The Dutch disease effect in a high versus low oil dependent countries

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Abstract

To investigate the main impacts of the recent increase of oil price on oil exporting economies, we estimate a DSGE model for a sample of 16 oil exporting countries (Algeria, Argentina, Ecuador, Gabon, Indonesia, Kuwait, Libya, Malaysia, Mexico, Nigeria, Oman, Russia, Saudi Arabia, United Arab Emirates, and Venezuela) over the period from 1980 to 2010, except for Russia where our sample begins in 1992. In order to distinguish between high-dependent and low-dependent countries, we use two indicators: the ratio of fuel exports to total merchandise export and the ratio of oil exports to GDP. We verify if the first group is more sensitive to the Dutch disease effect. We also assess the role of monetary policy.

Our main findings are twofold. First, our results confirm the fact that the Dutch disease occurs mainly in high oil dependent countries. More precisely, we find that the manufacturing production decreases in the aftermath of a positive oil price shock in six countries (on eight) of our first sample while only Mexico suffers from a Dutch disease in the sample of low oil dependent economies. Second, the appropriate monetary policy rule -exchange rate rule *versus* inflation targeting one-to prevent the Dutch disease differs according to the countries. In other words, the best monetary rule is specific to each country.

Keywords: Dutch disease, oil exporting economy, DSGE model, Monetary Policy.

JEL codes: E3, F4, Q40.

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Introduction

Since the early 2000's, oil price -as many commodity prices- has risen dramatically. By the end of 2012, the IMF oil index was five times as high as just a decade ago. The boom in commodity prices has renewed interest of analyzes focusing on its macroeconomic effects in countries abundant in natural resources[1]. More specifically, an extensive literature suggests that resource dependence may be detrimental to economic growth. Indeed, the natural resource curse hypothesis shows that the abundance of natural resources may lead to lower long-term economic growth[2]. Two transmission channels are especially important for our purpose. First, fluctuations in commodity prices are positively associated with higher macroeconomic volatility. For a sample of the G7 economies and 23 developing countries over the period 1955-1990, Mendoza (1995) finds that terms of trade shocks account for nearly one-half of aggregate output variability. In a similar way, Kose (2002) shows that terms of trade shocks explain a large fraction of the output volatility in small open developing countries. The important point for the resource curse hypothesis is that macroeconomic volatility is negatively correlated with growth (Ploeg and Poelhekke, 2009). The Dutch disease effect is the second transmission channel, and this paper focuses its attention on such effect.

Following Corden and Neary (1982) and Corden (1984), the Dutch disease shows that an exogenous increase in resource prices or in resource output results in real exchange rate appreciation and a decline in the manufacturing sector. This effect occurs mainly in two forms. First, the spending effect can be defined as the negative consequence of real exchange rate appreciation on manufacturing sector production. Second, the resource movement effect results from the perfect mobility of capital and labor from the manufacturing sector to the oil and services sectors. This effect occurs because an increase in oil prices generates a rise in wages and/or profits and generates a rise in aggregate demand in the economy. To the extent that a part of this demand will move toward the service sector, the price of non-tradable goods will rise. Consequently, the real exchange rate appreciates. Such real appreciation may lead to a de-industrialization process -especially in advanced countries such as Canada or Netherlands- or may undermine future possibilities of industrialization. Indeed, a smaller tradable sector may slowdown the growth in total factors productivity.

The Dutch disease effect has been the object of an extensive literature. On the empirical side, Oomes and Kalcheva (2007), Egert and Leonard (2008), and Johan-Parvan and Mohammadi

[1] See, for instance the collective book edited by Arezki et al. (2011).
[2] For an overview of the resource curse hypothesis, see Ploeg (2011).

(2011) estimate the long-term relationship between the real exchange rates and real oil prices (for Russia, Kazakhstan, and 14 oil exporting countries respectively) with alternative cointegration techniques. These macroeconomic studies get mixed results on the relevance of the Dutch disease. Sectorial studies tend to support the presence of the Dutch disease in resource abundance countries. Thus, the size of the tradable sector in resource-rich countries is lower than in other economies (Brahmbhatt et al., 2010). Commodity windfall shocks lead to a decrease in the value added of the manufacturing sector (Ismail, 2010) and to a fall in non-resources exports (Harding and Venables, 2011). On the theoretical side, the Dutch disease effect has been studied in the context of dynamic stochastic general equilibrium (DSGE) models. For instance, Lartey (2008) analyze the impact of capital inflows in terms of Dutch disease effect while Acosta et al. (2009) study to what extent countries highly dependent from remittances are sensitive to this effect. Sosunov and Zamulin (2007) for Russia, Bénassy-Quéré et al. (2010) in the context of the Economic Community of West-African States, and Lama and Medina (2012) for Canada, use DSGE models to analyze the macroeconomic effects of terms of trade or oil prices shocks.

In line with previous studies, to investigate the impact of the recent increase of oil price on a small open oil exporting economy, we estimate a DSGE model for a set of oil producing countries using the Bayesian approach. The main drawback of the previous literature is to consider the Dutch disease in oil exporting economies whatever their oil dependence. However, all oil exporting countries are not identical in terms of their dependence on oil. In other words, in some countries, exports of oil may exceed 70% of total exports, while in other countries, oil exports account for, only, a small part of total exports. This difference is crucial because the most dependent countries to their oil exports are more vulnerable to oil price shock compared to the other countries. From this perspective, the first aim of this paper is to determine to what extent the degree of dependence on oil exports matters to induce the Dutch disease effect. Our model is based on recent studies that have developed models for small open oil exporting economies (Dib, 2008; and Benkhodja, 2014). We investigate the efficiency of two policy rules, namely exchange rate (ER) and inflation targeting (IT) rules. The choice of these rules is important in the case of a Dutch disease. Indeed, since the Dutch disease occurs under the spending and the resource movement effects, each monetary policy could play a central role to avoid this effect. Theoretically, in the case of an ER rule, the exchange rate will be fixed, which will lead to lock the spending effect channel. Similarly for the IT rule, the inflation rate will be stabilized. Knowing that wages are indexed to price index, this rule will prevent the resource movement effect. Thus, it would be interesting to verify if, empirically, these rules could prevent the Dutch disease.

Our paper is related to the literature that studies to what extent monetary policy responses can counteract the negative impact of terms of trade shocks and Dutch disease effects. On this point, it is important to stress that the literature is far from achieving a consensus. Aizenman et al. (2012) find, for a sample of Latin American countries from 1970 to 2009, that foreign exchange reserves are effective to protect against the risk of real appreciation in the aftermath of commodity terms of trade shocks. In addition, they show that fixed exchange rate regimes insulate the economy from these shocks. Céspedes and Velasco (2012) consider commodity boom and bust episodes in a small open economy with nominal rigidities and financial imperfections. Over a sample of 33 countries covering the period 1970-2008, they find that the size of the output responses to these episodes decrease with the flexibility degree of the exchange rate. Their finding suggests also that a policy of exchange rate interventions -*via* international reserves- can be effective to insulate the countries against such shocks. For countries heavily dependent from a particular commodity exports, Frankel (2011) advocates a specific monetary regime called "Peg the Export Price". Under this regime, the price of that commodity is fixed in terms of domestic currency. The advantage of this regime relative to an inflation targeting framework or a fixed exchange rate regime is the following: a positive (negative) commodity price shock should be compensated by an appreciation (depreciation) of the nominal exchange rate in order to allow the stabilization of export prices in domestic currency. Using a DSGE framework, Lama and Medina (2012) studies the role of an exchange rate stabilization policy to face Dutch disease effect. Their model includes two rigidities: a nominal rigidity in domestic prices and a real rigidity under the form of learning-by-doing externalities in the tradable sector. Their main result is the following: if an exchange rate stabilization policy may contain the real appreciation of the domestic currency, and hence prevents a fall in the tradable production, this policy may increase macroeconomic volatility to the detriment of the learning-by-doing externalities. As a consequence, an exchange rate stabilization policy is welfare-reducing relative to a floating regime. Sosunov and Zamulin (2007) show that a monetary policy responding to both inflation and the real exchange rate is more effective than alternative monetary framework -based on the inflation targeting or the real exchange rate targeting- to stabilize output in the aftermath of the oil price shocks.

Empirically, we consider a sample of 16 oil exporting countries (See Table 1) spanning the period from 1980 to 2010[3] . In order to distinguish between high-dependent and low-dependent countries, we use two indicators: the ratio of fuel exports to total merchandise exports and the ratio of oil exports to GDP. We estimate the median for each ratio on our 16 studied countries. Countries above (below) the median are considered as high (low) oil dependent economies. We verify if the first group is more sensitive to the Dutch disease effect.

Our main findings show that in the first sample, namely high oil dependent economies, 6 countries are affected by the Dutch disease (decrease in the manufacturing production).

Table 1: Oil Exporting Countries Ranked According to their Dependence Degree to Oil Sector.

	$\frac{X_o}{X}$ *	$\frac{X_o}{GDP}$ **
Algeria	97,70	35,59
Venezuela	95,90	21,25
Kuwait	93,21	46,54
Libya***	92,61	59,31
Nigeria	90,36	34,36
Saudi Arabia	87,58	48,07
Gabon	85,61	50,98
Oman	79,04	43,62
Russia	66,69	13,94
UAE	64,81	25,66
Ecuador	50,32	16,68
Egypt	43,98	3,68
Indonesia	28,42	2,22
Malaysia	14,81	7,44
Mexico	13,51	4,03
Argentina	10,34	1,71
Median	72,865	23,455

* Fuel exports in 3 of merchandise exports in 2009. World Bank, World Bank database.
** Oil exports in 3 of GDP (2010). IMF, World Economic Outlook database.
*** Last available data: 1998

In the low oil dependent countries sample, we see that the economies are less affected by the fluctuation of oil price. Indeed, only one country has suffered a Dutch disease effect after the shock. In this paper, it also appears that the flexible exchange rate seems to be the best way to avoid the Dutch disease under its both spending and resource movement effects. In other words, it is preferable for a central bank, in high oil dependent countries, to adopt inflation targeting regime to prevent the impact of oil shocks.

The remainder of the paper is organized as follows. Section 2, presents the model. Section 3, describes solving and calibration methods. Section 4, discusses the data and the estimation results. Section 5 determines the best monetary policy rule. Section 6 concludes.

[3] Except for Russia where our sample begins in 1992.

2. The model

As in previous studies (Dib (2008) and Benkhodja (2014)), we assume that the economy is inhabited by eight agents: households, oil producing firms, non-tradable and manufacturing goods producers, an intermediate foreign goods importer, a final good producer, a central bank and a government.

2.1 Households

There is a continuum of households indexed by $\iota \in (0,1)$. Each household ι derives utility from consumption, $c_t(\iota)$, and disutility from labor, $h_t(\iota)$:

$$U_0(\iota) = E_{0t=0}^{\infty} \beta^t \left\{ \frac{1}{1-\gamma} \eta_t \left(\frac{c_t(\iota)}{c_{t-1}(\iota)^{\varpi}} \right)^{1-\gamma} - \varsigma_t \frac{h_t(\iota)^{1+\sigma}}{1+\sigma} \right\} \qquad (1)$$

where E_0 is the conditional expectation operator, $(0 < \beta < 1)$ is the subjective discount factor and $\gamma > 1$ and $\sigma > 0$ are the inverse of the elasticity of intertemporal substitution of consumption and the inverse of the wage elasticity of labor supply, respectively; $\varpi \in (0,1)$ is a habit formation parameter and η_t and ς_t denote respectively a taste shock and the labor supply shock.

We assume that the aggregate labor supply, $h_t(\iota)$, depends on sector-specific labor supplies according to:

$$h_t(\iota) = h_{o,t}(\iota)^{\alpha_{ho}} h_{nT,t}(\iota)^{\alpha_{hnT}} h_{M,t}(\iota)^{\alpha_{hM}} \qquad (2)$$

where $h_{o,t}(\iota)$, $h_{nT,t}(\iota)$ and $h_{M,t}(\iota)$ represent hours worked by the household ι at time t in oil, non-tradable and manufacturing sectors, respectively. The parameters $\alpha_{ho}, \alpha_{hnT}$ and α_{hM} denote the elasticity of substitution of the labor in the three sectors, where $\alpha_{ho} + \alpha_{hnT} + \alpha_{hM} = 1$.

The household's budget constraint in period t is:

$$P_t(c_t(\iota) + i_t(\iota)) + \frac{B_t^d(\iota)}{R_t} + \frac{e_t B_t^f(\iota)}{R_t^f \kappa_t} \circ B_{t-1}^d(\iota) + e_t B_{t-1}^f(\iota) +$$
$$\sum_{j=o,M,nT} Q_{j,t} k_{j,t}(\iota) + (1-\aleph) \sum_{j=o,M,nT} W_{j,t} h_{j,t}(\iota) + \rho(\iota) P_{O,t} O_t + D_t \qquad (3)$$

where c_t denotes total consumption and $P_t i_t = P_{o,t} i_{o,t} + P_{M,t} i_{M,t} + P_{nT,t} i_{nT,t}$ denotes total investment, P_t is the consumption price index (CPI), R_t is the gross nominal interest rate on domestic debt, B_t^d, between t and $t+1$, $W_{o,t}$, $W_{M,t}$ and $W_{nT,t}$ are the nominal wages received by the household, in period t, for its labor supply in the oil, manufacturing, and non-tradable sectors respectively, $D_t = D_{nT,t} + D_{I,t}$ is the dividend payment received from non-tradable and import firms, $\rho(\iota)P_{O,t}O_t$ is the factor payment of oil resources, where $P_{O,t}$ is the nominal price of oil resource input O_t and $\rho(\iota)$ is the share of the household ι in oil resource payment with $\int_0^1 \rho(\iota)d\iota = 1$, $B_{t-1}^d(\iota)$ and $B_{t-1}^f(\iota)$ denote, respectively, domestic non-state-contingent bonds denominated in units of domestic currency and foreign bonds denominated in units of foreign currency.

We assume that the representative household enter period t with holdings of domestic and foreign non-state contingent bonds because in oil exporting economies, household's consumption is not smooth and there is no international risk sharing. Also, since the dynamics of exchange rate and the current account play a central role in explaining the spending effect, the assumption of the incomplete international financial markets is necessary. The parameter, $\aleph$, denotes a lump-sum tax paid by the representative household to finance government spending. At time t, B_t^f is bought or sold by household for the price that depends on the world interest rate R_t^f and a country-specific risk-premium, κ_t. The latter has the following functional form:

$$\kappa_t = \exp\left(-\phi \frac{e_t \tilde{B}_t^f / P_t^f}{P_t Y_t}\right) \tag{4}$$

where ϕ denotes the parameter measuring the risk premium, e_t is the nominal exchange rate and $\tilde{B}_t^f$ is the average nominal stock of external debt which take either a positive value if the domestic economy is a net borrower or negative value if the domestic economy is a net lender[4]. Note finally that, Y_t, is the total real GDP, and P_t^f is the foreign price index. By following this functional form, the model would not have a unit root because the holding bond would not follow a random walk[5]. The risk premium also ensures that the model has a unique steady state.

Note finally that the representative household accumulates $k_{o,t}, k_{M,t}$ and $k_{nT,t}$ units of capital stocks, used in the oil, manufacturing and non-tradable sectors and receives nominal rentals

[4]If the domestic economy is a net lender households receive a lower remuneration on their saving. If the economy is a net lender, households charge a premium on the foreign interest rate. In our case, we assume that $B_t^f < 0$ to the extent that several oil exporting economies are net borrower.

[5] The risk premium associated with asset transactions is an increasing function of a monotonic transformation of the external debt to output ratio. This feature has the additional positive externality of making the model stationary à la Schmitt-Grohé and Uribe (2003).

$Q_{o,t}, Q_{M,t}$ and $Q_{nT,t}$ respectively. The law of motion of capital stock in each sector is given by:

$$k_{j,t+1}(\iota) = (1-\delta)k_{j,t}(\iota) + i_{j,t}(\iota) - \Psi_j\left(k_{j,t+1}(\iota), k_{j,t}(\iota)\right) \quad (5)$$

where δ is depreciation rate, common to all sectors $(0 < \delta < 1)$ and $\Psi_{j,t}(\mathrm{k}_{j,t+1}(\iota), \mathrm{k}_{j,t}(\iota))$ is an adjustment cost paid by households and satisfy $\psi_j(0) = 0, \psi_j^{'}(.) > 0$ and $\psi_j^{''}(.) < 0$. The functional form of $\Psi_j(.)$ is:

$$\Psi_{j,t}(.) = \frac{\psi_j}{2}\left(\frac{k_{j,t+1}(\iota)}{k_{j,t}(\iota)} - 1\right)^2 k_{j,t}(\iota) \quad (6)$$

As in Erceg et al. (2000), we assume that households are monopolistic suppliers of differenciated labor services to the three production sectors, namely oil, manufacturing and non-tradable sectors. Following these authors, a representative labor aggregator combines households' hours in the same proportions as firms would choose optimally. Thus, in each sector j, the demand curve for each type of labor is:

$$h_{j,t}(\iota) = \left(\frac{W_{j,t}(\iota)}{W_{j,t}}\right)^{-\theta} h_{j,t} \quad (7)$$

variables $h_{o,t}, h_{M,t}$ and $h_{nT,t}$ denote aggregate labor supplies to oil, manufacturing and non-tradable sectors respectively, $\theta > 1$ denotes the constant elasticity of substitution between different types of labor services, $W_{j,t}(\iota)$ is the wage rate set by the household ι and $W_{o,t}, W_{M,t}$ and $W_{nT,t}$ are the aggregate wage index, or the unit cost of sales to the oil, manufacturing and non-tradable sectors, respectively.

The aggregate wage index $W_{j,t}$ in sector j is given by:

$$W_{j,t} = \left(\int_0^1 W_{j,t}(\iota)^{1-\theta} d\iota\right)^{\frac{1}{1-\theta}} \quad (8)$$

where $W_{j,t}$ and $h_{j,t}$ are considered as given.

Households set nominal wages according to a stochastic time dependent rule as in Calvo (1983) and Yun (1996). In each period, the constant probability of changing the nominal wages is given by $(1-\varphi_j)$. Therefore, in average, the wage remains unchanged for $\frac{1}{1-\varphi_j}$ periods. However, if household ι is not allowed to adjust its wage, it updates it according to the following rule: $W_{j,t} = \bar{\pi} W_{j,t-1}$, where $\bar{\pi} > 1$ is the long run average gross rate inflation.

Thus, the aggregate real wage index in sector j, evolves over time according to:

$$\left(w_{j,t}\right)^{1-\theta}=\varphi_j\left(\pi\frac{w_{j,t-1}}{\pi_t}\right)^{1-\theta}+\left(1-\varphi_j\right)\left(\tilde{w}_{j,t}\right)^{1-\theta} \tag{9}$$

where $\tilde{w}_{j,t}(\iota)=\dfrac{\tilde{W}_{j,t}(\iota)}{P_t}$ and $w_{j,t+s}=\dfrac{W_{j,t+s}}{P_{t+s}}$ denote the real optimized wage and the real wage in sector j respectively.

2.2 Tradable sector

In this sector, we assume that there are two types of tradable goods[6]: oil and manufacturing goods. It's assumed that oil firm operates under perfect competition, while manufactured intermediate goods producing firms operate in a monopolistic competitive market indexed by $i\in(0,1)$.

2.21 Oil firm

There is a single oil firm which combines capital, $k_{o,t}$, labor, $h_{o,t}$, and an oil resource, O_t, to produce crude oil, $Y_{o,t}$. Its production function is given by:

$$Y_{o,t}=Y_{o,t}^{d}+Y_{o,t}^{ex}=A_{o,t}k_{o,t}^{\alpha_o}h_{o,t}^{\beta_o}O_t^{\theta_o} \tag{10}$$

where α_o,β_o and $\theta_o\in(0,1)$ and $\alpha_o+\beta_o+\theta_o=1$. $A_{o,t}$ is a technology shock specific to the oil sector and evolves exogenously according to a stochastic process.

2.22 Manufacturing firms

There are a continuum of monopolistic competitive manufactured intermediate goods producing firms indexed by $i\in(0,1)$. The manufacured goods are produced by firm i by using capital, $k_{M,t}=\int_0^1 k_{M,t}(\iota)d\iota$, labor, $h_{M,t}=\int_0^1 h_{M,t}(\iota)d\iota$, and oil input, $Y_{o,t}^{M}$. Its production function is given by the following Cobb-Douglas function:

$$Y_{M,t}(i)=Y_{M,t}^{d}(i)+Y_{M,t}^{ex}(i)=A_{M,t}k_{M,t}^{\alpha_M}(i)h_{M,t}^{\beta_M}(i){Y_{o,t}^{M}}^{\theta_M}(i) \tag{11}$$

where α_M,β_M and $\theta_M\in(0,1)$ and $\alpha_M+\beta_M+\theta_M=1$. These coefficients denote, respectively, a share of capital, labor, and oil input, in the production of manufactured goods. $A_{M,t}$ is a technology shock specific to the manufacturing sector and evolves exogenously according to a stochastic process.

[6] In our model, tradable goods are defined as intermediate goods that have export or import potential.

2.3 Non-tradable sector

We assume that in the non-tradable sector, there is a continuum of services producing firms indexed by $i \in (0,1)$. Each firm i, produces non-tradable goods, $Y_{nT,t}(i)$, by using capital, $k_{nT,t}(i)$, labor, $h_{nT,t}(i)$, and a part of oil output, $Y_{o,t}^{I_{nT}}(i)$, with the following constant returns to scale production function:

$$Y_{nT,t}(i) = A_{nT,t} k_{nT,t}^{\alpha_{nT}}(i) h_{nT,t}^{\beta_{nT}}(i) Y_{o,t}^{nT^{\theta_{nT}}}(i) \tag{12}$$

where α_{nT}, β_{nT} and $\theta_{nT} \in (0,1)$ are the share of capital, labor and oil input in output respectively, and $\alpha_{nT} + \beta_{nT} + \theta_{nT} = 1$. $A_{nT,t}$ is a technology shock specific to the non-tradable sector and evolves exogenously according to a stochastic process.

2.4 Import goods producers

In our model, we assume that an imported-composite good, $Y_{I,t}$, purchased in a domestic monopolistically competitive market, is used by the final good producer. To produce $Y_{I,t}$, the firm uses differentiated goods, $Y_{I,t}(i)$, that are produced by a continuum of domestic importers, indexed by $i \in (0,1)$, using a homogeneous intermediate good produced abroad for the world price P_t^f. The differentiated goods are sold at price $P_{I,t}(i)$ subject to Calvo (1983) and Yun (1996) contracts[7]. In each period, importer faces an exogenous and constant probability of changing the nominal prices $(1-\phi_I)$. Therefore, in average, the price remains unchanged for $\frac{1}{1-\phi_I}$ periods.

2.5 Final good producer

Firm in the final-good sector is perfectly competitive. It combines a fraction of tradable output, $Y_{M,t}^d$, which is domestically-produced, the non-tradable output, $Y_{nT,t}$, and imports, $Y_{I,t}$: Its production function is:

$$z_t = \left[\chi_M^{\frac{1}{\tau}} Y_M^{d^{\frac{\tau-1}{\tau}}} + \chi_{nT}^{\frac{1}{\tau}} Y_{nT}^{\frac{\tau-1}{\tau}} + \chi_I^{\frac{1}{\tau}} Y_I^{\frac{\tau-1}{\tau}} \right]^{\frac{\tau}{\tau-1}} \tag{13}$$

where $Y_{M,t} = \left(\int_0^1 Y_{M,t}(i)^{\frac{1-\vartheta}{\vartheta}} di \right)^{\frac{\vartheta}{1-\vartheta}}$, $Y_{nT,t+s} = \left(\int_0^1 Y_{nT,t}(i)^{\frac{1-\vartheta}{\vartheta}} di \right)^{\frac{\vartheta}{1-\vartheta}}$ and $Y_{I,t+s} = \left(\int_0^1 Y_{I,t}(i)^{\frac{1-\vartheta}{\vartheta}} di \right)^{\frac{\vartheta}{1-\vartheta}}$ are aggregate of domestic tradable good, non-tradable goods and import goods; and $\vartheta > 1$ is the

[7] Introducing price rigidities allows the deviation from the law of one price in the import sector, leading to incomplete pass-through effects of exchange rate movements.

constant elasticity of substitution between intermediate goods in composite goods aggregate; $\tau > 0$ is the elasticity of substitution between the fraction of manufacturing output, the non-tradable output and imported goods and χ_M, χ_{nT}, $\chi_I \in (0,1)$ represent the share of manufactured, non-tradable and imported goods in the final good. Note that $P_{M,t+s} = \left(\int_0^1 \pi^s \tilde{P}_{M,t}(i)^{1-\vartheta} di \right)^{\frac{1}{1-\vartheta}}$, $P_{nT,t+s} = \left(\int_0^1 \pi^s \tilde{P}_{nT,t}(i)^{1-\vartheta} di \right)^{\frac{1}{1-\vartheta}}$ and $P_{I,t+s} = \left(\int_0^1 \pi^s \tilde{P}_{I,t}(i)^{1-\vartheta} di \right)^{\frac{1}{1-\vartheta}}$ are the price index associated with the aggregators $Y_{M,t}^d$, $Y_{nT,t}$ and $Y_{I,t}$ respectively.

2.6 Monetary Policy

We assume that the central bank manages its nominal interest rate, R_t, in response to fluctuation in CPI inflation, π_t, nominal exchange rate changes, Δe_t, and output, Y_t. We use in this exercice, the following Taylor rule:

$$\log\left(\frac{R_t}{R}\right) = \rho_R \log\left(\frac{R_{t-1}}{R}\right) + (1-\rho_R)\left[\upsilon_\pi \log\left(\frac{\pi_t}{\pi}\right) + \upsilon_e \log\left(\frac{\Delta e_t}{\Delta e}\right) + \upsilon_y \log\left(\frac{Y_t}{Y}\right)\right] + \varepsilon_{R_t} \qquad (14)$$

Variables without time subscripts denote deterministic steady state values. This rule implies that the steady state inflation rate is interpreted as the target level of inflation. The parameter ρ_R is the degree of interest rate smoothing which reflects the central bank's preference for interest rate stability. υ_π, υ_e and υ_y are the policy coefficients measuring central bank's responses to deviation of inflation rate, exchange rate and output respectively, and $\varepsilon_{R,t}$ is an iid monetary policy shock.

2.7 The government

It's assumed that the government is the owner of the oil firm. Its budget constraint is:

$$s_t p_{o,t}\left(Y_{o,t}^d + Y_{o,t}^{ex}\right) + \grave{u} \sum_{j=o,M,nT} W_{j,t} h_{j,t} = w_{o,t} h_{o,t} + q_{o,t} k_{o,t} + p_{O,t} O_t \qquad (15)$$

where the left hand side represents the government's revenu that include lump-sum taxes $\left(\aleph \sum_{j=o,M,nT} W_{j,t} h_{j,t}\right)$ and receipts from selling oil to domestic $\left(s_t p_{o,t} Y_{o,t}^d\right)$ and foreign $\left(s_t p_{o,t} Y_{o,t}^{ex}\right)$ firms. The right hand side represents the government spending that include payment of wages, capital return and a factor payment of oil resource $\left(w_{o,t} h_{o,t} + q_{o,t} k_{o,t} + p_{O,t} O_t\right)$ in the oil sector.

2.8 Symmetric equilibrium

A symmetric equilibrium for this economy is composed of an allocation[8] and a sequence of

[8] $\{c_t, i_t, i_{o,t}, i_{M,t}, i_{nT,t}, Y_{o,t}, Y_{nT,t}, Y_{o,t}^d, Y_{o,t}^M, Y_{o,t}^{nT}, Y_{o,t}^{ex}, Y_M, Y_M^d, Y_M^{ex}, Y_{I,t}, Y_t, Y_{nT,t}^{va}, Y_M^{va}, z_t$, k

price and co-state variables[9] satisfying households, oil, tradable and non-tradable first order conditions, the aggregate resources constraints, the monetary policy rules, the current account equation and the stochastic processes $\{ \eta_t , \varsigma_t , R_t^f , \pi_t^f , P_{o,t} , O_t , Y_{o,t}^f , Y_{M,t}^f , A_{o,t} , A_{M,t} , A_{nT,t} \}_{t=0}^{\infty}$ of the shocks and the following market clearing conditions $b_t = b_{t-1} = 0$, $b_t^f = \tilde{b}_t^f$ and:

$$Y_{o,t} = Y_{o,t}^d + Y_{o,t}^{ex} \tag{16}$$

$$Y_{o,t}^d = Y_{o,t}^M + Y_{o,t}^{nT} \tag{17}$$

$$Y_{M,t} = Y_{M,t}^d + Y_{M,t}^{ex} \tag{18}$$

According to McCallum and Nelson (1999) and Gertler et al. (2003), we assume that the foreign demand for the oil and the manufacturing goods, $Y_{o,t}^{ex}$, and $Y_{T,t}^{ex}$, are given by : $Y_{o,t}^{ex} = \nu_o \left(\frac{e_t P_{o,t}}{P_t^f} \right)^{-\omega_o} Y_{o,t}^f$ *and* $Y_{M,t}^{ex} = \nu_M \left(\frac{e_t P_{M,t}}{P_t^f} \right)^{-\omega_M} Y_{M,t}^f$ where ν_o and ν_M are parameters determining the fraction of domestic tradable goods exports in foreign spending. The economy is small, so domestic exports form an insignificant fraction of foreign expenditures and have a negligible weight in the foreign price index. $Y_{o,t}^f$ and $Y_{M,t}^f$ are the foreign output and ω_o and ω_M, denote the elasticity of demand for domestic tradable goods by foreigners. we assume that the foreign production of oil and tradable goods are exogenous and evolve according AR(1) processes.

The aggregate GDP is defined as:

$$Y_t = p_{M,t} Y_{M,t}^{va} + p_{nT,t} Y_{nT,t}^{va} + s_t p_{o,t} Y_{o,t} \tag{19}$$

where $Y_{M,t}^{va}$, and $Y_{nT,t}^{va}$ are the value-added output in manufacturing and non-tradable sectors respectively. These variables are constructed by subtracting oil input as follow[10]:

$$Y_{M,t}^{va} = Y_{M,t} - s_t p_{o,t} \frac{Y_{o,t}^M}{p_{M,t}} \tag{20}$$

$_{o,t}$, $k_{M,t}$, $k_{nT,t}$, h_t, $h_{o,t}$, $h_{M,t}$, $h_{nT,t}$, b_t^f, $\kappa \}_{t=0}^{\infty}$.

[9] $\{ w_{o,t}, w_{M,t}, w_{nT,t}, \tilde{w}_{o,t}, \tilde{w}_{M,t}, \tilde{w}_{nT,t}, q_{o,t}, q_{M,t}, q_{nT,t}, p_{M,t}, \tilde{p}_{M,t}, p_{nT,t}, \tilde{p}_{nT,t}, p_{I,t}, \tilde{p}_{I,t}, p_{O,t}, \pi_t, \pi_{nT,t}, \pi_{I,t}, s_t, e_t, R_t, \lambda_t, \Lambda_{o,t}, \Lambda_{M,t}, \Lambda_{nT,t}, mc_{M,t}, mc_{nT,t}, mc_{I,t} \}_{t=0}^{\infty}$.

[10] Our model suppose that tradable and non-tradable firms use refined oil as material inputs in their productions which is defined as gross output. Thus, value added output in each sector can be constructed by substracting commodity inputs.

$$Y_{nT,t}^{va} = Y_{nT,t} - s_t p_{o,t} \frac{Y_{o,t}^{nT}}{p_{nT,t}} \quad (21)$$

Combining the households' budget constraint, the single period profit functions of manufactured and non-tradable goods producing firms and foreign good importers and the first order conditions of the three sectors and applying the market clearing conditions yields the following current account equation:

$$\frac{b_t^f}{R_t^f \kappa_t} = \frac{b_{t-1}^f}{\pi_t^f} + p_{o,t} Y_{o,t}^{ex} + \frac{p_{M,t}}{s_t} Y_{M,t}^{ex} - Y_{I,t} \quad (22)$$

2.9 Exogenous processes

Our oil exporting economy is affected by twelve structural shock processes, including a taste shock, a labor supply shock, an oil price shock, an oil resource shock, foreign interest rate and the world inflation rate shocks, three technological shocks and a monetary policy shock.

Apart from the monetary policy shock, which is a zero-mean iid shock with a standard deviation, the rest of structural shocks follows an AR(1) process given by:

$$\log(\hat{o}_t) = (1-\rho_{\hat{o}})\log(\hat{o}) + \rho_{\hat{o}} \log(\hat{o}_{t-1}) + \varepsilon_{\hat{o},t} \quad (23)$$

where $\hat{o}$ is the steady state value of $\hat{o}_t$, $\rho_{\hat{o}}$ is the autocorrelation coefficients, and $\varepsilon_{\hat{o},t}$ is uncorrelated and normally distributed innovations with zero mean and standard deviation $\sigma_{\hat{o}}$.

and $\hat{o} = \{\eta_t, \varsigma_t, R_t^f, \pi_t^f, P_{o,t}, O_t, A_{o,t}, A_{T,t}, A_{nT,t}, Y_{o,t}^f, Y_{M,t}^f\}$

3. Bayesian estimation

The model is estimated by using the Bayesian method as in Sungbae and Schorfheide (2007), Fernández-Villaverde (2010) and Del Negro and Schorfheide (2008).

There are 54 parameters to be estimated gathered in $\Theta = \{\eta, \varsigma, \varpi, \psi_o, \psi_M, \psi_{nT}, \varphi_o, \varphi_M, \varphi_{nT}, \alpha_o, \beta_o, \theta_o, \alpha_M, \beta_M, \theta_M, \phi_M, \alpha_{nT}, \beta_{nT}, \theta_{nT}, \alpha_{ho}, \alpha_{hM}, \alpha_{hnT}, \phi_{nT}, \phi_I, \chi_I, \chi_{nT}, \chi_M, \mu_\pi, \mu_e, \mu_y, \rho_r, \rho_{r^f}, \rho_{p_o}, \rho_o, \rho_{y_o^f}, \rho_{y_M^f}, \rho_{\pi^f}, \rho_{a_o}, \rho_{a_M}, \rho_{a_{nT}}, \rho_\eta, \rho_\varsigma, \sigma_r, \sigma_{r^f}, \sigma_{p_o}, \sigma_o, \sigma_{y_o^f}, \sigma_{y_M^f}, \sigma_{\pi^f}, \sigma_{a_o}, \sigma_{a_M}, \sigma_{a_{nT}}, \sigma_\eta, \sigma_\varsigma\}$. The rest of the parameters are calibrated, as commonly done in the DSGE literature. This procedure helps to cope with the problem of identification from which DSGE models commonly suffer, arising from the fact that the data used in the estimation may contain little information about some parameters.

3.1 Calibration

We calibrate some parameters which cannot be estimated. These parameters' values are taken as fixed from the start of calculation. As in Almeida (2009), the parameters we chose to calibrate pertain mostly to three aspects: (i) those crucial to determine the steady-state; (ii) those for which we have reliable estimations from other sources; and (iii) those whose values are crucial to replicate the main steady-state key ratios of an oil exporting economy. The calibration matches some features of oil exporting countries[11]. Table 2 reports the calibration values.

The subjective discount factor, β, is set at $0{,}99$. Since, in the steady state, $\beta = 1/(1-r)$, this implies an annual real interest rate of 4%. The parameter, γ, is set at 2, as in Bouakez et al (2008) and Dib (2008), implying an elasticity of intertemporal substitution of consumption of 0.5. Following Devereux et al. (2006), the inverse of the elasticity of the intertemporal substitution of labor, σ, is set at 1. The depreciation rate of capital is fixed at 0.025. This value is common to the three sectors.

As in Dib (2008), we set the parameters that represent the degree of monopoly power in the intermediate good market, θ, and the labor market, ϑ, equal to 6 and 8 respectively. The steady state price and wage markup are equal to 20% and 14% respectively. The price elasticity of demand for imported, domestic tradable and non-tradable goods, τ, is set at $0{,}8$ as in Dib (2003, 2008).

Table 2: Calibration of structural parameters.

Description	Parameters	Values
Structural Parameters		
Subject discount factor	β	0.99
The inverse of the elasticity of intertemporal substitution of consumption	γ	2
The inverse of the Frish wage elasticity of labour supply	σ	1
Parameter measuring the risk premium	ϕ	0.0015
The depreciation rate of capital	δ	0.025
Lump-sum tax parameter	ϖ	0.2
Price elasticity of demand for imported and non-oil goods	τ	0.8
Share of import invoiced in the US dollar	μ	0.3
Oil price rule parameter	υ	0.3
Labor elasticity of substitution in the oil sector	α_{ho}	0.31
Labor elasticity of substitution in the non-oil sector	α_{hno}	0.69
Steady state values		
Gross steady-state domestic inflation rate	π	1.0085
Gross steady-state foreign inflation rate	π^f	1.0070
Steady state domestic interest rate	R	1.0185
Steady state foreign interest rate	R^f	1.0158

The labor elasticity of substitution in the three sectors namely, oil, non-tradable and manufacturing sectors are assigned values to match the shares of hours worked in the three

[11] We use all studies which could reflect features of oil exporting economies like Algeria, Canada and Mexico.

sectors (oil, manufacturing and non-tradable sectors) of Algerian economy, so that, $\alpha_{h_o}, \alpha_{h_M}$ and $\alpha_{h_{nT}}$ are equal to 0.32, 0.13 and 0.55 respectively[12].

Since we have two samples of oil exporting countries, we choose two values of the fraction of domestic oil exports in foreign spending. The first value, $\nu^1_{o,t}$, is set equal to 0.6 for the first sample which gather oil dependant countries. The second value, $\nu^2_{o,t}$, equal to 0.4 is assigned to the second sample. To match the ratio manufactured goods to GDP observed in the data of our sample, we set the parameter, ν_M, equal to 0.3. The risk premium parameter, ϕ, is set equal to 0.0115. This value is chosen to match the average ratio of foreign debt to GDP of our sample of oil exporting economies.

3.2 Data

To estimate our model, we use ten series of quarterly data collected from ECLAC (The Economic Commission for Latin America), WTO (World Trade Organization), OECD (Organization for Economic Cooperation and Development) and IMF (International Monetary Fund). Our series are: GDP, households consumption, investment (Gross Fixed Capital Formation), oil production, inflation rate, nominal exchange rate against the dollar, domestic interest rate (discount rate), international oil price, oil exports, and imports from 1980 to 2010. These series are chosen for sixteen oil exporting and emerging countries (Algeria, Argentina, Ecuador, Egypt, Gabon, Indonesia, Kuwait, Iran, Libya, Malaysia, Mexico, Nigeria, Oman, Qatar, Russian Federation, Saudi Arabia, United Arab Emirates and Venezuela). The choice of these countries was based essentially on their degree of oil dependent. As shown by Table 1, we divided our sample of countries into two subsamples: high oil dependent and low oil dependent countries. All the data has been detrended by the Hodrick-Prescott filter and centred around their means.

3.3 Priors

To reflect our beliefs about structural parameters, we specify prior distributions for the entire vector Θ. We choose priors based on evidence from previous studies for oil exporting economies (like Medina and Soto (2005), Dib (2008), Romero (2008)), but for those for which we had no references we used common sense while trying to construct the least restrictive priors possible. These priors are summarized in Tables 3 and 4 in appendix.

We assume Beta distribution for those parameters that must lie in the $[0\ 1]$ interval. This

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[12] These values are chosen by using ONS (national office of statistics) data. These values are approximatively the same in our sample of oil exporting economies.

applies to the persistence parameters of the exogenous stochastic processes which are assumed to follow a beta distribution with a mean of 0.6 and a standard deviation of 0.2. The Beta distribution is also assigned to the parameters of price and wage stickiness with a mean of 0.67 that corresponds to changing price and wage every 3 quarters on average. We set the shares of capital, α_o, labor, β_o, and oil resources, θ_o, in the production of oil to 0.35, 0.14 and 0.51 respectively. We also set to $0.41\ (0.26)$, 0.27 (0.47) and $0.32\ (0.27)$ the share of capital, $\alpha_M\ (\alpha_{nT})$, labor, $\beta_M\ (\beta_{nT})$, and a fraction of oil output, $\theta_M\ (\theta_{nT})$, in the production of non-oil goods. The standard deviations of these parameters are assumed to follow Beta distribution and a standard error of 0.05. As in Medina and Soto (2005) and Ben Aissa and Rebei (2010), we fix the mean of the habit formation parameter equal to 0.5. Its standard deviation is set at 0.25. The fraction of imported goods in the final good, χ_I, is set to 0.55. Since in the most oil exporting economies the share of import and non-tradable goods in the production of the final goods is higher than the tradable goods, we set χ_{nT} and χ_M equal to 0.3 and 0.15 respectively.

We also assume Gamma and inverted Gamma distributions for the parameters that must be positive. This is the case of the standard errors of various innovations which are assumed to follow the inverse Gamma distribution, with a mean of 0.5 and a standard error of 2. The remaining parameters have a normal distribution. Thus, we use a normal distribution for the capital adjustment costs in each sector with a mean of 5 and a standard deviation of 2. The prior of the parameter, ψ_j, reflect the extent to which changes in capital stocks are delayed. Also, as in Rabanal and Rubio-Ramirez (2005) and Medina and Soto (2005) we do not impose non-negativity restrictions on the policy rule coefficients. Thus, we assume a normal distribution for all monetary policy coefficients with a mean of 0.50 for inflation, exchange rate and 0.30 output coefficients respectively. A standard deviation of 0.3 is assigned to these parameters. Finally, for the interest rate smoothing coefficient, ρ_R, we assume a beta distribution with mean 0.75 and a standard deviation of 0.2.

4. Estimations results

We analyze our estimations results in three steps. First, in order to see to what extent our baseline model is relevant, we consider the posterior means. In this first step, both high oil and low oil dependent countries are studied. Steps two and three are dedicated to economies suffering from the Dutch disease effect in the aftermath of positive oil price shock. In this perspective, step two analyzes the impulse response functions of several domestic macroeconomic variables to the oil shock. Finally, step three introduces alternative monetary policy rules to estimate to what extent exchange rate and / or inflation targeting rules perform better than the monetary strategy of the baseline model to prevent the Dutch disease.

4.1 Posterior distributions

Tables 5-8 in appendix report the Bayesian estimation results of the structural parameters of the baseline model.

The degree of habit formation in consumption (ϖ) is consistently higher in high oil dependent countries (Table 5) relative to low oil dependent economies (Table 7). Indeed, in the first group, the posterior means range from (0.57) in Nigeria to (0.89) for Oman while these lower-higher values in the second group are Argentina (0.16) and Russia (0.77). The higher degree of habit formation in consumption means that changes in the level of consumption lead to high welfare costs. Our results suggest that such welfare costs are especially high in low diversified economies (high oil dependent)**.** Capital-adjustment costs (ψ) refer to the ability for an economy to change its capital stock from period to period. In oil sector, Tables 5 and 7 show that these costs are higher than prior means (5.0) in the major part of our studied countries. On average, there are no significant difference between our two groups of countries. The absence of a clear relationship between the capital-adjustment costs and the degree of oil dependence is confirmed inside each group. This parameter does not seem to depend from the weight of oil exports in total exports. For instance, for high oil dependent countries, the capital-adjustment cost is below the prior for Venezuela (3.63) and higher for Oman (8.34). Capital-adjustment costs are significantly higher in both manufacturing and non-tradable sectors in high oil dependent countries relative to low oil dependent ones. In the first group, Table 5 shows that posterior means are higher than the priors. Overall, the estimates of the capital-adjustment costs suggest that high oil dependent economies may meet more difficulties to respond to oil price shocks.

The shares of capital (α), labor (β), and oil resources (θ) in the different production sectors (oil, manufacturing, and non-tradable) estimated by posterior means are in line with our priors. This result suggests that our baseline model is relevant to analyze both high and low oil dependent countries.

In the two subsamples, posterior means suggest a higher prices rigidity (ϕ) in the non-tradable sector relative to the manufacturing and import ones. In the two latter sectors, posterior means are consistently below the priors. On average, the estimated Calvo probabilities of not resetting optimally prices are (0.72) and (0.69) in the non-tradable sectors for high and low oil dependent countries respectively. These probabilities are $(0.59)-(0.58)$ in the manufacturing sector and $(0.60)-(0.61)$ in the import sector. In other words, prices are adjusted every (2.4) and (2.6) quarters in the latter sectors while the adjustment take place every (3.6) (high oil dependent) and (3.2) (low oil dependent) quarters in the former. These parameters do not show significant differences in the two groups of countries.

As for prices, in high and low oil dependent economies, wages stickiness (φ) is higher in the non-tradable sector relative to oil and manufacturing ones. Considering for instance the high oil dependent sample (Table 5), on average, we see that wages are adjusted every (2.9) quarters in the oil sector and every (3.2) quarters in the manufacturing sector while the adjustment occurs every (4.2) quarters in the non-tradable sector. The share of imports in the final good (χ_I) tends to be lower in low oil dependent that in high oil dependent countries. In the two samples, the posterior means are below the priors, except for Argentina and United Arab Emirates. On average, in both high oil and low dependent economies, the share of manufacturing (χ_M) and non-tradable goods (χ_{NT}) are close to the prior means.

The lower part of tables 5 and 7 exhibits the monetary policy coefficients. In both high oil and low oil dependent countries, the posterior means on output target (μ_y) suggest that our studied countries do not consider output in the conduct of their monetary policy. Indeed, we see that for all countries posterior means are dramatically below the priors. To the opposite, the weights of the exchange rate (μ_e) estimated by the posterior means are consistently higher than those given by the prior means. This finding is broadly consistent with the evolution of exchange rate regimes in the studied countries. More precisely, *de facto* classification suggests that many countries in our two samples have chosen rigid exchange rate arrangements over the major part of the studied period. The inflation coefficients (μ_π) given by the posteriors are higher the priors in Oman (0.93), Saudi Arabia (0.88), and Venezuela (1.07) in the high oil dependent group. For the low oil dependent economies, Table 7 shows that only UAE (1.06) and Egypt (1.37) have posteriors higher than prior means.

Overall, our results suggest that in the two samples, exchange rate matters significantly in the conduct of the monetary policy. Inflation seems to be a secondary target for monetary authorities. To the opposite, countries disregard output target. Oil exporting countries may favor the stability of the exports receipts in dollar relative to domestic targets.

The middle part of Tables 6 and 8 displays the persistence of shocks affecting the macroeconomic variables considered in our model. In our two groups of countries, the persistence of the domestic interest rate shocks (ρ_r) given by the posteriors is lower than the priors. This finding is consistent with the role played by the exchange rate in the conduct of the monetary policy. More precisely, domestic authorities use the interest rate to manage their exchange rates, preventing a smoothing adjustment of this variable. Except for Venezuela (high oil dependent) and United Arab Emirates (low oil dependent), the persistence of the foreign interest rate shock (ρ_{rf}) estimated by the posteriors is higher than the priors. In addition, on average, the persistence is larger in high oil dependent countries. On average, the persistence of oil price shock (ρ_{po}) is close to the prior means. Among the high oil dependent economies, Kuwait exhibits the lowest persistence (0.45) while the shock has a sizeable persistence for Venezuela (0.85). In the other group, the lowest persistence is observed for Mexico (0.53) and the highest in Egypt (0.89). In the two samples, posterior means exhibit a stronger persistence of world inflation shock (ρ_{π^f}) relative to priors. On average, world inflation shock tend to be more persistent in high oil dependent countries. As expected in RBC models, technological shocks (ρ_a) in oil, manufacturing and non-tradable sectors are persistent. Tables 6 and 8 show that this persistence is larger in high oil dependent countries, especially in oil and non-tradable sectors.

Overall, posterior means suggest that shocks persistence tend to be larger in high oil dependent economies. As a result, we expect more difficulties in the group of countries to face to macroeconomic shocks, and, more particularly, to oil shocks.

The lower part of tables 6 and 8 display to what extent the monetary policy in our studied countries must face to a volatile environment. The tables show that the volatility directly associated to oil is especially high in the two samples. On average, the volatility of oil price shock (σ_{po}) is significantly higher in high oil dependent countries relative to low oil dependent ones. In these two groups of countries, posteriors means are dramatically higher than priors. Countries such as Algeria, Ecuador, Egypt, Indonesia, Kuwait, Libya, Malaysia, Oman, and Venezuela display oil prices volatility. Similarly, the volatility of technological shock in the oil sector (σ_{a_o}) is high in the two subsamples.

Foreign interest shocks (σ_{r^f}) exhibit higher volatility in low oil dependent countries. In addition, Table 8 shows that the dispersion between low oil dependent economies is significantly higher than in high oil dependent countries. If, on average, the volatility of the domestic interest rate (σ_r) is higher in low oil dependent countries, the two groups of economies exhibit a similar pattern. More precisely, Tables 6 and 8 show that Islamic countries (where the interest rates are highly regulated) and economies with more rigid exchange rate arrangements have the lowest domestic interest rate volatility.

Overall, both high and low oil dependent countries are characterized by a volatile environment. Interestingly, on average, we can note that in these two groups of countries oil prices, foreign inflation, and technological shock in the oil sector exhibit the highest volatilities.

4.2 Impulses response functions

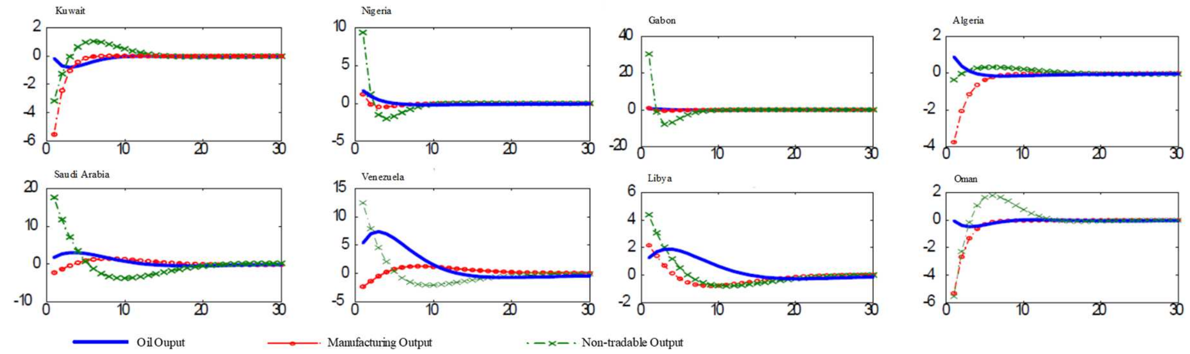
The purpose of this analysis is to identify oil producing countries in which a positive oil price shock leads to a Dutch disease effect. Then, for this group of countries, we study the respective impact of the resource movement effect and the spending effect.

Recall that, an increase in oil price and its subsequent surge in resource exports cause an appreciation of the real exchange rate (through the appreciation of the nominal exchange rate and/or a rise in the domestic price level) which decreases the competitiveness of the country's other, non-resource manufactured goods. This manufacturing goods sector experiences a decrease in production insofar as their higher relative prices lead to competitiveness losses. In addition, since the windfall involves the domestic price level to increase, producers of manufactured goods faces higher production costs, which causes them to reduce their output. Consequently, the manufacturing goods sector contracts, and de-industrialization sets in Rudd (1996).

The impulse response functions in the different sectors after a positive oil price shock exhibit a Dutch disease effect in high oil dependent countries. Indeed, the production in the manufacturing sector decreases after the shock in Algeria, Kuwait, Oman, Saudi Arabia, and Venezuela. As expected with the Dutch disease effect, Figure 1 exhibits strong positive responses of the non-tradable in Gabon, Libya, Nigeria, Saudi Arabia, and Venezuela. The increase in this sector is observed with a lag in Algeria, Kuwait, and Oman.

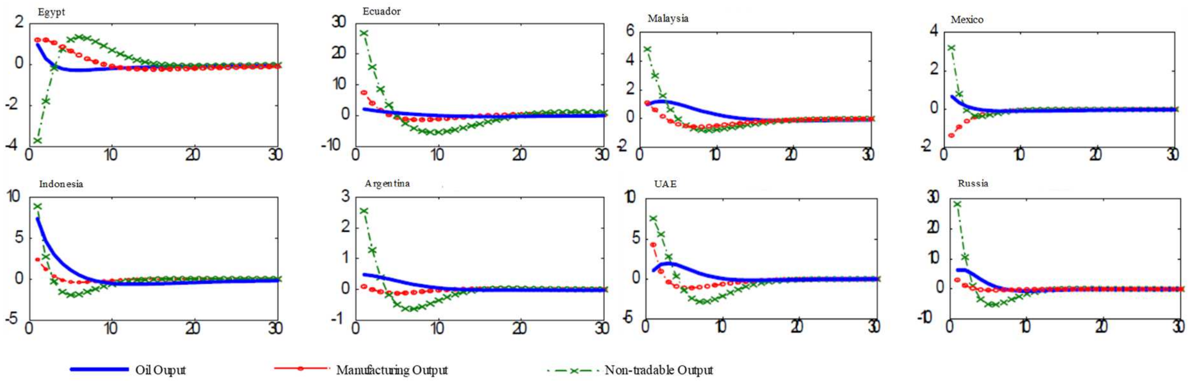
Figure 1: The effect of 1% positive oil price shock on sectorial output in high oil dependent

countries.



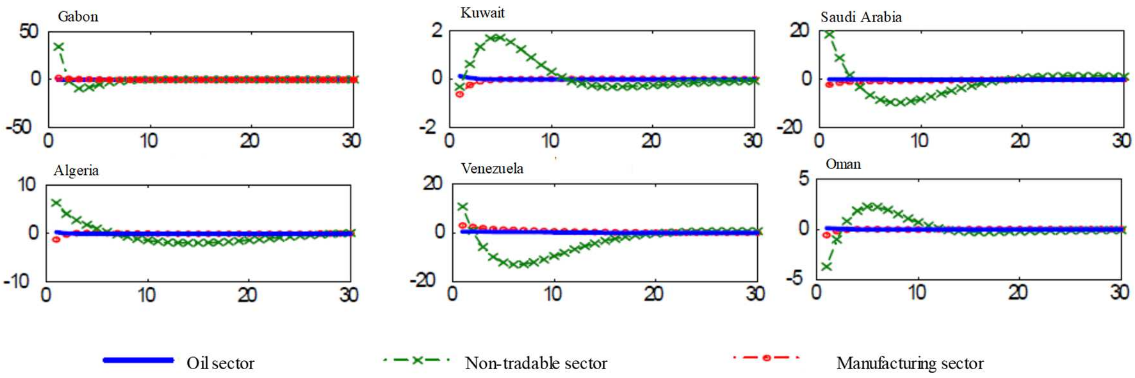
Results concerning low oil dependent countries (Figure 2) suggest that, except Mexico to a certain extent, a positive oil price shock does not induce a Dutch disease effect.

Figure 2: The effect of 1% positive oil price shock on sectorial output in low oil dependent countries.



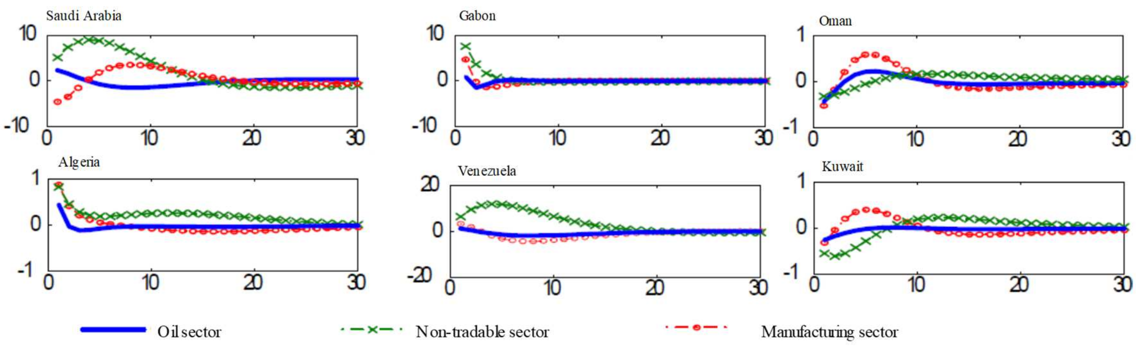
Figures 3 and 4 allow us to see to what extent the Dutch disease effect is explained by the resource movement effect and the spending effect respectively. The resource movement effect is based on the perfect capital and labor mobility between the production sectors. According to this effect, in the aftermath of a positive oil price shock, capital and labor move from the manufacturing sector to the oil and non-tradable sectors. As a result, if the resource movement effect is present, we expect a decrease (an increase) in the hours worked in the manufacturing sector (in the oil and non-tradable sectors). We must also observe a decrease (an increase) in the wages of the manufacturing sector (oil and non-tradable sectors). Figure 3 displays the responses of hours worked to a positive oil price shock in countries suffering from a Dutch disease effect. The main result is a weak response in manufacturing sector suggesting that the resource movement effect is not very important.

Figure 3: Responses of hours worked to oil price shock (Baseline model)



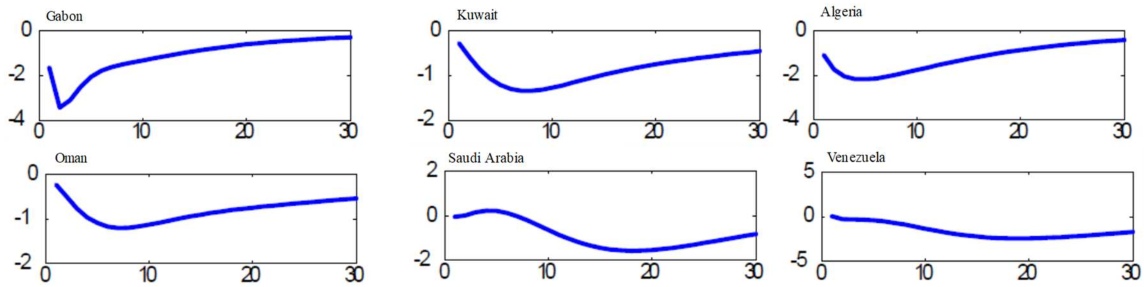
This finding is confirmed by the responses of wages to the oil price shock. In countries where wages in the manufacturing sector decrease -that is Algeria, Kuwait, Oman, and Saudi Arabia- the responses are weak and short-lived (Figure 4).

Figure 4: Response of wages to an oil price shock (Baseline model)



The spending effect refers to the negative consequence of the real exchange rate appreciation on the manufacturing production. Such appreciation rests on higher domestic incomes due to the increased revenues coming from an increase in oil price and/or the resource discovery. Figure 5 exhibits the responses of the real exchange rates to a positive oil price shock. In all countries, the oil shock is followed by a real appreciation of the domestic currency. The appreciation is persistent in all countries suffering from the Dutch disease. This appreciation is explained by an appreciation of the nominal exchange rate in all countries (except Saudi Arabia and Venezuela) and an increase in domestic price level in all countries. These results are in line with the theoretical literature.

Figure 5: Responses of real exchange rate to an oil price shock (Baseline model)



Overall, the previous findings show that the main channel explaining the Dutch disease rests on the spending effect. The smaller importance of the resource movement effect may be due to the size of wages stickiness in the manufacturing sector.

5. The role of monetary policy

To evaluate the role of two monetary policy rules, exchange rate (ER) and inflation targeting (IT) rules, we proceed in two steps: i) we assess the responses of key variables (manufacturing output) under each rule only for countries that have suffered a Dutch Disease; ii) then, we compare the welfare implications of alternative monetary policy reaction function in the context of oil price shock

5.1 Fixed exchange rate *vs* inflation targeting

In this step, we analyze the role of the monetary policy to limit the occurrence of the Dutch disease. More precisely, we compare the responses of selected macroeconomic variables which matter to understand the resource movement and the spending effects under the monetary policy defined in the baseline model and under two alternative monetary policy rules, the exchange rate rule and the inflation targeting rule[13].

Figures 6, 9, 12, 15, 18, and 21 in appendix display the responses of the production in the oil, manufacturing and non-tradable sectors according to our alternative monetary policy rules. If we focus on the manufacturing production, our main finding is that both the exchange rate and the inflation targeting rules exhibit mixed results relative to the baseline model. Except Gabon for the exchange rate rule, no monetary rules prevent a negative response to a positive oil price shock. However, inflation targeting rule allows weaker negative reaction in Kuwait, Saudi Arabia, and Venezuela. We get a similar conclusion for the responses of the non-tradable production in the aftermath of a positive oil price shock. Overall, monetary policy, whatever the monetary rule adopted by the authorities, seems to have only a weak influence on the production changes in the different economic sectors.

[13] All figures are inserted in Appendix.

Figures 7, 10, 13, 16, 19, and 22 in appendix exhibit the changes in hours worked after a positive oil price shock. Our main finding is the following: the two monetary policy rules get better performances than the baseline model to decrease the negative impact of the positive oil price shock on hours worked in the manufacturing sector. There are only two exceptions: Gabon and Oman. This two countries -with Saudi Arabia- share a similar characteristic: over the major part of the period, they have adopted the most rigid exchange rate regimes. More precisely, in Algeria, Kuwait, Saudi Arabia, and Venezuela, the contemporaneous response of the hours worked in the manufacturing sector is positive while the response expected by the Dutch disease effect is negative (as in the baseline model). In other words, the inflation targeting rule has a stabilizing influence. Exchange rate rule offers a similar stabilizing impact in Saudi Arabia and Venezuela. The analysis of the responses of the wages in the manufacturing sector (Figures 8, 11, 14, 17, 20 and 23 in appendix) show more mixed results. In Kuwait and Saudi Arabia the response of wages in the manufacturing sector on the impact of a positive oil price shock is positive under the inflation targeting rule while the response is negative in the baseline model. Inflation targeting rule allows smaller fluctuations in Gabon and Oman.

Overall, even if the monetary policy does not exert a strong influence on the resource movement effect in countries suffering from a Dutch disease effect, our results show that the inflation targeting rule is more efficient to contain the occurrence of the resource movement effect.

The figure 24 in appendix displays the responses of the real exchange rates according the alternative monetary policy rules. The exchange rate rule produces the best performances in all countries (only at long-horizon) exept in Oman.

5.2 Welfare analysis

To conduct this analysis, we solve the model to a second order approximation around its deterministic steady state[14]. The main goal is to compare the welfare implications of alternative optimized monetary policy reaction function. Following these studies, we compute the welfare using the unconditional expectation of the utility function. Formally, the welfare criterion is derived from the following single period utility function:

[14] In the deterministic steady state, all shocks are set to zero and there is no uncertainty. This method allows us to compare welfare implications of alternative monetary policy because the deterministic steady-state is invariant across all policy regimes considered.

$$u(.) = \frac{1}{1-\gamma}\eta_t\left(\frac{c_t}{c_{t-1}{}^{\varpi}}\right)^{1-\gamma} - \varsigma_t \frac{h_t^{1+\sigma}}{1+\sigma} \quad (24)$$

The welfare cost is measured by using the compensating variation. This method allows us to measure the percentage changes in consumption in the deterministic steady state.

We calculate the welfare implications for each country that suffered a Dutch Disease after an oil price shock. We use in each case two monetary policy rules: ER rule and IT rule. For this purpose, we follow the typical way to examine the welfare implications of monetary policy rules which consist to estimating the baseline model with a given monetary policy, then varying parameters in the monetary policy rule, while keeping all other parameters the same as in the baseline model. An advantage of this procedure is that policy parameters are the only factors that create differences in the welfare measure.

Table 9 reports that after an oil price shock, the inflation targeting rule yields the lowest welfare cost in Algeria, and Saudi Arabia. In other words, inflation targeting lowers, in these countries, the welfare cost which is at around 0.00136%, and 0.0056% of consumption in the deterministic steady state respectively in Algeria and Saudi Arabia. However, in the other economies, the exchange rate rule seems to be the best way to avoid the negative effects of an oil price shock. Indeed, the implied welfare cost of an oil price shock, in the case of four high dependent countries (Gabon, Kuwait, Oman and Venezuela), is higher in the model under ER rule. For example, after an oil price shock, using ER rule, the implied welfare is about 0.0121% in Venezuela and 0.0021% in Gabon.

Table 9: Welfare results (in percentage of the steady state of consumption).

	Oil price shock	
	IT rule	ER rule
Algeria	0.00136	0.00335
Gabon	0.0033	0.00210
Kuwait	0.001204	0.000624
Oman	0.00166	0.00085
Saudi Arabia	0.0056	0.0105
Venezuela	0.0134	0.0121

These values jump to 0.0033% and 0.0134% in Gabon and Venezuela respectively under an IT rule. These results are in line with our estimation results. Indeed, recall that our estimations suggest that in the high oil dependent countries, exchange rate matters significantly in the conduct of the monetary policy. Inflation seems to be a secondary target for monetary authorities.

In summary, the welfare analysis suggests that the best monetary rule is country specific. Indeed, we find that the inflation targeting rule yields the lowest welfare costs in Algeria, and Saudi Arabia while in the other economies the exchange rate rule is superior to reduce welfare costs following a positive oil price shock.

6. Conclusion

In this paper, we built a multisector DSGE model for a sample of countries that depend on oil exports (high and low oil dependent). The aim of this study is to investigate if the Dutch disease effect occurs in both high and low oil dependent countries, or only in one of them. To do so, the model takes into account three production sectors, namely, oil, manufacturing and non-tradable sectors. The oil producer operates under perfect competition and the other two sectors under monopolistic competition. We have, thus, attempted to compare the response of selected variables to an oil price shock in each subsample and then how monetary policy should be conducted to insulate the economy from the impact of this shock.

Our results show that high oil dependent countries are most likely vulnerable to oil price shock than low oil dependent ones. Regarding the appropriate monetary policy rule, we find that both inflation targeting and exchange rate rules may be effective to contain the size of the Dutch disease effect. Our results suggest that in Algeria and Saudi Arabia, inflation targeting offers better performances. We observe the opposite in Gabon, Kuwait, Oman, and Venezuela. Such results are consistent with economic theory. Indeed, we see that in more open economies and smaller countries (in terms of economic size), the exchange rate rule is preferable to inflation rule. Venezuela seems an exception. Such country does not fulfill the traditional criteria favoring the choice of the exchange rule. In fact, this exception is only apparent. First, if we consider the volatility (see Table 6), we see that Venezuela is among the most volatile economy. Second, Venezuela suffers from a fiscal dominance effect: both inflation rate and fiscal deficit are the highest relative to other studied countries.

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Appendix

A.1 Estimation results

Table 3: Prior distribution of the estimated parameters.

Coefficient	Description	Domain	Density	Priors	
				Mean	Std.
ϖ	Habit form parameter	[0 1]	Beta	0.5	0.25
ψ_o	Cap-adjust-oil	$\mathbb{R}$	Normal	5	2.00
ψ_M	Cap-adjust-manuf	$\mathbb{R}$	Normal	5	2.00
ψ_{nT}	Cap-adjust-non-trad	$\mathbb{R}$	Normal	5	2.00
α_o	Share of capital-oil	[0 1]	Beta	0.35	0.05
β_o	Share of labor-oil	[0 1]	Beta	0.14	0.05
θ_o	Share of oil-resource	[0 1]	Beta	0.51	0.05
α_M	Share of cap-manufac	[0 1]	Beta	0.41	0.05
β_M	Share of lab-manufac	[0 1]	Beta	0.27	0.05
θ_M	Share of oil-manufac	[0 1]	Beta	0.32	0.05
α_{nT}	Share of cap-non-trad	[0 1]	Beta	0.26	0.05
β_{nT}	Share of lab-non-trad	[0 1]	Beta	0.47	0.05
θ_{nT}	Share of oil-non-trad	[0 1]	Beta	0.27	0.05
ϕ_M	Calvo-price-manuf	[0 1]	Beta	0.67	0.05
ϕ_{nT}	Calvo-price-non-trad	[0 1]	Beta	0.67	0.05
ϕ_I	Calvo-price-import	[0 1]	Beta	0.67	0.05
χ_I	Share of imports	[0 1]	Beta	0.55	0.10
χ_{nT}	Share of non-trad	[0 1]	Beta	0.3	0.10
χ_M	Share of manufact	[0 1]	Beta	0.15	0.10
φ_o	Calvo-wage-oil	[0 1]	Beta	0.67	0.05
φ_M	Calvo-wage-manuf	[0 1]	Beta	0.67	0.05
φ_{nT}	Calvo-wage-non-trad	[0 1]	Beta	0.67	0.05

Table 4: Prior distribution of the estimated parameters (continued).

Coefficient	Description	Domain	Density	Priors	
				Mean	Std.
μ_π	Inflation pol-rule	$\mathbb{R}$	Normal	0.50	0.30
μ_e	Exch-rate pol-rule	$\mathbb{R}$	Normal	0.50	0.30
μ_y	Output-pol-rule	$\mathbb{R}$	Normal	0.30	0.30
ρ_r	Interest rate coef	[0 1]	Beta	0.65	0.20
ρ_{rf}	AR inter-interest rate	[0 1]	Beta	0.65	0.20
ρ_{p_o}	AR oil-price	[0 1]	Beta	0.65	0.20
ρ_o	AR oil-resource	[0 1]	Beta	0.65	0.20
$\rho_{y_{of}}$	AR foreign oil-prod	[0 1]	Beta	0.65	0.20
$\rho_{y_{Mf}}$	AR foreign manuf-prod	[0 1]	Beta	0.65	0.20
$\rho_{\pi f}$	AR world inflation	[0 1]	Beta	0.65	0.20
ρ_{a_o}	AR tech-shock oil-sect	[0 1]	Beta	0.65	0.20
ρ_{a_M}	AR tech-shock manuf-sect	[0 1]	Beta	0.65	0.20
$\rho_{a_{nT}}$	AR tech-shock non-trad-sect	[0 1]	Beta	0.65	0.20
ρ_η	AR tast shock	[0 1]	Beta	0.65	0.20
ρ_ς	AR labor-supply shock	[0 1]	Beta	0.65	0.20
σ_{rf}	s.d inter-interest rate	$\mathbb{R}^+$	InvGamma	0.5	inf
$\sigma_{y_{of}}$	s.d oil produc	$\mathbb{R}^+$	InvGamma	0.5	inf
σ_{p_o}	s.d oil price	$\mathbb{R}^+$	InvGamma	0.5	inf
$\sigma_{y_{Mf}}$	s.d manufact produc	$\mathbb{R}^+$	InvGamma	0.5	inf
σ_r	s.d interest rate	$\mathbb{R}^+$	InvGamma	0.5	inf
σ_o	s.d oil resource	$\mathbb{R}^+$	InvGamma	0.5	inf
$\sigma_{\pi f}$	s.d world inflation	$\mathbb{R}^+$	InvGamma	0.5	inf
σ_{a_o}	s.d tech-shock oil-sect	$\mathbb{R}^+$	InvGamma	0.5	inf
σ_{a_M}	s.d tech-shock manuf-sect	$\mathbb{R}^+$	InvGamma	0.5	inf
$\sigma_{a_{nT}}$	s.d tech-shock non-trad-sect	$\mathbb{R}^+$	InvGamma	0.5	inf
σ_η	s.d tast shock	$\mathbb{R}^+$	InvGamma	0.5	inf
σ_ς	s.d labor-supply shock	$\mathbb{R}^+$	InvGamma	0.5	inf

Table 5: Estimation results in the high oil dependent countries

	Libya	Algeria	Gabon	Nigeria	Oman	Saudi.A	Kuwait	Venezuela
ϖ	0.7533 [0.658 0.852]	0.5855 [0.466 0.714]	0.6314 [0.575 0.676]	0.5688 [0.158 0.976]	0.8949 [0.826 0.976]	0.8834 [0.778 0.999]	0.7846 [0.533 0.980]	0.6570 [0.391 0.946]
ψ_o	8.1028 [6.624 9.435]	8.7740 [6.220 11.177]	6.0440 [5.407 6.696]	7.1801 [4.820 9.550]	8.3405 [7.821 8.819]	7.9833 [6.802 9.154]	3.5331 [1.137 4.524]	3.6309 [1.885 5.488]
ψ_M	7.5628 [6.893 8.210]	8.2434 [6.136 10.293]	0.1962 [0.128 0.262]	0.2540 [0.095 0.407]	2.3133 [1.628 3.223]	9.0913 [7.880 10.480]	5.0308 [3.865 5.839]	6.0647 [4.285 7.927]
ψ_{nT}	4.1993 [3.589 4.727]	6.0035 [3.591 8.018]	5.6324 [5.282 6.030]	5.6586 [3.630 7.796]	10.4908 [9.766 11.331]	4.5019 [3.035 6.073]	3.6353 [2.490 4.367]	2.4032 [1.317 3.354]
α_o	0.3383 [0.292 0.372]	0.1934 [0.160 0.229]	0.3614 [0.346 0.376]	0.3200 [0.259 0.383]	0.3401 [0.315 0.366]	0.2618 [0.233 0.288]	0.3833 [0.304 0.444]	0.3743 [0.300 0.451]
β_o	0.0381 [0.014 0.059]	0.0744 [0.058 0.090]	0.0245 [0.018 0.030]	0.0835 [0.058 0.106]	0.0341 [0.015 0.054]	0.0273 [0.011 0.042]	0.0405 [0.022 0.057]	0.0731 [0.039 0.108]
θ_o	0.4578 [0.430 0.482]	0.4940 [0.425 0.564]	0.5101 [0.505 0.515]	0.4560 [0.379 0.523]	0.5802 [0.563 0.595]	0.4496 [0.413 0.479]	0.5568 [0.539 0.580]	0.4797 [0.412 0.549]
α_M	0.4128 [0.384 0.444]	0.3581 [0.285 0.432]	0.3499 [0.328 0.368]	0.4512 [0.363 0.536]	0.3880 [0.348 0.426]	0.3836 [0.331 0.456]	0.3745 [0.348 0.397]	0.4174 [0.374 0.464]
β_M	0.2518 [0.212 0.297]	0.4206 [0.361 0.488]	0.2968 [0.280 0.313]	0.2960 [0.212 0.361]	0.5030 [0.480 0.524]	0.2245 [0.185 0.257]	0.4483 [0.414 0.489]	0.3156 [0.254 0.366]
θ_M	0.3667 [0.334 0.408]	0.5092 [0.456 0.567]	0.3587 [0.354 0.366]	0.3364 [0.268 0.405]	0.5178 [0.501 0.533]	0.4006 [0.378 0.421]	0.5573 [0.523 0.586]	0.3078 [0.276 0.337]
α_{nT}	0.3620 [0.347 0.382]	0.3140 [0.275 0.352]	0.3154 [0.311 0.319]	0.3273 [0.292 0.364]	0.3573 [0.323 0.398]	0.2846 [0.259 0.307]	0.3971 [0.330 0.455]	0.3176 [0.281 0.362]
β_{nT}	0.4353 [0.421 0.449]	0.5214 [0.480 0.560]	0.4868 [0.480 0.493]	0.4586 [0.419 0.495]	0.4072 [0.365 0.441]	0.4932 [0.465 0.523]	0.3777 [0.316 0.439]	0.4273 [0.382 0.473]
θ_{nT}	0.0869 [0.081 0.092]	0.0856 [0.075 0.096]	0.1577 [0.153 0.162]	0.1307 [0.111 0.151]	0.0863 [0.080 0.092]	0.0925 [0.086 0.099]	0.0927 [0.078 0.107]	0.1282 [0.109 0.144]
ϕ_M	0.7547 [0.687 0.813]	0.6346 [0.555 0.708]	0.5495 [0.529 0.574]	0.5792 [0.539 0.623]	0.5981 [0.577 0.623]	0.6482 [0.618 0.673]	0.6139 [0.559 0.665]	0.3601 [0.336 0.383]
ϕ_{nT}	0.6969 [0.669 0.720]	0.6967 [0.633 0.771]	0.7108 [0.698 0.722]	0.6785 [0.602 0.746]	0.7146 [0.689 0.742]	0.8373 [0.811 0.861]	0.7155 [0.687 0.753]	0.6852 [0.619 0.744]
ϕ_I	0.6320 [0.603 0.662]	0.6517 [0.591 0.715]	0.5223 [0.514 0.530]	0.5639 [0.481 0.658]	0.7055 [0.684 0.724]	0.5762 [0.508 0.643]	0.6671 [0.643 0.692]	0.5058 [0.456 0.550]
χ_I	0.2407 [0.216 0.266]	0.0491 [0.047 0.051]	0.1558 [0.143 0.172]	0.1957 [0.131 0.261]	0.4409 [0.390 0.492]	0.2768 [0.208 0.333]	0.2642 [0.184 0.332]	0.1854 [0.150 0.218]
χ_M	0.2585 [0.212 0.315]	0.1476 [0.004 0.275]	0.1180 [0.107 0.131]	0.1042 [0.012 0.192]	0.1059 [0.010 0.188]	0.2411 [0.159 0.346]	0.1736 [0.103 0.256]	0.1220 [0.033 0.206]
χ_{nT}	0.1740 [0.134 0.219]	0.3594 [0.282 0.436]	0.4912 [0.461 0.518]	0.2183 [0.145 0.286]	0.5126 [0.461 0.555]	0.2946 [0.246 0.346]	0.3865 [0.315 0.437]	0.1567 [0.108 0.205]
φ_o	0.6692 [0.594 0.741]	0.6372 [0.568 0.705]	0.6706 [0.665 0.676]	0.7127 [0.648 0.783]	0.5645 [0.546 0.584]	0.6522 [0.592 0.715]	0.6700 [0.635 0.700]	0.6857 [0.629 0.732]
φ_M	0.7284 [0.706 0.750]	0.6808 [0.603 0.747]	0.6258 [0.615 0.635]	0.6929 [0.637 0.742]	0.7260 [0.705 0.744]	0.6981 [0.642 0.755]	0.6560 [0.576 0.736]	0.6914 [0.614 0.778]
φ_{nT}	0.8781 [0.859 0.897]	0.7811 [0.738 0.824]	0.5700 [0.562 0.575]	0.6816 [0.636 0.740]	0.8346 [0.816 0.850]	0.8219 [0.798 0.847]	0.7423 [0.712 0.776]	0.7569 [0.727 0.785]
μ_π	0.3159 [−0.025 0.645]	0.3233 [0.189 0.453]	−0.0370 [−0.084 0.010]	0.3637 [0.123 0.599]	0.9341 [0.756 1.076]	0.8779 [0.594 1.171]	0.2227 [0.086 0.346]	1.0755 [0.805 1.337]
μ_e	0.1180 [0.021 0.191]	1.1419 [1.004 1.358]	0.0013 [0.003 0.002]	0.7111 [0.373 1.099]	2.3305 [2.259 2.408]	1.6351 [1.346 1.881]	1.8625 [1.672 2.045]	2.3373 [2.240 2.408]
μ_y	−0.0358 [−0.067 0.004]	0.038 [−0.012 0.094]	−0.066 [−0.011 −0.020]	−0.0034 [0.025 0.019]	0.0079 [0.000 0.016]	0.0033 [−0.007 0.015]	−0.0022 [−0.009 0.004]	−0.0459 [−0.092 0.001]

Table 6: Estimation results in the high oil dependent countries (continued)

	Algeria	Libya	Gabon	Nigeria	Oman	Saudi.A	Kuwait	Venezuela
ρ_r	0.7852 [0.731 0.831]	0.1279 [0.028 0.127]	0.8454 [0.815 0.881]	0.5961 [0.465 0.737]	0.0550 [0.015 0.094]	0.2802 [0.147 0.409]	0.1290 [0.036 0.201]	0.0388 [0.006 0.069]
ρ_{rf}	0.9567 [0.922 0.995]	0.7333 [0.643 0.830]	0.7952 [0.755 0.829]	0.7662 [0.529 0.975]	0.7413 [0.681 0.799]	0.7474 [0.642 0.841]	0.8416 [0.772 0.892]	0.5370 [0.459 0.619]
ρ_{p_o}	0.5490 [0.445 0.661]	0.7052 [0.637 0.751]	0.5777 [0.560 0.598]	0.5335 [0.410 0.665]	0.5284 [0.464 0.592]	0.7569 [0.710 0.799]	0.4503 [0.385 0.512]	0.8560 [0.803 0.906]
ρ_o	0.6796 [0.338 0.906]	0.4845 [0.409 0.583]	0.9368 [0.893 0.967]	0.5593 [0.433 0.700]	0.6379 [0.568 0.723]	0.7319 [0.636 0.852]	0.7560 [0.612 0.948]	0.8331 [0.678 0.987]
$\rho_{y_{of}}$	0.3723 [0.253 0.501]	0.4145 [0.319 0.501]	0.9568 [0.949 0.964]	0.5725 [0.383 0.742]	0.4480 [0.325 0.564]	0.4810 [0.403 0.557]	0.5421 [0.471 0.650]	0.3821 [0.256 0.505]
$\rho_{y_{Mf}}$	0.8261 [0.748 0.905]	0.7274 [0.673 0.775]	0.9977 [0.995 0.999]	0.8772 [0.789 0.977]	0.8560 [0.783 0.915]	0.8583 [0.813 0.907]	0.9444 [0.903 0.989]	0.8988 [0.837 0.961]
$\rho_{\pi f}$	0.8456 [0.736 0.957]	0.6004 [0.546 0.652]	0.7994 [0.779 0.824]	0.7427 [0.693 0.792]	0.9899 [0.983 0.997]	0.7850 [0.732 0.831]	0.9114 [0.879 0.949]	0.7623 [0.709 0.804]
ρ_{a_o}	0.6222 [0.259 0.904]	0.7564 [0.609 0.900]	0.6409 [0.603 0.687]	0.6463 [0.396 0.888]	0.7074 [0.649 0.767]	0.7468 [0.646 0.846]	0.8645 [0.790 0.930]	0.5896 [0.325 0.851]
ρ_{a_M}	0.5758 [0.315 0.823]	0.5127 [0.318 0.718]	0.4027 [0.374 0.435]	0.6314 [0.343 0.967]	0.7543 [0.683 0.818]	0.3870 [0.252 0.575]	0.7909 [0.639 0.921]	0.4242 [0.136 0.672]
$\rho_{a_{nT}}$	0.9639 [0.941 0.988]	0.7631 [0.689 0.846]	0.8957 [0.843 0.948]	0.6783 [0.404 0.941]	0.8944 [0.792 0.995]	0.8793 [0.782 0.980]	0.9381 [0.825 1.000]	0.7936 [0.614 0.986]
ρ_η	0.7847 [0.744 0.822]	0.1781 [0.100 0.238]	0.7154 [0.698 0.728]	0.6815 [0.452 0.914]	0.5189 [0.424 0.620]	0.5625 [0.480 0.656]	0.6786 [0.506 0.889]	0.8130 [0.675 0.941]
ρ_ς	0.5892 [0.300 0.882]	0.8555 [0.767 0.944]	0.7614 [0.721 0.787]	0.6854 [0.484 0.913]	0.8008 [0.683 0.905]	0.8659 [0.747 0.986]	0.8620 [0.746 0.963]	0.7344 [0.545 0.958]
σ_{rf}	0.9227 [0.643 1.217]	0.1180 [0.088 0.146]	0.3251 [0.127 0.483]	2.7148 [1.640 3.755]	0.6796 [0.597 0.766]	0.1455 [0.097 0.187]	0.4224 [0.315 0.525]	5.9328 [5.237 6.656]
$\sigma_{y_{of}}$	8.1616 [7.355 8.949]	8.4479 [7.435 9.414]	2.4298 [2.136 2.684]	9.7520 [8.682 10.888]	9.3771 [8.205 10.408]	16.8475 [15.688 17.966]	8.5713 [7.942 9.324]	8.3352 [7.546 9.135]
$\sigma_{y_{Mf}}$	5.3860 [4.800 5.952]	1.9653 [1.795 2.178]	1.7661 [1.148 1.900]	4.8418 [4.271 5.349]	0.4739 [0.425 0.523]	12.3557 [11.041 13.634]	0.3964 [0.357 0.446]	0.9879 [0.882 1.109]
σ_{p_o}	12.2449 [10.998 13.452]	12.0238 [11.151 12.809]	2.7852 [2.016 2.979]	1.6465 [0.368 2.814]	11.7221 [10.639 12.788]	1.9378 [1.734 2.147]	12.0662 [10.962 13.394]	12.1548 [11.087 13.262]
σ_r	2.0881 [1.688 2.474]	0.1083 [0.082 0.134]	0.4869 [0.438 0.535]	4.8418 [4.271 5.349]	0.5167 [0.434 0.605]	0.1389 [0.095 0.179]	0.2056 [0.154 0.258]	4.6267 [3.947 5.348]
σ_o	1.6106 [0.143 2.782]	5.4303 [4.351 6.564]	0.2251 [0.124 0.320]	1.7263 [1.476 1.973]	0.8361 [0.143 1.417]	0.5722 [0.112 1.151]	0.4040 [0.138 0.703]	0.3782 [0.121 0.667]
$\sigma_{\pi f}$	0.6881 [0.262 1.142]	1.1205 [0.983 1.311]	2.0377 [1.680 2.338]	5.5883 [4.044 7.290]	0.1025 [0.082 0.121]	1.4278 [1.204 1.658]	0.8457 [0.750 0.957]	10.0467 [8.872 11.097]
σ_{a_o}	0.6449 [0.144 1.182]	0.4161 [0.127 0.690]	1.3733 [1.193 1.509]	10.1655 [8.604 11.647]	0.6392 [0.226 0.960]	2.1710 [1.869 2.439]	2.6382 [2.184 3.177]	0.4780 [0.117 1.009]
σ_{a_M}	0.5771 [0.118 1.303]	0.4180 [0.131 0.779]	0.3617 [0.143 0.647]	0.4852 [0.121 0.978]	0.2489 [0.117 0.373]	0.4101 [0.119 0.734]	2.6217 [0.442 5.199]	0.4798 [0.122 0.944]
$\sigma_{a_{nT}}$	1.6445 [1.319 1.997]	0.1022 [0.078 0.124]	0.2907 [0.149 0.412]	0.5776 [0.104 1.379]	0.0735 [0.060 0.085]	0.1128 [0.085 0.141]	0.1863 [0.100 0.285]	0.2738 [0.127 0.419]
σ_η	1.5805 [0.893 2.205]	0.3767 [0.283 0.459]	1.3000 [1.022 1.586]	0.3388 [0.126 0.571]	0.7946 [0.464 1.157]	0.5169 [0.242 0.770]	0.4645 [0.111 0.781]	0.5354 [0.126 1.046]
σ_ς	0.4911 [0.116 1.009]	0.4896 [0.127 1.007]	1.9912 [1.290 2.703]	1.7662 [0.111 4.668]	0.4103 [0.117 0.773]	0.4026 [0.119 0.759]	0.4281 [0.116 0.764]	0.3661 [0.121 0.629]

Table 7: Estimation results in the low oil dependent countries

	Mexico	Argentina	Malaysia	Ecuador	Egypt	UAE	Indonesia	Russia
ϖ	0.5125	0.1611	0.2973	0.5387	0.4993	0.4074	0.7245	0.7686
	[0.033 0.919]	[0.045 0.288]	[0.142 0.466]	[0.345 0.716]	[0.336 0.620]	[0.239 0.631]	[0.625 0.827]	[0.627 0.935]
ψ_o	9.7215	8.6483	10.2419	4.5036	6.2511	4.6287	7.4428	1.9366
	[5.980 12.373]	[7.319 9.805]	[8.508 11.506]	[3.347 5.582]	[4.982 7.499]	[2.782 5.818]	[6.530 8.373]	[0.152 3.347]
ψ_M	0.2387	2.4348	9.0910	4.9060	0.3551	3.9994	6.7479	4.7793
	[0.095 0.395]	[1.838 3.021]	[7.513 10.562]	[3.679 6.600]	[0.245 0.476]	[2.508 5.386]	[4.716 8.746]	[1.326 8.367]
ψ_{nT}	2.4277	9.9594	1.4786	1.1040	5.5228	4.9074	0.4915	6.1441
	[1.068 4.331]	[9.300 10.670]	[0.868 2.097]	[0.671 1.607]	[4.523 6.647]	[3.235 6.923]	[0.215 0.770]	[4.143 8.433]
α_o	0.1979	0.1328	0.3246	0.3218	0.3226	0.3069	0.3050	0.3469
	[0.156 0.244]	[0.110 0.152]	[0.283 0.357]	[0.246 0.398]	[0.287 0.361]	[0.281 0.331]	[0.266 0.343]	[0.293 0.408]
β_o	0.0564	0.1801	0.0430	0.0833	0.0736	0.0266	0.1636	0.0599
	[0.042 0.072]	[0.136 0.216]	[0.025 0.067]	[0.064 0.107]	[0.051 0.094]	[0.014 0.039]	[0.153 0.176]	[0.033 0.089]
θ_o	0.5131	0.4406	0.5020	0.4883	0.4691	0.4596	0.4372	0.5136
	[0.465 0.561]	[0.366 0.522]	[0.438 0.546]	[0.447 0.523]	[0.441 0.494]	[0.437 0.483]	[0.409 0.466]	[0.444 0.565]
α_M	0.4596	0.4326	0.4040	0.3201	0.4196	0.3682	0.3532	0.4167
	[0.386 0.531]	[0.397 0.467]	[0.366 0.446]	[0.261 0.368]	[0.366 0.469]	[0.343 0.390]	[0.302 0.389]	[0.346 0.492]
β_M	0.4089	0.3229	0.2738	0.1611	0.2987	0.2957	0.2909	0.3377
	[0.358 0.460]	[0.293 0.354]	[0.242 0.304]	[0.136 0.187]	[0.271 0.326]	[0.266 0.334]	[0.258 0.331]	[0.300 0.376]
θ_M	0.4155	0.3830	0.4013	0.3193	0.4027	0.3427	0.3600	0.2890
	[0.358 0.468]	[0.328 0.447]	[0.346 0.459]	[0.275 0.349]	[0.337 0.458]	[0.318 0.373]	[0.323 0.397]	[0.244 0.328]
α_{nT}	0.3295	0.3690	0.3587	0.2509	0.3084	0.3342	0.3169	0.2854
	[0.271 0.395]	[0.341 0.398]	[0.302 0.440]	[0.220 0.282]	[0.288 0.324]	[0.310 0.355]	[0.286 0.349]	[0.245 0.330]
β_{nT}	0.4282	0.4210	0.3455	0.5349	0.4538	0.4786	0.3856	0.4906
	[0.341 0.500]	[0.403 0.441]	[0.275 0.392]	[0.497 0.565]	[0.434 0.479]	[0.456 0.492]	[0.357 0.419]	[0.441 0.535]
θ_{nT}	0.1213	0.0747	0.1351	0.1561	0.0938	0.2786	0.1558	0.1411
	[0.099 0.143]	[0.051 0.091]	[0.120 0.152]	[0.133 0.180]	[0.088 0.099]	[0.262 0.298]	[0.139 0.170]	[0.102 0.173]
ϕ_M	0.6039	0.5898	0.6656	0.4442	0.5188	0.6839	0.6715	0.4492
	[0.531 0.674]	[0.568 0.612]	[0.627 0.705]	[0.413 0.471]	[0.497 0.547]	[0.655 0.711]	[0.619 0.704]	[0.388 0.508]
ϕ_{nT}	0.6724	0.6719	0.6616	0.8238	0.6330	0.6808	0.6708	0.7284
	[0.613 0.743]	[0.628 0.713]	[0.616 0.733]	[0.779 0.850]	[0.594 0.666]	[0.658 0.711]	[0.620 0.699]	[0.674 0.778]
ϕ_I	0.5814	0.4674	0.7424	0.6691	0.5476	0.7421	0.5834	0.5296
	[0.509 0.654]	[0.449 0.486]	[0.688 0.809]	[0.634 0.699]	[0.523 0.570]	[0.681 0.808]	[0.543 0.641]	[0.474 0.585]
χ_I	0.0754	0.5971	0.2244	0.0526	0.0788	0.7231	0.5321	0.5489
	[0.047 0.096]	[0.532 0.634]	[0.165 0.282]	[0.047 0.060]	[0.064 0.097]	[0.645 0.810]	[0.497 0.559]	[0.453 0.646]
χ_M	0.1338	0.0574	0.2244	0.1534	0.1553	0.0921	0.2242	0.3638
	[0.008 0.257]	[0.004 0.100]	[0.165 0.282]	[0.078 0.211]	[0.079 0.235]	[0.026 0.144]	[0.091 0.358]	[0.115 0.530]
χ_{nT}	0.2268	0.4087	0.1715	0.6006	0.2175	0.4756	0.2371	0.5366
	[0.162 0.296]	[0.352 0.464]	[0.088 0.260]	[0.519 0.662]	[0.136 0.312]	[0.398 0.554]	[0.178 0.294]	[0.420 0.652]
φ_o	0.6894	0.6507	0.7357	0.6957	0.6099	0.6877	0.6481	0.6632
	[0.639 0.749]	[0.605 0.697]	[0.683 0.780]	[0.662 0.731]	[0.555 0.664]	[0.652 0.726]	[0.615 0.684]	[0.576 0.760]
φ_M	0.6566	0.6598	0.6622	0.5732	0.6031	0.6367	0.6020	0.6543
	[0.612 0.701]	[0.624 0.697]	[0.613 0.701]	[0.493 0.625]	[0.575 0.638]	[0.603 0.672]	[0.563 0.646]	[0.607 0.699]
φ_{nT}	0.7055	0.8930	0.7714	0.7331	0.8949	0.7393	0.7998	0.6433
	[0.665 0.750]	[0.880 0.905]	[0.742 0.807]	[0.701 0.757]	[0.862 0.913]	[0.718 0.761]	[0.772 0.831]	[0.591 0.695]
μ_π	0.3035	0.2891	0.2225	0.4589	1.3658	1.0607	−0.2864	0.4007
	[0.073 0.522]	[0.130 0.444]	[0.038 0.376]	[0.269 0.608]	[1.182 1.548]	[0.844 1.294]	[−0.364 −0.213]	[0.206 0.587]
μ_e	1.3183	2.3051	1.5025	1.1423	1.6896	1.0973	0.8725	0.5835
	[1.068 1.564]	[2.169 2.408]	[1.279 1.695]	[0.968 1.335]	[1.475 1.863]	[1.007 1.196]	[0.784 0.988]	[0.405 0.777]
μ_y	−0.1743	0.0115	0.1695	0.0090	0.0034	−0.0097	0.0060	−0.0773
	[−0.224 −0.126]	[−0.003 0.025]	[0.095 0.231]	[−0.004 0.025]	[−0.004 0.011]	[−0.038 0.016]	[−0.005 0.017]	[−0.137 −0.041]

Table 8: Estimation results in the low oil dependent countries (continued)

	Mexico	Malaysia	Argentina	Ecuador	Egypt	Indonesia	UAE	Russia
ρ_r	0.1902 [0.093 0.291]	0.0497 [0.009 0.088]	0.7632 [0.722 0.802]	0.2952 [0.151 0.444]	0.0744 [0.008 0.132]	0.3367 [0.189 0.507]	0.6831 [0.651 0.716]	0.5018 [0.364 0.660]
ρ_{rf}	0.6650 [0.592 0.741]	0.6411 [0.574 0.712]	0.7770 [0.524 0.996]	0.8910 [0.839 0.918]	0.7538 [0.707 0.802]	0.9546 [0.933 0.978]	0.3375 [0.213 0.437]	0.7802 [0.632 0.936]
ρ_{p_o}	0.5297 [0.431 0.628]	0.7256 [0.624 0.818]	0.8584 [0.781 0.938]	0.5570 [0.459 0.654]	0.5554 [0.450 0.656]	0.5668 [0.503 0.631]	0.6516 [0.583 0.713]	0.5756 [0.469 0.688]
ρ_o	0.5595 [0.406 0.706]	0.6313 [0.463 0.822]	0.5103 [0.346 0.651]	0.5766 [0.300 0.816]	0.8977 [0.812 0.995]	0.5755 [0.385 0.773]	0.7371 [0.548 0.927]	0.8292 [0.716 0.950]
$\rho_{y_{of}}$	0.4329 [0.301 0.566]	0.8168 [0.695 0.946]	0.8129 [0.570 0.988]	0.7097 [0.550 0.850]	0.8663 [0.807 0.907]	0.4104 [0.246 0.581]	0.4001 [0.277 0.547]	0.6917 [0.570 0.822]
$\rho_{y_{Mf}}$	0.8372 [0.785 0.890]	0.6891 [0.620 0.748]	0.8121 [0.736 0.886]	0.5084 [0.350 0.606]	0.8855 [0.840 0.927]	0.7645 [0.554 0.948]	0.4645 [0.363 0.575]	0.8050 [0.710 0.899]
$\rho_{\pi f}$	0.7652 [0.728 0.802]	0.8193 [0.773 0.876]	0.5088 [0.392 0.624]	0.7037 [0.643 0.774]	0.7425 [0.711 0.770]	0.8223 [0.767 0.874]	0.6948 [0.537 0.869]	0.9390 [0.909 0.968]
ρ_{a_o}	0.5750 [0.369 0.762]	0.8471 [0.806 0.893]	0.8143 [0.728 0.894]	0.7174 [0.639 0.782]	0.8329 [0.779 0.891]	0.0985 [0.025 0.165]	0.5010 [0.392 0.615]	0.8307 [0.690 0.983]
ρ_{a_M}	0.7182 [0.482 0.991]	0.6834 [0.391 0.968]	0.5765 [0.367 0.749]	0.2629 [0.117 0.414]	0.3900 [0.236 0.526]	0.4775 [0.367 0.584]	0.3290 [0.139 0.522]	0.7697 [0.576 0.993]
$\rho_{a_{nT}}$	0.6217 [0.395 0.884]	0.8655 [0.786 0.960]	0.7153 [0.496 0.917]	0.9219 [0.898 0.938]	0.7331 [0.600 0.893]	0.8964 [0.825 0.984]	0.9379 [0.894 0.983]	0.5009 [0.184 0.827]
ρ_η	0.4936 [0.119 0.830]	0.9811 [0.956 0.999]	0.7785 [0.679 0.891]	0.4891 [0.310 0.663]	0.9413 [0.901 0.980]	0.5648 [0.457 0.702]	0.4612 [0.388 0.535]	0.8878 [0.807 0.968]
ρ_ς	0.7045 [0.448 0.950]	0.3397 [0.115 0.540]	0.5142 [0.387 0.655]	0.6929 [0.431 0.961]	0.9050 [0.834 0.979]	0.3828 [0.116 0.591]	0.7993 [0.610 0.995]	0.6478 [0.423 0.901]
σ_{rf}	5.8890 [4.904 6.814]	1.2454 [1.080 1.432]	0.3950 [0.108 0.777]	5.3395 [4.161 6.316]	0.9600 [0.826 1.080]	9.6439 [8.642 10.680]	0.7993 [0.610 0.995]	0.4256 [0.115 0.821]
$\sigma_{y_{of}}$	8.6707 [7.776 9.559]	9.4071 [8.309 10.460]	0.7290 [0.131 1.296]	9.2425 [8.337 10.104]	10.3466 [9.269 11.416]	0.3509 [0.127 0.611]	0.0938 [0.073 0.114]	1.3197 [1.084 1.503]
$\sigma_{y_{Mf}}$	1.4067 [1.097 1.768]	11.8206 [10.695 13.033]	4.3753 [3.958 4.804]	0.4425 [0.124 0.793]	1.2107 [1.060 1.356]	0.4060 [0.116 0.795]	17.1384 [15.491 18.503]	4.9351 [4.591 7.920]
σ_{p_o}	1.3530 [1.224 1.675]	12.9848 [11.660 14.308]	1.0320 [0.141 1.845]	11.4586 [10.530 12.484]	12.5252 [11.414 13.746]	11.9653 [10.803 13.118]	1.7602 [1.241 1.914]	1.4102 [1.137 1.616]
σ_r	0.6088 [0.118 0.950]	0.3113 [0.167 0.451]	0.1805 [0.103 0.252]	8.5882 [7.464 9.459]	0.2125 [0.132 0.294]	4.7856 [3.973 5.562]	1.7926 [1.546 2.006]	3.7102 [0.957 6.339]
σ_o	1.2923 [0.124 2.445]	0.4741 [0.115 0.886]	0.3577 [0.135 0.578]	0.5855 [0.120 1.290]	0.5493 [0.108 1.268]	0.4412 [0.118 0.882]	0.0849 [0.067 0.100]	0.6533 [0.116 1.549]
$\sigma_{\pi f}$	11.8121 [9.907 13.824]	1.0897 [0.950 1.216]	9.2394 [7.915 10.391]	9.3806 [7.766 10.792]	6.4872 [5.806 7.129]	11.3810 [10.182 12.468]	0.3413 [0.116 0.602]	3.3903 [3.002 4.143]
σ_{a_o}	0.7250 [0.149 1.232]	3.8869 [3.394 4.387]	2.9866 [2.531 3.506]	5.5227 [4.328 6.603]	4.6737 [4.028 5.296]	15.8658 [14.442 17.564]	0.1146 [0.085 0.143]	0.5263 [0.131 1.003]
σ_{a_M}	0.4081 [0.119 0.721]	0.3790 [0.124 0.651]	0.3532 [0.140 0.621]	0.3709 [0.128 0.678]	0.6285 [0.105 1.615]	0.5337 [0.117 1.061]	1.8057 [1.595 2.003]	0.4130 [0.111 0.760]
$\sigma_{a_{nT}}$	0.2909 [0.127 0.452]	0.2368 [0.132 0.340]	0.2534 [0.128 0.371]	9.6606 [7.761 11.314]	0.1538 [0.103 0.201]	0.3386 [0.117 0.591]	0.3119 [0.115 0.522]	0.4490 [0.106 0.911]
σ_η	0.4456 [0.119 0.855]	0.2323 [0.128 0.344]	0.2104 [0.124 0.302]	0.4370 [0.121 0.866]	0.2939 [0.151 0.430]	0.4558 [0.236 0.648]	0.1070 [0.080 0.132]	1.2791 [0.187 2.622]
σ_ς	0.4768 [0.117 0.863]	0.3926 [0.115 0.703]	0.4433 [0.122 0.904]	0.4119 [0.104 0.745]	0.4279 [0.115 0.885]	0.4561 [0.113 0.897]	0.1814 [0.100 0.260]	0.4633 [0.118 0.936]

A.2 Fixed exchange rate vs inflation targeting

Figure 6: Alternative monetary policy rules (Algeria)

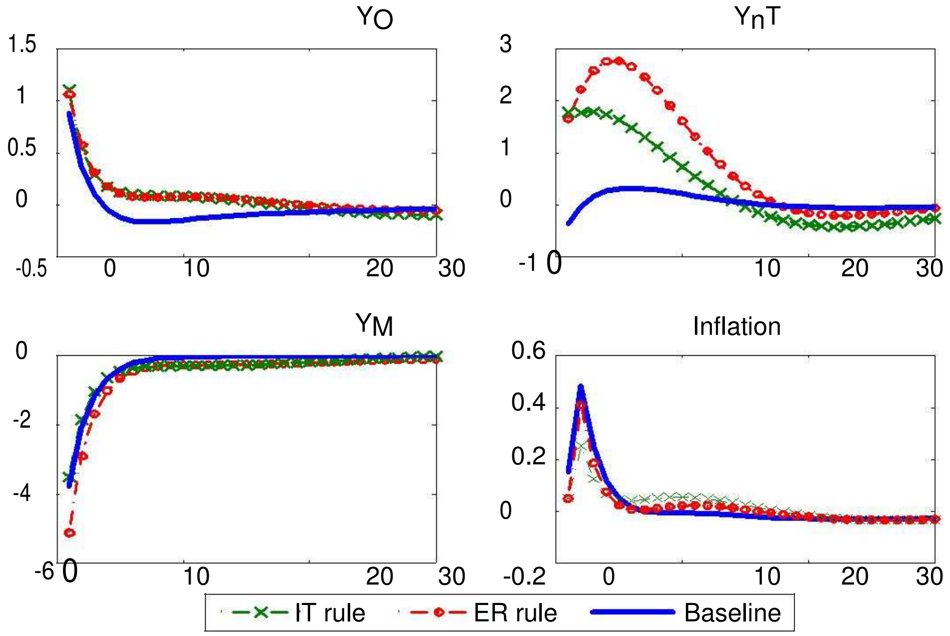

Figure 7: Alternative monetary policy rules (Algeria)

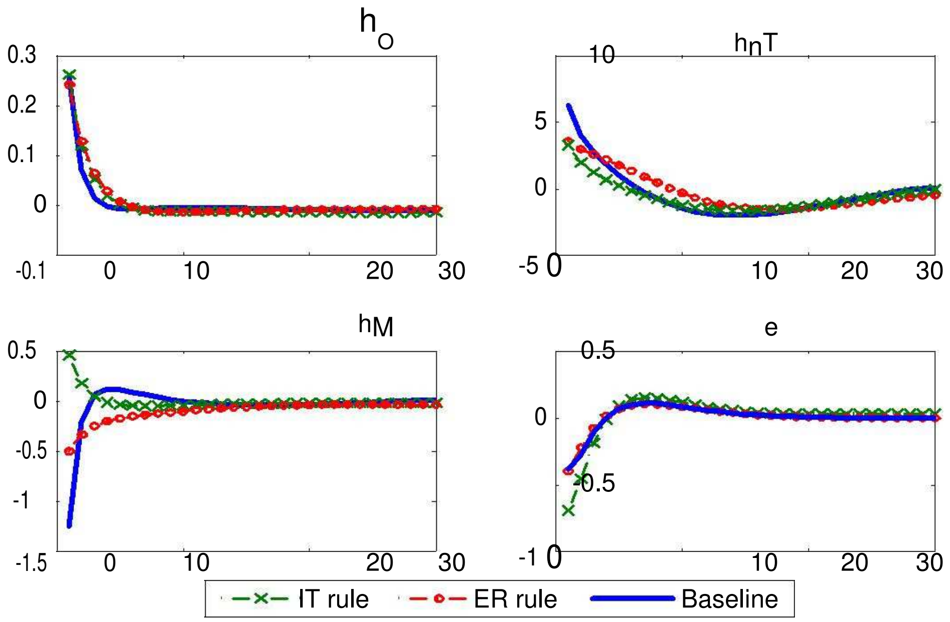

Figure 8: Alternative monetary policy rules (Algeria)

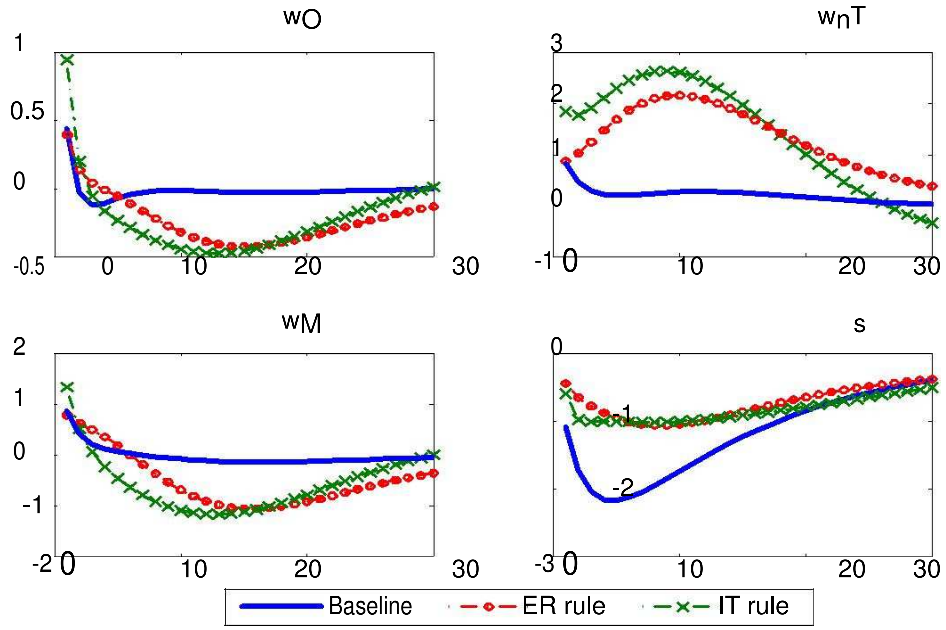

Figure 9: Alternative monetary policy rules (Gabon)

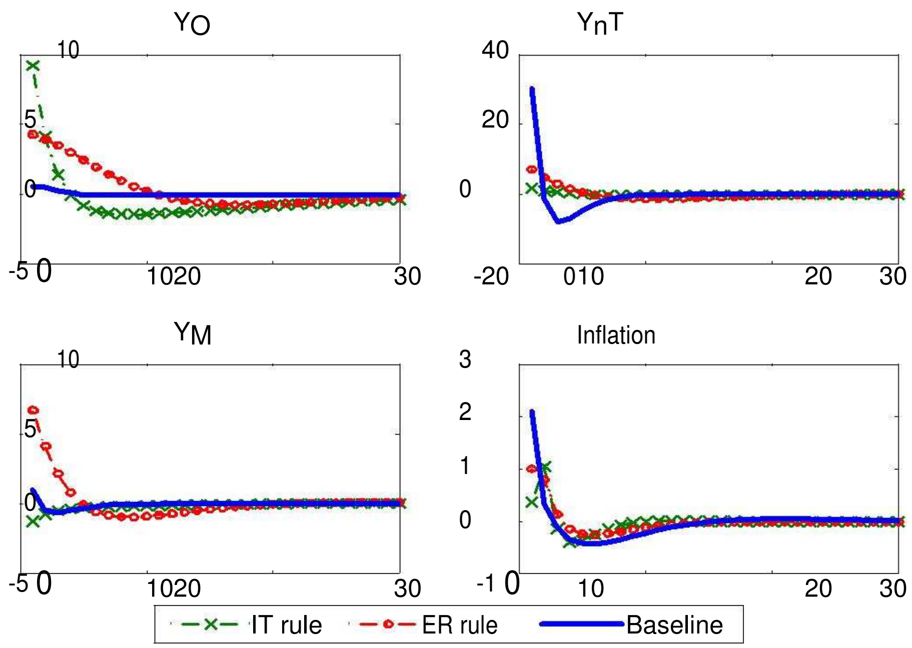

Figure 10: Alternative monetary policy rules (Gabon)

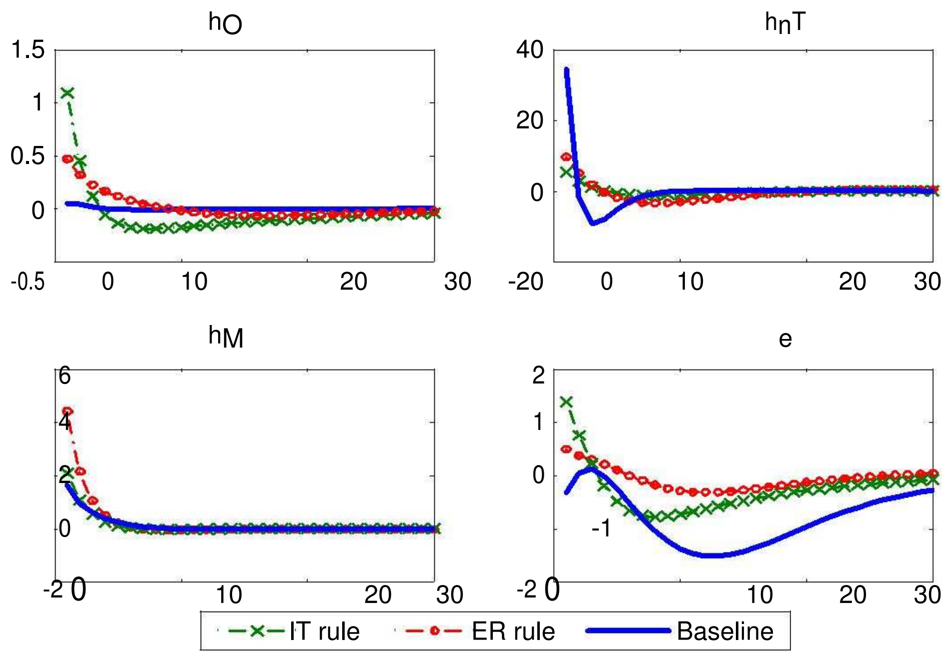

Figure 11: Alternative monetary policy rules (Gabon)

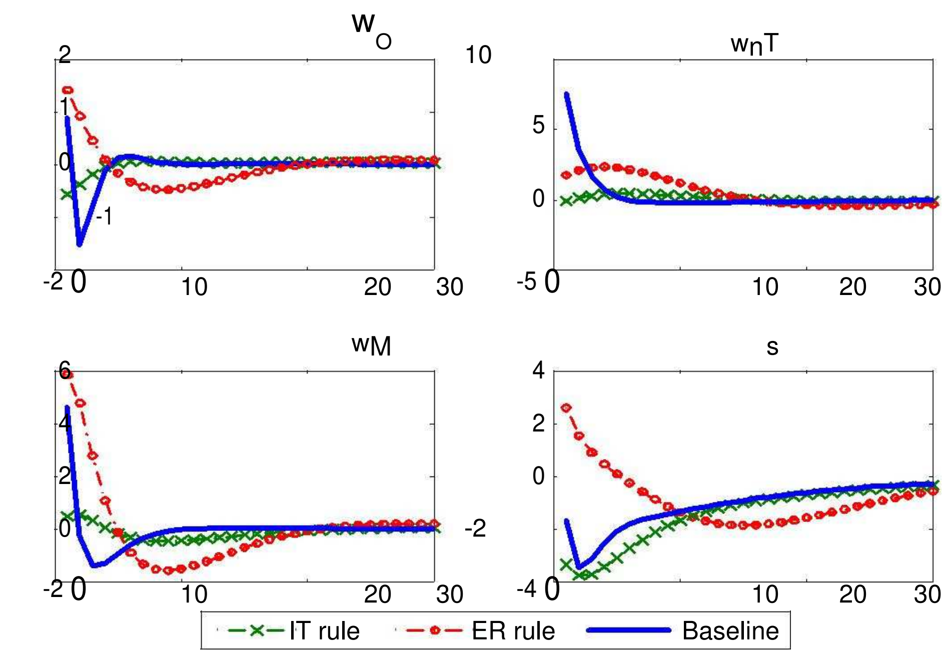

Figure 12: Alternative monetary policy rules (Kuwait)

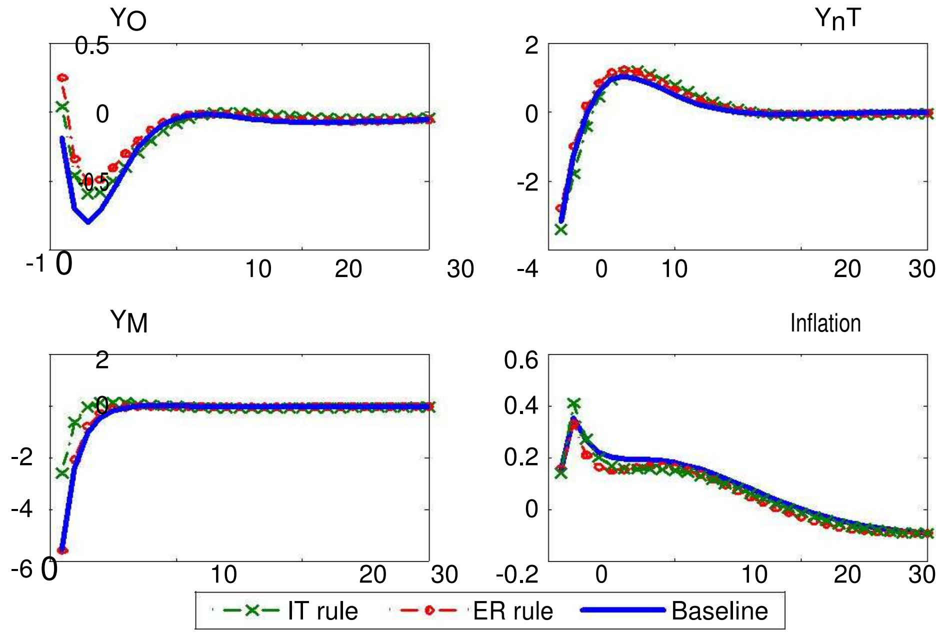

Figure 13: Alternative monetary policy rules (Kuwait)

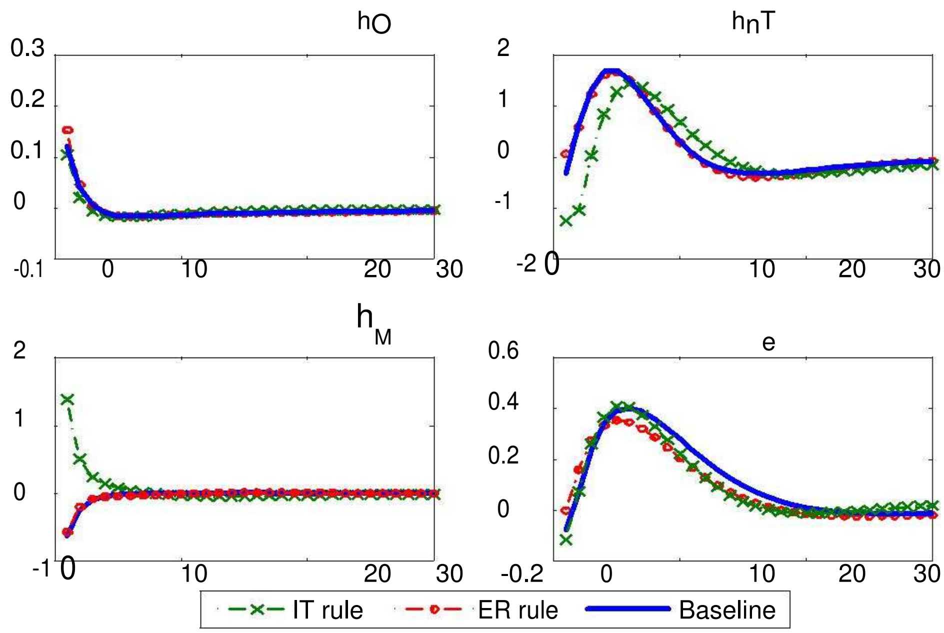

Figure 14: Alternative monetary policy rules (Kuwait)

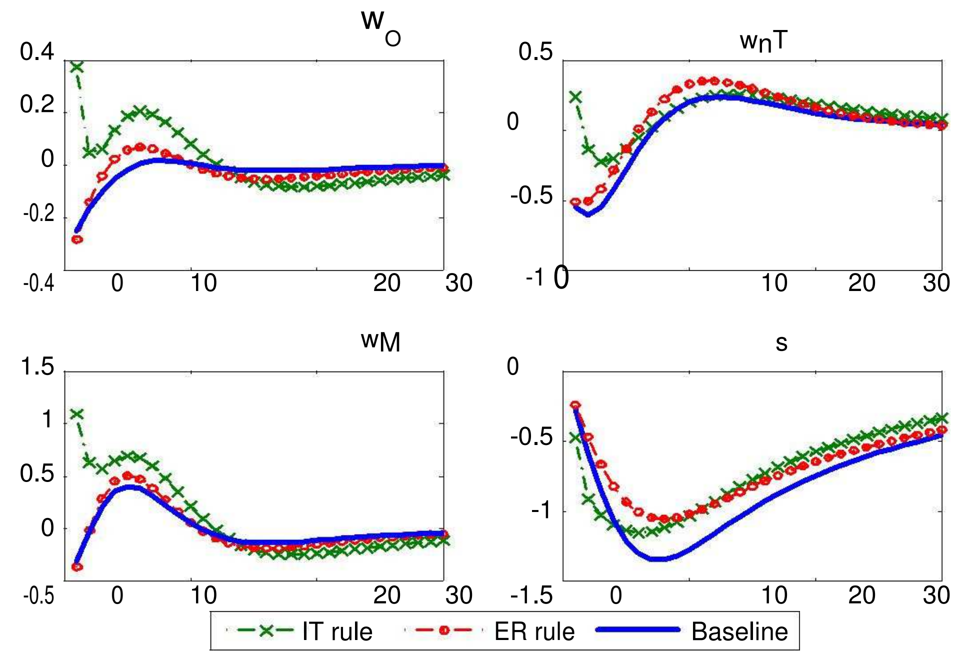

Figure 15: Alternative monetary policy rules (Oman)

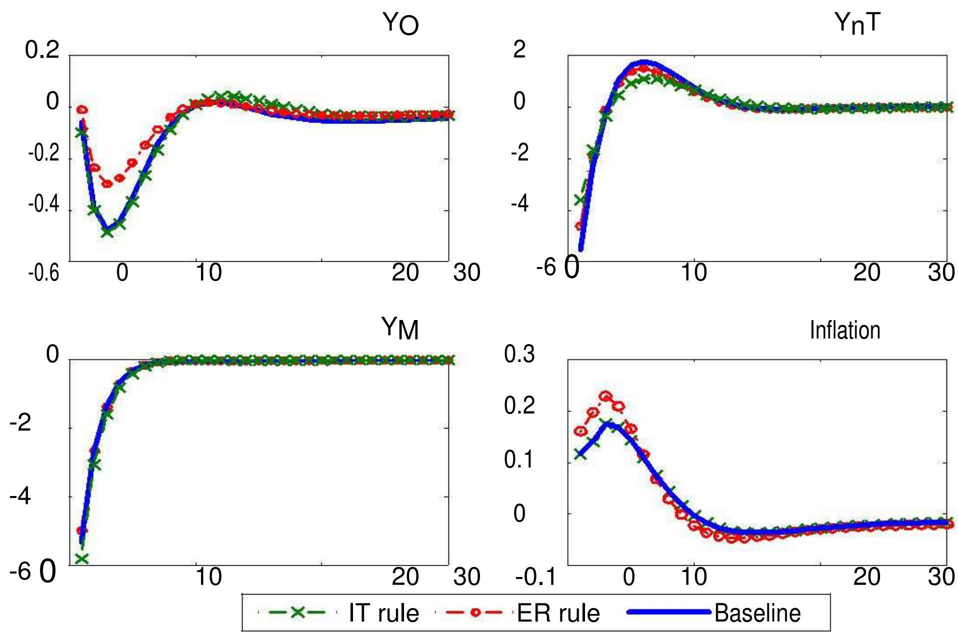

Figure 16: Alternative monetary policy rules (Oman)

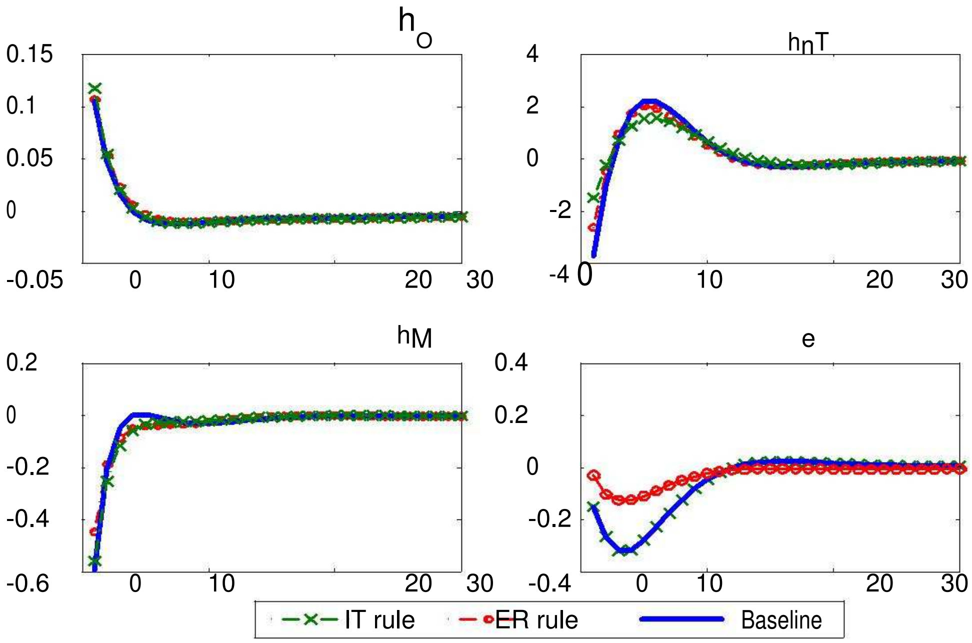

Figure 17: Alternative monetary policy rules (Oman)

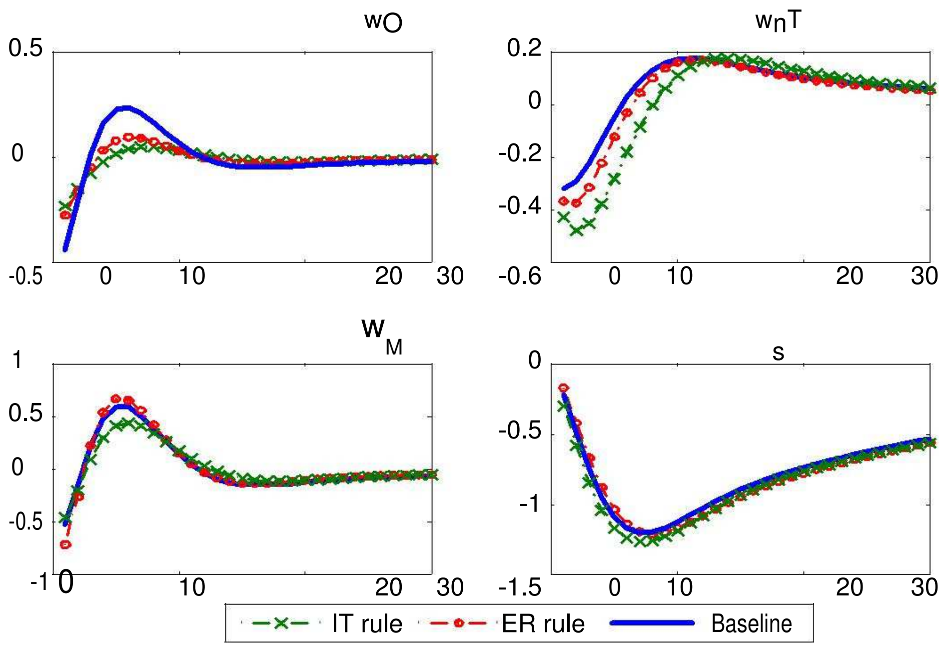

Figure 18: Alternative monetary policy rules (Saudi Arabia)

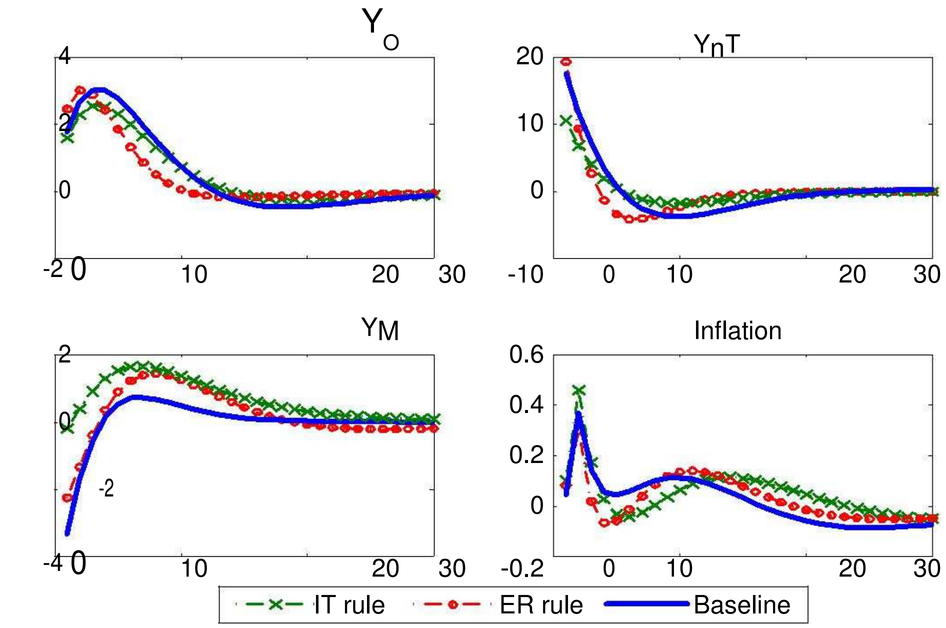

Figure 19: Alternative monetary policy rules (Saudi Arabia)

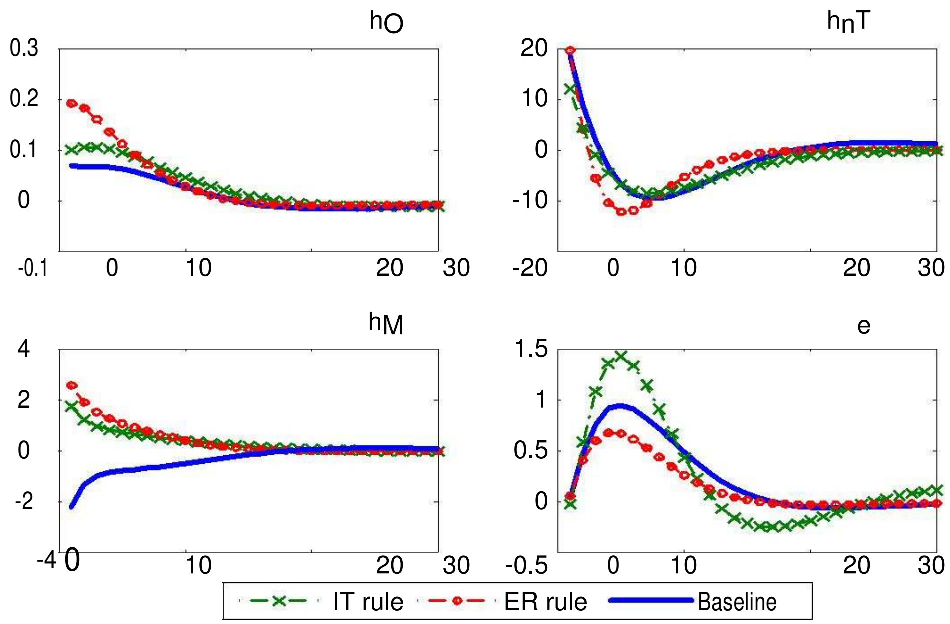

Figure 20: Alternative monetary policy rules (Saudi Arabia)

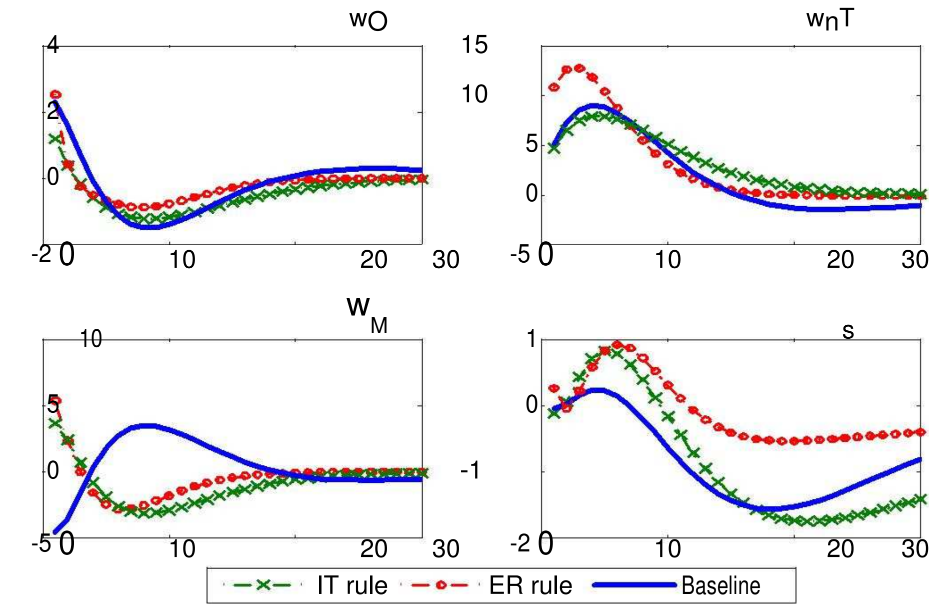

Figure 21: Alternative monetary policy rules (Venezuela)

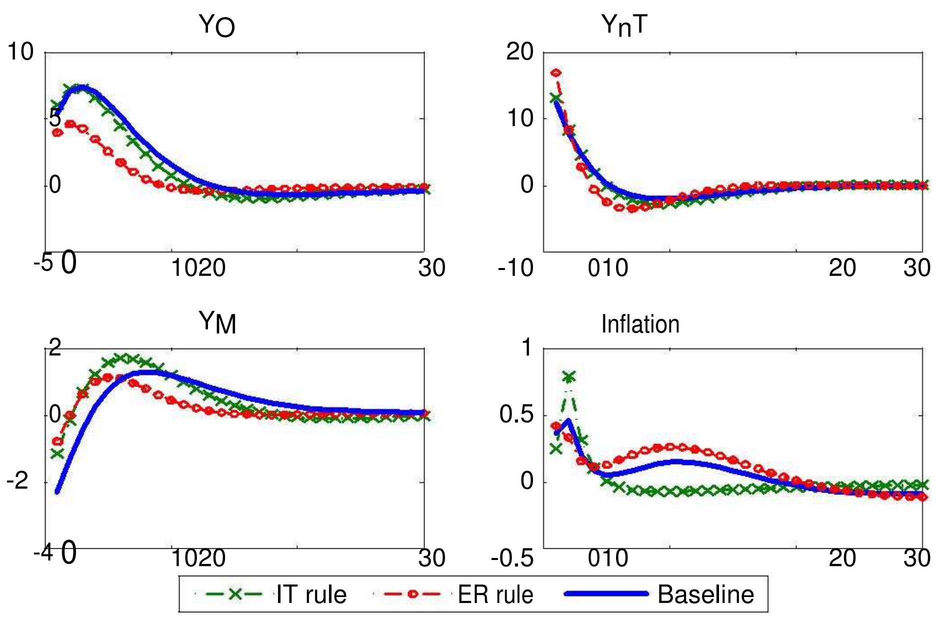

Figure 22: Alternative monetary policy rules (Venezuela)

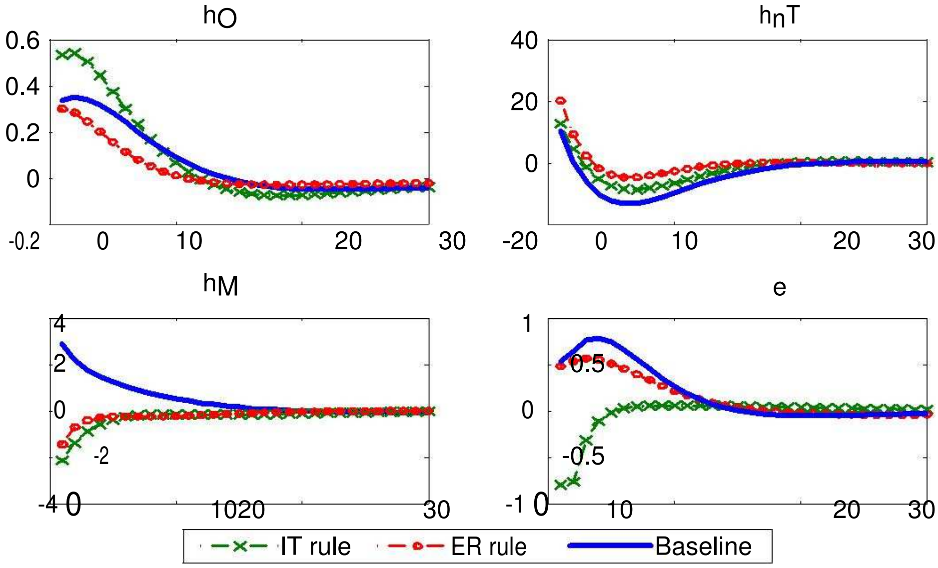

Figure 23: Alternative monetary policy rules (Venezuela)

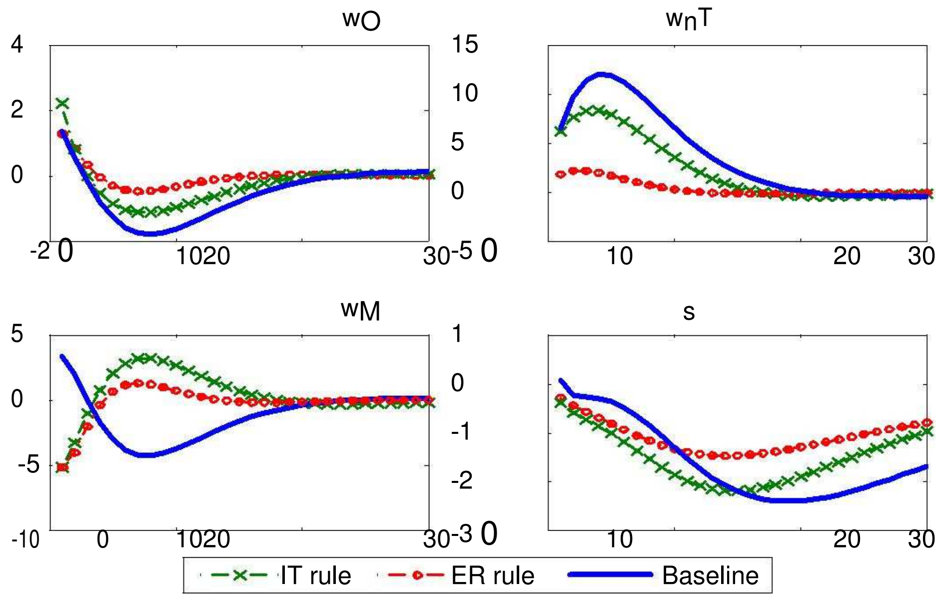

Figure 24: Real exchange rate under alternative monetary policy rule