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COMMODITY SHOCKS AND OPTIMAL FISCAL MANAGEMENT OF RESOURCE REVENUE IN AN ECONOMY WITH STATE-OWNED ENTERPRISES

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The working paper presents a work-in-progress.
All comments and suggestions are welcomed.

Commodity Shocks and Optimal Fiscal Management of Resource Revenue in an Economy with State-owned Enterprises

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Abstract

We present a dynamic model in which a resource-rich State allocates its resource revenue between a resource stabilization fund and investments in state-owned enterprises (SOEs). Despite being less productive efficient, SOEs' operation benefits from scale economies tied to the resource sector: its profitability is procyclical to commodity shocks. We identify analytically a threshold share of fiscal allocation to SOEs above which SOEs make non-zero profits. Based on a Bayesian-estimated model, we solve for an optimal resource revenue allocation between SOE investments and Resource Fund, and find the optimal share of SOE investment to be in the range of 9.0-12.9 percent.

JEL Classification Numbers: E32; F41; H54.

Keywords: Commodity Shocks, Fiscal Management, Open-economy DSGE models, Resource Wealth, State-owned Enterprises.

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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 nonresource tradable production, due to a sharp real exchange rate appreciation and increased demand for nontradables. Moreover, in recent context, the so-called "*natural resource curse*" (the volatility associated with global resource prices resulting in greater domestic macroeconomic instability) becomes a key concern for policymakers with multipronged objectives when managing resource revenue: consumption smoothing, built-up of precautionary savings, and domestic investments to overcome absorption capacity constraint (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 and others 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 nonresource primary fiscal balance, with its entirety saved in a resource stabilization fund abroad to serve as precautionary buffer. More recent analytical contributions, such as van den Bremer and van der Ploeg (2013), Berg and others (2013), Araujo and others (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 more flexible fiscal arrangements by having some resource rents invested domestically, more so in the short run when there exists absorptive capacity constraints.

To date, the consensus of the *natural resource curse* literature 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 invested domestically is usually parked in entities known as Sovereign Wealth Funds (SWFs), which "invest strategically" by owning shares or financing state-owned enterprises (SOEs) operating in the domestic market. These SWF-financed SOEs coexist with private firms in supplying the domestic market, and can remain in operation despite not being profitable due to their various strategic roles in driving industrial development and on occasion, serving as "fiscal stimulus vehicles" (Chang 2007; Wen and Wu 2019). This is known as "*state capitalism*" industrial policies, which include investments through SOEs in areas that are resource-intensive and possess long-term economies-of-scale potentials (Christiansen 2013; Cherif, Hasanov, and Kammer 2016; Cherif and Hasanov 2019).[1] The macroeconomic implication associated with the "invest domestically to overcome absorptive capacity constraints" perspectives is therefore not as straightforward. In spite of these features in emerging economies, a macroeconomic model with SOEs remains elusive.

We contribute to the literature by developing a dynamic stochastic general equilibrium (DSGE) model with the inclusion of both SWF-financed SOEs and a resource stabilization fund (henceforth, *Resource Fund*). In managing its resource revenue, the government decides on its allocation between SOE investments, Resource Fund, and a direct transfer to the budget. In our knowledge, this is the first study in the tradition of the natural resource curse that explicitly models the presence of the SOEs, and their implications to the business cycle associated with fiscal management of resource rents. In addition, this study also represents a 'scale-up' version of contributions such as Bems and de Carvalho Filho (2011), who focus narrowly on the role of precautionary savings in economies with exhaustible resources and

[1] In fact, collectively, SOEs accounted for 204 of the top 2000 listed companies in the Forbes ranking in 2011 (Kowalski and others 2013), equity value of almost USD2 trillion and more than 6 million employees (Christiansen 2011). Many SOEs 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 and Thurber 2014).

therefore cannot account for the dynamics brough about by the interactions of investment decisions between the different corporate sectors.

In the model context, we also identify analytically a threshold value of allocation to SOEs above which a typical SOE would make non-zero profits. Despite its relatively generalizable feature, to capitalize on the sufficiently long history of a SOE-dominant economy (see Menon, 2014, for a study of more descriptive nature on Malaysia's SOE 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. To preview, we find that, even without having to "shoehorn" a nontradable sector into the model, many classic features of the "*natural resource curse*" are still generated in the impulse responses following a commodity/resource price shock—an important influence to the business cycle of the SWF-financed SOEs-dominated economy of Malaysia.[2] We analyzed numerically for an optimal combination of allocation to SOE investments and Resource Fund in the context of the minimization of a social loss function, à la Agénor (2016). We find the optimal share of resource revenue allocated to SOE investments to be in the range of $0.09 - 0.129$, though it depends on the nature of the dominant business-cycle shock of concern. Although the feature of SWF-financed SOEs is novel, 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.

The rest of the paper are structured as follows. Section 2 presents the model. Section 3 defines the equilibriums, followed by the derivation of the theoretical condition for SOE

[2] 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 assymetric 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.

profitability. Section 4 discusses the calibration. The analysis and results are presented in Section 5, followed by concluding remarks in Section 6.

2 The Model

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^i_{t+s}, labor hours supplied to both categories of IG firms, $L^{i,POE}_{t+s}$ and $L^{i,SOE}_{t,s}$, a fund transferred to private capital good producer, $\zeta^{i,I}_{t+s}$, the holding of domestic government bonds, b^i_{t+s+1}, and the holding of foreign bonds, $B^{i,F}_{t+s+1}$, for $s = 0, 1, ..., \infty$, so as to maximize lifetime utility:

$$U^i_t = \mathbf{E}_t \sum_{s=0}^{\infty} \beta^s A^U_{t+s} \left\{ \frac{(C^i_{t+s})^{1-\varsigma^{-1}}}{1-\varsigma^{-1}} + \eta_N \ln(1 - L^{i,POE}_{t+s} - L^{i,SOE}_{t+s}) \right\}, \tag{1}$$

where $\beta \in (0,1)$ is a discount factor, $\varsigma > 0$ 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^U_t denotes a mean-one preference shock common to all individuals following a first-order autoregressive [AR(1)] process, $A^U_t = (A^U_0)^{1-\rho_U}(A^U_{t-1})^{\rho_U} \exp(\epsilon^U_t)$, where $A^U_0 > 0$, $\rho_U \in (0,1)$ is the associated autoregressive (AR) coefficient, and ϵ^U_t is a normally distributed stochastic shock with zero mean and a constant variance (σ^2_U).

The end-of-period flow budget constraint is

$$b^i_t + z_t B^{i,F}_t = w_t(L^{i,POE}_t + L^{i,SOE}_t) - T^i_t - C^i_t - \zeta^{i,I}_t + (\frac{1+i^B_{t-1}}{1+\pi_t})b^i_{t-1} + (\frac{1+i^{L,KP}_{t-1}}{1+\pi_t})\zeta^{i,I}_{t-1} \tag{2}$$

$$+(1+i^{F,P}_{t-1})z_t B^{i,F}_{t-1} + J^{i,POE}_t + J^{i,K}_t,$$

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^i_t ($B^{i,F}_t$) real (foreign-currency) holdings of one-period, noncontingent domestic (foreign) government bonds, i_t^B and $i_t^{F,P}$ are the interest rates on domestic and foreign government bonds, r_t^{POE} and w_t the economy-wide real wage, T_t^i real lump-sum taxes, $J_t^{i,POE} = \psi \int_0^{1-\phi} \pi_{jt}^{POE}$ 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

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

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

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

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

$$L_t^{i,POE} + L_t^{i,SOE} = 1 - \frac{\eta_N (C_t^i)^{1/\varsigma}}{w_t}, \tag{5}$$

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

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

2.2 Resource Production and Prices

Following Agénor (2016), the resource revenue is non-renewable, but the production is modelled by an exogenous stochastic process, such that

$$\frac{O_t}{\tilde{O}} = (\frac{O_{t-1}}{\tilde{O}})^{\rho_O} \exp(\epsilon_t^O), \tag{8}$$

where $\tilde{O}$ 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 ϵ_t^O a normally distributed random shock to resource production with zero mean and a constant variance (σ_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), Anderson, Kellogg, and Salant (2018). Given the size of the model, and that optimal extraction path is a peripheral topic to the main focuses of this article, 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 in Section 4, 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:

$$\frac{P_t^O}{\tilde{P}^O} = (\frac{P_{t-1}^O}{\tilde{P}^O})^{\rho_{P_O}} \exp(\epsilon_t^{P^O}), \tag{9}$$

where $\tilde{P}^O$ is the steady-state price, $\rho_{P_O} \in (0,1)$ is the associated AR coefficient, and $\epsilon_t^{P^O}$ 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 (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 Hasanoff (2013). Also, note that it is the **level** of P_t^O that is assumed to follow an AR(1) process here, and hence remains consistent with evidence documented in studies such as Hamilton (2009), who found the **change** in oil prices over time that exhibits a random walk process.

2.3 Domestic Final Good

There is a representative firm producing a final good, Y_t, in the economy using a basket of domestically-produced differentiated intermediate goods (IGs), Y_t^D, and a basket of imported

IGs, Y_t^F, as in:

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

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

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

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:

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

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

$$Y_t^D = \Lambda_D^\eta (\frac{P_t^D}{P_t})^{-\eta} Y_t, \qquad Y_t^F = (1-\Lambda_D)^\eta (\frac{P_t^F}{P_t})^{-\eta} Y_t, \tag{13}$$

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

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

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

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

where $\omega > 1$ is the elasticity of substitution across the domestic IGs, and $\phi \in [0,1]$ is the steady-state share of SOEs' production in aggregate domestic IGs.[3]

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

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

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

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

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

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

$$Y_{jt}^{SOE} = \Lambda_D^{\eta}(\frac{P_{jt}^{SOE}}{P_t^D})^{-\omega}(\frac{P_t^D}{P_t})^{-\eta}Y_t, \text{ and} \tag{18}$$

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

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

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

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

[3] As pointed out in Wen and Wu (2019), the aggregator for Y_t^D can be rewritten as $Y_t = \left[(Y_t^{SOE})^{\frac{\omega-1}{\omega}} + (Y_t^{POE})^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}}$, where $Y_t^{SOE} = \left[\int_0^{\theta}(Y_{jt}^{SOE})^{\frac{\omega-1}{\omega}}dj\right]^{\frac{\omega}{\omega-1}}$ and $Y_t^{POE} = \left[\int_0^{1-\phi}(Y_{jt}^{POE})^{\frac{\omega-1}{\omega}}dj\right]^{\frac{\omega}{\omega-1}}$. With $\omega > 1$, the aggregate domestic intermediate goods can be positive even if only one type of firms remain active.

rate if the foreign-currency price is normalized to unity), relative to the aggregate price index:

$$Y_t^X = (\frac{E_t}{P_t})^{\varkappa}, \qquad \varkappa > 0 \tag{21}$$

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

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

$$Y_t = Y_t^S + Y_t^X + P_t^O O_t, \tag{22}$$

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

2.4 Domestic Intermediate Goods

The modelling of the SOEs 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 SOEs 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, $k = POE, SOE$, takes the form:

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

where $mc_{j,t}^k$ is the unit marginal cost of production that is unique to firm j of category k, and F_t^k is the fixed cost of production incurred in each period t. In line with empirical and anecdotal evidence (Eller, Hartley, and Medlock III 2011; Kowalski and others 2013), we assume the operation of SOEs to be less efficient but natural-resource intensive, with the fixed cost differs between the POEs and SOEs:

$$F_{jt}^k = \begin{cases} F_0^{POE} & \text{if } i = POE \\ F_0^{SOE}/[(\frac{\omega_{SOE} P_t^O O_t}{\tilde{P}^O \tilde{O}})^\mu] & \text{if } i = SOE \end{cases}, \tag{24}$$

where $F_0^{POE} < F_0^{SOE}$, though an SOE's operation benefits from a scale-economies factor, $\mu \geq 1$, that depends on the government's investment in SOE ($\omega_{SOE} P_t^O O_t$) relative to the long-run size of the resource sector.

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

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

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

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

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

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

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

The main systematic difference between the POEs and the SOEs rest in the process of capital rental and accumulation. The former rents capital at a rate $r_t^{POE}, \forall j$ from a private capital good producer, while the latter has access to capital financed by the government's strategic investment made available only to SOEs, by paying a rental rate, $r_t^{SOE}, \forall j$. In terms of labor, both the POEs and SOEs are assumed to face perfectly competitive labor 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)-(19). Price settings are therefore non-forward looking in this economy, allowing us to compare the contemporary profits of SOEs and POEs.

Assuming that each firm is small, all firms take aggregate demand and aggregate prices as given. This means that the price of one firm exerts no influence on the aggregate price indices. Profit maximization then yields the standard constant mark-up optimal pricing:

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

or, by substituting in (28),

$$P_{jt}^k = \frac{\omega}{\omega - 1} (\frac{r_t^k}{\alpha})^{\alpha} (\frac{w_t}{1-\alpha})^{1-\alpha}, \; k = POE, SOE. \tag{30}$$

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

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

$$\Pi_{jt}^{SOE} = \Omega_1 [(\frac{r_t^{SOE}}{\alpha})^{\alpha} (\frac{w_t}{1-\alpha})^{1-\alpha}]^{1-\omega} (P_t^D)^{\omega - \eta} P_t^{\eta} Y_t - \frac{F_0^{SOE}}{[(\omega_{SOE} P_t^O O_t)/(\tilde{P}^O \tilde{O})]^{\mu}}, \tag{32}$$

respectively, where $\Omega_1 = \frac{(\omega-1)^{\omega}}{\omega^{\omega}} \Lambda_D^{\eta}$.

A typical SOE j makes more nominal (real) non-zero profits than a typical POE j if and only if $\Pi_{j,t}^{SOE}/\Pi_{j,t}^{POE} > 1$ ($\pi_{j,t}^{SOE}/\pi_{j,t}^{POE} > 1$). Using (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 SOE and POE are the same, $r_t^{SOE} = r_t^{POE}$, given that $F_0^{POE} < F_0^{SOE}$, there is no feasible allocation of resource revenue on SOE investment, ω_{SOE}, in which a typical SOE 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 SOE to have the possibility of making greater profits than a POE, the capital rental rate between the two firms cannot be the same.

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, $1 + r_t^{POE}$. The aggregate private capital stock, $K_t^{POE} = \int_0^{(1-\phi)} K_{jt}^{POE} dj$, is obtained by combining private investments, I_t, with the existing capital stock, adjusted for depreciation and adjustment costs:

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

where $\delta^P \in (0,1)$ is the depreciation rate, $\Theta_K > 0$ the capital adjustment cost parameter, and A_t^{KP} is a random shock to capital adjustment, governed by an AR(1) process, $A_t^{KP} = (A_0^{KP})^{1-\rho_{KP}} (A_{t-1}^{KP})^{\rho_{KP}} \exp(\epsilon_t^{KP})$, where $A_0^{KP} > 0$, $\rho_{KP} \in (0,1)$ is the associated AR coefficient, and ϵ_t^{KP} is the zero-mean error term with a constant variance (σ_{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 $(1 + i_t^{L,KP}) P_t \zeta_t^I$. Subject to (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:

$$\{I_{t+s}\}_{s=0}^{\infty} = \arg\max \mathbb{E}_t \sum_{s=0}^{\infty} \beta^s \lambda_{t+s} (\frac{\Pi_{t+s}^K}{P_{t+s}}), \tag{34}$$

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

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

2.6 Government and Investment into SOEs

2.6.1 Fiscal Budget

The government consumes final goods (G_t) and invests in SOEs (G_t^{SOE}). 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}^B—in the next period. The government receives resource revenue in the form of royalties [assumed to involve zero extraction cost, as in Agénor (2016)], expressed in net term, T_t^O, after some fractions of the resource revenue are invested in SOEs and saved in a Resource Fund holding foreign assets. Further, as in the specification of Bems and de Carvalho Filho (2011), it also receives net interest rate, i_{t-1}^W, on the stock of foreign-currency assets, F_{t-1}, held abroad, as well as real rental rate paid by the SOEs, $r_{t-1}^{SOE}K_{t-1}^{SOE}$, from the previous period. The government's budget constraint is therefore

$$T_t^O + i_{t-1}^W \frac{E_{t-1}}{P_{t-1}} F_{t-1} + r_{t-1}^{SOE} K_{t-1}^{SOE} + b_t - \frac{b_{t-1}}{1+\pi_t} = G_t - T_t + \frac{i_{t-1}^B b_{t-1}}{1+\pi_t}. \tag{36}$$

Government consumption is assumed to be a fraction $\upsilon \in (0,1)$ of domestic sales of the final good:

$$G_t = \upsilon Y_t^S. \tag{37}$$

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 and Carvalho 2010), in that,

$$i_t^B = \epsilon_t (i_{t-1}^B)^{\varpi_1} [\tilde{\imath}^B (\frac{Y_t}{\tilde{Y}})^{\varpi_2} (\frac{1+i_t^W}{1+\tilde{\imath}^W})^{\varpi_3}]^{1-\varpi_1}, \tag{38}$$

where ϵ_t denotes a source of random shock with an AR(1) process, $\epsilon_t = (\epsilon)^{1-\rho_M} (\epsilon_{t-1})^{\rho_M} \exp(\epsilon_t^{\varepsilon})$, where ϵ_t^{ε} is normally distributed with ϵ having mean one and constant variance (σ_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, Alper, and Pereira da Silva (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

In line with contributions such as Pieschacón (2012), Agénor (2016), the royalties, T_t^O, is first specified as

$$T_t^O = (1 - \omega_{SOE} - \omega_{RF}) P_t^O O_t, \tag{39}$$

where $\omega_{SOE} \in [0, 1]$ is a fraction of the resource revenue invested in the SWF-financed SOEs, and $\omega_{RF} \in [0, 1]$ is a fraction transferred to a Resource Fund to be invested in foreign assets. Note that $\omega_{SOE} + \omega_{RF} \leq 1$. The royalties that is transferred to the main budget is therefore net of the allocation to both the strategic investment in SOEs and the Resource Fund. As the cases of corner solutions are examined in greater details in studies such as Halland, Awiti, and Lim (2019), in what follows we consider only the interior solutions.

Resource Fund: The real value of foreign assets held in period t is

$$F_t = (1 - \chi) F_{t-1} + \omega_{RF} P_t^O O_t, \tag{40}$$

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.

State-owned Enterprises: Investment into the SOEs is in the form of capital investment, conducted by an implicit strategic Sovereign Wealth Fund (SWF) holding the SOE-specific capital stock. This specification of SWF-financed SOEs is consistent with the various business models observed in resource-rich developing economies, such as the GLICs model of Malaysia and the TEMASEK model of Singapore (Christiansen 2013; Halland and others 2016). Specifically, the evolution of the capital stock of SOEs, $K_t^{SOE} = \int_0^\phi K_{jt}^{SOE} dj$, is described by

$$K_t^{SOE} = (1 - \delta^{SOE}) K_{t-1}^{SOE} + \omega_{SOE} P_t^O O_t + \xi \frac{J_{t-1}^{SOE}}{P_{t-1}}, \tag{41}$$

where $\delta^{SOE} \in (0, 1)$ is the depreciation rate, and the SOE's aggregate profits from the previous period, $J_{t-1}^{SOE} = \int_0^\phi \Pi_{jt-1}^{SOE} dj$ are assumed to be fully reinvested into the capital accumulation process in the next period. $\xi \in (0, 1)$ measures the efficiency of the SOE's reinvestment process.

In a symmetric equilibrium, $J_{t-1}^{SOE} = \phi \Pi_{jt-1}^{SOE}$. This allows us to rewrite (41) as

$$\begin{aligned} K_t^{SOE} &= (1 - \delta^{SOE}) K_{t-1}^{SOE} + \omega_{SOE} P_t^O O_t \\ &+ \phi \xi \Omega_1 \left(\frac{r_{t-1}^{SOE}}{\alpha}\right)^{\alpha(1-\omega)} \left(\frac{w_{t-1}}{1-\alpha}\right)^{(1-\alpha)(1-\omega)} (P_{t-1}^D)^{\omega-\eta} (P_{t-1})^{\eta-1} Y_{t-1} \\ &- \frac{\phi \xi (F_0^{SOE} / P_{t-1})}{[(\omega_{SOE} P_{t-1}^O O_{t-1}) / (\tilde{P}^O \tilde{O})]^\mu}, \end{aligned} \tag{42}$$

where $\Omega_1 = \frac{(\omega-1)^\omega}{\omega^\omega} \Lambda_D^\eta$.[4]

Consistent with *Proposition 1*, the novel model feature is that, rental rate charged on SOEs in each period t is given by

$$r_t^{SOE} = \kappa_0 (r_t^{POE})^{\kappa_1} \left(\frac{\omega_{SOE} P_t^O O_t}{\tilde{P}^O \tilde{O}}\right)^{\kappa_2}, \tag{43}$$

[4] A capital adjustment cost term similar to that for the private capital stock can also be introduced to the SOE-specific capital accumlation process. For the purposes of this paper, this is not considered.

where $\kappa_0, \kappa_1, \kappa_2 \geq 0$, which depends positively on the prevailing market interest rate, r_t^{POE} (which can be viewed as the opportunity cost of capital rental had the SOEs borrows from the private market), and on the allocated sum to SOEs ($\omega_{SOE} P_t^O O_t$) relative to the long-run size of the resource sector. The latter means that, the more the government allocates its resource revenue to SOE investment, the higher the required rate of returns.

Finally, the non-resource primary balance, NB_t, is given by:[5]

$$NB_t = T_t + r_{t-1}^{SOE} K_{t-1}^{SOE} - G_t. \tag{44}$$

2.7 Market-Clearing Conditions

The domestic final good market equilibrium is defined as[6]:

$$Y_t^S = C_t + I_t + G_t, \tag{45}$$

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

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

which, as in Agénor, Alper, and Pereira da Silva (2018), is influenced by the risk-free world interest rate modelled as:

$$\frac{1 + i_t^W}{1 + \tilde{\imath}^W} = (\frac{1 + i_{t-1}^W}{1 + \tilde{\imath}^W})^{\rho_W} \exp(\epsilon_t^W), \tag{47}$$

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

[5] 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-resouce primary balance specification.

[6] Note that the investment in SOE-specific capital stock is straight from the resource revenue and not final good. This has therefore been accounted for in (22).

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 behaviors are also consistent. These mean, for all individuals $i \in (0,1)$, $C_t^i = C_t$, $L_t^{i,POE} = L_t^{POE}$, $L_t^{i,SOE} = L_t^{SOE}$, $b_t^i = b_t$, $B_t^{i,F,P} = B_t^{F,P}$. For all IG-producing firms $j \in (0,1)$, $K_{jt}^k = K_t^k$, $L_{jt}^k = L_t^k$ for $k = SOE,\ POE$. 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, all the variables ($\tilde{C}$, $\tilde{I}$, $\tilde{G}$, $\tilde{L}$, $\tilde{L}^{SOE}$, $\tilde{L}^{POE}$, $\tilde{b}$, $\tilde{B}^F$, $\tilde{D}$, $\tilde{K}^{SOE}$, $\tilde{K}^{POE}$, $\tilde{Y}$, $\tilde{Y}^X$, $\tilde{Y}^F$, $\tilde{Y}^{SOE}$, $\tilde{Y}^{POE}$, $\tilde{F}$, $\tilde{T}^O$) are constant$\forall t$; (ii) the prices, rates, and costs ($\tilde{P}^{SOE}$, $\tilde{P}^{POE}$, $\tilde{P}$, $\tilde{P}^S$, $\tilde{P}^X$, $\tilde{r}^{SOE}$, $\tilde{r}^{POE}$, $\tilde{w}$, $\tilde{\imath}^{F,R}$, $\tilde{z}$, $\tilde{\imath}^{F,P}$, $\tilde{\imath}^W$) are all constant $\forall t$; (iii) the variables associated with resource production ($\tilde{P}^O$, $\tilde{O}$) are constant $\forall t$, and by implications, (iv) 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 ($A_t^U = A_0^U$, $A_t^{KP} = A_0^{KP}$, $A_t^Y = A_0^Y$, $\epsilon_t = \epsilon_0$). Similar to studies such as Agénor, Alper, and Pereira da Silva (2014), we normalize the steady-state inflation to $\tilde{\pi} = 0$. The steady-state solution of the model is derived in Appendix B.

Having defined the symmetric and steady-state equilibrium, we derive *Proposition 2* in Appendix A, which state the following:

Proposition 2: In the symmetric equilibrium, a SOE makes positive real profits if and only if the fraction of the government's resource revenue invested in the SOEs, ω_{SOE}, is

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

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, this translates to:

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

Assumption: $\mu + \kappa_2\alpha(1-\omega) \neq 0$. With the assumption, (48) and (49) must be positive for all reasonable parameter values, hence $\omega^*_{SOE} > 0$ exists.

4 Calibration and Parameter Estimation

The model is estimated with the Bayesian method in the tradition of Smets and Wouters (2003, 2007). Given the dominant roles of SWF-financed SOEs domestically, and the presence of not just a large national oil conglomerate (PETRONAS), but also government-linked companies owned by strategic investment funds such as Khazanah Nasional, we calibrate the model to the Southeast Asian economy of Malaysia, using 7 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.[7] These series are obtained from Department of Statistics (DOS), Bank Negara Malaysia (BNM), and Bloomberg. 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. To avoid stochastic singularity, the number of structural shocks equals 7,

[7] 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 the 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 and Iacoviello 2017).

and in combination with the dynamic parameters in the relevant equations, means the overall empirical strategy involves estimating 24 parameters [ς, $\varkappa$, Θ_K, μ, μ^F, κ_1, κ_2, ϖ_1, ϖ_2, ϖ_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.[8]

The calibrated parameters are summarized in Table 1. The discount factor, $\beta = 0.988$, corresponds to a steady-state domestic bonds' rate, $\tilde{\imath}^B$, that matches average quarterly 10-year government bond rate. The preference parameter, η_N, is set to 4.5, as in Agénor, Alper, and Pereira da Silva (2014). The spread parameter for foreign bond returns, θ_0^F, is set at a very low value of 0.01, so that the rate of return on privately held foreign bonds approximates the risk-free world interest rate, $\tilde{\imath}^W$. On production, the distribution parameter, Λ_D, and the SOEs' share in domestic production, ϕ, 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, Alper, and Pereira da Silva (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, $\delta^{SOE} = \delta^P = 0.017$, which is consistent with the annual depreciation rate of 0.068 calculated from PETRONAS's financials, and in Lim (2018). The share of government spending in domestic output sales, $\upsilon = 0.122$, is calculated from macroeconomic data, whereas $\xi = 0.8$

[8]Indeed, in an alternative estimation that incorporates an additional stochastic shock (by making elasticity of substitution, ω, a time-varying variable subject to a stochastic price mark-up shock), the inclusion of inflation data makes no significant difference to the business-cycle properties of the Malaysian economy.

and $\kappa_0 = 1.0$ are set (in the absence of corresponding data) so as to match the steady-state SOE capital stock to the average real value of PETRONAS's *property, plant, equipments* in the 2010-17 period.[9] For the fraction of the resource revenue invested in SOEs, ω_{SOE}, and the fraction invested in foreign assets, ω_{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, ω_{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 oil royalties transferred to the government, $1 - \omega_{SOE} - \omega_{RF}$. Combining these two information, the fraction of resource revenue invested in the SOEs is then calculated, $\omega_{SOE} = 0.374$.

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 and others 2015), the prior mean for the (inverse) intertemporal elasticity of substitution is set at 0.5, in line with studies such as Trabandt and Uhlig (2011) and Jin (2012). This is so as to let the time series data dictates the country-specific posterior estimate. The prior mean for the exchange rate pass-through, μ^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, $\varkappa = 0.7$, 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 Carvalho (2010), Agénor, Alper, and Pereira da Silva (2014). The prior mean of the capital adjustment cost parameter, Θ_K, is set at a large value of 100, following Hristov and

[9] 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 and others (2016).

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 (43), the choice of the latter two means a market interest rate of 0.03 would yield a reasonable SOE rental rate of 0.035. These parameter choices yield a non-resource primary balance of -4.9 percent of GDP, which matches Malaysia's actual fiscal position.

Following Ojeda-Joya, Parra-Polanía, and Vargas (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, and Evans (2005), Geweke (1999, 2005), Smets and Wouters (2003, 2007); Smets and Villa (2016)], as well as notable emerging countries' business-cycle studies such as García-Cicco et al. (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 et al., 2012) covers only the short period of 2000-10 and is developed to study vastly different issues, the estimated posterior means are largely assessed against the aforementioned studies in the *natural resource curse* literature, such as Berg and others (2013), Araujo and others (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 $\varsigma = 1.65$, which yields $\varsigma^{-1} = 0.606$ and therefore higher than the 0.173 documented in Havranek et al. (2015) for Malaysia using meta-analyses.[10] Next, the posterior mean for the exchange rate elasticity of exports, $\varkappa = 1.71$, is at the upper-end

[10] Their value is based on a limited number of studies, including dated ones such as Ogaki, Ostry, and Reinhart (1996). This, couple 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.

of the empirical estimates of Ahmed, Appendino, and Ruta (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 SOEs' capital rental rate elasticity with respect to their investments, estimated at $\kappa_2 = 0.68$, 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 7 shocks examined, the reference rate-setting shock is the least persistent [AR(1) parameter equals to 0.11], while the preference shock is the most [AR(1) parameter equal to 0.84]. The other 5 shocks have AR(1) parameters ranging from 0.33 to 0.71, 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 ten 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 3.11, and for production shock, 2.18), indicating potentially large impact (compared to the other shocks) on the Malaysian business cycle. Nevertheless, such magnitudes have been commonly observed in the *natural resource curse* literature, such as the three aforementioned studies. All the other standard-deviation parameters have estimated posterior means that approximate the specified priors. For instance, $\sigma_A = 0.94$ and $\sigma_U = 0.46$ are estimated for the productivity and preference shocks, which are within a reasonable range (posterior standard deviations of the estimated mean are less than 0.105).

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. Next, we evaluate *Proposition 2* numerically to identify a threshold value of resource wealth allocation to SOE investments (ω^*_{SOE})

above which SOEs are profitable.[11] After that, the optimality considerations are analyzed 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 ($Y_t, Y_t^D, Y_t^{SOE}, Y_t^{POE}, Y_t^X, Y_t^F$), consumption, investment, rental rates of physical capital stock (r_t^{SOE}, r_t^{POE}), bonds' reference rate, inflation rate, profits (Π_t^{SOE}, Π_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, Pancrazi, and Uribe 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 percent of the variation in domestic inflation rate, and at least 39.5 percent of the variations in final good, domestic production, exports, imported IGs, consumption, and the movements in exchange rate. In addition, the two commodity shocks (both production and price shocks) 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 SOEs in driving the Malaysian business cycle. Indeed, in terms of variation in final good, Y_t, the combination of the resources shocks account for 32.6 percent, which trails only preference shock (37.2 percent). These results are consistent with the economic structure and historical performance of Malaysia—predominantly SOE-

[11] 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 π_t^{SOE} expression. This means it is not a pre-condition for SOE to make positive profits for the model to solve.

driven yet possesses a relatively robust private consumption components [see, for instance, Economic Planning Unit (2000, 2005, 2010, 2015)]. Further, despite a purely exogenous specification, the resources shocks account for over 90 percent of the variations in the SOE- and POE-intermediate goods' production, the SOE-specific rental rates, the Resource Fund's asset size, and most importantly, **both** SOE and POE profits in the economy. Such dominant role of resources shocks in driving the business cycle is consistent with non-estimated models in the recent *natural resource curse* literature, such as Araujo and others (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 in consistent with empirical documentations of the industrial structure in Malaysia: SWF-financed SOEs are industrial leaders and dominant players, hence dictating business terms and influencing private profitability (Menon 2014; Zeufack and Lim 2013).

Next, we examine the impulse responses of the seven shocks, where a one-percent 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 1-4 respectively. The first three are main business-cycle shocks typically considered in a small open economy, while the commodity price shock is a main source of cyclical dynamics in this economy.[12] Figure 1 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 2 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 de-

[12] 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.

mand. Both sets of results in Figures 1 and 2 are consistent with observations in conventional models such as Smets and Wouters (2003, 2007). In Figure 3, 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 (38)] result in a temporary dampening effect on production and by implications, profitability of both SOEs 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, Alper, and Pereira da Silva (2014, 2018). Lastly, Figure 4 presents the impulse response results associated with a temporary increase in commodity price. Despite the novel introduction of SOEs (making this a different model), overall the responses of macroeconomic variables are in line with the natural resource curse literature (van der Ploeg and Venables 2011, 2013; Agénor 2016), which include an expansionary effect on final good, temporary spike in cost-push inflation, and the classic real exchange rate appreciation. On top of these stylized facts, the introduction of SOEs provides further interesting dynamics that the aforementioned *natural resource curse* models have not been able to capture: When domestically-invested resource revenue does not go into infrastructure but more realistically, SOEs, the positive effects on SOEs' production and profitability would crowd out the POEs. As such, the expansionary effect usually assumed on private consumption (from a temporary positive commodity price shock) cannot be taken for granted, as it not only depends on industrial structure, but also the allocation of resource windfall between a direct transfer to the budget, to SOE investments, and to Resource Fund.

5.2 Optimal allocation to SOE Investment and Resource Fund

Having estimated key model parameters and then solved for both the dynamic system and steady-state solutions (see Appendix 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 ω^*_{SOE}, though it critically depends on the initial fixed cost value, F_0^{SOE}. In the benchmark calibration discussed, F_0^{SOE} is determined residually from the steady-state expression of (42), yielding $F_0^{SOE} = 0.0013$. From (49), this requires a threshold value of $\omega_{SOE} = 0.480$. Given that $\omega_{SOE} = 0.374$ in the benchmark, this means in the benchmark steady-state equilibrium solved for the calibrated Malaysian economy, a typical SOE does not make a profit. Nevertheless, from (48), the procyclicality of SOE profitability (to commodity shocks) is easily observed. For instance, during a "resource boom" period when $P_t^O O_t / \tilde{P}^O \tilde{O} = 1.5$, a much lower threshold $\omega_{SOE}^* = 0.330 < \omega_{SOE} = 0.374$ is obtained, indicating a period when SOEs are making positive profits. This resource procyclicality of SOE profitability—and by implications, their higher capital reinvestment behaviors 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 1.3216 can be established numerically: in any given year, a typical SOE makes positive profits if and only if the resource royalties generated is 32.16 percent higher than its steady-state value.

Next, we examine for optimal allocation of resource wealth between SOE investments and Resource Fund. Specifically, suppose the government, having set aside a fixed sum of royalties directly into the budget [T_t^O, as in (39)], is to decide how best to allocate the remaining windfall—–$0.56 P_t^O O_t$, based on the value of Malaysia—–between SOE investments [a fraction $\varphi \in (0, 1)$] and the Resource Fund (a fraction $1 - \varphi$). To address this, following Agénor (2016), we define a fundamental social loss function:

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

which is a weighted geometric average of the volatility of private consumption, σ_C^φ (welfare consideration for risk-averse households), and the volatility of the non-resource primary balance, σ_{NB}^φ (a macroeconomic stability criterion), normalized with respect to the respective volatility measures (σ_C^B, σ_{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 $\Gamma = 0$.[13]

Given that the main feature of resource windfalls is that these are largely temporary (see, for instance, van der Ploeg and Venables, 2011, 2013), the primary assessment of an optimal φ involves comparing the social loss function values across different φ (indirectly, various combination of $\omega_{SOE}, \omega_{RF} \leq 0.56$) when a temporary one standard-deviation negative shock to commodity price is simulated. Table 4 presents the summary results in which the values of the social loss function (50) are calculated for the combination of (φ, Γ) on the basis of (unconditional) asymptotic variances, hence accounting for the volatility of private consumption and nonresource primary balance throughout the entire solution path. Although the results show a clear decreasing function with respect to Γ (the greater emphasis policymakers placed on stabilizing consumption path, à la the PIH tradition, the smaller the losses during the period of resource revenue shortfall), it has a convex shape in φ for a given Γ. In other words, an interior optimal combination of allocation to SOE investments and Resource Fund exists for a government facing a temporary shortfall in resource revenue. Intuitively, in the initial domain of φ, an increase in the allocation to the SOE sector helps stabilizing production and consequently, consumption, despite the temporary fall in royalties putting pressure on fiscal balance. Nevertheless, as φ increases beyond the optimal φ value, the net effect from the social losses associated with volatile SOE profitability (SOEs' operations are by construction, natural resource-intensive) would 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 φ is warranted when managing commodity price shock—a result that is fundamentally similar in spirit to Agénor (2016), despite the complications of a stochastic shock and the addition of SOEs creating competitive pressure to the private firms. Specifically, in the context of our estimated model, a range of $\varphi \in [0.16, 0.23]$ is found to minimize the social loss function (ignoring the two corner cases of $\Gamma = 0$, $\Gamma = 1$), or equivalently,

[13] 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.

$\omega_{SOE} \in (0.090, 0.129)$.

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 share (between foreign assets and domestic economy), while exists, is not fixed and depends on the nature of the stochastic shock an economy is experiencing. For instance, when we "let the data speaks" and evaluate the optimal allocation based on a temporary one standard-deviation negative preference shock (from Table 3 it is clearly the primary shock in the economy, as it dominates the variations in final good production, consumption, inflation, and exchange rate), although an interior optimal φ remains, a range of $\varphi \in [0.48, 0.55]$ is found in Table 5 to minimize the social loss function, translating to $\omega_{SOE} \in (0.269, 0.308)$. This suggests that what constitutes an optimal resource wealth allocation to SWF-financed SOEs and Resource Fund overseas would ultimately depend on the nature of the dominant business-cycle shock of concern. Nevertheless, in the specific context of Malaysia, the present allocation to SWF-financed SOEs appears to be neither profitable to the SOEs nor socially optimal, regardless of the structural shocks considered.

6 Concluding Remarks

We contribute to the broad literature on fiscal management of resource wealth by developing a DSGE model with SWF-financed SOEs—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 allocation of resource revenue to SOE investments using a criterion that accounts for both welfare and fiscal stability considerations. 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 developed is a small open economy, many features concerning international trade and the financial assets market are vastly 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 explored and other macro-prudential regulations. Given that the presence of SOEs is likely to not only influenced the product market (explored in this study) but also the allocation of credit and 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, our model is not built on a stochastic growth framework, hence does not support analysis with respect to long-run economic growth. According to emerging-market real business-cycle studies (Aguiar and Gopinath 2007; García-Cicco, Pancrazi, and Uribe 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 SOEs domestically are often driven by long-run strategic considerations, the role of trend shocks, as well as their relative importance in affecting SOE profitability in developing economies, may be worth examining.

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Table 1
Benchmark Calibrated Parameter Values

Parameter	Value	Description
		Households
β	0.988	Discount factor
η_N	4.5	Preference parameter for leisure
θ_0^F	0.01	Spread parameter, household foreign bonds
		Production
Λ_D	0.7	Distribution parameter, final good
θ	3.93	Elasticity of substitution, within imported IGs
ϕ	0.4	SOE share in domestic production
ω	3.93	Elasticity of substitution, within domestic IGs
η	0.8	Elasticity of substitution, foreign-domestic IGs
α	0.35	Elasticity wrt physical capital stock
		Private Capital Good Producer
δ^P	0.017	Depreciation rate, physical capital stock
		Government and State-owned Enterprises
υ	0.122	Share of gov. spending in domestic output sales
δ^{SOE}	0.017	Depreciation rate, physical capital stock
ξ	0.8	Efficiency in SOE reinvestment process
κ_0	1.0	Shift parameter, SOE capital rental rate
ω_{SOE}	0.374	Resource revenue share, SOE investment
ω_{RF}	0.186	Resource revenue share, Resource Fund
χ	0.05	Administrative cost in managing foreign assets

Table 2
Summary Statistics for Prior and Posterior Distribution of Parameters

		Prior			Posterior	
Description		PDF	Mean	Std	Mean	Std
Structural Parameters						
Elasticity of intertemporal substitution	ς	Gamma	0.5	0.2	1.65	0.266
Private capital adjustment cost parameter	Θ_K	Gamma	100	50	152.4	31.61
Natural resource intensity, SOE fixed cost	μ	Gamma	7.0	2.0	7.16	2.011
Pass-through parameter	μ^F	Beta	0.3	0.2	0.39	0.112
Elasticity of exports wrt exchange rate	$\varkappa$	Gamma	0.7	0.2	1.71	0.295
SOE capital rental rate, wrt market rate	κ_1	Beta	0.7	0.2	0.78	0.159
SOE capital rental rate, wrt SOE investment	κ_2	Beta	0.3	0.2	0.68	0.118
Elasticity of gov reference rate, lagged rate	ϖ_1	Beta	0.7	0.1	0.85	0.080
Elasticity of gov reference rate, output	ϖ_2	Gamma	0.2	0.1	0.10	0.106
Elasticity of gov reference rate, riskfree rate	ϖ_3	Gamma	0.3	0.1	0.22	0.057
Shock Persistence Parameters						
Productivity shock	ρ_A	Beta	0.5	0.2	0.70	0.042
Preference shock	ρ_U	Beta	0.5	0.2	0.84	0.027
Bond reference rate-setting shock	ρ_M	Beta	0.5	0.2	0.11	0.063
POE investment/capital accumulation	ρ_{KP}	Beta	0.5	0.2	0.65	0.079
World interest rate shock	ρ_W	Beta	0.5	0.2	0.33	0.071
Commodity price-specific	ρ_{P_O}	Beta	0.5	0.2	0.61	0.054
Resource production-specific	ρ_O	Beta	0.5	0.2	0.71	0.045
Stochastic Shock Standard Deviation Parameters						
Productivity shock	σ_A	Inv-Gamma	0.1	2.0	0.94	0.070
Preference shock	σ_U	Inv-Gamma	0.1	2.0	0.46	0.105
Bond reference rate-setting shock	σ_M	Inv-Gamma	0.1	2.0	0.09	0.007
POE investment/capital accumulation	σ_{KP}	Inv-Gamma	0.1	2.0	0.06	0.005
World interest rate shock	σ_W	Inv-Gamma	0.1	2.0	0.10	0.007
Commodity price-specific	σ_{P_O}	Inv-Gamma	0.1	2.0	3.11	0.221
Resource production-specific	σ_O	Inv-Gamma	0.1	2.0	2.18	0.152

Table 3
Variance Decomposition Analysis

Variables	Oil Production	Oil Price	TFP shock	Preference shock	Investment specific	World interest	Reference rate shock
	Structural Shocks						
Final good, Y_t	19.02	13.54	17.99	37.19	10.66	0.27	1.33
Domestic IGs, Y_t^D	15.60	9.80	44.02	19.05	9.13	0.45	1.95
SOE IGs, Y_t^{SOE}	75.42	23.51	0.35	0.64	0.05	0.00	0.02
POE IGs, Y_t^{POE}	75.79	22.14	0.67	1.16	0.18	0.01	0.05
Exports, Y_t^X	2.15	1.23	51.58	21.54	1.27	1.57	20.65
Imported IGs, Y_t^F	17.02	13.18	2.85	52.94	9.15	0.26	4.60
Consumption, C_t	39.60	12.04	6.15	33.33	3.78	0.09	5.02
Investment, I_t	41.87	21.86	0.74	14.15	20.16	0.02	1.21
SOE rental rate, r_t^{SOE}	69.28	27.78	0.20	2.58	0.11	0.01	0.05
Private rental rate, r_t^{POE}	62.77	22.61	0.97	12.82	0.53	0.05	0.25
Reference rate, i_t^B	8.14	4.40	7.64	25.57	4.38	0.19	49.68
Inflation rate, π_t	4.01	3.15	26.81	63.21	1.41	0.47	0.94
SOE profits, Π_t^{SOE}	72.81	25.67	0.08	1.36	0.05	0.00	0.03
POE profits, Π_t^{POE}	68.94	21.54	0.25	8.71	0.32	0.03	0.22
Resource fund, F_t	77.92	22.08	0.00	0.00	0.00	0.00	0.00
Exchange rate, E_t	16.03	4.88	5.79	64.79	1.58	1.44	5.49

Table 4
Optimal allocation of resource revenue between SOE Investment and Resource Fund
A temporary one standard deviation, negative shock to resource price

Social loss function value

φ \ Γ	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.1	0.9521	0.8516	0.7618	0.6814	0.6095	0.5451	0.4876	0.4361	0.3901	0.3489	0.3121
0.2	0.8128	**0.7338**	**0.6624**	**0.5981**	**0.5399**	**0.4874**	**0.4401**	**0.3973**	**0.3587**	**0.3238**	**0.2923**
0.3	**0.8033**	0.7422	0.6858	0.6336	0.5855	0.5409	0.4998	0.4618	0.4267	0.3943	0.3643
0.4	0.8319	0.7884	0.7471	0.7080	0.6710	0.6358	0.6026	0.5710	0.5411	0.5128	0.4860
0.5	0.8818	0.8551	0.8292	0.8041	0.7797	0.7561	0.7332	0.7110	0.6895	0.6686	0.6483
0.6	0.9475	0.9369	0.9265	0.9161	0.9059	0.8957	0.8857	0.8758	0.8660	0.8563	0.8468
0.7	1.0270	1.0320	1.0369	1.0419	1.0469	1.0520	1.0570	1.0621	1.0672	1.0724	1.0775
0.8	1.1189	1.1390	1.1595	1.1804	1.2016	1.2232	1.2452	1.2676	1.2903	1.3135	1.3371
0.9	1.2230	1.2581	1.2942	1.3313	1.3695	1.4088	1.4492	1.4908	1.5336	1.5776	1.6229

Social loss function, weight φ between 0.15 and 0.30

φ \ Γ	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.15	0.8505	0.7621	0.6829	0.6119	0.5483	0.4914	0.4403	0.3945	0.3535	0.3168	0.2839
0.16	0.8397	0.7533	0.6758	0.6062	0.5438	0.4878	0.4376	0.3926	0.3522	**0.3159**	**0.2834**
0.17	0.8309	0.7464	0.6704	0.6022	0.5409	0.4859	**0.4364**	**0.3920**	**0.3521**	0.3163	0.2841
0.18	0.8236	0.7410	0.6666	0.5997	0.5395	**0.4854**	0.4367	0.3928	0.3534	0.3180	0.2860
0.19	0.8176	0.7368	0.6640	0.5983	**0.5392**	0.4859	0.4378	0.3945	0.3555	0.3204	0.2887
0.20	0.8128	0.7338	0.6624	**0.5981**	0.5399	0.4874	0.4401	0.3973	0.3587	0.3238	0.2923
0.21	0.8090	0.7318	**0.6620**	0.5988	0.5417	0.4900	0.4432	0.4009	0.3627	0.3281	0.2968
0.22	0.8060	0.7306	0.6622	0.6003	0.5441	0.4932	0.4471	0.4052	0.3673	0.3330	0.3018
0.23	0.8037	**0.7300**	0.6632	0.6024	0.5473	0.4971	0.4516	0.4102	0.3727	0.3385	0.3075
0.24	0.8021	0.7303	0.6649	0.6054	0.5512	0.5018	0.4569	0.4160	0.3787	0.3448	0.3139
0.25	0.8011	0.7310	0.6671	0.6088	0.5556	0.5070	0.4627	0.4222	0.3853	0.3516	0.3209
0.26	0.8007	0.7324	0.6700	0.6129	0.5607	0.5129	0.4692	0.4292	0.3927	0.3592	0.3286
0.27	**0.8006**	0.7342	0.6733	0.6174	0.5662	0.5192	0.4761	0.4366	0.4004	0.3672	0.3367
0.28	0.8012	0.7365	0.6771	0.6224	0.5722	0.5260	0.4836	0.4445	0.4087	0.3757	0.3454
0.29	0.8020	0.7392	0.6812	0.6278	0.5786	0.5333	0.4915	0.4530	0.4175	0.3848	0.3546
0.30	0.8033	0.7422	0.6858	0.6336	0.5855	0.5409	0.4998	0.4618	0.4267	0.3943	0.3643

Table 5

Optimal allocation of resource revenue between SOE Investment and Resource Fund

A temporary one standard deviation, negative preference shock

Social loss function value

						Γ					
φ	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
0.1	1.0218	1.0924	1.1679	1.2218	1.2485	1.4270	1.5256	1.6310	1.7436	1.8641	1.9928
0.2	1.0060	1.0360	1.0670	1.0779	1.0989	1.1656	1.2005	1.2364	1.2734	1.3114	1.3507
0.3	1.0010	1.0126	1.0243	1.0221	1.0361	1.0601	1.0723	1.0847	1.0972	1.1099	1.1226
0.4	0.9993	1.0020	1.0046	0.9975	1.0072	1.0125	1.0152	1.0178	1.0205	1.0232	1.0258
0.5	**0.9990**	**0.9981**	**0.9971**	**0.9914**	**0.9962**	**0.9943**	**0.9933**	0.9924	0.9914	0.9905	0.9895
0.6	0.9995	0.9984	0.9974	0.9947	0.9964	0.9944	0.9934	**0.9923**	**0.9913**	**0.9903**	**0.9893**
0.7	1.0003	1.0010	1.0018	1.0034	1.0025	1.0039	1.0047	1.0054	1.0061	1.0068	1.0076
0.8	1.0014	1.0053	1.0091	1.0163	1.0130	1.0208	1.0247	1.0286	1.0326	1.0366	1.0405
0.9	1.0027	1.0106	1.0186	1.0321	1.0266	1.0428	1.0510	1.0592	1.0675	1.0759	1.0844

Social loss function, weight φ between 0.45 and 0.60

φ											
0.45	0.9991	0.9995	0.9999	1.0002	1.0006	1.0010	1.0014	1.0018	1.0022	1.0026	1.0030
0.46	0.9990	0.9991	0.9992	0.9993	0.9993	0.9994	0.9995	0.9996	0.9997	0.9997	0.9998
0.47	0.9990	0.9985	0.9981	0.9976	0.9971	0.9966	0.9961	0.9956	0.9951	0.9947	0.9942
0.48	**0.9990**	0.9983	0.9975	0.9967	0.9960	0.9952	0.9944	0.9937	0.9929	0.9921	0.9914
0.49	0.9990	0.9982	0.9975	0.9967	0.9959	0.9951	0.9943	0.9935	0.9928	0.9920	0.9912
0.50	0.9990	0.9981	0.9971	0.9962	0.9952	0.9943	0.9933	0.9924	0.9914	0.9905	0.9895
0.51	0.9990	0.9981	0.9971	0.9961	0.9951	0.9942	0.9932	0.9922	0.9912	0.9903	0.9893
0.52	0.9991	0.9978	0.9968	0.9951	0.9948	0.9934	0.9921	0.9908	0.9895	0.9881	0.9868
0.53	0.9991	0.9978	0.9965	0.9951	0.9939	0.9926	0.9913	0.9900	0.9887	0.9874	0.9861
0.54	0.9991	0.9978	0.9964	0.9951	0.9937	0.9924	0.9911	0.9897	0.9884	0.9870	0.9857
0.55	0.9992	**0.9976**	**0.9961**	**0.9946**	**0.9930**	**0.9915**	**0.9900**	**0.9885**	**0.9869**	**0.9854**	**0.9839**
0.56	0.9992	0.9978	0.9963	0.9948	0.9934	0.9919	0.9905	0.9890	0.9876	0.9862	0.9847
0.57	0.9993	0.9980	0.9968	0.9956	0.9943	0.9931	0.9919	0.9907	0.9894	0.9882	0.9870
0.58	0.9993	0.9980	0.9967	0.9954	0.9941	0.9928	0.9915	0.9902	0.9889	0.9876	0.9863
0.59	0.9994	0.9980	0.9967	0.9953	0.9940	0.9926	0.9913	0.9899	0.9886	0.9872	0.9859
0.60	0.9995	0.9984	0.9974	0.99640	0.99538	0.9944	0.9934	0.9923	0.9913	0.9903	0.9893

Figure 1
Impulse Response: Temporary Productivity Shock
(one standard deviation increase)

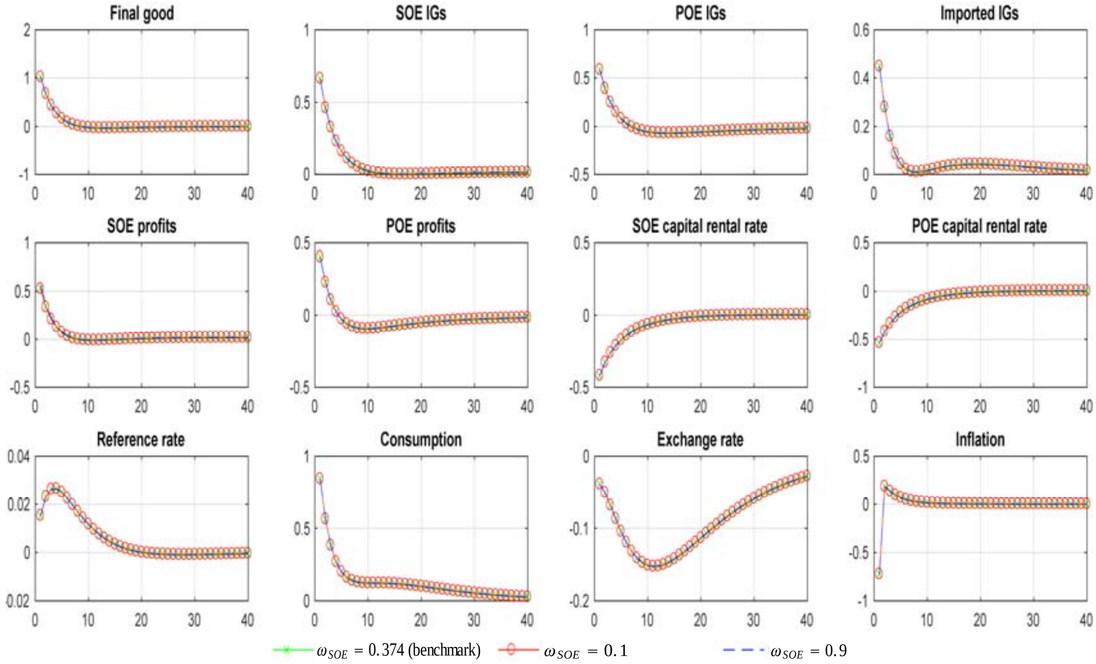


Figure 2
Impulse Response: Temporary Preference Shock
(one standard deviation increase)

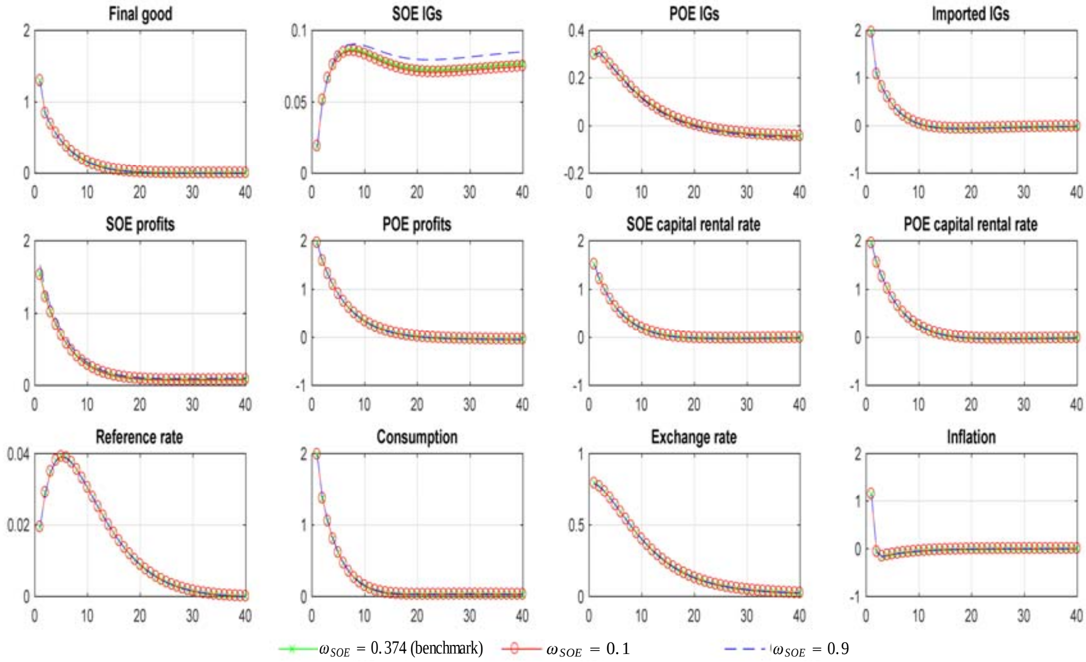


Figure 3
Impulse Response: Temporary World Interest-Rate Shock
(one standard deviation increase)

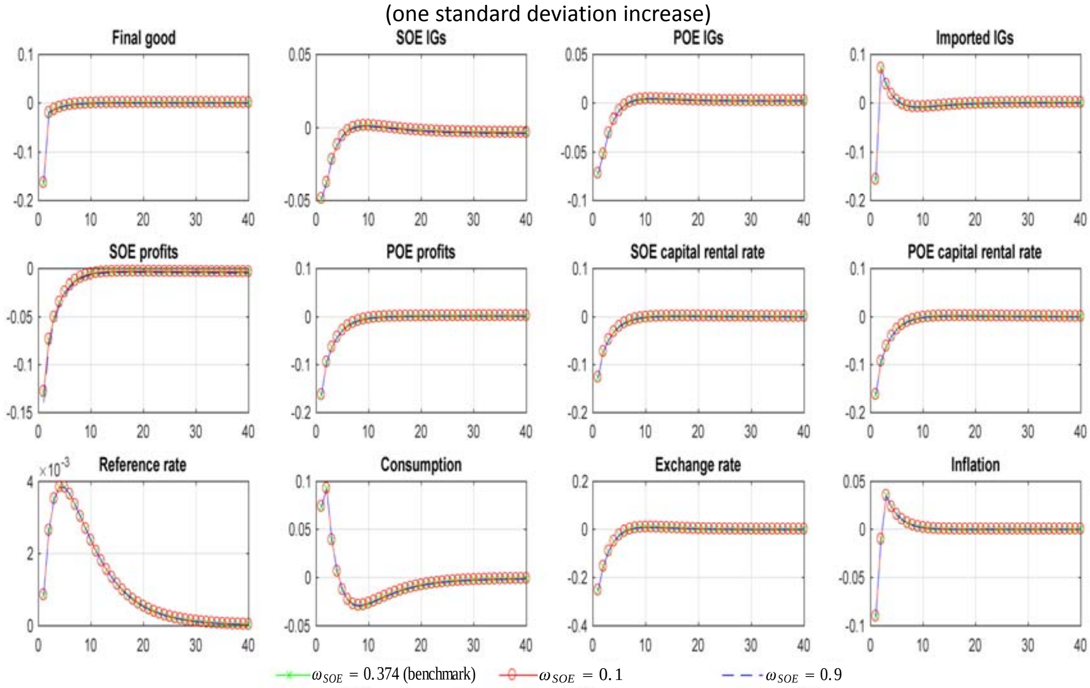
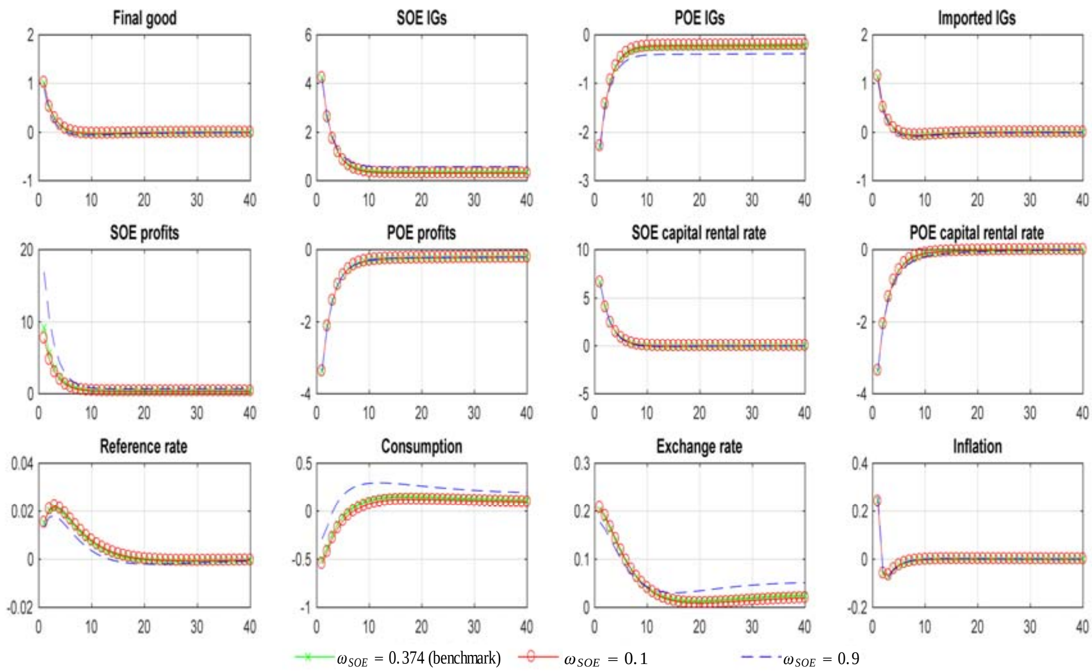


Figure 4
Impulse Response: Temporary Resource Price Shock
(one standard deviation increase)



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