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Abstract:

This paper develops a new Keynesian DSGE model compatible with the structural characteristics of commodity exporting developing economies (financial vulnerability, relatively high pass-through rates, procyclical fiscal policy, and high terms of trade volatility) to compare the performance of alternative policy regimes, namely flexible domestic inflation targeting, flexible consumer price index inflation targeting, and the real exchange rate targeting. Evaluation of the above alternative policy regimes and relative stability of key macroeconomic variables are conducted through an optimal Ramsey policy method. The policy evaluation results based both on stabilization and welfare measures obtained for the case of Iran imply that for the developing commodity (oil) exporting economies stabilization with a broader inflation targeting framework in which the real exchange rate is also targeted is the superior policy regime. Optimality of the alternative policy regimes and their rank are sensitive to the degree of financial vulnerability. Financial vulnerability in this model explains why departure from floating exchange rate in an inflation targeting framework is the appropriate policy and not merely a "fear". As the degree of financial development increases sufficiently, the standard flexible inflation targeting becomes the superior policy regime. A policy rule to weaken procyclicality of fiscal policy further enhances the welfare performance of this regime.

JEL Classification: E52; F31; F41; O24.
Keywords: Financial vulnerability; inflation targeting; fear of floating; Ramsey method.

1- Introduction:

Commodity dependence amongst the developing and emerging economies not only continues to be significant but for a large numbers of them it is currently more than in the past.[1] Capital inflows to this group of countries tend to co-move with commodity prices and magnify the effects of terms of trade shocks. The propagation effect associated with procyclicality of the terms of trade, capital inflow and fiscal policy frequently results in amplification of the aggregate demand and appreciation of the real exchange rate.[2] Without an accompanying productivity shock, the initial boom fizzles out in time--more rapidly if the initial positive commodity price shock is short-lived. A negative commodity price shock has a propagation effect in the opposite direction. Note, however, that in financially vulnerable emerging economies the influence of joint terms of trade shock and global credit shock may not be symmetric. In this type of economies, the consequences of a negative shock are more severe, often it is followed by a currency collapse, business bankruptcy, and economic contraction. The susceptibility of the developing and emerging countries, in particular commodity exporting economies, to global cycles implies the need for a robust stabilization policy. A large number of the countries that have experienced such booms and busts have been inflation targeters. In the standard flexible inflation targeting (IT) framework the central bank stabilizes the domestic economy with the short-term interest rate and the external sector through floating exchange rates. Is this policy arrangement suitable for the developing and the emerging market economies (EME) countries? The EMEs have had a generally positive experience with IT as average inflation rates have declined significantly subsequent to implementation of this stabilization policy framework. Nonetheless, IT performance in the EMEs has been inferior to that in the developing economies in at least two respects: deviations from both the central and the upper bound of the announced inflation targets (Fraga et al 2013). Such deviations could be due to differences in macroeconomic environment/structure, financial market conditions, and/or differences in the degree of policy credibility[3].

For standard IT to work properly at least two assumptions must be maintained: validity of Marshall-Lerner and uncovered interest rate parity (UIP) conditions. In this environment, short-term interest rate is the sole instrument for stabilization of both domestic and external sectors. Countries such as Australia, Canada, and New Zealand have relied on this standard approach for good use (Dib, 2008). Is the

[1] For more details see Akyüz (2017).
[2] Formore details on global cycles, commodity prices and capital inflows see Reinhart et al (2016).
[3] On this and related matters see Agénor and Pereira da Silva 2013.

standard IT equally suitable in economies with structural features like relatively high exchange rate pass through rates and incompletely integrated financial market prone to financial vulnerability[4]? This question is particularly relevant for commodity exporting developing economies as they face similar problems plus they often are subject to large terms of trade shocks. Negative terms of trade shocks can set speculative forces in the currency market resulting in a higher exchange rate risk premium that can create a new source of inefficiency with complicating effects on inflation, output, and the real exchange rate (RER). This is a kind of environment that can force the hand of the central bank to deviate from its announced inflation target. Under this setting, adjustment of short-term interest rates to stabilize the domestic and external sector does not suffice and the central bank requires a supplementary instrument to manage the external and along with that an amended loss function and a targeting rule to conduct optimal policy.

The existing literature suggests three ways of overcoming this problem for the *inflation targeting central banks*. For commodity exporting developing economies, one suggested policy solution is to target the export price index (Frankel 2010). Ghosh et al (2016) argue that, in the EMEs that face significant currency mismatches in the domestic balance sheets and exhibit structural features such as high exchange rate pass-through rates and restricted inter-sectoral factor mobility, the issue of exchange rate volatility cannot be ignored. They propose two target two instrument-dual instrument solution: interest rate for targeting domestic inflation and output and sterilized foreign exchange intervention for easing adverse currency movements.[5] Anamaría Pieschacón (2012) and Stephen Snudden (2016) highlight the role of fiscal policy in stabilizing macroeconomic volatility and welfare gain in oil exporting economies. It is argued that counter-cyclical fiscal policy can ameliorate oil (commodity) price shocks in small open oil exporting economies. Moreover, this creates a more suitable environment to practice standard inflation targeting.

[4] Financial vulnerability here refers to the capability of the domestic financial markets to deal with adverse currency market shocks. More specifically, the sensitivity of the currency-market risk premium to meaningful depreciation of the real exchange rate (Cavoli 2009). In a financially vulnerable economy, exchange rate shocks can strongly be transmitted to the real economy via induced changes in the risk premium. This term will be discussed more in detail in section 2.

[5] Note that in the context of the New Keynesian models and the associated inflation targeting literature, when pricing by firms is of Producer Currency Pricing (PCP) variety, optimal policy is to target domestic inflation rate and let the currency to float. However, monetary authority's reaction to exchange rate movements along with inflation and output gap is the optimal policy provided that price setting in the international market is of the Local Currency Pricing (LCP) variety and/or domestic financial market is incompletely integrated into the global markets Engel (2014) and Corsetti et al (2010). In this paper both issues is dealt with but goes further.

While the above policy approaches discuss the relevant issues and identify pertinent policy challenges facing the EMEs, the issues can be robustly integrated in a more general framework with explicit micro-foundation. Moreover, it is important to incorporate the issue of financial vulnerability as it helps to provide a channel for the impact of commodity-price (or terms of trade) volatility on variations of the exchange rate risk premia and the consequent negative balance-sheet effect that it may engender. We think this is a key channel and is a major rationale for the aversion to float[6]. Historical evidence suggests that numerous EMEs are disinclined to float their currencies. Even those countries that de jure proclaim to have a floating currency regime, de facto they do not practice it (Calvo and Reinhart 2002, Kliatskova et al, 2015)[7]. As a result, there is a tendency to limit exchange rate adjustments, even in the aftermath of terms of trade shocks.[8] To the extent that incomplete international financial market integration implies that EMEs cannot borrow from the global markets abroad in their own currency ("original sin") and foreign debt holding by the households and business sectors is not insignificant, there is reluctance on the part of the monetary authority to let their currencies float. The aversion to float emanates from the adverse effect of currency depreciation on household, corporate, and the banking sector balance sheets and the potential contractionary consequences of a sizable decline in the price of the domestic currency.[9] When the balance sheet effect overwhelms the Marshall-Lerner condition, contractionary devaluation is more likely. The inflationary consequences of exchange rate devaluation can also be an additional concern for the central bank.

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[6] Other reasons in this regard are lack of credibility and high level of exchange rate pass-through rate to prices. The latter is also incorporated in our model along with financial vulnerability.

[7] Kliatskova et al (2015) show that in a sample of 15 emerging economies namely Brazil, Chile, Colombia, Georgia, Hungary, Indonesia, Mexico, Peru, Philippines, Poland, Romania, Russia, South Africa, Thailand, and Turkey, with large foreign exchange debt in the non-financial private sector tend to react more strongly to exchange rate changes using both FX intervention and interest rate. Thus, their results support the important role of balanced sheet effect in the fear of floating behavior of aforementioned countries.

[8] Calvo and Reinhart (2002) argue that a long-standing challenge for monetary authorities in the developing economies has indeed been "fear of floating".

[9] When firms or households borrow (including financing imports) in units of foreign currency whereas income flow is in local currency, depreciation of the domestic currency results in higher debt-service costs. If the extent of borrowing and depreciation is significant, it can lead to bankruptcies, and reduction of aggregate expenditures. If currency exposures by household and firms are financed by the domestic banking system, the cash flow problems can further spill over to the banking sector, exacerbating financial instability.

This paper identifies two distinct routes through which policy trade-offs are affected by the existence of the above channel. First and foremost, this paper recognizes that financial vulnerability through its influence on the exchange rate risk premium results in the creation of a new source of economic inefficiency and policy trade-off. Breakdown of the uncovered interest rate parity (UIP) relationship warrants reaction to real exchange rate movement by the policy maker that helps to reduce exchange rate volatility and mitigates the welfare loss associated with this economic inefficiency. Hence, we justify “fear of floating” by explaining why under certain structural conditions departure from free floating is the appropriate policy. The paper also recognizes that, aside from capital inflows, in most commodity exporting countries, fiscal policy is the propagation mechanism for commodity price variation. Therefore, implementation of a fiscal rule to control propagation effects of pro-cyclical fiscal policies should augment standard monetary policy packages, particularly in those economies with large non-Ricardian agents. Implementation of a fiscal rule in commodity (oil) exporting countries can control flow of foreign exchange thus rendering currency fluctuations less disruptive. This creates a more conducive environment for monetary policy. Iran, like many commodity exporting developing economies, such as Brazil, Chili, Peru, Indonesia, and Russia, exhibits features described as in the above (Kliatskova et al 2015). In particular, fiscal spending have been strongly pro-cyclical during boom times; when oil revenues are high (above trend), oil-financed government expenditures rise and often during low oil price periods, real government expenditures fall.[10]

The model presented in this paper is in tune with the structural characteristics of commodity exporting developing economics, in particular Iran. The model pertains to economies with local currency pricing, incomplete international risk sharing, financial vulnerability, presence of non-Ricardian agents, and subject to the oil revenue shocks. Fiscal policy in the model is specified in such a way to cover different degrees of pro-cyclicality: complete and incomplete raiding of natural resource revenue (complete and incomplete procyclicality). The fiscal rule is the device that can weaken pro-cyclical oil-financed fiscal expansion in order to undermine positive correlation between oil revenue shocks and inflation. Using

[10] Government owned oil export revenues are denominated in foreign currency and to finance domestic expenditures, the export proceeds are sold by the fiscal authority to the central bank. This procedure establishes an institutional link between fiscal operations and central bank's balance sheet. In this scheme, when aggregate demand rises as a consequence of higher oil-financed government expenditures, large amount of foreign currency is also sold to the public which tends to keep a lid on the exchange rate.

optimal Ramsey rule approach, we evaluate the welfare and stabilization performance of three monetary policy regimes: flexible domestic inflation targeting, flexible consumer price inflation targeting, and real exchange rate targeting, respectively. The weight of the real exchange rate gap in the policy loss function is allowed to increase from zero in the first regime to the highest value in the third policy regime, reflecting the extent of foreign exchange market intervention by the central bank. Our findings show that given the model's structure and the Bayesian estimated parameters, the real exchange rate targeting (RERT) policy regime is the superior one. Moreover, the implementation of a fiscal rule through an oil (commodity) stabilization fund (OSF) do not change the superiority of this policy regime even though it has a meaningful influence on the welfare performance of the flexible consumer price inflation targeting. Notably, a reduction in the degree of vulnerability of the domestic financial market results in change of the rank of policy regimes. In a low financial vulnerability environment, flexible consumer price targeting becomes the superior policy regimes—indicating the influence of the relative deepness of the financial market and reduced sensitivity of the exchange rate risk premium to currency depreciation.

We proceed as follows. In section (2), the structural features of commodity-exporting developing economies, including Iran are described. In section (3), the model of this paper will be presented and elaborated. Section (4), discusses three distinct monetary regimes. In section (5) we provide Bayesian estimation of our models' parameters. In section (6) welfare and stabilization performance of the policy regimes are evaluated using optimal Ramsey policy method. Moreover, through variation of key parameters, sensitivity analysis of the optimal welfare measure of each policy regime will be performed. Section (7) presents the concluding section.

2- Economic Environment and the Structural Features

Monetary and exchange rate policy design is influenced by the institutional structure and the political economy environment of the economy in question. To provide a factual background and proper motivation and context for design of an optimal monetary policy rule, we identify the economic and institutional characteristics of a representative commodity-exporting, small-open-developing economy such as Iran. Prior observations and research work points to the following characteristics.

1- Terms of trade (henceforth, TOT) fluctuations is highly volatile and exogenous due to significant share of commodity (oil) revenues in exports.

Mendoza (1995) emphasized the quantitative significance of TOT shocks in generating business cycles. Koze (2002) points to the effect of world prices on business cycles in small open economies, Bhattacharya et al (2013) explore how financial integration influences the way in which TOT shocks impact business cycles in small developing countries. Mehrara et.al. (2007) found that TOT shock is the major contributing source of output fluctuations in Iran.

2- The domestic financial market in developing economies often lack sufficient depth and it is not well-integrated into international financial markets. Based on a fairly wide country observation, Rojas-Suarez (2010) shows that access by the household and business sector to finance in EMEs and developing economies are limited. Zheng (2016) shows that for countries with developed financial markets, integration to world markets (greater risk sharing) lessens business cycle volatility, however, it has the opposite effect for economies with underdeveloped financial markets. Since the capital account is semi-open in Iran, national currency is not a complete substitute for internationally major currencies. These facts imply violation of uncovered interest rate parity condition (henceforth UIP) and the existence of incomplete international risk sharing.[11]

3- The existence of a fraction of population with low savings and lack of access to the financial market does not provide opportunities for this non-Ricardian households (henceforth NRH) to smooth consumption over time. The existence of NHH type of households has certain implications regarding the effectiveness of monetary and fiscal policies on closing the output gap.[12]

4- Small commodity (oil) exporter developing countries are by definition open economies. However, the degree of openness differs. Iran is a fairly open economy and the ratio of exports and imports to GDP is around 55 percent.

5- The exchange rate pass-through rates is generally higher for the developing economies than those for the developed economies.[13] The exchange rate pass-through rate for developing economies is imperfect. For Iran the pass through

[11] Li, Dandan et al (2012) show that the exchange rate risk premium in UIP relationship is significant for a set of emerging and developed economies.

[12] Following Gali (2004), since households are Ricardian fiscal policy are neutralized by their saving behaviors, however this generalization does not extend to non-Ricardians. In this paper our focus is on the raiding behavior of the government with regard to a natural resource windfall not exclusively tax policy. Moreover, when non-Ricardians are present fiscal policy can affect income distribution as well.

13 The above generalization is not inconsistent with the observation that for many emerging economies the pass through rate has been declining over the last fifteen years.

rate is around 0.4-0.5. That is, the law of one price does not hold and there is no one-to-one relationship between the rate of change of the nominal exchange rate and CPI. [14]

6- Similar to a number of oil exporting countries, Iranian government sells all or parts of its oil revenue, denominated in foreign currency, to the central bank to receive domestic currency equivalent on the revenue side of the government budget. The larger are such revenues and the higher is the exchange rate, the larger is its budgetary revenues and expenditures. This institutional link between the government budget and the central bank's balance sheet creates a positive correlation between TOT and real exchange rate.
7- The exchange rate policy and movement in Iran has historically been influenced by the volume of oil revenues. During high-oil-revenue (positive price shock) periods, the supply of foreign exchange expands due to higher oil-financed government expenditures, and the material conditions for implicit use of exchange rate anchor improves. Such confluence of events tends to strengthen positive correlation between TOT and real exchange rate during oil-boom years.
8- Hematy and Jalali-Naini (2015) show that for the period 1990-2013, the Central Bank did not pursue systematic policies to counter inflation; if any the policies tend to have accommodated inflation, hence the existence of an inflation risk premium originating in the gap between central bank targets and the realized levels of inflation in the Iranian economy.

3-Model Description

We present a new Keynesian small open economy model for a class of commodity (oil) exporting countries (such as Iran) incorporating their salient characteristics like, imperfect international risk sharing, limited monetary policy credibility, local currency pricing[15], and the existence of non-Ricardian households.

3-1- Domestic Households

The economy is populated by a continuum of infinitely lived households on the interval [0,1]. A fraction (1-μ) consists of Ricardian households (RH) with access to financial markets where they can trade a full set of contingent claims. The remaining

[14] Notwithstanding the incomplete exchange rate pass-through, the speed of nominal exchange rate influence on CPI inflation in Iran is relatively considerable, particularly during the negative TOT shocks.
[15] This feature entails of the law of one price hence exchange rate pass-through rate can be either high or low.

fraction μ, are NRH types that do not own assets and financial liability. Moreover, due to their lack of access to financial markets they consume all their disposable income in each period. It is assumed that the labor market is competitive, the wage rate is the same across all households, and both types of households work the same number of hours.

The Ricardian households seek to maximize their intertemporal utility

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{(C_t^r)^{1-\sigma}}{1-\sigma} - \Psi \frac{(N_t)^{1+\eta}}{1+\eta} \right] \quad (1)$$

Where E_t denotes conditional expectation based on information set in period t. Parameter β is the subjective discount factor, σ is the inverse inter-temporal elasticity of substitution and η denotes inverse of the Frisch elasticity of labor supply.

Ricardian households have access to two distinct assets: one period domestic savings (borrowing), D_t, and one period foreign savings (borrowing), B_t^*. There are no adjustment costs for changes in the portfolio composition. Therefore, each RH enters period t with nominal domestic savings (D_t) and nominal foreign saving ($\varepsilon_t B_{t-1}^*$). RH receives labor income ($W_t N_t$) and profits Π_t and Π_t^o from both the final good producing firms, respectively. The representative household uses these funds to finance Ricardian consumption (C_t^r), pay lump sum taxes (T_t^r) and to accumulate additional amounts of domestic and foreign savings. As in Engel (2014), it is assumed that there is a wedge between the returns to contingent claims for the domestic and foreign households due to international financial market imperfections. Therefore, each time a domestic RH borrows from abroad, it must pay an endogenous premium over the international price for external borrowings. RHH budget constraint is thus given by:

$$P_t C_t^r + P_t T_t^r + E_t\{Q_{t,t+1} D_{t+1}\} + \frac{\varepsilon_t B_t^*}{(R_t^*) RP_t} = D_t + \varepsilon_t B_{t-1}^* + W_t N_t + \Pi_t \quad (2)$$

R_t^* denotes the gross foreign nominal interest, and $Q_{t,t+1}$represents the stochastic discount factor. The premium that the domestic RH have to pay each time they borrow from abroad is shown by RP_t. Corsetti et al. (2010) define RP_t as the marginal utility of a unit of currency for foreign households relative to domestic households and label it the relative demand gap. If international financial markets are perfect, i.e. international risk sharing is complete, then RP_t=1.

The RH maximizes (1) with respect to consumption, domestic and foreign savings (borrowings), and its labor supply subject to its resource constraint (2). The first-order conditions for consumption-domestic saving decision, consumption-foreign saving decision and labor-leisure choice can be used to obtain:

$$\beta E_t\left[\frac{P_t}{P_{t+1}}\frac{(C_{t+1}^r)^{-\sigma}}{(C_t^r)^{-\sigma}}\right]=\frac{1}{R_t} \quad (3)$$

$$\beta E_t\left[\frac{\varepsilon_{t+1}P_t}{\varepsilon_t P_{t+1}}\frac{(C_{t+1}^r)^{-\sigma}}{(C_t^r)^{-\sigma}}\right]=\frac{1}{R_t^* RP_t} \quad (4)$$

$$\Psi(N_t^s)^{\eta}(C_t^r)^{\sigma}=\frac{W_t}{P_t} \quad (5)$$

Equation (3) is the Euler condition for the domestic saving denoting consumption-domestic saving optimal choice, (4) is the efficiency condition for the consumption-foreign saving, and equation (5) is the optimal labor-leisure choice.

NRH consume all of their labor income in a "hand to mouth" fashion, therefore, they neither smooth their consumption against labor income fluctuations nor they react to interest rate changes by altering their consumption. While NRH has the same preferences as RH, their control variables are limited to their consumption and labor supply subject to following budget constraint:

$$P_tC_t^{nr}+P_tT_t^{nr}=\mathrm{W_t N_t^s} \quad (6)$$

Accordingly, the level of consumption can be derived as:

$$C_t^{nr}=\frac{W_t}{P_t}\mathrm{N_t^s}-T_t^{nr} \quad (7)$$

For the sake of simplification, it is assumed that NRHs do not pay taxes and hence $T_t^{nr}=0$. Each consumption bundle ($C_t^i, \forall i\epsilon\{r,nr\}$) is a composite of domestic goods ($C_{H,t}^i$) and imported consumption goods ($C_{F,t}^i$) which is aggregated based on

$$C_t^i=\left[(1-\gamma)^{1/\theta}(C_{H,t}^i)^{\theta-1/\theta}+\gamma^{1/\theta}(C_{F,t}^i)^{\theta-1/\theta}\right]^{\theta/\theta-1} \quad \forall i\epsilon\{r,nr\} \ (8)$$

Parameter θ is the elasticity of substitution between domestic and imported goods and γ is a degree of openness. Each consumer, either Ricardian or non-Ricardian, at each level of consumption purchases a composite of domestic and foreign goods to minimize the total cost of its consumption basket. The aggregate price index (P_t) for the consumption bundle for both RH and NRH is given by:

$$P_t = \left[\gamma P_{H,t}^{1-\theta} + (1-\gamma) P_{F,t}^{1-\theta}\right]^{1/1-\theta} \quad (9)$$

Where $P_{H,t}$ and $P_{F,t}$ are the price of domestic and imported consumption basket, respectively. Minimization of total consumption expenditure ($P_{H,t}C_{H,t}^{i} + P_{F,t}C_{F,t}^{i}$), $i\epsilon\{r, nr\}$ result in the demand function for differentiated domestic and imported goods by RH and NRH:

$$C_{H,t}^{i} = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\theta} C_t^{i} \quad , i\epsilon\{r, nr\} \quad (10)$$

$$C_{F,t}^{i} = \gamma\left(\frac{P_{F,t}}{P_t}\right)^{-\theta} C_t^{i} \quad , i\epsilon\{r, nr\} \quad (11)$$

Aggregate consumption is a weighted average of consumption for each household type:

$$C_t = \mu C_t^{nr} + (1-\mu) C_t^{r} \quad (12)$$

Based on the notion of centralized economy-wide union in Gali (2004), with similar preferences and a uniform wage rate, Ricardian and non-Ricardian labor supply are equal. Given the real wage rate, each firm decides how much labor to hire and allocates its labor employment uniformly across households, independently of their type.

The percentage deviation around the steady-state (lower case with tilde variables) for the first order condition equations (3) and (5) of RH can be written as:

$$\tilde{c}_t^{r} = E_t\tilde{c}_{t+1}^{r} - \frac{1}{\sigma}(\tilde{\imath}_t - E_t\tilde{\pi}_{t+1}) \quad (13)$$

$$\eta\tilde{n}_t + \sigma\tilde{c}_t^{r} = \widetilde{w}_t - \tilde{p}_t \quad (14)$$

Equation (7) for NRH in the log-linearized form is given by:

$$\tilde{c}_t^{nr} = \widetilde{w}_t + \tilde{n}_t - \tilde{p}_t \quad (15)$$

Using equations (12), (13), (14) and (15), the aggregate Euler equation for all households in log-linearized form is derived as:

$$\tilde{c}_t = E_t\tilde{c}_{t+1} - (\mu + \tfrac{1-\mu}{\sigma})(\tilde{\imath}_t - E_t\tilde{\pi}_{t+1}) - \mu(\eta+1)E_t(\tilde{n}_{t+1} - \tilde{n}_t) \quad (16)$$

Notice that in this Euler equation, aggregate consumption depends on μ which is the fraction of non-Ricardian households. Moreover, the presence of NRH generates a direct effect from employment on the level of consumption and hence on aggregate demand--beyond the effect of the interest rate.

3-2- Incomplete international risk sharing:

Foreign households solve a problem similar to that of domestic households in the model. First order conditions for optimal labor supply and consumption, analogous to (3), (4) and (5) also hold for the households in the rest of the world. Given identical preferences, the following relationship can be derived:

$$\beta E_t\left[\frac{P_t}{P_{t+1}}\frac{(C_{t+1})^{-\sigma}}{(C_t)^{-\sigma}}\right] = \beta RP_t E_t\left[(\frac{\varepsilon_t}{\varepsilon_{t+1}})(\frac{P_t^*}{P_{t+1}^*})\frac{(C_{t+1}^*)^{-\sigma}}{(C_t^*)^{-\sigma}}\right] = \frac{1}{R_t} \quad (17)$$

Variables and parameters with asterisks denote the foreign country. The real exchange rate is defined as $Q_t = \frac{\varepsilon_t P_t^*}{P_t}$, and equation (17) implies that

$$\frac{C_t}{C_t^*} = \nu^*(Q_t RP_t)^{\frac{1}{\sigma}} \quad (18)$$

Where $\nu^*$is a proportionality constant. According to equation (18), the ratio of marginal utility of consumption to its price (marginal utility of a domestic currency) is not equal for domestic and foreign households resulting in a relative demand gap, captured by $RP_t \neq 1$.[16] In other words, international risk sharing is not complete in the model. The basis for the presence of a relative demand gap is the existence of currency mismatch that may result in the balance sheet effect (Motyovzski 2016). The first order linear approximation around the steady state is shown by equation (19).

$$\tilde{c}_t = \tilde{c}_t^* + \frac{1}{\sigma}(\tilde{q}_t + \widetilde{rp}_t) \quad (19)$$

The law of one price gap $(\Psi_{F,t})$, and terms of trade (S_t), are defined below, respectively as:

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[16] This is the standard relationship in the open economy models, where $\frac{u'(c_t)}{u'(c_t^*)}) = \frac{1}{Q_t\ RP_t}$. With completely integrated financial markets, the theory predicts that consumption growth positively and perfectly is correlated across economies, given an equilibrium RER. In such a case RP_t is zero. However the above implication is not supported by the empirical evidence (Backus-Smith 1994). In countries with incomplete financial markets, the positive correlation is not perfect and it may even be negative. In this case a risk premium will appear in (18) and in the UIP relationship (23).

$$\Psi_{F,t} = \frac{\varepsilon_t P_t^*}{P_t} \qquad (20)$$

$$S_t = \frac{P_{F,t}}{P_{H,t}} \qquad (21)$$

The log-linearized relationship between the law of one price gap, real exchange rate and terms of trade is:

$$\tilde{q}_t = (1-\gamma)\tilde{s}_t + \tilde{\psi}_{F,t} \qquad (22)$$

Based on first order conditions (3) and (4) and similar first order conditions for foreign households, it is also possible to derive the no-arbitrage condition for the exchange rates:

$$\frac{1}{R_t}\frac{\varepsilon_t}{E_t\varepsilon_{t+1}} = \frac{1}{R_t^* RP_t} \qquad (23)$$

Equation (23) is a deviation from the nominal interest parity condition. Linearizing this condition yields:

$$(\tilde{\imath}_t - E_t\tilde{\pi}_{t+1}) = (\tilde{\imath}_t^* - E_t\tilde{\pi}_{t+1}^*) + E_t(\tilde{q}_{t+1} - \tilde{q}_t) + \widetilde{rp}_t \qquad (24)$$

According to this equilibrium condition, the difference between the domestic and foreign real interest rates will result in expected future change of real exchange rate and relative demand gap.

Historical observations in many EMEs and developing economies indicate that when access to foreign capital markets are limited, the ratio of foreign exchange reserves to imports (import-coverage ratio) tends to be negatively correlated to RER. The risk premium (RP_t) can be endogeniszed either via Q_t or the import coverage ratio. In this paper, the risk premium is modelled according to the former. Following Cavoli (2009), the sensitivity of the relative demand gap ($\widetilde{rp}_t$) to the real exchange rate (ψ_q) can be perceived as an indicator of the degree of financial vulnerability in a small open economy and can be shown as:

$$\widetilde{rp}_t = \rho_f \widetilde{rp}_{t-1} + \psi_q \tilde{q}_t + \varepsilon_t^{rp} \qquad (25)$$

$\widetilde{rp}_t$ is influenced by an exogenous shock (ε_t^{rp}) like a sudden stop or a global contraction in credit availability[17]. It is also affected endogenously by movements in the real exchange rate—for instance, brought about by a commodity price (TOT)

[17] The shock term is also referred elsewhere to a "sudden stop" shock. See for example (Motyovzski 2016).

shock. According to equations (24) and (25), for given levels of foreign interest rate and the exchange rate, a positive risk premium shock (ε_t^{rp}) results in an increase in the domestic interest rate ($\tilde{\imath}_t$) via nominal interest parity condition (equation 24) which, in turn, lowers Ricardian domestic consumption through equation (13). Such a fall in domestic consumption reduces real wage rates since it stimulates labor supply via labor-leisure choice (equation 14), even when there is no output gap. The risk premium shock generates a new source of trade-off between the relative demand gap ($\widetilde{rp}_t$) stabilization and output gap—since by changing consumption it changes the level of welfare. This outcome breaks the divine coincidence and requires a new instrument to complement monetary policy.[18]

Moreover, equation (25) indicates that, other things being equal, a real exchange rate depreciation results in a higher relative demand gap ($\widetilde{rp}_t$), mainly due to incomplete hedging of the exchange rate risk in an environment of incomplete international risk sharing. A real depreciation results in an increase of the domestic currency value of external debts (for households, banks and firms) through a channel called the balance-sheet effect. In economies with high degrees of incomplete international risk sharing (financially vulnerable economies), the negative effect of currency depreciation via balance sheet effect could potentially more than compensate its positive effect on the current account, in order for the currency depreciation to have a contractionary effect on the domestic output.

3-3- Domestic Firms

There is a continuum of final good variety producers. Labor $N_t\,(j)$ is the only factor of production for domestic firms to produce differentiated final goods. Domestic firms operate with a Cobb-Douglas production technology

$$\mathrm{Y_{H,t}} = \mathrm{A_t N_t(j)} \qquad (26)$$

Where A_t represents total factor productivity. It is assumed that this variable is exogenously determined and it evolves according to an AR(1) stochastic process:

$$\ln \mathrm{A_t} = \rho_\mathrm{A} \ln \mathrm{A_{t-1}} + \varepsilon_\mathrm{A,t} \quad , \quad \varepsilon_\mathrm{A,t} \sim \mathrm{IN}\,(0, \sigma_\mathrm{A}) \qquad (27)$$

Where the parameter ρ_A is the first-order autocorrelation coefficient, reflecting the persistence of domestic production technology, $\varepsilon_{A,t}$ is an independent and identically distributed random variable with mean zero and standard deviation σ_A.

[18] See Zeineddine Alla et al (2017).

Domestic firms supply their output in a monopolistic competition market with differentiated goods and face Calvo (1983) type nominal rigidity that prevents them from adjusting their prices. In every period, the probability of price adjustment is $1-\eta_H$ for all firms, and it is independent of its history. When the domestic firms have an opportunity to adjust prices, they will optimally adjust the price of their differentiated good $\bar{P}_{H,t}(j)$ in order to maximize the present discounted value of the flows of profits according to the following problem:

$$\max_{\bar{P}_t(j)} \sum_{k=0}^{\infty} \beta^k \eta_H^k \mathrm{E}_t\{\mathrm{Q}_{t,t+k}\mathrm{Y}_{H,t+k}(j)[\bar{P}_{H,t}(j)(1+\zeta)-\mathrm{MC}_{t+k}]\} \quad (28)$$

s.t:

$$\mathrm{Y}_{H,t+k}(j) = \left(\frac{\bar{P}_{H,t+k}(j)}{P_{H,t+k}}\right)^{-\theta_H} (C_{H,t+k}+G_{H,t+k}+C^*_{H,t+k}) \quad (29)$$

Where parameter ζ denotes the Pigovian subsidy to the firms. Equation (29) is the demand function for the differentiated good that the domestic firm faces. Domestic firm's optimization for price setting is constrained by total demand for the domestic differentiated goods. In equation (29), $G_{H,t+k}$ is the government demand for domestic goods and $C^*_{H,t+k}$ is the aggregate foreign demand for domestic goods. They are included in the domestic demand function due to the inclusion of firm's domestic production and export (foreign demand for domestic goods) to the public and foreign sectors. In equilibrium, aggregate domestic firm production ($Y_{H,t}$) equals aggregate domestic consumption ($C_{H,t}$) and government domestic consumption ($G_{H,t}$) plus aggregate foreign demand for domestic goods ($C^*_{H,t}$):

$$\mathrm{Y}_{H,t} = \left[\int_0^1 \mathrm{Y}_{H,t}(\ell)^{\frac{\theta_H-1}{\theta_H}} d\ell\right]^{\frac{\theta_H}{\theta_H-1}} = C_{H,t}+G_{H,t}+C^*_{H,t} \quad (30)$$

Nominal marginal costs (MC_t) in equation (28) can be derived from the production function (26):

$$\mathrm{MC}_t = \frac{W_t}{P_{H,t}\mathrm{A}_t} \quad (31)$$

Now, if the optimization problem of the domestic representative firm is solved with respect to the control variable, i.e. the reset price $\bar{P}_{H,t}(j)$, the first order condition is:

$$\overline{P}_{H,t}(j) = \overline{P}_{H,t} = \frac{\theta_H}{(\theta_H - 1)(1+\zeta)} \frac{\sum_{k=0}^{\infty}(\eta_H \beta)^k E_t\left[Q_{t,t+k} Y_{H,t+k} MC_{t+k}\right]}{\sum_{k=0}^{\infty}(\eta_H \beta)^k E_t\left[Q_{t,t+k} Y_{H,t+k}\right]} \quad (32)$$

As the price-setting problem for all domestic firms in each period is similar, they will set the same price. Thus, the aggregate price index is:

$$P_{H,t} = \left[\int_0^1 P_{H,t}(j)^{1-\theta_H} dj\right]^{\frac{1}{1-\theta_H}} \quad (33)$$

Since there are an infinite number of firms, there will be exactly the fraction $1 - \alpha_H$ firms who can update their price in any period and exactly α_H fraction of firms that cannot. Furthermore, since these firms are randomly drawn, the distribution of any subset of the firms is the same as the distribution of all firms. This implies the following law of motion for the dynamics of the domestic price:

$$P_{H,t} = \left[\alpha_H P_{H,t-1}^{1-\theta_H} + (1-\alpha_H)\overline{P}_{H,t}^{1-\theta_H}\right]^{\frac{1}{1-\theta_H}} \quad (34)$$

By log-linearizing (34) and combining with (33), a typical forward-looking Philips curve can be derived

$$\tilde{\pi}_{H,t} = \beta E_t \tilde{\pi}_{H,t+1} + \lambda_H \widetilde{mc}_t \quad (35)$$

Where $\lambda_H = \frac{(1-\alpha_H)(1-\beta\alpha_H)}{\alpha_H}$. Equation (35) yields the New Keynesian aggregate supply relation.

3-4- Importing retail firms

Local currency pricing or incomplete exchange rate pass-through is captured in our model through retail import pricing. It is assumed that domestic market is populated by local retailers who import differentiated import goods at competitive world prices. These firms act as monopolistically competitive re-distributors of these goods to solve for their optimal markup problem. This creates a gap between the imported goods price in the domestic currency terms and the domestic retail price of imported goods. In this setup along with incomplete exchange rate pass-through, the deviation from the law of one price is allowed.

Consider a local retailer importing good j at a cost $\varepsilon_t P_{F,t}^*$ that denotes the price paid in the world market. Like the domestic firms, the same retailer faces a downward sloping demand for such a good and therefore chooses a price $\overline{P}_{F,t}(j)$, expressed in units of domestic currency, to maximize:

$$\max_{\overline{P}_{F,t}(j)} \sum_{k=0}^{\infty} \beta^k \eta_F^k E_t\{Q_{t,t+k} Y_{F,t+k}(j)[\overline{P}_{F,t}(j) - \varepsilon_t P_{F,t}^*]\} \quad (36)$$

s.t:

$$Y_{F,t+k}(j) = \left(\frac{\overline{P}_{F,t+k}(j)}{P_{F,t+k}}\right)^{-\theta_F} (C_{F,t+k} + G_{F,t+k}) \quad (37)$$

In general, the degree of stickiness in the adjustment process of domestic prices (α_H) is allowed to differ from that of import prices expressed in local currency (α_F). The FOC for this problem yields:

$$\overline{P}_{F,t}(j) = \overline{P}_{F,t} = \frac{\theta_F}{(\theta_F - 1)} \frac{\sum_{k=0}^{\infty} (\alpha_F \beta)^k E_t[Q_{t,t+k} Y_{F,t+k} \varepsilon_{t+k} P_{F,t+k}^*]}{\sum_{k=0}^{\infty} (\alpha_F \beta)^k E_t[Q_{t,t+k} Y_{F,t+k}]} \quad (38)$$

In equilibrium, aggregate import supply ($Y_{F,t}$) equals aggregate domestic demand for foreign goods by households and government ($C_{F,t} + G_{F,t}$):

$$Y_{F,t} = \left[\int_0^1 Y_{F,t}(\ell)^{\frac{\theta_F - 1}{\theta_F}} d\ell\right]^{\frac{\theta_F}{\theta_F - 1}} = C_{F,t} + G_{F,t} \quad (39)$$

Since the price-setting problem for all import retailers in each period is similar, they all set the same price. Thus, the aggregate import price index in this condition is:

$$P_{F,t} = \left[\int_0^1 P_{F,t}(j)^{1-\theta_F} dj\right]^{\frac{1}{1-\theta_F}} \quad (40)$$

For the reasons mentioned in conjunction with (34) the following law of motion for the dynamics of the domestic foreign price is obtained:

$$P_{F,t} = \left[\alpha_F P_{F,t-1}^{1-\theta_F} + (1-\alpha_F) \overline{P}_{F,t}^{1-\theta_F}\right]^{\frac{1}{1-\theta_F}} \quad (41)$$

By log-linearizing (41) and combining it with (38), a typical forward-looking Philips curve is obtained:

$$\tilde{\pi}_{F,t} = \beta E_t \tilde{\pi}_{F,t+1} + \lambda_H \tilde{\psi}_{F,t} \quad (42)$$

Where $\lambda_F = \frac{(1-\alpha_F)(1-\beta\alpha_F)}{\alpha_F}$ and $\psi_{F,t}$is the linear version of the law of one price gap variable. It is defined as:

$$\tilde{\psi}_{F,t} = \tilde{e}_t + \tilde{p}_t^* - \tilde{p}_{F,t} \quad (43)$$

Based on (43), import price inflation rises as the world price of imports exceeds the local currency price of the same good hence a nominal depreciation determines a wedge between the price paid by the importers in the world market and the local currency price charged in the domestic market. This wedge tends to increase the real marginal cost and therefore increases foreign good inflation.

3-5- Aggregate Supply

Incomplete pass-through rate breaks down the proportionality relationship between the real marginal cost (mc_t) and output gap (Monacelli 2003). In the local currency pricing environment, the real marginal cost is proportional to both the deviations of current output from its natural level and to the deviation from the law of one price. Interpreting deviation from the law of one price as the endogenous supply (cost-push) shock, the Philips curve for domestic prices can be rearranged as:

$$\tilde{\pi}_{H,t} = \beta E_t \tilde{\pi}_{H,t+1} + k_y \tilde{y}_t + k_\psi \tilde{\psi}_{F,t} \qquad (44)$$

Based on (9), CPI inflation is a convex combination of both domestic and import price inflation up to a log-linear approximation. By combining log linearized version of (9), (42), and (44) we can obtain a CPI-based aggregate supply curve:

$$\tilde{\pi}_t = \beta E_t \tilde{\pi}_{t+1} + k_y^c \tilde{y}_t + k_\psi^c \tilde{\psi}_{F,t} + \varepsilon_t^\pi \qquad (45)$$

Like domestic producer inflation in (44), CPI inflation is also influenced by law of one price gap ($\tilde{\psi}_{F,t}$) for a given level of output gap. Stabilizing inflation in the face of movements in $\tilde{\psi}_{F,t}$ requires that the output gap $\tilde{y}_t$ be allowed to fluctuate. Stabilizing the output gap in the face of movements in $\tilde{\psi}_{F,t}$ requires fluctuation of the rate of inflation rate. Therefore, an additional source of trade-off between stabilization of output gap and CPI measure of inflation emerges that violates the divine coincidence.

3-6- The Oil sector

Oil production is highly capital intensive and much of capex in the oil exporting developing economies is financed by foreign direct investment of various type. Thus, for simplification we can assume the following exogenous process for output in oil sector:

$$Y_t^o = \left(\frac{Y_{t-1}^o}{Y^o}\right)^{\rho_{Y^o}} e^{\varepsilon_t^{Y^o}} \qquad (46)$$

Where $\rho_{Y^o} \leq 1$, $\varepsilon_t^{Y^o} \sim iidN\left(0, \sigma_t^{Y^o}\right)$ is the oil production shock and Y^o (without a time subscript) is the magnitude of oil production at the initial steady state. We also assume that the domestic volume of oil production is small relative to global production hence the international oil price $P_t^{O^*}$is exogenous and follows the following process:

$$\frac{P_t^{O^*}}{P^{o^*}} = (\frac{P_{t-1}^{O^*}}{P^{o^*}})^{\rho_{P^o}} e^{\varepsilon_t^{p^o}} \qquad (47)$$

Where $\rho_{P^o} \leq 1$, $\varepsilon_t^{P^o} \sim iidN(0, \sigma_t^{P^o}$is the oil price shock. Oil revenue in units of foreign currency is:

$$OR_t = P_t^{O^*} Y_t^o \qquad (48)$$

Government owns the oil sector and thus oil revenues enters government budget as a key source of income.

3-7- Fiscal policy:

Following Berg (2013), the government collects lump-sum taxes, receives oil revenues, and receives transfers from oil stabilization fund (henceforth OSF). Therefore, the flow government budget constraint is written as:

$$\varepsilon_t OR_t + T_t + \varepsilon_t (R_t^*) F_{t-1} = G_t + \varepsilon_t F_t \qquad (49)$$

Where $T_t = T_t^r$, G_t denotes real government expenditures, F_t represents OSF's asset value, and R_t^* is the exogenous foreign gross real interest rate.

Government expenditure is assumed exogenous and follows the process in (50)

$$G_t = (\frac{G_{t-1}}{G})^{\rho_G} e^{\varepsilon_t^G} \qquad (50)$$

Where $\rho_G \leq 1$, $\varepsilon_t^G \sim iidN(0, \sigma_t^G)$is the government expenditure shock.

Government consumption is composed of both domestic and imported goods. It is assumed that the elasticity of substitution and import ratio in government consumption is the same as that for private consumption. Government demand for domestic and foreign goods is obtained from minimization of $\mathrm{P_{H,t}} G_{H,t} + \mathrm{P_{F,t}} G_{F,t}$, which yields:

$$G_{H,t} = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\theta} G_t \qquad (51)$$

$$G_{F,t} = \gamma \left(\frac{P_{F,t}}{P_t}\right)^{-\theta} G_t \qquad (52)$$

In this setting, fiscal policy is represented by the value of parameter $0 \leq \chi \leq 1$ in equation (53). When the coefficient assumes the value of zero, we have the case of complete raiding fiscal policy (consumption of all oil revenues) and when it is a positive fraction, that fraction of oil revenues is invested in an OSF for macroeconomic stabilization. In this case the fund provides a fiscal buffer to smooth government spending. Our simple policy rule allows for depositing in withdrawing from the OSF as in (53).

$$F_t - F_{t-1} = \chi(OR_t - OR) \qquad (53)$$

Where $OR_t - OR$ is the quantity of oil revenue above its steady-state level, i.e. surplus oil revenue or the windfall. For a given path of government consumption, surplus oil revenues $(OR_t - OR) > 0$ are saved in stabilization oil fund. Conversely, when there is a revenue shortfall, $(OR_t - OR) < 0$ the fund is drawn down to maintain a level of expenditure commensurate with the given government expenditure path. 1-χ is negative when funds are withdrawn from the fund.

3-8- The Foreign Economy

By assuming that the foreign country is large relative to the home country, it becomes unnecessary to distinguish between consumer price inflation and domestic inflation in the foreign country and that foreign and consumption are equal (Walsh 2017). Therefore, both the foreign interest rate and inflation rate are exogenous and obey AR(1) process as follows:

$$i_t^* = \rho_i i_{t-1}^* + \varepsilon_t^{i^*} \qquad (54)$$

$$\pi_t^* = \rho_\pi \pi_{t-1}^* + \varepsilon_t^{\pi^*} \qquad (55)$$

3-9- Equilibrium Condition:

Given prior specifications, the conditions for market equilibrium can now be specified. Equilibrium requires that non-oil domestic production equals consumption of the domestically produced goods. Since the domestic good is consumed by both the domestic residents (households and government) and by residents of the rest of the world, equilibrium requires that:

$$Y_t = C_{H,t} + G_{H,t} + C_{H,t}^* = (1-\gamma)\left(\frac{P_{H,t}}{P_t}\right)^{-\theta}(C_t + G_t) + \gamma\left(\frac{P_{H,t}}{\varepsilon_t P_t^*}\right)^{-\theta} C_t^* \qquad (56)$$

Taking the first order linear approximation of equation (56) around symmetric steady-state yields:

$$\tilde{y}_t = (1 - g_y)\left[(1-\gamma)\tilde{c}_{H,t} + \gamma\tilde{c}^*_{H,t}\right] + g_y\tilde{g}_t \qquad (57)$$

By combining the goods market equilibrium condition (57) with international risk sharing (19) yields:

$$\tilde{y}_t = (1 - g_y)\tilde{c}_t + g_y\tilde{g}_t + \Omega_s\tilde{s}_t + \Omega_\psi\tilde{\psi}_{F,t} + \Omega_f\widetilde{rp}_t \qquad (58)$$

Where: $\Omega_s = (1 - g_y)(\frac{\gamma(\theta\sigma+(\theta\sigma-1)(1-\gamma)}{\sigma}) + g_y(\gamma\theta)$, $\Omega_\psi = (1 - g_y)\frac{\gamma((\theta\sigma-1)}{\sigma}$, $\Omega_f = -(1 - g_y)\frac{\gamma}{\sigma}$ denote the elasticity of output with respect to the terms of trade ($\tilde{s}_t$), the law of one price gap ($\tilde{\psi}_{F,t}$), and relative demand gap ($\widetilde{rp}_t$).

Replacing $\tilde{c}_t$ from equation (58) in the aggregate Euler equation for households (16) yields the expectational IS- relationship:

$$\begin{aligned}\tilde{y}_t = E_t\tilde{y}_{t+1} - (1 - g_y)(\mu + \frac{1-\mu}{\sigma})(\tilde{\imath}_t - E_t\tilde{\pi}_{t+1}) - \mu(1 - g_y)(\eta + 1)E_t\Delta\tilde{n}_{t+1} \\ - g_yE_t\Delta\tilde{g}_{t+1} - \Omega_sE_t\Delta\tilde{s}_{t+1} - \Omega_\psi E_t\Delta\tilde{\psi}_{F,t+1} - \Omega_fE_t\Delta\widetilde{rp}_{t+1} \\ + \varepsilon^y_t \qquad (59)\end{aligned}$$

This version of the IS relationship contains certain structural features of the economy under consideration like, local currency pricing, incomplete international risk sharing, and presence of non-Ricardian households. The output gap ($\tilde{y}_t$) not only depends on its expectation and real interest rates, but it also depends on expected future change in the government expenditures ($E_t\Delta\tilde{g}_{t+1}$), employment ($E_t\Delta\tilde{n}_{t+1}$), terms of trade ($E_t\Delta\tilde{s}_{t+1}$), law of one price gap ($E_t\Delta\tilde{\psi}_{F,t+1}$), and the relative demand gap ($E_t\Delta\widetilde{rp}_{t+1}$).

4-Policy specification

In a closed economy with Calvo type price setting and the assumption of a constant Pigovian employment subsidy to compensate for the distortions associated with firm's market power, Rotemberg and Woodford (1999) show that the optimal monetary policy is the one that replicates the flexible price equilibrium allocation. The policy requires stabilization of the real marginal costs (mark-ups) at their steady-state level, implying that domestic prices are fully stabilized. With the Pigovian subsidies in place, there is only one effective distortion left in economy, namely, sticky prices. By stabilizing mark-ups at their frictionless level, firms have no desire to adjust prices hence nominal rigidities are no longer binding. However, in an open economy violation of the law of one price and uncovered interest parity create inefficiencies that distort the economy beyond the presence of market power (Corsetti and Pesenti 2001). Generally, unlike the standard NK closed economy models, there are three possible sources of rigidities in the open economy: nominal price rigidity, nominal import price rigidity and imperfect international risk sharing. These rigidities bring about additional distortions that the monetary authority must deal with in an open economy. Therefore, the closed economy monetary-policy prescription does not hold and other forms of optimal monetary policy should be explored.

We follow the standard assumption of a monetary authority that maximizes the inter-temporal utility function of the representative household subject to the structural equations of the hypothesized model. Furthermore, we assume that the policymaker can credibly commit to the chosen path of action and does not re-optimize along the way. In short, it is assumed that the monetary authority pursues Ramsey-optimal policy[19].

4-1. Ramsey optimal monetary policy

A number of research papers attempt to find Ramsey optimal monetary policy in models with nominal rigidity. In this setting, Levin, Ontaski, Williams, and Williams (2005) investigate the design of monetary policy when central bank faces uncertainty about the true structure of the economy and the optimal policy regime is found to be consistent with the solution that maximizes household welfare a la Ramsey.[20] The Ramsey optimal policy under commitment can be computed by formulating an infinite horizon Lagrangian problem. In terms of setting the policy, the social planner wants to maximize the welfare given the decision of the private sector without relying on a particular form of policy rule. The welfare metric which is the planner's objective is in the form of the lifetime utility of the representative agent—most often represented by the (social planner's) policy loss function.

[19] See Khan, King and Wolman (2003), Levin et al. (2006), and Schmitt-Grohe and Uribe (2007) for detailed discussions in New-Keynesian models.

20 The authors then evaluate the performance of alternative simple policy rules relative to this benchmark.

The model presented in this paper exhibits incomplete exchange rate pass through variety—local currency pricing type. This specification leads to import price rigidity, hence existence of the law of one price gap. In this case the expenditure-switching mechanism is partially operative and hence presents a potential role for the CB to remove or minimize the gaps that arise from import price rigidity. Alternatively, the central bank can target the real exchange rate (q_t) to stabilize the law of one price gaps (ψ_t). In this case, q_t is also included into the loss function. Following Kam et al. (2009), De Paoli (2004) and Engel (2008), it is assumed that the central bank seeks to minimize the following loss function[21].

$$W_0 = E_0 \sum_{t=0}^{\infty} \beta^t [\mu_\pi (\tilde{\pi}_t)^2 + \mu_x (\tilde{y}_t)^2 + \mu_q (\tilde{q}_t)^2] \qquad (60)$$

Maximization of (60) is subject to the structure of the model economy and appropriate initial values stipulated for forward-looking variables and Lagrange multipliers. In other words, the constrained optimization is subject to the equilibrium characterization for endogenous variables. The optimality condition for this Ramsey policy problem can be obtained by differentiating the Lagrangian problem with respect to each of the endogenous variables and setting the derivatives to zero. This is done numerically by using Dynare software.

Solution to the above constrained optimization problem yields 18 endogenous variables and seventeen equations. Hence the planner's optimization procedure would pin down the variable with an extra degree of freedom, namely the nominal interest rate schedule or the policy instrument. Moreover, the solution to the problem gives the policy instrument as a function of all state variables and shocks that can be obtained using numerical methods.[22]

4.2. Comparative analysis of monetary policy regimes

This section briefly describes the method of determining the effects of different policy regimes through changing the specification and the weights of the arguments in the policy loss function under different scenarios. We arrange our policy

[21] Kam et.al (2009) raises three arguments in defense of this type of ad-hoc loss function. 1) It might be impossible to map a second-order approximation of the social welfare maximizing CB loss function based on household preferences. 2) Empirical studies indicate that the above loss function includes the goal variables of many developed and developing commodity-exporting economies. 3) The above loss function covers the alternative monetary policy in the literature that has been used to assess the usefulness of alternative monetary policy rules using quadratic loss functions. For more details, see Kam et al (2009).

[22] For more details, see Schmitt-Grohe and Uribe (2007).

evaluation simulations from a free-float situation to cases where the weight of the real exchange rate (RER) in the loss function is significant, even larger than CPI inflation--indicating stronger policy reaction to the exchange rate. We begin with the base case scenario of flexible domestic inflation targeting (FDIT) where the policy maker is only interested in stabilization of domestic inflation. In this case, reaction to exchange rate affects policy only to the extent that it influences domestic inflation through the Phillips curve (equation 44). In this policy regime, flexible targeting of domestic inflation combined with a floating exchange rate, the coefficient of the real exchange rate in the loss function is zero, and is given by (61). The "fear of floating" can be considered as some form of departure from this benchmark policy.

$$W_0 = E_0 \sum_{t=0}^{\infty} \beta^t [(\tilde{\pi}_{H,t})^2 + 0.5(\tilde{y}_t)^2] \qquad (61)$$

The next prototype policy regime is flexible CPI inflation targeting (FCIT). In this framework, monetary policy maker targets CPI inflation, which entails both imported and domestic inflation. In contrast to the domestic inflation, CPI inflation contains a stronger exchange rate influence. The degree of exchange rate influence on CPI inflation depends on the magnitude of the exchange rate pass-through rate and the share of imported consumer goods in the consumption basket (openness ratio). Central bank reaction to fluctuations of the exchange rate depends on the degree by which it affects CPI inflation rate. The loss function for this case is given by:

$$W_0 = E_0 \sum_{t=0}^{\infty} \beta^t [(\tilde{\pi}_t)^2 + 0.5(\tilde{y}_t)^2] \qquad (62)$$

Note that in contrast to (61), inflation term in (62) contains exchange rate effect due to the inclusion of imported inflation ($\tilde{\pi}_{F,t}$) in the determination of CPI inflation. The final case is that of a flexible real exchange rate targeting regime (RERT), equation (63). In this case, RER ($\tilde{q}_t$) has a greater coefficient than CPI inflation, hence is regarded as more important by the policy maker. Specification and weighting of $\tilde{q}_t$ can be seen as reflecting the fear of floating emanating from both exchange rate pass through and the adverse balance-sheet effects--increase in the relative value of foreign exchange denominated liabilities held by the domestic firms, banks, and households, as has occurred repeatedly in many developing economies including Iran. Since the central bank continues to be concerned about the output and CPI inflation stabilization, they are also included in its loss function (59).

$$W_0 = E_0 \sum_{t=0}^{\infty} \beta^t [0.5(\tilde{\pi}_t)^2 + 0.5(\tilde{y}_t)^2 + (\tilde{q}_t)^2] \qquad (63)$$

Next we proceed by conducting Bayesian parameter estimation in the base line model for the Iranian economy. The performance of FDIT, FCIT and RERT in the base line scenario will be evaluated. We obtain unconditional standard deviation (stability property) of endogenous key variables as well as the optimal Ramsey values of the loss functions under alternative policy regimes for the base line and also all other scenarios.

We solve the model with two distinct fiscal policy rules: complete and incomplete raiding. The former represents a perfect pro-cyclical fiscal policy and the latter can be interpreted as both partially pro-cyclical and acyclical ($0 < \chi \leq 1$) fiscal rule depending on the values assumed by χ. The influence of fiscal policy cyclicality on optimality of monetary policy regime will be assessed in our simulations. The performance of each policy regime is evaluated in terms of unconditional standard deviations for key variables and the value of the loss function.

4- Bayesian parameter estimation

In this section we present Bayesian estimates of the deep structural parameters to solve the model for the Iranian economy. The approach taken here closely follows Lubik and Schorfhide (2006) and Fernández-Villaverde (2007). The log-linearized version of the model is comprise of a linear rational expectation system of difference equations that can be written in the following form:

$$\Omega_0(\vartheta)X_t = \Omega_1(\vartheta)X_{t-1} + \Omega_2(\vartheta)\varepsilon_t \quad (64)$$

Where

$$X_t = \{y_t, i_t, \pi_t, \pi_{H,t}, \pi_{F,t}, \pi_t^*, q_t, rp_t, i_t^*, n_t, tot_t, \tilde{\psi}_{F,t}, g_t, t_t, f_t, e_t, or_t, a_t\} \quad (65)$$

and

$$\varepsilon_t = \{\varepsilon_t^x, \varepsilon_t^\pi, \varepsilon_t^{rp}, \varepsilon_t^g, \varepsilon_t^a, \varepsilon_t^{or}, \varepsilon_t^{i^*}, \varepsilon_t^{\pi^*}\} \quad (66)$$

Vector X_t contains all the variables in the model in the log-linearized form and ε_t is the vector for all structural shocks in the model. $\Omega_0(\vartheta)$, $\Omega_1(\vartheta)$ and $\Omega_2(\vartheta)$ are three matrices that are non-linear function of structural parameters of the model.

The general solution to this model can be obtained by multiplying inverse of matrix $\Omega_0(\vartheta)$ to both sides of equation (64) to get:

$$X_t = \Omega_X(\vartheta)X_{t-1} + \Omega_e(\vartheta)\varepsilon_t \quad (67)$$

We need first estimate the structural parameters to find the specific solution of the model in (67). Bayesian approach based on a maximum-likelihood estimation of parameters in the state space form of a linear rational expectation model is the most efficient method. Beside state equation (67), we need to add a measurement equation to build up a state-space representation of our model in matrix form (67). Hence, an observable variable vector Y_t is defined which is linearly related to X_t in the following form:

$$X_t = SY_t \quad (68)^{23}$$

Measurement equation (68) combined with state equation (67) is a state-space representation for our rational expectation model. Assuming normally distributed innovations, it is possible to compute the conditional likelihood function of the structural parameters using the Kalman filter. In the Bayesian approach, a prior distribution with a specific density for the structural parameters is assumed, then, with the aid of observable data we update the prior distribution through the likelihood function to obtain the posterior distribution of structural parameters. Since the maximization of the likelihood function is not possible analytically, numerical Bayesian simulation methods (Metropolis-Hasting Algorithm) are utilized to draw from the posterior distribution. Based on these draws, we can compute the summary statistics, namely, posterior means and standard deviations that characterize the structural coefficients.

4.1. Data:

In the theoretical model there are 8 structural shocks. To avoid stochastic singularity, each of these structural shocks should be matched to eight observable time series. To estimate the model, quarterly data over the period 1987:4 to 2016:4 is used for output, inflation, terms of trade, government expenditure, real exchange rate, and oil revenue in dollars. In addition, it is also assumed that the foreign block–foreign inflation, and interest rate –is observable and that it is well approximated by US data.

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[23] Matrix S contains 0 and 1 elements for selecting variables of X_t which are observable variables. In order to avoid stochastic singularity, we have matched each structural shock contained in vector (66) to an observable variable—which is an element of vector X_t. We chose one set of the elements of X_t represented as, $Y_t = \{y_t, \pi_t, q_t, g_t, tot_t, or_t, i_t^*, \pi_t^*\}$ and the rest of the variables contained in X_t vector are assumed to be non-observable.

All U.S. data were downloaded from the FRED, while Iranian data are from Central Bank of Iran (CBI) time series database.

The output, government expenditure, oil revenues series, RER, and terms of trade were de-trended via the HP filter. The interest rate and inflation (both CPI and foreign) series are de-trended. We have 8 observable variables and the same number of structural shocks.

4.2. Bayesian estimation results

The first step toward estimating the parameters in the Bayesian approach is to choose the prior's density function. The values for priors were mostly taken from Cavoli (2008), Medina and Soto (2007), Kam et al. (2009) and Roger et al. (2009). Table (1) provides an overview of the priors used which reflect our views regarding the structural parameters of the Iranian economy. Once the priors have been specified, the model can be estimated by computing the posterior mode, and then posteriors are evaluated numerically according to the Metropolis-Hasting algorithm—using 5 blocks of 500,000 random draws in which the first 40 per cent of the draws are used as a "burn-in" period. Convergence of the estimates is assessed graphically in order to check and ensure the stability of the posterior distribution as described in Brooks and Gelman (1998). In table (1), the posterior mean of each parameter are presented.

Table (1): Baseline Bayesian Estimation for Selected Structural Parameters

Parameter	Description	Prior			Posterior Mode
		Density	Mean	St.Dev.	
σ	Inverse intertemporal elasticity of substitution	Inverse Gamma	1.7	0.25	2.175
η	Inverse Frisch elasticity	Normal	2	0.15	2.15
γ	Degree of openness	Gamma	0.4	0.05	0.55
θ	Elasticity of substitution between domestic and imported goods	Normal	1	0.06	0.12
μ	Fraction of non-Ricardian house holds	Beta	0.4	0.08	0.39
ψ_q	Reaction of risk premium to real exchange rate	Beta	0.5	0.25	0.73
ρ_f	Persistence of risk premium	Beta	0.5	0.25	0.8
α_H	Fraction of domestic firms who do not update their price in any period	Beta	0.5	0.02	0.42
α_F	Fraction of importing retailers who do not update their price in any period	Beta	0.6	0.05	0.55
χ	Oil stabilization fund coefficient	Beta	0.4	0.05	0.36
g_y	Share of government expenditure in output in steady state	Beta	0.4	0.01	0.43
ρ_{Y^o}	Persistence of oil production shock	Beta	0.5	0.25	0.8
ρ_{P^o}	Persistence of oil price shock	Beta	0.5	0.25	0.8
ρ_i	Persistence of foreign interest rate	Beta	0.5	0.25	0.8
ρ_π	Persistence of foreign inflation	Beta	0.5	0.25	0.8
ρ_G	Persistence of government expenditure	Beta	0.5	0.25	0.8
β	Discount rate for loss function	Beta	0.9	0.1	0.985

Source: Author calculations.

5-Results

The base-line case stipulates that all windfalls are spent and hence there are no accumulated reserves and there are no accumulated fiscal deficit. Due to incomplete international risk sharing, access to world credit markets for Ricardian agents are limited, hence the degree of financial vulnerability is high. Under such conditions, occurrence of a negative terms of trade shock results in a higher RER which in turn increase the risk premium in the UIP relationship and a higher cost of foreign and domestic borrowing. The risk premium in some ways reflect the “country risk”. In equation (25) this risk is endogenized via the real exchange rate. For countries with limited access to the world capital markets, RER is a function of the import-coverage-ratio. In high risk states, i.e. when oil-revenue or sudden stop type shocks occur, most often import-coverage ratio falls hence the risk premium rises. The effect of heightened risks premium is channeled through the UIP condition (equation 24) and it increases domestic interest rates compared to foreign rates leading to a consumption disturbance via Euler equation (16). In our model, the risk premium appears in the IS equation (59) with a negative sign. The magnitude of contraction in aggregate demand depends on the size of the risk-premium coefficient. This coefficient is positively dependent on structural features such as the degree of openness and the intertemporal elasticity of substitution and it is negatively related to the ratio of government expenditure to output in the steady state.[24] For a contractionary depreciation (devaluation) to occur, the coefficient of RER should be sufficiently small so that the impact of a depreciation on the aggregate demand is quantitatively less than the impact of a higher risk premium. Our simulations for the Iranian economy indicate that a negative oil price (oil revenue) shock results in contraction of GDP which emanates from depreciation of RER.

In the following tables, the value of the relevant structural parameters are shown at the top of the table and the estimated value of the loss function and the standard deviation of key macroeconomic variables under three distinct monetary-policy scenarios are shown in the cells.

[24] The coefficient, given in conjunction with equation (54), is: $\Omega_f = -(1 - g_y)\frac{\gamma}{\sigma}$

Table 2: Conditional standard deviation for key variables in baseline case.

Key parameters: openness=0.55, exchange rate pass through=0.48, non-Ricardian=0.4, financial vulnerability parameter=0.5.

	FDIT	**FCIT**	**RERT**
Real Exchange rate (SD)	15.98	0.98	0.69
Risk premium (SD)	22.08	1.78	1.28
CPI(SD)	4.91	1.00	1.25
Output gap(SD)	1.33	1.35	1.11
Domestic inflation (SD)	0.97	1.02	1.26
Loss function value	84	89	**75**

SD=conditional standard deviation. Source: calculations of the authors.

Table 3: Baseline augmented with an oil stabilization fund (OSF)

Key parameters: openness=0.55, exchange rate pass through=0.48, non-Ricardian=0.4, financial vulnerability parameter=0.5.

	FDIT	**FCIT**	**RERT**
Real Exchange rate (SD)	14.9	0.84	**0.62**
Risk premium (SD)	21.78	1.42	**1.2**
CPI(SD)	4.97	1.02	**1.24**
Output gap(SD)	1.30	1.28	**1.04**
Domestic inflation (SD)	0.97	1.009	**1.20**
Loss function value	82	80	**79**

SD=conditional standard deviation. Source: calculations of the authors.

Result of the simulations for the base-line case are shown in table (2). From a welfare perspective, the optimal policy regime is RERT; it has lower loss values compared to the other two policy regimes. The value of the loss function in this framework reflects different degrees of trade-offs between CPI, domestic inflation rate, output gap and RER. Meaning that the central bank must assume a greater loss for closing the output gap in terms of inflation and RER.[25] Stabilization performance of the three policy regimes is also evaluated on the basis of the conditional standard deviation of the key variables. Standard deviation for RER, output gap, and the risk premium under RERT is lower while it is bigger for the domestic inflation.

Table (3) provides simulation results with the same set of key structural parameters as in table (2) but assumes the existence of an OSF which allows a different fiscal

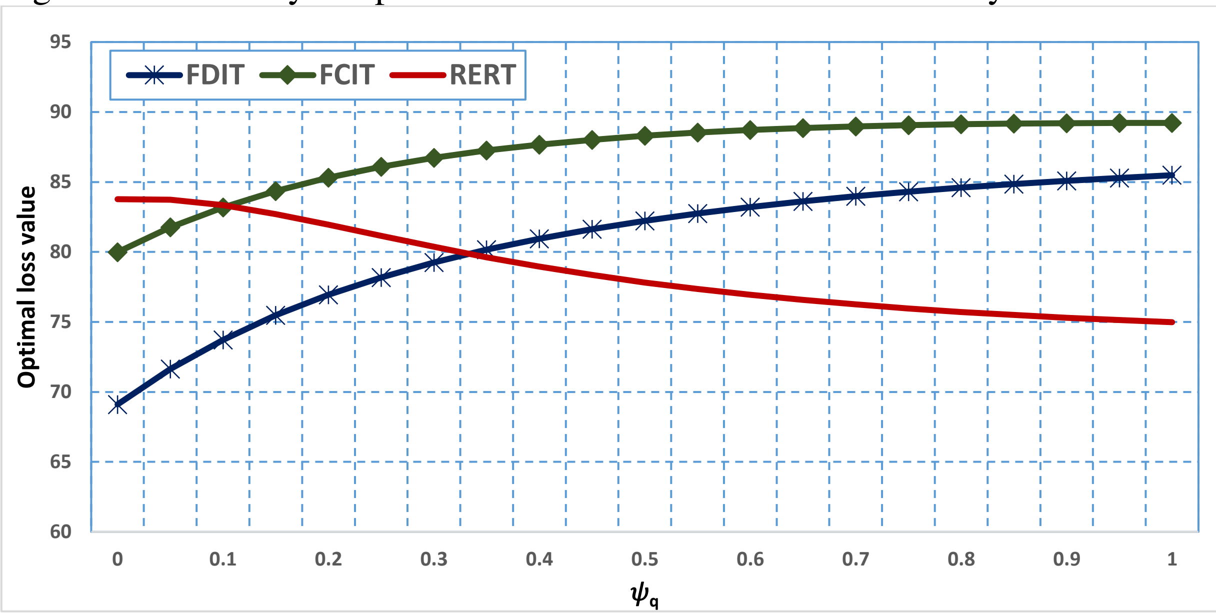
[25] More precisely, the law of one-price gap, as implied from the Phillips curve.

policy posture in that oil windfalls, i.e. revenues above the long-run trend, is saved in the OSF. In this case, the loss function value for FCIT falls significantly (from 89 to 80), that for FDIT is reduced slightly, and the loss value for RERT regime increases from 75 to 79, close to that for FCIT. Despite the changes in loss function values induced by inclusion of the OSF, RERT continues to be the superior policy regime compared to the alternatives. Activation of the OSF has the capability of reducing the level of financial vulnerability through a more stable RER and risk premium that tends to mitigate the strength of contractionary depreciation channel. Table (2) shows that under RERT, the standard deviation of CPI, domestic inflation and RER are lower compared to the base-line while that for the output gap is fairly similar. Activation of the OSF also results in the reduction of the standard deviation for the key macroeconomic variables shown in tables (2) and (3). Note, that smoothing of fiscal policy through the OSF tends to promote stability under RERT, FCIT, and slightly for FDIT. Since activation of an OSF fund tend to reduce financial vulnerability, it is unambiguously stability enhancing.

5-1-Sensitivity analysis

The main reason RERT was found to be the superior policy is due to the high degree of financial vulnerability in the model economy. To a lesser extent the degree of openness, the exchange rate pass-through rate, and the non-Ricardian work force ratio influence the policy simulation results mentioned in the previous section. In this section we present the sensitivity of the loss function for different values of the key parameters of the model. We first present the findings for the base-line scenario (complete raiding). On the vertical side of figure (1), we have the value of the loss function and the coefficient of the real exchange rate in the risk premium equation (financial vulnerability coefficient or index). When this coefficient is low RERT is an inferior monetary policy regime based on welfare criterion. A low value of ψ_q limits the effect of RER depreciation on the risk premium (hence lower financial vulnerability) and the balance sheet effect. RERT curve in figure (1) shows the sensitivity of the loss function to a range of the values for ψ_q. In contrast, high values of ψ_q makes RERT the superior policy regime. At the lower values of ψ_q, FDIT is superior to RERT, respectively. FDIT is the superior policy regime for the lower values of financial vulnerability (0-0.3). Because of relatively rapid rate of the exchange rate pass through in the Iranian economy, it is better for the monetary authority to control domestic prices rather than to target exogenous import price inflation that influences heavily the CPI. That is why FDIT is superior to FCIT when domestic financial markets are well integrated.

Figure 1: Sensitivity of optimal loss value to financial vulnerability coefficient



We also present the sensitivity of the loss function to different values of the degree of openness, which through the IS equation influences the impact of a change in the risk premium on the aggregate demand. In figure (2) the vertical axis represents the value of loss and the horizontal axis represents the degree of openness for a reasonable range of this coefficient (0.2-0.8). For a given value of other parameters (in particular a high financial vulnerability ratio of 0.7 given in table 1), for openness values between 0.3-0.7 RERT is the superior policy regime. When the economy is nearly completely open, FDIT is the superior policy strategy for the reason mentioned previously. When the level of exchange rate pass through is high, the predominant effect of exchange rate movements is expenditure switching thus by controlling domestic prices economic inefficiencies are minimized.

Figure 2: Sensitivity of optimal loss value to degree of openness.

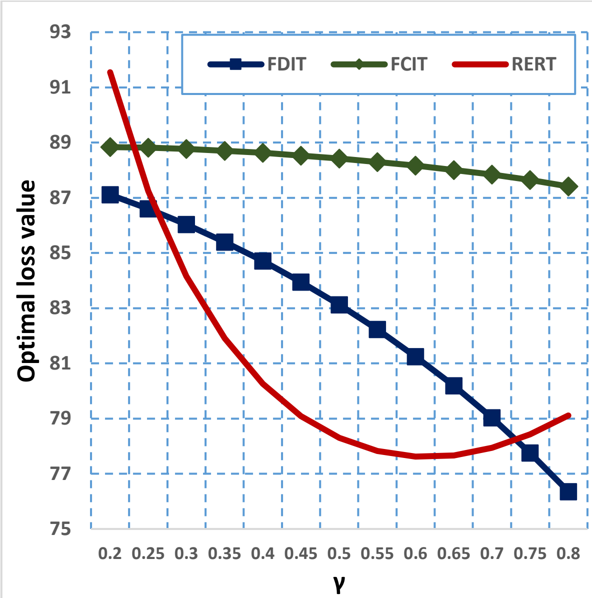
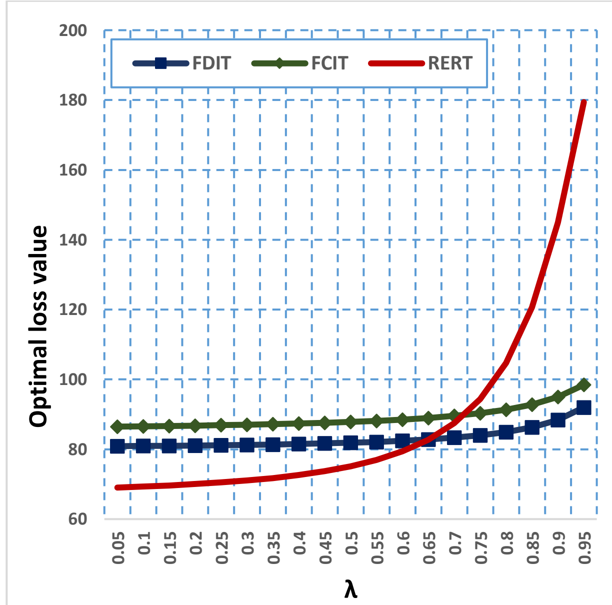


Figure 3: Sensitivity of optimal loss value to exchange rate pass-through rate.



In figure (3) the horizontal axis is the degree of the exchange rate pass through. With low pass through rates, expenditure switching effect due to exchange rate movements is weak. This combined with high financial vulnerability render RERT the superior policy regime. As pass-through rates increases, FDIT becomes the superior policy regime.[26] Note that, under complete international risk sharing, FCIT would be the optimal policy since at low values of pass through there is also the possibility of import-price distortions and hence CPI price targeting is the optimal policy (Engel, 2010). However, in our case, financial integration into the world markets is incomplete, hence the results differ from the standard case.

What happens when a higher proportion of the agents are non-Ricardian? In figure (4), the horizontal axis represents the ratio of NRH to total work force. As indicated in this figure, a higher share of NRH will increase the loss function value for RERT and FDIT, while it is almost unchanged for the FCIT regime. Since NRH's consumption is not sensitive to interest rate changes, when their share in total workforce increases the effectiveness of monetary policy to close output gap via tuning the interest rate adjustment is dented. Therefore, loss function values is

[26] Note that if we make standard base-case New-Keynesian assumption like complete international risk sharing FCIT would be the optimal policy since at low values of pass through there is also the possibility of import-price distortions and hence CPI price targeting is the optimal policy (Engel, 2008).

increasing in higher non-Ricardian share. Moreover, the efficacy of the fiscal rule is even more pronounced at the high ratios of NRHs.

Figure 4: Sensitivity of optimal loss value to Non-Ricardian workforce ratio.

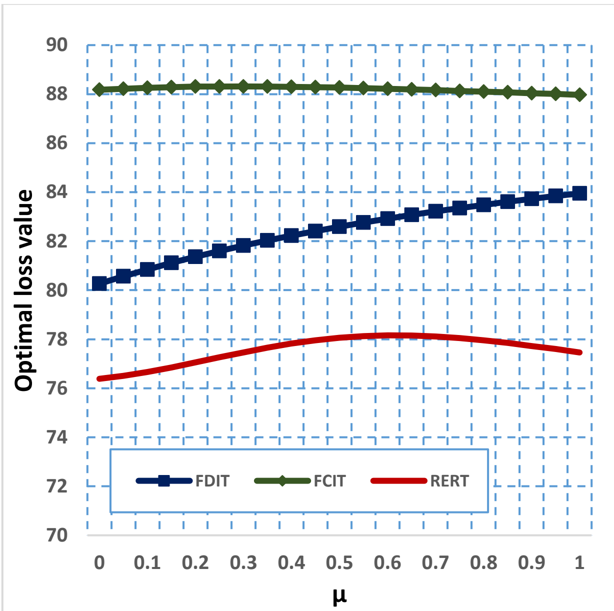
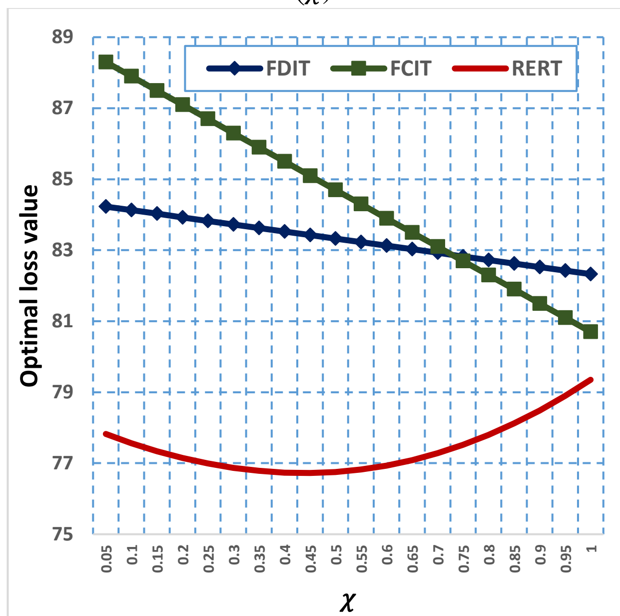


Figure 5: Sensitivity of optimal loss values to OSF coefficient (χ).



Next, we augment the base-line scenarios with a fiscal rule that stipulates what fraction of oil windfalls is injected into the OSF in high revenue periods and what fraction is withdrawn from it during low oil revenue periods—χ in equation (53). In figure (5), the horizontal axis represents the value of χ. The loss function value for FCIT and FDIT are declining with respect to the value of χ while in the RERT policy regime the loss function values is u-shaped in χ and increases at a higher rate as it reaches its extreme upper value. Despite lower loss value for FCIT when χ is higher, both FCIT and FDIT are dominated by RERT regime in our model. Note that this result assumes high financial vulnerability and other structural parameters that are specified in table (1). Note that fiscal policy rule significantly reduces the loss function for the FCIT regime, its influence is not sufficient to dominate RERT regime.

6-Concluding remarks

Standard flexible IT with floating exchange rates tends to work fairly well as a macro-stabilization framework in the country-groups where the macroeconomic environment is less volatile, financial vulnerability is relatively low (e.g., foreign currency reserves are high and foreign debt by households and business sectors are low), and monetary policy is more credible. Is the standard IT the proper policy framework to stabilize output and inflation in an economy with relatively high exchange rate pass through rates and financially vulnerable economies? To answer this question we developed a micro-founded New Keynesian DSGE model that incorporates three features of the latter group: commodity (oil) exporting countries that are exposed to significant price volatility and are financially vulnerable. In our model economy, RER is subject to large commodity price shocks which in turn renders risk premium highly variable.[27] Depreciation of RER emanating from a negative oil (commodity) price shock has two distinct consequences: expenditure-switching and the balance-sheet effect. If the latter is stronger, which is more probable in financially vulnerable economies, "contractionary devaluation" would be the outcome. In such a case, the standard IT with flexible exchange rate is not the optimal policy since the central bank cannot rely solely on short-term interest rates to conduct internal and external stabilization and should react to unwarranted movements in RER.

High exchange rate pass-through and financial vulnerability result in the emergence of two sources of trade-offs namely the law of one price gap and relative demand gap beside domestic price rigidity in our model. We evaluated the stability and welfare performance of a loss function consisting of the CPI inflation gap, output gap and real exchange rate gap, utilizing optimal Ramsey rule method[28]. Within this context, we evaluated monetary policy regimes described as flexible domestic inflation targeting, flexible CPI inflation targeting, and real exchange rate targeting. The result of the simulations indicate that with the economic structure specified as in this paper and parameters presented in table (1), RERT is the superior policy regime. Financial vulnerability in this model explains why departure from floating exchange rate in an inflation targeting framework is the appropriate policy and not merely a “fear”. The sensitivity analysis indicates that the policy regime superiority depends on the parameter values for financial vulnerability, the degree of openness, the pass-through rate, and the share of Non-Ricardian agents in the work force. The fiscal rule introduced into the model did not change the main result of the paper, that is, the superiority of the RERT for the Iranian economy—even though its inclusion improved FCIT performance very significantly. However, with low financial vulnerability, FCIT regime's welfare performance is better than RERT and the central bank can practice standard inflation targeting without any requirement for its intervention in the currency market. Financial vulnerability is a key factor with a

[27] This is supported empirically by econometric test of the UIP relationship in Iran. See Jalali-Naini and Naderian (2016).

[28] As explained in section (4-1), in this method a feedback rule is not imposed on the model structure. Instead, the policy rules are obtained from minimizing the above-mentioned loss functions subject to model structure.

very significant influence for the conduct of monetary policy and, in particular, the choice of the appropriate policy regime.

One aspect of commodity-exporting countries that has significant bearing on the conduct of monetary policy is the pro-cyclicality of fiscal policy, in particular the positive correlation between the commodity price shock and RER. A positive price shocks usually is translated into a larger oil-financed government budget, and higher supply of foreign currency. The initial impact is to increase aggregate demand and appreciation of RER. Since the expansion is not either due to or accompanied by a positive productivity shock, higher inflation and depreciation of RER dampen the initial expansion. In our model, a simple fiscal rule along with an oil stabilization fund is added to the model that can control demand cycles associated with oil-financed fiscal expansions. The rule creates an environment where monetary policy can be more effective, currency fluctuations less disruptive, hence there would be less aversion to floating of the currency. By directing a fraction of oil revenues during high price states into OSF and withdrawing from it during low price states, pro-cyclicality is contained and the propagation effects of the price shocks through the fiscal side is controlled. Operationalizing the OSF reduces exchange rate volatility, which in-turn, provides more space for the central banks to follow inflation targeting with less requirement with more limited intervention in the foreign exchange market.

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