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Exchange Rate Dichotomy: Demand versus Supply Side Dominance

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Abstract: Changes in exchange rate have profound effects on economic activity in an economy. Generally, appreciation of domestic currency is considered contractionary, while a depreciation expansionary. However, depreciation can be contractionary too-hence the term Exchange Rate Dichotomy-for countries with high share of imported capital.
Using cross country analysis of 91 economies over the period, 2003-2017, we show that this indeed happens as supply side effects overwhelm the effects on demand side for a group of countries dependent highly on imported capital (G2) than the group with lower share of imported capital to total investment (G1). Impulse Responses obtained from SVAR and DSGE models show that depreciation in G2 countries has result in lower exports growth and higher inflation for longer durations compared to export growth and inflation in G1 thus indicating that supply side dominates the demand side effects in G2.

The evidence shows that overemphasis on adjustment in exchange rate may not be the panacea. Instead, the policy makers must focus on reforms aimed at enhancing the productive capacity of an economy. This, of course, must be achieved without prejudice to the principles and mechanisms needed for a market-based adjustment of exchange rate.

Keywords with JEL Codes: International Economics: Genera (JEL FOO), Exchange and Production Economies (JEL D51), Development Planning and Policy: Trade Policy; Factor Movement; Foreign Exchange Policy (JEL O24), Exchange Rate Policy, International trade

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Introduction

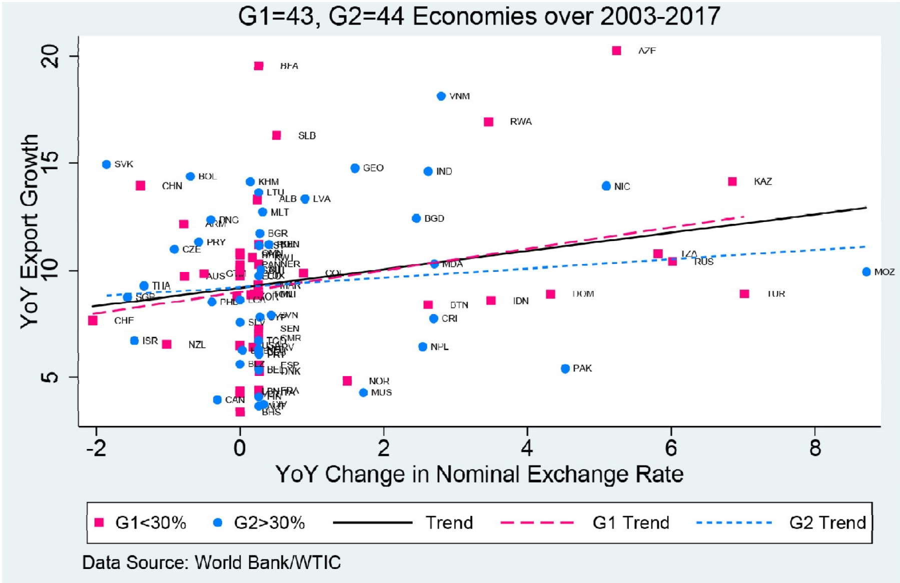
Movement in exchange rate is one of the most concerned areas for the policy makers and researchers. Generally, the adjustment in exchange rate i. e. the price of domestic currency in terms of foreign currencies is considered a self-correcting mechanism in the forex market. The exchange rate exerts its effects on economic activity through trade channel (or demand substitution channel). Changes in exchange rate alter the cost of exports, export demand and the domestic cost of imports, leading to a substitution between domestic production and imported goods [Kearns and Patel (2016)]. Thus, an appreciation of domestic currency is considered contractionary, while a depreciation expansionary for domestic economic activity. However, this simplistic logic of expansionary effect of currency depreciation is not accepted by all [Upadhyaya *et al.* (2013)]. According to them the effect is possibly opposite particularly in developing countries. The contractionary effect of depreciation can come from both the demand side as well as the supply side. From demand side this may lead to a negative real balance effect and redistribution of income from the group with higher marginal propensity to consume to the group with lower propensity to consume. The redistribution lowers aggregate demand and output. From supply side, exchange rate depreciation raises the cost of imported inputs. Therefore, the impact of exchange rate may differ from country to country depending upon the nature of the economy especially its imports and exports. For example, a common feature embodied in the cost structure of firms in small open economies is that these firms heavily depend on imported capital goods especially machinery in their production process. For firms in these countries, the rising demand for exports because of depreciation may be more than offset by rising costs on the supply side. This supply side effect makes exports less competitive in the world market. Therefore, the net impact of exchange rate depreciation on exports is limited in such economies. In this case, the depreciation of domestic currency is less likely to boost the export growth and hence economic growth. This disconnect of exchange rates from exports would complicate policymaking. Therefore, effectiveness of a key channel for the transmission of monetary policy would be compromised. This would also make it harder for policy makers to reduce trade imbalances through exchange rates adjustments. In addition, the depreciation will be more inflationary due to higher cost of production of the local firms. In such economies, monetary policy may be less effective in taming inflation or exerting its expansionary impacts on income and employment level.

The literature analyzing the impact of exchange rate depreciation on growth and exports remains inconclusive. Some studies [Gylfason and Schmid (1983), Connolly (1983), Upadhyaya, Mixon and Bhandari (2004)] find positive effects of depreciation on the economy. On the other hand, researcher [Gylfason and Risager (1984) and Branson (1986), Upadhyaya et al (2013), Upadhyaya *et al.* (2000)] also find contractionary impacts of depreciation. Sawyer and Sprinkle (1987) found that trade balance improved upon peso's depreciation but at the expense of contraction in domestic GDP in Mexico. Upadhyaya (1999) did not find depreciation increase exports in the long run. Studies based on cross-country analysis consider varying levels of development as well as exports composition in explaining the impact of exchange rates movements on exports. Freund and Pierola (2012) on manufacturing exports in developing countries, but no such evidence in case of developed countries. Eichengreen and Gupta (2013) also finds stronger effect of the real exchange rate on exports of services as compared to exported goods. Amiti *et al.* (2014), using disaggregated data for Belgian firms, shows that impact of depreciation on export volumes is lower for firms with higher import shares. Ahmed *et al.* (2015), using panel framework covering 46 countries, finds that elasticity of manufacturing export volumes to the real effective exchange rate has decreased over time. Furthermore, their estimates show that 40 percent of this decline in the elasticity is due to integration of trade as result of global value chains.

In this study, we divided the countries into two groups[1] to check the demand and supply side dominance resulting from exchange rate movements. Our stance here is that in countries where supply side effects dominate, exchange rate depreciation will have limited benefits as compared to countries where demand side effects are dominant. The countries included in the first group (G1) have a smaller share of imported capital goods (<30%) and the other group (G2) includes countries with higher share of imported capital goods (>30%). We hypothesize that the supply side effects are severe in the G2, therefore, any movement in exchange rate will more adversely affect the exports and economic growth of countries in G2 compared to those in G1.

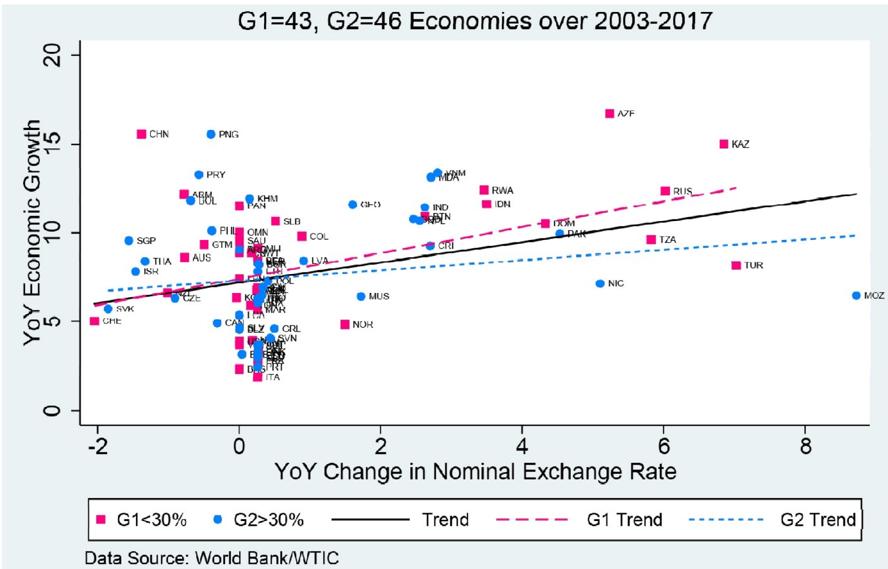
The figure 1 shows the relationship between exchange rate depreciation and export growth in two groups of countries. It is evident that the relationship between exchange rate depreciation and export growth is stronger in case of G1 as compared to G2.

Figure 1: Export Growth and Exchange Rate



Correspondingly, in figure 2 we can see the similar impact of exchange rate depreciation on economic growth. This shows that exchange rate depreciation is less likely to enhance exports and output growth in countries more dependent on imported capital goods.

Figure 2: Economic Growth and Exchange Rate



The figure 3 presents the relationship between exchange rate depreciation and inflation. The relationship is positive for both groups, but stronger for G2. This shows that depreciation of exchange rate also contributes to inflation through higher cost of production in G2 economies.

Figure 3: Inflation and Exchange Rate

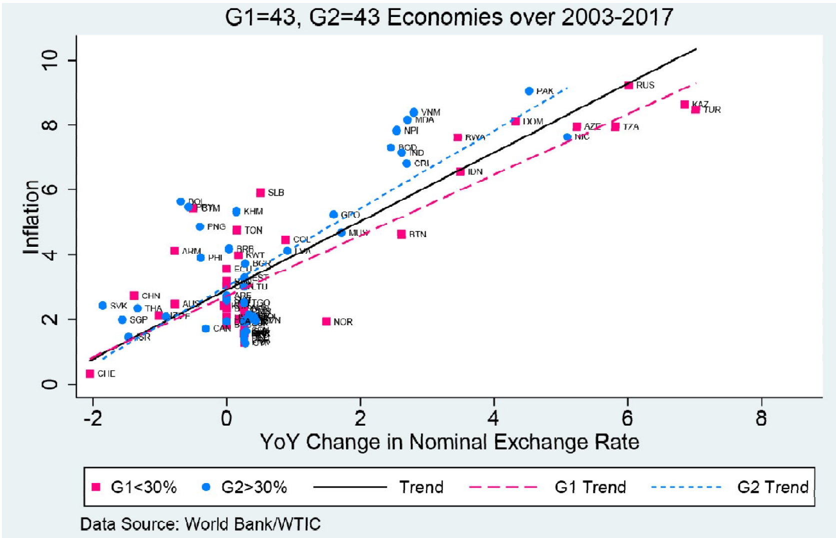
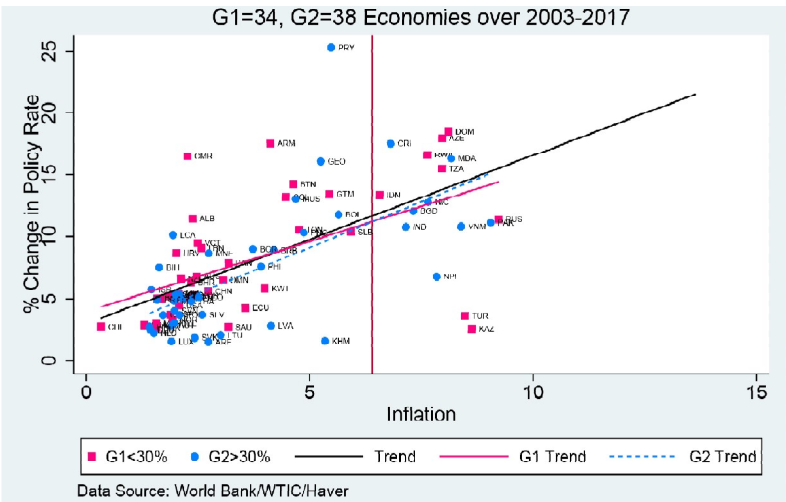


Figure 4 presents policy response to increase in inflation. When inflation is low, the policy reaction is smaller in G2. But after a threshold level (indicated by vertical

Figure 4: Inflation and Policy Rate



line) countries in G1 require a larger increase in policy rate compared to their counterparts in G2 to tame the same increase in inflation. In other words, the monetary policy is relatively less effective to curb inflation in countries with higher share of imported capital goods in total investment.

After having crude analysis, we estimate the impacts of exchange rate changes on export growth, output growth, and inflation for two sets of countries discussed above. On the confirmation of differences empirically, we developed a DSGE model incorporating this feature and then compared the results for two scenarios developed above.

Our DSGE model is close to Vukotic (2007), however, our focus is different from his study. The focus of Vukotic's study was to assess the importance of different frictions in replicating the exchange rate movements. In his model capital comprised of domestic and imported components. We think there are important differences in use of capital by firms and households. Accordingly, our model also comprises of domestic and imported components of the capital. But the important difference is that the capital in our model is owned by firms instead of households. Firms borrow from household to purchased domestic capital. They also purchases capital from abroad. In this way both interest rate and exchange rate directly affect their cost of production not only in current period but for a longer period of time in future. So, in our model, firms' decisions about capital accumulation also depend on the stream of benefits accrued in future. Secondly, we compare the impacts of exchange rate changes on the countries where dependency on imported capital is higher with those less dependent on imported capital. Thirdly, we also test whether the effectiveness of monetary policy differ in two groups of countries.

Rest of the paper is structured as follows, the next section present empirical results. DSGE model and its results are given in section 3, while section 4 concludes.

2. Empirics

In this section results of empirical exercise are presented. We used panel Structural Vector Auto Regression (SVAR) approach developed by Holtz-Eakin (1988) for empirical analysis.

2.1. Summery Statistics

The table 2.1 shows the summery statistics of variables of interest[2]. Average output growth is higher and volatile in first group as compared to second group. Average inflation and its volatility is almost same in both groups. However, exchange rate changes and volatility are significantly smaller in G2. Interest rate, on average, is slightly higher and volatile in G2. This indicates that the countries in this group may be more cautious about exchange rate changes and thus try to keep exchange rate stable.

Table 2.1: Summery Statistics of the economies in the sample

Import Share	*Output Growth*	*Exports Growth*	*Inflation*	*Exchange Rate Changes (%)*	*Interest Rate*
Group-1 < 30%	4.11	9.52	3.69	1.04	9.31
	(2.18)	(3.86)	(2.38)	(2.21)	(4.46)
Group-2 > 30%	3.66	9.17	3.71	0.75	9.84
	(1.71)	(3.72)	(2.25)	(1.85)	(4.94)
Full Sample	3.84	9.28	3.70	0.97	10.20
	(1.94)	(4.09)	(2.24)	(2.02)	(5.01)

YoY Change Averages, Standard Error in Parentheses

Source: World Bank/World Integrated Trade System/Haver

2.2. Panel Vector Auto Regression

Panel VARs have the same structure as VAR models, but a cross sectional dimension is added to the representation. Suppose that there are N cross-sectional units (countries in our case) observed over period T (years in our case). The model analogous to simple VAR model, with the assumption that all variables are endogenous and interdependent, allowing for individual effects and no stationarities across time can be expressed as:

$$y_{it} = \alpha_{ot} + \sum_{l=1}^{m} \alpha_{lt} y_{it-1} + \sum_{l=1}^{m} \delta_{lt} x_{it-1} + \psi_i f_i + \mathrm{u}_{it} (i = 1, \dots N, t = 1, \dots T) \quad (2.1)$$

Where subscript i index the cross-sectional observations and t the time over years. The term f_i denotes an unobserved individual effect and $\alpha_{lt}, \ldots, \alpha_{mt}, \ldots, \delta_{mt}, \psi_t$ are the coefficients of the linear projections of y_{it} on constant, past values of y_{it} and x_{it} and the individual effect f_i.

The equation (2.1) can be transformed to following relationship using simple algebra.

$$y_{it} = \alpha_t + \sum_{l=1}^{m+1} c_{lt} y_{it-1} + \sum_{l=1}^{m+1} d_{lt} x_{it-1} + \psi_i f_i + \upsilon_{it} (i = (m+2), \ldots T) \quad (2.2)$$

Where

$a_t = \alpha_{0t} - r_t \alpha_{0t-1},$

$c_{1t} = r_t - \alpha_{1t},$

$c_{lt} = \alpha_{lt} - r_t \alpha_{l-1,t-1} (l = 2, \ldots m),$

$c_{m+1,t} = -r_t \alpha_{m,t-1},$

$d_{1t} = \delta_{it},$

$d_{lt} = \delta_{lt} - r_t \delta_{l-1,t-1} (l = 2, \ldots m),$

$d_{m+1,t} = r_t \delta_{m,t-1},$

$v_{it} = u_{it} - r_t u_{i,t-1}$

The error term of the transformed equation (2.2) satisfies the orthogonality condition.

$$E[y_{is} v_{it}] = E[x_{is} v_{it}] = 0 , \big(s < (t-1)\big) \quad (2.3)$$

Thus, the vector of instrument variables that is available to identify the parameters of equation 2.2 is

$$Z_{it} = [1, y_{it-2,} \ldots, y_{i1}, x_{it-2}, \ldots, x_{i1}]$$

In this case the transformed equation 2.2 can be written as follows[3] :

$$y_{it} - y_{it-1} = \alpha_t + \sum_{l=1}^{m} \alpha_l (y_{it-1} - y_{it-l-1}) + \sum_{l=1}^{m} \delta_{lt} (x_{it-1} - x_{it-l-1}) + e_{it} \quad (2.4)$$

2.2.1. Structural Autoregressive

We use Structural Vector Autoregressive (SVAR) discussed above to identify exchange rate shocks. We use recursive-ordering SVAR for empirical characterization of dynamic effects of exchange rate. We specify the model as follows:

$X_t = G(L)\, X_{t-1} + e_t$ Where $X_t = [w, y, q, \pi, \gamma, i]$ is a sector that includes World Output, Real output growth of a country, Change in REER, Inflation and interest respectively. All the variables are real except inflation and lending rate. Lending rate has not been adjusted because instrument of monetary policy is used in nominal terms not real.

$e_t = [e_t^w, e_t^y, e_t^q, e_t^\pi, e_t^\gamma, e_t^i]$ is a vector of reduced form residuals or forecast errors of the variables *w*, *y*, *q*, π, γ, *i* respectively.

The system of equations can be expressed in the following matrix form

$$\begin{bmatrix} 1 & -a_2 & -a_3 & -a_4 & -a_5 & -a_6 \\ 0 & 1 & -b_3 & -b_4 & -b_5 & -b_6 \\ 0 & 0 & 1 & -c_4 & -c_5 & -c_6 \\ 0 & 0 & 0 & 1 & -d_5 & -d_6 \\ 0 & 0 & 0 & 0 & 1 & -g_6 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} e_t^w \\ e_t^y \\ e_t^q \\ e_t^\pi \\ e_t^\gamma \\ e_t^i \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} u_t^w \\ u_t^y \\ u_t^q \\ u_t^\pi \\ u_t^\gamma \\ u_t^i \end{bmatrix}$$

Where $u_t = [u_t^w, u_t^y, u_t^q, u_t^\pi, u_t^\gamma, u_t^i]]$ is a vector of structural shocks to output growth, change in exchange rate, inflation, exports growth and policy rate respectively.

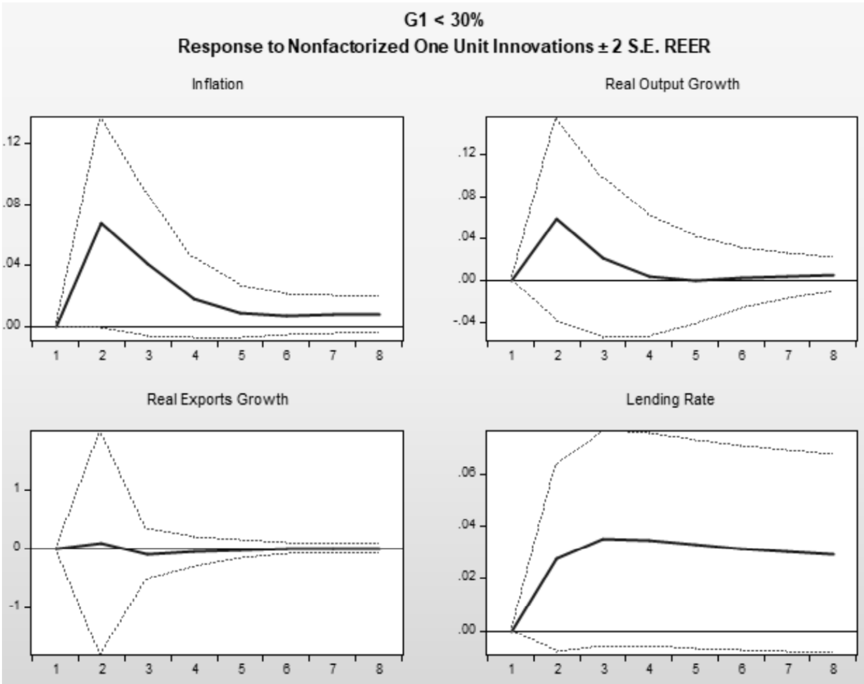
Annual panel data for 91 economies over the period 2003-2017 was considered for SVAR analysis. From this sample, we only picked countries which did not have missing data for a consecutive three years. Resultantly, the sample size is reduced. In the final analysis, 176 observations have been used for G1 while 313 have been used for SVAR estimation of countries in G2. Since the data is on annual basis, therefore, only one lag is included in estimation.

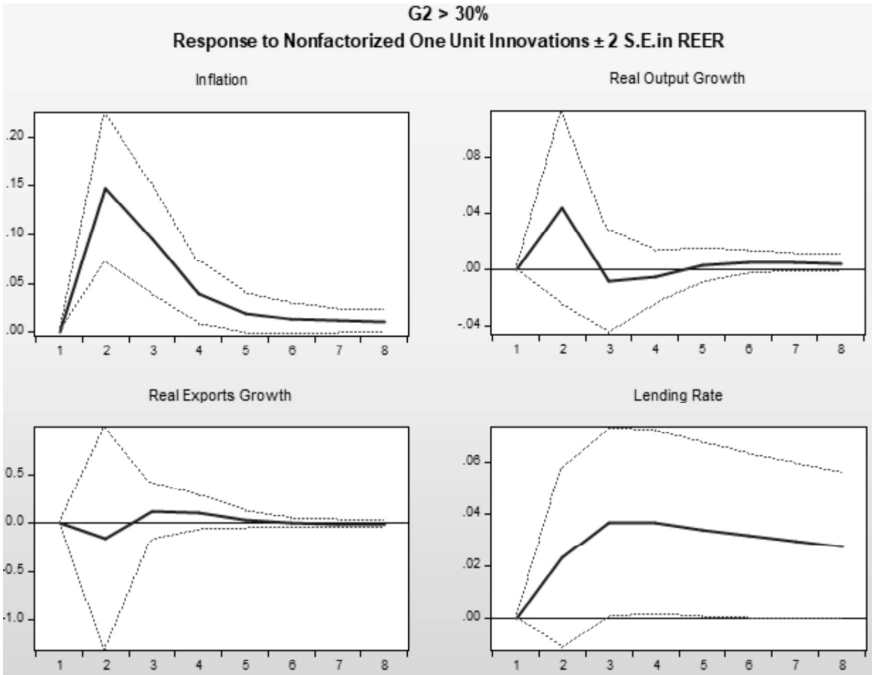
2.2.2. Estimation Results

The impulse responses generated for Exchange rate shock are shown in figure 2.1 below. The results show that inflation in both groups increases in response to depreciation in exchange rate. However, it is higher and long-lasting for countries with higher share of imported capital goods (G2) than it is for countries with lower share of imported capitals. The impact of exchange rate depreciation on export growth is positive in case of G1, while it is negative for countries in G2.

The impact on output growth is positive in both cases but larger at the peak for G1 (0.058 against 0.044 for G2). This positive impact in case of G2 could possibly be due to strong substitution effect. The impact also lasts for long duration in case of G1. The interest rate increases in both cases but slightly higher for G2. Perhaps it is because of high inflation as result of exchange rate depreciation. Together these results show that the cost channel is more dominant for countries in G2. These results support our hypothesis stated earlier.

Figure 2.1: IRFs of Exchange Rate Shock

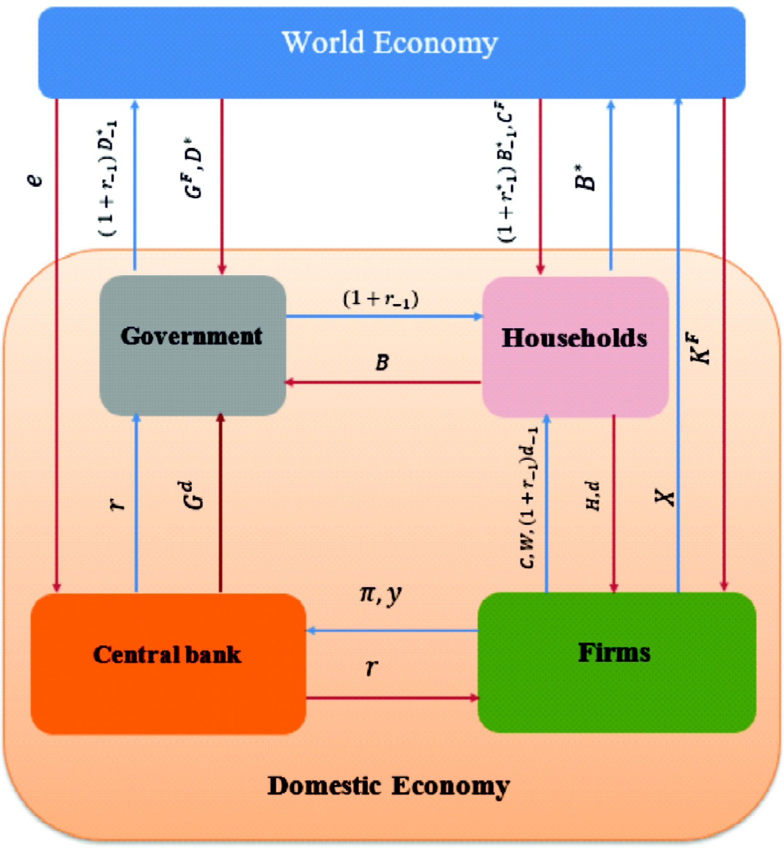




3. Model

The economy is populated with infinitely lived agents. Households derive utility from the consumption of goods produced domestically as well imported. They supply labor to intermediate firms[4], purchase foreign bonds, and lend remaining savings to intermediate firms. There are two types of firms in production sector: intermediate goods producers; and final good producers. Intermediate firms hire labor and borrow from households to invest in new capital. The final goods producers aggregate the intermediate goods into homogenous final goods. Government consumes domestically produced goods as well as imported goods and borrows from rest of the world to finance the fiscal gap. Finally, monetary authority sets the policy rate following Taylor type rule in a way that policy rate is adjusted for movements in inflation, output, and nominal exchange rate. Figure 3.1 characterizes the model.

Figure 3.1 Characterization of the DSGE Model



3.1. The Household

We assume that the economy is populated with identical infinitely lived households. The representative household faces two optimization problems: firstly, the optimal allocation, given prices, domestically produced goods and imported goods in the consumption basket subject to expenditure constraint. Secondly, the utility maximization subjects to his budget constraint.

The aggregate consumption can be written as:

$$c_t = \left[\gamma^{\frac{1}{\omega}}(c_t^d)^{\frac{\omega-1}{\omega}} + (1-\gamma)^{\frac{1}{\omega}}(c_t^m)^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}} \tag{3.1}$$

The parameter ω is the elasticity of substitution between domestically produced consumption goods c_t^n and foreign produced consumption goods c_t^m, while γ is the share of domestic consumption in total consumption. The expenditure constraint can be written as:

$$p_t^d c_t^d + e_t p_t^m c_t^m = p_t c_t \tag{3.2}$$

The Marshallian demand for each of the domestically produced and imported goods can be obtained from optimization of equation (3.1) subject to (3.2) and can be expressed as:

$$c_t^d = \gamma(\frac{p_t^d}{p_t})^{-\omega} c_t \tag{3.3}$$

and

$$c_t^m = (1-\gamma)(\frac{e_t p_t^m}{p_t})^{-\omega} c_t \tag{3.4}$$

The aggregate price in an economy takes the following formulation:

$$p_t = [\gamma(p_t^d)^{1-\omega} + (1-\gamma)(e_t p_t^m)^{1-\omega}]^{\frac{1}{1-\omega}} \tag{3.5}$$

The household preferences are illustrated by the following utility function.

$$U = E_t \sum_{t=0}^{\bowtie} \beta^t u(c_t, h_t)$$

Where $u(c_t, h_t)$ is given as

$$u(c_t, h_t) = \ln(c_t) - \eta \frac{{h_t}^{1+\chi}}{1+\chi} \tag{3.6}$$

Here parameter $\chi > 0$ is labor supply elasticity and η is preference parameter.

Households' faces the following budget constraint:

$$p_t c_t + d_t + e_t b_t^* = w_t h_t + (1 + r_{t-1}) d_{t-1} + (1 + r_{t-1}^*) e_t b_{t-1}^* + \Pi \qquad (3.7)$$

Where b_t^* denotes foreign bonds, e is nominal exchange rate, w_t and h_t denote nominal wage and labor hours respectively. The symbols d, r, and r^* represent deposits, domestic interest rate, and interest rate on foreign bonds. The last terms is profits obtained from the production sectors.

The households' optimization gives following FOCs.

$$\frac{1}{c_t} = \lambda_t p_t \qquad (3.8)$$

$$h_t^{\chi} = \frac{\lambda_t}{\eta} w_t \qquad (3.9)$$

$$\frac{\lambda_t}{\lambda_{t+1}} = (1 + r_t) \qquad (3.10)$$

$$\frac{\lambda_t}{\lambda_{t+1}} = \frac{e_{t+1}}{e_t}(1 + r_t^*) \qquad (3.11)$$

$$\frac{1}{c_{t+1}} = \lambda_{t+1} p_{t+1} \qquad (3.12)$$

Equation (3.8) and (3.9) implies

$$\frac{1}{p_t c_t} = \frac{\eta h_t^{\chi}}{w_t} \qquad (3.13)$$

From (3.8), (3.10) and (3.12) we can write

$$\frac{c_t}{c_{t+1}} = \left(\frac{\pi_t}{(1+r_t)}\right) \qquad (3.14)$$

Similarly, from (3.10) and (3.11) we can write

$$\left(\frac{1+r_t}{1+r_t^*}\right) = \frac{e_{t+1}}{e_t} \qquad (3.15)$$

Equation (3.13) represents the marginal rate of substitution between consumption and leisure, while equation (3.14) is Euler equation. The equation (3.15) is interest rate parity, which links the domestic interest rate with foreign interest rates.

3.2. Firms

There are four types of firms. intermediate good producer, final good producer i.e. aggregator, importing firms and exporting firms. The intermediate good producers produce differentiated goods and have market power to set prices monopolistically. The importing firms are packers, aggregate the imported goods into homogenous consumption and investment goods. Exporting firms also aggregate the domestically produced goods into homogenous final good. All types of firms strive to optimize their profitability.

3.2.1. Final Good Producer

The final good producer aggregates the intermediate goods into homogenous final good using following technology.

$$y_t^d = \left(\int_0^1 \left(y_{i,t}^d\right)^{\frac{\alpha-1}{\alpha}} di\right)^{\frac{\alpha}{\alpha-1}} \tag{3.16}$$

Where α is elasticity of substitution between differentiated intermediate goods. The aggregator chooses units, y_t^d, of finished goods that maximize its profit given the prices and quantity of differentiated intermediate goods as well as the price of final goods. Then it sells her goods in perfectly competitive market. The aggregator's optimization problem can be written as:

$$\max_{y_{i,t}^d} p_t^d\, y_t^d - \int_0^1 p_{i,t}^d\, y_{i,t}^d di \tag{3.17}$$

Where p_t^d denotes the price of the finished good while $p_{i,t}^d$ is the price of the ith intermediate good. The maximization gives the following demand function for each intermediate good:

$$y_{i,t}^d = \left(\frac{p_{i,t}^d}{P_t^d}\right)^{-\alpha} y_t^d \tag{3.18}$$

In equilibrium, the finished goods producer earns zero profits as it operates under perfect competition. Therefore, the following price-level would determine the under zero-profit condition.

$$p_t^d = \left(\int_0^1 \left(p_{i,t}^d\right)^{1-\alpha} di\right)^{\frac{1}{1-\alpha}} \tag{3.19}$$

3.2.2. Intermediate Goods Producers

The intermediate goods producing firm uses labor and capital to produce homogenous goods. It borrows from households to accumulate required capital.

The standard Cobb-Douglas production function is used as follows:

$$y_{it}^{d} = a_{t}^{d}(h_{it}^{d})^{1-\theta}(k_{it}^{d})^{\theta} \quad (3.20)$$

Where y_{it}^{d} is intermediate good, while h_{it}^{d} and k_{it}^{d} denote labor and capital respectively, and a_{t}^{d} is total factor productivity assumed to follow AR process.

The representative firm maximizes following profit function:

$$\max_{h_{it}^{d}k_{it}^{d}} \sum_{S=0}^{\infty} \beta^{t} \{p_{it+s}^{d} y_{it+s}^{d} - w_{it}^{d} h_{it}^{d} - e_{t+s} p_{t+s}^{m} i_{it+s-1}^{m} - (1 + r_{t+s-1}) d_{it+s-1}^{d}\} \quad (3.21)$$

subject to

$$k_{it+1}^{d} = i_{it}^{d} + (1-\delta) k_{it}^{d} \quad (3.22)$$

and

$$d_{it}^{d} = i_{it}^{d} \quad (3.23)$$

Here d_{t}^{n} denotes borrowing.

$$i_{it} = \left[(1-\sigma)^{\frac{1}{v}}(i_{it}^{d})^{1+v} + \sigma^{\frac{1}{v}}(i_{it}^{m})^{1+v}\right] \quad (3.24)$$

Where

$$i_{t}^{d} = (1-\sigma)(\frac{p_{t}^{d}}{p_{t}})^{-v} i_{it} \quad (3.25)$$

$$i_{t}^{m} = \sigma(\frac{e_{t} p_{t}^{m}}{p_{t}})^{-v} i_{it} \quad (3.26)$$

Where p_{t}^{n} and p_{t}^{F} denote price of non-traded goods and foreign goods.

The optimization gives following FOCs:

$$p_{it}^{d} y_{it}^{d} = \frac{1}{1-\theta} w_{it}^{d} h_{it}^{d} \quad (3.27)$$

And

$$p_{it}^{d} y_{it}^{d} = \frac{1}{\theta} k_{it}^{d} z_{it} \quad (3.28)$$

Where

$$z_{it} = \sigma p_{t} \left(\frac{p_{t}^{m} e_{t}}{p_{t}}\right)^{1-v} + (1-\sigma)(1 + r_{t}^{b}) p_{t} \left(\frac{p_{it}^{d}}{p_{t}}\right)^{1-v} - (1-\delta)(1-\sigma)\beta$$

$$(1 + r_{t+1}^{b}) p_{t+1} \left(\frac{p_{t+1}^{d}}{p_{t+1}}\right)^{1-v} - \beta(1-\delta) p_{t+1} (\frac{p_{t+1}^{m} e_{t+1}}{p_{t+1}})^{1-v} \quad (3.29)$$

The equation (3.28) and (3.29) equate the value of marginal product of capital and labor to their respective nominal marginal costs.

Combining equation (3.28) and (3.29) we get

$$h_{it}{}^{d} w_{it}{}^{d} = \left(\frac{\theta}{1-\theta}\right) k_{it}{}^{d} z_{it} \tag{3.30}$$

The real marginal cost is same for all firms and can be expressed as

$$mc_t^d = \left(\frac{1}{1-\theta}\right)^{1-\theta} \left(\frac{1}{\theta}\right)^{\theta} (z_t)^{\theta} (w_t^d)^{1-\theta} \tag{3.31}$$

The intermediate firms set their prices a la Calvo (1983). That is, in each period a fraction (1–σ) of firms can change their prices while remaining σ ε(0,1) only index the prices to past inflation.

$$\max_{p_{it}} E_t \sum_{S=0}^{\infty} (\beta\varphi_p) \frac{\lambda_{t+k}}{\lambda_t} \left\{ \left(\prod_{s=1}^{k} \Pi_{t+s-1}^{\chi_p} \frac{p_{it}^d}{p_{t+s-1}^d} - mc_{it+k}^d \right) y_{it+k}^d \right\} \tag{3.32}$$

$$\text{s.t} y_{t+k}^d = \left(\prod_{s=1}^{k} \Pi_{t+s-1}^{\chi_p} \frac{p_{it}^d}{p_{t+s-1}^d} \right) y_{it+k}^d \tag{3.33}$$

Finally, the aggregate price index can is given by following equation

$$\left(p_t^d\right)^{1-\varepsilon} = \varphi_p (\Pi_{t-1}^{\chi_p})^{1-\varepsilon} \left(p_{t-1}^d\right)^{1-\varepsilon} + \left(1-\varphi_p\right)(p_{t,*}^d)^{1-\varepsilon} \tag{3.34}$$

3.2.3. Importing Firms

The importing firm purchases the imported goods from the world market, packs it to final consumption and investment good, and sell it in domestic market in perfectly competitive environment. It uses following packing technology.

$$y_t^m = \left(\int_0^1 \left(y_{l,t}^m\right)^{\frac{\eta-1}{\eta}} dl \right)^{\frac{\eta}{\eta-1}} \tag{3.35}$$

Where η is elasticity of substitution between imported and domestically available similar goods. The aggregator chooses units, y_t^m, of finished goods that maximize its profit given the prices and quantities of imported goods as well as the price of final goods. Then it sells it goods in perfectly competitive market. Her optimization problem can be written as:

$$\max_{y_{l,t}^m} p_t^m y_t^m - \int_0^1 p_{l,t}^m y_{l,t}^m dl \tag{3.36}$$

Where p_t^m denotes the price of the finished good while $p_{l,t}^m$ is the price of the lth intermediate good. The maximization gives the following demand function for each imported good:

$$y_{l,t}^m = \left(\frac{P_{l,t}^m}{P_t^m}\right)^{-\eta} y_t^m \tag{3.37}$$

The aggregate price, P_t^m, of final imported good y_t^m can be written as:

$$P_t^m = \left(\int_0^1 \left(P_{l,t}^m\right)^{1-\eta} dl\right)^{\frac{1}{1-\eta}} \tag{3.38}$$

3.2.4. Exporting Firms

The exporting firm buys finished goods produced domestically and differentiates it using following technology.

$$x_t^e = \left(\int_0^1 \left(x_{n,t}^e\right)^{\frac{\tau-1}{\tau}} dn\right)^{\frac{\tau}{\tau-1}} \tag{3.39}$$

Where τ is elasticity of substitution between domestically produced final goods. The aggregator chooses units, x_t^e, of finished goods to be exported that maximize its profit given the price and quantity of domestic goods as well as the price of final goods to be exported. Then it sells her goods in perfectly competitive world market. Her optimization problem can be written as:

$$max_{x_{n,t}^e}\, p_t^e\, y_t^e - \int_0^1 p_{n,t}^e\, y_{n,t}^e dn \tag{3.40}$$

Where p_t^e denotes the price of the finished good while $p_{n,t}^e$ is the price of the nth intermediate good. The maximization gives the following demand function for each imported good:

$$x_{n,t}^e = \left(\frac{p_{n,t}^e}{p_t^e}\right)^{-\tau} x_t^e \tag{3.41}$$

The price index for exported good can be expressed as:

$$P_t^e = \left(\int_0^1 \left(p_{n,t}^e\right)^{1-\tau} dn\right)^{\frac{1}{1-\tau}} \tag{3.42}$$

Exports demand depends upon the income of foreign nationals consuming our exportable goods. Therefore, the demand for export sector goods can be written as:

$$x_t^e = \phi_t^e \left[\frac{p_t^e}{e_t p_t^*}\right]^{-\varsigma} y_t^* \tag{3.43}$$

3.3. Government

Government consumes domestically produced goods, g_t^d, as well as imported goods, g_t^m. Government purchases bonds, b_t, from households, and borrows d_t^* from abroad to finance the fiscal gap.

The aggregate government consumption is given by the following Dixit- Stieglitz function.

$$g_t = \left[\kappa^{\frac{1}{\sigma}}(c_t^d)^{\frac{\sigma-1}{\sigma}} + (1-\kappa)^{\frac{1}{\sigma}}(e_t c_t^m)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}} \tag{3.44}$$

The expenditure constraint can be written as:

$$p_t^d g_t^d + e_t p_t^m g_t^m = p_t g_t \tag{3.45}$$

Following demand equations for domestic and imported goods are obtained respectively.

$$g_t^d = \kappa\left(\frac{p_t^d}{p_t}\right)^{-\sigma} g_t \tag{3.46}$$

and

$$g_t^m = (1-\kappa)\left(\frac{e_t p_t^m}{p_t}\right)^{-\sigma} g_t \tag{3.47}$$

The government budget constraint is as under:

$$e_t d_t^* + b_t = (1 + r_{t-1}^*) e_t d_{t-1}^* + (1 + r_{t-1}) b_{t-1} + p g_t \tag{3.48}$$

3.4. Monetary Authority

Monetary Authority uses Taylor rule to adjust policy rate in response to any deviation of inflation, GDP growth, or exchange rate from their respective target levels.

$$r_t = (r_{t-1})^{\rho_r}\left[\left(\frac{\pi_t}{\pi}\right)^{\rho_\pi}\left(\frac{y_t}{y}\right)^{\rho_y}\left(\frac{e_t}{e}\right)^{\rho_e}\right]^{1-\rho_r} \varsigma_t \tag{3.49}$$

3.5. Balance of Payment

Small open economy is affected by any development in the rest of the world through two channels. First through trade channel and the second through international financial markets channel. The current account i.e. trade balance plus net interest payments can be expressed as:

$$ca_t = (x_t^e - e_t y_t^m) + (b_{t-1}^* - d_{t-1}^*) r_{t-1}^* e_t \tag{3.50}$$

Similarly, the capital account, the net foreign liabilities, is given by:

$$ka_t = e_t\{(d_t^* - d_{t-1}^*) - (b_t^* - b_{t-1}^*)\} \tag{3.51}$$

Let us assume that the balance of payment holds every period we can write:

$$ca_t + ka_t = 0 \tag{3.52}$$

This implies

$$d_t^* = \left(y_t^m - \frac{x_t^e}{e_t}\right) + (d_{t-1}^* - b_{t-1}^*)(1 + r_{t-1}^*) + b_t^* \tag{3.53}$$

We assume following external debt elastic interest rate charged in international financial market.

$$r_t^* = \bar{r}^* + \xi_t^d \left(e^{d_t^* - \bar{d}^*} - 1\right) \tag{3.54}$$

And the country debt premium can be written as:

$$r_t^* = \xi_t^d \left(e^{d_t^* - \bar{d}^*} - 1\right) \tag{3.55}$$

Finally, the resource constraint for the economy can be expressed as

$$y_t^d = c_t^d + i_t^d + x_t^e + g_t^d \tag{3.56}$$

3.6. Parameters Choice

There are 17 main parameters in the model to be calibrated / estimated. As we are doing cross-country analysis, we picked the values of the parameters between the ranges given in the literature on different countries.

Table 3.1 summarizes the parameter values fixed by calibration. The quarterly value of discount factor, β, is set equal to 0.975 which is slightly lower than the value 0.985 in the literature [Rosario, Devereux *et al.* (2006)]. The reason is that real interest rate in the two groups during 2003-2017 was higher than the world real interest rate i.e. 6% considered in the literature. The quarterly depreciation rate is set to δ = 0.025 as in many papers [Rosario 2010, Christiano *et al.*, 2005; Acosta *et al.*, 2009; Devereux *et al.*, 2006). The parameter χ is set to unity value which is taken from

Devereux *et al.* (2006). The interest rate smoothing parameter, ρ_r, in Taylor Rule is set to value 0.65, lower than literature 0.84 [Rosario (2010), Schmitt-Groh´e and Uribe (2007)]. This is because of higher standard deviation of interest rate in both groups. The parameters ρ_π, ρ_e, and ρ_y in Taylor Rule are assigned values 1.02, .65 and 0.65 respectively as compared to literature values of 1.6, 0.2 and 0.7.

The elasticity of substitution between home produced and imported consumption goods (ω), investment goods (ν), and Government consumption goods (ϕ) are all set at value of 6. The value for consumption in literature is between 1 and 7. The Share of household's domestic consumption (γ) and Share of government's domestic consumption (κ) in their respective total consumption is set equal to 0.75 which is generally in the range of 70-80 percent depending the level development of on the countries. Vukotic (2007) sets values of 0.6 for these parameters.

Share of imported inputs in total investment (α) is set to a value of 0.10 for G1 and 0.35 for G2 which is highly dependent on imported capital. Majira (2007) sets a

Table 3.1: Choice of Parameters

Parameter	*Value*	*Parameter*	*Value*
Preference parameter (η)	1.6	Calvo probability of not changing price (φ_p)	0.8
Labor supply elasticity (χ)	1	Domestic government consumption to total government consumption (κ)	0.75
Household's domestic consumption to total consumption (γ)	0.75	Interest rate smoothening parameter in Taylor Rule (ρ_r	0.65
Capital to intermediate production (θ)	0.54	Weight assigned to inflation in Taylor Rule (ρ_π)	1.02
Imported inputs to total investment (σ)	0.10/0.35	Weight assigned to output gap in Taylor Rule (ρ_y)	0.65
Discount factor (β)	0.975	Weight assigned to exchange rate in Taylor Rule (ρ_e)	0.65
Capital depreciation rate (δ)	0.025	Demand elasticity of exports(ς)	0.85
Elasticity of substitution between domestic and imported investment goods (υ)	6	Elasticity of substitution between home produced and imported Government consumption goods (ϕ)	6
Elasticity of substitution between domestic and imported consumption goods (ω)	6		

value of 0.4 for this parameter. This value of demand elasticity of exports (ς) is set equals to 0.85. Share of capital in intermediate production (θ) is set at 0.54, between the ranges of 30-70 percent depending on the level development of the countries. The preference parameter (η) is given a value of 1.6. The Calvo probability of not changing price (φ_p).

3.7. Results

In this section, we present the second order simulated moments from the model and compare them with their counterparts obtained from the sample. Table 3.2 reports the annual simulated moments obtained by the model. Since data used for empirical analysis is of annual frequency, therefore, we use annual values of main parameters to generate these moments to ensure the results are comparable. However, the impulse responses shown in figures 3.2 to 3.5 are based on quarterly values of parameters already discussed in section 3.6.

3.7.1. Second Order Moments

The volatility of GDP growth simulated by the model is close to that exhibited by the data for G1. However, model overestimates GDP growth for G2. The volatility of export growth shown by data is higher than the model simulated value for both groups. The model slightly underestimates the volatility of inflation in both cases, but it is not off by big margins from what the data shows. The volatility of exchange rate and interest rate shown by data is higher than the model simulated values for both groups.

The export growth is less volatile relative to output growth for both groups. However, the relative volatility of inflation to both interest rate and exchange rate is closer to data. Similarly, the relative volatility exchange rate to interest rate and export to exchange rate are not far away from their counterparts from data.

In terms of correlations of variables with one another, model performance is mixed. The model underestimates the association of interest rate with GDP growth for G1 but overestimated for G2. The association of exchange rate with output growth revealed by the model is higher than what is exhibited in the data for G1. The correlation between inflation and exchange rate in the G2 is very close to data. Similarly, the association between exchange rate and interest rate is well captured by model in both cases. Model underestimates the correlation between inflation and interest rate for both Groups. However, the model misses out on the positive correlation of exchange rate with output growth and export growth in G2, positive correlation of exchange rate and inflation, and negative correlation between exchange rate and export growth in G1.

Table 3.2: Annual Moments of Data and DSGE Model

Statistics	*G1 < Low Share*		*G2 > High Share*	
	Data	*Model*	*Data*	*Model*
Volatility				
σ(y)	2.18	2.04	1.71	2.62
σ(x)	3.86	1.99	3.72	1.42
σ(π)	2.38	1.74	2.25	1.64
σ(r)	4.46	2.26	4.94	2.53
σ(e)	2.21	1.07	1.85	1.09
Relative Volatility				
σ(x)/σ(y)	1.77	0.98	2.16	0.54
σ(π)/σ(r)	0.53	0.78	0.53	0.65
σ(π)/σ(e)	1.07	1.64	1.22	1.53
σ(e)/σ(r)	0.50	0.47	0.37	0.42
σ(x)/σ(e)	1.75	1.86	2.01	1.33
Correlations				
σ(r,y)	0.28	0.12	0.24	0.46
σ(e,y)	0.16	0.71	0.20	-0.10
σ(π,r)	0.49	0.29	0.57	0.19
σ(π,e)	0.33	-0.13	0.14	0.19
σ(x,e)	-0.02	0.80	0.03	-0.12
σ(e,r)	0.25	0.27	0.17	0.10

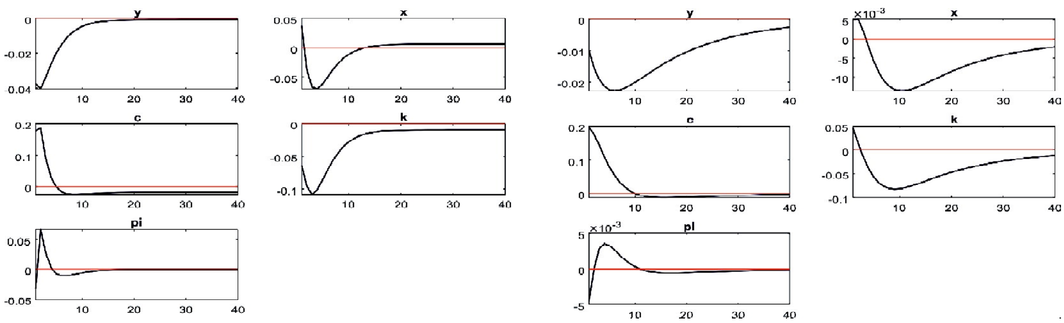
In sum, it is nearly impossible to identify a single model that excels in moments matching exercise for all variables and all moments. Keeping these limitations in mind, our model did a good job in replicating the stylized facts in the data on average. However, it does not necessarily mean that this model is perfect. Since data used is panel, therefore, it is possible that model may perform poorly for some individual countries. As performance of any model may vary from economy to economy, over different time horizons as well as frequencies.

3.7.2. Impulse Response Functions (IRFs)

This section presents results of the DSGE model i.e. the impulse response functions (IRFs) of variable of interest to different shocks. We compare results for the two scenarios; when share of imported capital (inputs) is high versus when it is low in total capital. Figure 3.2 shows the IRFs of variables in response to monetary policy shock in the two scenarios. Output (y) falls below steady state, while exports (x) show as slight increase first but then decrease afterwards. The increase in exports was due to decline in inflation, which makes exports relatively cheaper in the international market. However, when inflation increases above steady state, the exports fell below its steady state value. Since monetary policy affects inflation from both demand and supply side, therefore, inflation can spike only when supply side effects dominate as result of tight monetary policy. Capital (k) tracks the pattern as of exports. Similar impact of monetary policy can be observed in the second scenario but with longer duration. The effects of monetary policy on output and inflation are larger in first scenario. This shows that higher dependency of firms on exported inputs makes monetary policy less effective.

Figure 3.2: Response of variables to monetary policy shock

Low share of imported inputs (σ = 0.10) High share of imported inputs (σ = 0.35)



The responses of variables to technology shock are shown in Figure 3.3. Output, exports, and consumption all show an increase in both scenarios. However, exports take longer time in converging to their steady state value in the second scenario. Inflation in both scenarios falls below the steady state but reverts back after two quarters in first scenario.

Figure 3.3: Response of variables to TFP shock

low share of imported inputs (σ = 0.10) high share of imported inputs (σ = 0.35)

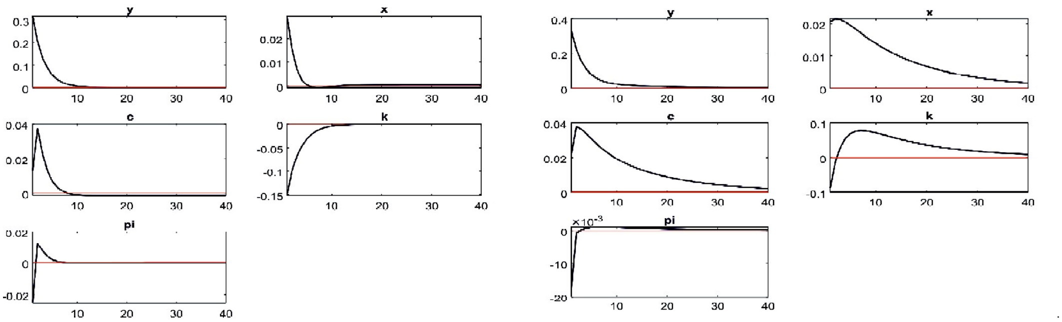
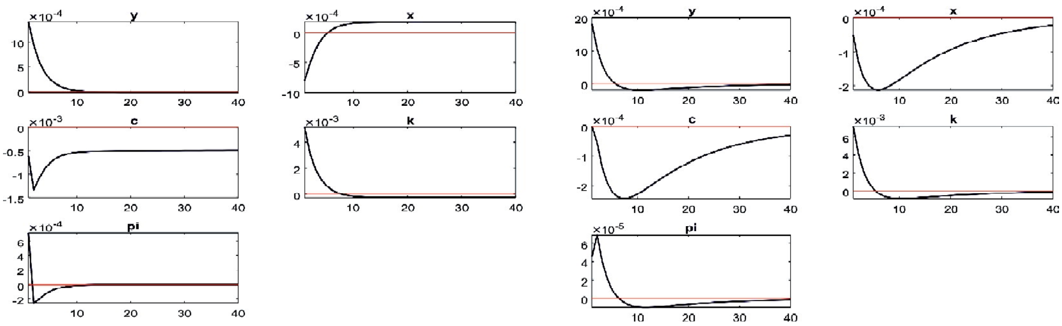


Figure 3.4 presents impulse responses to fiscal policy shock i.e. increase in government spending. Output increases in both scenarios. However, fiscal expansion has crowding out impact on exports and consumption while capital increases. Inflation in both scenarios increases, though higher in second scenario relatively. Impacts, in both scenarios, are small in magnitude on all variables. The exports take longer time to return to their steady state in second scenario.

Figure 3.4: Response of variables to fiscal policy shock

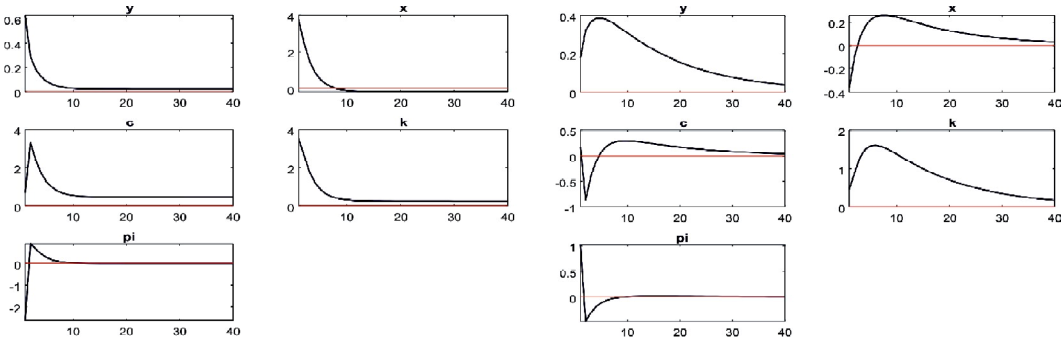
low share of imported inputs (σ = 0.10) high share of imported inputs (σ = 0.35)



Responses of variables to exchange rate depreciation are presented in figure 3.5. Output increases in both scenarios. The impact is larger in first scenario but is of longer duration in second scenario. The exports show pronounced increase in first scenario. However, these fell below the steady state on impact, but shows increase after the second quarter in second scenario. Consumption also declines below steady state but then increases in second scenario. Inflation in first scenario decreases while it increases in second case due to supply dominance. Though the impacts are larger in first scenario but take longer to die out in second case.

Figure 3.5: Response of variables to exchange rate shock

Low share of imported inputs (σ = 0.10) High share of imported inputs (σ = 0.35)



Overall our model is capable of replicating the dynamics exhibited by data empirically. Results of our DSGE model are in conformity with empirical evidence that exchange rate depreciation would be less likely to enhance exports in case firms are highly dependent on imported inputs in production process. Furthermore, model also replicates the feature, exhibited in data, that impacts of shocks are smaller in magnitude but last longer for in cases where share of imported capital is higher compared to the one when it is low. The results show that positive technology shock is most important of all the shocks that increase competitiveness of exports by lowering production cost and price level.

4. Conclusions

The exchange rate appreciation is believed to be harmful for an economy. As it reduces the competitiveness of country's exports. Imports become cheaper in relative terms, which deteriorates trade balance and hence balance of payment position of that country. So free movement of exchange rate is considered as natural stabilizer in such circumstances. It is for this reason that the international institutions like IMF and World Bank advise free-floating exchange rates to member countries. However, this prescription would not work for the economies where supply side impacts of exchange rate movements are stronger compared to it demand side counterparts. In countries where firms are highly dependent on imported inputs in production process, the positive effects of exchange rate depreciation on export will be more than offset by its negative impact through cost channel thus making exports expensive. Besides, it would be more inflationary in these economies compared to the countries less dependent on imported inputs. In such circumstances, more focus should be on enhancing productivity rather than exchange rate depreciation as a quick fix to make exports more competitive in the international market.

These finding should not be taken to mean that we do not support the market-based adjustment in exchange rate. Instead we provide evidence, which shows that overreliance on exchange rate adjustments as a policy tool to achieve compatibility may be erroneous. Therefore, the focus of policy should be to increase the total factor productivity though investment in human capital and research & development. This approach to policy will help reduce avoidable costs of firms in an economy and increase its competitiveness in world market. Yet, this is half the story. The types of goods exported is also important. The elasticity of exports to exchange rate changes also depends on whether the goods exported are high-tech or low-tech goods. That is a totally different debate.

Notes

1. The groups have been formed based on share of imported capital goods (CG) to total investment (TI) in an economy. Total Investment is sum of CG and Gross Capital Formation (GCF) hence SIC=CG/(CG+GCF). We calculated this ratio for countries in the sample and noted the maximum value for each country during the sample period. The range of values is from 0 to 0.79 with 0.28 as 50^{th} percentile. We then classified the countries based on Median.
2. Note that we have included data in this table until 2017 (as well as in the figures shown earlier and subsequent analysis) for a simple reason that in the first year of reporting, the data is usually provisional. In the year after, it is estimates are revised in most economies. It is only finalized in the third year after the year to which the data belongs. This limiting the sample till 2017 helps us get rid of measurement errors in the sample.
3. For more detail see Holtz-Eakin (1988).
4. For the sack of simplicity, we assume that the firms directly borrow from households rather than banks.

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