

IMPACT OF NFPS CAPITAL EXPENDITURE ON ECONOMIC GROWTH IN BOLIVIA IN YEARS 2006-2016

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ABSTRACT

In recent years, public investment has become considerably more dynamic with the application of the Economic Social Communitarian Productive Model (MESCP) since 2006, which helped reactivate and boost the domestic demand, unlike what happened in previous periods. The scenario simulations based on a Dynamic Stochastic General Equilibrium (DSGE) model proposed by the study reveal the importance of capital expenditure in economic growth. The results show that changes in capital spending in the short term persistently boost economic growth and have positive effects on consumption and private investment, dismissing the existence of a possible crowding-out effect in the private sector.

JEL Classification: C11, C31, G21.

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I. INTRODUCTION

Without any doubt, as pointed out by most institutional bodies such as the Inter-American Development Bank (IADB), the Latin American Development Bank (CAF) and others, one of the main tasks to be addressed by Latin American governments is to reduce the so-called infrastructure-gap in order to ensure continuity of the sustained economic growth. Foremost, this has to be done through a greater public investment.

In this sense, Bolivia's public investment has grown in a sustained manner since 2006, in line with the approach of the Economic Social Comunitarian Productive Model (MESCP). The aim was not only to reduce the so-called infrastructure gap but, unlike other countries, the idea was for the State to have a dominant and active role in the economy through projects for both industrialization and productive diversification, which have had a favorable impact on growth in recent years. On the other hand, analyzing the period from the mid-1990s until the start of application of the MESCP, it is clear that public investment hardly had any impact in economic activity.

Taking into account that public investment is a fundamental part of Non-Financial Public Sector (NFPS) capital expenditure, this paper intends to analyze the dynamics of fiscal expenditure on capital in Bolivia, in the short and in the medium terms, as well as the impact thereof in the overall economy, analyzing the growth of GDP, consumption and private investment, among other aggregate variables, by means of a Dynamic Stochastic General Equilibrium (DSGE) model with micro foundations associated to performance of the Bolivian economy based on other papers and international experiences. Likewise, taking advantage of the specification made, secondly the paper seeks to analyze the dynamics behind current public expenditure and the impact thereof on the economy.

The paper is organized as follows: the second part is a literature review with an analysis of previous works for different locations and of the main results of their estimations, particularly emphasizing the impact of capital spending. The next part provides a brief description of the data to be used and some stylized facts. This is followed by development of the DSGE model with the micro foundations for the different sectors of the economy and their respective closing equations. The last part sets out the results of the Bayesian estimation and the main conclusions, highlighting the differences there may be between existing literature on the topic and the main findings of the study for the Bolivian case.

II. LITERATURE REVIEW

There is a permanent discussion in economic theory about the impact of public expenditure, particularly in terms of public investment, on the level of economic activity and employment. There are two main positions or currents about this matter. The first one, from a classical perspective, assumes that public expenditure represents a displacement of private expenditure, which is known as the crowding-out effect; moreover, by its very nature, public spending is seen as inefficient, and so the impact of an excessive public investment expenditure is somehow counterproductive, since this investment could be financed through greater taxes to the private sector.

The other position, which is the one considered in this study, shows that from the Keynesian perspective one of the fundamental roles of the State is to boost economic activity through public spending, primarily through capital expenditure to finance economic and social infrastructure, provided the markets are competitive.

Although there is limited literature on the topic, we can mention the work of Aschauer (1989), which makes a clear distinction between the effects of current expenditure and capital expenditure; the author says that the capital expenditure for infrastructure has direct and indirect positive effects on investment and production of the private sector and also has a favorable impact on the growth of productivity.

On the other hand, Baxter and King (1993) show that the macroeconomic effects of fiscal spending depend largely on the effect on productivity of the private sector, they find that public investment may have a significant and positive impact on private investment. Likewise, in line with Aschauer *óp. cit.*, they find that the decline observed in productivity of the private sector in the period covered by their study may be associated to the reduction of public investment.

Furthermore, Blanchard and Perotti (2002) use a Vector Autoregression (VAR) model to quantify the response of output and consumption to shocks on the different components of fiscal expenditure, showing a positive relationship between the variables. Nonetheless, the reaction of private investment is of the opposite sign, which may be associated to the characteristics and nature of public investment.

Rozas (2004) shows, from an economic point of view, that the investments made in capital, and more specifically in infrastructure, contribute to growth in four manners: (1) generation of Gross Domestic Product (GDP), (2) greater positive externalities on investment and the productive apparatus through their impact on the cost structure, (3) impact on the productivity of other factors and the possibility of accessing better services associated to use of the infrastructure, and (4) attracting private investment as a result of the companies' gains in terms of competitiveness.

Within this context, Rioja (2003) estimates a DSGE model which, based on the parameterization for three Latin American countries -Brazil, Mexico and Peru-, finds that infrastructure can have positive effects on output, private investment and well-being, in accordance with the Keynesian theory and the comments made in the foregoing paragraph.

Recently, there has been a revival of this literature, particularly in developed countries and primarily in the United States, as a consequence of the financial crisis in 2007-2009 and the implemented recovery plans that are mainly based on fiscal policy responses. Feldstein (2009) says that even though in the past there was a general consensus among economists that fiscal policy was not helpful as a countercyclical tool, today the governments, both in Washington and the rest of the world, are developing massive fiscal stimuli through a greater public investment.

With respect to the Bolivian economy, Diaz (2011) finds that private investment seems to respond positively to public investment, especially when it targets construction and capital goods, in which complementarity and substitution, respectively, were accomplished.

Likewise, Machicado, Estrada and Flores (2012) point out that current fiscal expenditure in the Bolivian economy is unable to generate output growth rates; on the contrary, efficient fiscal capital expenditure (public investment) and increases in the productivity of the economic sectors do give rise to positive impacts. The study is conducted through a Dynamic Stochastic General Equilibrium model with price flexibility.

Finally, Montero (2012) uses disaggregated panel data on departmental public investment for years 1989-2008 and finds that Bolivia's real per capita Departmental Gross Domestic Product has a negative relationship with public investment of the social and productive sectors. Nonetheless, the results show that the investment in infrastructure and education has a positive impact on real per capita GDP.

III. DESCRIPTION OF DATA AND STYLIZED FACTS

The estimation of the DSGE model in this document is based on quarterly data for the period between the first quarter of 2006 and the last quarter of 2016.

The total expenditure of the Non-Financial Public Sector (NFPS) is divided into: i) capital expenditure, and ii) current expenditure.

Capital expenditure refers to fixed capital acquisition for:

- Construction and upgrades of roads, bridges and public improvement projects such as irrigation systems, paving or asphaltting of roads.
- Purchase of fixed assets, which comprises resources for the acquisition of buildings, land, productive real estate, machinery and production equipment, transportation and traction equipment, among others.
- Social investment, which is the expenses associated to the health, education, social, citizen security and basic sanitation sectors.

Current expenditure is broken down as follows:

- i. Personnel expenditure, i.e. public sector wages and salaries, severance pay, retirement pensions and pensions for distinguished citizens¹.

¹ See *Dossier Fiscal* 2012.

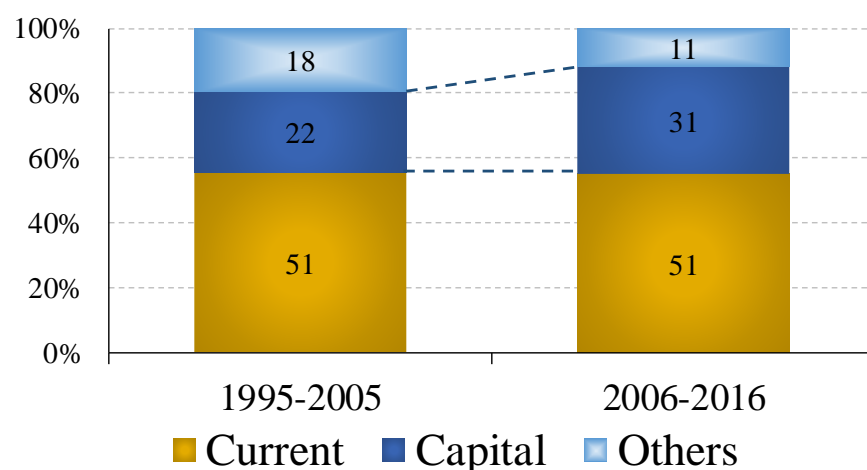
ii. Expenditure on Goods and Services considered operational expenses of the General Government (Central and Subnational Administrations) and State-Owned Enterprises.

iii. Expenses related to Transfers, including transfers to the private sector and different population sectors, in the form of conditioned transfers² (Juancito Pinto and Juana Azurduy), and non-conditioned transfers (Dignidad retirement pension).

In addition, there are another two accounts, called iv) other expenses, and v) expenses related to payment of the total debt or the debt service (both the domestic and external debt).

Looking at the composition of public expenditure, comparing the average of 1995 to 2005 with that of 2006 to 2016, it is clear that the capital expenditure share has increased in the period in which the MESCP was implemented. It is important to highlight that the expenditure on personnel, goods and services (current) has remained practically constant in the two periods (Graph 1).

Graph 1: Average share of the public expenditure components of Non-Financial Public Sector, by period
(In percentage)



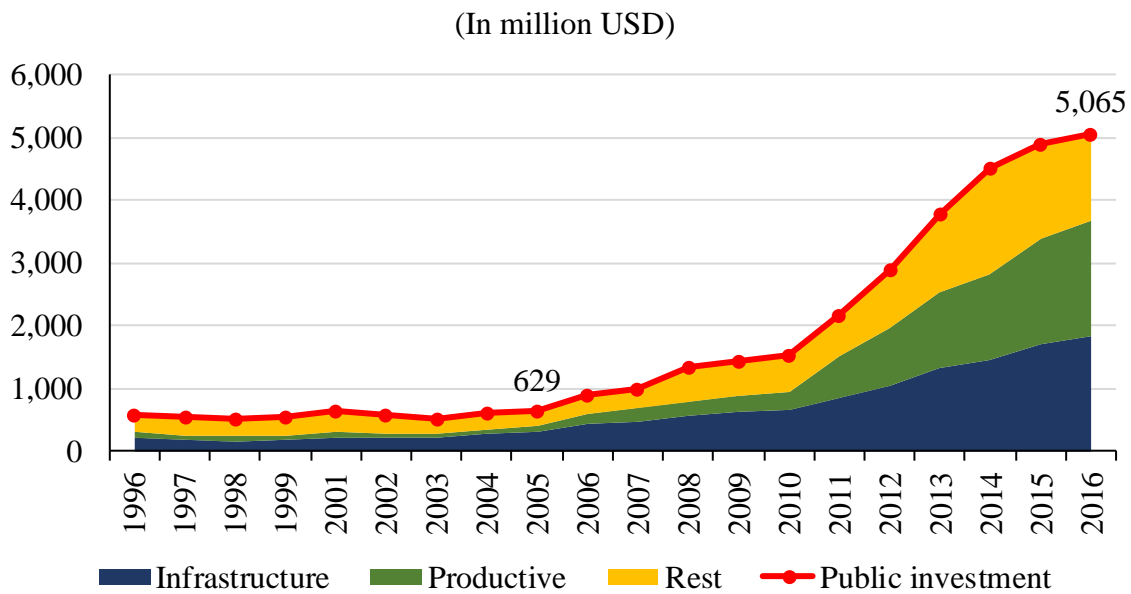
Source: Ministry of Economy and Public Finance.

Furthermore, it should be emphasized that as a result of application of the MESCP, public investment –primarily the capital expenditure component- increased from hardly USD 629 million in 2005 to USD 5.065 billion in 2016, i.e. eight times more (Graph 2). This investment centered on infrastructure projects, especially until 2013, after which productive investment in the hydrocarbons and energy sectors increased with the aim of industrializing and diversifying the economy³.

Graph 2: Evolution of public investment

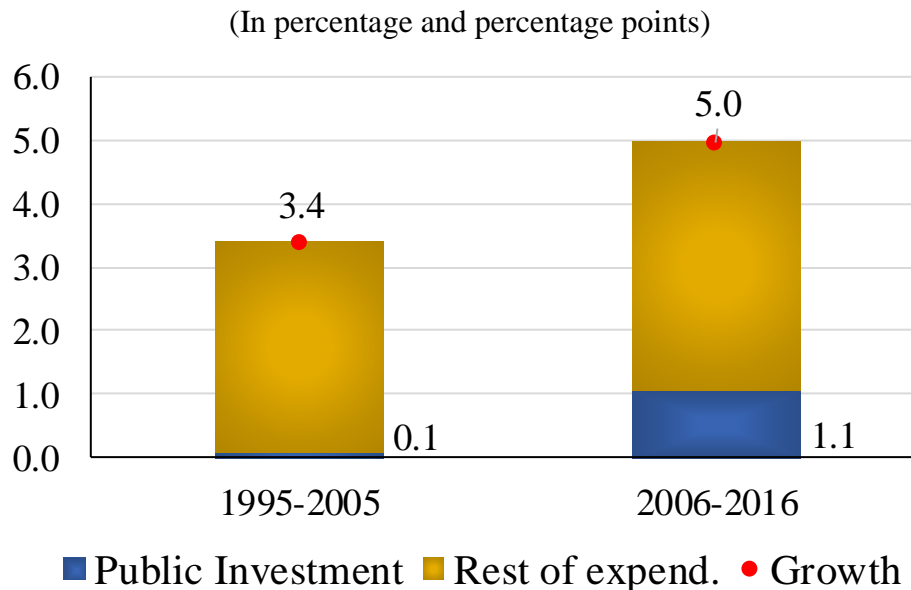
² The conditioned transfers through the Juana Azurduy social program are granted on condition that the mothers receive prenatal and postnatal care, aimed at reducing maternal and infant mortality; the Juancito Pinto social program is a payment made to children who go to state schools or private non-profit confessionnal schools and who are about to complete the school year, with the aim of reducing the school dropout rates.

³ See *Memoria de la Economía Boliviana* of years 2013 and 2016 for more details about this point.



Source: Vice Ministry of Public Investment and External Financing.

Graph 3: Impact of Gross Fixed Capital Formation of the public sector on economic growth in real terms



Source: National Statistics Institute.

This substantial increase in public investment was translated into the ensuing increase of the incidence of gross fixed capital formation of the public sector on GDP growth, which went up from an impact of 0.1 percentage point (pp) on average growth in the years between 1995 and 2005 (3.4%) to 1.1 pp in 2006-2016, when growth averaged 5% (Graph 3). In this sense, it is important to highlight that the impact increased by more than 10 times in the aforementioned period.

IV. MODEL

Modeling in this investigation is of Keynesian type, incorporating micro foundations in behavior of the economic agents (households and companies), whereby the results are in line with neo-Keynesian theory.

The proposed model seeks to analyze the impact of the different components of Non-Financial Public Sector expenditure, particularly emphasizing capital expenditure. A Dynamic Stochastic General Equilibrium model (DSGE) is used with price rigidities as in Galí (2008), making estimations of the parameters on the basis of Bayesian methods in order to obtain a greater robustness. The effects on certain variables of the model will be explained and described in the section on results and the explanation of the estimated parameters in the section on the estimation methodology. Below is a detailed overview of the different sectors of the DSGE:

1. Households

A Constant Relative Risk Aversion (CRRA) function is assumed, where C_t = consumption, h_t = labor supply, and $m_t = (M_t / p_t)$ represents the real balances. Therefore, the functional form of the utility to be maximized $u(C_t, h_t, m_t)$ is:

$$\text{Max}_{\{C_t, h_t, B_{t+1}, m_t\}} E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{\phi_t^c C_t^{1-\vartheta} - 1}{1-\vartheta} - \frac{\phi_t^w h_t^{1+\nu} - 1}{1+\nu} + \theta^m \ln(m_t) \right] \quad (1)$$

subject to:

$$p_t C_t + \frac{B_{t+1}^h}{R_t} + I_t^{priv} + m_t = Z_t K_t^{priv} + W_t h_t \phi_t^w + B_t^h + g_t^{Tr} + I_{t-1}^{pub} + m_{t-1} \quad (2)$$

where the households are the owners of private capital K_t^{priv} which generates an income Z_t ; in addition, they receive a wage⁵ W_t paid by the companies and, finally, they receive resources from loans B_{t+1}^h at an interest rate R_t . And the families also benefit from the expense in transfers g_t^{Tr} and from public investment I_{t-1}^{pub} .

Since the households are the owners of capital, they themselves generate private investment I_t^{priv} , which is part of total investment I_t^T .

⁵ In addition, within the budget restriction there is a shock of preferences in the labor supply $\phi_t^w \phi_t^w$, to avoid the problem of stochastic singularity.

2. Companies

The model has two types of representative companies: i) the production companies, and, ii) the intermediary companies. In view of the type of production function, this implies a decreasing demand for every type of intermediary companies, which generates a certain power over the price of the goods. In this sense, the intermediary companies behave under a market of monopolistic competition (the other firms take the price as given). This entails that there is no instantaneous adjustment of the price in each period (price rigidities).

2.1 Production companies

Modeling of the production is expressed through a j -th representative firm under a market of monopolistic competition with a Constant Elasticity of Substitution (CES) production function among the variety of products from different firms. Likewise, the firms use capital and labor as production factors. Hence, the function of benefits to be maximized is as follows:

$$\text{Max}_{\{Y_t(j)\}} p_t Y_t - \int_0^1 p_t(j) Y_t(j) dj \quad (3)$$

subject to:

$$Y_t = \left\{ \int_0^1 [Y_t(j)]^{\frac{\varepsilon-1}{\varepsilon}} dj \right\}^{\frac{\varepsilon}{\varepsilon-1}} \quad (4)$$

where p_t represents the price level (Consumer Price Index, CPI) and Y_t is the production that has a functional form of aggregation of technologies in line with Dixit and Stiglitz (1975).

2.2 Intermediary companies

A j -th intermediary goods production company is assumed with a constant return to scale function in labor $h_t(j)$ and in capital $K_t^{priv}(j)$, which resolves the following problem:

$$\text{Min}_{\{h_t(j), K_t^{priv}(j)\}} W_t h_t(j) + Z_t K_t^{priv}(j) \quad (5)$$

subject to:

$$Y_t(j) \equiv f(A_t, h_t(j), K_t^{priv}(j), K_t^{pub}) \quad (6)$$

Through the first order conditions of this minimization problem, we obtain the factor demands:

$$\frac{Z_t}{W_t} = \frac{\alpha^{priv}}{\alpha^h} \frac{h_t}{K_t^{priv}} \quad (7)$$

Since it is assumed that the prices are not adjusted instantaneously in each period, there is a probability $1 - \theta$ of adjusting in the prices; this means that the representative firm has a

probability θ of market power on market prices in period s , under which these prices would not be modified. Thus, the dynamic problem for the j -th firm will be:

$$MAX_{P_t^*(j)} \sum_{t=0}^{\infty} \theta^s E_t \left\{ \Omega_{t,t+s} \left\{ P_t^*(j) Y_{t+s}(j) - \varphi_{t+i} Y_{t+s}(j) \right\} \right\} \quad (8)$$

subject to:

$$Y_{t+s}(j) = \left[\frac{P_t^*(j)}{P_{t+s}} \right]^{-\varepsilon} Y_{t+s} \quad (9)$$

where $\Omega_{t,t+s} = \beta^s \frac{u'(C_{t+s})}{u'(C_t)} \frac{P_t(j)}{P_{t+s}}$ is the stochastic discount factor.

On the other hand, the aggregation of prices with inertia, has a behavior that is described as follows:

$$\pi_t^{1-\varepsilon} = \theta + (1-\theta) \left[\frac{P_t^*}{P_{t-1}} \right]^{1-\varepsilon} \quad (10)$$

with $\pi_t = P_t / P_{t-1}$ inflation and P_t^* the optimal price reached in t by the firms that reoptimize their price in that period. Thus the log-linear approximation for (10) is:

$$\pi_t = (1-\theta)(P_t^* - P_{t-1}) \quad (11)$$

Resolving the problem of maximization, the following neo-Keynesian hybrid Phillips curve is obtained:

$$P_t(j) = \frac{\mu E_t \sum_{s=0}^{\infty} \left[(\beta\theta)^s cmg_{t+s} \varnothing_t^\pi C_{t+s}^{-\vartheta} Y_{t+s} P_{t+s}^\varepsilon \right]}{E_t \sum_{s=0}^{\infty} \left[(\beta\theta)^s P_{t+s}^{\varepsilon-1} Y_{t+s} C_{t+s}^{-\vartheta} \right]} \quad (12)$$

where $\mu = \varepsilon / \varepsilon - 1$ represents the mark-up and cmg_t the marginal cost obtained from the minimization process of the intermediary firms. This equation expressed in log-linear terms has the following form:

$$\pi_t = \gamma \pi_{t-1} + \beta \pi_{t+1} + \lambda^\pi Y_t + \phi_t^\pi \quad (13)$$

Parameter $\lambda^\pi = (1-\theta)(1-\theta\beta) / \theta$ measures the degree of price rigidity.

2.3 Production function

All firms have a differentiated output. Nonetheless, they have the same technology represented by a Cobb-Douglas production function which includes the capital stock of the public sector (K_t^{pub}) in line with Pedersen and Hove (2013), as well as the private capital stock of the economy and the labor demand $f(A_t, h_t(j), K_t^{priv}(j), K_t^{pub})$:

$$Y_t(j) \equiv f(A_t, h_t(j), K_t^{priv}(j), K_t^{pub}) = A_t (K_t^{priv}(j))^{\alpha^{priv}} h_t^{\alpha^h}(j) (K_t^{pub})^{1-\alpha^{priv}-\alpha^h} \quad (14)$$

Moreover, a closing equation by identity of national accounts was added, supposing a closed economy:

$$Y_t = C_t + I_t^T + G_t^T \quad (15)$$

where I_t^T represents total investment in the economy, which is the sum of private sector investment and public sector investment. On the other hand, G_t^T is total spending of the NFPS.

The total capital stock K_t^T is described by a law of typical capital movement; but at the same time there are two additional capital movement laws, both of the private sector K_t^{priv} , and of the government K_t^{pub} ; the aggregation will be based on two types of investment I_t^{priv} and I_t^{pub} ⁶.

$$K_{t+1}^T = (1 - \delta^T) K_t^T + I_t^T \quad (16)$$

$$K_{t+1}^{pub} = (1 - \delta^{pub}) K_t^{pub} + I_t^{pub} \phi_t^{pub} \quad (17)$$

$$K_{t+1}^{priv} = (1 - \delta^{priv}) K_t^{priv} + I_t^{priv} \phi_t^{priv} \quad (18)$$

For the aggregation of K_t^T and I_t^T the assumption is that the weightings (parameters) in the stock of capital and investment will be the same $\varrho^{Kpub} = \varrho^{Ipub}$ and $\varrho^{Kpriv} = \varrho^{Ipriv}$.

$$K_t^T = \varrho^{Kpub} K_t^{pub} + \varrho^{Kpriv} K_t^{priv} \quad (19)$$

$$I_t^T = \varrho^{Ipub} I_t^{pub} + \varrho^{Ipriv} I_t^{priv} \quad (20)$$

⁶ The assumption of not inserting Tobin's Q from the stock of private capital is based on Tobin and Brainard (1977), who argue that Tobin's Q plays an important role at the time of transition of the monetary policy (through a monetary policy rate) and directly affects the companies' decision to invest.

3. Fiscal sector

A government, represented by an intertemporal restriction complied with in all periods, is considered, where taxes and total debt finance government spending.

$$T_t + B_t^T = G_t^T + B_{t-1}^T R_{t-1} \quad (21)$$

Thus, T_t are the taxes which the government obtains at each instant in time, B_t^T is the government's total debt (broken down in domestic and external debt). On the expenditure side, G_t^T represents the total expenditure of the NFPS. And payment of the debt that was taken out is made: $B_{t-1}^T R_{t-1}$.

The breakdown of G_t^T is associated to the different types of expenditure, which was as follows for the case of Bolivia:

$$G_t^T = \varrho^{g^{SP}} g_t^{SP} + \varrho^{g^{BS}} g_t^{BS} + \varrho^{g^{TR}} g_t^{TR} + \varrho^{g^{OG}} g_t^{OG} + \varrho^{I^{pub}} I_t^{pub} \quad (22)$$

This breakdown shows that G_t^T is explained by g_t^{SP} (personnel expenditure), g_t^{BS} (expenditure on goods and services), g_t^{TR} (expenditure on transfers), g_t^{OG} other expenses, and I_t^{pub} (public investment or capital expenditure). This specification is made in order to describe behavior of the NFPS in Bolivia; every described variable is explained in part III, where the data are described. Parameters $\varrho^{g^{SP}}$, $\varrho^{g^{BS}}$, $\varrho^{g^{TR}}$, $\varrho^{g^{OG}}$ and $\varrho^{I^{pub}}$ are the average weightings within the sample used for the Bayesian estimation.

Additionally, two fiscal rules were inserted:

$$T_t = \rho^{T-Bint} T_{t-1} + \rho^{B^{int}} B_t^{int} + \varepsilon_t^{T-Bint} \quad (23)$$

$$T_t = \rho^{T-Bext} T_{t-1} + \rho^{B^{ext}} B_t^{ext} + \varepsilon_t^{T-Bext} \quad (24)$$

The objective thereof is to measure the reaction of tax collection in relation to domestic debt (B_t^{int}) and external debt (B_t^{ext}) as suggested by Leeper (1991).

4. Monetary policy

Zhang (2009) incorporates the McCallum rule in a DSGE model for China and points to the importance of monetary policy implemented through the quantity of money circulating therein. Valdivia (2016) uses a DSGE to evaluate the coordination of fiscal and monetary policies and incorporates a rule called Henderson-McKibbin-Taylor (HMT), which is based on quantities. Therefore, the rule proposed in this investigation is based on both studies mentioned above:

$$m_t = (m_{t-1})^{\rho^m} \left[\left(\frac{\pi_t}{\pi^*} \right)^{\varphi_m^\pi} \left(\frac{y_t}{y^*} \right)^{\varphi_m^y} \right]^{1-\rho^m} \phi_t^m \quad (25)$$

Taylor (2000) mentions that using the McCallum rule is relevant for small economies. The rule proposed in this study points to the smooth adjustment of the quantity of money used as a monetary policy instrument (hence the insertion of inertia of the quantity of money), which seems to be in accordance with what the Central Bank of Bolivia mentioned and its implementation of the monetary policy.

5. Closing Equations

From the problem of maximizing households, we obtain the Euler equation (26), the equation of the decision between work and leisure (27) and also the micro founded money demand (28). This last equation describes behavior of the real balances in the economy, which is driven by the interest rate due to the Euler equation and because of the income (due to the identity of the national accounts).

$$\beta E_t \left\{ \left(\frac{\phi_t^c c_t}{\phi_{t+1}^c c_{t+1}} \right)^{\theta} (1 + i_t) \frac{P_t}{P_{t+1}} \right\} = 1 \quad (26)$$

$$h_t^v c_t^{\theta} = W_t \phi_t^W \quad (27)$$

$$\theta^m \frac{1}{m_t} = c_t^{\theta} - \beta E_t c_{t+1}^{\theta} \quad (28)$$

The price aggregation is described by:

$$p_t = \left\{ \int_0^1 [p_t(j)]^{1-\varepsilon} dj \right\}^{\frac{1}{1-\varepsilon}} \quad (29)$$

The total debt is explained by the domestic and external debt. The average weightings thereof ϱ^{Bint} and ϱ^{Bext} guarantee the share of both debts in performance of the total debt:

$$B_t^T = \varrho^{Bint} B_t^{int} + \varrho^{Bext} B_t^{ext} \quad (30)$$

Some of the autoregression AR(1) processes that have not been mentioned before, which describe the dynamics of the model and have effects on the behavior of certain aggregate variables, are:

$\phi_t^C = \rho^C \phi_{t-1}^C + \varepsilon_t^C$	Demand shock (preferences in consumption)
$\phi_t^W = \rho^W \phi_{t-1}^W + \varepsilon_t^W$	Demand shock (preferences in labor supply)
$\phi_t^{\pi} = \rho^{\pi} \phi_{t-1}^{\pi} + \varepsilon_t^{\pi}$	Shock in the Phillips curve (cost push inflation)
$\phi_t^R = \rho^R \phi_{t-1}^R + \varepsilon_t^R$	Shock in the monetary policy rule (interest rate)
$\phi_t^{I^{priv}} = \rho^{I^{priv}} \phi_{t-1}^{I^{priv}} + \varepsilon_t^{I^{priv}}$	Shock in private investment
$\phi_t^{I^{pub}} = \rho^{I^{pub}} \phi_{t-1}^{I^{pub}} + \varepsilon_t^{I^{pub}}$	Shock in public investment

$g_t^{SP} = \rho^{g^{SP}} g_t^{SP} + \varepsilon_t^{g^{SP}}$	Shock in government spending on personnel services
$g_t^{BS} = \rho^{g^{BS}} g_t^{BS} + \varepsilon_t^{g^{BS}}$	Shock in government spending on goods and services
$g_t^{TR} = \rho^{g^{TR}} g_t^{TR} + \varepsilon_t^{g^{TR}}$	Shock in government spending on transfers
$g_t^{OG} = \rho^{g^{OG}} g_t^{OG} + \varepsilon_t^{g^{OG}}$	Shock in government spending on other expenditures
$A_t = \rho^A A_{t-1} + \varepsilon_t^A$	Shock in the technological process
$\phi_t^m = \rho^m \phi_{t-1}^m + \varepsilon_t^m$	Shock in the monetary policy rule (quantity of money)

where $\varepsilon_t^{T_Bint}$, $\varepsilon_t^{T_Bext}$, ε_t^C , ε_t^W , ε_t^π , ε_t^R , $\varepsilon_t^{I^{priv}}$, $\varepsilon_t^{I^{pub}}$, $\varepsilon_t^{g^{SP}}$, $\varepsilon_t^{g^{BS}}$, $\varepsilon_t^{g^{TR}}$, $\varepsilon_t^{g^{OG}}$, ε_t^A and ε_t^m are the independent and identically distributed (i.i.d.) stochastic processes with distribution $N(0, \mathcal{G}^2)$.

V. ESTIMATION METHODOLOGY

The parameters of the model were estimated with a Bayesian econometric methodology in order to measure the effects of the shocks presented above in the observed variables. The Bayesian approach contributes much more information to the decision under uncertainty, unlike classical (frequentist) econometrics. This approach considers different types of information –often subjective- which may be available about the parameters to be estimated before taking into account the data. The Bayesian estimation in the DSGE models can be seen as a bridge between calibration and Maximum Likelihood (ML) estimation, as detailed by Escudé (2010).

The estimated model was adapted by using Fernández-Villaverde y Rubio-Ramírez (2004), and Smets and Wouters (2007) as a reference. The estimation is based on a likelihood function generated by the solution of the log-linearized version of the model. Prior distributions of the parameters of interest are used to provide additional information in the estimation. The whole of linearized equations form a system of linear equations of rational expectations, which can be written as follows:

$$\Gamma_0(\mathcal{G})z_t = \Gamma_1(\mathcal{G})z_{t-1} + \Gamma_2(\mathcal{G})\varepsilon_t + \Gamma_3(\mathcal{G})\Theta_t \quad (31)$$

where z_t is a vector containing the variables of the model expressed as logarithmic deviations from their stationary states, ε_t is a vector containing white noise of the exogenous shocks of the model and Θ_t is a vector containing the rational expectations of the prediction errors. Matrices Γ are non-linear functions of the structural parameters contained in vector \mathcal{G} . Vector z_t contains the endogenous variables of the model and the exogenous shocks: $\varepsilon_t^{T_Bint}$, $\varepsilon_t^{T_Bext}$, ε_t^C , ε_t^W , ε_t^π , ε_t^R , $\varepsilon_t^{I^{priv}}$, $\varepsilon_t^{I^{pub}}$, $\varepsilon_t^{g^{SP}}$, $\varepsilon_t^{g^{BS}}$, $\varepsilon_t^{g^{TR}}$, $\varepsilon_t^{g^{OG}}$ and ε_t^A .

The solution to this system can be expressed as follows:

$$z_t = \Omega_z(\mathcal{G})z_{t-1} + \Omega_\varepsilon(\mathcal{G})\varepsilon_t + \Gamma_3(\mathcal{G})\Theta_t \quad (32)$$

where Ω_z and Ω_ε are functions of the structural parameters. Moreover, y_t is a vector of the observed variables, which is related to the variables in the model, through a measurement equation:

$$y_t = Hz_t \quad (33)$$

Denoting H as a matrix that selects elements of z_t and y_t , and that comprises the following observed variables (the sample comprises 2006 Q1 – 2016 Q4):

$$y_t = \left[Y_t, C_t, I_t^T, G_t^T, K_t^T, K_t^{pub}, K_t^{priv}, I_t^{pub}, I_t^{priv}, B_t^T, B_t^{int}, B_t^{ext}, g_t^{SP}, g_t^{BS}, g_t^{TR}, g_t^{OG}, T_t, \pi_t \right] \quad (34)$$

These equations correspond to the state-space form that represents y_t . Assuming that white noise ε_t is distributed normally and using the Kalman filter, it is possible to calculate the conditional likelihood function for the structural parameters. Be $p(\mathcal{G})$ the prior density function of the structural parameters and $L(\mathcal{G} / Y^T)$ the likelihood function that describes the density of the observed data given $Y^T = \{y_1, y_T\}$, which contains the observed variables. The posterior density of the parameters is calculated by using Bayes' theorem:

$$p(\mathcal{G} / Y^T) = \frac{p(Y^T / \mathcal{G})p(\mathcal{G})}{p(Y^T)} \quad (35)$$

Given that the conditional likelihood function does not have analytical expressions, it was approximated by using numerical methods based on the Metropolis-Hastings algorithm.

5.1 Priors and Results

The values of the priors (Table 1) are in line with existing literature and incorporate possible ranges in function of the nature and behavior of the variables (Smets and Wouters, 2007; Laxton and Pesenti, 2003). One of the properties of the Bayesian method is that it gives voice to the data, providing information about the adjustment of the parameters to the economic reality. The values of the parameters used in the DSGE models in the different countries are included in literature with typical ranges. For this paper, in addition we have taken the criteria established for a small and open economy as in the case of García (2012). Finally, the respective results of the estimations of the posteriors are presented.

Table 1: Prior and Posterior Distribution

Parameter	Distribution	Prior	Post
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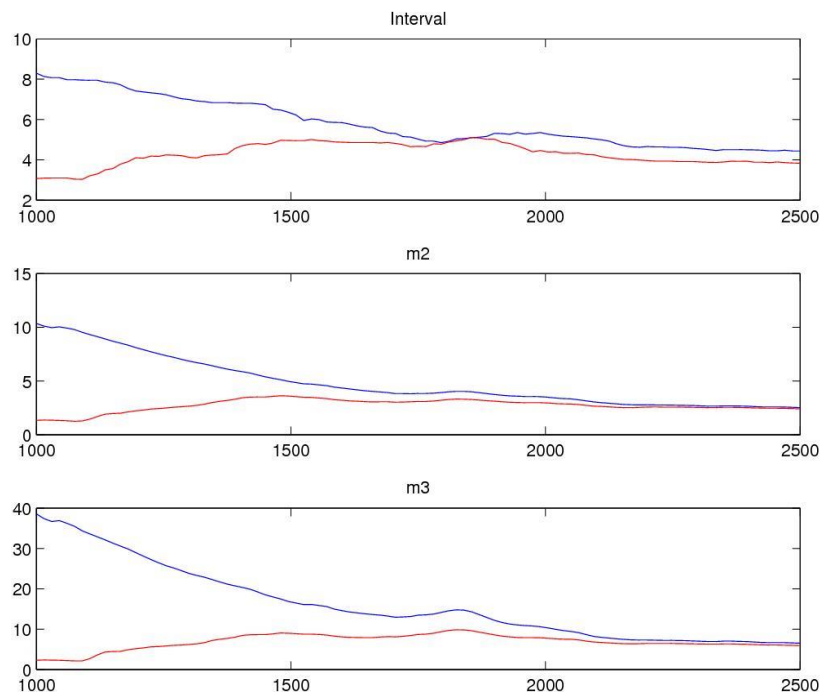
		Mean	Standard Deviation	Mean
\mathcal{G}	Normal	1.50	0.0006	1.5162
β	Beta	0.99	0.0013	0.9879
α	Beta	0.30	0.0006	0.3032
α^{pub}	Beta	0.60	0.0028	0.6057
θ	Normal	0.40	0.0008	0.4127
γ	Normal	0.40	0.0007	0.3978
ρ^R	Beta	0.75	0.0019	0.7670
φ^y	Normal	0.12	0.0008	0.1341
φ^π	Normal	1.50	0.0005	1.4779
ρ^A	Beta	0.50	0.0006	0.4927
ρ^{T_Bint}	Beta	0.50	0.0014	0.4827
ρ^{T_Bext}	Beta	0.50	0.0014	0.5068
ρ^{Bint}	Beta	0.50	0.0012	0.4926
ρ^{Bext}	Beta	0.50	0.0004	0.4986
$\rho^{g^{SP}}$	Beta	0.50	0.0004	0.4830
$\rho^{g^{BS}}$	Beta	0.50	0.0023	0.4540
$\rho^{g^{TR}}$	Beta	0.50	0.0073	0.3862
$\rho^{g^{OR}}$	Beta	0.50	0.0326	0.1757
ρ^R	Beta	0.50	0.0015	0.5363
$\rho^{I^{priv}}$	Beta	0.50	0.0006	0.4952
$\rho^{I^{pub}}$	Beta	0.50	0.0007	0.5089
ρ^π	Beta	0.50	0.0004	0.5225
ρ^W	Beta	0.50	0.0008	0.5070
ρ^C	Beta	0.50	0.0008	0.5031
σ_t^A	Inv. Gamma	2	0.0010	2.5970
$\sigma_t^{g^{SP}}$	Inv. Gamma	2	0.0024	7.7160
$\sigma_t^{g^{BS}}$	Inv. Gamma	2	0.0036	11.857
$\sigma_t^{g^{TR}}$	Inv. Gamma	2	0.0112	2.2639
σ_t^R	Inv. Gamma	2	0.0007	2.7270

$\sigma_t^{I^{priv}}$	Inv. Gamma	2	0.0007	1.8150
$\sigma_t^{I^{pub}}$	Inv. Gamma	2	0.0005	1.1120
σ_t^{π}	Inv. Gamma	2	0.0011	1.2500
σ_t^W	Inv. Gamma	2	0.0007	2.2610
σ_t^C	Inv. Gamma	2	0.0012	2.0000

Elaboration: Own

On the other hand, the convergence of the Monte Carlo Markov Chain (MCMC) is satisfactory, which implies that the multivariate analysis of the parameters of the model converges towards its stationary state given the different iterations of the Metropolis Hastings (MH) algorithm requested (2500 draws)⁷. There are three measures: “interval” represents a confidence interval of 80% around the average, “m2” measures the variance and “m3” the third moment. The blue and red lines converge satisfactorily. (Graph 4).

Graph 4: Convergence of the Markov Chain Monte Carlo



The equations of the used model were worked on in their log-linear expressions, which are expressed in deviations around the stationary state. This implies that it is related to the above-described parameters⁸.

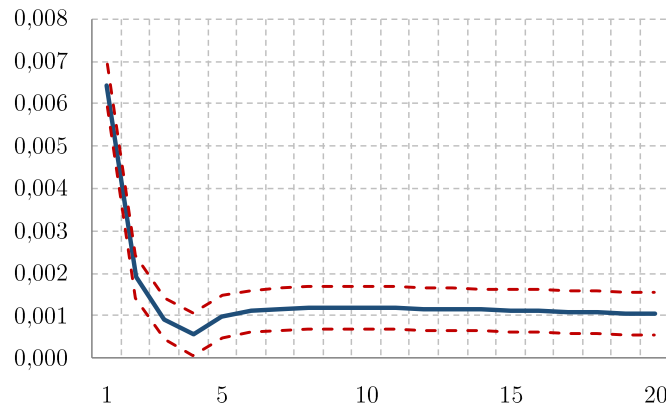
⁷ The blue lines represent measures of the vectors of parameters within (among) the requested chains.

⁸ In case of requiring the equations of the stationary state or the variance decompositions of the results, the reader can request them by email to the author or the editors of the CIEB.

VI. RESULTS

Based on the proposed model, the results corresponding to positive shocks in the capital expenditure of the NFPS show that:

Graph 5: Impulse response function of GDP to capital expenditure



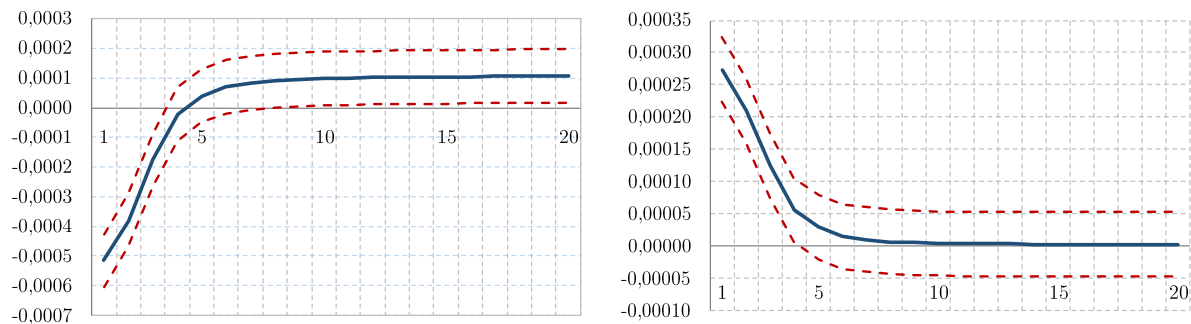
Output increases are observed (typical effect described in the IS – LM model) and in accordance with existing literature, from 0.007% in the short term, there is a gradual dilution in the long term to 0.001%, due to effects of financing of the investment expenditure through taxes. This result seems to confirm that the greater capital expenditure is translated into a higher economic growth, which is in line with the postulates of the MESCP (Graph 5).

On the other hand, as a result of the shock in capital expenditure, there is a crowding-out reaction in the short-term consumption due to an increase of the interest rate (because of the inverse relationship in the Euler equation); however, after 5 periods there is a sustained increase in consumption above its stationary state, which reinforces the impact on long-term growth of the domestic demand. This aspect is interesting in terms of what the MESCP and its pillars are, since this result reveals a new channel of transmission of public investment to growth (Graph 6).

Graph 6: Impulse response function of private consumption and the interest rate to capital expenditure

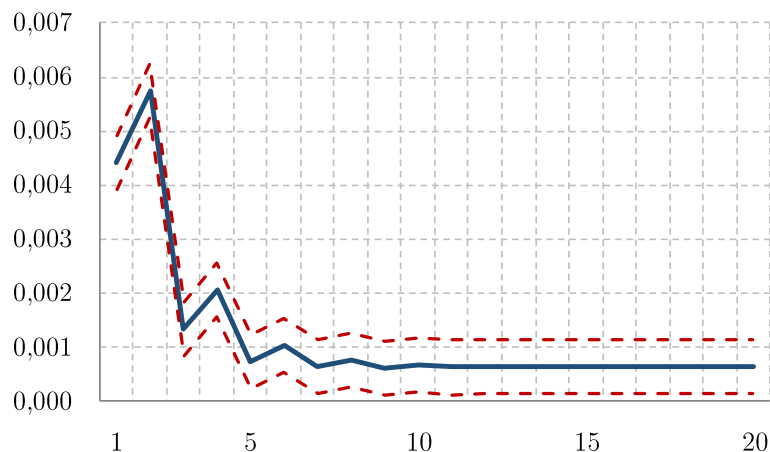
CONSUMPTION

INTEREST RATE



Additionally, with regard to the behavior of private investment, in the short term there are increases above 0.004% associated to the emphasis of public investment on infrastructure projects, which have favorable repercussions in private enterprises. The effect on private investment starts to be diluted and becomes almost neutral as from the 5th quarter. This result is different from other studies, as observed in the review of existing literature; in essence, this phenomenon can be explained by the combination of policies developed within the framework of the MESCP. In this sense, the most important finding is that in Bolivia public investment gives rise to a positive impulse effect (crowding-in) on private investment (Graph 7).

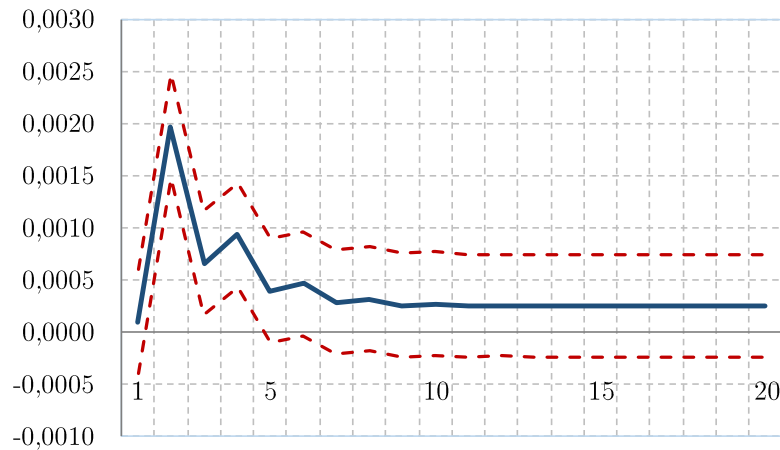
Graph 7: Impulse response function of private investment to capital expenditure



It is important to highlight that, according to the estimations, the increase of capital expenditure was essentially financed by greater tax revenues, which explains why Bolivia has one of the lowest levels of indebtedness in the region (Graph 8).

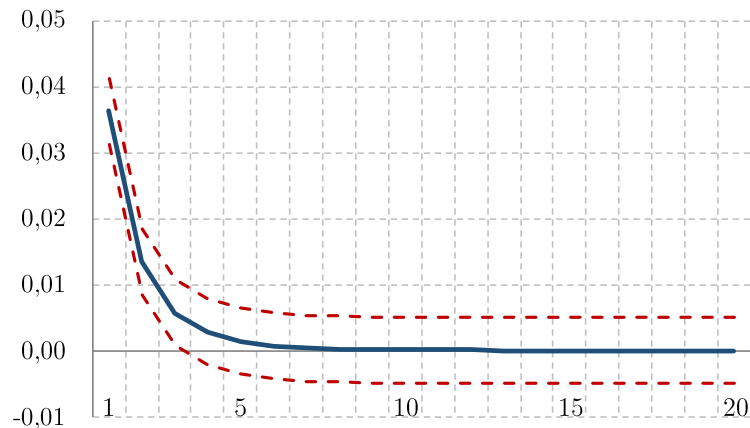
Finally, there is a slight response in inflation, associated to the higher level of economic activity induced by the greater investment and consumption; but this is very small and so public investment does not tend to overheat the economy (see Annex 1).

Graph 8: Impulse response function of tax revenues to capital expenditure

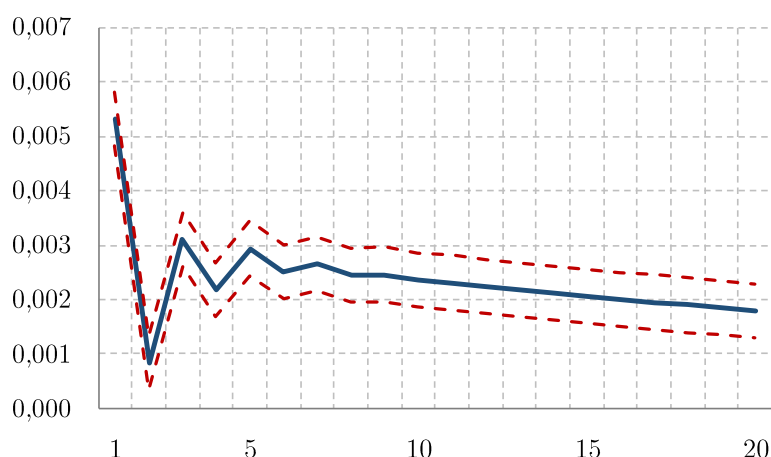


On the other hand, complementing the above-mentioned results, we have observed that a shock in current expenditure has a high short-term effect on output, which tends to disappear in the medium term, since the impulse is essentially translated into a greater consumption associated to a higher personnel expenditure, i.e. primarily higher salaries for the public sector. It is important to underscore the short-term nature of this type of response (Graphs 9 and 10).

Graph 9: Impulse response function of GDP to current expenditure



Graph 10: Impulse response function of consumption to current expenditure



VII. CONCLUSIONS

This study used a DSGE model with Bayesian estimation techniques to study the effects of NFPS spending in the economy, especially with regard to capital expenditure (public investment).

As described in the data, in the period in which the MESCP was applied (2006 -), the share of capital expenditure in relation to total expenditure increased considerably, pushing economic growth by means of a greater fixed gross capital formation of the public sector.

The different studies conducted with regard to the evaluation of fiscal expenditure and its components show that capital spending has a positive impact on economic growth (Blanchard and Perotti, 2012). On the other hand, prior research conducted for the Bolivian economy (Valdivia, 2008) shows positive effects on output and a slight effect in terms of inflationary pressure.

The main results of the model estimated in this paper show that the greater capital spending, through a greater public investment, had a positive and persistent effect on GDP growth and, unlike existing literature, because of the characteristics of the MESCP, this also favored private investment, in view of the nature of public investment which gives rise to positive externalities that may be taken on by the private sector. Furthermore, since public investment is labor-intensive, a favorable shock thereof triggers a lasting impulse in terms of consumption, underpinning a sustained long-term growth.

Additional estimations show that a shock of current expenditure produces a short-term impulse on economic growth and consumption.

This paper did not incorporate financial frictions as in the case of Bernanke, Gertler and Gilchrist (1998) or any other type of frictions, which is open to further deepening and development in future research.

BIBLIOGRAPHIC REFERENCES

- Aschauer, D. (1989). Public Investment and productivity Growth in the group of seven. *Economic Perspectives*, Federal Reserve Bank of Chicago, 13.
- Baxter, M. & King, R. (1993). Fiscal Policy in General Equilibrium. *The American Economic Review*, Vol. 83, No. 3.
- Bernanke, B., Gertler, M. & Gilchrist, S. (1998) "Financial accelerator in a quantitative business cycle framework", NBER, Working Paper No. 6455
- Blanchard, O. & Perotti, R. (2002). An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output. *Quarterly Journal of Economics* 117(4): 1329-68.
- Diaz, O. (2011). ¿Influye la cartera de créditos en la dinámica de la inversión? Central Bank of Bolivia. Working Paper No. 01/2011.
- Ministry of Economy and Public Finance Fiscal, (2012). Dossier Fiscal 2012.
- Ministry of Economy and Public Finance Fiscal, (2013). Memoria de la Economía Boliviana 2013.
- Ministry of Economy and Public Finance Fiscal, (2016). Memoria de la Economía Boliviana 2016.
- Dixit, A. & Stiglitz, J. (1975). Monopolistic Competition and Optimum Product Diversity. The Warwick Economics Research Paper Series, University of Warwick, Department of Economics.
- Escudé, G. (2010), Modelos de Equilibrio General Dinámico y Estocástico - Introducción. *Investigaciones Económicas*, Central Bank of the Republic of Argentina, No. 59, September 2010.
- Feldstein, M. (2009). Rethinking the Role of Fiscal Policy. National Bureau of Economic Research (NBER), Chicago Press.
- Fernández-Villaverde, J. & Rubio-Ramirez, J. (2004). Comparing dynamic equilibrium models to data: a Bayesian approach. *Journal of Econometrics*, 123, issue 1, 153-187.
- García, C. (2012). Why Does Monetary Policy Respond to the Real Exchange Rate in Small Open Economies? A Bayesian Perspective. ILADES-Georgetown University Working Papers, Ilades-Georgetown University, Universidad Alberto Hurtado/School of Economics and Business.
- Galí, J. (2008). *Monetary Policy, Inflation, and the Business Cycle*. Cambridge, USA:MIT Press.
- Laxton, D. & Pesenti, P. (2003). Monetary rules for small, open, emerging economies. *Journal of Monetary Economics*, 50, issue 5.
- Leeper, E. (1991). Equilibria under 'active' and 'passive' monetary and fiscal policies. *Journal of Monetary Economics* 27 (1991), 129-147.
- Montero, C. (2012)"Inversión pública en Bolivia y su incidencia en el crecimiento económico: un análisis desde la perspectiva espacial", American University of Beirut.
- Machicado, G., Estrada P. & Flores, X. (2012). Is Fiscal Policy Alone Enough for Growth? A Simulation Analysis for Bolivia. INESAD.
- Pedersen, J. & Hove Ravn, S. (2013). "What Drives the Business Cycle in a Small Open Economy? Evidence from an estimated DSGE Model of the Danish Economy", Economic Policy Research Unit (EPRU), University of Copenhagen, 05-02.

Rioja, F. (2001). Growth, Welfare, and Public Infrastructure: A General Equilibrium Analysis of Latin American Economies. *Journal of Economic Development*, Volume 26, Number 2, December 2001.

Rozas, P. & Sánchez, R. (2004). Desarrollo de infraestructura y crecimiento económico: Revisión conceptual. ECLAC, Series 75.

Smets, F. & Wouters, R. (2007), Shocks and frictions in US business cycles: a Bayesian DSGE approach, No. 722, Working Paper Series, European Central Bank.

Taylor, J. (2000). Using monetary policy in emerging market economies. Stanford University, Unpublished.

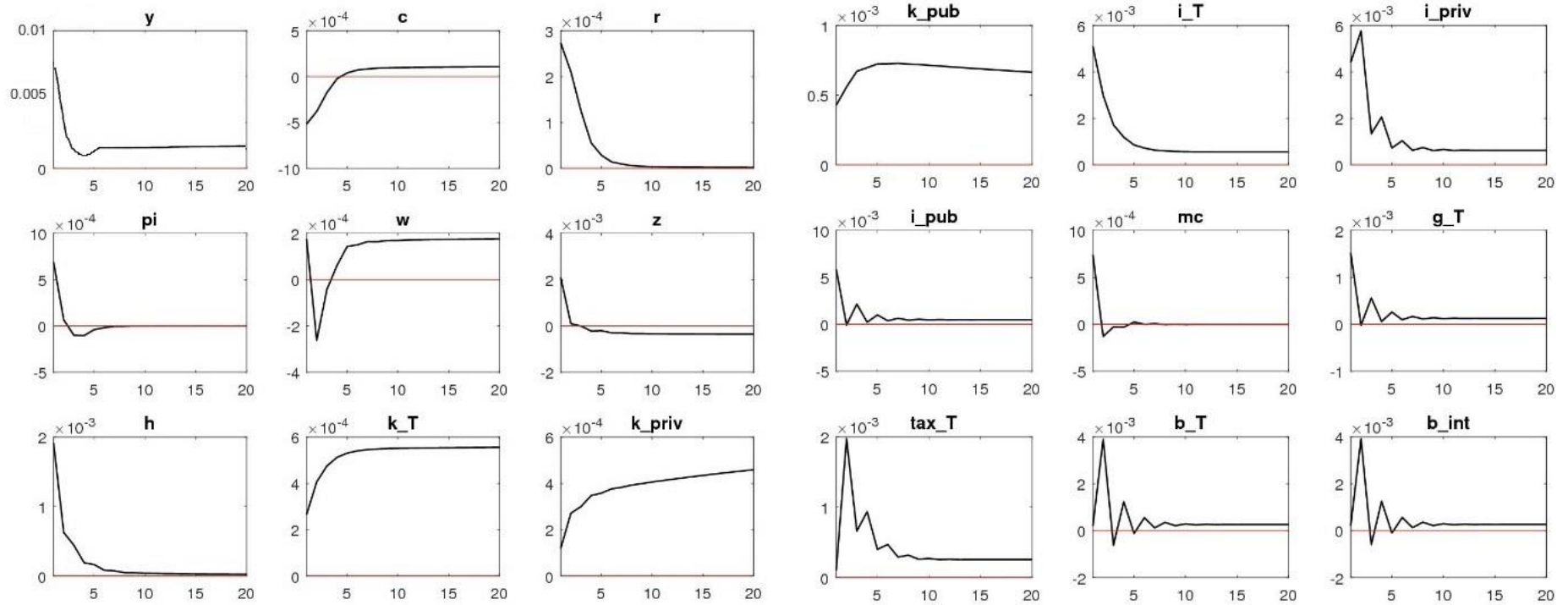
Tobin, J. & Brainard, W. (1977). Asset Markets and the Cost of Capital. *Economic Progress, Private Values and Public Policy: Essays in Honour of William Fellner*. 235-62.

Valdivia, D. (2008). ¿Es importante la fijación de precios para entender la dinámica de la inflación en Bolivia?. INESAD, WP No. 02/2008.

Valdivia, J. (2016). Evaluación de la Política Fiscal de Bolivia, Noveno encuentro de economistas de Bolivia.

Zhang, W. (2009). China's monetary policy: Quantity versus price rules. *Journal of Macroeconomics* - ELSEVIER.

ANNEX 1
IMPULSE RESPONSE FUNCTIONS IN CASE OF SHOCKS IN PUBLIC INVESTMENT



ANNEX 2

IMPULSE RESPONSE FUNCTIONS IN CASE OF SHOCKS IN CURRENT EXPENDITURE

