Fiscal stabilization in resource-rich developing economies amid a resource revenues downturn: A new-Keynesian analysis

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Abstract

In the present paper we study the stabilizing effect of alternative fiscal policy measures in response to a fall in a developing country's revenues from their natural resources sector. The theoretical framework of a new-Keynesian small open economy is used, and the model is calibrated to the economy of Guinea. We find that a countercyclical public investments policy reduces private consumption further in the short run while the associated increasing level of public capital allows for a higher net increase in future private consumption only from the medium run onwards. The tax relief policy, in addition to requiring less public borrowing than the countercyclical spending policy as well as leading to less inflationary pressures, raises private consumption from baseline, on-impact and in the short run. The commonly recommended use of a sovereign wealth fund does raise private consumption and non-resource output, on impact and durably afterwards, and reduces inflation and public borrowing requirements, but does contract the demand for domestically produced intermediate goods and leads to higher domestic unemployment in the short run.

Keywords: Fiscal stabilization, Small open economy, Natural resources, Business Cycle.
JEL: E12, E32, E62, F41.

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1. Introduction

Natural resource exporting economies tend to share the common trait of having a high export concentration, as opposed to a diversified set of export goods [2], in addition to significantly low shares of non-resource exports in the country's total exports. This makes them highly reliant on resource exports for foreign reserves and for balance of payments equilibrium, and thus vulnerable to international fluctuations in the prices and demand for the commodities that they export. One such country is the west African country of Guinea. Besides exporting many other natural resources such as gold, the country has particularly been one the world's largest producers of bauxite for decades, frequently ranking as the third largest producer of the product after Australia and China like in 2018 and is the largest exporter as of the same year [21]. In addition, the country not only still holds the largest bauxite reserves in the world, it also boasts of the world's highest reserves of unexploited iron ore. On the other hand, however, natural resource exports have recently constituted around 90% of the country's exports [21], completely dominating non-resource exports which remain low and undiversified.

The negative effect that the discovery and exploitation of exhaustible natural resources can have on the very structure of an economy has been the subject of many research work in the natural resource literature. Paul Krugman [23] shows that when treated as international transfers from abroad towards the domestic economy, natural resource revenues, whether short-lasting or long-lasting, do permanently reduce the international market share of the considered economy's exports. The non-resource exports sector is also found to permanently lose productivity relative to the non-export sector when there is an exogenous additional inflow of foreign currency [40]. The latter paper argues that such foreign exchange gifts negatively alter the long-run productivity of the tradeable goods sector relative to the non-tradeable sector through a learning-by-doing mechanism and ultimately leads to a depreciated domestic currency in the long run. Van Wijnbergen [41] had come to a similar conclusion by stating that the so-called Dutch disease does manifest through a relative fall in production in the non-oil traded goods sector in oil exporting countries through a delay of the learning-by-doing experience.

One short-run implication of such a structurally dominant share of natural resource in exports is the vulnerability of these economies to changes, and especially downturns, in resource revenues. Natural resource-exporting countries including Peru, Iran, Ecuador, Libya, and Saudi Arabia experienced a fall of more than 33% in real public expenditures between 1982 and 1988 during busts that followed the preceding spikes in commodity prices, and subsequent falls in said prices undermined the speedy recovery of some of the countries even in the 1990s, including Nigeria and Algeria [24]. While this might be attributed to the higher procyclicality of public spending in resource-rich developing countries [3], it shows the extent to which these countries are vulnerable to variations in the prices of the commodities that they export.

Further, 25 out of 34 resource exporting countries studied were found to have been unable to keep their usual fiscal rules in the years following the 2014 fall in commodity prices [28]. In Guinea, a fall in fiscal revenues from the natural resources sector in 2019 and 2020 forced the government to have to rely on the central bank for urgent funding towards financing the fiscal deficit, and in so doing failed to meet two of the IMF conditionalities during the sixth ECF review in 2020 [20]. Resource revenue downturns are, however, not only a source of difficulties for the government's budget but do also lead to risks of balance of payment disequilibrium by putting a downward pressure on official reserves and an upward pressure on the exchange rate [29].

Research on appropriate fiscal behavior in natural resource exporting countries have mostly focused on the optimal management of windfalls and booms instead of the right fiscal response to downturns. But even for papers studying the management of upswings in resource revenues, one of the commonly recommended policy measures has been the constitution of a buffer or a sovereign wealth fund (SWF) not only as a way for the government to avoid efficiency losses related to too much frontloading of public investments [27], but also as a way of dealing with international fluctuations in commodity prices [16]. The accumulation of such a buffer indeed helped some resource exporting countries smooth the effects of the fall in commodity prices caused by the 2008-09 financial crisis, including countries like the Republic of Congo, Angola, Kazakhstan, Venezuela, and Ecuador [24].

Besides the use of such a fund however, and in terms of using more traditional policy tools, Medina and Soto [25] analyzed the effect of alternative fiscal policy rules for the Chilean government during positive as well as negative shocks to the export price of copper. In the latter case, they found that among the three rules considered, which are rules where (1) public spending, (2) non-distortionary taxes and transfers, and (3) outstanding government asset are the respective factors of adjustment during the shock, the third rule leads to the least fall in private consumption in the short run when half of the households are non-Ricardian as is the case in Chile.

Given that physical capital in some key sectors in developing countries have a relatively higher depreciation rate, a fall in replacement expenditures can lead to short-run welfare effects for the households during the years following the shock, in the form of shortfalls in the provision of key services or a costlier provision of them.[1] Further, in addition to the primary objective of avoiding an ultimate fall in overall private consumption level both during the shock and afterwards, controlling the rise in inflation and unemployment is of a demonstrated importance on its own, as these phenomena can have disparate effects

[1] Yisheng Bu [46] uses firm level data to arrive to the finding that physical capital depreciates at a higher rate in developing countries than is usually assumed for developed industrial economies, making a reduction in public investments even more preoccupying in said developing countries.

on different groups of households, causing a negative equity effect.[2] Thus, a fiscal stabilization objective in developing countries, where the overall quality of life is already low, should include the control of both inflation and unemployment not only because they are signs of a downward pressure on overall purchasing power, but because they can constitute negative equity phenomena on their own.

The literature on fiscal behavior in the face of fluctuations in natural resource revenues has so far been mostly comprised of studies that either completely ignore the monetary sector and adopt a purely neoclassical approach to the analysis, such as Melina et al. [27], or studies that do include the monetary sector but assume some version of the law of one price in such a way that shocks are partially absorbed by ensuing adjustments in internationally exchanged quantities, such as Medina and Soto [25].[3] We therefore intend the present paper to be one of the first studies to not only focus on fiscal response to natural resource revenue downturns, but to also propose a tailored micro-founded theoretical framework that includes both the monetary sector as well as nominal rigidities in domestic prices, while abstaining from assuming a law of one price through specifying a path for international prices that is exogenous to the domestic economy and only subject to unexpected international shocks. Furthermore, since the intention is to study short run fiscal policy only, non-resource exports are expressly ignored in the model as to capture, in the event of a sudden and temporary foreign shock, the implications of the above-mentioned structurally low share of these exports in the total exports of resource-rich countries.[4]

It might be important to point out that replicating the economy of Guinea is not part of the objectives of the present study. One of the reasons for this is that our approach is somewhat normative in the sense that the baseline model will assume an already-existing Sovereign Wealth Fund in which the country saves part of its resource revenues, and that can readily be used in the eventuality of a shock. This is currently the case neither for Guinea nor for most of the resource-exporting developing countries targeted by our study. Our work is therefore a simulation one instead, based on a framework that is grounded in the existing new-Keynesian literature. Most of the country-specific parameters are calibrated to the economy of Guinea, both because the country is representative enough of the set of countries targeted by our work and for keeping some consistency across parameter values.

The rest of the paper is structured such that section 2 provides a presentation of the theoretical framework of the model, including optimization programs and first order conditions, as well as policy rules

[2] Ales Bulir [4] finds that a lower inflation reinforces the income-equalizing effect of fiscal redistribution, and Cysne and Turchick [12] discusses the positive relationship between unemployment and income inequality as measured by the Gini coefficient.

[3] Isard [22] presents evidence that shocks to the exchange rate do alter international price differences instead of just resulting in exchanged quantities and domestic prices adjustments and maintaining a law of one price internationally. Frenkel [17] also finds important short-run deviations from the purchasing power parity following the 1970's international shocks.

[4] For similar reasons, Sosunov and Zamulin [37] ignored the non-resource traded sector when studying the short-run effects of a positive resource revenue shock on the Russian economy, as they assumed that the country was already 'suffering from the Dutch Disease' because of a dominant natural resource sector.

for policy makers. Section 3 presents the calibration of the model including estimation results where parameters were estimated using data. Section 4 contains a description of our simulation results for both the baseline scenario and the scenarios with the respective policy responses, as well as an additional subsection discussing the policy implications of these results. Finally, section 5 provides a conclusion to the paper.

2. The model

Our work borrows from Christiano et al. [9], Sidrauski [35], Smets and Wouters [36] and Melina et al. [27] for specifying agents' roles and behaviors. Although the model is a monetary one, all local-currency nominal variables are expressed in terms of the consumption good through being divided by the price of the latter.

2.1. Households

The infinitely lived representative household seeks to maximize their lifetime discounted utility subject to their intertemporal budget constraint. They get their active income from providing labor to domestic firms through a perfectly competitive labor market and, after spending part of their total income on consumption, split the remaining proportion of said income between purchasing government bonds and holding real money balances, with the latter providing them utility as in Christiano et al. [9]. The maximization problem is written as follows:

$$\max_{\{C_t, N_t, M_t, B_{C,t}\}} E_t \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\sigma}}{1-\sigma} + Z_t^M \frac{{M_t}^{1-\nu}}{1-\nu} - \frac{N_t^{1+\varphi}}{1+\varphi} \right),$$

subject to

$$\begin{aligned} (1+\tau_{C,t})C_t + M_t + (1+i_{C,t-1})\frac{B_{C,t-1}}{\pi_t} + B_{G,t} = \\ N_t W_t + \frac{M_{t-1}}{\pi_t} + S_t W_{O,t} + (1+i_{C,t-1})\frac{B_{G,t-1}}{\pi_t} + Tr_t + \int_0^1 \Omega_{j,t} dj + B_{C,t}. \end{aligned} \quad (1)$$

C, N and M represent the household's consumption, supply of labor, and holdings in real money balances (i.e., the purchasing power of the amount of currency they hold, in terms of consumption the good), respectively. Z^M represents potential exogenous shocks to the marginal utility of the household's holdings

of real money balances. Tr is social transfers received by the household from the government, W is the wage rate, W_O is the income received by the household from the natural resources sector, and Ω_j is the profit paid to the household by a typical profit-making domestic firm. $B_{G,t}$ represents the current stock of the government's domestic debt, and $B_{C,t}$ is household's current borrowing from the central bank (i.e., money newly supplied by the central bank, hereafter referred to as simply the money supply). i_C is the interest rate charged on the household's borrowings from the central bank and is also the rate paid by the government to the household on domestic debt. τ_C is the tax rate on the household's consumption. S is the real exchange rate, representing the amount of local currency that it takes to buy one unit of the foreign currency, expressed in terms of the consumption good. π is the rate of inflation, defined here as the ratio of the current price level for the consumption good to the same price level in the previous period. E is the expectation operator, σ is the risk aversion coefficient of the household, β is the subjective discount factor, and ν is the elasticity of marginal utility with respect to real money balances holding.

Solving the household's maximization problem leads to the Euler equation (Eq. 1), the optimal labor supply equation (Eq. 2), and an optimality condition on the current quantity of real money balances to hold (Eq. 3), given the expected level of future interests.

$$\left(\frac{C_{t+1}}{C_t}\right)^{\sigma} = \beta\left(\frac{1+\tau_{C,t}}{1+E_t\tau_{C,t+1}}\right)\left(\frac{1+i_{C,t}}{E_t\pi_{t+1}}\right), \tag{2}$$

$$C_t^{\sigma} N_t^{\varphi} = \frac{W_t}{\left(1+\tau_{C,t}\right)}, \tag{3}$$

$$C_t^{\sigma} {M_t}^{-\nu} Z_t^M = \frac{i_{C,t}}{\left(1+\tau_{C,t}\right)\left(1+i_{C,t}\right)}. \tag{4}$$

2.2. Firms

There are three types of firms in the model participating in the production process at three different stages. The first two stages are based on the monopolistic competition model of Dixit and Stiglitz [13] and the staggered prices model of Calvo [6].

2.2.1. Final goods producers

The representative final good producer has the following maximization problem:

$$\max_{\{Q_{i,t}, Q_{i,t}^*\}} P_{i,t}Y_{i,t} - q_t Q_{i,t} - S_t q_t^* Q_{i,t}^*, \qquad \text{where } i = C, G;$$

subject to

$$Y_{i,t} = Q_{i,t}^{vi} Q_{i,t}^{*\,(1-vi)}.$$

Y_C and Y_G are the consumption good and the public investment good, respectively. Q_C and Q_G are the quantities of the domestically produced composite intermediate good demanded by the consumption good producer and the investment good producer, respectively, and q is the good's price. Q_C^* and Q_G^* are the quantities of the imported intermediate good demanded by the consumption good producer and the investment good producer, respectively. vC and vG are the respective output elasticities of the domestic intermediate good for the consumption good producers and the investment good producers. P_C and P_G are the respective prices of the consumption good and the investment good.[5] q^* is the imported intermediate good's price, assumed to be exogenous, and to which domestic firms optimally react to determine their respective demands for the imported intermediate good. The following first order conditions are obtained from solving the maximization problem:

$$Q_{i,t}^{vi} = (vi) P_{i,t} Y_{i,t} q_t^{-1}, \tag{5}$$

$$Q_{i,t}^{*} = (1 - vi) P_{i,t} Y_{i,t} (S_t q_t^{*})^{-1}. \tag{6}$$

2.2.2. Composite intermediate goods producers

The representative intermediate composite good producer has the following maximization problem:

$$\max_{\{Q_{j,t}\}} q_t Q_t - \int_0^1 q_{j,t} Q_{j,t} d_j ,$$

subject to

$$Q_t = \left(\int_0^1 Q_{j,t}^{\frac{\epsilon-1}{\epsilon}} d_j \right)^{\frac{\epsilon}{\epsilon-1}}.$$

[5] Since all nominal variables are expressed in terms of the final consumption good, P_C is set to unity and P_G is expressed in terms of the said good.

Q is the total output quantity (Q_C+Q_G), Q_j is the quantity of the differentiated good j used in production, of which q_j is the price. ϵ is the elasticity of substitution between any two of the differentiated goods. We solve the maximization problem to obtain the following optimal demand for good j as the first order condition:

$$Q_{j,t} = Q_t q_t^{\epsilon} q_{j,t}^{-\epsilon} . \tag{7}$$

Following Calvo [6], it is assumed that out of a continuum of monopolistically competitive firms indexed from 0 to 1, a proportion θ keep their prices unchanged from last period's price, while the remaining proportion of firms update their prices to the new optimal price. Taking this into consideration after substituting equation (7) into the related production constraint, we derive the following price dynamics equation:

$$q_t^{1-\epsilon} = \theta \frac{q_{t-1}^{1-\epsilon}}{\pi_t} + (1-\theta) {q_t^0}^{1-\epsilon} , \tag{8}$$

where q^0 is the new optimal monopolistically competitive price for the differentiated goods producers.

2.2.3. Differentiated intermediate goods producers

Given the relatively little contribution of private investments movements to private capital formation at business cycle frequencies [11] and as to remain focused on the role of fiscal policy through public infrastructure investments while maintaining a certain simplicity, investment in private capital accumulation is ignored. The common production technology for the differentiated goods producers is thus specified as a Cobb-Douglas production function and takes the following form:

$$Q_{j,t} = A_t N_{j,t} K_{G,t}^{\alpha_G} ,$$

N_j is the quantity of labor used by good j's producer, K_G is the stock of public capital currently available to be used by the private sector, and A_t is current total factor productivity. We assume that output at this stage has constant returns to scale with respect to private inputs which, in the present case, is labor only. The elasticity of intermediate output with respect to labor is therefore set to 1 while the elasticity with respect

to public capital is the parameter α_G . From the above production technology equation, we can derive the equation for the marginal cost (MC) to be:

$$MC_t = \frac{W_t}{A_t K_{G,t}^{\alpha_G}} . \tag{9}$$

The typical firm that updates its price to the new optimal level takes into account the likelihood of not been able to change the set price in the future, and thus maximizes the ensuing expected value of its lifetime profit. The maximization program is formulated as follows:

$$\max_{\{q_t^O\}} E_0 \sum_{i=0}^{\infty} (\beta\theta)^i \left(q_t^O Q_{t+i}^O - MC_{t+i} Q_{t+i}^O \right)$$

subject to the constraint that

$$Q_t^O = Q_t q_t^{\epsilon} {q_t^O}^{-\epsilon} ,$$

where Q^O is the optimal quantity produced by the firm. Solving the firm's problem leads to the following first order condition:

$$q_t^0 = \left(\frac{\epsilon}{\epsilon - 1} \right) \frac{P_{N,t}^{\epsilon}}{P_{D,t}^{\epsilon}} , \tag{10}$$

where P_N and P_D are auxiliary variables such that

$$P_{N,t}^{\epsilon} = MC_t Q_t q_t^{\epsilon} + \beta\theta (E_t \pi_{t+1} P_{N,t+1})^{\epsilon} , \tag{11}$$

and

$$P_{D,t}^{\epsilon} = Q_t q_t^{\epsilon} + \beta\theta (E_t \pi_{t+1} P_{D,t+1})^{\epsilon} . \tag{12}$$

Given the production technology and the first order maximization conditions, we can derive the economy's aggregate level of labor used to be as follows:

$$N_t = \frac{Q_t q_t^{\epsilon}}{A_t K_{G,t}^{\alpha_G}} q_{J,t}^{-\epsilon}\,, \tag{13}$$

where

$$q_{J,t}^{-\epsilon} \equiv \int_0^1 q_{j,t}^{-\epsilon}\, d_j\,,$$

and

$$q_{J,t}^{-\epsilon} = \theta \frac{q_{J,t-1}^{-\epsilon}}{\pi_t} + (1-\theta) q_t^{0\,-\epsilon}\ . \tag{14}$$

2.3. The Government

The budget constraint of the government is as follows:

$$G_t + P_{G,t}Y_{G,t} + Tr_t + \left(1 + i_{G,t-1}\right)B_{G,t-1} + S_t(1 + i_{t-1}^*)B_{t-1}^* + S_t F_t^* = T_t + S_t T_{O,t} + S_t(1 + i_F^*)F_{t-1}^* + D_t\ . \tag{15}$$

B_t^* is the current stock of commercial foreign debt contracted by the government in foreign currency, i_t^* is the rate of interest paid to foreign investors on their lending to the government, and i_F^* is the interest rate paid to the government on savings in the sovereign wealth fund. D_t is the government's total deficit in the current period, evaluated in the domestic currency. The deficit is structured such as

$$D_t = B_t + S_t B_t^*\ , \tag{16}$$

and

$$B_t = (b)D_t\,, \tag{17}$$

where b is the proportion of the current total deficit that is financed by domestic borrowing. The tax revenues of the government comprise tax levied on households' consumption, whose volume is denoted by T, and tax levied on the natural resources sector, denoted by T_O. The volume of collected consumption tax, in real terms, is as follows:

$$T_t = \tau_{C,t} C_t \,. \tag{18}$$

The non-interest spending components of the government's budget are specified as follows:

$$Y_{G,t} = (igZ_t^{Ig}) GDP_t \,, \tag{19}$$

$$G_t = gGDP_t \,, \tag{20}$$

$$Tr_t = trGDP_t \,. \tag{21}$$

ig, g and tr are the respective ratios of public investment, government consumption, and social transfers to GDP. GDP is the gross domestic product of the economy and is a measure of the total added value created within the economy. It is defined to be as follows:

$$GDP_t = Y_t + S_t PY_{O,t} - S_t q_t^* (Q_{C,t}^* + Q_{G,t}^*) \,. \tag{22}$$

Y is the economy's real non-resource output, that is:

$$Y_t = Y_{C,t} + P_{G,t} Y_{G,t} \,, \tag{23}$$

where

$$Y_{C,t} = C_t + G_t \,. \tag{24}$$

Public capital is formed through government investments, according to the following law of motion:

$$K_{G,t+1} = (1 - \delta) K_{G,t} + Ig_t \,, \tag{25}$$

where $K_{G,t}$ is the current stock of public capital, and δ the constant depreciation rate of said capital stock on an annual basis. Because in Guinea the added value tax (or government subsidies on consumption for some goods) tends to be the fiscal adjustment metric for the government as it tends to change the most frequently in response to active changes in expenditures, tax on consumption is specified in our model as

structurally constant but varying in the short-run in response to deviations of debt-to-GDP ratio from its steady state level in the following way:[6]

$$\tau_{C,t} - \tau_{Cp} Z_t^{\tau} = \alpha_C (d_t - d_{ss}) \,. \tag{26}$$

τ_{Cp} is the long-term consumption tax rate, α_C is a constant parameter. d is the ratio of public debt-to-GDP and d_{ss} is its steady state value, that is:

$$d_t = \frac{D_t}{GDP_t} \,. \tag{27}$$

The interest rate on foreign debt is positively related to the debt-to-GDP ratio by having a debt-elastic premium component such that

$$i_t^* - i_p^* = \alpha_{i*} (d_t - d_{ss}) \,, \tag{28}$$

with i_p^* being the long-term rate when the economy is resting at its potential, and α_{i*} a parameter. Instead of just a stationarity-inducing specification, this assumption follows the observation that high debt ratios do have a positive effect on the risk premium over the interest rate paid by developing countries to international investors, as evidenced Edwards [15].[7]

As in Melina et al. [27], one feature of the model is that the government has an interest-bearing sovereign wealth fund held in foreign currency abroad which can be used for stabilization purposes in case of unexpected shocks. The fund, denoted by F^*, is a constant proportion of current tax revenues from the natural resources sector, and is assumed to earn an annual interest payment whose rate is assumed to be constant. The current amount of the fund is thus specified as follows:

$$F_t^* = (g_F Z_t^F) T_{O,t} \,, \tag{29}$$

where g_F is the value of said proportion and Z^F represents shocks to g_F.

[6] In 2022, for instance, an increase in public investment by 1.4 percentage point from the previous year was accompanied by a fall in government subsidies to the electricity sector by approximately 1 percentage point, according to the World Bank [43].

[7] The work consists of an empirical study on country risks and borrowing costs, specifically for developing countries, using data on debt stocks and bonds from said countries, and concludes in support of the assumption made herein.

2.4. The natural resources sector

The nominal value of total natural resources output, in foreign currency, is denoted by PY_O. The above-mentioned amounts paid by the natural resources sector to the government in taxes and to the households by convention are both specified to be constant proportions of the total natural resource sales, that is:

$$T_{O,t} = \tau_O PY_{O,t}\,, \tag{30}$$

and

$$W_{O,t} = w_O PY_{O,t}\,. \tag{31}$$

τ_O and w_O are the respective proportions of the natural resources output paid to the government and to the households. The foreign currency amount of natural resource exports is assumed to be constant as in Melina et al. [27], subject only to temporary shocks. It is thus specified as follows:

$$PY_{O,t} = \overline{PY}_O Z_t^O\,, \tag{32}$$

where $\overline{PY}_O$ denotes resource exports in the absence of all resource shocks, and Z^O stands for exogenous resource income shocks.

2.5. The Central bank

In accordance with the mission and roles of the central bank of Guinea, as legally conferred to it [34], the central bank in our model is specified as having the duty of implementing both an official reserves policy vis-à-vis the foreign currency, and an internal monetary policy aimed at maintaining stable domestic prices and contributing to keeping the economy close to its potential.[8] Based on the balance of payments identity (see Equation 4.3 in Ouanes and Thakur [31]), the law of motion of official reserves, with the latter denoted by Res, is derived to be:[9]

$$Res_t = Res_{t-1} + W_{O,t} + T_{O,t} + (1 + i_F^*)F_{t-1}^* + B_t^* - q_t^*(QC_t^* + QI_t^*) - F_t^* - (1 + i_{t-1}^*)B_{t-1}^*\,.$$

[8] The referred law states that the central bank has the primary objective of maintaining price stability and the secondary objective of helping the government's efforts for a sound and durable economic growth, through monetary and exchange rate policies.

[9] The expression conveys that at equilibrium the capital account, net of the change in foreign reserves, balances out with the current account. In other words, the equilibrium balance of payments net of foreign reserves equals zero.

From equations (6) and the above, the equilibrium real exchange rate is derived to be:

$$S_t = \frac{(1 - vC)Y_{C,t} + (1 - vI)P_{G,t}Y_{G,t}}{(\tau_O + w_O)PY_{O,t} + B_t^* + (1 + i_F^*)F_{t-1}^* + Res_{t-1} - (1 + i_{t-1}^*)B_{t-1}^* - F_t^* - Res_t} . \quad (33)$$

Eq. (33) states that the exchange rate is the ratio of the domestic demand for imports and the net supply of the foreign currency on the domestic foreign exchange market.

Since the central bank of Guinea maintains a semi-floating exchange rate [7], the real exchange rate is made subject to a reserves policy rule specified as follows:

$$\frac{Res_t}{Res_{T,t}} = \left(\frac{S_{ss}}{S_t}\right)^{\alpha_{res}} . \quad (34)$$

To express it in months of imports, the time dependent target level of official reserves, Res_T, is specified as a linear function of the lagged volumes of imports in the previous two periods:

$$Res_{T,t} = res(q_{t-1}^*(QC_{t-1}^* + QI_{t-1}^*) + q_{t-2}^*(QC_{t-2}^* + QI_{t-2}^*)) , \quad (35)$$

where res is a parameter.

As for the internal monetary policy, the central bank has the double mandate of being responsive to changes in the general price level while contributing to keeping the economy close to its potential [34]. For this purpose, the bank's role is specified as following a rule whereby money is supplied until the common interest rate's deviation from its long-term value is at the target level, which is a linear function of the respective deviations of inflation and non-resource output from their own target values, in the spirit of Taylor [39]. The specification takes the following form:

$$i_{C,t} - i_{Css}Z_t^{ic} = \alpha_\pi \pi_{gap,t} + \alpha_y Y_{gap,t} , \quad (36)$$

where Y_{gap} and π_{gap} are the output gap and the deviation of inflation from its target level, respectively. In the present paper, we will define these gaps as the rate of deviation of their actual levels from their steady state levels, as opposed to deviations from their respective values in the flexible-price counterpart of the

model.[10] Z^{ic} denotes a monetary policy shock to the current central bank's rate. α_y and α_π are parameters indicating the degree to which the central bank's rate adjusting policy is sensitive to deviations of non-resource output, and inflation, respectively. A typical shock factor in the model, Z, is assumed to follow an autoregression AR(1) process such that:

$$Z_t = \exp(e_Z) Z_{t-1}{}^{\rho}\ , \tag{37}$$

where e_Z and ρ are parameters indicating the magnitude of the shock and its degree of persistence over time, respectively.

3. Calibration

Given the lack of reliable data on low-income developing economies in general, and on Guinea in particular, we will make use of existing studies carried out on these economies, and of the broader new-Keynesian DSGE literature, when necessary, to calibrate the model. This will be in addition to making use of as much relevant and reliable data as we could find, mostly from the World Bank databases, retrieved from the official website of the institution.

- *Households.* The representative household's subjective discount factor is calibrated such that the steady state interest rate corresponds to the most recent (2019, pre-pandemic) level of the Guinean central bank's rate, as found in published documents by the bank [8], implying a subjective discount rate of 0.889 for a steady state interest rate of 12.5%. The average intertemporal elasticity of substitution for consumption in Low Income Developing Countries was estimated by Ogaki et al. [30] to be 0.34. We therefore calibrate the coefficient of relative risk aversion σ, such that the elasticity is set to the said estimated value, and that implies a relative risk aversion coefficient of 2.94. We adopt the estimated value of the Frisch elasticity of labor supply for the developing country of Malawi, another sub-Saharan low-income developing country, by Goldberg [18], which is 0.10, and accordingly set the value of φ to 10. For the inverse of the elasticity of real money holdings ν, we adopt the same calibrated value as Peiris and Saxegaard [32], which was one of the first attempts at building an estimated DSGE model for the sub-Saharan African region, excluding South Africa. The latter study specifically uses macroeconomic data from the low-income developing country of Mozambique and estimates the said elasticity to be equal to 2. The households' income from the

[10] Vetlov et al. [42] provides a detailed analysis of the implications of each of these specifications concerning the output gap and the inflation gap, as defined here.

natural resources sector as a percent of total natural resources revenue, w_O, is set to total salaries paid by Société Minière de Boké, one the largest mining companies in Guinea, as a percentage of total revenues of the companies in 2018, based on a report by PwC on the activities of the company that year.

- *Firms and production.* Estimating the share of domestically produced intermediate goods in the output of both final consumption goods and final investment goods was made straightforward by the Cobb-Douglas production function specification at the final level of production, as these shares simply become the respective ratios of the nominal value of each input to the nominal value of the relevant output. The parameter v_G was therefore computed as the ratio of the nominal value of imported capital goods to the nominal value of total capital formation in the same year for Guinea. v_C was similarly computed as the ratio of the nominal value of imported consumption goods to the nominal value of total consumption in the same year. Using relevant imports data from World Integrated Trade Solutions [45] with consumption and total capital formation data from the world bank [44], v_C and v_G were computed and set to their respective 2016 values for Guinea, which are 86.48% and 73.1%. These shares support the premise that investment and capital formation goods tend to rely more on imports than consumption goods, which is the main reason for how final goods production was theoretically specified in the present paper, as to allow for the possibility of different calibrated values for the two proportions. Following Peiris and Saxegaard [32], we adopt the value of 1.09 for the Calvo markup factor and therefore accordingly set the value of ϵ to 12.11. The Calvo parameter, θ,indicating the degree of price stickiness is set to the posterior mean value of an estimation done by Takyi and Leon-Gonzalez [38] for Ghana, in the context of a study regarding monetary policy in the broader sub-Saharan African region, which estimated the said value to be 0.75. Following a similar study on macroeconomic stabilization in Latin America by Easterly and Servén [14], the elasticity of private output with respect to public capital is set to the estimated value of 16%. We set the annual depreciation rate of public capital to 7%, as in Melina et al. [27].

- *The fiscal authority.* The respective ratios of government consumption and public transfers to GDP are set to their respective 2020 levels of 8.35% and 5.84%, based on GDP data obtained for the World Bank [44] and approximative government spending data obtained from the 2020 Guinea government's readjusted budget. As for the public investment to GDP ratio ig, it is computed as the ratio of total capital formation within the country to GDP in the same year. Due to the choice to forgo private investment in the model, the entirety of capital formation observed within the country from pertaining data (including public and private capital formation) is considered public investment in the model. The parameter ig is therefore set to the 2020 level of the ratio of total capital formation to GDP for Guinea according to data from the World Bank [44], which is a ratio value of 22.02%. The government's income from the natural resources sector as a

percent of total natural resources revenue, τ_O, is set to the sum of the corporate income tax of 30% and an additional 15% of the income of all mining companies operating within the country, as the state has a free and legal minimum of 15% share in these companies, according to the 2013 amendment of the of the country's 2011 mining law [10]. As for the proportion of its natural resources income that the government saves in the sovereign wealth fund abroad each year, we simply assume it to be of 0.5%, since the country doesn't currently have such a fund which would have served as a basis for an appropriate estimation. The interest rate that the government receives on the sovereign wealth fund is assumed to be lower than the domestic steady state interest rate by a factor of 6, which is roughly the factor by which interest rates in the US have consistently been lower than the central bank's rate in Guinea, based on data on both interest rates obtained from the World Bank [44] and Guinea's central bank legal documents [8]. That entails an international interest rate of 2% paid on the savings in the Fund. The steady state level of interests paid by the government to foreign investors is also set to this rate, although, as specified in the model, it does deviate from this long run rate in the same direction as the country's debt-to-GDP ratio variations. With the aim of calibrating the long-term consumption tax rate to Guinea's and given that an indirect value added tax instead is being implemented by the country, the long-term level of the consumption tax rate is set to the recent rate of said value added tax, that is 18%, as indicated by the current tax laws of the country. The proportion of the government's debt that is financed domestically is set to 44%, reflecting its 2022 value [26]. Due to a lack of relevant and reliable data for their estimation, the response coefficients of consumption tax and interest rate on foreign debt to deviations of the debt-to-GDP ratio from its steady state level are both set to 0.5, as to make sure they are responding less than proportionally but at the same time not too insignificantly.

- *The monetary authority.* Regarding the central bank's response sensitivity parameters with respect to inflation and the output gap, we start by adopting their respective prior means as assumed by Smets and Wouters [36], that is 0.5 and 1.7 respectively, but then apply the further theoretical restriction of reducing their scales by a common factor equal to their sum as to maintain their relative strengths with respect to each other but avoid overreaction from the central bank and guarantee a unique solution path to the model. Their relative strengths are maintained to reflect the behavior of a central bank that places significantly higher weight on the stabilization of prices than on actively managing aggregate demand, which is particularly the case for the Guinean central bank, as stated in its mission statement [34]. Besides, the relatively higher inflation rates that these countries tend to have, coupled with lower quality of institutions leave them with little space for having a countercyclical monetary policy with respect to the output gap as much as is done in developed countries [5], and targeting lower levels of inflation or overreacting to higher inflation levels can undermine growth at least in the short run. The steady state ratio of official reserves to average monthly import for a given year is set to 3, as this is roughly the average official reserves in months

of import for Guinea from 2009 to 2020, based on data from the World Bank [44]. The parameter res is accordingly calibrated to 1/8, as to make target reserves the average of three months of imports for the last two years. We estimated a linearized version of Eq. (34) using World Bank [44] data on the exchange rate and reserves for Guinea, and the resulting estimate for the parameter α_{res} is 1.1.

- *The resources and external sectors.* We normalize the steady state levels of both the import price q^* and the nominal value of natural resources exports PY_0 to 1 unit of the foreign currency. Adopting these values to close the model implies a steady state export-to-import ratio of 61.57%, which is less than 5 percentage points away from the actual value of 57.5% for mining exports to total imports for Guinea in 2021 [1], as mining represents 84% of exports in that year, down from the estimated recent average of 90% for mining exports in the country's total exports [21].

- *Shocks.* A typical shock to the model, whether a resource revenue shock or a policy induced shock, is assumed to be non-permanent, but persistent, with a common degree of persistence for all shocks set to 0.9, as in Melina et al. [27]. The initial magnitude of the shock is a $\pm 1\%$ scaling of the related variable, with the sign depending on the intended direction of the impulse shock.

4. Resource revenue downswing

4.1. Baseline scenario

Fig. 1 shows the effect of a 1% initial fall in natural resources output under the baseline scenario, that is without an active policy response. The shock contracts non-resource output by 0.09% on impact and raises private consumption by 0.017% while overall GDP falls by 0.36%. Public spending falls proportionally to GDP, which itself is directly pulled down by the initial shock (Eq. 22), significantly reducing aggregate demand, and making the shock deflationary in nature. This contrasts, for instance, with Medina and Soto [25] which found that regardless of whether taxes, public spending or government asset is the adjustment policy tool following the shock, a downturn in the price of exported copper for Chile would result in a rise in inflation on-impact. In essence, effective demand in our model is contracted by the shock through the fall in public spending and the ensuing rise in money holdings, leading to negative inflation instead, with a fall in the demand for labor.

Although hours worked would have been raised by the shock had all prices been fully flexible, as shown by the positive response of hours in the flexible-price version of the model (Fig. 1), the presence of price stickiness however causes hours worked to go down on impact owed to the deflationary nature of the shock. Furthermore, the lower level of resource revenues raises the real exchange rate from the supply side

of the foreign exchange market (Eq. 33) and reduces the quantity of imported intermediate goods, causing a negative productivity shock to the domestic economy. Non-resource output thus falls not only because of the decreased level of imported intermediate goods affordable to the economy, but also because of the demand-driven fall in hours worked domestically.

As the domestic interest rate is lowered in response to the fall in both inflation and non-resource output, private spending is sustained and private consumption even rises slightly due to more affordable borrowings from the central bank and lower opportunity cost of current consumption (Eq. 2), also due to the government reducing its spending, freeing up production factors to be used in making private consumption goods. Real public debt is reduced by 0.049% by the shock because of lower public spending and sustained consumption tax revenue. Since the on-impact rise in private consumption is also owed to the automatic stabilization policy of the central bank, when the shock starts dissipating from the second year after impact and inflation turns positive, private consumption quickly and durably falls below its steady state level, partially because of the ensuing rise in the interest rate. The continued lower level of private consumption is also because of the steady rise in public spending from the second year after the initial shock, despite the economy's depleted public capital stock, causing relatively low supply capacity for the economy and a continued crowding-out of private consumption.

Since public spending rises faster than resource revenues recover from the shock, the real exchange rate is driven further up from its initial rise, and public debt also grows as a result, causing a similar hump-shaped dynamics for a few related variables after impact, including the real exchange rate, domestic public debt, and the ratio of domestic intermediate goods to imported intermediate goods (Fig. 1). The stock of public capital keeps decreasing after its 0.078% on-impact fall, as it follows a U-shaped path which converges back up to the steady state level only in the long run. These results suggest that, on impact, a negative resource revenue shock happens to be more of an issue for public investments rather than an immediate and considerable down-pulling force for private consumption, provided that the size of the government's investments relative to GDP remains unchanged from prior to the shock. But from the second year after the shock however, private consumption is consistently drawn down by the still depleting public capital stock and stays as such into the medium run and longer afterwards. Our policy analysis will therefore consist of an attempt to find the most appropriate fiscal policy response that not only preserves the level of private consumption on impact, but also raises private consumption's dynamic path above its baseline scenario path, at least in the short run, with the lowest cost in terms of inflation, unemployment, and government borrowing requirements.

4.2. Policy response analysis

For each of the policy measures analysed in this section, the desirable effects of the policy will be analysed in comparison to the cost of the policy mainly in terms of borrowing requirements for the government, loss in non-resource output, rise in inflation and rise in unemployment, both on impact and afterwards. Movements in hours worked are used as the metric for tracking unemployment despite a perfectly competitive labour market, and that is because of the role of aggregate demand as well as supply shocks on hours worked, following the nominal rigidity assumption on prices.

4.2.1. Countercyclical public investment policy

When the government responds to the negative resource revenue shock with a concomitant 1% initial increase in infrastructure spending relative to GDP (Fig. 2), it results in a 0.23% net increase in non-resource output, a 0.087% net fall in private consumption, a 0.35% net increase in real public debt, and a 0.127% net rise in inflation, from their respective baseline scenario levels, on impact. Inflation rises because of the expansion in aggregate demand, fostered by the increased public investments and by the households reducing their holdings in money to sustain the falling private consumption (Eq. 4). Non-resource output rises because of the rise in the demand for labor and the rise in actual hours worked from baseline, which itself follows from the expansion in aggregate demand. The policy thus crowds out private consumption even further from baseline, on impact and in the short run only, and sustainably increases public debt both in the short run and afterwards.

The increased investments do, however, quickly build up the stock of public capital, allowing for a faster rise in domestic productivity than in the baseline scenario, and allowing private consumption to quickly rise above baseline level from around the fourth year after impact, following the short run downswing of the latter after the shock. As a proportion of the rising public debt is financed with foreign currency-denominated borrowings, and as the rise in domestic demand is attenuated by the higher domestic interest rate, the policy causes a less than proportional rise in the demand for the foreign currency in comparison with the rise in its supply, as a result of which the real exchange rate (Eq. 33) as well as the share of domestic intermediate goods in overall intermediate goods fall as sustainably as the rise in the level of public debt from baseline. In addition to higher inflation, higher public debt, lower unemployment, and higher non-resource output than baseline, a countercyclical public investment policy during a resource revenue downturn thus leads to a bigger fall in private consumption in the short run but a lesser fall from the medium run onwards.

4.2.2. Tax relief policy

The further short run fall in private consumption from its baseline level that happens with the countercyclical public investment policy can be avoided if a tax relief policy is carried out instead (Fig. 3),

as a 1% consumption tax rate reduction leads to a 0.025% net increase in private consumption from baseline on impact, as well as a 0.027% net increase in non-resource output, while it only increases real public debt by 0.09% from its baseline level as opposed to 0.34% in the increased public investments case. The tax cut both reduces the opportunity cost of current consumption, pushing the latter upward (Eq. 2), and increases the opportunity cost of holding money, putting a downward pressure on money holdings (Eq. 4). Moreover, reducing the consumption tax rate raises labor supply (Eq. 3), while the households spending part of their money holdings on consumption increases the demand for consumption goods and the demand for labor. The rise in households' consumption is therefore made possible by a jump in hours worked, although the rise in hours in this case, by going more into the production of consumption goods than public capital goods, causes the policy to leave the dynamic path of public capital stock almost unchanged from the baseline scenario. Further, in addition to requiring a smaller increase in real public debt, the policy raises inflation from baseline on impact only by 0.009%, as opposed to the 0.127% inflation increase in the countercyclical investments case. The tax cut response therefore leads to lower inflationary pressures together with lower increase in real debt than countercyclical public spending, at least on impact and in the short run.

Private consumption remains above its baseline level until converging back to its steady state level in the long run. It can be observed that as increasing public investments in response to the resource revenue shock builds up public capital while crowding out private consumption in the short run, reducing the consumption tax rate, on the other hand, sustains a higher level of private consumption than baseline, both in the short run and in the long run, without crowding out public investment. One of the main reasons for this observation is that the tax cut affects the structural decision-making process of the households by increasing their optimal supply of labor, such that the increased labor demand doesn't feed into the already-existing workforce but is instead met with additional supply of labor.

4.2.3. Making use of the sovereign wealth fund

Fig. 4 contains the economy's response when the government decreases its planned Sovereign Wealth Fund savings relative to its resource income by an initial 1% during the resource revenue downturn. Real public debt, contrary to the previous two policies, is reduced on impact by 3.76E-4% from baseline. Both consumption and non-resource output are raised, by 0.7E-4% and 0.2E-4%, respectively, and stay above their baseline scenario levels until converging back to their respective steady state levels in the long run. The additional inflow of the foreign currency pushes down the real exchange rate, causing an important productivity gain for the domestic economy caused by significantly more affordable foreign intermediate goods. This results in a double downward pressure on hours worked from the demand side of the labor market. First, because firms substitute domestic intermediate goods off for the imported ones, putting a

downward pressure on hours worked, and second, because sticky prices cause positive productivity shocks to put a downward pressure on not only prices but also hours worked [19].

In addition, as the policy puts a downward pressure on inflation from the supply side of production, the domestic interest rate is lowered and the demand for private consumption rises as a result. Public capital formation is crowded out due to both higher private demand and the fall in hours worked, as the policy raises private consumption by more than three times the rate at which it raises non-resource output on impact (Fig. 4). It is interesting to notice that although reducing current SWF savings represents additional resources for the government, the policy ultimately increases households' purchasing power multiple times more than it does non-resource output, sustainably decreasing public capital stock, as domestic unemployment is also raised due to more competitive foreign intermediate goods and much lower demand for the domestic labor.

The use of the SWF is thus not a flawless policy in response to a resource revenue downturn. Despite leading to a favorable outcome for both consumption and non-resource output, the policy can cause the domestic industry to be outcompeted by imported intermediate goods, leading to domestic unemployment with other possible undesirable ramifications for the economy. This is in line with the so-called Dutch disease effect whereby additional foreign currency inflows, even when temporary, cause a possibly permanent loss of competitiveness for the domestic industry [23].

Another interesting aspect of the effect of the policy is that the lower real exchange rate reduces the real value of the total natural resources output while only a fraction of said resources are used to import foreign intermediate goods, leading to more value being taken from real GDP than is added to it through increased non-resource output, and consequently causing a fall in said real GDP. In other words, since the country has a positive trade balance, the fall in the real exchange rate constitutes a net loss in value for the economy due to a lower real value of the trade surplus. However, the said lost value is, for the most part, not incurred by the households or the government, but by the natural resource exploiting firms and their shareholders who, in the case of a typical developing country targeted by our study, are usually foreign residents to whom the dollar value of the resource sales remains unaffected by domestic policy or shifts in domestic subjective valuation.

5. Conclusion

The present study consists of analyzing the stabilizing effect of alternative fiscal policy responses to a downturn in the revenues of a resource-rich developing country from the exports of natural resources. The model considers nominal rigidities in domestic prices and is mostly calibrated to the economy of the Republic of Guinea. Our results suggest that if the policy objective is strictly to maintain households

purchasing power both on impact and in the short run with the least borrowing requirements or the lowest inflation possible, then purely making use of the SWF is the recommended policy, as this even lowers both metrics on impact and keep them relatively close to baseline afterwards. If domestic unemployment is more of a worry for the fiscal authority than inflation and borrowing requirements, then reducing the consumption tax rate is recommended. Further, a mixture of both policies could also be adopted with an appropriately higher weight assigned to the policy whose effects are more desired by the fiscal authority.

One important policy implication of the results is the determinant role that the size of government spending plays in the response of key macroeconomic variables to a negative resource revenue shock. Not only does countercyclical public investment not serve the purpose of sustaining private consumption on impact and in the short run, it also requires higher levels of borrowing and only raises consumption over the baseline level from the medium run onwards. Thus, except if done together with the use of the SWF to raise short run consumption enough, or within the context of an inflation-tolerating government with very little external borrowing constraints, which is hardly the case for a developing country, and in which case it could be used together with some tax relief measures, raising public spending in response to a resource revenue shock is not an advisable short run policy on its own, or even as a main policy measure.

The alternative policy consisting of cutting consumption tax during the resource revenue downturn achieves the goal of sustaining a higher path for private consumption than baseline, from the impact year until convergence in the long run, and requires lower government borrowing, at least on impact and in the short run. Making consumption goods more affordable through government policy also makes households more eager to work at a given wage, raising labor supply and the economy's internal productive capabilities, and helping avoid a rise in domestic unemployment as is the case with using the SWF.

While financing part of the government's deficit with the SWF can be straightforward, implementing a temporary tax relief in a developing country is, however, context-dependent and can be a challenging task that requires taking into account the fact that the expected positive effects of the policy are highly dependent on labor supply being elastic enough with respect to after-tax consumption prices, as the policy can result in more inflationary pressures and a crowding out of public capital formation than found here if that is not the case. The policy could take the form of subsidizing necessity consumption goods, which, in the case of Guinea, would consist of temporarily extending the already existing government subsidies but in a more targeted way. If properly carried out, the expectation is that the tax cut leads to not only workers but also contractors, both in the formal and informal sectors, keener to take on jobs and contracts for the same level of monetary remuneration, thereby boosting employment from the supply side of the labor market, and protecting private consumption both on impact and afterwards, without the rise in domestic unemployment caused by the use of the SWF and the higher inflationary pressures caused by a countercyclical investment policy.

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Figures

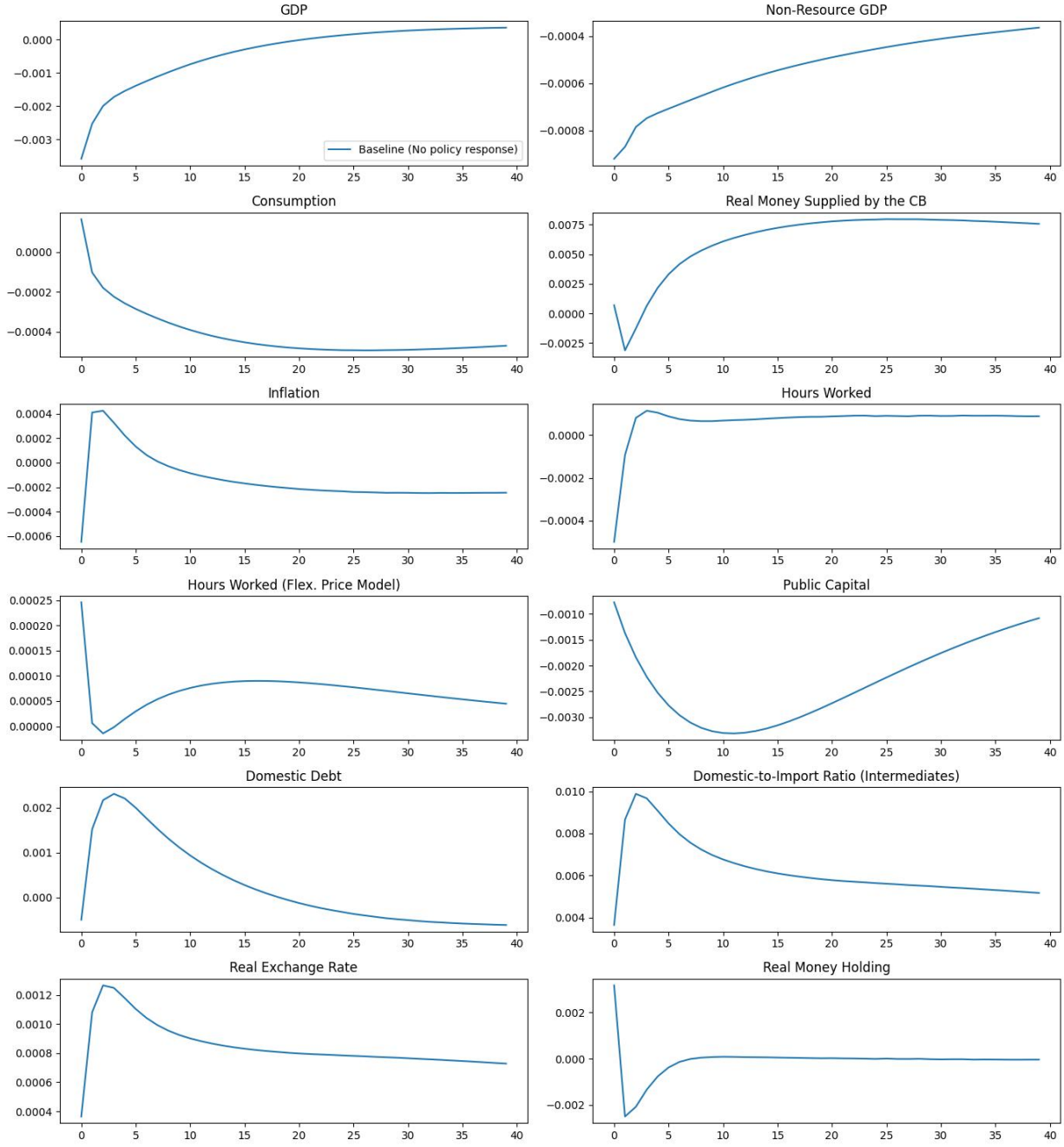

Fig. 1 Fall in natural resource revenues under the baseline scenario (i.e. with no policy response)

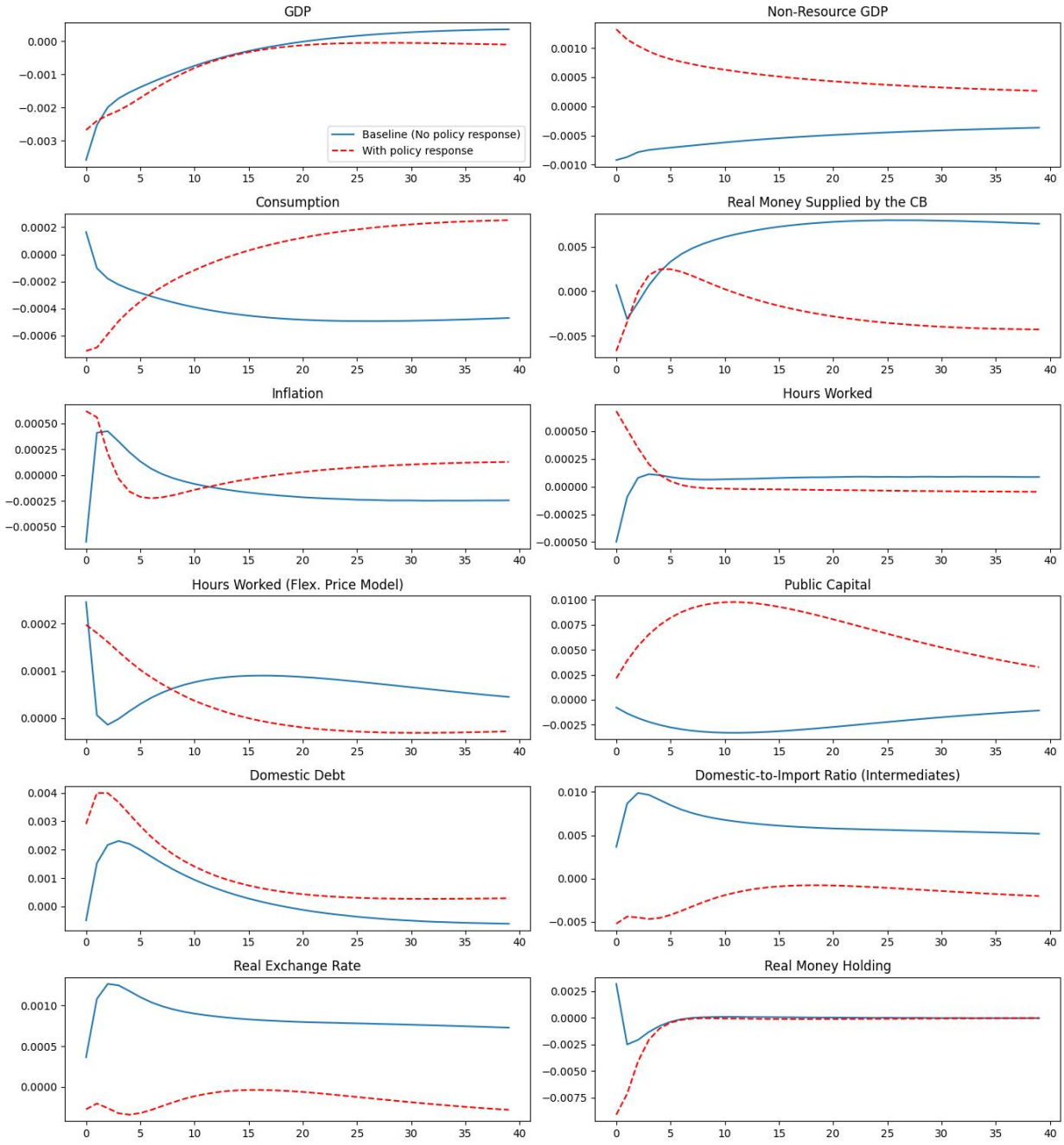

Fig. 2 Fall in natural resource revenues with increased government investments

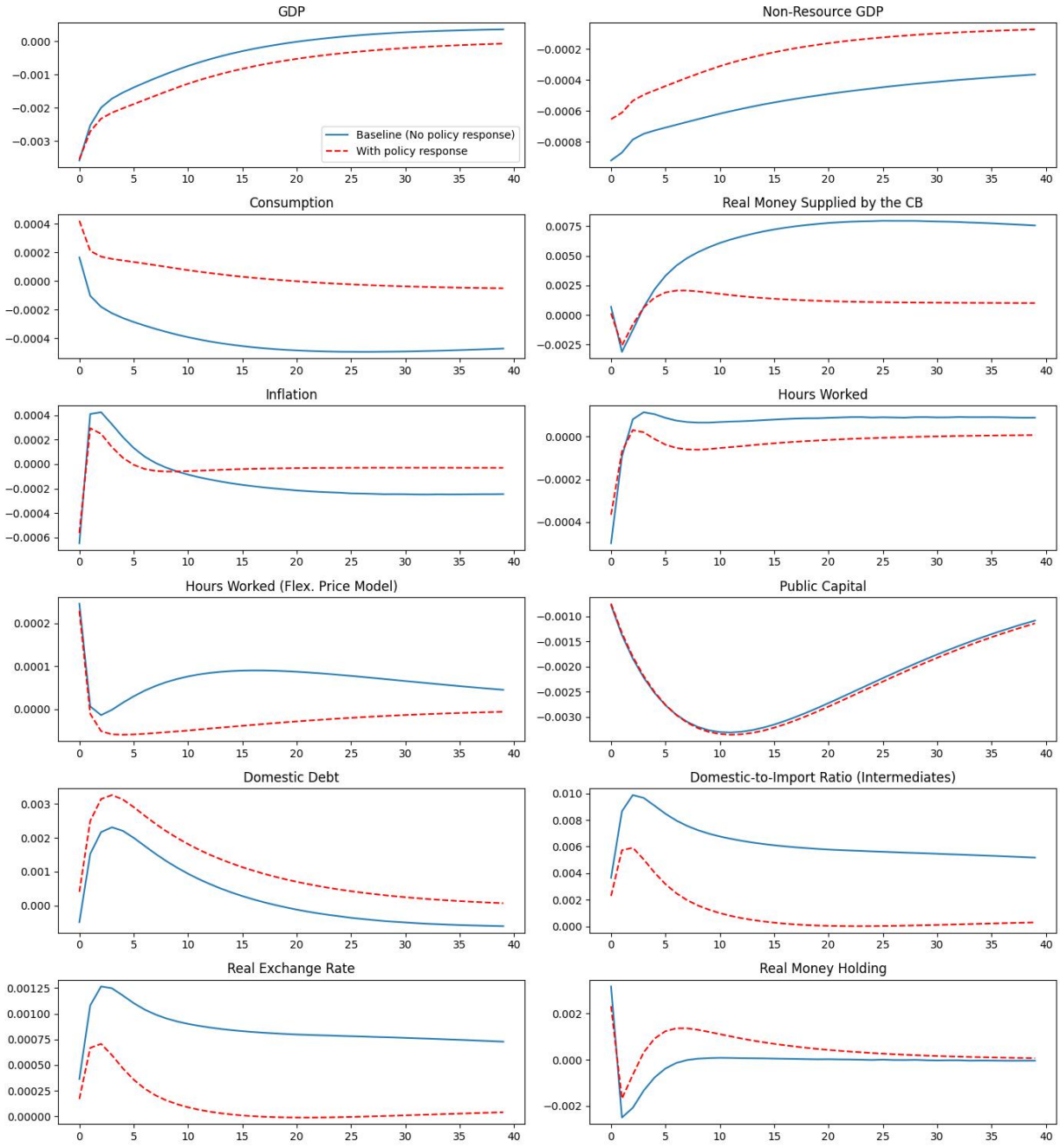

Fig. 3 Fall in natural resource revenues with a reduced consumption tax rate

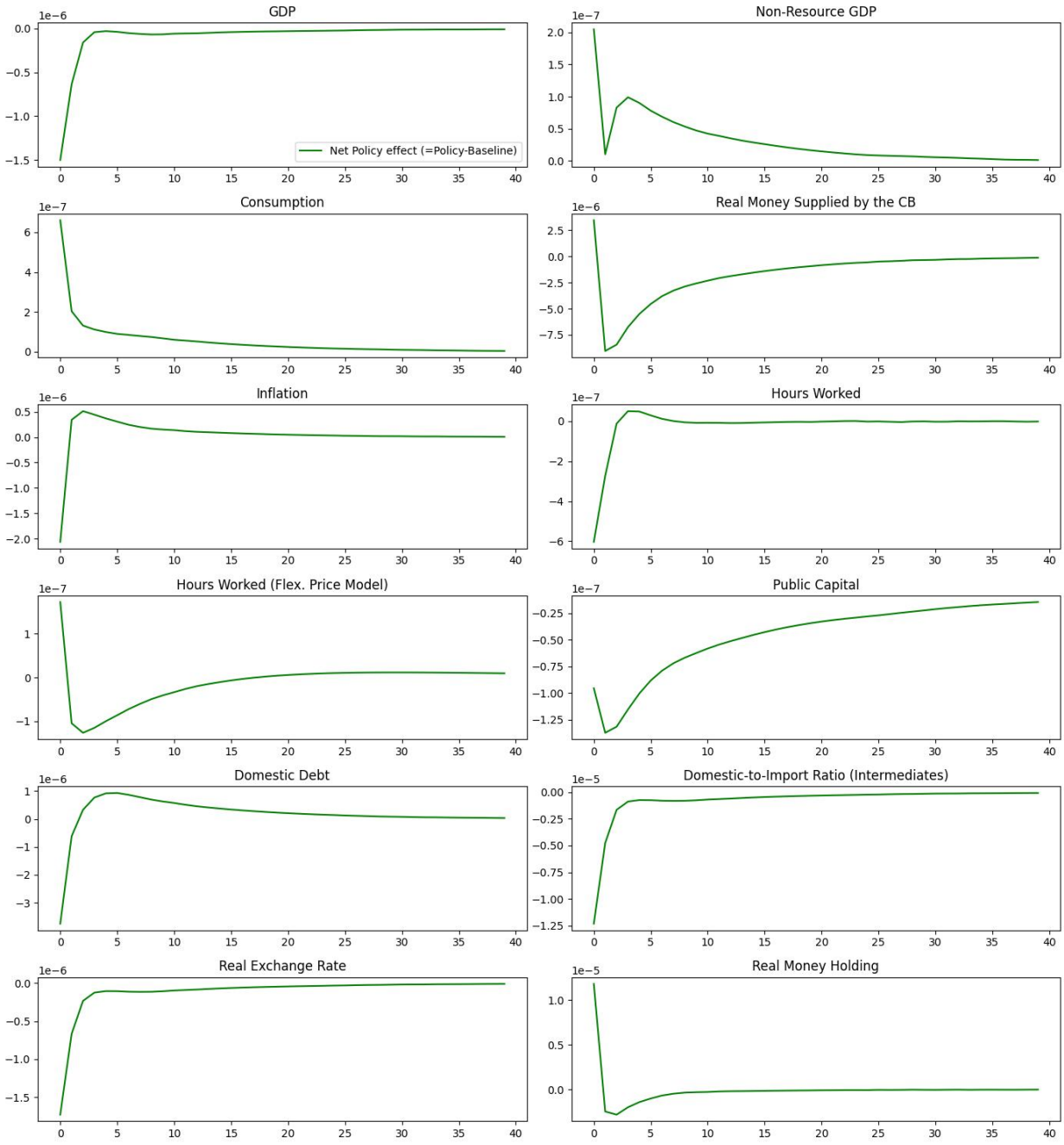

Fig. 4 Fall in natural resource revenues with reduced current savings in the SWF