responses on the real variables. The relevance of a productivity shock should be mentioned to explain the variability (89% and 92%) and positive responses on the real product, private consumption and private fixed investment to a great extent. At the same time, the productivity shocks strongly and persistently affect the product in Bolivia (Vargas, 2010) and these results are consistent, as found by Pham, Sala, and Silva (2020) who demonstrated that productivity shocks explain more than 50% of the variability of output growth, such as in the Vietnamese economy.

6.2. Implications of External Shocks

Oil shock is the most severe external disturbance found. It generates a positive impact on the fiscal balance, due to its direct relationship with it, and also an increase in domestic prices (Brown & Yücel, 2002; Rahman, 2015) and wages. On the other hand, Schmitt-Grohé and Uribe (2018) found that terms of trade shocks explain the movements of macroeconomic aggregates. The findings of external disturbances are related to what was said by Palermo (2014)[5]: a shock in international energy prices tends to raise domestic prices and has a limited effect on the product. It is also consistent with Balke and Brown (2018) whose finding regarding U.S. oil shock price has an inelastic impact on the output. In addition, Banegas et al. (2019) reported that positive shocks in the terms of trade have a direct impact on aggregate investment with positive innovations on the fiscal sector and the external sector of the Bolivian economy.

6.3. Implications of Innovations in Monetary Policy

According to Cerezo (2010)[6], there is a discussion on the effects of monetary disturbances within the economy; therefore, a monetary shock on product and real variables dissipates in the short term. Likewise, a monetary policy innovation also generates an increase in inflation (temporary), a decrease in the real interest rate as well as the relevance of monetary policy in the fiscal balance; on the other hand, the results obtained are consistent with Palermo (2014) and Vargas (2010) who pointed out that a monetary policy shock has a weak impact on production, so monetary policy innovations do not significantly affect the output.

6.4. Implications of Fiscal Expansion Innovations

For fiscal policy shocks on the expansion area of spending the product does not respond to positive innovations in current spending. However, a positive shock of fixed government investment explains more than half of the variations in product and real variables (when there are no internal disturbances). The above is related to what Machicado and Estrada (2012) have said, who considered that fiscal policy alone is not capable of generating high economic growth rates because it must be accompanied by an efficient provision of public capital, especially in the

[5] Also, measurement of the magnitudes and responses to shocks are considered by a SVAR model.

[6] It should be mentioned that Cerezo took two different specifications for monetary policy rules and so differs in the calibration period of the model.

absence of positive productivity disturbances. Likewise, Palermo (2014) pointed out that fiscal shock had the greatest influence on economic activity. As suggested by Kamber, McDonald, Sander, and Theodoridis (2016), government spending shocks are important drivers of change in consumption and GDP growth.

Previously, Jemio and Wiebelt (2003) pointed out that a fiscal expansion may present limited room for operation for the implementation of anti-shock policies in scenarios of persistent fiscal deficits and high levels of public debt (budgetary restriction), which can be conceived as a sufficient and necessary condition to employ the government's fixed investment instrument as a measure of economic stimulus.

On the other hand, Furceri and Li (2017) found empirical evidence that public investment has a considerable multiplier effect that is greater than current government spending and this because capital spending has a positive effect on the productive capacity of the economy. Additionally, Alarcón (2020) found that an increase in public investment generates a positive externality allowing better levels of economic growth and an improvement in the wage level of the labor force as well as an increase in consumption, savings and employment in the Bolivian economy.

6.5. Implications of Exchange Rate Policy Innovations (Real Devaluation)

For the exchange rate policy shock, the real devaluation of the exchange rate is considered, which generates a negative impact on foreign savings with limited implications on the output. These results coincide with those found previously, therefore, the response of the product to a devaluation shock is zero. On the contrary, in the presence of government budget restrictions, Jemio and Wiebelt (2003) argued that a devaluation shock could help to place the Bolivian economy on a more expansive path, which is not reflected in the estimates obtained (the temporal roles of policies are different).

7. CONCLUSIONS

This document addresses the role of economic policy for a small and open economy, in this case the Bolivian economy, through a DSGE model with three stochastic process experiments, also known as *alternative specifications*. The central purpose was based on evaluating the implications of public policies in the macroaggregates. Likewise, the severity and impacts of internal and external shocks was quantified, especially public policy as a response to an economic crisis.

The results of the first experiment with unique economic policy innovations (fiscal, monetary and exchange rate) indicated that the government's fixed investment exerts around 52% on the variability of macroaggregates, and the remaining percentage of the variance corresponds to the real exchange rate in the absence of positive internal and external disturbances. It is worth mentioning that the main opportunity costs *(trade-off)* of public investment are presented in the short-term budget restrictions and future government investment.

In the second experiment, which includes additional external disturbances to economic policy innovations, there is consistency in the findings of the first experiment with the peculiarity that the oil price shock explains 31% of the variability on the fiscal balance through direct mechanism.

In the third experiment, with the addition of internal disturbances (productivity shock, intertemporal consumption shock and domestic savings shock), the findings indicate that the role of economic policy exerts a restricted participation (between 3% and 5% of the real variables) against domestic disturbances being the productivity shock (that explains between 89% and 92% of the variation in the real product, consumption, and investment among other macroaggregates).

In summary, the main contributions of the document are when there are no domestic disturbances, the most relevant instrument to stimulate the economy is the government's fixed investment; in the presence of external shocks, oil disturbances decrease with greater impact on the fiscal sector; in the presence of domestic disturbances,

the scope of economic policy is limited where positive productivity innovations are the generators of greater variability in the economy.

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A1. Appendix of the Stationary State of the Economy

The main variables of interest are obtained in equilibrium conditions (in the steady sense) and removing the tendencies among the indicators of variables; hence, it is determined as follows:

$$R_{ss}^{B} = 1/\beta \text{ (A1)}$$

$$P_{ss} = \left(\frac{\varphi}{\varphi-1}\right)^{2} \text{ (A2)}$$

$$R_{ss} = \left(\frac{\varphi}{\varphi-1}\right)^{2}\left(\frac{1+\tau_c}{1+\tau_k}\right)\left[\frac{1}{\beta}-(1-\delta)\right] \text{ (A3)}$$

$$W_{ss} = P_{ss}^{\frac{1}{1-\alpha}}(1-\alpha)\left[\left(\frac{\varphi}{\varphi-1}\right)^{\frac{1}{\alpha}}\frac{\alpha}{(1+R_{ss})}\right]^{\frac{\alpha}{1-\alpha}} \text{ (A4)}$$

From analytical information, the *Solow–Swan* stationary state is obtained, assuming that the technological constant takes the value of one:

$$\frac{K}{L_{ss}} = \left(\frac{s_q A_{ss}}{\delta+n}\right)^{\frac{1}{1-\alpha}} \text{ (A5)}$$

$$\frac{Y}{L_{ss}} = A_{ss}\left(\frac{K}{L_{ss}}\right)^{\alpha} \text{ (A6)}$$

$$l_{ss} = \left(\frac{Y_{ss}}{K_{ss}{}^{\alpha}}\right)^{1/(1-\alpha)} \text{ (A7)}$$

$$C_{ss} = Y_{ss}\left(1-\tau_k-s_q\right) \text{ (A8)}$$

$$\pi_{ss} = P_{ss} - P_{ss} \text{ (A9)}$$

To this end: $K_{ss} = 2.73$; $Y_{ss} = 1.10$; $l_{ss} = 0.14$; $A_{ss} = 1.00$

A2. Appendix of Alternative Specifications–DSGE

A3.1. Model moments (log-linearized)

A3. 2. Correlation matrix, experiment 3

(Internal and external shocks and economic policy innovations)