“The golden rule of public finance under active monetary stance: endogenous setting for a developing economy”

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THE GOLDEN RULE OF PUBLIC FINANCE UNDER ACTIVE MONETARY STANCE: ENDOGENOUS SETTING FOR A DEVELOPING ECONOMY

Abstract

The paper aims to verify the introduction of the golden rule of public finance under an active monetary stance for a developing economy using a dynamic stochastic general equilibrium model. Besides the two rigidities, namely the deep habit formation and Calvo-style price stickiness, the model structure incorporates real money holdings and welfare-enhancing government purchases in the utility-generating function and a modified Taylor rule. The simulation results have validated the visible crowding-out of private consumption and investment in the short run and a positive impact of the productive government spending on long-run growth, but with some important caveats. In the case of a developing economy that usually has low efficiency and high returns to public capital, the given factors prove significant in addressing the study issue. The results are robust in terms of the structure of utility-generating function, a relatively high share of liquidity-constrained households, and a degree of price stickiness. Moreover, to offset the debt accumulation as a result of increased public investment financing by persistent output growth, in the long run, the central bank should not only rely on response to the fluctuation of inflation and output but also account for a move of public debt.

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INTRODUCTION

The increased number of crises since the end of the 20th century has been a trigger for a new discussion dedicated to effective growth policy. Given the government's role in addressing the negative consequences of the crises that caused an increased debt burden, fiscal policy has occupied a central place in the discussion. In this context, the fiscal regime, as a core element of the policy framework, ranks first in the debates with a ruling spot of the golden rule of public finance (GRPF). The rule deals with a public investment that is one of the driving forces of growth. The GRPF regime prohibits from using budget receipts for public investment financing but allows for borrowing instead. The addressed prohibition is significant because the share of capital expenditures is much smaller than the share of current ones. Thus, it is possible to reduce the debt burden by taking advantage of high returns to productive public capital. In this context, the present paper attempts to verify the GRPF regime's introduction in the framework of active rather than passive monetary policy. Implementing active monetary policy is crucial because of the rising public debt as a response to the

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fiscal expansion that is a core impediment in supporting sustainable long-run growth. The ruling mission of monetary policy under given terms is to decelerate the speed of public debt accumulation up to the elimination of the excessive borrowing overhand.

1. LITERATURE REVIEW

The driving forces of public investment are twofold: a fiscal multiplier in the short run, a demand-side effect, and a supply-side effect through crowding-in of private investment in the long run. The public debt to GDP ratio is usually shrinking on behalf of higher output elasticity to budget revenues and more effective public investment. This efficiency in the way of translating into productive infrastructure is lower in less developed than developed economies. The rational motives are the competitiveness of project selection, a shortage of sound fiscal and legislative institution environments, and a clear identification of infrastructure needs (Dabla-Norris, Brumby, Kyobe, Mills, & Papageorgiou, 2011). If a pressing need for additional infrastructure is adequately diversified, the public investment can be more efficient in the short run due to an augmented demand-side effect mentioned above. The Government authority can make the right choice in case of small competitive projects with less bureaucracy, tight cash flow, and diminishing returns to additional capital (Warner, 2014). As confirmed by empirical results, the value of productive public spending is usually associated with the capital expenditures that, as opposed to developed countries, dominate in less-developed ones by its share in the total budget expenditures and by the impact factor (Laboure & Taugourdeau, 2018).

The successful implementation of the GRPF regime is non-common. There were episodes of the developed countries England and Germany that could not keep on the rule for a considerable period because of unpredictable impediments. Apart from a certain high level of productivity, public investment is difficult to distinguish correctly from other productive expenditures. The issue of public capital depreciation and its sources of financing should be clarified, as well as other minor inconsistencies of budget assets administration. Given cyclically-adjusted net-of-public-investment deficit, the endogenously limited accumulation of public investment restrains growth. The short-run crowding-out of private consumption and investment is also a compelling drawback that is difficult to remove or mitigate without losses in the long run (Truger, 2015). There is a case for the relatively low capital-to-GDP ratio in developing economies where the debt financing of increased public investment can be beneficial in supporting long-run growth. The last statement is significant, given a relatively small fiscal space, significant growth potential, and limited investment capabilities of a developing economy (Mintz & Smart, 2006).

Public investment has much in common with a well-known concept of productive government spending. The concept has occupied a regular place among the up-front issues of the policy debate dedicated to the most effective driving forces of growth. Successfully developed by Barro (1990) in the framework of endogenous growth theory, the concept of productive government spending has been an essential component of the world economy's policy agenda. Unlike unproductive government expenditures, the productive ones have a significant impact on growth and account for a relatively small share of the total public spending. The advanced interpretation of productive government spending was addressed by Agénor and Yilmaz (2011). The scientists analyzed not only major component infrastructure but also health and maintenance as productive ones of the current budget expenditures. The research results, among other things, have proved that the growth rate at a steady-state is higher if health, the most productive component, uses in combination with permission to pay interest by new debt accumulation. Moreover, it is a distinct crowding-out of private investment in the short run, which mitigates and eliminates in the long run.

The positive impact of productive government spending on growth depends on many factors. One of those factors is sources of financing associated with budgetary regimes and the GRPF rule in particular. Concerning the given rule, the closing inference about its performance is rather vague. Greiner and Semmler (2000) examined public

capital as a growth factor under several budgetary regimes related to the GRPF regime introduction. The general conclusion of the study has not denied a positive impact of public investment on growth. The result was productive if the chosen fiscal regime was less strict. The lower rate of long-run growth in the face of a stricter GRPF regime (debt interest financed by tax revenue) was due to the impact of the so-called internal crowding-out effect. The increasing interest payment accounted for this effect that is in line with augmented productive spending.

The value of the GRPF regime was verified by Ghosh and Nolan (2007) in the case of excessive government consumption. The positive effect of the given regime was revealed by rising private consumption and lower tax rate, which brought to higher growth and greater welfare level in the long run. As opposed to the mentioned results, the positive effect of the GRPF regime introduction was not confirmed in the long run but was present in the short run, according to the research of Minea and Villieu (2009). By applying cash-in-advance (CIA) constraint, the authors have shown that the positive outcome of additional public capital mobilization is overlapped by the future raise of taxes to cover increased debt maturity. Subject to chosen condition, the expected budget deficit is a matter of tax financing in the long run, as well as a lower level of growth. Other results obtained by Groneck (2011) have confirmed the positive impact of public investments on growth under the GRPF regime that allows for servicing debt obligations by adjusting public consumption. The work emphasized that the magnitude of the positive welfare effect depends on the amount of public consumption that has to equal or surpass a social optimum.

The debt threshold and the rate of its maturity are also crucial points of the GRPF study. Kellermann (2007) has correctly pointed out that the GRPF regime's introduction does not guarantee a long-run growth if the social rate of time preferences is lower than the rate of debt maturity. Yakita (2008) has shown that the debt threshold is crucial in keeping on the ratios of the public capital and debt to GDP. The author has demonstrated in a series of simulation results that, if surpassing the threshold, the economy no more returns to a baseline scenario, and the budget deficit restriction violates.

It is worth noting that only a minor number of papers dedicated to the GRPF study pays due attention to the stance of monetary policy, whose impact may be of great importance considering the interplay between fiscal and monetary policy. The high performance of active monetary stance compared to passive accommodation in reaction to fiscal expansion is proved by Gali, Lopez-Salido, and Valles (2007) and Malik (2013). The recent study of Zeyneloglu (2018) has had an essential contribution to the GRPF topic by integrating active monetary policy as well. The work has confirmed that the GRPF rule may be one of the significant terms to obtain a positive impact on output due to public spending shock in the case of a developed economy.

Aims

Given a shortage of proper attention that the academic community pays to monetary policy stance in the GRPF study, the goal of the present paper is to explore the endogenous growth of a developing economy under a combination of the GRPF regime and active monetary policy. To pursue the goal, a well-defined dynamic stochastic general equilibrium (DSGE) model is built to simulate a response to positive fiscal expansion shock. The research has validated the presence of notable crowding-out of private consumption and investment in the short-run and the positive impact of productive government spending on long-run growth. The study results are robust in terms of sufficiently high efficiency and productivity of public investment and the strictness of Taylor rule responsiveness to public debt move.

The paper has the following structure. After the introduction, the model building is demonstrated in detail, and then the calibration data and simulation results with concluding remarks are laid out.

2. METHODOLOGY

The submitted small-scale model reproduces a closed developing economy in the endogenous setting. An endogenous setting is developed under the interplay of the GRPF regime and active monetary policy. Generally speaking, the model is a stylized New Keynesian DSGE framework that incorporates welfare-enhancing government

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purchases, deep habit formation, and real money holdings in the utility-generating function, as well as a modified Taylor rule. Besides a lagged interest rate, inflation, and output, the given rule also includes a response to the public debt-to-output ratio. There are two rigidities in the model: real rigidity is the deep habit formation, and nominal rigidity is Calvo-style price stickiness. The model structure comprises three economic agents: households, firms, and government. Fiscal and monetary authorities are components of government agents that follow a specific administration regime that combines GRPF rule and active monetary stance. Price stickiness is incorporated in a world of monopolistically competitive firms, which violates the principle of neutrality of money balances.

2.1. Households

The economy is populated by a continuum of identical infinitely-lived households on the interval [0,1]. The households maximize their expected lifetime utility, which is a combination of logarithmic function and a constant relative risk aversion (CRRA) aggregation additively separable in consumption, real money balances, M_t/P_t, and labor supply, L_t. In each period, the representative household is endowed with one unit of time that is divided between labor and leisure, that is why the labor supply is negatively introduced into the utility function. The consumption has an aggregate effective form and consists of private consumption in the current period, C^P_t, the same variable, but in the lagged period, C^P_{t-1}, which is an element of habit formation, and the so-called "utility-generating" or "welfare-enhancing" government purchases, C^G_t. This portion of purchases granting by the government takes its origin from the assumption that public consumption in such a way can move the private agents' marginal utility of consumption. The degree of external habit formation, h, and the elasticity of substitution between the private and government consumption, ϕ, are indexed by [0,1]. Hence, the representative household maximizes the expected discounted value of the lifetime utility function:

$$U_0 = E_0 \sum_{t=0}^{\infty} \beta^t \left[\log(C_t^P - hC_{t-1}^P + \varphi C_t^G) + \right.$$
$$\left. + \chi_M \log \frac{M_t}{P_t} - \chi_L \frac{L_t^{1+\phi}}{1+\phi} \right], \quad (1)$$

where $\beta \in [0,1]$ is the parameter corresponds to subjective discount factor, $\varphi > 0$ is the inverse of the Frisch elasticity of labor supply, and χ_M and χ_L are positive numbers fixing the steady-state utility of real money balances and labor supply, respectively.

Suggested by Ravn, Schmitt-Grohe, and Uribe (2006), "Joneses good-by-good" or "deep habits" description of preferences becomes vastly applied in the modern DSGE literature, and the alternative known as consumption with deep habits formation is one that uses in the model. The detailed comparative analysis of the different consumption specifications that include habit formation is presented by Havranek et al. (2017). Given the impact of public investment on growth, Leeper, Walker, and Yang (2010) successfully employed the specification of deep habit formation in the utility-generating function to examine the implementation delays and distorted fiscal adjustments in the short and long run.

The introduction of government spending in the utility-generating function with a substitution effect in a simple form is applied, for example, by Christiano and Eichenbaum (1992). The more combined form of the government spending aggregation in the structure of utility function, namely CES specification with deep habit formation, was explored by Ercolani and Azevedo (2018). The case is taken that the government purchases crowding out private consumption by choosing $\phi \in [0,1]$. As government consumption substitutes for a private one, the marginal utility of consumption is shifting. Incorporating welfare-enhancing government purchases inseparably in the structure of utility function, as well as a component of aggregate effective consumption and deep habit formation, intend to adopt some empirical evidence verified in the above works for developed economies. As will show the simulation results, these settings contribute to mitigating a crowding-out effect in the short-run and strengthening growth in the long run.

All households divided into two fractions, intertemporal or Ricardian and "rule-of-thumb" or non-Ricardian. The first fraction (1–η) behaves as forward-looking optimizers that, by having access to financial markets, accumulate and rent out capital to firms and holds government bonds. The second fraction (η) is myopically acting customers that consume all of their current labor income without making any

far-seeing economic decisions. Apart from this, the labor market is competitive, wages are equal across all households, and both types of households work the same number of hours.

Ricardian households consume private goods, C^P_t, gain welfare from keeping real money-holdings in the current and previous periods, $(M_t\text{-}M_{t-1})/P_t$, access financial market by holding riskless government bonds in real terms (denominated in a composite consumption good) each period under no-Ponzy-game condition, B_t/P_t, plus obtaining benefit in the form of past-term real interest, i_{t-1}, charge real interest, r_t, on past-period capital accumulation, K^P_{t-1}, invest in production of goods, I^P_t, and pay lump-sum taxes (in a consumption good equivalent), T_t. The households' budget is equal in each period, and in real terms corresponds to the constraint:

$$C_t^P + I_t^P + \frac{M_t}{P_t} + \frac{B_t}{P_t} = \frac{W_t}{P_t} L_t + r_t K_{t-1}^P + \\ + \frac{M_{t-1}}{P_t} + (1 + i_{t-1}) \frac{B_{t-1}}{P_t} - T_t. \quad (2)$$

The infinite-horizon Ricardian households are endowed with capital, K^P_t, used for the production of goods, and, considering the depreciation rate $\delta \in [0,1]$, the law of motion for private capital follows the rule:

$$K_t^P = (1-\delta) K_{t-1}^P + I_t^P, \quad (3)$$

The intertemporal consumer maximizes (1) by choosing the sequence

$$\left\{ C_t^P, \frac{M_t}{P_t}, L_t, \frac{B_t}{P_t}, K_t^P \right\}_{t=0}^{\infty}$$

subject to (2) and (3). The gross rate of inflation corresponds to the ratio $\pi_t = P_t / P_{t-1}$. Applying with a little algebra the first-order-condition (FOC) and eliminating the multiplier, one obtains:

The Euler equation:

$$\left(C_t^P - hC_{t-1}^P + \phi C_t^G \right)^{-1} = \\ = E_t \beta h \left(C_{t+1}^P - hC_t^P + \phi C_{t+1}^G \right)^{-1} + \\ + \left(\frac{i_t + 1}{i_t} \right) \frac{\chi_M P_t}{M_t}. \quad (4)$$

The labor supply equation:

$$\chi_L L_t^{\phi} = \left(\frac{i_t + 1}{i_t} \right) \frac{\chi_M W_t}{M_t}. \quad (5)$$

The ratio between the benefits of investment and capital accumulation:

$$\frac{i_t + 1}{\pi_{t+1}} = r_{t+1} + 1 - \delta. \quad (6)$$

Being liquidity-constrained, the non-Ricardian households consume all the disposable income each period. So, their budget constraint is:

$$C_t^P = \frac{W_t}{P_t} L_t. \quad (7)$$

The "rule-of-thumb" consumers maximize (1) by choosing the sequence $\left\{ C_t^P, L_t \right\}_{t=0}^{\infty}$ subject to (7). By employing the FOC and dropping the multiplier, have:

$$C_t^P + \varphi C_t^G = \frac{W_t}{\chi_L L_t^{\phi} P_t}. \quad (8)$$

Concluding the optimization process and taking a closer look at equation (4), it can be constituted that the marginal utility of private consumption equals the marginal utility of real money balances. That contradicts a conception of the Keynesian theory that is a positive correlation between money demand and gross income. According to a widespread view, real money balances are specific welfare that provides a saving on transaction costs by increasing time for leisure and reducing time for goods purchase. In developing this view, the author follows Ganelli (2003) and assumes that households can partially substitute the total efficient consumption to real money balances if the marginal utility of private consumption diminishes. That is why under the given utility function setup, the relationship between aggregate effective consumption and money demand is positive. There is also a positive correlation between money demand and public spending if considering welfare-enhancing government purchases. As a result of fiscal expansion, the change in the steady-state utility of real money balances positively correlates with output growth. That confirms an assumption about the motivation of households who shift their benefits for real money balances if the marginal utility of private consumption diminishes.

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2.2. Firms

There are two kinds of firms that do their operations on wholesale and retail markets. The final goods producers, which are entirely identical, sell their products in the retail market that is a perfectly competitive one. The retailer buys a large variety of wholesale goods, $Y_t(j)$, for $j \in [0,1]$, and transforms them, according to a Dixit-Stiglitz aggregator, with the elasticity of substitution between wholesale goods, $\omega > 1$, into a bundle of goods, Y_t as follows:

$$Y_t = \left(\int_0^1 Y_t(j)^{\frac{\omega-1}{\omega}} dj \right)^{\frac{\omega}{\omega-1}}. \quad (9)$$

Optimizing the profit maximization, the demand function of the intermediate goods is:

$$Y_t(j) = \left(\frac{P_t}{P_t(j)} \right)^{\omega} Y_t. \quad (10)$$

Merging (9) and (10) gives the expression of final goods price:

$$P_t = \left(\int_0^1 P_t(j)^{(1-\omega)} dj \right)^{\frac{1}{1-\omega}}. \quad (11)$$

The intermediate goods sector consists of a large number of monopolistically competitive firms that produce differentiable goods. The wholesale firms decide the price and the number of factor endowments using the Cobb-Douglas production function. The function exhibits constant returns to scale to the private production inputs of private capital, K^P_{t-1}, and labor force, L_t, which is a prerequisite in the structure of the endogenous growth setting. By additionally incorporating the aggregate public capital, K^G_{t-1}, the production function displays increasing returns to scale (Glomm & Ravikumar, 1997; Leeper et al., 2010). Concerning all components, the elasticity of output are positive numbers, and, for maintaining a balanced growth path, it is assumed that $\alpha + \alpha^G < 1$ (Turnovsky, 2004). So, the production function has the following specification:

$$Y_t = K^{P\ \alpha}_{t-1} L_t^{1-\alpha} K^{G\ \alpha^G}_{t-1}. \quad (12)$$

Considering prices for factor endowments, the retailer fixes the capital and labor volume to minimize the total production cost, which brings the following capital/labor trade-off:

$$\left(\frac{1-\alpha}{\alpha} \right) \frac{r_t K^P_{t-1}}{L_t} = \frac{W_t}{P_t}. \quad (13)$$

Allowing for the symmetry in the technology of firms, all agents are identical, so the j subscript is eliminated. Expressing the total cost by rearranging equation (13) in terms of the factor endowments of the production function and taking derivative to output yields the description of marginal consumption:

$$MC_t = \frac{1}{K^{G\ \alpha^G}_{t-1}} \left(\frac{W_t / P_t}{1-\alpha} \right)^{1-\alpha} \left(\frac{r_t}{\alpha} \right)^{\alpha}. \quad (14)$$

The wholesale firms have a market power of price setters according to the Calvo rule. In each period t, a randomly selected fraction of firms $(1-\vartheta)$ adjusts its prices for obtaining the highest discounted value of current and future profits. The rest firms of fraction ϑ follow a stickiness rule by keeping the prices of the previous period. Applying FOC to get the highest market value of goods at adjusted prices compared to the total cost and considering the demand function (10) gives the optimal price level for the $(1-\vartheta)$ firms:

$$P_t^{\circ} = \left(\frac{\omega}{\omega - 1} \right) E_t \sum_{n=0}^{\infty} (\beta\vartheta)^n MC_{t+n}. \quad (15)$$

Combining the optimal price index with one that is in line with stickiness rule yields the aggregate price level:

$$P_t = \left[\vartheta P_{t-1}^{1-\omega} + (1-\vartheta) P_t^{\circ 1-\omega} \right]^{\frac{1}{1-\omega}}. \quad (16)$$

2.3. Fiscal authority

The government finances public investment, I^G_t, public consumption, C^G_t, and the repayment of interest along with the principal of the public debt. The sources of financing are lump-sum taxes, T_t, one-period real bonds, B_t/P_t, and seigniorage, which is the revenue of money creation ex-

pressed by the difference of real money balances of the current and previous periods. In reality, the Government issues bonds of different maturities. For ease of math, it is assumed that all bonds are issued to mature at the end of the period. Taking the above interpretation, the fiscal authority budget constraint compiled in real terms is as follows:

$$\frac{B_t - B_{t-1}}{P_t} + \frac{M_t - M_{t-1}}{P_t} + T_t = \\ = I_t^G + C_t^G + i_{t-1}\frac{B_{t-1}}{P_t}. \quad (17)$$

Following Shen et al. (2018), the author assumes that investment efficiency is not perfect, which is actual for a developing economy. In connection with this, the one currency unit of investment expenditure can deliver less than one currency unit of public capital. Considering the marginal efficiency applied to the public investment expenditure, $0 < \varepsilon < 1$, the law of motion for public capital is:

$$K_t^G = (1-\delta)K_{t-1}^G + \varepsilon I_t^G. \quad (18)$$

By general assumption, public spending is divided into public consumption and public investment. Accepting the suggested by Groneck (2011) and Zeyneloglu (2018) terms, the public spending distributes as follows:

$$I_t^G = k\upsilon G_t, \quad (19)$$

$$C_t^G = (1-k\upsilon)G_t, \quad (20)$$

where υ is the steady-state ratio of public investment to the entire public spending, and $k > 1$ is the measure of augmenting the share of public investment in the allocation of entire public spending. The latter is a prerequisite for implementing the GRPF regime in the model specification. Thus, the share of public investment can surpass the steady-state level, assuming public debt as the source of financing and seigniorage.

Tax revenues are apportioned between public investment, public consumption, and repayment of the interest of the public debt. According to Zeyneloglu (2018) and following the GRPF regime, financing public investment is allowed at the expense of the budget revenue, but only to a minor extent, which corresponds to the parameter $0 < \sigma < 1$. Thus, the distribution of tax revenues meets the specification:

$$T_t = \sigma I_t^G + C_t^G + i_{t-1}\frac{B_{t-1}}{P_t}. \quad (21)$$

2.4. Monetary authority

The current endogenous installation introduces nominal rigidity and money. With this in mind, the monetary authority becomes one of the decision-making agents. While the fiscal policy associates with the GRPF regime, the monetary policy follows a modified Taylor rule. The alternative to Taylor rule specification suggested by Zeyneloglu (2018) is applied that, apart from the response to the inflation and output deviations from the steady-state, also accounts for the public debt-to-output ratio motion examined by Kumhof, Nunes, and Yakadina (2010):

$$i_t^N = \bar{i}^N + \rho_i\left(i_{t-1}^N - \bar{i}^N\right) + \\ + \rho_\pi\left(\pi_{t-1} - \bar{\pi}\right) + \rho_Y\left(Y_{t-1} - \bar{Y}\right) + \\ + \rho_B\left(\frac{B_{t-1} - \bar{B}}{\bar{Y}}\right), \quad (22)$$

where i^N_t is nominal interest rate, ρ_i, ρ_π, ρ_Y, and ρ_B are positive parameters, that measure a degree of reaction to deviations from the steady state of nominal interest rate, inflation, output, and the public debt-to-GDP ratio, respectively (apart from the others, which are in the range of (0,1), the parameter $\rho_\pi > 1$ to satisfy Taylor principle and be consistent with an active monetary policy).

In addition to smoothing parameter ρ_i, the effective interest rate policy ensures that the dynamics of key macroeconomic variables, such as aggregate price level, output, and public debt, are among the priorities of the central bank activity. Allowing for public debt dynamic is a necessary component of the interest rate adjustment tool since the GRPF regime has much to do with an increased debt burden, which should be taken into account in the implementation of monetary policy. Thus, the cooperation between fiscal and monetary authorities in the case of the combination of the GRPF regime and Taylor rule comes to the fore in the presented model structure.

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2.5. Equilibrium and aggregation

In equilibrium, the goods market-clearing condition is:

$$Y_t = C_t^P + I_t^P + C_t^G + I_t^G. \quad (23)$$

The model includes a violation related to the shock of public spending. The violation reproduces a typical AR(1) process including the degree of autoregression persistence, $\kappa < 1$, and a stochastic component $\nu_t \sim N\left(0, \sigma_G^2\right)$:

$$\log G_t = \kappa \log G_{t-1} + \nu_t. \quad (24)$$

Taking into account the presence of the intertemporal and rule-of-thumb households, the aggregate private consumption and labor supply interpolated as:

$$C_t^P = \left(1-\eta\right) C_t^R + \eta C_t^{NR}. \quad (25)$$

$$L_t = \left(1-\eta\right) L_t^R + \eta L_t^{NR}. \quad (26)$$

Given the choice variables $\left\{C_t^P, K_t^P, I_t^P, L_t, Y_t\right\}$, policy instruments $\left\{I_t^G, C_t^G, T_t, B_t, M_t, i_t\right\}$, and the sequence of prices $\left\{P_t, W_t, r_t\right\}$, the equilibrium conforms the system of equations:

- the Ricardian households' budget constraint (2) and optimality conditions (4)-(6);
- the non-Ricardian households' budget constraint (7) and optimality condition (8);
- the firms' optimality conditions (13) and (14), and the production function (12);
- the optimal (15) and general (16) price levels;
- the law of motion for private (3) and public capital (18);
- the fiscal authority's budget constraint (17), policy decisions (19)-(21), and shock description (24);
- the monetary authority's policy rule (22);
- the aggregates of private consumption (25) and labor supply (26);
- the benchmark equilibrium values.

2.6. Calibration

The development of DSGE endogenous model aims to generate the impulse responses of the key macro variables to the public spending positive shock and establish the most crucial parameters which address the GRPF regime's performance in cooperation with active monetary policy. There is no analytical solution if taking the system of the above 21 equations, so the numerical method is used. The method comprises the calibration of benchmark equilibrium values with a subsequent log-linearization procedure around the zero-inflation steady-state. To perform the following simulation procedure, the Octave software together with Dynare add-on is used.

The unit of time observation is a quarter. The discount factor is set to $\beta = 0.9314$, implying the annualized real interest rate of around 8%. In the premium works concerning DSGE modeling for developing economies, the given real interest rate is in the range of 6%-10%, and the median value is chosen. The inverse of the Frisch elasticity of labor supply φ is equal 2, which is in the array of values used in calibration for the majority of economies from developed to less developed ones. The degree of private consumer's habit formation, *h*, varies considerably from 0.1 to 0.9 and depends on the micro/macro foundation of the estimation procedure, the frequency of the data, the precautionary saving motive, the country region, and the openness of an economy (Havranek, Rusnak, & Sokolova, 2017). The given parameter is set to 0.7, which corresponds to the value adopted by Ercolani and Azevedo (2018). The paper, along with other things, examined an aggregate effective form of consumption, formally CES specification, which adopted in a simpler specification in the present work.

The analytical research (Kwan, 2006) contributed to the estimation of the elasticity of substitution between private and government consumption, which has marked the value from negative –1.76 to positive 1.66. The other paper tested the given parameter for 24 African countries and concluded that the estimated pooled (average) value was 0.586 (Dawood & Francois, 2018). In the case of 15 EU member countries, the average intertemporal elasticity of substitution proved to be around 0.4

(Auteri & Costantini, 2010). Assuming a moderate disposition concerning a developing economy, the degree of elasticity substitution between private and government consumption is fixed at 0.3.

The steady-state disutility of labor supply is set to $\chi_L = 0.3$, which does not vary substantially in the DSGE structure and is consistent with steady-state labor hours (about 8 hours spent at work per day). Davig and Leeper (2011) suggested the steady-state utility of real money balances for the USA economy to be 0.4, which corresponds to the inverse of the average monetary base velocity. The calibrated value has to be adjusted as a developed economy differs from a less developed one. Since the monetary base velocity is an indicator that changes considerably and depends on many factors, the same parameter value $\chi_M = 0.4$ is accepted.

There are a few parameters reproduced as they were in the paper of Malik (2013). The linear term in the utilization cost function is set to $\delta = 0.025$ per quarter, which implies a steady-state annualized depreciation rate of 10%. The private capital income share of total output is set to $\alpha = 1/3$. The elasticity of substitution between a variety of goods is set to $\omega = 6$, so a steady-state markup in the goods market is 20 percent. The fraction of firms that keep their prices unchanged, ϑ, is given a baseline value of 0.75, which corresponds to an average price duration of one year.

The output elasticity to productive government spending is one of the crucial parameters of the present work. In the matching study literature that explores mainly advanced economies, the given parameter fluctuates greatly from a relatively large value 0.4 (Pereira & de Frutos, 1999), to even a small negative value (Evans & Karras, 1994). Simultaneously, the productivity of public capital in low-income countries concerning the spending on infrastructure is rated to 0.25 by Shen, Yang, and Zanna (2018). Given that in the case of a developing economy with the possibility of rendering higher productivity of public capital, especially in infrastructure terms, the elasticity of production to productive government expenditures αG is 0.22.

The efficiency of public investment, ε, fixes by following the results obtained by Dabla-Norris et al. (2011). The authors have built the index of public investment efficiency for 71 developing economies that reached on average 0.8. The other study related to the topic took the lower values corresponding to the range of 0.2-0.6 (Shen et al., 2018). It is assumed that the marked parameter is 0.6 providing the upper value in the given range of the verified public investment efficiency.

The share of the rule-of-thumb consumers differs considerably among the DSGE study literature. There is a common practice to set a higher value if a developing economy is a matter of study. In the paper of Shen et al. (2018), the given parameter fixed at 0.75 for low-income countries. In the case of non-EMU Central and Eastern European counties, the percentage of total population unable to face unexpected financial expenses varied from 36 in the Czech Republic to 72.2 in Hungary (Krajewski, 2017). A rather compromise decision is made, and the share of non-Ricardian households is set to $\eta = 0.6$.

The policy block is composed of the fiscal and monetary parameters. The author follows Groneck (2011) and Zeyneloglu (2018) by fixing the share of tax-financed public investment, σ, and the distribution of public spending in favor of investment, k, to 0.1 and 1.3, respectively. The size of the response of the monetary authority to inflation, ρ_π, is set to 1.5, as in Zeyneloglu (2018), a value that satisfies the so-called Taylor principle. The other monetary policy parameters except for the response of interest rate to public debt are also the same as in Zeyneloglu (2018). Thus, the persistence of interest rate, ρ_i, and the response of interest rate to output, ρ_Y, are 0.6 and 0.1, respectively. Given the similar specification of the modified Taylor rule applied for the Pakistan economy by Shahid et al. (2016), the response of interest rate to public debt, ρ_B, is taken in the same range, but a slightly lower value of 0.01.

The initial public debt and public spending to output ratios are evaluated by referring to the International Monetary Fund (IMF) database and the IMF's Fiscal Monitor periodic publication. According to the publication, the general government expenditure and gross debt measured in percent of GDP in the row of 40 low-income developing countries for 2018 are amounted, on average, to 0.19 and 0.45, respectively. Rounding-

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off and slightly adjusting, the marked parameters are fixed at 0.3 and 0.4, respectively. Another publication is considered, "Government at a glance: Latin America and the Caribbean 2017", and the initial public investment is fixed to the entire public spending ratio, which is set to $\upsilon = 0.08$. The initial value of money velocity, *Y/M*, is located at 1/0.3, and the persistency of government spending shock, κ, is set to 0.75.

Table 1. Calibrated parameters

Parameter	Description	Value
β	Discount factor	0.9314
h	Degree of private consumer's habit formation	0.7
ϕ	Elasticity of substitution between private and government consumption	0.3
χ_M	Steady-state utility of real money balances	0.4
χ_L	Steady-state disutility of labor supply	0.3
ϕ	Inverse of the Frisch elasticity of labor supply	2
δ	Depreciation rate	0.025
α	Private capital income share of output	1/3
α^G	Output elasticity to productive government spending	0.22
ε	Efficiency of public investment	0.6
ω	Elasticity of substitution between wholesale goods	6
ϑ	Degree of price stickiness	0.75
η	Share of rule-of-thumb consumers	0.6
σ	Share of tax-financed public investment	0.1
k	Distribution of public spending in favor of investment	1.3
ρ_i	Persistence of interest rate	0.6
$\rho\pi$	Response of interest rate to inflation	1.5
ρ_Y	Response of interest rate to output	0.1
ρ_B	Response of interest rate to public debt	0.01
υ	Initial public investment to the entire public spending ratio	0.08
G/Y	Initial public spending-to-output ratio	0.3
B/Y	Initial public debt-to-output ratio	0.4
Y/M	Initial money velocity	1/0.3
κ	Degree of autoregressive shock	0.75

2.7. Results

The impulse responses of the key macro variables to the public spending positive shock are generated using the elaborated DSGE framework that is calibrated for monitoring a developing economy at a quarterly frequency. The timeline covers 40 quarters corresponding to 10 years. The impulse responses are measured in percent deviations from the steady states. The shock parameter of the rise in public spending, *v*, is 1 percentage point. The simulation results demonstrate that the dynamics of output remains in the positive domain of values keeping the long-run growth around 0.6 percentage point higher than the steady-state (Figure 1). There is evidence of visible crowding-out of private consumption and investment that gradually vanishes at the end of the second year. The presence of the crowding-out effect in the short run is consistent with the results reported in several studies, for example, Gali, Lopez-Salido, and Valles (2007), Malik (2013), and Zeyneloglu (2018). As exhibited in the given works, the results may differ in terms of fiscal policy regime and the sources of budget deficit financing, as well as calibrating the parameters that modulate the welfare effect and a degree of rigidities in the model structure.

The simulation results demonstrate that the given terms related to crowding-out effect are still sound if taking into account a predominate share of "rule-of-thumb" consumers, 0.6 to be exact. The presence of Non-Ricardian households contributes to the crowding-in effect instead. They consume all available income, not having any bias for future decisions. That contradicts the mission of Ricardian consumers who are responsible for the crowding-out effect. Ricardian consumers restrain their consumption needs due to excessive public spending. Their decision is motivated by the following inevitable fiscal restriction that the government is going to implement to compensate the excessive public spending. Pessimistic expectations generate a negative wealth effect that brings to the crowding-out effect in the short-run. As proved by the simulation results, between the two representative agents, the finale score settles by Ricardian households, and the crowding-out remains audible even if allowing for a non-separable aggregate consumption. The given aggregation involves a substitution between private and public consumption in conjunction with a deep habit formation in the utility function specification. It worth emphasizing that the obtained short-run results are different from the long-run ones.

Public spending expansion leads to a reduction in the marginal utility of private consumption through increased tax pressure. Given the structure of the presented model, the fiscal strain is partly dampened because of the public investment

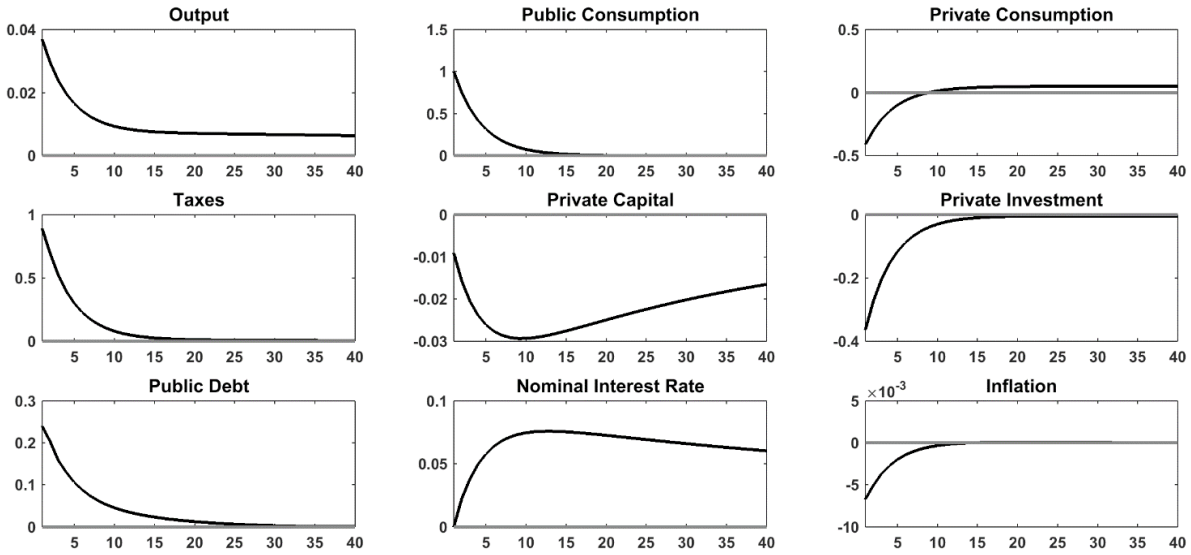

Figure 1. The response of key macro variables to public spending shock

component financed by debt accumulation. The incorporated element of habit formation also contributes to smoothing a downward dynamics of private consumption. Ravn, Schmitt-Grohe, and Uribe (2006) have demonstrated that the deep habit formation is of great value to ensure co-movement between private consumption and aggregate demand in response to public spending shock, which is in line with empirical evidence, in such a case, for the USA economy. The substitution of private consumption for a public one in the aggregate consumption specification induces the households to temporarily shift their priorities in favor of welfare-enhancing government purchases, which additionally reduces the pressure of fiscal shock. The intertemporal decision of Ricardian consumers leads to contracting aggregate demand that motivates firms to be less competitive (Ercolani & Azevedo, 2018). The lower aggregate demand translates into the supply side because of the presence of nominal rigidities. It is worth noting that nominal price rigidity plays a significant role in supporting higher demand over time. Gali, Lopez-Salido, and Valles (2007) have correctly pointed out that the introduction of price rigidity has to be taken into account in interconnection with the presence of rule-of-thumb consumers to raise aggregate consumption in response to positive public spending shock. That is because sticky prices can retain a real wage in case of shrinking the marginal product of labor, which is consistent with empirical evidence. Asimakopoulos, Lorusso, and Pieroni (2016) have also emphasized the vital place of nominal price rigidity but together with productive government expenditures, which are key factors to provide a positive impact of increasing public spending on private consumption.

The simulation results have shown that the indicated crowding-out effect leads to a reduction in private capital, which is quite noticeable for up to two years. The accumulation of private capital has hardly restored half the contraction from the initial position at the end of the observed timeline. On the contrary, given persistent long-run growth, the resulting drift of private consumption goes beyond its steady-state and retains the level by five percentage points higher. The long-run private investment also restores its initial position but without gaining additional score. The similar dynamic of private investment as a response to public spending shock has been outlined by Gali, Lopez-Salido, and Valles (2007), Malik (2013), Zeyneloglu (2018), and Shen et al. (2018). Of four mentioned, the last paper examined low-income countries that are not popular among research dedicated to the given topic. All addressed works pertained to a passive fiscal policy and a more simplified Taylor rule that did not follow a public debt move. It should be noted that a synchronous adaptation of passive fiscal and active monetary policy to the public debt movement is a strict rule for the economy to have an adequate degree of autonomy. Bear in mind the productive public spending incorporated in the production function of wholesale firms,

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the role of government can be more vital in accelerating long-run growth thanks to crowding-in effect. Concerning productive public spending, the efficiency and productivity of public capital are of great importance to a developing economy. That is because such an economy usually has low efficiency but high returns to public capital.

3. DISCUSSION

The crowding out of private consumption and investment as a result of public spending shock in the short-run is due to debt accumulation to finance an increased public investment. That is why the author decides to discuss a special place of public debt, growth of which in the short run must be offset by persistent output growth in the long run. It is significant because the final response of the economy has to be the same or even better than it is under the initial condition to demonstrate the positive impact of the GRPF rule introduction under an active monetary stance.

Public debt growth proves to be more aggressive in the first year, moving up to almost 25 percentage points higher than its steady-state value. Considering persistent long-run growth, the burden of debt mitigates and gradually reaches the initial level. That is a significant result, which is that over time, the crowding-out effect is balancing. The nominal interest rate reaction to the fiscal shock is augmented by the growing demand for financial assets of the public sector. The debt accumulation is one of the primary factors of the accelerated interest rate dynamic that is still visible following two years of volatility and decelerates slightly in the long run up to 6 percentage points higher than its steady-state.

It is challenging to follow an accommodative monetary policy in the case of persistent fiscal expansion without inflation's negative consequences generated by inflation. The aggregate price level has another reason for moving up. That is due to the so-called "intra-temporal substitution effect" that Davig and Leeper (2011) introduced. Driven by the positive shock of government spending, the increased demand for labor raises real wages and encourages households to work harder. In doing so, households consume less for leisure. The increased real wages put pressure on the aggregate price level due to an adequate increase in firms' marginal costs.

It is the so-called "divine coincidence" if output and an aggregate price level go up in one direction in response to positive fiscal shock. An active monetary policy is implemented to restrain the pressure of inflation. Given the modified Taylor rule that the central bank monitors not only inflation and output gap but also keeps an eye on public debt dynamic, the nominal interest rate will be a ruling instrument of price stability. The short-run fiscal demand puts pressure on the aggregate price level forcing the monetary authority to raise the nominal interest rate more than one-for-one, resulting in a rapid reduction of inflation. Davig and Leeper (2011) described the given repercussion by introducing the term of "inter-temporal substitution effect". As the crowding-out effect

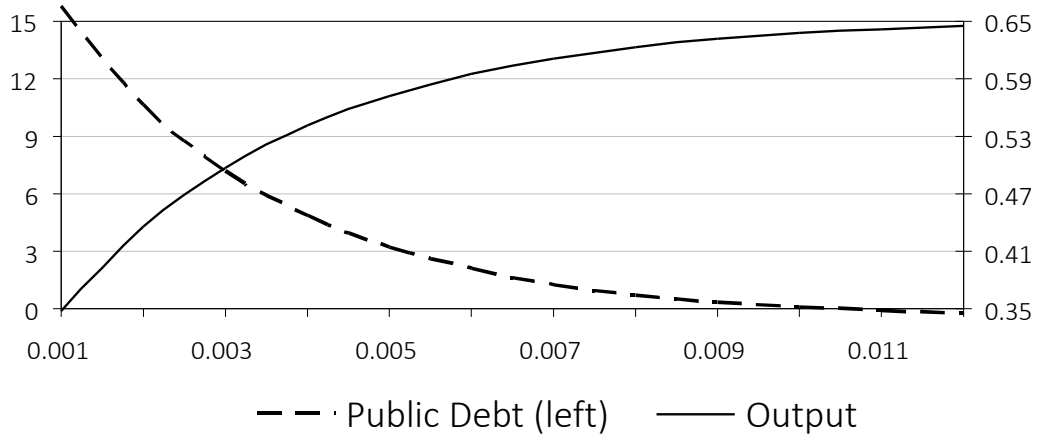

Figure 2. The response of the output and public debt to public spending shock: sensitivity to parameter ρ_B

becomes moderate and the influence of debt burden mitigates, the inflation dynamic restores its zero steady-state. Malik (2013) has come to similar autonomy over inflation, emphasizing, among other things, that seigniorage plays a minor role, as price dynamic remains relatively subdued over the visible timescale. Antunes and Ercolani (2019) have also obtained similar results by simulating public debt growth to finance increased government purchases. Besides, the authors have stressed a negative wealth effect in the short run.

The performed sensitivity analysis has proved that the growth response to the fiscal shock, together with a shift in the response of the interest rate to the public debt-to-output ratio motion, ρ_B, reiterates non-linear dynamics demonstrating a visible overload in the long run. Unlike output, the public debt dynamic is quite the opposite, which does not change since coming down to the steady-state. What is important, the output overload position matches the initial level of public debt, which corresponds to the value of the parameter $\rho_B = 0.01$. Therefore, there is no need for a more severe debt restriction as production moves to the upper limit (Figure 2). Concluding the simulation results, one can constitute that under accepted fiscal-monetary regime, the public spending expansion is a negative step in maintaining short-run growth but has a substantial long-run value.

CONCLUSION

The present work attempted to verify the GRPF regime's introduction under a well-defined fiscal-monetary stance for a developing economy using a proper DSGE framework. Several notable features of the given framework distinguish it from the models used in the papers related to the GRPF study. Besides the two rigidities, namely the deep habit formation and Calvo-style price stickiness, the current DSGE structure includes real money holdings and welfare-enhancing government purchases in the utility-generating function, as well as a modified Taylor rule. The general idea of incorporating the above settings was to adopt consistent empirical evidence that contributes to mitigating a crowding-out effect in the short-run and strengthening growth in the long-run. The mentioned modified Taylor rule, apart from the response to the inflation and output deviations from the steady-state, also accounts for a debt-to-output ratio motion. Incorporating such a parameter to the Taylor rule is significant because the given composition enables to dampen an increasing public debt burden more persistently.

The simulation results obtained as a response to public spending expansion demonstrate that the dynamics of the output remains in a positive domain of long-run growth. There is a visible crowding-out of private consumption and investment in the short run. The indicated crowding-out effect leads to reduced private capital, whose accumulation has hardly restored half the contraction from the initial position at the end of the observed timeline. On the contrary, given persistent long-run growth, the resulting drift of private consumption goes slightly beyond its steady-state. The long-run private investment also restores its initial position but without gaining additional score. The nominal interest rate reaction to the fiscal shock is augmented by the growing demand from the public sector for financial assets. As a response to fiscal expansion, public debt growth proves to be more aggressive in the short run. Given persistent long-run growth, the debt burden mitigates and gradually reaches the initial level. That is a significant result, which is that over time, the crowding-out effect is balancing.

The simulation results are robust in terms of a share of liquidity-constrained households, a relatively high degree of price stickiness, as well as efficiency and productivity of public investment. The last two factors are significant because, in the case of a developing economy, the low efficiency and high returns to public capital distinguish such an economy from others. What is also important, to succeed in the GRPF regime introduction under the active monetary stance, the central bank has to rely not only on response to the inflation and output deviations from the steady-state but also accounts for a move of public debt.

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Further research should also look at the external sector in the context of external sources of budget deficit financing, as well as exchange rate dynamics, given their contribution to growth through fiscal and monetary transmission channels.

AUTHOR CONTRIBUTIONS

Conceptualization: Serhii Shvets.
Data curation: Serhii Shvets.
Formal analysis: Serhii Shvets.
Funding acquisition: Serhii Shvets.
Investigation: Serhii Shvets.
Methodology: Serhii Shvets.
Project administration: Serhii Shvets.
Resources: Serhii Shvets.
Software: Serhii Shvets.
Validation: Serhii Shvets.
Visualization: Serhii Shvets.
Writing – original draft: Serhii Shvets.
Writing – review & editing: Serhii Shvets.

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