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Exogenous Shocks and Exchange Rate Management in Developing Countries

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Exogenous Shocks and Exchange Rate Management in Developing Countries

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Sajid Anwar and S. Zahid Ali

1. Introduction

During the last two decades, there has been a significant increase in capital mobility across the globe. Trade liberalization and increased capital mobility has led to a closer integration of the world economy. Developing countries such as China and India have greatly benefited from increased capital mobility. However, the Asian financial crisis of 1997-98 shows that increased capital mobility has also significantly increased the degree of vulnerability of the economies of developing countries to adverse shocks. Increased foreign investment and trade liberalization has contributed to a situation where a number of developing countries are producing and exporting good quality manufactured final goods by combining imported and locally produced inputs. For example, China is producing and exporting a whole range of electronic products including laptop computers, televisions and washing machines. These products are generally produced by combining imported and locally produced inputs. Multinational corporations have played an important role in technology transfer and availability of capital. Another development that is noteworthy in the recent years is that instead of relying on international lending agencies (such as the IMF, the Asian Development Bank, and the Paris Club), the LDCs are raising significant amount of capital by selling government bonds in international capital market. The switch to lending from international capital market can be partly attributed to the fact that international capital market transactions are not subject to IMF type conditionality. However, heavy reliance on international capital market increases the risk of external shocks to the domestic economy thereby jeopardizing economic growth and stability. Exchange rate management is an important strategy to deal with such a situation. In the late eighties and up to early nineties a number of studies such as Delong and Summers (1986) and Myers and Scarth (1990) among others focused on the desirability of wage and price flexibility in the event of random shocks.

Flexible exchange rate regimes are generally favoured over fixed exchange rate regimes because of their ability to absorb exogenous shocks. Indeed, based on Mundell-Fleming model, one can argue that in the event of negative demand-side shock, for example, the domestic rate of interest would decrease and that may cause capital outflow. In this process, however, the exchange rate depreciates which increases exports and decreases imports and consequently the negative demand-side shock is defused. Myers and Scarth (1990), while examining price flexibility issues, argued that exchange rate could also act as a shock amplifier. Lam and Scarth (2002) addressed the issue of price level targeting, wage-rate targeting, and exchange rate targeting in context of built in stability of the economy. In general, they found mixed results heavily biased to price-level and wage-rate targeting. Nevertheless, they found that exchange rate targeting is the second best option. Berger (2007) utilized a stochastic sticky-price general-equilibrium model to examine the welfare effects of optimal monetary policy and exchange rate targeting rules and argued that exchange rate targeting could be a viable option.

Surprisingly, few available studies have considered such issues within the context of developing countries. In this context, Khan (1986) examined exchange rate management as a policy response to random shocks. However, his work is largely descriptive. While examining the exchange rate management objectives of the Indian central bank over the period 1993-2001, Kholi (2003) concludes that the Indian central bank was heavily involved in managing the exchange rate to target the real exchange rate. In recent years, there has been lots of pressure on China to allow its currency to fluctuate. While Xu (2000) argues that China should continue to practice stable exchange rate policy, Goldstein (2004) has argued that the Chinese currency is 15-25% overvalued and that contrary to the IMF rules, China has been manipulating its currency[1]. Frankel (2004) argues that while every country has the right to choose an exchange rate system that suits its needs, China's economy has reached a stage in its economic growth where a continued peg with the US dollar is not useful anymore. Trade surpluses have led to a substantial increase in China's foreign exchange rate reserves that could be used to avert the future currency or economic crises[2]. Larrenceson (2006) argues that institutional realities make a move towards flexible exchange rate harder. He believes that China should consider a policy of managed float[3]. While this paper does not directly deal with China, the analysis presented in this paper can serve as a basis for developing a more appropriate exchange rate management policy.

By making use of a simple stochastic open economy model that captures a number of important features of the present day LDCs, this paper examines the choice of an appropriate exchange rate policy for a developing country. The model captures the effects of random shocks that stems from four sources, i.e., money market, goods market, foreign exchange market, and supply-side of the economy. The special feature of the model is its production side. We assume throughout that domestic good is produced with the help of domestic value added and imported inputs. This form of production process especially in the context of LDCs has been highly supported by McCallum and Nelson (2001) both on theoretical and empirical grounds. We also assume that firms hire labor based on (i) a two-period wage contract; and (ii) when

[1]He argued that it is in China's long term interest to allow its currency to appreciate. He suggested that in stage one, China should peg its currency to a basket of currencies rather than maintaining a peg with the US dollar. In stage one China should allow its currency to appreciate by 15-25%. In stage two China should move towards a managed float, which requires liberalization of capital controls. Stage two should be implemented only when the banking system is strong enough. Bailliu, Lafrance and Perrault (2003) argue that from economic growth point of view the presence of a monetary policy anchor is much more important as compared to the type of exchange rate system.

[2] Having too much surplus is not necessarily good especially when a significant proportion of the reserves are invested in US treasury bills that are not currently yielding attractive return. Frankel believes that the Chinese currency is almost 35% undervalued because prices or goods and services in China are lower not only in comparison with other countries. Ping and Xiaopu (2003) argue that Chinese economic growth can be partly attributed to government actions that led to elimination of the conflicts between the exchange rate and monetary policy.

[3]For a discussion of the case for greater exchange rate flexibility in China, see Roberts and Tyers (2003). They argue that exchange rate flexibility will increase as capital mobility increases.

wage contracts are negotiated. While negotiating wages, workers form expectation about output and prices, which indirectly involves exchange rate expectations.

Since the model utilised in this paper involves solution to a set of simultaneous non-linear equations and a system of first-order difference equations, we resort to a numerical solution by making use of plausible parameter values. This paper considers four kinds of exchange rate policies, namely fixed exchange rate policy, perfectly flexible exchange rate policy, leaning against the wind, and leaning with the wind policies. This paper shows that "leaning against the wind" minimizes asymptotic variance of output in general and social welfare loss in particular. However, fixed exchange rate policy is best when wages are less flexible.

The rest of the paper is organized as follows. A simple stochastic macroeconomic model is presented in Section 2. Section 3 contains a description of preliminary manipulations and solution of the model. The model developed in section 3 is calibrated in section 4, whereas section 5 contains some concluding remarks.

2. Model

The following equations characterize the demand side of the model:

$$m_t - p_t = a_2 y_t - a_1 i_t + u_{1t} \tag{1}$$

$$y_t = -c_1 r_t + c_2 (e_t - p_t + p^*) + u_{2t} \tag{2}$$

$$i_t = r_t + E_t p_{t+1} - p_t \tag{3}$$

$$m_t - \bar{m} = \theta (e_t - \bar{e}) \tag{4}$$

$$i_t = \bar{i} + E_t e_{t+1} - e_t + u_{3t} \tag{5}$$

The supply-side of the model can be described by means of the following equations:

$$x_t = 0.5[E_{t-1} p_t + E_{t-1} p_{t+1} + f(hE_{t-1} y_t + (1-h) E_{t-1} y_{t+1})] + u_{4t} \tag{6}$$

$$p_t = 0.5(x_t + x_{t-1}) + p^* + e_t \tag{7}$$

where

y_t =ln of domestic output, Y_t; ln is the natural logarithm; m_t = ln of money supply, M_t.

$\bar{m}$ = ln of money stock; p_t = ln of domestic price (P_t) of good y_t.

x_t = ln of nominal wage rate; e_t = ln of nominal exchange rate E.

$E_{t-j} p_{t-j}$ = mathematical expectation of p_{t-j}; $E_{t-j} y_{t-j}$ = mathematical expectation of y_{t-j}

u_{jt} = disturbance term; r_t = real interest rate; i_t = nominal domestic interest rate

$\bar{i}$ = foreign interest rate; p^* = ln of price of the foreign good

We start by explaining the model's supply side. We assume that workers are free of money illusion and they enter into a two period contract with firms. For example, at time t-1 a group of workers, whose contract is expiring at time t-1, enter a contract with the firm for periods t and t+1. Equation (6) indicates that to make a contract, workers use their expectations regarding prices, p_t, p_{t+1} and output y_t, y_{t+1}, which are expected to prevail in period t and t+1 respectively. Whereas f represents the weight given to the weighted average of the output expected in period t and t+1. The disturbance term, captures the stochastic shift in the wage rate or simply the cost-push shock. Akerlof and Yellen (1985), Mankiw (1985), and Blanchard (1985) and many others in the past have suggested that contracts of this type can be justified on microeconomic grounds. Fisher (1984) on the other hand defended such contract model on empirical grounds as well.

We assume throughout that all imports are intermediary inputs and that domestic output Y_t is produced in two stages. In the first stage, a domestic value added (Z) is produced by combining labor N and fixed capital $\overline{K}$ through a general production technology $Z = f(N, \overline{K})$. In stage two, the domestic value added is combined with an imported input (IM). Each unit of the domestic value-added is combined with one unit of imported input to produce one unit of the final good Y_t. Assuming that marginal producitivity of labor is constant, one can normalize domestic prices, wage rate and foreign prices to equal unity in the initial equilibrium. This allows one to derive equation (7) which is a usual profit maximization condition. This condition reflects a mark-up pricing rule. All variables are expressed in natural log form.

After discussing the basic structure of the supply-side of the model, we now describe the demand-side. Equation (1) is the money market equilibrium condition. We assume that demand for real money balances (M / P), is positively related to output and negatively related to nominal interest rate. Equation (2) shows that demand for goods is negatively related to the real interest rate but positively related to the terms of trade, $E_t P^* / P_t$. The disturbance terms u_{1t} and u_{2t} capture random shocks in the money and goods market, respectively. The presence of nominal rate of interest in the demand for money function and real interest rate in the investment function captures the so-called Mundell effect. In this situation, a decrease in price, for example, is expansionary but at the same time causes real rate of interest to increase, which in fact is contractionary. The net effect on output obviously depends upon the competing effects of price fall. Equation (3) is the definition of real interest rate, i.e., real interest rate is equal to nominal interest rate plus expected inflation. Equation (4) shows the extent of government intervention in foreign exchange market. If θ takes a value equal to zero then it means that central banks follow a perfect flexible exchange rate policy. On the other hand, if θ takes a value of minus infinity then it implies fixed exchange rate. Other possibilities also follow from the equation such as leaning against the wind (θ<0) and leaning with the wind (θ<0). Equation (5) is the interest rate parity condition. This condition assumes that the domestic rate of interest is equal to foreign rate of interest plus (i) the expected growth in the exchange rate and (ii) the stochastic fluctuation in the foreign exchange rate (u_{3t}). This completes the basic structure of our model.

Before closing discussion on model description, one point is worth mentioning about the properties of disturbance terms, which captures exogenous shocks. Delong and Summers (1986, p. 1034) have demonstrated that in such models (like the one we are dealing with) the demand side shock generates no persistent fluctuations in the output unless at least one demand side shock is serially correlated. The only source of persistent fluctuations is the supply-side shock. To appreciate Delong and Summer's findings we assume throughout that the disturbance term u_{2t} is serially correlated of first order ($u_{2t} = pu_{2t} + \varepsilon_{2t}$). Finally, we also assume that all other disturbance terms, including ε_{2t} are uncorrelated to each other and that each is distributed normally with zero mean and constant variance and satisfy all the classical assumptions pertaining to disturbance terms. However, in one case where we assume that goods market is stable, we assume that u_{1t} is serially correlated of first order, $u_{2t} = pu_{2t} + \varepsilon_{2t.}$ This completes the discussion of our model. We have seven equations involving seven endogenous variables:
y_t, m_t, p_t, x_t, e_t, r_t, and i_t, y_t, m_t.

3. Preliminary Manipulations

Using equations (1) to (7) we can derive the following form of output, prices, and wage equations (see the appendix for the derivation):

$$y_t = \phi_1 + \phi_2 E_t y_{t+1} - \phi_3 p_t + \phi_4 E_t p_{t+1} - \phi_5 E_t p_{t+2} - \phi_6 u_{1t} + \phi_7 u_{2t} + \phi_8 u_{3t} \tag{8}$$

$$p_t = \alpha_1 + \alpha_2 (x_t + x_{t-1}) + \alpha_3 y_t - \alpha_4 E_t p_{t+1} + \alpha_5 u_{1t} - \alpha_6 u_{2t} \tag{9}$$

$$x_t = (1-\psi_4) p^* + 0.25(E_{t-1} x_{t+1} + 2E_{t-1} x_t + x_{t-1}) + 0.5\psi_1 (E_{t-1} y_t + E_{t-1} y_{t+1}) + \tag{10}$$
$$0.5\psi_2 (E_{t-1} p_t + E_{t-1} p_{t+1}) - 0.5\psi_3 (E_{t-1} p_{t+1} + E_{t-1} p_{t+2}) + 0.5 f(hE_{t-1} y_t + (1-h) E_{t-1} y_{t+1}) + u_{4t}$$

For ϕ's, and α's see the appendix below.

In order to solve equations (8), (9), and (10) simultaneously we substitute expressionssuch as $E_t y_{t+1}$, $E_t P_{t+1}$, $E_{t-1} x_{t+1}$, etc. For this purpose, we may make use of the method of undetermined coefficients. By inspecting the model and equations (8), (9), and (10) above, one can assume the following trial solution of y_t, x_t, and p_t:

$$y_t = \delta_0 + \delta_1 x_{t-1} + \delta_2 u_{1t} + \delta_3 u_{2t} + \delta_4 u_{3t} + \delta_5 u_{4t} \tag{11}$$

$$x_t = \beta_0 + \beta_1 x_{t-1} + \beta_2 u_{1t} + \beta_3 u_{2t} + \beta_4 u_{3t} + \beta_5 u_{4t} \tag{12}$$

$$p_t = \gamma_0 + \gamma_1 x_{t-1} + \gamma_2 u_{1t} + \gamma_3 u_{2t} + \gamma_4 u_{3t} + \gamma_5 u_{4t} \tag{13}$$

In order to avoid non-uniqueness problem, which is quite common in rational expectation models, we have not included additional lags of x_t (see McCallum (1983) for details). By using equations (11), (12), and (13) we can derive expressions for $E_t y_{t+1}$, $E_t P_{t+1}$, $E_{t-1} x_{t+1}$, etc. By substituting these expressions back into equation (8), (9), and (10) and after several manipulations the following reduced form equations for y_t, x_t and p_t can be derived .

$$y_t = k_0 + k_1 x_{t-1} + k_2 u_{1t} + k_3 u_{2t} + k_4 u_{3t} + k_5 u_{4t} \tag{14}$$

$$x_t = \upsilon_0 + \upsilon_1 x_{t-1} + u_{4t} \tag{15}$$

$$p_t = \xi_0 + \xi_1 x_{t-1} + \xi_2 u_{1t} + \xi_3 u_{2t} + \xi_4 u_{3t} + \xi_5 u_{4t} \tag{16}$$

For k's, υ's, and ξ's see the appendix.

We have now two reduced form y_t, x_t of and p_t . For rational xpectation consistency, we need:

$$\delta_0 = \kappa_0,\ \delta_1 = \kappa_1,\ \delta_2 = \kappa_2,\ \delta_3 = \kappa_3,\ \delta_4 = \kappa_4, \delta_5 = \kappa_5$$

$$\gamma_0 = \xi_0,\ \gamma_1 = \xi_1,\ \gamma_2 = \xi_2,\ \gamma_3 = \xi_3,\ \gamma_4 = \xi_4, \gamma_5 = \xi_5$$

$$\beta_0 = \upsilon_0, \beta_1 = \upsilon_1,\ \beta_2 = 0,\ \beta_3 = 0, \beta_4 = 0, \beta_5 = 1 \tag{17}$$

The model can be solved by making use of non-linear equations given in (17). The solution of the model is presented in the appendix.

4. Calibration of the Model

Since the model involves a system of difference equations, an analytical solution may not be possible. In order to assess the out come of various exchange rate policies, we carried out a simulation exercise. In the first stage, we solved the system of non-linear equations given in (17) above by making use of plausible parameters values such that the system remains stable. A mere inspection of equations (14), (15) and (16) above, reveals that the model would be stable if and only if $|\upsilon_1| < 1$. For calibration purposes, we have selected the following parameter values, which were taken from the work of Delong and Summer (1986) and Scarth and Myers (1990):

$c_1 = 3$, $c_2 = 0.8$, $a_1 = 5$, $a_2 = 1$, $i = 0.01$, $f = 0.1$, and $h = 0.5$

After deriving values for $\kappa_0, \kappa_1, \kappa_2, \kappa_3, \kappa_4, \kappa_5, \upsilon_0, \upsilon_1, \xi_0, \xi_1, \xi_2, \xi_3, \xi_4$ and ξ_5, in the second stage, we calculate asymptotic variances of output, prices (see appendix for asymptotic variance of output and prices) and the following Social Welfare loss (L) for various values of parameter θ:

$$L = 0.5[\sigma_Y^2 + \sigma_p^2] \tag{18}$$

where σ_u^2 is asymptotic variance of output and σ_p^2 is asymptotic variance of prices.[4]

CASE – I

In case I, we assume that the economy is subject to a number of demand and supply shocks. In particular we assume that $\rho = 0.5$ and $\sigma_{u_{1t}}^2 = \sigma_{u_{3t}}^2 = \sigma_{u_{4t}}^2 = \sigma_{\varepsilon_t}^2 = 1$. As a result, we observe the following behavior of asymptotic variance of output, prices, and welfare loss.

[4] For an excellent discussion of the social welfare loss function, see Carlin and Soskice (2005).

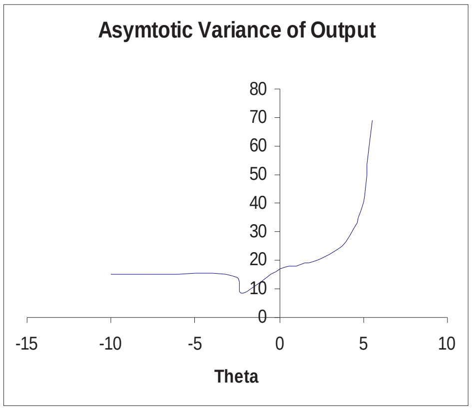

Fig. la

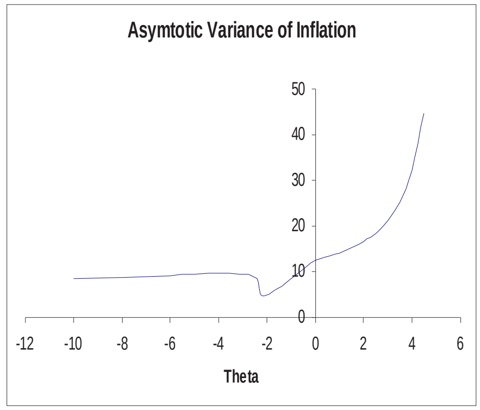

Fig. lb

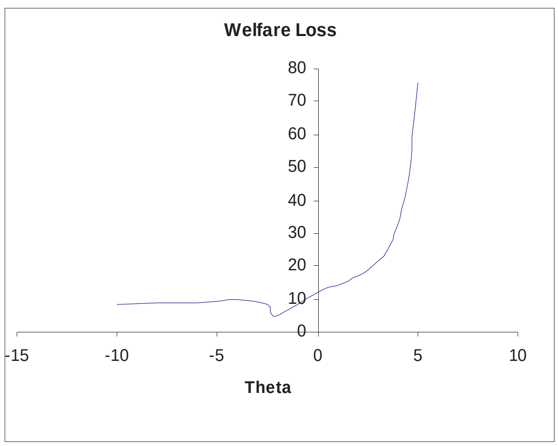

Fig. lc

CASE – II (No Cost Push Shock)

In this case, we assume that the economy is experiencing only demand side shock. In particular, we assume that $\rho = 0.5$ and $\sigma^2_{u_{1t}} = \sigma^2_{u_{3t}} = \sigma^2_{\varepsilon_t} = 1, \sigma^2_{u_{4t}} = 0$. In this particular case, we observe the following behavior of asymptotic variance of output, prices, and welfare loss.

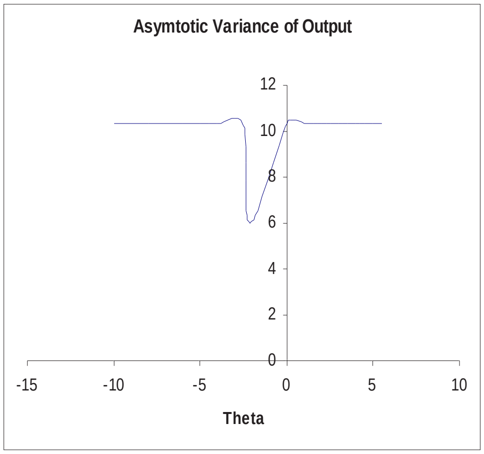

Fig. 2a

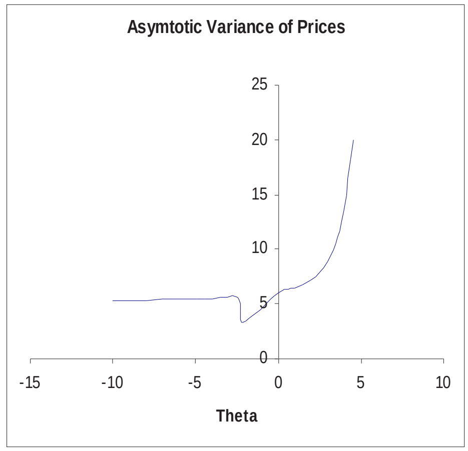

Fig. 2b

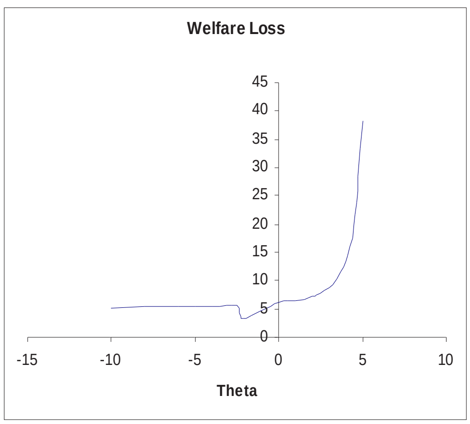

Fig. 2c

Case III (No Money Market shock)

In this case, we assume that $\rho = 0.5$ and $\sigma^2_{u_{3t}} = \sigma^2_{u_{4t}} = \sigma^2_{\varepsilon_t} = 1, \sigma^2_{u_{1t}} = 0$. In other words, the money market is stable. In this case we observe the following.

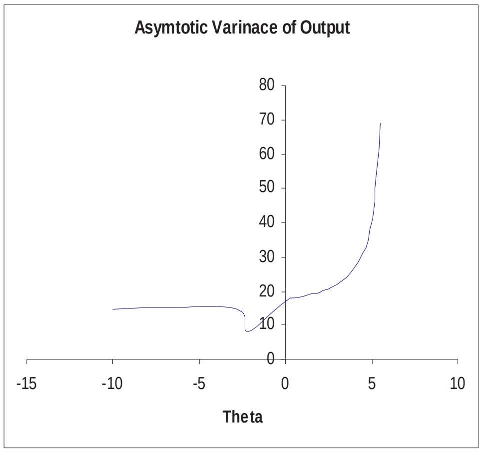

Fig. 3a

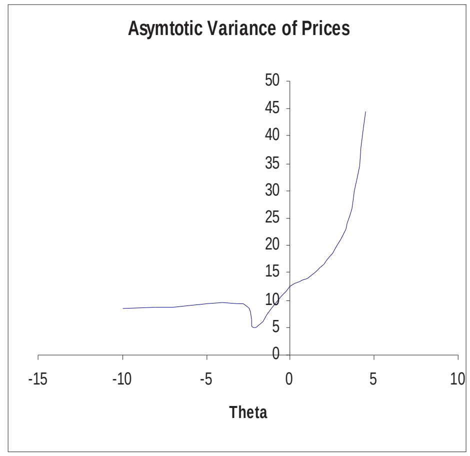

Fig. 3b

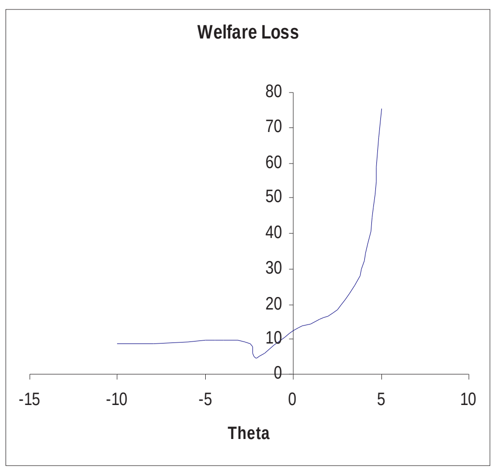

Fig. 3c

CASE IV

In case IV, we assume that $\rho = 0.5$ and $\sigma^2_{u_{3t}} = \sigma_{4t} = \sigma^2_{\varepsilon_t} = 1, \sigma^2_{u_{2t}} = 0$ (i.e., the goods market is stable). In this case, we observe the following behaviour of variances and social welfare loss.

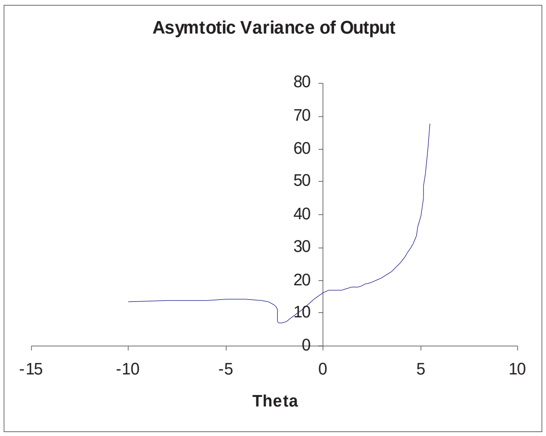

Fig. 4a

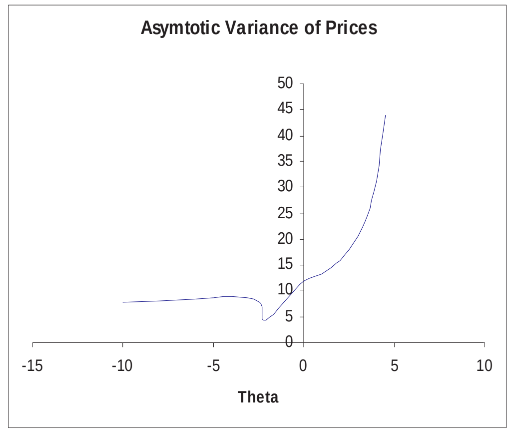

Fig. 4b

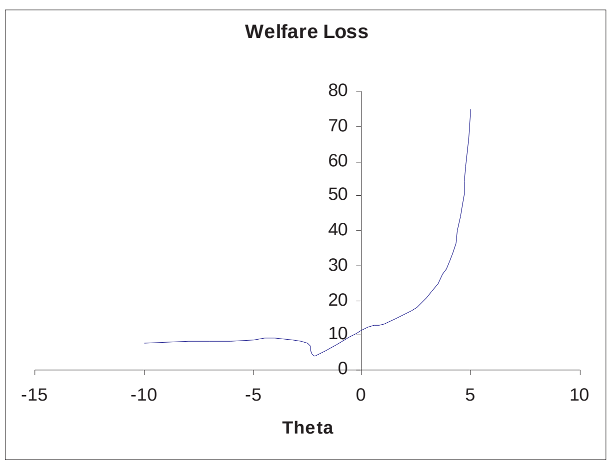

Fig. 4c

CASE V (No Foreign Exchange Market Shock)

In this case, we assume that $\rho = 0.5$ and $\sigma^2_{u_{1t}} = \sigma_{4t} = \sigma^2_{\varepsilon_t} = 1, \sigma^2_{u_{3t}} = 0$

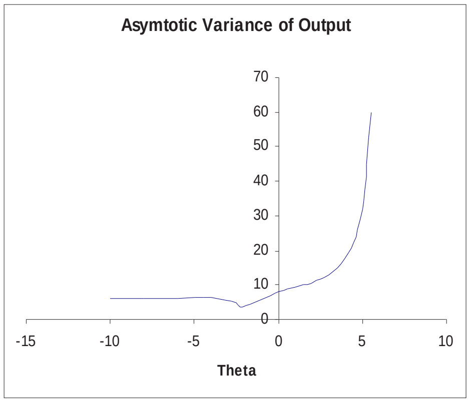

Fig. 5a

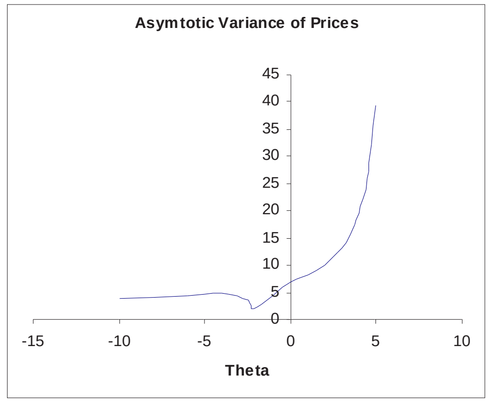

Fig. 5b

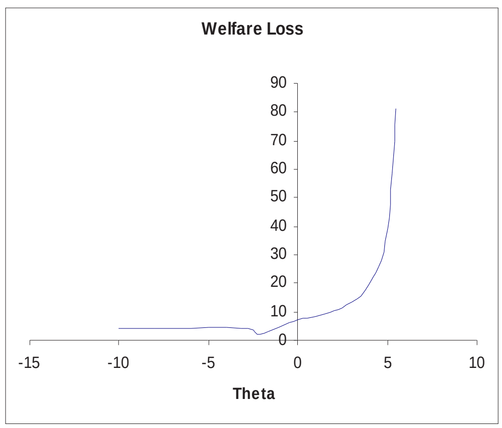

Fig. 5c

All the above cases suggest that leaning against the wind ($\theta < 0$) minimizes asymptotic variance of output and prices in general and social welfare loss in particular. We also noticed that in most of the cases, social welfare loss is at a minimum when θ takes a value close to -2. These results are in sharp contrast to conventional wisdom. It is generally believed that leaning with the wind could be a better answer to random shocks. The philosophy behind this belief runs as follows. In the event of say a negative demand side shock, both prices and output would fall. However, due to lower prices, exports of the country would increase and this increase would beeven more if central bank intervenes and buys foreign currency and allows the exchange rate to depreciate. If Marshal-Lerner condition holds then exchange rate depreciation would increase net exports, which in turn would counter the negative demand-side shock largely, and help in improving balance of payments position of the country. On the contrary, our results suggest that leaning against the wind is a right strategy. Unlike conventional models, our model has both demand-side and supply-side effects of exchange rate. In our model along with positive demand-side effects of exchange rate, exchange rate has also negative supply-side effects. A depreciated currency would cause unavoidable increase in the cost of production, at least in the short-run. This follows from the fact that in order to maintain the quality of final goods, expensive imported inputs cannot be substituted with cheap but low quality locally produced inputs. Moreover, substitution is also not possible due to technical nature of production process. The net effect of deprecation, however, depends upon the competing effects of demand-side and supply-side effects of the exchange rate. Our calibrations reveal that supply-side effects of exchange rate would dominate and thus leaning against the wind makes sense. Likewise, in the event of say negative demand side shock, there is a pressure on both output and prices to fall. In this situation, however, if central bank sells dollar in the open market, exchange rate would improve which puts pressure on exports to fall. However, at the same time, an appreciated local currency would make imported input less expensive and that in turn has positive supply-side effects. As we noted above that the calibrations of our model suggest that supply-side effects of exchange rate, on average, dominate the demand side effects.

The negative effects of exchange rate depreciation are profound in LDCs case, not only, because of imported inputs, but also, due to large foreign debt. In the case of exchange rate depreciation, the real foreign debt for such countries would increase significantly. In these circumstances, LDCs suffer not only due to high cost of production but also due to burden of foreign debt. In recent times, we notice that LDCs resort to foreign borrowing and end up in debt trap situation.

CASE VI (Wages are less flexible)

In this case we assume that $\rho = 0.5$ and $\sigma^2_{u_{1t}} = \sigma_{3t} = \sigma_{4t} = \sigma^2_{\varepsilon_t} = 1$, and $f = 0$. This is the case when wages are less flexible.

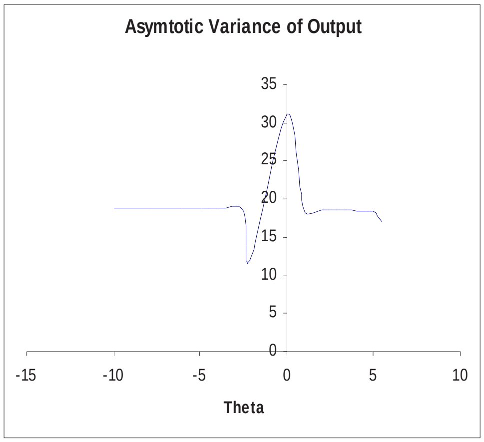

Fig. 6a

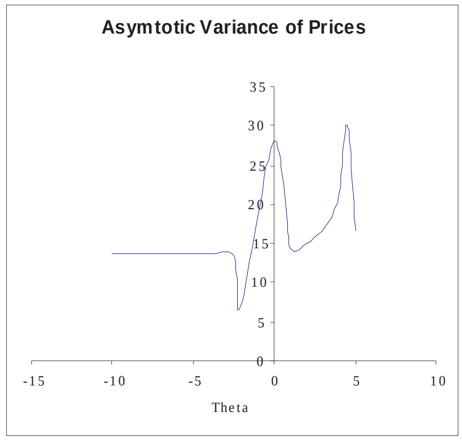

Fig. 6b

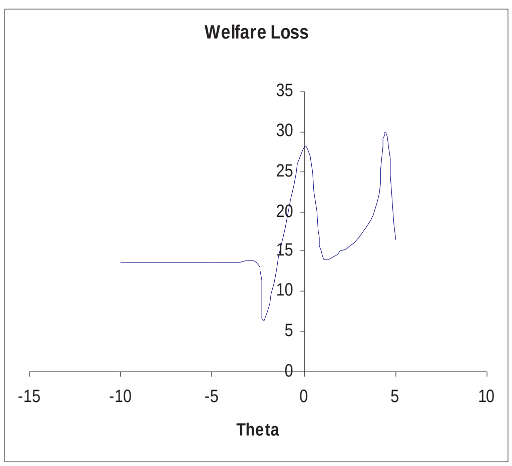

Fig. 6c

In this case, we note that Keynesian concern that when wages are less flexible then best way to go about is to follow a fixed exchange rate policy. Figure 6 suggests that if government follows a dirty floating exchange rate policy then variance of output, prices, and welfare loss follow a cyclical behavior.

5. Conclusion

This paper examined the choice of an appropriate exchange rate policy for developing countries. This paper utilized a model that has both demand-side and supply-side exchange rate effects. We assumed in particular that the small open economy produces a final good by combining imported and locally produced intermediate inputs. We also assumed that workers enter into a two-period wage contract with firms. Due to complexities involved in the solution of model, this paper considered a numerical solution. By means of a simulation exercise, we examined social welfare loss and the behaviour of the asymptotic variance of the output and prices. The exchange rate options considered include (i) fixed exchange rate policy, (ii) perfectly flexible exchange rate policy, (iii) leaning against the wind and (iv) leaning with the wind. We considered various types of shocks. For example, goods market shocks, money market shocks, foreign exchange market shocks and supply-side shocks. In general, contrary to conventional wisdom, we found that in the event of a shock, leaning against the wind is likely to be the most appropriate exchange rate policy. However, we found the fixed exchange rate policy to be useful only when wages are less flexible. This result supports orthodox Keynesian wisdom that in the event of rigid wages a fixed exchange rate policy could be better.

While this paper does not capture all aspects of the current Chinese economy, the results presented in this paper can provide useful lessons to a developing country like China. Trade imbalance with the rest of the world has resulted in increased pressure on China to re-value its currency. India on the other hand has wage and exchange rate flexibility. China would have to allow greater wage flexibility if it is to embark on a flexible exchange rate policy.

APPENDIX

Derivation of Equation (8)

From equation (7) we may have:

$$E_{t-1}p_t = 0.5(E_{t-1}x_t + x_{t-1}) + \bar{p}^m + E_{t-1}e_t \qquad \text{(A1)}$$

$$E_{t-1}p_{t+1} = 0.5(E_{t-1}x_{t+1} + x_t) + \bar{p}^m + E_{t-1}e_{t+1} \qquad \text{(A2)}$$

Adding (A1) and (A2) gives:

$$E_{t-1}p_t + E_{t-1}p_{t+1} = 0.5(E_{t-1}x_{t+1} + 2E_{t-1}x_t + x_{t-1}) + 2\bar{p}^m + E_{t-1}e_t + E_{t-1}e_{t+1} \qquad \text{(A3)}$$

Substituting (A3) into (6) gives:

$$x_t = 0.25(E_{t-1}x_{t+1} + 2E_{t-1}x_t + x_{t-1}) + p^* + 0.5E_{t-1}e_t + 0.5E_{t-1}e_{t+1} + 0.5f(hE_{t-1}y_t + (1-h)E_{t-1}y_{t+1}) + u_{4t} \qquad \text{(A4)}$$

To substitute out expressions involving e_t we may proceed as follows.

From (3) and (5) we may write:

$$r_t + E_t p_{t+1} - p_t = \bar{i} + E_t e_{t+1} - e_t + u_{3t} \qquad \text{(A5)}$$

In addition, from (1) and (4) after setting $\bar{m} = \bar{e} = 0$ we can write:

$$r_t = \frac{a_2}{a_1}y_t - \frac{\beta}{a_1}e_t + \frac{1}{a_1}p_t - (E_t p_{t+1} - p_t) + \frac{1}{a_1}u_{1t} \qquad \text{(A6)}$$

Substituting (A6) into (2) gives:

$$e_t = \Psi_1 y_t + \Psi_2 p_t - \Psi_3 E_t p_{t+1} - \Psi_4 p^x - \Psi_5 u_{2t} + \Psi_6 u_{1t} \qquad \text{(A7)}$$

where $\Psi_0 = c_1\theta + c_2a_2$; $\Psi_1 = (a_1 + c_1a_2)/\Psi_0$; $\Psi_2 = (c_1 + c_2a_1 + c_1a_1)/\Psi_0$

$\Psi_3 = c_1a_1/\Psi_0$; $\Psi_4 = c_2a_1/\Psi_0$; $\Psi_5 = a_1/\Psi_0$; $\Psi_6 = c_1/\Psi_0$.

From (1), (4), and (5) we may write:

$$p_t = -a_2 y_t + a_1\bar{i} + a_1 E_t e_{t+1} - (a_1 - \theta)e_t + a_1 u_{3t} - u_{4t} \qquad \text{(A8)}$$

From (14) we may have:

$$E_t e_{t+1} = \psi_1 E_t y_{t+1} + \psi_2 E_t p_{t+1} - \psi_3 E_t p_{t+2} - \psi_4 p^x \qquad \text{(A9)}$$

Substituting (A7) and (A9) back into (A8) we will get equation (8) reported in the text:

$$y_t = \phi_1 + \phi_2 E_t y_{t+1} - \phi_3 p_t + \phi_4 E_t p_{t+1} - \phi_5 E_t p_{t+2} - \phi_6 u_{1t} + \phi_7 u_{2t} + \phi_8 u_{3t} \qquad \text{(A10)}$$

where $\phi_0 = a_2 + (a_1 - \theta)\psi_1$; $\phi_1 = (a_1 \bar{i} - \beta\psi_4 p^*)/\phi_0$; $\phi_2 = a_1\psi_1/\phi_0$; ϕ_3 $= (1 + (a_1 - \theta)\psi_2)/\phi_0$

$\phi_4 = (a_1\psi_2 + (a_1 - \theta)\psi_3)/\phi_0$; $\phi_5 = a_1\psi_3/\phi_0$; $\phi_6 = (1 + (a_1 - \theta)\psi_6)/\phi_0$; ϕ_7 $= (a_1 - \theta)\psi_5/\phi_0$; $\phi_8 = a_1/\phi_0$.

Derivation of Equation (9)

Substituting (A7) into (7) gives equation (9) reported in the text.

$$p_t = \alpha_1 + \alpha_2(x_t + x_{t-1}) + \alpha_3 y_t - \alpha_4 E_t p_{t+1} + \alpha_5 u_{1t} - \alpha_6 u_{2t} \qquad \text{(A11)}$$

where $\alpha_0 = 1 - \psi_2$; $\alpha_1 = (p^* - \psi_4 p^*)/\alpha_0$; $\alpha_2 = 0.5/\alpha_0$; $\alpha_3 = \psi_1/\alpha_0$;α_4 $= \psi_3/\alpha_0$; $\alpha_5 = \psi_6/\alpha_0$; $\alpha_6 = \psi_5/\alpha_0$.

Derivation of equation (11)

From (A7) we may have:

$$E_{t-1}e_t + E_{t-1}e_{t+1} = \psi_1(E_{t-1} + E_{t-1}y_{t+1}) + \psi_2(E_{t-1}p_t + E_{t-1}p_{t+1}) - \psi_3 (E_{t-1}p_{t+1} + E_{t-1}p_{t+2}) - 2\psi_4 p^* \qquad \text{(A12)}$$

Substituting (A12) into (A4) gives equation (11) reported in the text.

$$x_t = (1 - \psi_4)p^* + 0.2(E_{t-1}x_{t+1} + 2E_{t-1}x_t + x_{t-1}) + 0.5\psi_1(E_{t-1}y_t + E_{t-1}y_{t+1}) + 0.5\psi_2(E_{t-1}p_t + E_{t-1}p_{t+1}) - 0.5\psi_3(E_{t-1}p_{t+1} + E_{t-1}p_{t+2}) + 0.5f(hE_{t-1}y_t + (1-h)E_{t-1}y_{t+1}) + u_{4t} \qquad \text{(A13)}$$

Derivation of Equations (14), (15), and (16)

Using equations (11), (12), and (13) we can derive the following expressions:

$$E_{t-1}x_t = \beta_0 + \beta_1 x_{t-1}$$

$$E_{t-1}x_{t+1} = \beta_0 + \beta_1\beta_0 + \beta_1^2 x_{t-1}$$

$$E_t x_{t+1} = \beta_0 + \beta_1\beta_0 + \beta_1^2 x_{t-1} + \beta_1\beta_2 u_{1t} + \beta_1\beta_3 u_{2t} + \beta_1\beta_5 u_{4t}$$

$$E_{t-1}p_t = \gamma_1 + \gamma_1 x_{t-1}$$

$$E_{t-1}p_{t+1} = \gamma_0 + \gamma_1\beta_0 + \gamma_1\beta_1 x_{t-1}$$

$$E_{t-1}p_{t+2} = \gamma_0 + \gamma_1\beta_0 + \gamma_1\beta_0\beta_1 + \gamma_1\beta_1^2 x_{t-1}$$

$$E_t p_{t+1} = \gamma_0 + \gamma_1\beta_0 + \gamma_1\beta_1 x_{t-1} + \gamma_1\beta_2 u_{1t} + \gamma_1\beta_3 u_{2t} + \gamma_1\beta_4 u_{3t} + \gamma_1\beta_5 u_{4t}$$

$$E_t p_{t+2} = \gamma_0 + \gamma_1\beta_0 + \gamma_1\beta_1\beta_0 + \gamma_1\beta_1^2 x_{t-1} + \gamma_1\beta_1\beta_2 u_{1t} + \gamma_1\beta_1\beta_3 u_{2t}$$
$$+\gamma_1\beta_1\beta_4 u_{3t} + \gamma_1\beta_1\beta_5 u_{4t}$$

$$E_{t-1}y_t = \delta_0 + \delta_1 x_{t-1}$$

$$E_{t-1}y_{t+1} = \delta_0 + \delta_1\beta_0 + \delta_1\beta_1 x_{t-1}$$

$$E_t y_{t+1} = \delta_0 + \delta_1\beta_0 + \delta_1\beta_1 x_{t-1} + \delta_1\beta_2 u_{1t} + \delta_1\beta_3 u_{2t} + \delta_1\beta_4 u_{3t} + \delta_1\beta_5 u_{4t}$$

Substituting above expressions back in (8), (9), and (10) and after doing a series of manipulations, we get equations (14), (15), and (16) reported in the text.

$$y_t = k_0 + k_1 x_{t-1} + k_2 u_{1t} + k_3 u_{2t} + k_4 u_{3t} + k_5 u_{4t} \tag{A14}$$

$$x_t = \upsilon_0 + \upsilon_1 x_{t-1} + u_{4t} \tag{A15}$$

$$p_t = \xi_0 + \xi_1 x_{t-1} + \xi_2 u_{1t} + \xi_3 u_{2t} + \xi_4 u_{3t} + \xi_5 u_{4t} \tag{A16}$$

$$\kappa_3 = \phi_2\delta_1\beta_3 - \phi_3\gamma_3 + \phi_4\gamma_1\beta_3 - \phi_5\gamma_1\beta_1\beta_3 + \phi_7;$$

$$\kappa_0 = \phi_1 + \phi_2\delta_0 + \phi_2\delta_1\beta_0 - \phi_3\gamma_0 + \phi_4\gamma_0 + \phi_4\gamma_1\beta_0 - \phi_5\gamma_0 - \phi_5\gamma_1\beta_0 - \phi_5\gamma_1\beta_1\beta_0;$$

$$\kappa_1 = \phi_2\delta_1\beta_1 - \phi_3\gamma_1 + \phi_4\gamma_1\beta_1 - \phi_5\gamma_1\beta_1^2; \kappa_2 = \phi_2\delta_1\beta_1 - \phi_3\gamma_2 + \phi_4\gamma_1\beta_2 - \phi_5\gamma_1\beta_1\beta_2 - \phi_6;$$

$$\kappa_4 = \phi_2\delta_1\beta_4 - \phi_3\gamma_4 + \phi_4\gamma_1\beta_4 - \phi_5\gamma_1\beta_1\beta_4 + \phi_8; \kappa_5 = \phi_2\delta_1\beta_5 - \phi_3\gamma_5 + \phi_4\gamma_1\beta_5 - \phi_5\gamma_1\beta_1\beta_5$$

$$\upsilon_0 = (1-\psi_4)p^* + 0.75\beta_0 + 0.25\beta_0\beta_1 + \psi_1\delta_0 + 0.5\psi_1\delta_1\beta_0 + \psi_2\gamma_0 + 0.5\psi_2\gamma_1\beta_0$$

$$-\psi_3\gamma_0 - \psi_3\gamma_1\beta_0 - 0.5\psi_3\gamma_1\beta_1\beta_0 + 0.5f\delta_0 + 0.5f(1-h)\delta_1\beta_0$$

$$\upsilon_1 = 0.25\beta_1^2 + 0.5\beta_1 + 0.25 + 0.5\psi_1\delta_1 + 0.5\psi_1\delta_1\beta_1 + 0.5\psi_2\gamma_1 + 0.5\psi_2\gamma_1\beta_1 -$$

$$0.5\psi_3\gamma_1\beta_1 - 0.5\psi_3\gamma_1\beta_1^2 + 0.5fh\delta_1 + 0.5f(1-h)\delta_1\beta_1$$

$$\xi_0 = \alpha_1 + \alpha_2\beta_0 + \alpha_3\delta_0 - \alpha_4\gamma_0 - \alpha_4\gamma_1\beta_0;\ \xi_1 = \alpha_2\beta_1 + \alpha_2 + \alpha_3\delta_1 - \alpha_4\gamma_1\beta_1$$

$$\xi_2 = \alpha_2\beta_2 + \alpha_3\delta_2 - \alpha_4\gamma_1\beta_2 + \alpha_5;\ \xi_3 = \alpha_2\beta_3 + \alpha_3\delta_3 - \alpha_4\gamma_1\beta_3 - \alpha_6$$

$$\xi_4 = \alpha_2\beta_4 + \alpha_3\delta_4 - \alpha_4\gamma_1\beta_4;\ \xi_5 = \alpha_2\beta_5 + \alpha_3\delta_5 - \alpha_4\gamma_1\beta_5$$

Derivation of Asymptotic Variance of Output, wages, and Prices

Rewriting equation (15)

$$x_t = \upsilon_0 + \upsilon_1 x_{t-1} + u_{4t} \qquad \text{(A17)}$$

From (A17) we may have:

$$E_{t-\infty}x_t = \upsilon_1 + \upsilon_1 E_{t-\infty}x_{t-1} \qquad \text{(A18)}$$

Using (A17) and (A18) reader can readily drive

$$E(x_t - E_{t-\infty}x_t)^2 = \upsilon_1^2 E(x_{t-1} - E_{t-\infty}x_{t-1})^2 + E(u_{4t})^2$$

$$\sigma_{x_t}^2 = \frac{\sigma_{u_{4t}}^2}{1-\upsilon_1^2}$$

where $\sigma_{x_t}^2 = E(x_t - E_{t-\infty}x_t)^2 = E(x_{t-1} - E_{t-\infty}x_{t-1})^2$; $\sigma_{u_{4t}}^2 = E(u_{4t})^2$.

Similarly, reader can easily derive the following asymptotic variances of output and prices:

where $\sigma_y^2 = \kappa_1^2\sigma_x^2 + \kappa_2^2\sigma_{u_{1t}}^2 + \kappa_3^2\sigma_{u_{2t}}^2 + \kappa_4^2\sigma_{u_{3t}}^2 + \kappa_5^2\sigma_{u_{4t}}^2$;

$$\sigma_p^2 = \xi_1^2\sigma_x^2 + \xi_2^2\sigma_{u_{1t}}^2 + \kappa_3^2\sigma_{u_{2t}}^2 + \xi_4^2\sigma_{u_{3t}}^2 + \xi_5^2\sigma_{u_{4t}}^2;\ \sigma_{2t}^2 = \frac{\sigma_{\varepsilon t}^2}{1-\rho^2}$$

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Abstract

Even though globalization benefits less developed countries (LDCs), it also makes them more vulnerable to the exogenous shocks to the economies. Many LDCs rely on imported technologies and intermediate inputs to compete in the international export markets with better quality and cost efficient products. In this regard, exchange rate policies in respective countries have a direct bearing on the cost of production. This paper examines alternative exchange rate regimes to suggest an appropriate exchange rate policy in the context of developing countries. The paper utilizes a small open economy model involving direct supply-side effects of exchange rate and expectations of key economic variables and considers four possible exchange rate policies, e.g., fixed exchange rate, perfectly flexible exchange rate, leaning against the wind, and leaning with the wind. Contrary to the conventional wisdom, the paper finds that in the event of a shock, leaning against the wind is likely to be the most appropriate exchange rate policy. Moreover, in the event of rigid wages, a fixed exchange rate policy is advisable.

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