

# Optimal fiscal management in an economy with resource revenue-financed government-linked companies

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## Abstract

We present a dynamic stochastic general equilibrium (DSGE) model in which a resource-rich government allocates its excess resource rents between a resource stabilization fund and the facilitation of costly domestic fund-raising activities of sovereign wealth funds (SWF), which holds a portfolio of government-linked companies (GLCs). Despite being less productive efficient, GLCs' operation benefits from scale economies tied to the resource sector: its profitability is procyclical to commodity shocks. The model is estimated to Malaysia using the Bayesian approach, with the results suggesting a business cycle heavily influenced by resource shocks. Based on this, we solve numerically for a socially optimal combination of excess resource savings allocation. We find the present allocation to be sub-optimal, regardless of the structural shocks. This suggests that the Malaysian economy might have hit its absorptive capacity constraint (i.e., a domestic economy saturated by GLCs).

## KEYWORDS

commodity shocks, fiscal management, government-linked companies, open-economy macroeconomics, resource wealth

## 1 | INTRODUCTION

Over three decades of theoretical contributions have advised on the fiscal management strategies of resource rents, notably in resource-rich developing economies, ever since the 'Dutch disease' phenomenon was formally modelled by Corden and Neary (1982). Although sudden resource windfall provides opportunities to promote growth and development, economies have historically shown a tendency to experience a decline in non-resource tradable production, due to a sharp real exchange rate appreciation and increased demand for nontradables. Moreover, in recent years, macroeconomic policymakers with multipronged objectives when managing resource revenue (consumption smoothing, built-up of

precautionary savings, and ensuring domestic business stability) have grown increasingly concerned of the volatility associated with global resource prices resulting in greater domestic macroeconomic instability (van der Ploeg, 2011). Broadly, the evolution of the theoretical models, and associated policy prescriptions, can be defined by two paradigms. Traditionally, the central tenet of resource revenue management is heavily influenced by the consumption-smoothing consideration of the *Permanent Income Hypothesis* (PIH) (Collier, van der Ploeg, Spence, & Venables, 2010; van der Ploeg, 2011). In sum, the government ought to keep its expenditure to a sustainable level, implying that any resource windfall generated should be kept independent from the financing of the non-resource primary fiscal balance, with its entirety

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saved in a resource stabilization fund abroad to serve as a precautionary buffer. More recent theoretical contributions, or 'second generations' models such as van den Bremer and van der Ploeg (2013), Berg, Portillo, Yang, and Zanna (2013), Araujo, Li, Poplawski-Ribeiro, and Zanna (2016), Agénor (2016), questioned the appropriateness of the PIH approach for developing economies. Due to persistent infrastructure gaps, they argue that these economies would benefit more from flexible fiscal arrangements by having some resource rents invested domestically, insofar as it is being met by policies reducing these capacity constraints.<sup>1</sup>

To date, the consensus of the two generations of *Dutch Disease* theoretical models appears to be to devise fiscal management rules that balance the investments of resource windfall domestically and in offshore assets. Nevertheless, there is an obvious gap between the theoretical literature and actual policy practices observed in the real world. Specifically, in current theoretical models, the allocation of resource wealth to be invested domestically is almost always specified to take the form of infrastructure capital investments. In practice, this is often not the case. Resource wealth not saved abroad is usually spent on – both directly and indirectly – capitalizing state-owned enterprises (SOEs) or in a modern context, the facilitation of domestic fund-raising activities by strategic holding funds [herein, dubbed as the sovereign wealth funds (SWFs)] that invest or hold equity stakes in government-linked companies (GLCs). Unlike the traditionally inefficient bureaucratic leviathans of SOEs, these GLCs coexist with private firms in supplying the domestic market across a wide range of sectors, and in some instances can have lower hurdle rates of returns due to the strategic roles in driving industrial development or serving as 'fiscal stimulus vehicles' (Chang, 2007; Wen & Wu, 2019). This is known as 'state capitalism' industrial policies, which include investments through GLCs in areas that are resource-intensive and possess long-term economies-of-scale potentials (Cherif & Hasanov, 2019; Cherif, Hasanov, & Kammer, 2016).<sup>2</sup> In spite of these features in emerging economies, a macroeconomic model with GLCs remains elusive.

We contribute to the literature by developing a dynamic stochastic general equilibrium (DSGE) model with the inclusion of GLCs (which is 'owned' by a representative SWF) and a resource stabilization fund (henceforth, *Resource Fund*). Although all resource revenue is initially transferred to the budget, in deciding on its usage, the federal government inexplicably allocates this resource wealth between Resource Fund abroad, spending on facilitating fund-raising activities of the SWF (hence indirectly in relation to its portfolio GLCs' production), and other government operating expenditure. In our knowledge, this is the first study in the tradition of

the Dutch Disease literature that explicitly models the presence of the GLCs, towards understanding how optimal fiscal management of resource rents differs under different business-cycle conditions. The model also introduces a novel feature that is consistent with cross-country observations that distinguish GLCs from private firms: On average, SOEs' operations tend to have better linkages to the natural resource sector and hence benefitting from scale economies. Based on our calculation using the sample of 11,805 privately owned enterprises (POEs) and 220 SOEs surveyed across 113 economies in the World Bank Enterprise Surveys (WBES) during the 2008–2018 period, the former has an average fuel cost (as percentage of sales) of 0.413 whereas the latter has a lower average fuel cost of 0.344.

In the model context, we also identify analytically a threshold value of the spending on domestic facilitation of the fund-raising activities of the SWF, above which a typical GLC would make non-zero profits. Despite its relatively generalizable feature, to capitalize on the sufficiently long history of a GLC-dominant economy (see Menon, 2014, for a study of more descriptive nature on Malaysia's GLC sector), the model is estimated to Malaysia using the Bayesian approach, with the roles of resource price and other structural shocks evaluated using variance decomposition and impulse response analysis. Note that the calibration is mainly for a stylized applied theoretical macroeconomic purpose to yield generalizable findings with respect to the theories on optimal fiscal management of resource wealth in a developing economy. As such, it is not meant to be a specific study on Malaysia, which has a large number of government-linked strategic investment funds (usually dubbed as GLICs) with vastly different capitalization structure and stakeholders. To preview, we find that, even without having to 'shoehorn' a nontradable sector into the model, many classic features associated with the '*Dutch disease*' are still generated in the impulse responses following a commodity/resource price shock – an important influence to the business cycle of the GLCs-dominated economy.<sup>3,4</sup> We analysed numerically for an optimal combination of allocation to the external Resource Fund and the facilitation of fund-raising activities of the SWF in the context of the minimization of a social loss function, à la Agénor (2016). Given these, our study is closest to Agénor (2016), García-Cicco and Kawamura (2015), Ojeda-Joya, Parra-Polanía, and Vargas (2016). Our stability criterion is similar to the former, but the actual data-based business-cycle evaluations used to guide the optimality analysis is closer to the latter two, which are calibrated to Chile and Colombia respectively.

For an assumed share of resource wealth saved in each period, we find the optimal allocation between the Resource Fund abroad and the domestic facilitation of fund-raising activities of the SWF to critically depend on

the nature of the dominant business-cycle shock of concern. Specifically, if one were to believe that the Malaysian business-cycle is mainly driven by resource price shocks, as in our empirical results, then an optimal foreign-domestic allocation is in the range of (0.11, 0.89) to (0.19, 0.81) – in line with the fundamental recommendation of ‘first-generations’ Dutch Disease models. However, if one preferred to think that the economy is more affected by domestic preference shocks, then the optimal foreign-domestic allocation is approximately (0.38, 0.62). This socially optimal combination appears to be lower than the benchmark case, therefore suggesting that the Malaysian economy might have hit its absorptive capacity constraint (i.e., a domestic economy saturated by GLCs).

The rest of the article is structured as follows. Section 2 presents the model. Section 3 defines the equilibriums, followed by the derivation of the theoretical condition for GLC profitability. Section 4 discusses the calibration. The Bayesian-estimated results and optimal analysis are presented in Section 5, followed by concluding remarks in Section 6.

## 2 | THE MODEL

The model considered is a discrete-time, small open-economy model with infinitely lived individuals and representative agents. Similar to Agénor, Alper, and Pereira da Silva (2014, 2018), private individuals hold both domestic and foreign bonds – rates of returns to investments made, be it into capital or bonds, are therefore influenced by structural shocks affecting both domestic and foreign interest rates. However, unlike them and most DSGE contributions, we abbreviate from modelling explicitly the banking system, so as to concentrate on the macroeconomic impacts brought about by the GLCs. The government in the economy extracts non-renewal resources (in a non-Hotelling framework similar to Berg et al., 2013; Agénor, 2016), and the resource revenue is then transferred to the budget. In deciding on its usage, the federal government inexplicably allocates this resource wealth between Resource Fund abroad, spending on facilitating fund-raising activities of the SWF, and other government operating expenditure. Given that we interpret GLCs as modernized corporations that produce imperfectly substitutable differentiated variety of goods (similar to private firms, that is, the POEs), they are therefore consistent with the diverse business nature of GLCs in Malaysia (see Ramirez & Tan, 2004; Nawawi, 2018 for a description of SOEs/GLCs in Malaysia), and can be interpreted as the portfolio companies of the SWF. In addition to the original capitalization made by the government and the dividends received from the GLCs, the SWF finances its activities by issuing one-

period bonds to high-profile investors (assumed to be external to the economy). To allow for the examination of our main research question, this fund-raising activity is assumed to be costly and depends on the federal government's spending to facilitate fund-raising; this serves as our model's ‘counterpart’ to a measure of domestic capacity constraint in conventional Dutch Disease models. In the model, the key distinctions between GLCs and POEs are (a) the rental rates they paid for capital stock are different; (b) although initially higher, the fixed cost of the GLCs can potentially benefit from a scale-economies factor that depends on the government spending on facilitation of the fund-raising activities of its ‘parent’, the representative SWF.

### 2.1 | Households

There is a continuum of identical infinitely lived individuals, indexed by  $i \in (0, 1)$ , who derive utility from consumption ( $C_{it}$ ) and leisure. They solve the intertemporal optimization problem by choosing sequences of final good consumption,  $C_{t+s}^i$ , labour hours supplied to both categories of intermediate good (IG) firms,  $L_{t+s}^{i,POE}$  and  $L_{t+s}^{i,GLC}$ , a fund transferred to private capital good producer,  $\zeta_{t+s}^{i,I}$ , the holding of domestic government bonds,  $b_{t+s+1}^i$ , and foreign bonds,  $B_{t+s+1}^{i,F}$ , for  $s = 0, 1, \dots, \infty$ , so as to maximize lifetime utility:

$$U_t^i = \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s A_{t+s}^U \left\{ \frac{(C_{t+s}^i)^{1-\zeta}}{1-\zeta} + \eta_N \ln(1 - L_{t+s}^{i,POE} - L_{t+s}^{i,GLC}) \right\}, \quad (1)$$

where  $\beta \in (0, 1)$  is a discount factor,  $\zeta > 0$  the (inverse) intertemporal elasticity of substitution in consumption,  $\mathbb{E}_t$  the expectation operator conditional on the information available at the beginning of period  $t$ ,  $\eta_N > 0$ , and  $A_t^U$  denotes a mean-one preference shock common to all individuals following a first-order autoregressive [AR(1)] process,  $A_t^U = (A_0^U)^{1-\rho_U} (A_{t-1}^U)^{\rho_U} \exp(\varepsilon_t^U)$ , where  $A_0^U > 0$ ,  $\rho_U \in (0, 1)$  is the associated AR coefficient, and  $\varepsilon_t^U$  is a normally distributed stochastic shock with zero mean and a constant variance ( $\sigma_U^2$ ).

The end-of-period flow budget constraint is

$$\begin{aligned} b_t^i + z_t B_t^{i,F} = & w_t (L_t^{i,POE} + L_t^{i,GLC}) - T_t^i - C_t^i - \zeta_t^{i,I} \\ & + \left( \frac{1 + i_{t-1}^B}{1 + \pi_t} \right) b_{t-1}^i + \left( \frac{1 + i_{t-1}^{L,KP}}{1 + \pi_t} \right) \zeta_{t-1}^{i,I} \quad (2) \\ & + (1 + i_{t-1}^{F,P}) z_t B_{t-1}^{i,F} + J_t^{i,POE} + J_t^{i,K}, \end{aligned}$$

where  $z_t = E_t/P_t$  is the real exchange rate (with  $E_t$  the nominal exchange rate),  $1 + \pi_t = P_t/P_{t-1}$ ,  $b_t^i$  ( $B_t^{i,F}$ ) real

(foreign-currency) holdings of one-period, non-contingent domestic (foreign) government bonds,  $i_t^B$  and  $i_t^{F,P}$  are the interest rates on domestic and foreign government bonds,  $r_t^{\text{POE}}$  and  $w_t$  the economy-wide real wage,  $T_t^i$  real lump-sum taxes,  $J_t^{i,\text{POE}} = \psi \int_0^{1-\phi} \pi_{jt}^{\text{POE}}$  and  $J_t^{i,K} = \psi \pi_t^K$ ,  $\psi \in (0, 1)$  are an individual's share of real profits received from the IG-producing POEs and the private capital good producer. The domestic households are the only holders of domestic government bonds. The gross rate of return on foreign bonds is

$$1 + i_t^{F,P} = (1 + i_t^W)(1 - \theta_t^F), \quad (3)$$

where  $i_t^W$  is the risk-free world interest rate and  $\theta_t^{F,P}$  an endogenous spread taken as given by households, defined as  $\theta_t^F = (\theta_0^F/2)B_t^F$ , with  $\theta_0^F > 0$ .

Each individual  $i$  maximizes Equation (1) with respect to  $C_t^i$ ,  $L_t^{i,\text{POE}}$ ,  $L_t^{i,\text{GLC}}$ ,  $\zeta_t^{i,J}$ ,  $b_{t+1}^i$ , and  $B_{t+1}^{i,F}$ , subject to Equation (2), taking prices, factor returns, premium, and existing stocks as given, yielding first-order conditions of:

$$\mathbb{E}_t \left[ \left( \frac{C_{t+1}}{C_t} \right)^{1/\zeta} \right] = \mathbb{E}_t \left[ \frac{A_{t+1}^U \beta (1 + i_t^B)}{A_t^U (1 + \pi_{t+1})} \right], \quad (4)$$

$$L_t^{i,\text{POE}} + L_t^{i,\text{GLC}} = 1 - \frac{\eta_N (C_t^i)^{1/\zeta}}{w_t}, \quad (5)$$

$$1 + i_t^B = 1 + i_t^{L,\text{KP}}, \quad \text{and} \quad (6)$$

$$B_t^{i,F} = \frac{(1 + i_t^W) \mathbb{E}_t(E_{t+1}/E_t) - (1 + i_t^B)}{(0.5)\theta_0^F (1 + i_t^W) \mathbb{E}_t(E_{t+1}/E_t)}, \quad \forall t. \quad (7)$$

## 2.2 | Resource production and prices

Following Berg et al. (2013) and Agénor (2016), the resource revenue is non-renewable, but the production is modelled by an exogenous stochastic process,

$$\frac{O_t}{\bar{O}} = \left( \frac{O_{t-1}}{\bar{O}} \right)^{\rho_O} \exp(\varepsilon_t^O), \quad (8)$$

where  $\bar{O}$  is the steady-state value of extraction,  $\rho_O \in (0, 1)$  is the associated AR coefficient (which depends on how quickly the resources are depleted), and  $\varepsilon_t^O$  a normally distributed random shock to resource production with zero mean and a constant variance ( $\sigma_{\rho_O}^2$ ). This is a simplified exogenous specification that assumes costless drilling, therefore abstracts from the intertemporal Hotelling

arbitrage considerations explored in studies such as Mason and van't Veld (2013) and Anderson, Kellogg, and Salant (2018). Given that optimal extraction path is a peripheral topic to our main focus, the stream of resource revenue in each period can be interpreted as net profits/dividend stream that is taken as given – albeit subject to random shocks. Nevertheless, as seen later, for our analysis the identification of the variable is based on actual real per capita GDP series: the extraction series in the model context (measured in constant prices, per capita gross value added) is determined residually from the domestic output identity, hence to an extent, ‘endogenous’.

Given that the country is assumed to be not a major world supplier of the non-renewable resource, the real price of resource,  $P_t^O$ , follows an exogenous stochastic process:

$$\frac{P_t^O}{\bar{P}^O} = \left( \frac{P_{t-1}^O}{\bar{P}^O} \right)^{\rho_{P_O}} \exp(\varepsilon_t^{P_O}), \quad (9)$$

where  $\bar{P}^O$  is the steady-state price,  $\rho_{P_O} \in (0, 1)$  is the associated AR coefficient, and  $\varepsilon_t^{P_O}$  a normally distributed random shock with zero mean and a constant variance ( $\sigma_{P_O}^2$ ). Despite the simplified specification, the stochastic AR specification of Equations (8) and (9), together with Bayesian estimation using actual oil price data, allow us to estimate the actual degree of persistence, as in Cherif and Hasanov (2013).

## 2.3 | Domestic final good

There is a representative firm producing a final good,  $Y_t$ , using a basket of domestically produced differentiated intermediate goods (IGs),  $Y_t^D$ , and a basket of imported IGs,  $Y_t^F$ , as in:

$$Y_t = \left[ \Lambda_D (Y_t^D)^{(\eta-1)/\eta} + (1 - \Lambda_D) (Y_t^F)^{(\eta-1)/\eta} \right]^{\eta/(\eta-1)}, \quad (10)$$

where  $\Lambda_D \in (0, 1)$  and  $\eta > 0$  is the elasticity of substitution between the two baskets.

The basket of imported IGs is defined as

$$Y_t^F = \left\{ \int_0^1 \left[ Y_{jt}^F \right]^{(\theta-1)/\theta} dj \right\}^{\theta/(\theta-1)}, \quad (11)$$

where  $\theta > 0$  is the elasticity of substitution among the imported IGs, and  $Y_{jt}^F$  is the quantity of type- $j$  imported intermediate good (IG),  $j \in (0, 1)$ .

Profits maximization by the representative firm yields the demand functions for the domestic and imported IGs:

$$Y_{jt}^i = \left( \frac{P_{jt}^i}{P_t^i} \right)^{-\theta_i} Y_t^i, \quad i = D, F, \quad (12)$$

where  $P_{jt}^D$  ( $P_{jt}^F$ ) is the price of domestic (imported) IG  $j$ , and  $P_t^D$  and  $P_t^F$  are the price indices, given by  $P_t^i = \left\{ \int_0^1 (P_{jt}^i)^{1-\theta_i} dj \right\}^{1/(1-\theta_i)}$ ,  $i = D, F$ , so that  $P_t^i Y_t^i = \int_0^1 P_{jt}^i Y_{jt}^i dj$ .

Demand for baskets of domestic and foreign goods is

$$Y_t^D = \Lambda_D^\eta \left( \frac{P_t^D}{P_t} \right)^{-\eta} Y_t, \quad Y_t^F = (1 - \Lambda_D)^\eta \left( \frac{P_t^F}{P_t} \right)^{-\eta} Y_t, \quad (13)$$

where  $P_t$  is the aggregate price index of final output, given by

$$P_t = \left[ \Lambda_D^\eta (P_t^D)^{1-\eta} + (1 - \Lambda_D)^\eta (P_t^F)^{1-\eta} \right]^{1/(1-\eta)}. \quad (14)$$

Further, the domestically produced intermediate varieties along the continuum  $j \in (0, 1)$  are produced by two categories of firms: the GLCs and the POEs, as given by

$$Y_t^D = \left\{ \int_0^\phi [Y_{jt}^{\text{GLC}}]^{(\omega-1)/\omega} dj + \int_\phi^1 [Y_{jt}^{\text{POE}}]^{(\omega-1)/\omega} dj \right\}^{\omega/(\omega-1)}, \quad (15)$$

where  $\omega > 1$  is the elasticity of substitution across the domestic IGs, and  $\phi \in [0, 1]$  is the steady-state share of GLCs' production in aggregate domestic IGs.<sup>5</sup>

For the domestically produced IGs, profit maximization gives, for each variety  $j$ :

$$Y_{jt}^{\text{GLC}} = \left( \frac{P_{jt}^{\text{GLC}}}{P_t^D} \right)^{\frac{1}{\omega}} Y_t^D, \quad Y_{jt}^{\text{POE}} = \left( \frac{P_{jt}^{\text{POE}}}{P_t^D} \right)^{\frac{1}{\omega}} Y_t^D, \quad (16)$$

where  $P_{jt}^{\text{GLC}}$  and  $P_{jt}^{\text{POE}}$  are the price of IG  $j$ , and the aggregate domestic intermediate price index,  $P_t^D$ , is given by

$$P_t^D = P_0^D \left[ (P_t^{\text{GLC}})^{1-\omega} + (P_t^{\text{POE}})^{1-\omega} \right]^{\frac{1}{1-\omega}}, \quad (17)$$

where  $P_0^D > 0$ ,  $P_t^{\text{GLC}} = \left[ \int_0^\phi (P_{jt}^{\text{GLC}})^{1-\omega} dj \right]^{\frac{1}{1-\omega}}$ , and

$$P_t^{\text{POE}} = \left[ \int_0^{1-\phi} (P_{jt}^{\text{POE}})^{1-\omega} dj \right]^{\frac{1}{1-\omega}}.$$

Using Equation (16), and the representative firm's demand function from Equation (13), we derive

$$Y_{jt}^{\text{GLC}} = \Lambda_D^\eta \left( \frac{P_{jt}^{\text{GLC}}}{P_t^D} \right)^{-\omega} \left( \frac{P_t^D}{P_t} \right)^{-\eta} Y_t, \quad \text{and} \quad (18)$$

$$Y_{jt}^{\text{POE}} = \Lambda_D^\eta \left( \frac{P_{jt}^{\text{POE}}}{P_t^D} \right)^{-\omega} \left( \frac{P_t^D}{P_t} \right)^{-\eta} Y_t. \quad (19)$$

Following Agénor and Jia (2015), the assumptions of no transportation cost and producer currency pricing are imposed. The domestic-currency price of imported good  $j$  is therefore

$$P_{jt}^F = E_t^{\mu^F} E_{t-1}^{1-\mu^F}, \quad (20)$$

where  $\mu^F \in (0, 1)$  measures the degree of exchange rate pass-through. Thus, the law of one price holds only in the steady state.

Exports,  $Y_t^X$ , depend on the domestic-currency price of exports (which equals the exchange rate if the foreign-currency price is normalized to unity), relative to the aggregate price index:

$$Y_t^X = \left( \frac{E_t}{P_t} \right)^\chi, \quad \chi > 0 \quad (21)$$

and is therefore a positive function of the real exchange rate.

Total output in the domestic economy, inclusive of the resource production, is

$$Y_t = Y_t^S + Y_t^X + P_t^O O_t, \quad (22)$$

where  $Y_t^S$  denotes the volume of final goods sold in the domestic market.

## 2.4 | Domestic intermediate goods

The modelling of the GLCs as IG-producers coexisting with the private firms is similar to Tabarraei, Ghiaie, and Shahmoradi (2018), Wen and Wu (2019). Each domestically produced IG,  $Y_{jt}^i$ , is sold in a monopolistically competitive market. For simplicity, we abbreviate from entry and exit considerations, and assume a fixed unit mass of domestic firms operating in the market in each period  $t$ . Each firm  $j$  is assumed to produce one variety  $j$  along the continuum of IGs. Upon entry,  $\phi \in [0, 1]$  firms become



GLCs and  $1 - \phi$  firms become POEs. The firms learn their production function and cost profile, and then proceeds to minimize unit marginal cost given the production function they face. After that, each firm  $j$  chooses prices for the differentiated variety  $j$  produced, taking unit cost as given.

The unit production cost of each variety  $j$  in category  $k$ ,  $k = \text{POE, GLC}$ , takes the form:

$$C_{jt}^k(Y_{jt}^k) = F_{jt}^k + mc_{jt}^k Y_{jt}^k, \quad (23)$$

where  $mc_{jt}^k$  is the unit marginal cost of production that is unique to firm  $j$  of category  $k$ , and  $F_{jt}^k$  is the fixed cost of production incurred in each period  $t$ . To capture our documented empirical stylized fact in Section 1, as well as in line with other anecdotal evidence (for instance, Kowalski et al., 2013), we assume the operation of GLCs to be less efficient but potentially benefitting from the facilitation of fund-raising activities by the government, with the fixed cost differs between the POEs and GLCs:

$$F_{jt}^k = \begin{cases} F_0^{\text{POE}} & \text{if } i = \text{POE} \\ F_0^{\text{GLC}} / \left[ \left( \frac{G_t^{\text{SW}}}{\bar{P}^O \bar{O}} \right)^\mu \right] & \text{if } i = \text{GLC} \end{cases} \quad (24)$$

where  $F_0^{\text{POE}} < F_0^{\text{GLC}}$ , though a GLC's operation can potentially benefit from the government's effort in supporting the SWF fund-raising activities (measured by the amount spent,  $G_t^{\text{SW}}$ , adjusted by the steady-state size of the national resource sector,  $\bar{P}^O \bar{O}$ ) at a magnitude,  $\mu \geq 1$ .

In terms of unit production, output of IG  $j$ ,  $Y_{jt}^k$ ,  $k = \text{POE, GLC}$  is produced by combining labour,  $L_{jt}$ , and physical capital,  $K_{jt}$ , using a Cobb–Douglas production technology,

$$Y_{jt}^k = A_t^Y (L_{jt}^Y)^{1-\alpha} (K_{jt}^k)^\alpha, \quad k = \text{POE, GLC}, \quad (25)$$

where  $\alpha \in (0, 1)$  and  $A_t^Y$  denotes a technology shock common to all IG firms, following an AR(1) process,  $A_t^Y = (A_0^Y)^{1-\rho_A} (A_{t-1}^Y)^{\rho_A} \exp(\varepsilon_t^A)$ , where  $A_0^Y > 0$ ,  $\rho_A \in (0, 1)$  is the associated AR coefficient, and  $\varepsilon_t^A$  is a normally distributed stochastic shock with zero mean and a constant variance ( $\sigma_A^2$ ).

Cost minimization yields the factor returns, the capital-labour ratio, and the unit real marginal cost,  $mc_t$ , as:

$$r_t^k = \alpha \frac{Y_{jt}^k}{K_{jt}^k}, \quad w_t = (1-\alpha) \frac{Y_{jt}^k}{L_{jt}^k}, \quad (26)$$

$$\frac{K_{jt}^k}{L_{jt}^k} = \left( \frac{\alpha}{1-\alpha} \right) \left( \frac{w_t}{r_t^k} \right), \quad (27)$$

$$mc_{jt}^k = \left( \frac{r_t^k}{\alpha} \right)^\alpha \left( \frac{w_t}{1-\alpha} \right)^{1-\alpha}. \quad (28)$$

The main systematic difference between the POEs and the GLCs rests in the process of capital rental and accumulation. The former rents capital at a rate  $r_t^{\text{POE}}, \forall j$  from a private capital good producer, while the latter has access to capital stock financed by the fund-raising activities of its ‘parent’, the representative SWF, at a rental rate,  $r_t^{\text{SW}}, \forall j$ . In terms of labour, both the POEs and GLCs are assumed to face perfectly competitive labour market, and therefore pay a common market wage rate,  $w_t$ .

We assume that firms face zero nominal price adjustment cost, and chooses price in each period  $t$  so as to maximize variable profit,  $\Pi_{jt}^k = (P_{jt}^k - mc_{jt}^k) Y_{jt}^k$ , subject to the demand functions (18) and (19). Price settings are therefore non-forward looking in this economy, allowing us to compare the contemporary profits of GLCs and POEs, while minimizing unnecessary complication brought about by price adjustments (be it Calvo or Rotemberg style).

Assuming that each firm is small, all firms take aggregate demand and aggregate prices as given. Profit maximization then yields the standard constant mark-up optimal pricing:

$$P_{jt}^k = \frac{\omega}{\omega-1} mc_{jt}^k, \quad (29)$$

or, by substituting in Equation (28),

$$P_{jt}^k = \frac{\omega}{\omega-1} \left( \frac{r_t^k}{\alpha} \right)^\alpha \left( \frac{w_t}{1-\alpha} \right)^{1-\alpha}, \quad k = \text{POE, SW}. \quad (30)$$

Using Equations (18), (19), (24), and (30), the nominal profits function of each POE and GLC  $j$  can be expressed as

$$\Pi_{jt}^{\text{POE}} = \Omega_1 \left[ \left( \frac{r_t^{\text{POE}}}{\alpha} \right)^\alpha \left( \frac{w_t}{1-\alpha} \right)^{1-\alpha} \right]^{1-\omega} (P_t^D)^{\omega-\eta} P_t^\eta Y_t - F_0^{\text{POE}}, \quad \text{and} \quad (31)$$

$$\Pi_{jt}^{\text{GLC}} = \Omega_1 \left[ \left( \frac{r_t^{\text{SW}}}{\alpha} \right)^\alpha \left( \frac{w_t}{1-\alpha} \right)^{1-\alpha} \right]^{1-\omega} (P_t^D)^{\omega-\eta} P_t^\eta Y_t - \frac{F_0^{\text{GLC}}}{\left[ (\omega_{\text{SW}} P_t^O O_t) / (\bar{P}^O \bar{O}) \right]^\mu}, \quad (32)$$

respectively, where  $\Omega_1 = [(\omega - 1)^\omega / \omega^\omega] \Lambda_D^\eta$ .

A typical GLC  $j$  makes more nominal (real) non-zero profits than a typical POE  $j$  if and only if  $\Pi_{j,t}^{\text{GLC}} / \Pi_{j,t}^{\text{POE}} > 1$  ( $\pi_{j,t}^{\text{GLC}} / \pi_{j,t}^{\text{POE}} > 1$ ). Using Equations (31) and (32), it is shown in Appendix A that:

**Proposition 1.** *If all privately owned firms make non-zero, positive profits, when the capital rental rate of GLC and POE are the same,  $r_t^{\text{SW}} = r_t^{\text{POE}}$ , given that  $F_0^{\text{POE}} < F_0^{\text{GLC}}$ , there is no feasible solution of government spending on the facilitation of SWF fund-raising activities, in which a typical GLC  $j$  makes more profit than a typical POE  $j$ .*

Proposition 1 provides a formal derivation that is consistent with anecdotal evidence presented in studies such as Wen and Wu (2019). In order for a GLC to have the possibility of making greater profits than a POE, the capital rental rate between the two firms cannot be the same. Indeed, analytically,  $r_t^{\text{SW}} \geq r_t^{\text{POE}}$  for the existence of solutions.

## 2.5 | Private capital good producer

The private capital good producer, owned collectively by the households, keeps the private capital stock in the economy and rents to the privately owned firms (POEs) at the gross rental rate,  $1 + r_t^{\text{POE}}$ . The aggregate private capital stock,  $K_t^{\text{POE}} = \int_0^{(1-\phi)} K_{jt}^{\text{POE}} dj$ , is obtained by combining private investments,  $I_t$ , with the existing capital stock, adjusted for depreciation and adjustment costs:

$$\mathbb{E}_t K_{t+1}^{\text{POE}} = (1 - \delta^P) K_t^{\text{POE}} + A_t^{\text{KP}} \left[ I_t - \frac{\Theta_K}{2} \left( \frac{K_{t+1}^{\text{POE}} - K_t^{\text{POE}}}{K_t^{\text{POE}}} \right)^2 K_t^{\text{POE}} \right], \quad (33)$$

where  $\delta^P \in (0, 1)$  is the depreciation rate,  $\Theta_K > 0$  the capital adjustment cost parameter, and  $A_t^{\text{KP}}$  is a random shock to capital adjustment, governed by an AR(1) process,  $A_t^{\text{KP}} = (A_0^{\text{KP}})^{1-\rho_{\text{KP}}} (A_{t-1}^{\text{KP}})^{\rho_{\text{KP}}} \exp(\varepsilon_t^{\text{KP}})$ , where  $A_0^{\text{KP}} > 0$ ,  $\rho_{\text{KP}} \in (0, 1)$  is the associated AR coefficient, and  $\varepsilon_t^{\text{KP}}$  is the zero-mean error term with a constant variance ( $\sigma_{\text{KP}}^2$ ).

When investments are paid for in advance at the beginning of period  $t$ , the private capital good producer borrows a fund from the households, denoted in real term,  $\zeta_t^I = \int_0^1 \zeta_t^{i,I} di = I_t$ . At the end of period, capital producer receives the income and fully repays the loans to households at a gross nominal rate of  $(1 + i_t^{\text{L,KP}}) P_t \zeta_t^I$ . Subject to Equation (33), the level of investment is chosen to maximize the present value of the discounted stream of

profits, taking the lending rate, rental rate, prices and existing stock as given:

$$\{I_{t+s}\}_{s=0}^\infty = \operatorname{argmax} \mathbb{E}_t \sum_{s=0}^\infty \beta^s \lambda_{t+s} \left( \frac{\Pi_{t+s}^{\text{K}}}{P_{t+s}} \right), \quad (34)$$

where  $\Pi_{t+s}^{\text{K}}$  denotes nominal profits at end of period  $t+s$ , defined as  $\Pi_{t+s}^{\text{K}} = P_{t+s} (1 + r_{t+s}^{\text{POE}}) K_{t+s}^{\text{POE}} - (1 + i_{t+s-1}^{\text{L,KP}}) P_{t+s-1} \zeta_{t+s-1}^I$ , yielding the first-order condition:

$$\mathbb{E}_t (1 + r_{t+1}^{\text{POE}}) = \frac{(1 + i_t^{\text{B}})}{1 + \pi_{t+1}} \mathbb{E}_t \left\{ \left[ (A_t^{\text{KP}})^{-1} + \Theta_K \left( \frac{K_{t+1}^{\text{POE}}}{K_t^{\text{POE}}} - 1 \right) \right] \right\} - \mathbb{E}_t \left\{ (1 - \delta^P) (A_{t+1}^{\text{KP}})^{-1} + \frac{\Theta_K}{2} A_{t+1}^{\text{KP}} \left[ \left( \frac{K_{t+2}^{\text{POE}}}{K_{t+1}^{\text{POE}}} \right)^2 - 1 \right] \right\}. \quad (35)$$

## 2.6 | Government and GLCs

### 2.6.1 | Fiscal budget

The government consumes final goods ( $G_t$ ), saves in a Resource Fund to hold foreign assets ( $G_t^{\text{RF}}$ ), and spends on the facilitation of the fund-raising activities of the strategic holding fund/SWF that owns or holds majority stakes in the GLCs ( $G_t^{\text{SW}}$ ). The government finances its consumption by collecting lump-sum taxes from households ( $T_t = \int_0^1 T_t^i di$ ) and issuing one-period government bonds to households, denoted in real term as  $b_t$ . The bonds issued are repaid in gross term – plus interest,  $i_{t-1}^{\text{B}}$  – in the next period. The government also receives resource revenue in the form of royalties [assumed to involve zero extraction cost, as in Agénor, 2016], expressed in net term,  $P_t^O O_t$ , which is transferred fully to the fiscal budget. Further, as in the specification of Bems and de Carvalho Filho (2011), it also receives net interest rate,  $i_{t-1}^{\text{W}}$ , on the stock of foreign-currency assets,  $F_{t-1}$ , held abroad in the Resource Fund, as well as real (net) dividends from its original capitalization in the SWF,  $V_0$ . The government's budget constraint is therefore

$$P_t^O O_t + i_{t-1}^{\text{W}} \frac{E_{t-1}}{P_{t-1}} F_{t-1} + r_{t-1}^{\text{SW}} V_0 + b_t - \frac{(1 + i_{t-1}^{\text{B}}) b_{t-1}}{1 + \pi_t} = G_t + G_t^{\text{RF}} + G_t^{\text{SW}} - T_t. \quad (36)$$

The general government consumption is assumed to be a fraction  $v \in (0, 1)$  of domestic sales of the final good:

$$G_t = vY_t^S. \quad (37)$$

Without explicitly introducing an interest rate-setting Central Bank, we assume the government sets its domestic bonds rate in a reactionary rule similar to most developing countries' reference rate-setting (Moura & de Carvalho, 2010), in that,

$$i_t^B = \varepsilon_t (i_{t-1}^B)^{\varpi_1} \left[ \frac{Y_t}{\bar{Y}} \right]^{\varpi_2} \left( \frac{1+i_t^W}{1+i_{t-1}^W} \right)^{\varpi_3} ]^{1-\varpi_1}, \quad (38)$$

where  $\varepsilon_t$  denotes a source of random shock with an AR(1) process,  $\varepsilon_t = (\varepsilon)^{1-\rho_M} (\varepsilon_{t-1})^{\rho_M} \exp(\varepsilon_t^\varepsilon)$ , where  $\varepsilon_t^\varepsilon$  is normally distributed with  $\varepsilon$  having mean one and constant variance ( $\sigma_M^2$ ). The government adjusts its bonds rate in each period  $t$ , taking account of the deviations in output and the world interest rate from their respective steady-state levels. Lastly, following Agénor et al. (2014), the government is also assumed to keep its real stock of debt constant ( $b_t = b$ ), and balances its budget by adjusting lump-sum taxes.

## 2.6.2 | Resource fund versus state-owned enterprises

### Resource fund

The real value of foreign assets held in period  $t$  is accumulated according to:

$$F_t = (1-\chi)F_{t-1} + G_t^{\text{RF}}, \quad (39)$$

for an initial  $F_0 \geq 0$ , and  $\chi > 0$  is the asset management cost incurred. In each period  $t$ , the foreign assets held in the resource fund earns a net return, assumed to equal the risk-free world interest rate,  $i_t^W$ . To facilitate our analysis, we assume  $G_t^{\text{RF}}$  to be a fraction  $\omega_{\text{RF}} \in [0, 1]$  of the resource revenue.

### The representative SWF

In line with macroeconomic models such as Pieschacón (2012), Agénor (2016), the relationship between SWF and the GLCs can be interpreted as the latter being the portfolio companies of the former, renting capital stock built by the SWF. Although we recognize that the actual landscape of the government-linked investment funds in Malaysia is too complicated to be modelled in a representative framework, we believe that the specification below is sufficient for the purposes a macroeconomic analysis.<sup>6</sup>

The representative SWF plays a strategic investment role, as described in Halland, Noel, Tordo, and Kloper-Owens (2016). Specifically, in each period it invests in capital stock used by the GLCs,  $K_t^{\text{GLC}} = \int_0^\phi K_{jt}^{\text{GLC}} dj$ , as described by

$$K_t^{\text{GLC}} = (1-\delta^{\text{GLC}})K_{t-1}^{\text{GLC}} + I_t^{\text{GLC}}, \quad (40)$$

where  $\delta^{\text{GLC}} \in (0, 1)$  is the depreciation rate, and the investment amount,  $I_t^{\text{GLC}}$ , is financed by a combination of net fund-raising activities from borrowing/debt/Sukuk-issuance with external high-profile investors,  $\Delta d_t^{\text{SW}}$ , and dividends received from the GLCs, as in the flow-of-funds constraint below:

$$\Delta d_t^{\text{SW}} + \xi \frac{J_{t-1}^{\text{GLC}}}{P_{t-1}} = I_t^{\text{GLC}} + r_t^{\text{SW}} V_0, \quad (41)$$

where the dividends are  $J_{t-1}^{\text{GLC}} = \int_0^\phi \Pi_{jt-1}^{\text{GLC}} dj$ , at a dividend rate,  $\xi \in (0, 1)$ . We assume that the fund-raising activities with high-profile investors are costly. In order to facilitate these, the government spends  $G_t^{\text{SW}}$ , as well as any dividend received from the original capitalization. As such, if there is a one-to-one relationship, then  $G_t^{\text{SW}} + r_t^{\text{SW}} V_0 = \Delta d_t^{\text{SW}}$ . Given the presence of body such as the Putrajaya Committee in supporting the GLCs in Malaysia, as well as the various initiatives of MATRADE every year, this is a stylistic feature justifiable in the Malaysia context.

In a symmetric equilibrium,  $J_{t-1}^{\text{GLC}} = \phi \Pi_{jt-1}^{\text{GLC}}$ . Given these, we combine Equations (40) and (41) to yield:

$$\begin{aligned} K_t^{\text{GLC}} &= (1-\delta^{\text{GLC}})K_{t-1}^{\text{GLC}} + G_t^{\text{SW}} \\ &+ \phi \xi \Omega_1 \left( \frac{r_{t-1}^{\text{SW}}}{\alpha} \right)^{\alpha(1-\omega)} \left( \frac{W_{t-1}}{1-\alpha} \right)^{(1-\alpha)(1-\omega)} (P_{t-1}^D)^{\omega-\eta} (P_{t-1})^{\eta-1} Y_{t-1} \\ &- \frac{\phi \xi (F_0^{\text{GLC}}/P_{t-1})}{\left[ (G_{t-1}^{\text{SW}})/(\tilde{P}^O \tilde{O}) \right]^\mu}, \end{aligned} \quad (42)$$

where  $\Omega_1 = [(\omega-1)^\omega/\omega^\omega] \Lambda_D^\eta$ .

Consistent with Proposition 1, as well as the empirical evidence in studies such as Ramirez and Tan (2004), Feng, Sun, and Tong (2004), and Menon (2014), the novel model feature is that, rental rate charged on GLCs in each period  $t$  is given by

$$r_t^{\text{SW}} = \kappa_0 (r_t^{\text{POE}})^{\kappa_1} (\Delta d_t^{\text{SW}})^{\kappa_2}, \quad (43)$$

where  $\kappa_0, \kappa_1, \kappa_2 \geq 0$ , which depends positively on the prevailing market interest rate,  $r_t^{\text{POE}}$  (which can be



viewed as the opportunity cost of capital rental had the SOEs borrows from the private market), and on the (net) addition of borrowings incurred by the SWFs. The latter means that, the more SWF has to borrow from high-profile investors, the more expensive their required rate of returns will be.

Finally, the non-resource primary balance,  $NB_t$ , is given by<sup>7</sup>:

$$NB_t = T_t + r_{t-1}^{SW} V_0 - G_t. \quad (44)$$

## 2.7 | Market-clearing conditions

The domestic final good market equilibrium is defined as:

$$Y_t^S = C_t + I_t + G_t, \quad (45)$$

with the nominal identity,  $P_t Y_t = P_t^S Y_t^S + P_t^X Y_t^X$  holds.

The current account balance is given by

$$Y_t^X - Y_t^F + i_{t-1}^W F_{t-1} + i_{t-1}^W B_{t-1}^F + \theta_{t-1}^F B_{t-1}^F = \Delta F_t + \Delta B_t^F, \quad (46)$$

which is influenced by the risk-free world interest rate modelled as:

$$\frac{1 + i_t^W}{1 + \tilde{i}^W} = \left( \frac{1 + i_{t-1}^W}{1 + \tilde{i}^W} \right)^{\rho_W} \exp(\varepsilon_t^W), \quad (47)$$

where  $\rho_W \in (0, 1)$  is the AR(1) parameter,  $\tilde{i}^W$  is an exogenously given rate, and  $\varepsilon_t^W$  is the random shock with mean zero and a constant variance ( $\sigma_W^2$ ).

## 3 | SYMMETRIC AND STEADY-STATE EQUILIBRIUM

**Definition 1.** A *symmetric equilibrium* is where all individuals, all SOEs, and all POEs are identical. All individual and aggregate behaviours are also consistent. These mean, for all individuals  $i \in (0, 1)$ ,  $C_t^i = C_t$ ,  $L_t^{i,POE} = L_t^{POE}$ ,  $L_t^{i,GLC} = L_t^{GLC}$ ,  $b_t^i = b_t$ ,  $B_t^{i,F,P} = B_t^{F,P}$ . For all IG-producing firms  $j \in (0, 1)$ ,  $K_{jt}^k = K_t^k$ ,  $L_{jt}^k = L_t^k$  for  $k = POE, GLC$ . By implications, all IG firms produce the same output, and

prices, marginal costs, and profits are the same across firms, hence  $Y_{jt}^k = Y_t^k$ ,  $P_{jt}^k = P_t^k$ ,  $mc_{jt}^k = mc_t^k$ ,  $\Pi_{jt}^k = \Pi_t^k$ .

**Definition 2.** The *steady-state equilibrium* is a stationary symmetric equilibrium in which, for a given set of parameters, (a) all the variables ( $\tilde{C}, \tilde{I}, \tilde{G}, \tilde{L}, \tilde{L}^{GLC}, \tilde{L}^{POE}, \tilde{b}, \tilde{B}^F, \tilde{D}, \tilde{K}^{GLC}, \tilde{K}^{POE}, \tilde{Y}, \tilde{Y}^X, \tilde{Y}^F, \tilde{Y}^{GLC}, \tilde{Y}^{POE}, \tilde{F}, \tilde{T}^O$ ) are constant  $\forall t$ ; (b) the prices, rates, and costs ( $\tilde{P}^{GLC}, \tilde{P}^{POE}, \tilde{P}, \tilde{P}^S, \tilde{P}^X, \tilde{r}^{SW}, \tilde{r}^{POE}, \tilde{w}, \tilde{i}^{F,R}, \tilde{z}, \tilde{i}^{F,P}, \tilde{i}^W$ ) are all constant  $\forall t$ ; (c) the variables associated with resource production ( $\tilde{P}^O, \tilde{O}$ ) are constant  $\forall t$ , and by implications, (d) the inflation rate ( $\tilde{\pi}$ ), profits and marginal costs are constant  $\forall t$ . In addition, in the steady state, all adjustment costs equal zero and there is no random shock to the economy ( $A_t^U = A_0^U, A_t^{KP} = A_0^{KP}, A_t^Y = A_0^Y, \varepsilon_t = \varepsilon_0$ ). Similar to studies such as Agénor et al. (2014), we normalize the steady-state inflation to  $\tilde{\pi} = 0$ .

Having defined the symmetric and steady-state equilibrium, by assuming that  $G_t^{SW}$  is equivalent to a fraction  $\omega_{SW} \in [0, 1]$  of the resource revenue, we derive Proposition 2 in Appendix A, which state the following:

**Proposition 2.** In the symmetric equilibrium, a GLC makes positive real profits if and only if the fraction of the government's resource revenue,  $\omega_{SW}$ , that is equivalent to its spending on facilitating SWF fundraising activity is:

$$\omega_{SW}^* \geq \left[ \frac{(F_0^{GLC}/P_t)}{\Psi_t \kappa_0^{\alpha(1-\omega)} (r_t^{SW})^{\kappa_1 \alpha(1-\omega)}} \right]^{\frac{1}{\mu + \kappa_2 \alpha(1-\omega)}} \left( \frac{P_t^O O_t}{\tilde{P}^O \tilde{O}} \right)^{-1} - \frac{r_t^{SW} V_0}{P_t^O O_t}, \quad (48)$$

where  $\Psi_t = \Omega_2 w_t^{(1-\alpha)(1-\omega)} (P_t^D)^{\omega-\eta} P_t^{\eta-1} Y_t$ , and  $\Omega_2 = \Omega_1 \alpha^{-\alpha(1-\omega)} (1-\alpha)^{(\alpha-1)(1-\omega)}$ . In the steady state, if  $\tilde{r}^{SW} V_0$  is very small and approximates zero, then this translates to:

$$\omega_{SW}^* \geq \left[ \frac{(F_0^{GLC}/\tilde{P})}{\tilde{\Psi} \kappa_0^{\alpha(1-\omega)} (\beta^{-1} - 1 + \delta^P)^{\kappa_1 \alpha(1-\omega)}} \right]^{\frac{1}{\mu + \kappa_2 \alpha(1-\omega)}}. \quad (49)$$

**Assumption.**  $\mu + \kappa_2 \alpha(1-\omega) \neq 0$ . With the assumption, Equations (48) and (49) must be positive for all reasonable parameter values, hence  $\omega_{SW}^* > 0$  exists. Given that the right-hand-side of Equation (48) is influenced by shocks, in all our

subsequent numerical simulations we check this condition by first calculating Equation (49), and then evaluate the solution series computed numerically using Equation (48) to the threshold value implied by Equation (49).

#### 4 | CALIBRATION AND PARAMETER ESTIMATION

The model is estimated with the Bayesian method in the tradition of Smets and Wouters (2003, 2007). We calibrate the model to the Southeast Asian economy of Malaysia, using seven quarterly detrended time series for the period 1991Q1-2016Q4 (year 2016 is the latest year for which actual, and not projected, official population data is available): real per capita GDP, real per capita consumption, real per capita private investment, employment, real oil price, Malaysia's and United States' 10-year government bond rate.<sup>8</sup> These series are obtained from Department of Statistics (DOS), Bank Negara Malaysia (BNM), and Federal Reserve Bank of St Louis Economic Data (for the non-Malaysia data series). We use the real per capita GDP series, together with the domestic output identity, (22), to identify and construct the real oil production series. This is mainly due to the non-comparability of measurement unit between the model variable (in constant prices, per capita gross value added) and the extraction data published by PETRONAS in its financial reports (in barrels per day), with the latter also dated only back to 2005Q1. Note that PETRONAS Holding (or the Ministry of Finance Incorporated) is closest to the specification of the SWF in this model; therefore, some of the calibration strategies are based on its data.

To avoid stochastic singularity, the number of structural shocks equals 7, and in combination with the dynamic parameters in the relevant equations, means the overall empirical strategy involves estimating 24 parameters [ $\zeta$ ,  $\chi$ ,  $\Theta_K$ ,  $\mu$ ,  $\mu^F$ ,  $\kappa_1$ ,  $\kappa_2$ ,  $\varpi_1$ ,  $\varpi_2$ ,  $\varpi_3$ , 7 AR(1) parameters, and 7 standard deviation parameters]. The remaining parameters are calibrated to match the initial steady-state value of variables to first moment of annual data. Given that prices are not forward-looking in the model, and that Malaysia has historically maintained a very steady and low inflation rate, for analytical simplification a zero-inflation steady state is derived in Appendix B.

The calibrated parameters are summarized in Table 1. The discount factor,  $\beta = 0.988$ , corresponds to a steady-state domestic bonds' rate,  $\tilde{i}^B$ , that matches average quarterly 10-year government bond rate. The preference parameter,  $\eta_N$ , is set to 4.5, as in Agénor et al. (2014). The spread parameter for foreign bond returns,  $\theta_0^F$ , is set at a very low value of 0.01, so that the rate of return on

TABLE 1 Benchmark calibrated parameter values

Parameter	Value	Description
<b>Households</b>		
$\beta$	0.988	Discount factor
$\eta_N$	4.5	Preference parameter for leisure
$\theta_0^F$	0.01	Spread parameter, household foreign bonds
<b>Production</b>		
$\Lambda_D$	0.7	Distribution parameter, final good
$\theta$	3.93	Elasticity of substitution, within imported IGs
$\phi$	0.4	GLC share in domestic production
$\omega$	3.93	Elasticity of substitution, within domestic IGs
$\eta$	0.8	Elasticity of substitution, foreign-domestic IGs
$\alpha$	0.35	Elasticity wrt physical capital stock
<b>Private capital good producer</b>		
$\delta^P$	0.017	Depreciation rate, physical capital stock
<b>Government and state-owned enterprises</b>		
$\nu$	0.122	Share of gov. spending in domestic output sales
$\delta^{\text{GLC}}$	0.017	Depreciation rate, physical capital stock
$\xi$	0.08	Dividend raid
$\kappa_0$	1.0	Shift parameter, SWF rental rate
$\omega_{\text{SW}}$	0.374	Resource revenue share, domestic fund-facilitation
$\omega_{\text{RF}}$	0.186	Resource revenue share, resource fund
$\chi$	0.05	Administrative cost in managing foreign assets

privately held foreign bonds approximates the risk-free world interest rate,  $\tilde{i}^W$ . On production, the distribution parameter,  $\Lambda_D$ , and the GLCs' share in domestic production,  $\phi$ , are set to 0.7 and 0.4 respectively, in line with the averages observed in the *Annual Surveys of Manufacturing Industries* published by DOS. For the elasticities of substitution, first, we set the across-variety (domestic-foreign) elasticity,  $\eta = 0.8$ , following Agénor et al. (2014) and in line with the empirical estimates of Antràs (2004). From Zeufack and Lim (2013), the average profit margin of Malaysian firms is 0.2544. This yields a mark-up of 1.3412, which in turn, gives  $\omega = 3.93$ . We set the within-foreign IG elasticity to  $\theta = 3.93$  too, hence establishing a benchmark of  $\omega, \theta > \eta$ , consistent with the 'within-variety > across-variety' specifications of Brambilla, Hale, and Long (2009). The elasticity with respect to physical capital stock,  $\alpha = 0.35$ , is fairly standard and consistent with the macroeconomic data of Malaysia. We set the

two depreciation rates,  $\delta^{\text{SOE}} = \delta^P = 0.017$ , which is consistent with the annual depreciation rate of 0.068 calculated from PETRONAS's financials, and in Lim (2019). The share of government spending in domestic output sales,  $v = 0.122$ , is calculated from macroeconomic data, whereas  $\xi = 0.8$  and  $\kappa_0 = 1.0$  are set (in the absence of corresponding data) so as to match the steady-state GLC capital stock to the average real value of PETRONAS's *property, plant, equipments* in the 2010–2017 period.<sup>9</sup> For the fraction of the resource revenue equivalent to the spending in facilitating fund-raising activities of the SWF,  $\omega_{\text{SW}}$ , and the fraction invested in foreign assets,  $\omega_{\text{RF}}$ , we utilize publicly available information from the Annual Reports of PETRONAS in the same period. Specifically, investment breakdown by geographical segments are used as proxy, with the benchmark fraction invested in

foreign assets,  $\omega_{\text{RF}}$ , estimated using the annual total investments made outside of Malaysia, yielding an average of 0.186. Next, from the Economic Reports published annually by the Ministry of Finance Malaysia, we obtain real figures for the residual oil royalties spent on government operating expenditure,  $1 - \omega_{\text{SOE}} - \omega_{\text{RF}}$ . Combining these two information,  $\omega_{\text{SOE}} = 0.374$ .

For the Bayesian-estimated dynamic parameters, Table 2 reports the prior and posterior distributional forms, means, and standard deviations. The priors on these parameters are chosen so that they are in line with existing studies and harmonized across different shocks. Moreover, the choices of prior distributions take into consideration the parameters' domain and prior means, as in the existing literature. First, given the well-documented mixed empirical evidence (Havranek, Horvath, Irsova, &

**TABLE 2** Summary statistics for prior and posterior distribution of parameters

Description		Prior			Posterior	
		PDF	Mean	SD	Mean	SD
<b>Structural parameters</b>						
Elasticity of intertemporal substitution	$\zeta$	Gamma	0.5	0.2	1.55	0.254
Private capital adjustment cost parameter	$\Theta_K$	Gamma	100	50	158.6	34.88
Economies of scale, GLC fixed cost	$\mu$	Gamma	7.0	2.0	6.75	1.894
Pass-through parameter	$\mu^F$	Beta	0.3	0.1	0.40	0.109
Elasticity of exports wrt exchange rate	$\chi$	Gamma	0.7	0.2	1.73	0.275
SWF rental rate, wrt market rate	$\kappa_1$	Beta	0.7	0.2	0.80	0.150
SWF rental rate, wrt corporate debt change	$\kappa_2$	Beta	0.3	0.2	0.49	0.117
Elasticity of gov reference rate, lagged rate	$\varpi_1$	Beta	0.7	0.15	0.86	0.070
Elasticity of gov reference rate, output	$\varpi_2$	Gamma	0.2	0.1	0.22	0.104
Elasticity of gov reference rate, risk-free rate	$\varpi_3$	Gamma	0.3	0.1	0.10	0.058
<b>Shock persistence parameters</b>						
Productivity shock	$\rho_A$	Beta	0.5	0.2	0.70	0.041
Preference shock	$\rho_U$	Beta	0.5	0.2	0.84	0.027
Bond reference rate-setting shock	$\rho_M$	Beta	0.5	0.2	0.10	0.058
POE investment/capital accumulation	$\rho_{\text{KP}}$	Beta	0.5	0.2	0.65	0.077
World interest rate shock	$\rho_W$	Beta	0.5	0.2	0.34	0.068
Commodity price-specific	$\rho_{P_o}$	Beta	0.5	0.2	0.59	0.057
Resource production-specific	$\rho_O$	Beta	0.5	0.2	0.72	0.052
<b>Stochastic shock standard deviation parameters</b>						
Productivity shock	$\sigma_A$	Inv-gamma	0.1	2.0	0.94	0.069
Preference shock	$\sigma_U$	Inv-gamma	0.1	2.0	0.49	0.107
Bond reference rate-setting shock	$\sigma_M$	Inv-gamma	0.1	2.0	0.09	0.007
POE investment/capital accumulation	$\sigma_{\text{KP}}$	Inv-gamma	0.1	2.0	0.06	0.005
World interest rate shock	$\sigma_W$	Inv-gamma	0.1	2.0	0.10	0.007
Commodity price-specific	$\sigma_{P_o}$	Inv-gamma	0.1	2.0	1.51	0.106
Resource production-specific	$\sigma_O$	Inv-gamma	0.1	2.0	2.67	0.190

Rusnak, 2015), the prior mean for the (inverse) intertemporal elasticity of substitution is set at 0.5, in line with Trabandt and Uhlig (2011) and Jin (2012). This is so as to let the time series data dictate the country-specific posterior estimate. The prior mean for the exchange rate pass-through,  $\mu^F$ , is set at 0.3, in line with the estimates of Soto and Selaive (2003). The prior mean for exchange rate elasticity of exports,  $\kappa = 0.7$ , is in line with the country-level estimates of Ahmed, Appendino, and Ruta (2015). For the government bond rate-setting parameters, the prior means of  $\varpi_1 = 0.7$ ,  $\varpi_2 = 0.2$ ,  $\varpi_3 = 0.3$  are consistent with the Taylor-type rules literature for developing economies, such as Moura and de Carvalho (2010), Agénor et al. (2014). The prior mean of the capital adjustment cost parameter,  $\Theta_K$ , is set at a large value of 100, following Hristov and Hülsewig (2017). For the prior means of the SOE-related parameters,  $\mu = 7.0$ ,  $\kappa_1 = 0.7$ ,  $\kappa_2 = 0.3$  are set as priors. From Equation (43), the choice of the latter two means a market interest rate of 0.03 would yield a reasonable SOE rental rate of 0.0375. These parameter choices yield a non-resource primary balance of  $-4.9\%$  of GDP, which matches Malaysia's actual fiscal position.

Following Ojeda-Joya et al. (2016) and Hristov and Hülsewig (2017), we give relatively large prior variance to structural parameters so that the kurtosis of posterior distributions is not heavily influenced by prior means: the data can therefore 'speak for themselves'. For the shock persistence and standard deviation parameters, our choices of prior means are consistent with the existing Bayesian DSGE literature [for instance, Christiano, Eichenbaum, & Evans, 2005, Geweke, 1999, 2005, Smets & Wouters, 2003, 2007; Smets & Villa, 2016], as well as notable emerging countries' business-cycle studies such as García-Cicco, Pancrazi, and Uribe (2010). Specifically, we assume Beta distribution with 0.5 mean and 0.2 standard deviation for the AR(1) parameters, and inverse-gamma distribution with 0.1 mean and 2.0 standard deviation for the standard deviation parameters.

Given that, to our knowledge, the only existing estimated DSGE model for Malaysia (Alp, Elekdag, & Lall, 2012) covers only the short period of 2000–2010 and is developed to study vastly different issues, the estimated posterior means are largely assessed against the aforementioned studies in the *Dutch Disease* literature, such as Berg et al. (2013), Araujo et al. (2016), Agénor (2016), as well as country-specific empirical estimates. Diagnostic tests for the convergence of the Markov chains of the parameters are also performed using sample drawn from the Metropolis-Hasting algorithm, in line with Geweke (1999, 2005). Our estimation results give a posterior mean of  $\zeta = 1.55$ , which yields  $\zeta^{-1} = 0.645$  and therefore higher than the 0.173 documented in Havranek

et al. (2015) for Malaysia using meta-analyses.<sup>10</sup> Next, the posterior mean for the exchange rate elasticity of exports,  $\kappa = 1.73$ , is at the upper-end of the empirical estimates of Ahmed et al. (2015), but within-range of the country-specific estimates of Kumar (2011) and Tsen (2011). For the other 8 parameters, save for the novel variable of GLCs' capital rental rate elasticity, estimated at  $\kappa_2 = 0.49$ , the estimated posterior means are within reasonable range of the prior means imposed, indicating good fits. For the shock parameters, we find pronounced differences in persistence and volatility of various shocks. Among the seven shocks examined, the reference rate-setting and the world interest rate shocks are the least persistent [AR(1) parameters of 0.10 and 0.34 respectively], while the preference shock is the most [AR(1) parameter equal to 0.84]. The other four shocks have AR(1) parameters ranging from 0.34 to 0.72, all within reasonable range expected from the Malaysian business cycle in the past 20 years. In comparison to the small-sample estimates of Alp et al. (2012), which covers only 10 years, the overall shock persistence estimates appear to be smaller when the structural shocks of the natural resources sector are accounted for. In terms of volatility, we find both commodity shocks to be very large (posterior mean of standard deviation for oil price shock is 1.51, and for production shock, 2.67), indicating potentially large impact (compared to the other shocks) on the Malaysian business cycle. Nevertheless, such magnitudes have been commonly observed in the Dutch Disease literature. All the other standard-deviation parameters have estimated posterior means that approximate the specified priors. For instance,  $\sigma_A = 0.94$  and  $\sigma_U = 0.49$  are estimated for the productivity and preference shocks, which are within a reasonable range (posterior standard deviations of the estimated mean are less than 0.107).

## 5 | ANALYSIS

Based on the estimated model, we first examine how key variables react to exogenous unanticipated disturbances in the economy using variance decomposition and impulse response analysis. The results observed provide the necessary business-cycle context for the model economy in guiding the subsequent optimal analysis. For robustness, we further implement an alternative Bayesian-estimation analysis that accounts for measurement errors in observed variables, as in An and Schorfheide (2007). Next, we evaluate Proposition 2 numerically to identify a threshold value,  $\omega_{SW}^*$  above which GLCs are profitable.<sup>11</sup> After that, the optimality considerations are analysed in the context of the minimization of a fundamental social loss function, which takes

into account of both macroeconomic stability and consumption volatility [argued in Agénor, 2016 as a better welfare criterion to account for the revealed preference of developing-economy policymakers than pure utility-based measures].

## 5.1 | Variance decomposition and impulse responses

Table 3 reports the unconditional variance decomposition analysis of all the relevant output measures ( $Y_t, Y_t^D, Y_t^{GLC}, Y_t^{POE}, Y_t^X, Y_t^F$ ), consumption, investment, rental rates of physical capital stock ( $r_t^{SW}, r_t^{POE}$ ), bonds' reference rate, inflation rate, profits ( $\Pi_t^{GLC}, \Pi_t^{POE}$ ), resource fund size ( $F_t$ ), and exchange rate in the estimated model. First, similar to what is commonly observed for the business cycles of developing economies (García-Cicco et al., 2010), both preference and productivity shocks are key drivers to changes in many variables in the economy, with the former largely dominating the latter. For instance, both shocks combine to account for 90% of the variation in domestic inflation rate, and over 60% of the variations in final good, domestic production, exports, imported IGs, and the movements in exchange rate. In addition, the two commodity shocks (both production and price shocks) are found to play significant

roles in driving the Malaysian business cycle. Conditional on the simplistic specification of the evolution of resource extraction in the model (in practice, the effects of both are intertwined), between the two, oil production shock plays a larger role than the WTI crude oil price-proxied price shock, indicating the dominant role of PETRONAS and GLCs in driving the Malaysian business cycle. Indeed, in terms of variation in final good,  $Y_t$ , the combination of the resources shocks account for 21.91%, which trails only preference shock (42.7%). These results are consistent with the economic structure and historical performance of Malaysia – predominantly GLC-driven yet possesses a relatively robust private consumption of components [see, for instance, Nawawi, 2018, Government of Malaysia, 2006, 2012]. Further, despite a purely exogenous specification, the resources shocks account for over 90% of the variations in the GLC- and POE-intermediate goods' production, the SWF-specific rental rates, the Resource Fund's asset size, and most importantly, both GLC and POE profits in the economy. Such a dominant role of resources shocks in driving the business cycle is consistent with non-estimated models in studies such as Araujo et al. (2016) and Agénor (2016). The role of the commodity shocks in being the main drivers of the variations in POEs' profitability, investment, rental rate, and employment share is also inconsistent with empirical documentations of the industrial structure in Malaysia:

**TABLE 3** Variance decomposition analysis

Variables	Structural shocks						
	TFP shock	World interest	Reference rate shock	Resource price	Preference shock	Investment specific	Resource production
Final good, $Y_t$	21.45	0.31	1.46	7.74	42.70	12.16	14.17
Domestic IGs, $Y_t^D$	50.72	0.50	2.28	5.14	20.40	10.10	10.87
GLC IGs, $Y_t^{GLC}$	0.31	0.00	0.03	14.00	1.03	0.05	84.57
POE IGs, $Y_t^{POE}$	0.57	0.01	0.05	13.20	1.40	0.15	84.62
Exports, $Y_t^X$	51.37	1.48	19.39	0.63	24.48	1.27	1.39
Imported IGs, $Y_t^F$	3.24	0.28	4.91	7.56	61.25	10.09	12.67
Consumption, $C_t$	4.64	0.06	3.54	8.29	27.53	2.63	53.32
Investment, $I_t$	0.75	0.02	1.19	16.19	14.28	18.60	48.98
SWF required return, $r_t^{SW}$	0.29	0.01	0.07	18.83	3.71	0.14	76.95
Private rental rate, $r_t^{POE}$	1.27	0.06	0.29	14.31	16.48	0.63	66.96
Policy/reference rate, $i_t^B$	8.40	0.19	51.66	2.12	27.40	4.68	5.54
Inflation rate, $\pi_t$	26.70	0.45	0.84	1.70	65.92	1.30	3.09
GLC profits, $\Pi_t^{GLC}$	0.08	0.00	0.03	16.19	1.64	0.05	82.01
POE profits, $\Pi_t^{POE}$	0.25	0.03	0.21	13.08	8.98	0.30	77.13
Resource fund, $F_t$	0.00	0.00	0.00	13.49	0.00	0.00	86.51
Exchange rate, $E_t$	5.47	1.24	4.80	3.72	59.68	1.39	23.70



GLCs are industrial leaders and dominant players, hence dictating business terms and influencing private profitability (Menon, 2014; Zeufack & Lim, 2013).

A potential criticism of these macroeconomic data-driven findings is that Malaysia is not very resource-dependent and many of its GLICs hold equity stakes

across horizontally diversified sectors. While these can be easily countered by the fact that oil revenue as a percentage of total government revenue in Malaysia averages at 24.6% over our sample period, reaching as high as 35.5% during the 2006–2014 period (not including any multiplier effect associated with backward and forward-

**TABLE 4** Summary statistics for prior and posterior distribution of parameters (alternative est.)

Description		Prior			Posterior	
		PDF	Mean	SD	Mean	SD
<b>Structural parameters</b>						
Elasticity of intertemporal substitution	$\zeta$	Gamma	0.5	0.2	1.69	0.332
Private capital adjustment cost parameter	$\Theta_K$	Gamma	100	50	191.9	40.79
Economies of scale, GLC fixed cost	$\mu$	Gamma	7.0	2.0	6.64	1.86
Pass-through parameter	$\mu_F$	Beta	0.3	0.1	0.35	0.11
Elasticity of exports wrt exchange rate	$\chi$	Gamma	0.7	0.2	1.36	0.26
SWF rental rate, wrt market rate	$\kappa_1$	Beta	0.7	0.2	0.80	0.150
SWF rental rate, wrt corporate debt change	$\kappa_2$	Beta	0.3	0.2	0.56	0.119
Elasticity of gov reference rate, lagged rate	$\varpi_1$	Beta	0.7	0.15	0.85	0.100
Elasticity of gov reference rate, output	$\varpi_2$	Gamma	0.2	0.1	0.22	0.105
Elasticity of gov reference rate, risk-free rate	$\varpi_3$	Gamma	0.3	0.1	0.14	0.077
<b>Shock persistence parameters</b>						
Productivity shock	$\rho_A$	Beta	0.5	0.2	0.81	0.036
Preference shock	$\rho_U$	Beta	0.5	0.2	0.84	0.034
Bond reference rate-setting shock	$\rho_M$	Beta	0.5	0.2	0.46	0.278
POE investment/capital accumulation	$\rho_{KP}$	Beta	0.5	0.2	0.76	0.074
World interest rate shock	$\rho_W$	Beta	0.5	0.2	0.32	0.072
Commodity price-specific	$\rho_{P_o}$	Beta	0.5	0.2	0.60	0.057
Resource production-specific	$\rho_O$	Beta	0.5	0.2	0.78	0.042
<b>Stochastic shock standard deviation parameters</b>						
Productivity shock	$\sigma_A$	Inv-gamma	0.1	2.0	0.67	0.071
Preference shock	$\sigma_U$	Inv-gamma	0.1	2.0	0.43	0.094
Bond reference rate-setting shock	$\sigma_M$	Inv-gamma	0.1	2.0	0.06	0.011
POE investment/capital accumulation	$\sigma_{KP}$	Inv-gamma	0.1	2.0	0.03	0.005
World interest rate shock	$\sigma_W$	Inv-gamma	0.1	2.0	0.09	0.008
Commodity price-specific	$\sigma_{P_o}$	Inv-gamma	0.1	2.0	1.51	0.106
Resource production-specific	$\sigma_O$	Inv-gamma	0.1	2.0	2.44	0.191
<b>Measurement error parameters</b>						
Output obs. error vol.	$\sigma_Y^e$	Inv-gamma	0.1	2.0	1.21	0.153
Consumption obs. error vol.	$\sigma_C^e$	Inv-gamma	0.1	2.0	0.13	0.150
Inv. obs. error vol.	$\sigma_I^e$	Inv-gamma	0.1	2.0	0.09	0.082
Labour obs. error vol.	$\sigma_L^e$	Inv-gamma	0.1	2.0	0.06	0.021
Reference rate obs. error vol.	$\sigma_r^e$	Inv-gamma	0.1	2.0	0.05	0.008
World interest rate obs. error vol.	$\sigma_w^e$	Inv-gamma	0.1	2.0	0.04	0.008
Resource price obs. error vol.	$\sigma_{P_o}^e$	Inv-gamma	0.1	2.0	0.08	0.052

linkages), we implement a further robustness check by Bayesian-estimating the model again using the methodology of An and Schorfheide (2007). Particularly, we consider the possibility that elements not captured by this model may be absorbed by shock processes, such as the resource shocks, and hence affect our estimation results. The inclusion of measurement errors is then useful to isolate the variation of observed variables arising from non-captured variables.

Table 4 presents the estimation results with measurement errors. In comparison to Table 2, it is obvious that the estimated posterior mean values of the structural parameters and shock processes are consistent with the benchmark results. Further, the measurement errors for the majority of observed variables appear to be negligible, apart from the output. However, as illustrated in Figure 1, the model-implied output path (in logs) traces closely to the actual data, which means that this is also immaterial to the overall results. These findings, therefore, indicate that unaccounted factors are unlikely to fundamentally change our benchmark results. Indeed, Table 5 presents the variance decomposition analysis using this alternative estimation method. Despite some slight numerical differences, all the qualitative findings documented earlier remain robust and minimally affected by measurement errors associated with omitted variables. In other words, the significance of resource shocks in driving the Malaysian business cycle remains robust, despite the economy having a much more diversified structure than OPEC economies.

Next, we examine the impulse responses of the seven shocks, where a 1% temporary increase in the relevant standard deviation is simulated for each case. For illustration, four cases of temporary shocks are presented: productivity shock, preference shock, world interest rate shock, and commodity price shock, as in Figures 2–5 respectively. The first three are main business-cycle

shocks typically considered in a small open economy, while the commodity price shock is the main source of cyclical dynamics in this economy.<sup>12</sup> Figure 2 shows that, following a classic positive *productivity* shock, output, consumption, and profits all rise, though both the physical capital rental rates fall, implying a lower utilization rate. The inflation rate is also lower temporarily in the short run. On the other hand, following a positive preference shock, in Figure 3 we see that output, consumption, and profits increase too. The difference from the supply-side shock is that both the capital rental rates increase in this case due to the higher capital utilization arisen from a higher demand. The exchange rate effect is also positive due to the derived exports demand associated with higher domestic demand. Both sets of results in Figures 2 and 3 are consistent with observations in conventional models such as Smets and Wouters (2003, 2007). In Figure 4, following an increase in world interest rate, the combination of a reallocation of household portfolio towards foreign assets and the higher domestic bond rate set [as in Equation (38)] results in a temporary dampening effect on production and by implications, the profitability of both GLCs and POEs. Although external risk is not a key focus in this article, the interest-rate responses and real contractionary effects observed are consistent with the results in external risk-focused open economy models, such as Mendoza (2010), Agénor et al. (2014, 2018). Lastly, Figure 5 presents the impulse response results associated with a temporary increase in commodity price. Despite the novel introduction of a representative SWF and its portfolio GLCs, overall the responses of macroeconomic variables are in line with the Dutch Disease literature (Agénor, 2016; van der Ploeg & Venables, 2011, 2013), which include an expansionary effect on final good, temporary spike in cost-push inflation, and the classic real exchange rate appreciation.

**FIGURE 1** Comparing model-implied output with data [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

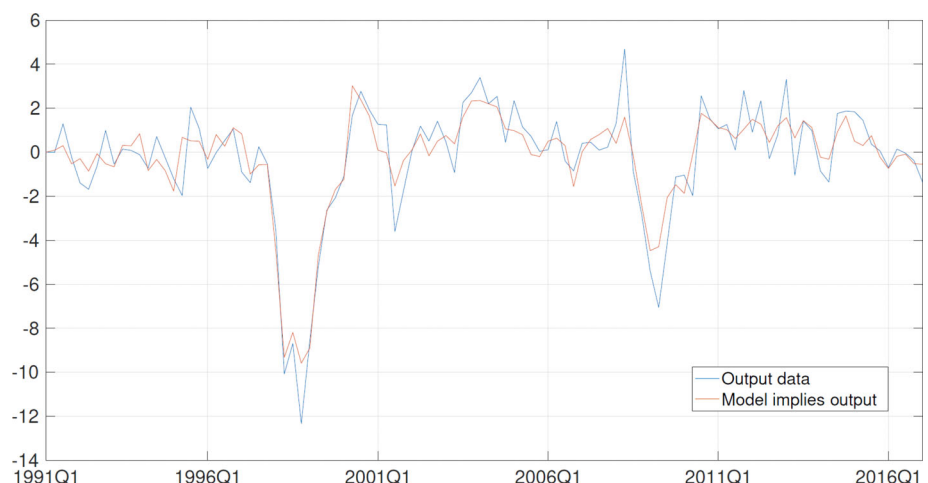


TABLE 5 Variance decomposition analysis (alternative results)

Variables	Structural shocks						
	TFP shock	World interest	Reference rate shock	Resource price	Preference shock	Investment specific	Resource production
Final good, $Y_t$	13.76	0.34	3.46	11.94	54.34	7.50	8.66
Domestic IGs, $Y_t^D$	46.20	0.61	2.91	8.16	26.96	7.80	7.37
GLC IGs, $Y_t^{GLC}$	0.15	0.00	0.03	12.22	0.55	0.02	87.04
POE IGs, $Y_t^{POE}$	0.22	0.00	0.04	11.36	0.73	0.05	87.60
Exports, $Y_t^X$	54.60	1.90	25.77	0.88	13.29	1.89	1.67
Imported IGs, $Y_t^F$	1.27	0.37	10.53	10.18	66.60	4.52	6.53
Consumption, $C_t$	2.66	0.05	3.43	8.76	16.00	1.88	67.22
Investment, $I_t$	1.69	0.02	1.20	22.46	8.90	9.45	56.28
SWF required return, $r_t^{SW}$	0.30	0.01	0.07	19.49	2.21	0.03	77.88
Private rental rate, $r_t^{POE}$	1.27	0.03	0.31	15.55	9.25	0.14	73.44
Policy/reference rate, $i_t^B$	8.64	0.15	42.38	3.69	36.87	4.01	4.26
Inflation rate, $\pi_t$	24.06	0.50	1.60	2.11	69.13	0.38	2.22
GLC profits, $\Pi_t^{GLC}$	0.02	0.00	0.03	14.99	0.95	0.01	84.00
POE profits, $\Pi_t^{POE}$	0.08	0.02	0.19	12.30	4.61	0.07	82.74
Resource fund, $F_t$	0.00	0.00	0.00	11.63	0.00	0.00	88.37
Exchange rate, $E_t$	7.39	1.24	5.47	4.10	50.41	1.11	30.28

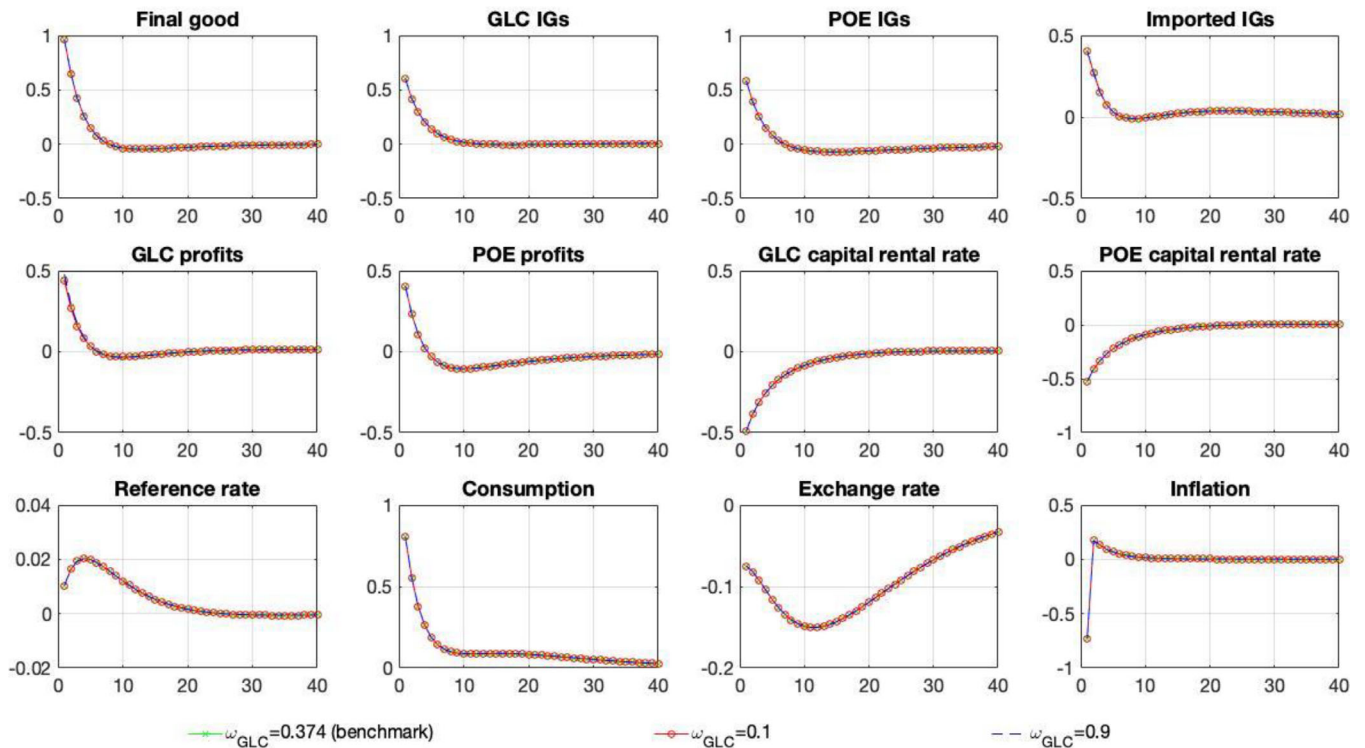
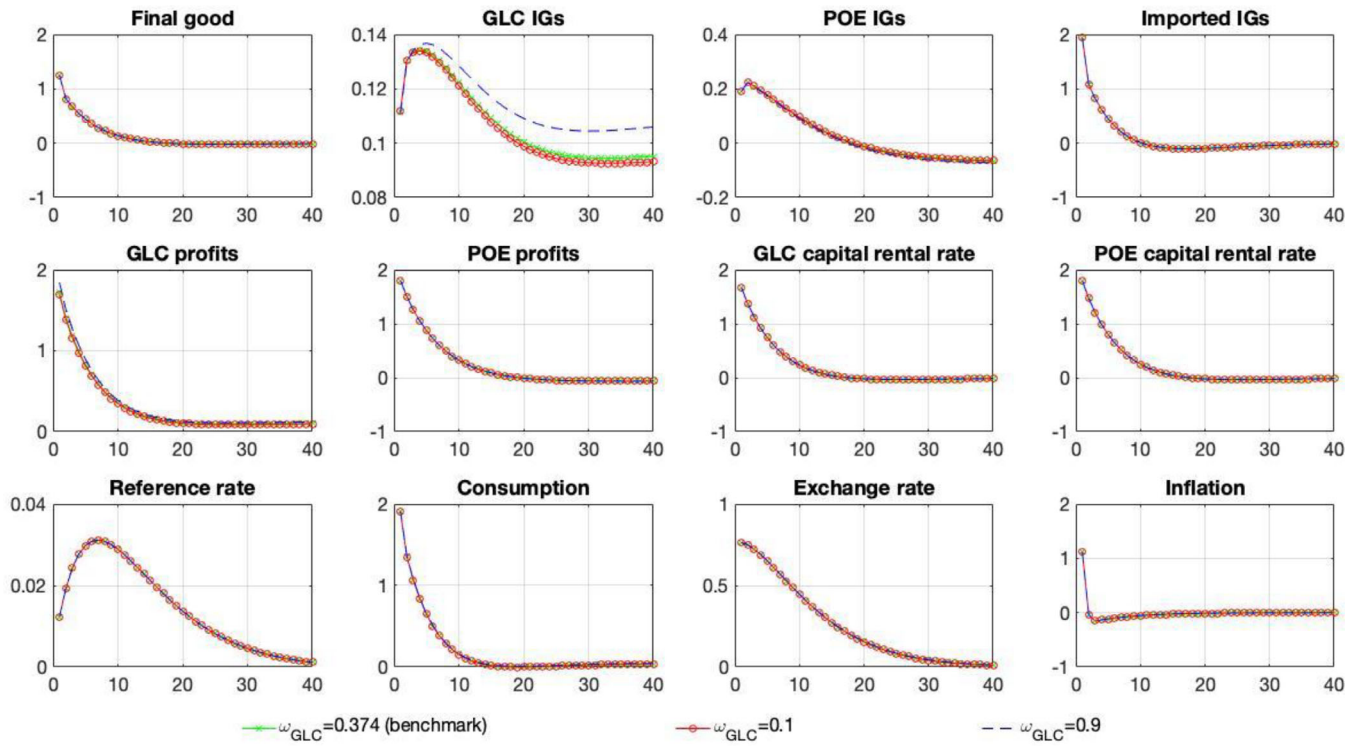
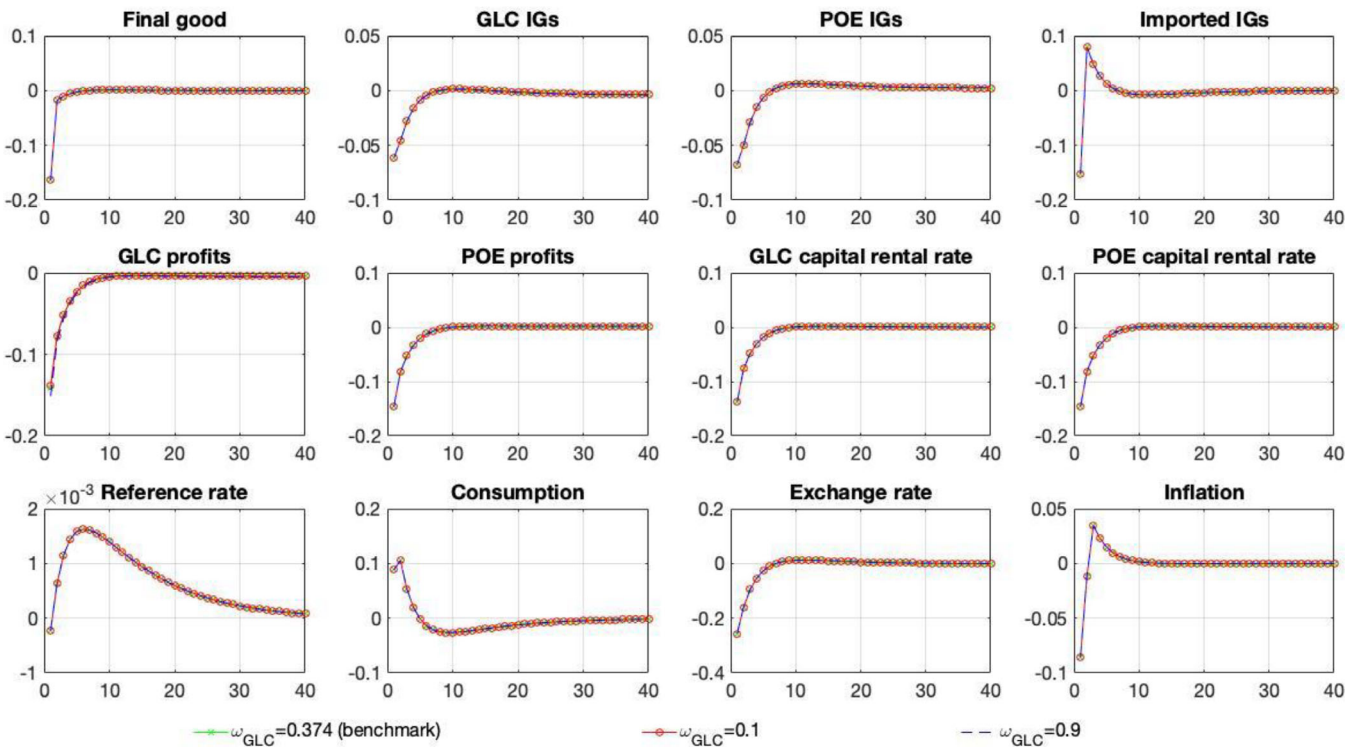


FIGURE 2 Impulse response: temporary productivity shock (one standard deviation increase) [Colour figure can be viewed at wileyonlinelibrary.com]



**FIGURE 3** Impulse response: temporary preference shock (one standard deviation increase) [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



**FIGURE 4** Impulse response: temporary world interest-rate shock (one standard deviation increase) [Colour figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

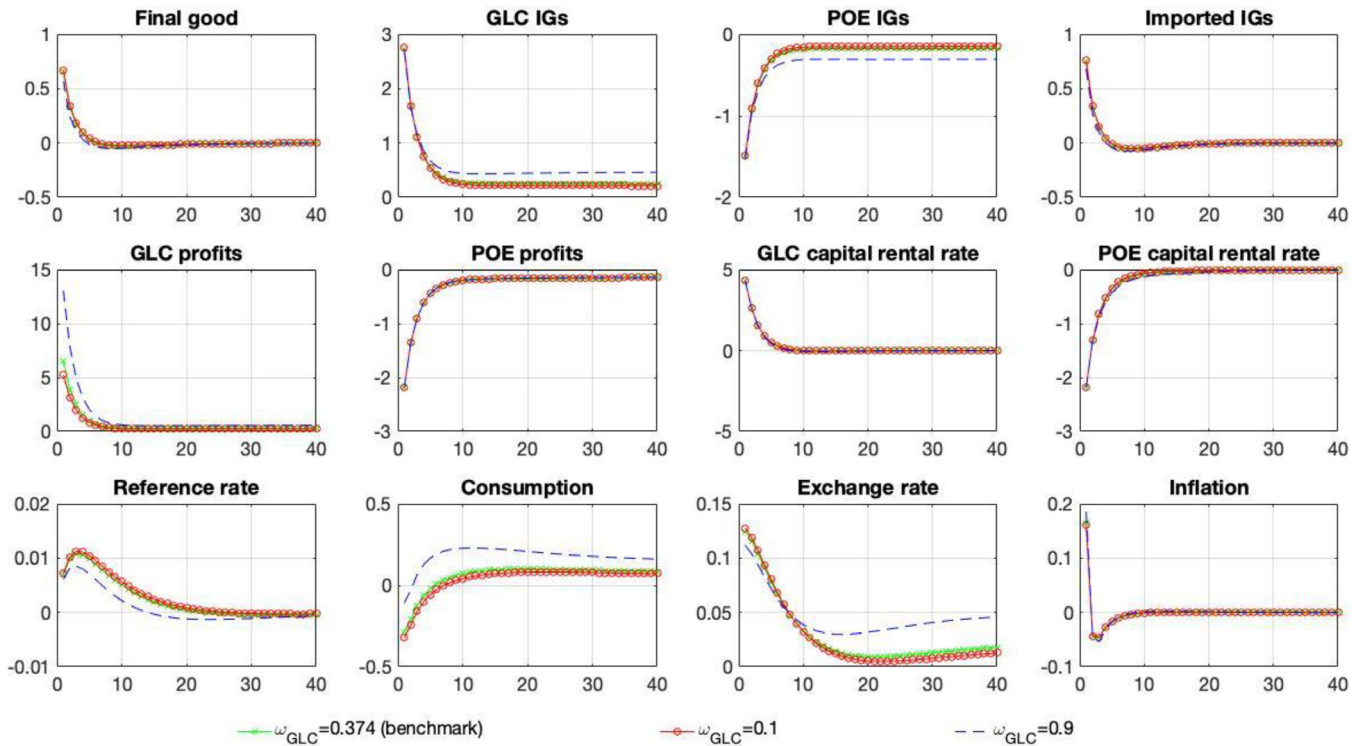


FIGURE 5 Impulse response: temporary resource price shock (one standard deviation increase) [Colour figure can be viewed at wileyonlinelibrary.com]

### 5.2 | Optimal allocation

Having estimated key model parameters and then solved for both the dynamic system and steady-state solutions (see Appendices A and B), we evaluate the theoretical conditions determining SOE profitability using the analytically derived expressions for Proposition 2. It is straightforward to calculate a positive threshold value of  $\omega_{SW}^*$ , which depends on the fixed cost value,  $F_0^{GLC}$ . In the benchmark calibration discussed,  $F_0^{GLC}$  is determined residually from the steady-state expression of (42), yielding  $F_0^{GLC} = 0.0013$ . From Equation (49), this requires a threshold value of  $\omega_{SW} = 0.480$ . Given that  $\omega_{SW} = 0.374$  in the benchmark, this means in the benchmark steady-state equilibrium solved for the calibrated Malaysian economy, a typical GLC does not make a profit. Nevertheless, from Equation (48), the procyclicality of GLC profitability (to commodity shocks) is easily observed. For instance, during a ‘resource boom’ period when  $P_t^O O_t / \bar{P} \bar{O} = 1.5$ , a much lower threshold  $\omega_{SW}^* = 0.324 < \omega_{SW} = 0.374$  is obtained, indicating a period when SOEs are making positive profits. This resource procyclicality of GLC profitability – and by implications, their higher capital reinvestment behaviours during resource boom – is entirely consistent with the empirical evidence documented in Arezki and Ismail (2013). Indeed, for the calibrated Malaysian economy, a

threshold ratio of 1.3178 can be established numerically: in any given year, a typical GLC makes positive profits if and only if the resource royalties generated is 31.78% higher than its steady-state value.

Next, we examine for optimal allocation of resource wealth. Specifically, suppose 44% of resource revenue is spent on other operating expenditure by the government in each period, and the remaining 56% is allocated between  $\omega_{SW}$  and  $\omega_{RF}$ , as in the benchmark calibration. Let  $\varphi \in (0, 1)$  be the fraction of resource wealth spent on facilitation of fund-raising activities of SWF and  $1 - \varphi$  on foreign asset investment in the resource fund, to address this, following Agénor (2016), we define a fundamental social loss function:

$$W^F(\varphi) = \left(\frac{\sigma_C^\varphi}{\sigma_C^B}\right)^\Gamma \left(\frac{\sigma_{NB}^\varphi}{\sigma_{NB}^B}\right)^{1-\Gamma}, \quad (50)$$

which is a weighted geometric average of the volatility of private consumption,  $\sigma_C^\varphi$  (welfare consideration for risk-averse households), and the volatility of the non-resource primary balance,  $\sigma_{NB}^\varphi$  (a macroeconomic stability criterion), normalized with respect to the respective volatility measures ( $\sigma_C^B, \sigma_{NB}^B$ ) corresponding to a shock in the benchmark case with baseline resource wealth allocation.  $\Gamma \in [0, 1]$  is the policy weight. A government that concerns



only about household welfare corresponds to  $\Gamma = 1$ , whereas a regime with pure fiscal-stability goal corresponds to  $\Gamma = 0$ .<sup>13</sup>

Given that the main feature of resource windfalls is that these are largely temporary (see, for instance, van der Ploeg & Venables, 2011, 2013), the primary assessment of an optimal  $\varphi$  involves comparing the social loss function values across different  $\varphi$  (indirectly, various combination of  $\omega_{SW}$ ,  $\omega_{RF} \leq 0.56$ ) when a temporary one standard deviation negative shock to commodity price is simulated. Table 6 presents the summary results in which the values of the social loss function (50) are calculated for the combination of  $(\varphi, \Gamma)$  on the basis of (unconditional) asymptotic variances, hence accounting for the volatility of private consumption and non-resource

primary balance throughout the entire solution path. Although the results show a clear decreasing function with respect to  $\Gamma$  (the greater emphasis policymakers placed on stabilizing consumption path, à la the PIH tradition, the smaller the losses during the periods of short-fall), it has a convex shape in  $\varphi$  for a given  $\Gamma$ . In other words, an interior optimal combination of allocation exists. Intuitively, in the initial domain of  $\varphi$ , an increase in the allocation to the facilitation of domestic fund-raising activities would help stabilizing the production of the GLCs and consequently consumption, despite the temporary fall in oil revenue putting pressure on fiscal balance. Nevertheless, as  $\varphi$  increases beyond the optimal  $\varphi$  value, the net effect from the social losses associated with the increased volatility in GLC profitability would

**TABLE 6** Optimal allocation of resource revenue between resource fund and SWF fund-raising facilitation

		Social loss function value										
		$\Gamma$										
		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
$\varphi$	0.1	1.1939	1.0185	<b>0.8688</b>	<b>0.7412</b>	<b>0.6323</b>	<b>0.5394</b>	<b>0.4601</b>	<b>0.3925</b>	<b>0.3348</b>	<b>0.2856</b>	<b>0.2437</b>
	0.2	<b>1.1470</b>	<b>0.9996</b>	0.8711	0.7592	0.6616	0.5766	0.5025	0.4379	0.3817	0.3326	0.2899
	0.3	1.1750	1.0554	0.9480	0.8516	0.7649	0.6871	0.6172	0.5544	0.4980	0.4473	0.4018
	0.4	1.2341	1.1405	1.0540	0.9740	0.9001	0.8318	0.7687	0.7104	0.6565	0.6067	0.5607
	0.5	1.3145	1.2445	1.1783	1.1156	1.0562	1.0000	0.9468	0.8964	0.8487	0.8035	0.7608
	0.6	1.4128	1.3644	1.3177	1.2725	1.2289	1.1868	1.1461	1.1069	1.0689	1.0323	0.9969
	0.7	1.5269	1.4985	1.4706	1.4432	1.4163	1.3899	1.3641	1.3387	1.3137	1.2893	1.2653
	0.8	1.6562	1.6465	1.6368	1.6272	1.6177	1.6082	1.5988	1.5894	1.5801	1.5708	1.5616
	0.9	1.8003	1.8083	1.8164	1.8245	1.8327	1.8408	1.8491	1.8573	1.8656	1.8740	1.8823
<b>Social loss function, weight between 0.06 and 0.20</b>												
$\varphi$	0.06	1.2917	1.1034	0.9426	0.8052	0.6878	0.5876	0.5019	0.4288	0.3663	0.3129	0.2673
	0.07	1.2562	1.0716	0.9141	0.7797	0.6651	0.5674	0.4840	0.4128	0.3521	0.3004	0.2562
	0.08	1.2298	1.0485	0.8939	0.7621	0.6497	0.5539	0.4722	0.4026	0.3432	0.2926	0.2495
	0.09	1.2096	1.0313	0.8792	0.7496	0.6391	0.5449	0.4645	0.3961	0.3377	0.2879	0.2454
	0.10	1.1939	1.0185	0.8688	0.7412	0.6323	0.5394	0.4601	0.3925	0.3348	0.2856	0.2437
	0.11	1.1816	1.0090	0.8615	0.7356	0.6281	0.5363	<b>0.4580</b>	<b>0.3910</b>	<b>0.3339</b>	<b>0.2851</b>	<b>0.2434</b>
	0.12	1.1720	1.0021	0.8569	0.7327	0.6265	<b>0.5357</b>	0.4581	0.3917	0.3349	0.2864	0.2449
	0.13	1.1644	0.9972	0.8541	<b>0.7315</b>	<b>0.6264</b>	0.5365	0.4595	0.3935	0.3370	0.2886	0.2472
	0.14	1.1586	0.9942	<b>0.8532</b>	0.7322	0.6283	0.5392	0.4627	0.3971	0.3407	0.2924	0.2509
	0.15	1.1542	0.9927	0.8538	0.7343	0.6316	0.5432	0.4672	0.4019	0.3456	0.2973	0.2557
	0.16	1.1509	<b>0.9922</b>	0.8553	0.7373	0.6356	0.5479	0.4724	0.4072	0.3510	0.3026	0.2609
	0.17	1.1487	0.9928	0.8580	0.7415	0.6409	0.5539	0.4787	0.4137	0.3575	0.3090	0.2671
	0.18	1.1474	0.9943	0.8616	0.7466	0.6469	0.5606	0.4858	0.4209	0.3648	0.3161	0.2739
	0.19	<b>1.1469</b>	0.9966	0.8661	0.7527	0.6541	0.5684	0.4940	0.4293	0.3731	0.3242	0.2817
0.20	1.1470	0.9996	0.8711	0.7592	0.6616	0.5766	0.5025	0.4379	0.3817	0.3326	0.2899	

Note: A temporary one standard deviation, negative shock to resource price. The social loss function value is normalized to the value of 1.0 at the combination of (0.5, 0.5).

Bold values indicates the loss-minimising combination of parameters.

outweigh the gains. This then makes the traditional ‘overseas stabilization fund’ option relatively more beneficiary. This volatility trade-off means a ‘non-corner solution’ combination of  $\varphi$  is warranted when managing resource price shock – a result that is fundamentally similar in spirit to Agénor (2016), despite the complications of a stochastic shock and the addition of GLCs creating competitive pressure to the private firms. Specifically, in the context of our estimated model, a range of  $\varphi \in [0.11, 0.19]$  is found to minimize the social loss function, or equivalently,  $\omega_{SW} \in (0.062, 0.106)$ . Fundamentally, this is similar to the earliest contributions in *Dutch Disease*: if resource price volatility is the only policy concern, then the bulk of any savings from resource windfall ought to be invested into foreign assets.

However, in contrast to Agénor (2016), whose results and counterfactual analysis are based on altering deep parameters (the shocks generated are therefore deterministic, not stochastic), we find that the optimal allocation depends on the nature of the stochastic shock considered. For instance, when we ‘let the data speak’ and evaluate the optimal allocation based on a temporary one standard deviation negative preference shock (the primary shock in the economy, as it dominates the variations in final good production, consumption, inflation, and exchange rate), although an interior optimal  $\varphi$  remains, it is at a higher value of  $\varphi = 0.38$ , or equivalently,  $\omega_{SW} = 0.213$  (see Table 7). This suggests that what constitutes an optimal resource savings allocation would ultimately depend on the nature of the dominant business-cycle shock of

**TABLE 7** Optimal allocation of resource revenue between resource fund and SWF fund-raising facilitation

Social loss function value		$\Gamma$										
		0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
$\varphi$	0.1	6.5896	4.6884	3.3357	2.3733	1.6885	1.2014	0.8547	0.6081	0.4327	0.3078	0.2190
	0.2	6.5493	4.5462	3.1558	2.1906	1.5206	1.0555	0.7327	0.5086	0.3531	0.2451	0.1701
	0.3	<b>6.5399</b>	4.4982	3.0939	2.1280	1.4637	1.0067	0.6925	0.4763	0.3276	0.2253	0.1550
	0.4	6.5402	<b>4.4873</b>	<b>3.0788</b>	<b>2.1124</b>	<b>1.4494</b>	<b>0.9944</b>	<b>0.6823</b>	<b>0.4681</b>	<b>0.3212</b>	<b>0.2204</b>	<b>0.1512</b>
	0.5	6.5448	4.4949	3.0870	2.1201	1.4561	1.0000	0.6868	0.4717	0.3239	0.2225	0.1528
	0.6	6.5518	4.5158	3.1126	2.1454	1.4787	1.0192	0.7025	0.4842	0.3337	0.2300	0.1585
	0.7	6.5601	4.5403	3.1424	2.1749	1.5053	1.0418	0.7211	0.4991	0.3454	0.2391	0.1655
	0.8	6.5692	4.5683	3.1769	2.2092	1.5363	1.0684	0.7430	0.5167	0.3593	0.2499	0.1738
	0.9	6.5788	4.5981	3.2137	2.2462	1.5699	1.0972	0.7669	0.5360	0.3746	0.2618	0.1830
<b>Social loss function, weight between 0.30 and 0.45</b>												
$\varphi$	0.30	6.5399	4.4982	3.0939	2.1280	1.4637	1.0067	0.6925	0.4763	0.3276	0.2253	0.1550
	0.31	6.5397	4.4955	3.0903	2.1243	1.4603	1.0039	0.6901	0.4744	0.3261	0.2242	0.1541
	0.32	6.5395	4.4932	3.0872	2.1212	1.4574	1.0014	0.6880	0.4727	0.3248	0.2232	0.1533
	0.33	6.5393	4.4918	3.0853	2.1193	1.4557	0.9999	0.6868	0.4718	0.3240	0.2226	0.1529
	0.34	<b>6.5393</b>	4.4899	3.0839	2.1177	1.4544	0.9981	0.6855	0.4709	0.3236	0.2221	0.1523
	0.35	6.5393	4.4896	3.0823	2.1162	1.4528	0.9975	0.6848	0.4701	0.3228	0.2216	0.1521
	0.36	6.5394	4.4880	3.0801	2.1139	1.4507	0.9956	0.6833	0.4690	0.3218	0.2209	0.1516
	0.37	6.5395	4.4870	3.0786	2.1124	1.4493	0.9944	0.6823	0.4682	0.3212	0.2204	0.1512
	0.38	6.5397	<b>4.4867</b>	<b>3.0781</b>	<b>2.1118</b>	<b>1.4488</b>	<b>0.9940</b>	<b>0.6819</b>	<b>0.4679</b>	<b>0.3210</b>	<b>0.2202</b>	<b>0.1511</b>
	0.39	6.5399	4.4868	3.0783	2.1119	1.4489	0.9940	0.6820	0.4679	0.3210	0.2202	0.1511
	0.40	6.5402	4.4873	3.0788	2.1124	1.4494	0.9944	0.6823	0.4681	0.3212	0.2204	0.1512
	0.41	6.5405	4.4875	3.0789	2.1124	1.4490	0.9941	0.6820	0.4679	0.3210	0.2202	0.1511
	0.42	6.5409	4.4877	3.0790	2.1125	1.4494	0.9945	0.6823	0.4681	0.3212	0.2204	0.1512
	0.43	6.5413	4.4881	3.0794	2.1128	1.4496	0.9946	0.6824	0.4682	0.3213	0.2204	0.1512
	0.44	6.5417	4.4891	3.0806	2.1140	1.4507	0.9955	0.6831	0.4688	0.3217	0.2208	0.1515
	0.45	6.5421	4.4900	3.0816	2.1150	1.4515	0.9962	0.6837	0.4693	0.3221	0.2210	0.1517

Note: A temporary one standard deviation, negative preference shock. The social loss function value is normalized to the value of 1.0 at the combination of (0.5, 0.5).

Bold values indicates the loss-minimising combination of parameters.

concern. Nevertheless, in the specific context of Malaysia, it appears that the present allocation is sub-optimal, regardless of the structural shocks considered. This suggests that the Malaysian economy might have hit its absorptive capacity constraint (i.e., a domestic economy saturated by GLCs), therefore requiring greater allocation of savings from resource revenue to foreign assets investment abroad to be socially optimal.

## 6 | CONCLUDING REMARKS

We contribute to the broad literature on fiscal management of resource wealth by developing a DSGE model with SWF-financed GLCs – a lasting phenomenon in emerging economies that, to date, have received very little attention from macroeconomists. Based on a Bayesian-estimated model, we identify an optimal combination of allocation of excess resource savings between the offshore Resource Fund and domestic facilitation of SWF's fund-raising activities (indirectly in relation to its portfolio GLCs' production). It appears that the present allocation is sub-optimal, regardless of the structural shocks considered. This suggests that the Malaysian economy might have hit its absorptive capacity constraint (i.e., a domestic economy saturated by GLCs), therefore requiring greater allocation of savings from resource revenue to foreign assets investment abroad to be socially optimal. Other key findings have also been previewed in the introduction and need not be repeated. Instead, we identify potential avenue for extensions and future research.

First, although the model is a small open economy, many features concerning international financial markets are simplified. As such, unlike studies such as García-Cicco and Kawamura (2015), our model does not allow for the assessment of policy complementarities between fiscal management strategies and other macroprudential regulations. Given that the presence of GLCs is likely to not only influence the product market but also the allocation of financial resources, these are worth exploring in the future. Second, nominal rigidities in prices and wages can also be introduced, as in Heer and Schubert (2012), therefore allowing greater roles for monetary policy (vastly simplified in this model that focuses on fiscal policy) in influencing the business cycle of a resource-rich economy. Third, according to emerging-market real business-cycle studies (Aguiar & Gopinath, 2007; García-Cicco et al., 2010), macroeconomic volatility experienced in developing economies is due as much to stochastic trend shocks as random unanticipated shocks. Given that the objective of establishing a SWF in seeding and managing GLCs domestically are often driven by long-run

strategic considerations, the role of trend shocks may be worth examining.

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## ENDNOTES

<sup>1</sup> Note that the literature discussed, including this article, has a slightly different emphasis compared to the largely empirical-based literature of *natural resource curse*, which concerns the lower long-term growth rate of resource-rich economies relative to comparable but less resource-rich economies. See Frankel (2010) and Badeeb, Lean, and Clark (2017) for a review of this related but peripheral literature.

<sup>2</sup> In fact, collectively, SOEs/GLCs accounted for 204 of the top 2,000 listed companies in the Forbes ranking in 2011 (Kowalski, Büge, Sztajerowska, & Egeland, 2013), equity value of almost USD2 trillion and more than 6 million employees (Christiansen, 2011). Many GLCs in developing economies are also among the largest corporations on FORTUNE Global 500, with most having both direct and indirect links with the natural resources ownership of the country (Bremmer, 2010; Victor, Hults, & Thurber, 2014).

<sup>3</sup> It is customary to introduce a nontradable sector to generate sectorial reallocation effects following a commodity price shock (due to real exchange rate reflecting the movement of nontradable prices). The asymmetric learning-by-doing externality between the tradable and nontradable sectors is the mechanism that generates the so-called *Dutch Disease* effects in most models. We argue that this is not necessary and comes with a trade-off in analysis involving developing economies: Data-based calibration necessarily requires the authors to make assumptions on what constitutes nontradable sectors, as in the case of García-Cicco and Kawamura (2015). As such, most existing contributions, including Agénor (2016), have adopted a parameterization strategy, instead of actual data-based Bayesian calibration.

<sup>4</sup> One could argue that the Malaysian economy is diversified enough that it is not resource-dependent. However, within the sample period of our estimation (1991–2016), oil revenue (not including indirect levies) as a percentage of total government revenue averages at 24.6%, reaching as high as 35.5% during the 2006–2014 period when the Putrajaya Committee-driven GLC Transformation Programme is at its most active. These certainly imply an economy whose business cycle is influenced by the oil price cycle, irrespective of the heterogeneity in the structure of the financing/investing activities of its different GLICs.

<sup>5</sup> As pointed out in studies such as Menon (2014), in the GLC-dominant economies of Malaysia, GLCs have footprints that

cover almost all the sectors in the domestic economy, ranging from banking, telecommunication, pharmaceuticals, wholesale and retail. As such, the assumption that GLCs and POEs' goods are gross substitutes ( $\omega > 1$ ) is reasonable.

<sup>6</sup> The government-linked investment funds in Malaysia, collectively GLICs, consist of a heterogeneous group of investment funds. While the capitalization structure and investment strategy is vastly different (and in some cases, such as the EPF and KWAP, it is arguable that they should not be labelled as government entities), the Malaysian government has a direct oversight in most of their operations through the Putrajaya Committee on GLC High Performance, as can be seen in Government of Malaysia (2006, 2012). As such, we believe our representative SWF is able to reflect stylistically this feature.

<sup>7</sup> As would be seen in the variance decomposition results in Table 3 later, the variation in the foreign asset value held by the Resource Fund,  $F_t$ , is solely driven by the two resource shocks. It is therefore not included in the non-resource primary balance specification.

<sup>8</sup> A one-sided HP filter, rather than first-difference, is used to detrend data. We detrend all observed variables because they exhibit trend movement over the sample to remove low-frequency variations. This treatment follows Christensen and Dib (2008), and suits the data of developing countries like Malaysia, which exhibit stochastic trend, hence making first-difference less appropriate in separating trend and cycle. Plus, the one-sided HP filter is a 'causal' filter, in that, the detrending process is not affected by the correlation between current and subsequent observations (Guerrieri & Iacoviello, 2017).

<sup>9</sup> The parameter values reflect an efficient capital accumulation process, which is consistent with the business model of modern corporatized strategic sovereign investment funds, as described in Halland et al. (2016).

<sup>10</sup> Their value is based on a limited number of studies, including dated ones such as Ogaki, Ostry, and Reinhart (1996). This, coupled with our Bayesian-estimated posterior mean (over a longer sample period) falling well-within the range of their full-sample mean and the more rigorous microdata-based estimates of studies such as Crossley and Low (2011), leads us to deduce that the Malaysian households are likely to have a higher willingness to substitute consumption intertemporally over a longer time period.

<sup>11</sup> Note that, unlike POE's profits, neither the dynamic system characterizing the model's general equilibrium in Appendix A nor the static simultaneous equation system characterizing the steady state in Appendix B contains the  $\pi_t^{GLC}$  expression. This means it is not a pre-condition for GLC to make positive profits for the model to solve.

<sup>12</sup> The simplified specification of resource revenue in this model means the results from a temporary resource production shock would provide essentially the same dynamics of variables to those from a temporary resource price shock, albeit at a larger magnitude. As such, we only present the impulse responses for the resource price shock.

<sup>13</sup> The merits of this stability criterion relative to the standard utility-based social welfare measure are elaborated in greater details by Agénor (2016) and therefore are not repeated here.

## DATA AVAILABILITY STATEMENT

The estimation and analysis done in this study were based on the following resources available in the public domain:

- Bank Negara Malaysia, Monthly Statistical Bulletin, at: [https://www.bnm.gov.my/index.php?ch=en\\_publication&pg=en\\_msb&ac=283&en&uc=2](https://www.bnm.gov.my/index.php?ch=en_publication&pg=en_msb&ac=283&en&uc=2);
- Department of Statistics Malaysia, Time Series Data, at: [https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu\\_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09](https://www.dosm.gov.my/v1/index.php?r=column/ctimeseries&menu_id=NHJlaGc2Rlg4ZXlGTjh1SU1kaWY5UT09);
- Federal Reserve Bank of St. Louis Economic Data, at: <https://fred.stlouisfed.org/tags/series?t=oil>

The estimated result series (from solving the model) are in a Matlab data file (.mat) format, and can be made available upon request.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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