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Money Growth Rules in an Emerging Small Open Economy with an informal sector

Maryam Mirfatah[1] Zahra Nasrollahi[2]
Paul Levine [3] Vasco Gabriel[4]

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Abstract:

This paper is concerned with the saddle-path stability of monetary growth rules in a two-country two-sector dynamic stochastic general equilibrium model. Alongside standard features of emerging economies, such as a combination of producer and local currency pricing for exports, fiscal dominance and oil exports, this model also incorporates informal labour and production sectors and examines how these features matter in the context of monetary policy in emerging economies.

We estimate the model on Iran and US data for home and foreign block respectively using Bayesian estimation techniques. Under a benchmark instruments of monetary policy, we show that a Taylor-type money growth rule rather than interest rate, even up to a four period ahead forward-looking has complete stability and determinacy properties in the economy which is also hold regardless of the level of asset market participation, therefore the inverted Taylor principles does not apply in our economy.

Our findings confirm the important propagation channels which are active in the emerging economies and taking into account these features is essential for any policy-related study, such as the stabilizer effect of terms of trade between formal and informal sector, buffer behaviour of informal sector which is dampened in the model of higher informal frictions, disturbance effects of credit constrained household on the business cycle fluctuations and finally, monetary policy shock which is less effective in an environment of high share of informal sector, low informal frictions, high share of limited asset market participations and a trade autarky economy.

[1] PhD Candidate in Economics, Department of Economics, Management & Accounting, Yazd University, Iran.
[2] Associate Professor of Economics, Department of Economics, Management & Accounting, Yazd University, Iran. (Corresponding Author: Nasr@yazd.ac.ir.)
[3] Professor of Economics, Centre for International Macroeconomic Studies (CIMS), School of Economics, University of Surrey, Guildford, UK.
[4] Reader in Economics, Centre for International Macroeconomic Studies (CIMS), School of Economics, University of Surrey, Guildford, UK.

1. Introduction

What is the monetary policy transmission in emerging economies? Do monetary growth rules (rather than interest rate rules) successfully stabilize the economy? The nature of the monetary transmission mechanism, is an active and unsettled area of research in developing economies. Various distinctive features of emerging economies have been analysed and identified in the literature as being relevant for monetary policy analysis. For instance, these countries are characterised by a substantial degree of openness, which makes them vulnerable to shocks in foreign countries, also financial sector of these economies is underdeveloped, where financial frictions generate countercyclical costs of financing. On the other hand, empirical evidence has shown that monetary policy transmission especially the interest rate pass-through is weak and incomplete in emerging and developing countries. A number of factors have been attributed to this weak transmission of monetary policy in developing countries. Among these are: larger size of the informal market; inefficiency in the capital markets and poorly developed money and interbank markets (Mishra et al. (2012)). Existence of considerable informality in the goods and labour markets, imposes constrains on inflation management and monetary policies. All these features of emerging economies generate different reactions to the same shocks from that in a developed economy, which has important implications for conduct of monetary policy. Finally, since we are using a monetary growth rule which is not Shari-law complaints, we also claim that our model is a comprehensive fashion which not only can be used as a policy tool in emerging economies but also in Islamic countries. As our aim is to draw the saddle-path stability of an Islamic monetary policy, we have implemented complete financial autarky in our model due to the Islamic financial markets.

Presence of these specific characteristics, has indeed led to a number of developments in the theoretical literature addressing these issues.

First, a part of this literature models linkages between the financial markets and the real economy in a dynamic stochastic general equilibrium (DSGE) setting, by incorporating financial frictions in the form of credit constrained households (Bilbiie (2008) and Boerma (2014)). They all find that existence of considerable financial frictions, distort the saddle path stability of interest rate rules and the impact of the shocks in emerging economies. They do take into account credit-constrained consumers who form an important transmission channel of shocks in emerging economies as they lack access to financial services. This has an impact on the efficacy of changes in the monetary policy with interest rate rule, as constrained access to financial markets makes demand of such consumers insensitive to interest rate fluctuations (Gabriel et al. (2010)). This literature has significantly improved our understanding of the importance of financial frictions for conduct of monetary policy in these economies. However, these studies do not take into account money growth Taylor-type rules, as by this

monetary policy tool the aggregate dynamics and stability properties of the SOE model do not depend on the fraction of LAMP and we do not know any studies which is related to the saddle path stability of money growth rule in the presence of financial frictions or LAMP.

Second, another part of this literature models linkages between the real economy and informal sector in a dynamic stochastic general equilibrium (DSGE) setting by emphasizing on monetary policy. (khera (2016) and Gabriel et al. (2010) estimate this DSGE model for India; Batini et al.

(2011) and Castillo et al. (2008) calibrate the model for emerging economies; and Ahmed et al. (2012) and Haider et al. (2012) calibrate the model for Pakistan). This literature is about the implications of a large informal sector, which limits their relevance for monetary policy-related use. For instance, shocks in the economy will generate different impacts on the formal and informal sectors, resulting in reallocation of resources between the two sectors, which might potentially have important implications for the conduct of monetary policies. Following Patrick and Akanbi (2017), the informal sector economic activity responds counter to monetary policy shocks and could essentially affect the effectiveness of the interest rate pass through, and following Castillo et al. (2008) inflation responds less in informal markets than in formal markets because wages in this sector do not quickly re-align and therefore, this implies that in an economy with a large informal labour market the correlation between inflation and output gap conditional on demand shock is lower, thus the interest rate channel of monetary policy is weaker. Although this group of studies develop more comprehensive models, these models are closed (except khera (2016)), where the issue of incomplete exchange rate pass through and impact of exchange rate fluctuations, are not considered.

Incorporating these will help understand the relative importance of each of these features for monetary policy-related decisions. In addition, except khera (2016) and Gabriel et al. (2010) not so much has been done when it comes to the econometric estimation of these models.

Therefore, we are firmly convinced that informality and financial exclusion must be considered both separately and in conjunction when studying the effects of monetary policy.

Motivated by these observations, our contribution is to set up and estimate a comprehensive DSGE model that takes into account all the above characteristics of emerging economies within a single unified framework.

In particular, our framework includes a small open economy with informality in the goods and labour markets, incomplete exchange rate pass through, complete financial autarky, government debt and deficit as well as price and wage rigidities. Additionally, nineteen driving forces, both of domestic and foreign origin, are considered. We follow a Bayesian approach to estimate the

model using quarterly data of Iran on eight observables: GDP, consumtion, investment, inflation, nominal exchange rate, wage rate, broad money (M2) and oil.

A novel feature of this paper is the use of money growth policy for a small open economy, and showing that dominant features of emerging economies has strong implications for the determinacy and stabilization properties of monetary policy rules, even up to 4 periods ahead forward looking. By the knowledge of the authors this is the first study done about the impact of monetary growth rule on Informality in a small open economy with LAMP.

After establishing the empirical relevance of these features, we analyse how they impact transmission of shocks and business cycles. Posterior impulse responses indicate that fluctuations of shocks to the economy are amplified by the presence of LAMP. More-over, trade autarky is found to further intensify these effects of financial frictions, leading to even more amplified responses. On the other hand, the informal sector has a smoothing impact, lowering the variability of aggregate and formal fluctuations, instead. These results are in line with other findings in the literature.

Choosing Iran as a subject of our research is mainly motivated by two reasons. First, it features all the typical characteristics of emerging economies that are analysed in this paper. This highlights the relevance of money growth rule, informality, credit constrained households and incomplete exchange rate pass-through features and especially complete financial autarky as an Islamic country. Second, we are aware of many studies in the literature that attempt to develop a DSGE model for Iran, which can be used for monetary policy analysis. These include Manzoor and Taghpour (2015), Komijani and Tavakolian (2012), Soleimani Movahed, Afshari and Pedram (2014), Jafarai Samimi, et al. (2014), Anvari, et al. (2011), Feiz (2008) who estimate a DSGE model for Iran, however, they use a one sector economy setting with no financial frictions and no exchange rate pass-through imperfection. Hence, while all provide significant contributions, they do lack in some respect or the other. Lastly, in terms of monetary policy, the Bank of Iran, uses a 'multiple indicator approach' to set the policy rates. Under this the bank considers a range of economic and financial variables as policy indicators, due to which there is lack of a clear objective for the monetary policy. Hence, we estimate a general Taylor-type rule for Iran, where the RBI adjusts money growth rate in response to deviations in inflation, output, output growth and the exchange rate depreciation. In addition, this paper is also related to studies estimating DSGE models for emerging economies in particular Islamic countries.

In this paper we refer to informal sector as Schneider (2012) (page 6) claims: "The shadow economy includes all market based legal production of goods and services that are deliberately concealed from public authorities. Distinction between the two sectors are summarized in table 1.

Export, government consumption and investment goods are provided only from the formal sector. Only the formal sector is taxed by the government and finally LCP setting in exports which is the main differences of two sectors. Regulations are modelled as rigidities in the market, where informality results from significantly higher rigidities in the formal sector.

Table 1: Formal Sector versus Informal Sector

Feature	Formal Sector	Informal Sector
Local Currency Pricing	Yes	No
Taxation	Yes	No
Traded	Yes	No
Government spending	Yes	No
Investment goods	Yes	No
Labour	Yes	Yes
Production	Yes	Yes
Market Power	High	Low
Rigidities	High	Low

We also draw a distinction between exchange rate deflations that would occur under perfect exchange rate pass-through for exports and the actual observed in the data. A crucial modelling assumption of perfect exchange rate pass-through for exports implying that home retailers set export prices in the home currency referred to as producer currency pricing (PCP). A possible model of currency pricing could assume both types with fixed proportions or ideally endogenous switching between. Smets and Wouters (2002), Christiano et al. (2011) have models of the former and Gopinath, et al. (2010) provide empirical evidence across countries for a low degree of pass-through. However, in this paper while keeping the perfect exchange rate pass-through for imports, we have assumed that retailers set a fixed proportion of export prices in the dollar referred to as local currency pricing (LCP).

The reminder of this paper is structured as follows. Section 2 presents a brief description of the previous literature. In Section 3, we display the model that will lead our analysis. The empirical strategy including our data set and calibration is described in Section 4, and the estimation results are shown in Section 5. The extent to which the model can fit the data and variance decomposition is analyzed in section 6, which also evaluates the relative empirical relevance of emerging countries various frictions by comparing the results across different model specifications. Section 7 discusses how these frictions impact the transmission and responses to exogenous shocks. Section 8 analysis and depicts the determinacy and stability of money growth rule and indeterminacy of interest rate rule. Section 9 concludes.

2 Literature Review

In this section, we discuss how our modelling approach relates to similar theoretical frameworks in the literature, restricting our discussion to the DSGE literature.

Mishra et al. (2012) argue on a priori grounds that the main channels of monetary policy are likely to be weak and unreliable in countries with underdeveloped financial markets and limited de facto exchange-rate flexibility. Empirically, these authors found that the correlation between short-term interest rates and bank lending rates is weaker in Sub-Saharan Africa (SSA) than in higher-income regions, while Mishra and Montiel (2013) concluded from a survey of the vector auto regression (VAR) evidence that the impulse responses to monetary policy shocks are typically too weak and statistically unreliable in low-income countries to support the successful use of countercyclical monetary policy.

On the other hand, the recent financial crisis highlighted the vulnerability of emerging economies to shocks in foreign countries, as these economies which were not directly linked to the event in the US housing market, were significantly affected in the process. Motivated by these observations, many researchers have built DSGE models by incorporating financial frictions such as credit constrained households, using which they analyse the relevance of these features for policy analysis in emerging economies.

LAMP[1] is best motivated by the work of Boerma (2014) in exploring the relation of limited access market participants and the degree of openness which is done on cross-country data. The results in Table 2 clearly capture a significant variation, as only a small fraction of the population in low income countries can participate in the asset market while in high income countries this figure is considerably high.

Table 2: Cross-Country Data on Financial Inclusion, and Openness

Country Classication	No. of Countries	Financial Exclusion	Openness
Low Income	25/36	0.81	0.40
Lower Middle Income	31/48	0.72	0.45
Upper Middle Income	33/55	0.50	0.46
Government spending	40/78	0.11	0.55

On the Other hand, following Gali et al. (2004), the presence of credit constrained households can change the properties of widely used Taylor type interest rate rules. So interest rates could not play a role of reliable monetary

[1] LAMP is introduced into the standard representative agent framework by allowing for a share of `rule-of-thumb' consumers which do not have access to saving and borrowing instruments, so their current consumption is equal to their current income.

policy instrument in these economies. Bilbiie (2008), studies the role of non-Ricardian households on the transmission mechanism of monetary policy in the New Keynesian model. He shows that depending on the the share of rule of thumb consumers, the total impact of interest rate variations will differ. In the case of increasing the former the effect of the latter decreases or overturnes.

Soleimani Movahed et al. (2014) in their paper considered the determination of an optimal policy rule for Iranian economy from an Islamic perspective. This study draws on an Islamic instrument known as the Musharakah contract to design a dynamic stochastic general equilibrium model. In this model the interest rate is no longer considered as a monetary policy instrument and the focus is on the impact of economic shocks on the Dynamics of Macroeconomic variables. Finally, a policy rule based on Musharakah is introduced from which the optimal policy and empirical coefficients are derived. Their empirical results indicate that the policy responses of central bank to output gap and inflation are in accordance with expectations and therefore, economically meaningful.

Faizi (2008) makes the first attempt to model and estimate a New Keynesian small open economy DSGE model based on the Islamic banking system for Iran. He implemented the nominal exchange rate as the Taylor rule for Iran economy and declares that in such frameworks; the central banks should make Sharia-compliant policies that are also consistent with the typical economics. Anvari, et al. (2011), by using a dynamic stochastic general equilibrium model simulated the inflation and output gaps by applying an interest rate rule that was consistent with the objectives of Islamic economy in Iran. They concluded that minimum interest rate will be obtained, when the inflation rate reaches 3 percent within 6 years. Jafari Samimi et al. (2014) have evaliuated the effect of monetary and non monetaryshocks in Iran economy through New Keynesian Dynamic Stochastic General Equilibrium Modelling in Open Economy condition. Komijani and Tavakolian (2012) using a money growth rule in an adjusted New Keynesian DSGE model for Iran, investigate the monetary policy under fiscal dominance and implicit inflation targeting of Iran. Manzoor and Taghipour (2015) specify and estimate a dynamic stochastic general equilibrium (DSGE) model using money growth rule for an oil exporting and small open economy in accordance with the structure of the Iranian economy. Their paper aims to examine the effects and also the mechanism of monetary, fiscal, oil export revenues and foreign exchange shocks on real and nominal macroeconomic variables.

However, this literature does not take into account informality, which has been shown to impose constraints on policy-related decisions in these economies, hence lowering the relevance of these frameworks for policy-related use. Different sets of modelling techniques have been used in the literature to incorporate informality. Below we present a brief description of this literature on informality.

Paliwal (2013) models the economy of India in two NK formal and RBC informal sectors. By emphasizing on the crucial role of price stickiness in the formation of domestic inflation, he argues that monetary policy can only be effective in the stabilization of formal output rather than informal output. At the end he concludes that due to the large size of informal economy, monetary policy can not meet the policy targets in India.

points out that monetary policy in India has a very poor control on real variables of the economy in short run due to presence of huge informal sector shows that monetary policy affects the real variables of the economy only in formal sector and for the informal sector just the nominal variables (price and wage level) are affected. So the degree of stickiness in prices in the formal sector markets plays a major role to determine the domestic inflation and enables the monetary policy to stabilize formal sector output.

Ahmed et al. (2012) develop a closed economy DSGE model for Pakistan economy, where they find that transmissions of productivity, fiscal and monetary policy shocks to informal sector are weak. In this way, informal sector damps the impact of shocks to economy. Haider et al.

(2012) develop an open DSGE model which incorporate informal labor and production sectors and focus on optimal monetary policy analysis by evaluating alternative interest rate rules and calibrate the model using data from Pakistan economy and through a determinacy analysis suggest that monetary authority in developing economies to follow Taylor principle in large and to put some weight on exchange rate fluctuations even if there is relatively less inertia in the setting of policy interest rate. Batini et al. (2011) analyze costs and benefits of informality under optimal monetary policy in a closed NK-DSGE model. Policy experiments of tax smoothing lead this study to conclude that costs of informality are greater than its benefits.

Anand and Khera (2016) consider the effect of formal regulations in the both labour and product markets on the extension of informal sector in developing economies through a two sector DSGE model. By estimating the model for India and South Africa, they declare that based on the GDP and employment trend, the deregulation outcome is different. By increasing the former the latter reduces the informality. They also study the relations between the resource reallocation of sectors and the short run effects and show that to the extent the reallocation is slower, the adverse impacts on the short run effects are higher. However, they suggest a combined package of reforms to make these adverse effects at very least.

Our work is closest to Gabriel et al. (2010), who develop a DSGE model for the Indian economy characterised by informality in goods, labour and financial markets. They model informality in the goods market by allowing for the existence of a formal sector along with a less capital-intensive informal sector, where both sectors produce different goods and sell these at different prices.

Capital goods and government services are provided solely from the formal sector, where the latter are financed by an employment tax in the formal sector. Firms borrow funds from domestic financial intermediaries to finance part of their capital acquisition, where formal firms borrow from the formal financial sector, whereas informal firms only have access to informal financial services. Credit market frictions exist in both sectors in the form of a financial accelerator mechanism. Finally, labour market frictions are introduced in the form of an exogenous formal wage markup over perfectly competitive informal wages. They use Bayesian techniques for estimating parameters, and show that inclusion of the informal sector and financial frictions improves the fit of their model to Indian data.

Our approach differs, however, from theirs in two important aspects. First, Gabriel et al. (2010) model these features in a closed economy setting and khera (2016) does not considere LAMP and second, they have implemented interest rate rule while we develop a small open economy framework with LAMP accounting for the determinacy of monetary growth rule in a comprehensive model which is applicable for all emerging economies even for Islamic countries.

To fill the above-described gap in the literature, this paper complements the work of Bilbiie (2008), Boerma(2014), khera (2016) and Gabriel et al. (2010) on the determinacy properties of money growth rule in a two-country two-sector small open economy, emphasizing on the money in utility function, informality in the goods and labour markets, share limited financial market participation and imperfect exchange rate path-through to understand how these features matters in the context of monetary policy and estimate the short run and long run impact of money growth rule in the presence of informality.

3 Model Discription

The model economy is a two-block two-sector MIU dynamic general equilibrium model in complete financial autarky. This small open economy interacting with the rest of the world (ROW) but with no policy strategic interdependence. We replace all the processes of foreign block with a DSGE model thus allowing for co-movement between variables and their dependence on the monetary policy in the foreign block. Then the ROW is modelled as a new Keynesian model which can be estimated separately. In addition, we consider incomplete exchange rate pass-through for exports which is an important feature distinguishing the two sectors that the informal sector being Producer Currency Pricing (PCP) and the traded formal sector being a combination of PCP and Local Currency Pricing (LCP). The model is extended to include oil sector and the dominant features of developing economies, such as fiscal deficit, government debt and limited asset market participation.

The SOE model is based on the framework of Gali and Monacelli (2005), who model the world economy as "a continuum of small open economies on the unit interval". The latter feature is introduced by assuming that some households have limited access to the save and borrowing instruments in the financial markets. So, these households consume out of their current wage revenue each period and therefore, they can not smooth their consumption over time. These consumers are labelled non-Ricardian, denoted C, as they break the Ricardian (R) Equivalence.

Based on Smet and Wouters (2007) the model incorporates imperfect labour market and monopolistic trade union. A role of monetary policy is introduced by assuming that prices are slow to adjust.

There is a continuum of households, a single perfectly competitive intermediate good producer and a continuum of monopolistic-ally competitive final producers setting prices and trade-union setting wages on a Calvo type staggered basis. We further develop the model by allowing for the existence of a formal and less-capital intensive informal sector, producing different goods with different technologies sold at different prices with following features distinguishing them from the formal sectors: only produces consumption goods, only producer currency pricing (PCP), different labour share in wholesale sectors, different degree of price-wage stickiness and elasticity of demand, different technology, price-wage markup shocks.

There is a monetary authority setting its policy instrument, the money growth rate with respect to government budget constraint. The demand for domestic goods, goods sold by the formal and informal sectors, imports, formal and informal labour, the corresponding CPI prices and wage indexes characterized by a CES Dixit-Stiglitz aggregators. For modeling convenience, we introduce capital producers who, rather than households, accumulate the capital stock and rent it to firms. We introduce endougenous distortionary tax rate on wage rate and exogenous distortionary tax rate on capital income to pay for government spending which is given by a Taylor-type rule. We also allow the government to run a fiscal deficit, use the government spending rule as a stabilization instrument and to borrow only from domestic investors. We follow Gabriel et al. (2010), Khera (2016) for our model structure.

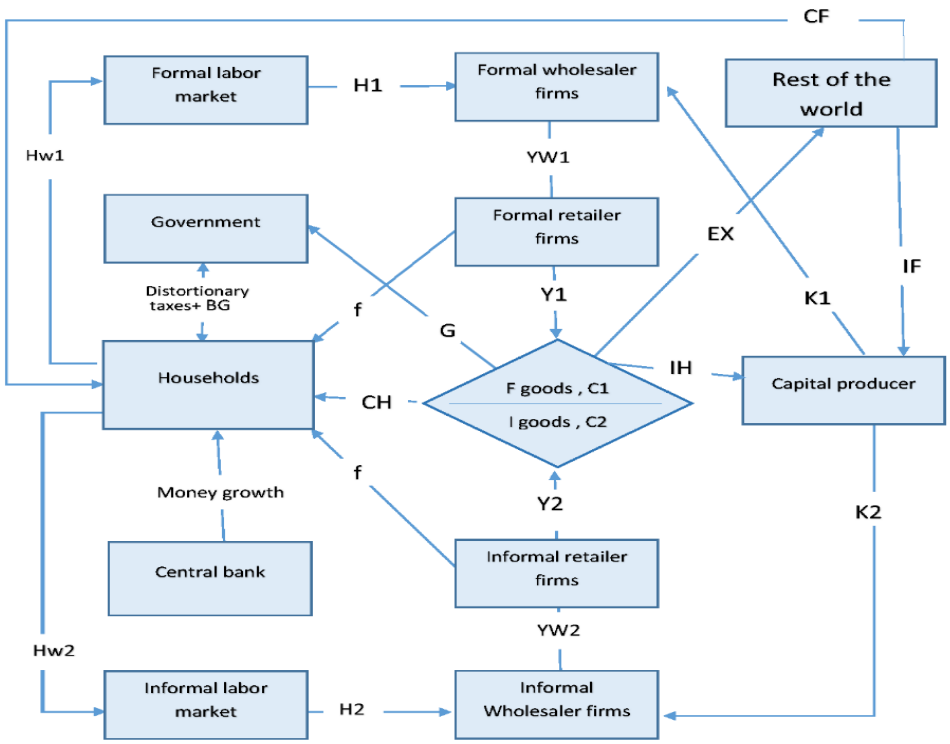


Figure 1: Model Structure

3.1 Households

A small open economy is inhabited by a continuum of infinitely-lived households on the unit interval. The index h ¸ [0,1], refers to household h, one among the continuum of domestic households. Households are divided in those who participate in the financial sector and can lend or borrow to each other.

These are *Ricardian consumers*. The remaining rule-of-thumb consumers are credit-constrained and must consume out of wage income net of tax. Both types supply hours to both formal and informal sectors.

3.1.1 Ricardian Consumers

There are $(1-\lambda)$ non-credit constrained Ricardian consumers. The Ricardian household's decision problem is to choose a path of aggregate consumption (C_t^R), money holding (m_t) and labour supply (H_t^{WR}) that maximizes:

$$U_t^R = U(C_t^R, L_t^{WR}, m_t^R) = \frac{\left(C_t^R - \chi C_{t-1}^R\right)^{(1-\gamma)(1-\sigma)} \left(1 - H_t^{WR}\right)^{(1-\sigma)} - 1}{1-\sigma} + \Psi\left(\frac{m_t^{R1-\psi} - 1}{1-\psi}\right) \quad (1)$$

Where the utility function is non-separable and consistent with a balanced growth path when the inter-temporal elasticity of substitution, $1/\sigma$ is not unitary ($\sigma > 0$ is a risk aversion parameter). γ in the interval (0, 1) defines the relative weight households place on utility from leisure relative to consumption. The total time available is normalized to 1, so that $(1 - L_t)$ denotes leisure. Ψ is relative weight assign to real money balances as the preference parameter on money holding and ψ is the inverse elasticity of real money holding. χ is the external habit formation parameter in the interval [0, 1).

The household solves

$$\max_{C_t^R, L_t^R, m_t^R} \mathrm{E}_t \left[\sum_{s=0}^{\infty} PS_t \beta^s U(C_{t+s}^R, H_{t+s}^{WR}, m_{t+s}^R) \right] \quad (2)$$

Subject to a nominal budget constraint is given by

$$P_t^B B_{H,t} + P_t C_t^R + P_t m_t^R = B_{H,t-1} + W_{1,t}^{nW} \left(1 - \tau_t^w\right) H_{1,t}^{WR} + W_{2,t}^{nW} H_{2,t}^{WR} + P_{t-1} m_{t-1}^R + \Gamma_t \quad (3)$$

where $W_{1,t}^{nW}$, $W_{2,t}^{nW}$ are the pre-tax nominal wage rates in the formal and informal sector respectively, $H_t^{WR} = H_{1,t}^{WR} + H_{2,t}^{WR} = 1 - L_t^{WR}$ with nominal profits given by Γ_t and a proportional endogenous labour tax given by τ_t^w. Subscript 1 refers to the formal sector, and 2 the informal sector. Taxes are not paid for wages from employment in the informal sector. Note that $B_{H,t}$ is nominal domestic bonds bought at nominal price P_t^B and denominated in the respective currency. R_t is the gross interest rate paid on assets held at the beginning of period t, I_t is investment and T_t are lump-sum taxes; P_t is the CPI index. S_t is the nominal exchange rate, β is home discount factor and PS_t is preference shock. Note here K_t is end-of-period t capital stock and r_t^K is rental rate of capital.

Maximizing (2) subject to the budget constraint we have

$$P_t^B = \mathrm{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \right] \quad (4)$$

$$\frac{U_{H,t}^R}{U_{C,t}^R} = \frac{\gamma}{1-\gamma} \frac{C_t^R - \chi C_{t-1}^R}{1 - H_t^{WR}} = W_{1,t}^W \left(1 - \tau_t^w\right) = W_{2,t}^W \quad (5)$$

$$U^R_{m,t} = U^R_{C,t} - \beta \mathrm{E}_t \left[\frac{U^R_{C,t+1}}{\Pi_{t+1}} \right] = U^R_{C,t} \left[1 - \frac{1}{R_t} \right] \quad (6)$$

where $U^R_{m,t} = \Psi m_t^{R-\psi}$, $U^R_{C,t} = (1-\ ^{*})(C_t^R - \chi C^R_{t-1})^{(1-\ ^{'})(1-\sigma_R)-1}(1-H_t^{WR})^{(1-\sigma_R)}$.

$\Lambda_{t,t+1} \equiv \beta \left(\frac{U^R_{C,t+1}}{U^R_{C,t}} \right)$ is the real stochastic discount rate over the interval $[t, t+1]$ and it is convenient to write the Euler consumption equation as $\mathrm{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \right] R_t = 1$ which equates the expected discounted return on a riskless bond over the period $[t, t+1]$.

3.1.2 Credit-constrained Households

The agents in the interval $[0; \lambda]$ are non-Ricardian. These agents are excluded from the international financial market, they do not borrow and do not save, and therefore consume their disposable income each period.

The remaining λ consumers are credit constrained (C) and have no income from monopolistic retail firms. They work in both formal and informal sectors and must consume out of wage income and their consumption is given by $C_t^C = W^W_{1,t} \left(1 - \tau_t^w\right) H^{WC}_{1,t} + W^W_{2,t} H^{WC}_{1,t} - m_t^C + \frac{m^C_{t-1}}{\Pi_t}$ (7)

Liquidity constrained consumers now choose C_t^C and $L_t^{WC} = 1 - H_t^{WC}$, to maximize an analogous welfare function to (2) subject to their budget constraint. The first order conditions are now the same for both types.

Aggregate Consumption, Labour and Money Balance: Total consumption, hours and money balance are then as following wher M_t is the money demand shock.

$$\begin{aligned} C_t &= \lambda C_t^C + (1-\lambda) C_t^R \quad \& \quad m_t M_t = \lambda m_t^C + (1-\lambda) m_t^R \\ H_t^W &= \lambda H_t^{WC} + (1-\lambda) H_t^{WR} \quad \& \quad H_t^W = H^W_{1,t} + H^W_{2,t} \end{aligned} \quad (8)$$

Consumption and Investment Demand: Demand for goods sold by the formal and informal sectors respectively chosen to maximise

$$C_{H,t} = \left[\mathrm{w}_S^{\frac{1}{\mu_S}} C_{1,t}^{\frac{\mu_S - 1}{\mu_S}} + (1 - \mathrm{w}_S)^{\frac{1}{\mu_S}} C_{2,t}^{\frac{\mu_S - 1}{\mu_S}} \right]^{\frac{\mu_S}{\mu_S - 1}} \quad (9)$$

where w_S and $1 - \mathrm{w}_S$ are sector shares and μ_S is the elasticity of substitution between formal and informal goods. $C_{1,t}$ and $C_{2,t}$ are baskets of differentiated

consumption goods with price index $P_{1,t}$ and $P_{2,t}$ - these are defined in further detail below. Maximising total home consumption $\left(C_{H,t}\right)$ subject to $P_{H,t}C_{H,t} = P_{1,t}C_{1,t} + P_{2,t}C_{2,t}$ yields

$$C_{1,t} = \mathrm{w}_S \left(\frac{P_{1,t}}{P_{H,t}}\right)^{-\mu_S} C_{H,t} \quad \& \quad C_{2,t} = (1-\mathrm{w}_S)\left(\frac{P_{2,t}}{P_{H,t}}\right)^{-\mu_S} C_{H,t} \qquad (10)$$

Likewise, households demand consumption goods from domestic retailers and foreign retailers (imports) are:

$$C_{H,t} = \mathrm{w}_C \left(\frac{P_{H,t}}{P_t}\right)^{-\mu_C} C_t \quad \& \quad C_{F,t} = (1-\mathrm{w}_C)\left(\frac{P_{F,t}}{P_t}\right)^{-\mu_C} C_t \qquad (11)$$

Where μ_C is the elasticity of substitution between home and foreign goods. Parameter w_C is related to the degree of home bias in preferences and plays a critical role in this paper. $1-\mathrm{w}_C$ is interpreted as an index for openness to international trade in final goods. $\mathrm{w}_C = 1$ denotes an economy in autarky, i.e. a closed economy.

In the small open economy, we take foreign aggregate consumption and investment, denoted by C_t^* and I_t^* respectively, as exogenous processes. Then foreign counterpart of the above defining demand for the export of the home goods are

$$C_{H,t}^* = (1-\mathrm{w}_C^*)\left(\frac{P_{1,t}^*}{P_t^*}\right)^{-\mu_C^*} C_t^* \qquad (12)$$

where $1-\mathrm{w}_C^*$ determining the share of domestic goods in foreign consumption bundle. $\mu_C^* > 1$ is the substitution elasticity between exports and foreign domestic productions. $P_{1,t}^*$ and P_t^* denote the price of home consumption and aggregate consumption goods in foreign currency. Because the home country is small, the law of one price (perfect exchange rate pass-through for imports) implies that $P_t^* = P_{F,t}^*$, $S_t P_t^* = P_{F,t}$, Define the real exchange rate as the relative aggregate consumption price $RER_t \equiv P_t^* S_t / P_t$ so $RER_t = P_{F,t} / P_t$. We can then write $C_{H,t}^* = (1-\mathrm{w}_C^*)\left(\mathrm{T}_t^*\right)^{-\mu_C^*} C_t^*$

and The *terms of trade* for the home country are defined as the price of the imported good relative to the domestic one, and the same for the foreign bloc,

$$\mathrm{T}_t\ tot_t \equiv \frac{P_{F,t}}{P_{1,t}} \quad \& \quad \mathrm{T}_t^* \equiv \frac{P_{1,t}^*}{P_{F,t}^*} \tag{13}$$

Export Demand : We consider as following $EX_C = cs_{exp}\ EX$ and $EX_I = is_{exp}\ EX$ where export shares cs_{exp} and is_{exp} are calibrated from trade data. Then defining an equilibrium that pins down EX , we write total exports relative to this steady state by

$$\frac{EX_t}{EX} = cs_{exp}\left(\mathrm{T}_t^*\right)^{-\mu_C^*}\frac{C_t^*}{C^*} + is_{exp}\left(\mathrm{T}_t^*\right)^{-\mu_I^*} \tag{14}$$

3.2 Labor market and Wage setting

There are two main sectors in the labour market, a formal and an informal sector, within which based on Smets and Wouters (2007), we assume that each household supplies homogeneous labour at a nominal wage rate $W_{i,t}^{nW}$ to a monopolistic trade-union who differentiates the labour and sells type $H_{it}^{W}(j)$ at a nominal wage $W_{i,t}^{n}(j) > W_{i,t}^{nW}$ to a labour packer in a sequence of Calvo staggered nominal wage contracts. The real wage and wage inflation are then defined as $W_{i,t} \equiv \frac{W_{i,t}^{n}}{P_{i,t}}$. $\Pi_{i,t}^{W} \equiv \frac{W_{i,t}^{n}}{W_{i,t-1}^{n}}$. Each sector is equivalent and so for neatness we describe it once for sector $i \in \{1,2\}$.

As with price contracts we employ Dixit-Stiglitz quantity and price aggregators. Calvo probabilities are now ξ_i and $\xi_{w,i}$ for price and wage contracts respectively. The competitive labour packer forms a composite labour service according to

$$H_{i,t} = \left(\int_0^1 H_{i,t}(j)^{(\zeta_{w,i}-1)/\zeta_{w,i}}\,dj\right)^{\zeta_{w,i}/(\zeta_{w,i}-1)} \tag{15}$$

and sells onto the intermediate firm. where $\zeta_{i,w}$ is the elasticity of substitution across labour varieties in sector i. For each j the labour packer chooses $H_{i,t}(j)$ at a wage $W_{i,t}^{n}(j)$ to maximize H_t given total expenditure $\int_0^1 W_{i,t}^{n}(j)H_{i,t}(j)dj$. This results in a set of labour demand equations for each differentiated labour type j with wage $W_{i,t}^{n}(j)$ of the form

$$H_{i,t}(j) = \left(\frac{W_{i,t}^{n}(j)}{W_{i,t}^{n}}\right)^{-\xi_{w,i}} H_{i,t}, i = 1,2 \tag{16}$$

where $W_{i,t}^{n} = \left[\int_0^1 W_{i,t}^{n}(j)^{1-\xi_{w,i}}\,dj\right]^{\frac{1}{1-\xi_{w,i}}}, i = 1,2$ is the aggregate wage index in each sector. Wage setting by the trade-union follows the standard Calvo framework supplemented with indexation. At each period there is a probability $1-\xi_{i,w}$ that the wage is set optimally. The optimal wage derives from maximizing discounted profits. For those trade-unions unable to reset, wages are indexed to last period's aggregate inflation, with wage indexation parameter γ_i^w. Then as for price contracts the wage rate trajectory with no re-optimization is given by

$$W_{i,t}^{nO}(j), W_{i,t}^{nO}(j)\left(\frac{P_{i,t}}{P_{i,t-1}}\right)^{\gamma_i^w}, W_{i,t}^{nO}(j)\left(\frac{P_{i,t+1}}{P_{i,t-1}}\right)^{\gamma_i^w}, \cdots. \qquad (17)$$

The trade union then buys homogeneous labour at a nominal price $W_{i,t}^{nW}$ and converts it into a differentiated labour service of type j. The trade union at time t then chooses $W_{i,t}^{nO}(j)$ to maximize real profits

$$\mathrm{E}_t \sum_{k=0}^{\infty} \xi_{w,i}^k \frac{\Lambda_{t,t+k}}{P_{i,t+k}} H_{i,t+k}(j)\left[W_{i,t}^{nO}(j)\left(\frac{P_{i,t+k-1}}{P_{i,t-1}}\right)^{\gamma_i^w} - W_{i,t+k}^{nW} MS_{W_{i,t}}\right], i = 1,2 \qquad (18)$$

where $MS_{W_{i,t}}$ is mark-up shock and with indexing $H_{i,t+k}(j)$ is given by

$$H_{i,t+k}(j) = \left(\frac{W_{i,t}^{nO}(j)}{W_{i,t+k}^{n}}\left(\frac{P_{i,t+k-1}}{P_{i,t-1}}\right)^{\gamma_i^w}\right)^{-\zeta_{w,i}} H_{i,t+k}, i = 1,2 \qquad (19)$$

This leads to the following first-order condition

$$\mathrm{E}_t \sum_{k=0}^{\infty} \xi_{w,i}^k \frac{\Lambda_{t,t+k}}{P_{i,t+k}} H_{i,t+k}(j)\left[W_{i,t}^{nO}(j)\left(\frac{P_{i,t+k-1}}{P_{i,t-1}}\right)^{\gamma_i^w} - W_{i,t+k}^{nW} MS_{W_{i,t}}\right] = 0, i = 1,2 \qquad (20)$$

and hence this leads to the optimal real wage

$$\frac{W_{i,t}^{nO}}{P_{i,t}} \equiv W_{i,t}^{O} = \frac{1}{\%(1-1/\zeta_{w,i})} \frac{\mathrm{E}_t \sum_{k=0}^{\infty} \xi_{w,i}^k \Lambda_{t,t+k} \left(\Pi_{W_{i,t,t+k}}\right)^{\zeta_{w,i}} H_{i,t+k} \frac{W_{i,t+k}^{nW}}{P_{i,t+k}} MS_{W_{i,t}}}{\mathrm{E}_t \sum_{k=0}^{\infty} \xi_{w,i}^k \Lambda_{i,t,t+k} \left(\Pi_{W_{i,t,t+k}}\right)^{\zeta_{w,i}} \left(\Pi_{i,t,t+k}\right)^{-1} H_{i,t+k}}, i = 1,2 \qquad (21)$$

where $\Pi_{i,t-1,t}^{W} = \frac{W_{i,t}}{W_{i,t-1}} \Pi_{i,t}$ and $\Pi_{t-1,t}^{W} = \frac{W_t}{W_{t-1}} \Pi_t$ as before.

Denoting the numerator and denominator $JJ^{w}_{i,t}$ and $J^{w}_{i,t}$ we write in recursive form

$$JJ_{W_{i,t}} = \frac{\zeta_{w,i}}{\zeta_{w,i}-1} H_{i,t} W^{W}_{i,t} MS_{W_{i,t}} + \xi_{w,i} \mathrm{E}_t \left[\Lambda_{t,t+1} \left(\Pi_{W_i,t,t+1} \right)^{\zeta_{w,i}} JJ_{W_{i,t+1}} \right], i = 1,2 \qquad (22)$$

$$J_{Wi,t} = H_{i,t} + \xi_{w,i} \mathrm{E}_t \left[\Lambda_{t,t+1} \left(\Pi_{W_i,t,t+1} \right)^{\zeta_{w,i}} \left(\Pi_{i,t,t+1} \right)^{-1} J_{W_{i,t+1}} \right], i = 1,2 \qquad (23)$$

Using the aggregate wage index $W_{i,t}$ and the fact that all resetting packers in sector i will choose the same wage, by the Law of Large Numbers we can find the evolution of the wage index as given by

$$W_{i,t}^{1-\zeta_{w,i}} = \xi_{w,i} W_{i,t-1}^{1-\zeta_{w,i}} + (1-\xi_{w,i}) W_{i,t}^{O\,1-\zeta_{w,i}}, i = 1,2 \qquad (24)$$

which can be written in the form required

$$1 = \xi_{w,i} \left(\Pi^{W}_{i,t-1,t} \right)^{\zeta_{w,i}-1} + (1-\xi_{w,i}) \left(\frac{W^{O}_{i,t}}{W_{i,t}} \right)^{1-\zeta_{w,i}}, i = 1,2 \qquad (25)$$

where $W^{O}_{i,t} = \frac{JJ_{W_{i,t}}}{J_{W_{i,t}}}$. Whilst the distribution of wages is not required to track the evolution of the aggregate wage index, equation below implies a loss of labour due to dispersion in wages. Using the demand schedules, we can write the wage dispersion that gives the average loss in labour as

$$\Delta_{H_i,t} = \frac{1}{M} \sum_{j=1}^{M} \left(\frac{W_{i,t}(m)}{W_{i,t}} \right)^{-\zeta_{w,i}}, i = 1,2$$

for non-optimizing firms $\$j = 1,...,J\$$. It is not possible to track all $W_{j,t}$ but as it is known that a proportion $1-\xi_{w,i}$ of packers will optimize prices in period t, and from the Law of Large Numbers, that the distribution of non-optimized prices will be the same in as the overall distribution. Therefore, wage dispersion can be written as a law of motion

$$\Delta_{H_i,t} = \xi_{w,i} \Pi^{W}_{i,t-1,t}{}^{\zeta_{w,i}} \Delta_{H_i,t-1} + (1-\xi_{w,i}) \left(\frac{JJ_{W_{i,t}}}{J_{W_{i,t}} W_{i,t}} \right)^{-\zeta_{w,i}}, i = 1,2 \qquad (26)$$

Using this, final labour is given as a proportion of the intermediate labour

$$H_{i,t} = \frac{H^{W}_{i,t}}{\Delta_{H_i,t}}, i = 1,2 \;\&\; H^{W}_{t} = H^{W}_{1,t} + H^{W}_{2,t} \qquad (27)$$

3.3 Firms

There are two main sectors, a formal and an informal sector, within which there are wholesale and retail sectors. The former act in perfect competition producing a homogeneous intermediate good, the latter in monopolistic competition producing differentiated final goods. The formal sector wages are subject to a proportional tax rate, whereas the informal sector is not subject to taxes. In addition, we have capital producers.

As this is a model with local currency prices (LCP) and producer currency prices (PCP) in the formal and informal retail sectors respectively, therefore we have perfect exchange rate path-through in the informal sector and therefore the law of one price applies to each informal differentiated good but we have the issue of incomplete exchange rate pass-through for exports and keep the assumption of perfect exchange rate pass-through for imports.

3.3.1 Wholesale Sector

For production we assume a Cobb-Douglas function in which $A_{i,t}$ is the technology shock in sector i $Y_{i,t}^{W} = F(A_{i,t}, H_{i,t}, K_i) = (A_{i,t} H_{i,t})^{\alpha_i} K_i^{1-\alpha_i}; i = 1,2$ .Wholesale firms sell at nominal price $P_{i,t}^{W}$ to retailers, so profit maximisation implies labour demand and capital demand in each sector respectively as following:

$$F_{H_{i,t}} = \alpha_i \frac{Y_{i,t}^{W}}{H_{i,t}} MC_{i,t} = W_{i,t}, i = 1,2 \tag{28}$$

$$F_{K_{1,t}} = (1-\alpha_1)\frac{Y_{1,t}^{W}}{K_{1,t}} MC_{1,t}(1-\tau_K)\frac{P_{1,t}}{P_t} = r_t^K \quad \& \quad F_{K_{2,t}} = (1-\alpha_1)\frac{Y_{2,t}^{W}}{K_{2,t}} MC_{2,t}\frac{P_{2,t}}{P_t} = r_t^K \tag{29}$$

where $F_{H_{i,t}}$ equates the marginal product of labour with the real wage and $F_{K_{i,t}}$ equates the marginal product of capital with the rental rate in each sector.

3.3.2 Capital Producers

Capital producers accumulate the capital stock and rent it to firms. They convert investment goods (I_t) into $\left(1-\mathrm{S}\left(X_t\right)\right)I_t$ of new capital sold at real price Q_t at a cost of $\mathrm{S}\left(X_t\right)$ to maximize expected discounted profits

$$E_t \sum_{k=0}^{\infty} \Lambda_{t,t+k} \left[Q_{t+k} \left(1-\mathrm{S}\left(I_{t+k} / I_{t+k-1}\right)\right) I_{t+k} - I_{t+k} \right] \tag{30}$$

where total capital accumulates according to $K_t = (1-\delta)K_{t-1} + (1-\mathrm{S}(X_t))I_t IS_t$ and $K_{t-1} = K_{1,t} + K_{2,t}$ summing over formal and informal sectors, IS_t is introduced as investment shock. This results in the first-order condition:

$$IS_t Q_t (1-\mathrm{S}(X_t)-X_t \mathrm{S}'(X_t))+E_t\left[\Lambda_{t,t+1} Q_{t+1} IS_{t+1} \mathrm{S}'(X_{t+1})\frac{I_{t+1}^2}{I_t^2}\right]=1 \quad (31)$$

$$\mathrm{E}_t\left[R_{t+1}^K \Lambda_{t,t+1}\right]=1 \quad (32)$$

which is the expected discounted return on a capital over the period $[t,t+1]$. Demand for capital by firms must satisfy

$$R_t^K=\frac{r_t^K+(1-\delta)Q_t}{Q_{t-1}} \quad (33)$$

Where the right-hand-side is the gross return to holding a unit of capital in from $t-1$ to t. The left-hand-side is the gross return from holding bonds and the opportunity cost of capital.

We define investment adjustment cost and rate of change of investment respectively as

$$\mathrm{S}(X_t)\equiv \phi_X (X_t - X)^2 \;\&\; X_t \equiv \frac{I_t}{I_{t-1}}; S', S'' \geq 0; S(1)=S'(1)=0 \quad (34)$$

Where ϕ_X is the elasticity of investment adjustment cost. Finally, we define R_t^K as gross real return on capital.

3.3.3 Retail Sector and Incomplete Exchange Rate Pass-through for Exports

As supported by empirical literature on emerging economies, there is incomplete exchange rate pass-through to exports to prices. From the conclusions of these studies, it is therefore justifiable that there is a need to introduce a mechanism that captures the process of incomplete exchange rate pass-through in the open economy model. So we provide a more general set-up in which a fixed proportion θ of formal retailers set export prices $P_{1,t}^{*p}$ in the home currency (producer currency pricing, PCP) and a proportion $1-\theta$ of them set export prices $P_{1,t}^{*\ell}$ in the dollars (local or destination currency pricing, LCP). Then the price of exports in foreign currency is given by

$$P_{1,t}^{*}=\theta P_{1,t}^{*p}+(1-\theta)P_{1,t}^{*\ell} \quad (35)$$

where $S_t P_{1,t}^{*p}=P_{1,t}$ .Putting $\theta=1$ gets us back to the model with complete exchange rate pass-through, so we have as following: Each retailer $m\in(0,1)$ in sector $i=1,2$ purchases output from the intermediate good sector at price $P_{i,t}^W$ and converts into a differentiated home goods sold at price $P_{i,t}$ to households, capital good producers and governments who use the technology

$$C_{i,t} = \left(\int_0^1 C_{i,t}(m)^{(\zeta_{p,i}-1)/\zeta_{p,i}} dm \right)^{\zeta_{p,i}/(\zeta_{p,i}-1)}, i = 1,2 \quad (36)$$

to combine into baskets, where $\zeta_{p,i}$ is the elasticity of substitution between the goods in sector i. Maximising $C_{i,t}$ implies a set of demand equations for each intermediate good m $C_{i,t}(m) = \left(\frac{P_{i,t}(m)}{P_{i,t}} \right)^{-\zeta_{p,i}} C_{i,t}, i = 1,2$ (37)

Summing the demand schedules from each buyer implies a total demand for home produced good m given by $Y_{i,t}(m) = \left(\frac{P_{i,t}(m)}{P_{i,t}} \right)^{-\zeta_{p,i}} Y_{i,t}, i = 1,2.$

Every period, each firm faces a fixed probability $1-\xi_{p,i}$ that they will be able to update their prices. Denoting the optimal price at time \$t\$ for good m as $P_{i,t}^*(m)$, the firms allowed to re-optimize prices maximise expected discounted profits by solving

$$\max_{P_{i,t}^*(m)} \mathrm{E}_t \sum_{k=0}^{\infty} \xi_{p,i}^k \frac{\Lambda_{t,t+k}}{P_{t+k}} Y_{i,t+k}(m) \left[P_{i,t}^O(m) - P_{i,t+k}^W MS_{i,t+k} \right], i = 1,2 \quad (38)$$

Price setting in export markets by domestic LCP exporters follows is a very similar fashion to domestic pricing. The optimal price in units of domestic currency is $\hat{P}_{1,t}^{*\ell} S_t$, costs are as for domestically marketed goods so the above equation become

$$\max_{P_{H,t}^{*O\ell}(m)} \mathrm{E}_t \sum_{k=0}^{\infty} \xi_{p,1}^k \frac{\Lambda_{t,t+k}}{P_{1,t+k}^{*\ell}} Y_{1,t+k}^{*\ell}(m) \left[P_{1,t}^{*O\ell}(m) S_{t+k} - P_{1,t+k}^W MS_{1,t+k}^{*\ell} \right] \quad (39)$$

Where $MC_{1,t}^{*\ell} \equiv \frac{MC_{1,t} P_{1,t}}{S_t P_{1,t}^{*\ell}}$

Then by analogy with the wage setting equations we reach to the following:

$$Y_{2,t} = \frac{Y_{2,t}^W}{\Delta_{2,t}} \;\&\; Y_{1,t} = \left(1-(1-\theta_1)(1-\theta)\right) \frac{Y_{1,t}^W}{\Delta_{1,t}} \;\&\; Y_{1,t}^{*\ell} = (1-\theta_1)(1-\theta) \frac{Y_{1,t}^W}{\Delta_{1,t}^{*\ell}} \quad (40)$$

Where θ_1 is the export share of production. The system is completed with $\Pi_{1,t,t+1}^* = \theta \Pi_{1,t,t+1}^{*p} + (1-\theta) \Pi_{1,t,t+1}^{*\ell}$ where $\Pi_{1,t,t+1}^*$ is the aggregate export inflation in foreign currency, $\Pi_{1,t,t+1}^{*p}$ or PCP inflation is the part of export inflation set in law of one price and $\Pi_{1,t,t+1}^{*\ell}$ or LCP inflation is the part of export

inflation which is not based on the perfect exchange rate pass through and θ is the share of price setting in export sector holding law of one price.

3.4 Oil Sector

We introduce oil sector treating output as an exogenous constant endowment which is given by $Y_t^{O} = k * Y$. The price of the oil denominated in foreign currency which is a exogenous AR (1) process as for the other shock processes in the model.

3.5 Market Clearing

A resource constraint implies

$$Y_{1,t} + \frac{S_t P_{1,t}^{*\ell}}{P_{1,t}} Y_{1,t}^{*\ell} = C_{1,t} + I_{1,t} + \left(\theta + (1-\theta) \frac{S_t P_{1,t}^{*\ell}}{P_{1,t}} \right) EX_t + G_t \tag{41}$$

$$Y_{2,t} = C_{2,t} Y_t = \frac{P_{1,t}}{P_{H,t}} Y_{1,t} + \frac{S_t P_{1,t}^{*\ell}}{P_{H,t}} Y_{1,t}^{*\ell} + \frac{P_{2,t}}{P_{H,t}} Y_{2,t} \tag{42}$$

3.6 Monetary and Fiscal Policy

Consider government borrowing as the domestic nominal bonds held by domestic households and define the total stock of government bonds held in home country consumption units as: $B_{G,t} \equiv \frac{B_{H,t}}{P_t} \equiv B_{GH,t}$ and the nominal trade balance

$$P_t TB_t = S_t P_{O,t}^{*} Y_t^{O} + P_{H,t} Y_t - P_t C_t - P_{I,t} I_t - P_{H,t} G_t P_t \tag{43}$$

Then by analogy with the national budget constraint, the government budget constraint is

$$P_t^{B} B_{GH,t} = \frac{1}{\Pi_{t-1,t}} B_{GH,t-1} + D_t \tag{44}$$

where the nominal government deficit is given by the following:

$$P_t D_t = P_{1,t} G_t - P_t W_{1,t}^{nW} H_{1,t}^{W} \tau_t^{w} - (1-\alpha_1) Y_{1,t}^{W} P_{1,t} MC_{1,t} \tau_t^{k} - P_t (m_t - \frac{m_{t-1}}{\Pi_t}) - S_t P_{O,t}^{*} Y_t^{O} \tag{45}$$

Two Policy Rules

The Money growth rate is the monetary policy variable, is defined as

$$\mu_t = \frac{M_t}{M_{t-1}} = \frac{m_t}{m_{t-1}} \Pi_{1,t}$$

The monetary authority sets the money growth rate, to stabilize the business cycle fluctuations, based on a Taylor feedback rule. It responds to deviations in inflation and gross domestic product, also to the gross domestic product growth and exchange rate depreciation. Then θ_π, θ_s , θ_y and θ_{dy} are the long-run elasticities of the inflation, deprecation rate, output and output growth respectively with respect to the money growth.

$$\log\left(\frac{\mu_t}{\mu}\right)=\rho_\mu \log\left(\frac{\mu_{t-1}}{\mu}\right) \\ -(1-\rho_\mu)\left(\theta_\pi \log\left(\frac{\Pi_{1,t}}{\Pi_1}\right)+\theta_s \log\left(\frac{\Pi_{S,t}}{\Pi_S}\right)+\theta_y \log\left(\frac{Y_{1,t}}{Y_1}\right)+\theta_{dy} \log\left(\frac{Y_{1,t}}{Y_{1,t-1}}\right)\right)+ \varepsilon_{\mu,t} \tag{46}$$

The fiscal stabilization instrument follows a Taylor-type rule where θ_{bg} is the long run elasticity of domestic bonds with respect to government expenditures and $\varepsilon_{G,t}$ is the fiscal policy shock process.

$$\log\left(\frac{G_t}{G}\right)=\rho_G \log\left(\frac{G_{t-1}}{G}\right)+(1-\rho_G)\left(\log(\bar{G}_t)-\theta_{bg} \log\left(\frac{B_{G,t-1}}{B_G}\right)\right)+ \varepsilon_{G,t} \tag{47}$$

3.7 Shock processes

The structural shock processes in log-linearised form are assumed to follow AR (1) processes for the home country and ROW model, leaving the monetary and fiscal policy shocks process as i.i.d, where the steady state values are set equal to one. This completes the specification of the two-block open-economy model. The correspocing equations are in the appendieces. All the equilibrium equations of Row model are in the appendices.

4 Method of Estimation

We estimate the model using Bayesian approach in Dynare. As the model has a two block of ROW and SOE, we need to have the ROW model estimated first and then call the posterior means of estimated parameters for the estimation of small open economy. We estimate directly the non-linear ROW model using the US dataset and (results are in Appendices).

For the purpose of estimating the models, the steady state equations are based on a non-zero inflation steady state. This is done using Dynare for the estimation of our model. In the appendices the steady state of the model is described.

4.1 Data

To estimate the model, we use quarterly information on eight key variables for Iran: GDP, consumption, investment, consumer price index (CPI), broad money (M2), oil price, nominal exchange rate and wage rate. The sample runs from QI: 1993 to QIV: 2009 to compute posterior distributions and marginal likelihood values. Quarterly crude Oil price is obtained from FRED Economic Data; other quarterly data are from IMF's International Financial Statistics and annual wage rate is from World Bank as the compensation of employees and converted to quarterly ones by Eviews software. We compute quarter to quarter growth as log difference of real series and multiply the growth rates by 100 to convert them into percentages. Inflation rates are defined as log differences of the consumer price index (CPI) and converted into percentages. All variables are seasonally adjusted except the exchange rate.

Looking at the nominal exchange rate series there is a sharp structural break in year 2001. In order to cover this break, we define a dummy variable EXW in the form of AR (1) process as following and estimate it`s standard deviation.

4.2. Calibrated Parameters

In order to evaluate the performance of the model, we use a combination of calibrated and estimated parameters, mainly because the data set is not rich enough to identify all the parameters, particularly informal sector ones. Table 3 summarizes the calibrated values of parameter in our model, at a quarterly frequency for an emerging economy, where we calibrate a set of parameters, and the steady state values for some endogenous variables, which characterise the model economy. Our calibration strategy aims to match, as accurately as possible, the empirical evidence and available data on key statistics of formal and informal sector in emerging economies which is completely described in the appendices.

Table 3: Common Parameter Values- Calibrated or Imposed Parameters

Calibrated/Imposed parameter	Value	Calibrated/Imposed parameter	Value
Home Discount factor	0.99	Labour share in the formal sector	0.70
Depreciation rate	0.025	Labour share in the informal sector	0.80
Ricardian Risk aversion	2.00	Substitution elasticity (Formal/Informal labours)	2.00
Inverse elasticity of real money holding	1.40	Substitution elasticity (Home/Foreign goods)	1.50
Hours worked	1/3	Substitution elasticity (Export/Foreign goods)	1.50
Preference parameter	Calibrated so $H^W = 1/3$	Share of Investment in exports	0.001
Preference parameter on money holding	Calibrated so $m/Y_t^T = 1$	Share of consumption in exports	0.999
Government spending	0.23	Formal Calvo prices	0.60
Capital taxation rate	0.20	Informal Calvo prices	0.30
Oil export relative to output	0.20	Formal Calvo wages	0.60
Share of government bonds	0.10	Informal Calvo wages	0.30
Export share of production	0.30	Formal substitution elasticity	7.00
Share of Local Currency Pricing	0.80	Informal substitution elasticity	9.00
Share of formal sector	0.80	Formal labour substitution elasticity	2.50
Share of formal labour market	0.55	Informal labour substitution elasticity elasticity	6.00

4.3 Estimation of Oil Price Shock

According to the commodity section, the price of oil has an exogenous process in the model, so we have estimated the standard deviation of this shock separately by fitting an AR (1) process and then imposed the estimated coefficient and standard deviation to the model.

Table 4: Estimation of Oil Price Shock

Variable	Coefficient	Std. Error	t-Statistic	Prob.
CO(-1)	0.341538	0.103996	3.407686	0.0010
S.E. of regression	12.95848			

4.4 Prior distribution

In order to implement Bayesian estimation, it is first necessary to define prior distributions for the estimated parameters usually by theoretical implications and evidence from previous studies. However, since estimated DSGE models for emerging economies are limited, especially for Iran, we will choose relatively diffuse priors that cover a wide range of parameter values. Table 5 and 6 (columns 1 to 4) lists the prior distribution of all the estimated parameters. The full description is in appendices.

5 Empirical Results

Table 5 and 6 states the posterior means of the Bayesian estimation along with the 90% confidence intervals. Overall, the parameter estimates are plausible. The economy has higher values for the volatility of shocks, which is consistent with the literature regarding open economies being more volatile in general (Uribe and Schmitt-Grohe (2017)): Prior and Posterior Distributions analysis with the corresponding figures are in the appendices. Below, we provide a detailed description of posterior estimates in the model.

Turning to the habit persistence parameter estimate (0.41), is close to the estimates of Manzoor and Taghpour (2015) and Saxegaard et al. (2010). Given the high share of credit-constrained consumers estimated (0.31), this result seems reasonable, as a large share of the population in Iran is unable to smooth consumption. The posterior mean estimate for investment adjustment cost (1.44) is consistent with the calibrated value in Gabriel et al. (2010) but is considerably lower compared to Manzoor and Taghpour (2015). Looking at price indexation parameters estimates in the formal (0.35) and informal sector (0.48), the estimations indicates that in the informal sector relative to formal sector the prices are more indexed to last period's aggregate inflation. Following Boerma (2014), estimated values of 0.56 and 0.54 for domestic consumption and investment share respectively, are matched with upper-middle income in the country classification of openness. The value estimated for the substitution elasticity between traded and non-traded goods (1.21), is consistent with the Khera (2016) estimate a value of 1.41 for India and developing countries respectively.

In terms of the policy parameters, there is a high degree of policy inertia (0.71), however the estimate for output stabilization (0.099), implying that the central bank does not place too much importance on output fluctuations, a result also found in Saxegaard et al. (2010) but is in contrast with Manzoor and Taghpour (2015) and also it does not react too strongly to exchange rate depreciation (0.33) which indicate that the central bank is likely to choose a relatively less flexible exchange rate regime. On the other hand, consistent with estimates in in Manzoor and Taghpour (2015) we observe that the central bank responds more strongly to the inflation rate in comparison to GDP (1.48). We

find a relatively less response of money growth to movements in output growth (0.11) as well.

Finally, in terms of shocks, the formal technology shock is more persistent than the informal technology shock, whereas persistence in informal price-wage markup shocks are estimated to be higher. The persistence of all shocks is high ranging from 0.52 for investment shock to 0.84 for LCP markup shocks. In terms of standard errors, shocks to government spending, investment, oil price and formal wage-price markups are the ones with highest volatility. Overall we get high estimated values for the standard deviation of all shocks in particular government spending, investment, LCP markup and formal wage markup relative to other shocks in the economy, which ranges from 10.11 to 16.35. These high values which are estimated for standard deviation of shocks are due to the Iran economy which is highly vulnerable by different shocks. This can be improved upon by modelling the formation of priors in different approach, we can address this issue for example with endogenous priors. Note that higher estimate for LCP markup shock in the model in comparison to the other shocks, suggesting that without LCP setting there will be even higher misspecifications in the model as important channels in the economy are shut down.

Table 5: Estimated Parameter Values of SOE Model

Estimated Parameter Values	Prior		Posterior	
	Dist.	(Mean,Std)	Mean	90% Interval
Formal technology persistence	β	0.75,0.10	0.7989	0.6552 , 0.9455
Informal technology shock persistence	β	0.75,0.10	0.7510	0.5993 , 0.9062
Formal markup shock persistence	β	0.75,0.10	0.7255	0.6102 , 0.8598
Informal markup shock persistence	β	0.75,0.10	0.7448	0.5903 , 0.9039
Formal wage markup persistence	β	0.75,0.10	0.6953	0.5715 , 0.8108
Informal wage markup persistence	β	0.75,0.10	0.7500	0.5821 , 0.9027
Investment shock persistence	β	0.75,0.10	0.5165	0.3350 , 0.6958
Preference shock persistence	β	0.75,0.10	0.7414	0.5887 , 0.8982
Terms of trade shock persistence	β	0.75,0.10	0.7254	0.5523 , 0.9005
Money demand shock persistence	β	0.75,0.10	0.7510	0.5983 , 0.9155
LCP mark-up shock persistence	β	0.75,0.10	0.8419	0.7122 , 0.9748
Government shock persistence	β	0.75,0.10	0.5724	0.4094 , 0.7289
Monetary policy persistence	β	0.75,0.10	0.7009	0.5961 , 0.8040
Dummy AR(1) Std Dev	β	0.75,0.10	0.6435	0.4974 , 0.7870
Share of non-Ricardian consumers	β	0.50,0.10	0.3057	0.2027 , 0.4095
Consumption habit formation	β	0.50,0.10	0.4113	0.2595 , 0.5585
Formal price and wage index	β	0.50,0.10	0.3532	0.2115 , 0.4933
Informal price and wage index	β	0.50,0.10	0.4833	0.3168 , 0.6359
Elasticity of Investment adjustment cost	N	3.00,1.50	1.4438	0.4668 , 2.4255
Non-Ricardian risk aversion	N	2.00,0.25	1.9046	1.4990 , 2.3131
Feedback from inflation	N	1.50,0.25	1.4851	1.0973 , 1.9003
Feedback from output	N	1.50,0.25	0.0999	-0.0090 , 0.2023

Feedback from output growth	N	0.10,0.05	0.1051	0.0296 , 0.1902
Feedback from exchange rate depreciation	N	0.50,0.25	0.3351	-0.0138 , 0.6563
Home Share of consumption	β	0.50,0.10	0.5566	0.4541 , 0.6648
Home Share of investment	β	0.50,0.10	0.5395	0.3820 , 0.6942
Substitution elasticity (Formal/Informal)	N	1.50,0.20	1.2009	0.8886 , 1.5303

Table 6: Estimated standard deviation of shocks and correlated shocks

Estimated standard deviation of shocks	**Prior**		**Posterior**	
	Dist.	**(Mean,St**	**Mean**	**90% HPD**
Formal technology shock	IG	3.00,3.00	2.0396	1.0945, 2.9718
Informal technology shock	IG	3.00,3.00	2.4307	0.9799 , 3.9724
Formal markup shock	IG	3.00,3.00	7.6984	6.0280 , 9.5451
Informal markup shock	IG	3.00,3.00	2.6844	0.9783 , 4.6379
Formal wage markup shock	IG	3.00,3.00	11.597	9.2047 , 13.898
Informal wage markup shock	IG	3.00,3.00	2.5144	0.9686 , 4.1623
Investment shock	IG	3.00,3.00	10.105	4.2953 , 6.0312
Preference shock	IG	3.00,3.00	1.9255	0.9352 , 2.8045
Terms of trade shock	IG	3.00,3.00	6.7394	4.2733 , 9.4597
Money demand shock	IG	3.00,3.00	3.0379	0.9014 , 5.8718
LCP mark-up shock	IG	3.00,3.00	16.352	4.8382 , 28.268
Government spending shock	IG	3.00,3.00	11.386	8.2918 , 4.852
Monetary policy shock	IG	3.00,3.00	2.6780	2.2266 , .11470
Dummy AR(1) Std Dev	IG	3.00,3.00	9.9035	6.9958 , 2.5395

6 Model Evaluation

6.1 Model Fit to the Data (Standard Moment Criteria)

Can the model capture the underlying characteristics of the actual data? To further evaluate the absolute performance of our model against data, the results of the models' second moments are compared with the second moments in the actual data to evaluate the models' empirical performance.

In terms of the standard deviations, the model is able to reproduce acceptable volatility for the main variables of the DSGE model, however relatively high volatility compared to the actual data except for the wage rate. Table 7 also reports the cross-correlations of observable variables vis-a-vis output. Except for the consumption, the model does very well at capturing the contemporaneous correlations observed in the data.

Table 7: Selected Second Moments of the Model

	Output	Consumption	Investment	Money	Inflation	Exchange	Wage
Standard Deviation							
Data	4.3823	4.3158	7.3557	3.1009	2.3911	13.0836	3.8795
Model	5.8917	6.6644	9.5599	5.9965	3.8246	16.0085	3.0903
Cross-Correlation with Output							
Data	1.00	0.2827	0.3229	0.3358	-0.3566	0.2203	0.1710
Model	1.00	0.7583	0.2069	0.3540	0.2492	0.2993	0.1261
Autocorrelations (Order=1)							
Data	0.0771	-0.1166	-0.2073	0.4569	0.6096	0.4773	0.4405
Model	0.1604	0.1460	0.3453	0.6342	0.6009	0.3568	0.2809

6.2. Variance Decomposition of Business Cycle Fluctuations

What are the driving forces of the observed business cycle fluctuations? what are the impacts of the structural shocks on the main macroeconomic time series? To address these questions this section investigates the contribution of each of the structural shocks to the variance of endogenous variables in the model, i.e. the underlying sources of fluctuations, which explains how important a shock is in business cycle dynamics. The detail investigation is in the appendices.

Overall, the results of the variance decomposition are in line with the business cycle literature for emerging economies. The disturbances from the formal price markup, formal wage markup and formal technology are the most important at explaining the dynamics of endogenous variables in the Iranian economy, with relatively smaller contribution by the monetary policy, government expenditures, oil price, investment, LCP markup and terms of trade shocks following by other shocks.

As a comparative analysis, consider the model with higher degree of trade openness, the general observation is concerned with the more significant role of foreign shocks in overall variations including informal sector, in particular foreign technology following by terms of trade and oil shocks. Monetary policy shock is then dampened in particular in controlling the fluctuations of aggregate and formal consumption. In contrast, in the model of trade autarky, oil price shock dominates over the 90 percent fluctuations in the model. High share of RT consumers dampens the effect of monetary policy on aggregate and formal variations in particular inflation and money growth and also informal shocks on informal variations whereas the role of informal shocks have increased by a small contribution in the variations of formal sector. In the presence of larger informal sector, the overall variations especially aggregate fluctuations are more explained with the informal shocks on both sectors than the formal shocks and the role of monetary and government spending policies decreases. Comparing the baseline model with the model of higher informal stickiness and market power the same as the formal sector, the intersectoral interactions or buffer effect reduces and so

lead to a less and more contribution of monetary policy and informal shocks in explaining the variations of informal sector respectively. Therefore, macroeconomic policies could fail in controlling the informalities. With no significant change in the importance of monetary policy, as a results by ignoring the feature of LCP from modeling, the contribution of LCP markup is transferred to the terms of trade shock.

Hence, in order to properly rank the relative importance of different driving forces in emerging economies, shutting down important channels in the economy leads to biased results. This reinforces the choice of the Baseline model as our preferred model specification.

7 Posterior Impulse Response Analysis

In this part, we analyse the response of economy to a monetary policy shock in order to investigate the importance of this shock to the dynamics of the endogenous variables. The posterior impulse responses are obtained from a positive one standard deviation of each shock's innovation and show the quarterly percentage changes to the relevant variables about their steady-state values. In appendices, we provide a detailed description of economy response to each shock by analysing the impulse responses and comment when there are any relevant differences in the impacts across the model specifications.

Impulse Response to a Monetary Policy Shock

A positive monetary growth shock unlike a positive interest rate Rule is an expansionary policy, leads to an inflationary condition which causes a decrease in the nominal interest rate and by the rise in inflation reduces the real interest rate, thus Ricardian households invest less in domestic bonds and increase more the consumption as the marginal utility of savings compared to consumption decreases. The consumption of RT consumers also increases due to the increase in marginal rate of substitution or the real wage rate they offer to trade union and so aggregate consumption increases further with higher proportion of RT consumers. Because of the fall in real interest rate and the rise in money supply, demand for money will be increased for both type of households. Increase in domestic demand leads to expansion in formal output, where this expansion is just for the formal sector as a result of increased competitiveness of formal exports as real exchange rate depreciates. Since investment is formed entirely from the output of the formal sector, investment increases.

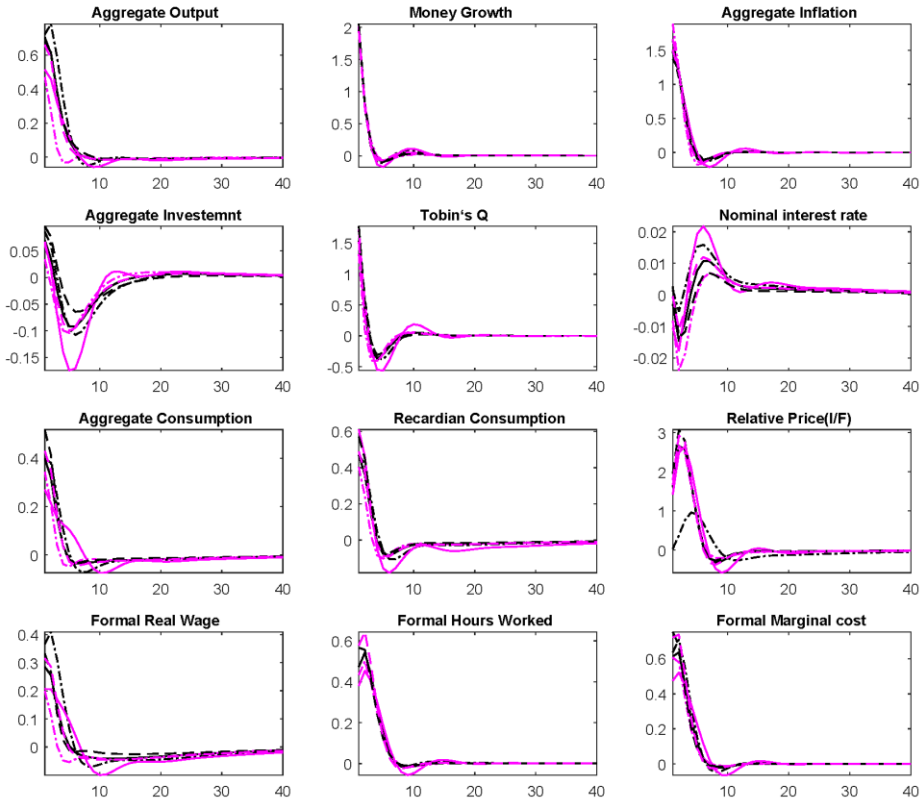


Figure3: Estimated Impulse Response to Monetary Policy Shock-The black thick line represents our Baseline model, the dashed black line is model of trade autarky, the dotted black line is model with high informal rigidities and market power the same as formal sector, the magenta thick line is model with higher share of credit constrained consumer, the dotted magenta line is model of higher informal sector size and finally dashed magenta line is model with no LCP specification.

The increased liquidity of money, depreciates the domestic currency, raises the demand for foreign currency and import, depreciate nominal and real exchange rate and consequently boosts exports of formal tradable goods, causing an expansion in formal output and in contrast, informal output shrinks, which is caused due to the terms of trade effect between the formal and the informal sector as relative prices of informal goods increases. There are two opposing forces on the informal inflation, the inward shift of informal demand and the outward shift of informal supply which the latter dominates and raise the informal inflation.

For the real exchange rate, the increase of nominal exchange rate dominates the increase of inflation and so it depreciates.

Regarding labour market, there are two opposing forces on the real wage rate in the formal sector, the increase in inflation pushes it down, whereas higher demand for formal labour has a positive impact. The latter effect dominates, and we see an increase in the real wage rate in the formal sector. In the informal labour market, due to the fall in informal supply, demand for informal labour decreases and consequently because of high demand for labour in the formal sector, formal sector act as a buffer and absorb the informal labour, and in spite of the rise in the informal inflation, the buffer effect of formal labour market dominates both of reduction in informal labour demand and increase of informal inflation and therefore informal real wage rises.

The 'stabilizer effect' of the informal sector in the Baseline model is evident when we compare it to the higher informal size specification i.e. we find a less increase in aggregate output, consumption, investment, and the price of capital and a more decrease in informal aggregates. This is due to the terms of trade effect between the two sectors. Removing LCP setting from export sector shows higher increase of export, import, trade balance and more decrease of export prices are seen.

8 Stability and Determinacy

We have provided a Matlab program which loops .mod file and call the model, examines the condition for different values of coefficients in the Taylor rule and reports and plots the results of the Blanchard-Kahn determinacy and stability condition for our model. Figure 4 show the determinacy and stability analysis of interest rate rule and money growth rule by putting inflation feedback parameter and the degree of policy inertia in a loop of different values of them. Overall, we can can see significant signs of indeterminacy and instability of interest rate rule, but for money growth rule we have complete determinacy and stability.

In conclusion, here in an open economy setting, namely the 'Taylor Principle' that the feedback parameter in the Taylor rule must exceed unity for the economy to have a unique stable equilibrium is not hold and we have the saddle-path stability of money growth rule for any value of inflation feedback parameter.

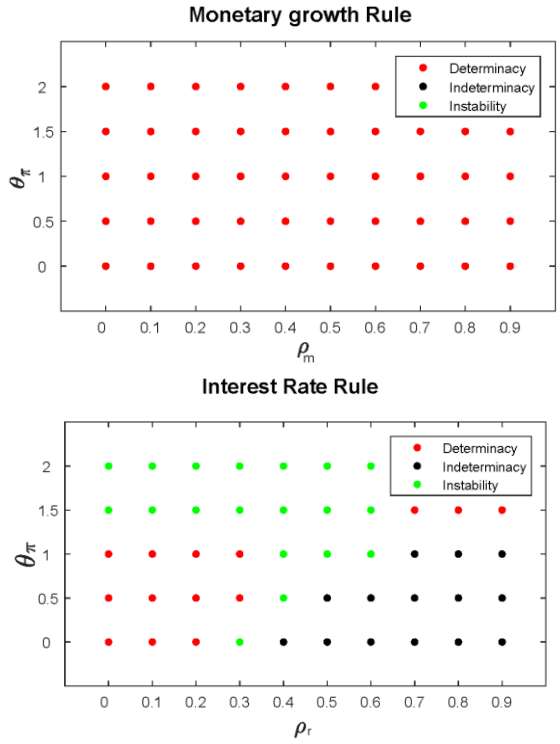


Figure 4: Determinacy and Stability Analysis

8.1 Rule of Thumb Consumers and the Inverted Taylor Principle

According to the part of literature explained in section 2 regarding the interest rate rule and limited asset market participation share, in this section we show that monetary rules avoid the inverted Taylor principle of interest rate rules.

Following Boerma (2014) the effect of interest rate variation on output will be inverted by a considerable share of limited asset market participants in the economy and following Bilbiie (2008), this inverted relation is called the inverted aggregate demand logic (IADL) that is basically due to the role of interest rate in optimizing the utility function of Ricardian consumers which is not the case for LAMP. However, a money growth policy delivers equilibrium determinacy regardless of LAMP fraction and openness degree and so the IADL does not apply with this policy.

Boerma (2014) extended the model of Bilbiie (2008) to a small open economy and argues that openness dampens the variations in response to a real interest rate change and so the inverted Taylor Principle would not be hold in small open

economies but make a warning to those economies who are valnurable to a low level of openness.

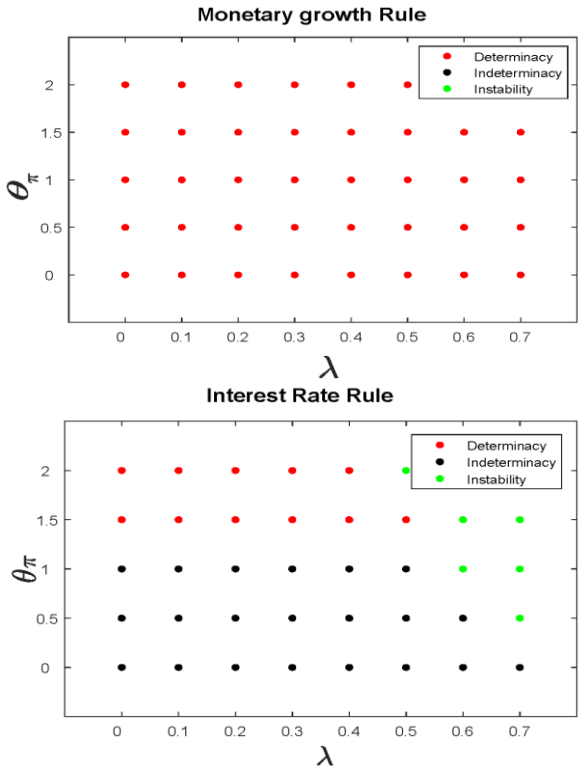


Figure 5: Determinacy and Stability Analysis

In order to show the saddle-path stability of monetary rules with increasing the share of RT consumers, we put inflation feedback parameter and share of credit constrained households in a loop of different values of them and keeping policy inertia fixed. Figure 5 below examine the stability properties of the estimated model with interest rate and money growth rule respectively. As we can see there is significant sign of indeterminacy for interest rate rule, but for money growth rule we have complete determinacy and stability.

In sum, figure 5 confirms the important policy implication of the existence of a large proportion of credit-constrained rule-of-thumb consumers found by Bilbiie (2008) for interest rate rule.

9 Conclusions

In this study, we aim to present an analysis of the empirical relevance of several frictions in emerging economies for the saddle-path stability of monetary

policy, such as the expected substantial informality in the goods and labour markets, market power and rigidities of informal sector, limited asset market participation, imperfect exchange rate path-through, trade openness and financial autarky. For this, we build a comprehensive DSGE model by incorporating all the above features. In particular, our framework includes a money growth Taylor type rule and examines whether monetary growth rules can successfully stabilize the economy.

We were motivated by the fact that, while the recent literature has focused on each of these frictions individually, it does not incorporate all of them within a unified framework, which is important for analysing the relative importance of each for policy-related decisions.

Our findings in this study, can be summarised as follows. First, by the stability and determinacy analysis of Taylor rule, we show that in an emerging economy, Taylor-type money growth rule rather than interest rate, even up to a four period ahead forward looking has complete stability and properties of determinacy. In addition, regarding the inverted Taylor principle of interest rate rules that the aggregate dynamics and stability properties of a standard business cycle model strongly depended on the share of RT consumers, we show that monetary rules regardless of credit constrained consumers share have complete stability and determinacy.

Second, by analysing the variance decomposition of business cycle fluctuations, the dominance role of price-wage markup and formal productivity shock in overall fluctuations are seen, and by the IRFs, we noticed that the terms of trade effect between the formal and informal sector acts like a ’stabilizer’ over the economy’s response to an exogenous shock. Higher informal sector size amplifies its buffer effect leading to the reduction of variations in aggregate and formal output, investment and consumption, in contrast to the specification of high informal market power and stickiness the same as formal sector which reduces the effects of the shocks in the informal sector, so it`s buffer effect decreases and consequently leads to further effects in the aggregate outcomes. High share of RT consumers escalates the business cycles and also disturb their smoothing trend.

However, our research has some limitation, which are as follows. First, the model overestimates the variances observed in the data. Second, we find that the data is not very informative about some of the parameters, in particular, standard deviation of informal shocks. This can be improved upon by using informal data and also a larger data set for estimation.

Regarding what we have mentioned above, we suggest that using endogenous priors instead of imposed ones will improve our model fit.

We conclude by suggesting several potential venues for research. First, estimating our proposed model for different emerging economies will provide an

additional empirical test for its applicability. Moreover, the role of these frictions will be different across economies, depending on many factors, such as the degree of trade openness, the share of RT consumers, the size of informal sector and the intensity of its frictions which would provide an interesting international comparison as well. Second, it might be useful to further investigate the performance of the model. Third, including other features specific to emerging economies such as the financial openness which can captures the effects of foreign interst rate and the foreign financial relations in particular, foreign debt and risk premium that will help quantify the relative importance of these features in further detail.

References

1- Ahmed, S., Ahmed, W., Khan, S., Pasha, F., & Rehman, M. (2012). Pakistan economy DSGE model with informality.

2- Anand, R., & Khera, P. (2016). *Macroeconomic impact of product and labor market reforms on informality and unemployment in India*. International Monetary Fund.

3- Anvari, E., ZARRA, N. M., & FAKHRAEE, E. (2011). Evaluating optimum monetary rule in a dynamic stochastic general equilibrium model using control approach.

4- Batini, N., Levine, P., Lotti, E., & Yang, B. (2011). Informality, frictions and monetary policy. *School of Economics Discussion Papers*, *711*.

5- Benhabib, J., Schmitt-Grohé, S., & Uribe, M. (2001). Monetary policy and multiple equilibria. *American Economic Review*, *91*(1), 167-186.

6- Bilbiie, F. O. (2008). Limited asset markets participation, monetary policy and (inverted) aggregate demand logic. *Journal of Economic Theory*, *140*(1), 162-196.

7- Blanchard, O. J., & Kahn, C. M. (1980). The solution of linear difference models under rational expectations. *Econometrica: Journal of the Econometric Society*, 1305-1311.

8- Boerma, J. (2014). Openness and the (inverted) aggregate demand logic.

9- Carlstrom, C. T., & Fuerst, T. S. (2000). *Forward-looking versus backward-looking Taylor rules* (No. 0009). Federal Reserve Bank of Cleveland.

10- Carlstrom, C. T., & Fuerst, T. S. (2001). Timing and real indeterminacy in monetary models. *Journal of Monetary Economics*, *47*(2), 285-298.

11- Castillo, P., & Montoro, C. (2008). *Monetary policy in the presence of informal labour markets*. Mimeo, Banco Central de Reserva del Peru.

12- Currie, D., & Levine, P. (1993). *Rules, reputation and macroeconomic policy coordination*. Cambridge University Press. Christiano, L. J., Eichenbaum, M., & Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of political Economy*, *113*(1), 1-45.

13- Christiano, L. J., Trabandt, M., & Walentin, K. (2011). Introducing financial frictions and unemployment into a small open economy model. *Journal of Economic Dynamics and Control*, *35*(12), 1999-2041.

14- Feizi, M. (2008, December). A new Keynesian small open economy DSGE model in Islamic economic framework: the case of Iran. In *Conference on Iran's Economy at University of Illinois at Urban Champaign* (pp. 11-13).

15- Gabriel, V., Levine, P., Pearlman, J., & Yang, B. (2010). An estimated DSGE model of the Indian economy. *NIPE WP*, *29*, 2010.

16- Gali, J., & Monacelli, T. (2005). Monetary policy and exchange rate volatility in a small open economy. *The Review of Economic Studies*, *72*(3), 707-734.

17- Galí, J., López- Salido, J. D., & Vallés, J. (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association*, *5*(1), 227-270.

18- Gopinath, G., Itskhoki, O., & Rigobon, R. (2010). Currency choice and exchange rate pass-through. *American Economic Review*, *100*(1), 304-36.

19- Haider, A., ud Din, M., & Ghani, E. (2012). Monetary policy, informality and business cycle fluctuations in a developing economy vulnerable to external shocks. *The Pakistan Development Review*, 609-681.

20- Jafari Samimi, A., Tehranchian, A. M., & Ebrahimi, E. (2014). The Effect of Monetary and Non-Monetary Shocks on Inflation and Output in Dynamic Stochastic General Equilibrium Model in Open Economy Condition: Case Study of Iran Economy. *Quarterly Journal of Applied Economics Studies in Iran (AESI)*, *3*(10), 1-32.

21- Khera, P. (2016). *Macroeconomic Impacts of Gender Inequality and Informality in India*. International Monetary Fund.

22- Komijani, A., & Tavakolian, H. (2012). Monetary policy under fiscal dominance and implicit inflation target in Iran: A DSGE approach.

23- Manzoor, D., & Taghipour, A. (2015). A dynamic stochastic general equilibrium model for an oil exporting and small open economy: the case of Iran.

24- Mishra, P., & Montiel, P. (2013). How effective is monetary transmission in low-income countries? A survey of the empirical evidence. *Economic Systems*, *37*(2), 187-216.

25- Mishra, P., Montiel, P. J., & Spilimbergo, A. (2012). Monetary transmission in low-income countries: Effectiveness and policy implications. *IMF Economic Review*, *60*(2), 270-302.

26- Paliwal, G. K. (2013). *Macroeconomic goals and inflation targeting in India* (Doctoral dissertation, University of KOTA, KOTA).

27- Patrick, C. M., & Akanbi, O. A. (2017). The impact of informal economy on the interest rate pass-through: evidence from an ARDL model. *African Journal of Economic Review*, *5*(2), 130-148.

28- Saxegaard, M., Anand, R., & Peiris, S. J. (2010). *An estimated model with macrofinancial linkages for India* (No. 10-21). International Monetary Fund.

29- Schneider, F. (2012). The shadow economy and work in the shadow: what do we (not) know?.

30- Smets, F., & Wouters, R. (2002). Openness, imperfect exchange rate pass-through and monetary policy. *Journal of monetary Economics*, *49*(5), 947-981.

31- Smets, F., & Wouters, R. (2007). Shocks and frictions in US business cycles: A Bayesian DSGE approach. *American economic review*, *97*(3), 586-606.

32- Soleimani Movahed, M., Afshari, Z., & Pedram, M. (2014). Optimal Policy Rules for Iran in a DSGE Framework (Islamic Musharakah Approach). *Journal of Money and Economy*, *9*(4), 1-30.

33- Uribe, M., & Schmitt-Grohé, S. (2017). *Open economy macroeconomics*. Princeton University Press.

34- Woodford, M. (2003). *Interest and Prices: Foundations of a Theory of Monetary Policy*, Princeton University.

قاعده رشد پولی در یک اقتصاد باز کوچک با در نظر گرفتن بخش غیر رسمی

چکیده:

این مقاله با به بررسی ثبات و پایداری قاعده رشد پولی در یک مدل اقتصادی نیوکنیزی دوکشوری دو بخشی تعادل عمومی پویای تصادفی می‌پردازد. در راستای ویژگی‌های استانداراد اقتصادهای نوظهور، همانند ترکیبی از قیمت‌گذاری مبتنی بر واحد پول تولیدکننده و مبتنی بر واحد پول مصرف‌کننده در بخش صادرات، حضور خانوار غیرریکاردویی، سلطه مالی و صادرات نفت، این مدل همچنین شامل بخش غیررسمی در بازار تولید و بازار نیروی‌کار بوده و اهمیت هریک از ویژگی‌های فوق را در بکارگیری سیاست پولی در اقتصادهای نوظهور مورد بحث و بررسی قرار می‌دهد.

مدل حاضر با بکارگیری روش بیزین و با استفاده از داده‌های کشورهای ایران و امریکا به ترتیب برای اقتصاد باز کوچک و اقتصاد دنیای خارج برآورد گردیده است. با استفاده از یک آنالیز مقایسه‌ای بر ابزارهای مختلف سیاست پولی، نشان می‌دهیم که قاعده رشد پولی نسبت به قاعده نرخ بهره، حتی تا چهار دوره آینده‌نگر دارای سازگاری و ثبات کامل در مدل می‌باشد و این خاصیت با وجود هر سهم از خانوار غیرریکاردویی در اقتصاد برقرار بوده و لذا اصل تیلور معکوس در این مدل اقتصادی اعمال نمی‌شود.

یافته‌های این تحقیق، کانال‌های انتشار مهم و فعال در اقتصادهای نوظهور را تایید کرده که در نظر گرفتن هریک از آنها برای هر مطالعه سیاستی ضروری و اساسی می باشد. اثر تثبیت کننده رابطه مبادله بین بخش رسمی و غیررسمی، اثر ضربه‌گیری بخش غیررسمی که با افزایش اصطکاک‌های بخش غیررسمی تعدیل می‌یابد، اثر اختلال کننده خانوار غیر ریکاردویی بر نوسانات سیکل‌های تجاری و نهایتا اثر شوک سیاست پولی که در یک اقتصاد با سهم بالاتر بخش غیررسمی، اصطکاک‌های کمتر در بخش غیررسمی، سهم بالاتر مصرف‌کننده غیرریکاردویی و خودکفایی تجاری تضعیف می‌یابد.

کلمات کلیدی:

پایداری مسیر–زینی، قاعده رشد پولی، بخش غیررسمی، مصرف‌کننده غیرریکاردویی، عبور ناقص نرخ‌ارز، خودکفایی‌مالی، مدل‌های تعادل عمومی پویای تصادفی (DSGE).