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Stability, Wage Contracts, Rational Expectations, and Devaluations*

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I. INTRODUCTION

The effects of devaluations on economies have caused a great deal of concern in recent years. Conventional economists such as Robinson (1947) and Meade (1951) hold the view that due to high unemployment and the absence of any supply-side effects of the exchange rates, devaluation will increase employment if it increases the demand for home goods. A number of papers have been written which seriously challenge this result on a number of grounds. For example, Turnovsky (1981) has derived the result that if agents under-predict changes in the exchange rate then output will increase with devaluation. On the other hand, if agents over predict changes in the exchange rate then output will reduce with devaluation. However, economists such as Calvo (1983) and Larrian and Sachs (1986) have supported the standard result by arguing that the stability of the system is sufficient to rule out perverse outcomes of devaluation. Buffie (1986), on the other hand, has derived the result that for stable economies, devaluation may or may not increase output. However, Buffie shows that if the production function is separable between primary factors and the imported input then devaluation will increase employment. Lai and Chang (1989) have derived the result that currency devaluation has a negative impact on output if workers are free from money illusion. Gylfason and Schmid (1983), report a similar result: if the real wage is assumed to be constant then devaluation contracts the real income.

The perverse effect of devaluation follows from the fact that the aggregate supply function of goods shifts up in response to changes in the exchange rate. In recent papers, economists have attempted to develop a more realistic supply-side of the economy. In doing so, however, they have enriched their models to the point that ambiguous results are obtained. In this paper we have attempted to study the short-run and long-run effects of devaluation of the domestic currency, numerically, in a stochastic model with variable employment, output, and prices. We have

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developed a model which involves both demand-side and supply-side effects of the exchange rate. Contrary to the studies cited above we have paid special attention to the nature of wage contracts. In our model, labour has a two-period wage contract. In this circumstance we have direct supply-side effects of the exchange rate in two periods. The findings of our study reveal that in stable economies, for plausible sets of parameter values, devaluation exerts a positive effect upon output both in the short and medium run. Devaluation is neutral in the long run.

II. THE MODEL

The model is defined by the following equations:

$$m_t - p_t = a_2 Y_t - a_1 i_t + u_{1t} \quad \ldots \quad \ldots \quad (1)$$

$$Y_t = -c_1 r_t + c_2(e_t - p_t^d + \bar{p}^m) + u_{2t} \quad \ldots \quad (2)$$

$$i_t = \bar{\imath} + u_{3t} \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$p_t = \gamma p_t^d + (1-\gamma)(e_t + \bar{P}^m) \quad \ldots \quad \ldots \quad (4)$$

$$i_r = r_t + E_t p_{t+1} - p_t \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Assuming that production of goods depends on labour and the fixed stock of capital, and that the marginal productivity of labour is constant, the supply-side of the model follows from this wage setting rule:

$$X_t = 0.5\left[E_{t-1} p_t + E_{t-1} p_{t+1} + f(hE_{t-1} Y_t + (1-h) E_{t-1} Y_{t+1})\right] + u_{4t} \quad \ldots \quad \ldots \quad (6)$$

where

m_t = *ln* of money stock;
p_t = *ln* of consumer price index (CPI);
p_t^d = *ln* of domestic price of good Y_t;
X_t = *ln* of nominal wage rate;
Y_t = *ln* of domestic output;
e_t = *ln* of nominal exchange rate;
$E_{t-j}p_{t-j}$ = mathematical expectation of p_{t-j};
u_{jt} = disturbance term;
$E_{t-j}Y_{t-j}$ = mathematical expectation of Y_{t-j};
r_t = real interest rate;
i_t = nominal domestic interest rate;
$\bar{\imath}$ = foreign interest rate; and
$\bar{p}^m$ = *ln* of foreign price of imported good.

We start by explaining the model's supply-side. It is assumed that workers, who are free of any money illusion, make a contract with firms for two periods. For example, at time $t-1$ a group of workers, whose contract is expiring at time $t-1$, makes a contract with the firm for periods t and $t+1$. Equation (6) indicates that to make the contract, workers use their expectations regarding the consumer price index p_t, p_{t+1} and output Y_t, Y_{t+1}, which are expected to prevail in period t and $t+1$. The parameters $(1-h)$ and h are the weight associated to the output 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 the period t and $t+1$. An important point to note is that due to the inclusion of the consumer price index in Equation (6) we have allowed for the supply-side effects of the exchange rate. For instance, if at time t the central bank devalues the currency, then the group of workers who are negotiating their wages for period $t+1$ and $t+2$ will take into account this increase in the price of the foreign currency. This will increase the average wage paid by the firms in the subsequent periods. Which in turn increases the cost of production. The disturbance term, u_{4t}, captures the stochastic shift in the wage rate. One final thing to note here is that the exchange rate is an exogenous variable and devaluation of the domestic currency is always an unanticipated event.[1]

Since we assume that the marginal productivity of labour is constant and equal to 1 then firms must set the price of goods at

$$p_t^d = 0.5\,(X_t + X_{t-1}) \quad \ldots \quad \ldots \quad \ldots \qquad (7)$$

This completes the basic structure of the supply-side of the model. Now we briefly describe the demand-side of the model. Equation (1) defines the equilibrium in the money market. It is assumed that demand for real money balances M/p is positively related to output and negatively related to the nominal interest rate. Equation (2) shows that the demand for goods is negatively related to the real interest rate but positively related to the terms of trade $e_t\, p^{-m}/p_t^d$. The disturbance terms, u_{1t} and u_{2t} capture random shocks in the money and goods markets respectively. Equation (3) defines perfect capital mobility. The stock of money M always makes a discrete jump to keep the domestic nominal interest rate, i_t, equal to the foreign interest rate, $\bar{\imath}$, plus the stochastic fluctuation in the foreign interest rate, u_{3t}. Equation (4) defines the consumer price index; it is the price of the basket of goods which contains both domestically produced goods and imported final goods. Equation (5) explains the difference between the nominal and the real interest rate. The real interest rate, r_t is equal to the nominal interest rate, i_t, minus the expected inflation, $E_t p_{t+1} - p_t$. This completes the explanation of the basic structure of the model. In the short–run we have seven endogenous variables: Y_t, p_t, p_t^d, r_t, m_t, and X_t which give values by solving Equations (1) to (7) simultaneously.

[1]See Turnovsky (1981) for a model in which agents form expectations about possible changes in the exchange rate and the foreign price level.

We assume throughout that the disturbance terms $u_{1t},..,u_{4t}$, have zero means, constant variances, and are independently distributed.

III. PRELIMINARY MANIPULATIONS

By solving Equations (1) to (7), we can express the model in more compact form as:

$$X_t + \quad 0.5\left[0.5\gamma\left(E_{t+1}X_{t-1} + 2E_{t-1}X_t + X_{t-1}\right) + 2(1-\gamma)(e_{t-1} + p^{-m}) + f.(hE_{t-1}Y_t + (1-h)E_{t-1}Y_{t+1})\right] + \mu_{4t} \quad \ldots \tag{8}$$

$$Y_t = -c_1\bar{i} + 0.5\,\gamma\,c_1E_tX_{t+1} + c_2e_t + c_2p^{-m} - 0.5\,c_2X_t - 0.5\,(c_1\gamma + c_2)X_{t-1} + u_{2t} - c_1u_{3t} \quad \ldots \quad \ldots \tag{9}$$

Equation (8) could be considered a reduced form of the aggregate supply function of good Y_t if we substitute out the expression for $E_{t-1}X_{t+1}$, $E_{t-1}X_t$, $E_{t-1}Y_t$ and $E_{t-1}Y_{t+1}$. Equation (9), on the other hand, can be interpreted as the aggregate demand function for good Y_t. Once we obtain the expression for $E_{t-1}X_{t+1}$, $E_{t-1}X_t$, $E_{t-1}Y_t$, $E_{t-1}Y_{t+1}$, E_tX_{t+1} and X_t we can solve Equations (8) and (9) simultaneously to get the equilibrium value of output Y_t and the wage rate X_t. The method we will use in deriving the expression for $E_t\,X_{t+1}$, $E_{t-1}Y_{t+1}$ etc., is called the undetermined coefficient method. According to this method, by inspecting the model carefully, we assume a trail solution of the endogenous variables. Then using the trail solution we eliminate the expression for current and future expectations of the variables. By inspecting Equations (8) and (9) we assume the following trail solution of X_t and Y_t:

$$Y_t = \psi_1\bar{i} + \psi_2e_t + \psi_3e_{t-1} + \psi_4p^{-m} + \psi_5X_{t-1} + \psi_6u_{2t} + \psi_7u_{3t} + \psi_8u_{4t} \tag{10}$$

$$X_t = \delta_1\bar{i} + \delta_2e_{t-1} + \delta_3p^{-m} + \delta_4X_{t-1} + \delta_5u_{2t} + \delta_6u_{3t} + \delta_7u_{4t} \quad \ldots \tag{11}$$

A point to note here is that following McCallum (1983), in order to avoid the non-uniqueness problem, we exclude the additional lags of the variables Y_t and X_t in the trial solution of Y_t and X_t. Using Equations (7) to (10) the reader can readily derive the following reduced forms for Y_t and X_t:

$$Y_t = \alpha_1\,\bar{i} + \alpha_2e_t + \alpha_3e_{t-1}\ \alpha_4p^{-m} + \alpha_5X_{t-1} + \alpha_6u_{2t} + \alpha_7u_{3t} + \alpha_8u_{4t} \tag{12}$$

$$X_t = \beta_1\bar{i} + \beta_2e_{t-1} + \beta_3p^{-m} + \mu_4X_{t-1} - \beta_5u_{4t} \quad \ldots \quad \ldots \tag{13}$$

where

$$\alpha_1 = -c_1 + 0.5\,\gamma\, c_1(\delta_1 + \delta_4\delta_1) - 0.5c_2\delta_1$$

$$\alpha_2 = c_2 + 0.5\,\gamma\, c_1\,\delta_2$$

$$\alpha_3 = 0.5\,\gamma\, c_1\,\delta_4\,\delta_2 - 0.5c_2\,\delta_2$$

$$\alpha_4 = c_2 + 0.5\,\gamma\, c_1(\delta_3 + \delta_4\delta_3) - 0.5c_2\delta_3$$

$$\alpha_5 = 0.5\,\gamma\, c_1\,\delta_4^2 - 0.5c_2\,\delta_4 - 0.5\,(c_1\gamma + c_2)$$

$$\alpha_6 = 1 - 0.5\,c_2\,\delta_5$$

$$\alpha_7 = -\,(c_1 + 0.5\,c_2\,\delta_6)$$

$$\alpha_8 = -\,0.5\,c_2\,\delta_7$$

$$\beta_1 = 0.25\gamma\,(3\,\delta_1 + \delta_4\,\delta_1) + 0.5fA_1$$

$$\beta_2 = 0.25\gamma\,(3\,\delta_2 + \delta_4\,\delta_2) + 0.5fA_2 + 1 - \gamma$$

$$\beta_3 = 0.25\gamma\,(3\,\delta_3 + \delta_4\,\delta_3) + 0.5fA_3 + 1 - \gamma$$

$$\beta_4 = 0.25\gamma\,(\delta^2{}_4 + 2\delta_4 + 1) + 0.5fA_4$$

$$\beta_5 = 1$$

$$A_1 = \psi_1 + \psi_5\,\delta_1\,(1-h)$$

$$A_2 = \psi_2 + \psi_3 + \psi_5\,\delta_2\,(1-h)$$

$$A_3 = \psi_4 + \psi_5\,\delta_3\,(1-h)$$

$$A_4 = h\psi_5 + (1-h)\,\psi_5\,\delta_4$$

We have now two reduced form of Y_t and X_t. Equations (10) and (12) are the reduced form of Y_t. While, Equations (11) and (13) are the reduced form of X_t. For rational expectation consistency we need:

$$\psi_1 = \alpha_1\,,\ \psi_2 = \alpha_2\,,\ \psi_3 = \alpha_3\,,\ \psi_4 = \alpha_4\,,\ \psi_5 = \alpha_5\,,\ \psi_6 = \alpha_6\,,\ \psi_7 = \alpha_7\,,\ \psi_8 = \alpha_8$$

$$\delta_1 = \beta_1,\ \delta_2 = \beta_2\ ,\ \delta_3 = \beta_3\ ,\ \delta_4 = \beta_4\ ,\ \delta_5 = 0\ ,\ \delta_6 = 0\ \ ,\ \delta_7 = \ \beta_5 \qquad \ldots \qquad (14)$$

By solving the system of Equation (14) we will get the solution to the model.

IV. STABILITY ANALYSIS AND SHORT-RUN AND LONG-RUN EFFECTS OF DEVALUATION

Taking the first differences of Equations (12) and (13), while setting changes in all exogenous variables except the exchange rate to zero we get:

$$\Delta Y_t = \ \alpha_2\, \Delta e_t + \alpha_3 \Delta e_{t-1} + \alpha_5 \Delta\, X_{t-1} \qquad \ldots \qquad \ldots \qquad \ldots \qquad (15)$$

$$\Delta\, X_t = \ \beta_2\, \Delta e_{t-1} + \beta_4 \Delta\, X_{t-1} \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (16)$$

Assuming that initially there is no change in the exchange rate, from Equation (16) we get:

$$\Delta\, X_t = \begin{cases} \beta_2\, \Delta e_1 \sum\limits_{j=0}^{t-2} \beta_4^{\,j} & \mathit{if}\ t \geq 2 \\ 0 & \mathit{otherwise} \end{cases} \qquad \ldots \qquad \ldots \qquad (17)$$

Similarly, solving Equations (15) and (17) simultaneously we get:

$$\Delta Y_t = \begin{cases} \alpha_2 \Delta e_1 & \mathit{if}\ t = 1 \\ \alpha_2 \Delta e_1 + \alpha_3 \Delta e_1 & \mathit{if}\ t = 2 \\ \alpha_2 \Delta e_1 + \alpha_3 \Delta e_1 + \alpha_5\, \beta_2 \Delta e_1 \sum\limits_{j-0}^{t-3} \beta_4^{\,j} & \mathit{if}\ t \geq 3 \\ 0 & \mathit{otherwise} \end{cases} \quad \ldots (18)$$

Finally, using Equations (4), (9) and (16) we get:

$$\Delta p_t = \begin{cases} (1-\gamma)\Delta e_1 & \mathit{if}\ t = 1 \\ (1-\gamma)\Delta e_1 + 0.5\gamma\, \beta_2 \Delta e_1 & \mathit{if}\ t = 2 \\ (1-\gamma)\Delta e_1 + 0.5\gamma\, \beta_2 \Delta e_1 + 0.5\gamma\, \beta_2 \left(\sum\limits_{j-0}^{t-2} \beta_4^{\,j} + \sum\limits_{j=0}^{t-3} \beta_4^{\,j} \right) \Delta e_1 & \mathit{if}\ t \geq 3 \\ 0 & \mathit{otherwise} \end{cases} \qquad (19)$$

Equation (18) gives the discounted sum of change in output in the event of devaluation. While Equations (17) and (19) gives the discounted sum of change in nominal wage rate and the CPI respectively. From (17), (18) and (19) it is evident that the discounted sum of output, prices, and nominal wage rate will be on stable path if and only if $|\beta_4| < 1$.

In order to derive the impact effect of devaluation upon the endogenous variables, we first get the solution to the model. For this purpose we first need to solve the system of equation given in (14). Since it is cumbersome to obtain the mathematical solution, we solve this system for a plausible set of parameter values. Following Fischer (1988) we assume $c_1 = 0.1$, $c_2 = 0.2$, $\gamma = 0.8$. We also assume that $h = 0.5$ and $f = 0.65$. When these values are substituted in (14) we get the following solution to the model:

$$\alpha_1 = -0.09593,\ \alpha_2 = 0.22778 = \alpha_3 = -0.06097,\ \alpha_4 = 0.16681 = -\alpha_5$$

$$\beta_1 = -0.08518,\ \beta_2 = \beta_3 = 0.69454,\ \beta_4 = 0.30546$$

Since this solution to the model meets the stability condition i.e. $|\beta_4| < 1$, we proceed to study the effect of devaluation on output and prices. For a more direct comparison we have plotted the variable $\Delta Y_t (= Y_t - Y_{t-1})/Y_{t-1})$, $\Delta p_t (= (p_t - p_{t-1})/p_{t-1})$ and $\Delta X_t (= (X_t - X_{t-1})/X_{t-1})$ against time, t, which we have generated for a ten-point devaluation of the domestic currency. From Figure 1 it is evident that devaluation is expansionary in the impact period. In the first period there is a 2.28 percent increase in the output. From Figure 2, on the other hand, it can be seen that this increase in output is achieved at the expense of higher inflation. The price level has increased by 2 percent. A point to note here is that the change in the inflation rate has not exceeded the change in the exchange rate. This implies that the nominal devaluation has resulted in real devaluation (fall in competitiveness). In the second period the change in output reduces from 2.28 percent to 1.67 percent while inflation has further increased. This happens as the group of workers whose contract expired in the second period, has demanded an increase in the wage rate for the next two periods in response to the increase in the CPI and output. This can be seen in Figure 3 where the nominal wage increases from 0 percent to 6.95 percent in the second period. After the sixth period, however, the change in output becomes zero while, both inflation and the nominal wage rate increases to the full amount of the nominal devaluation i.e., 10 percent. These results re-establish the conventional belief that devaluation is expansionary in the short and medium run, but neutral in the long run. The reader can confirm easily that in the long run $\Delta X_t = \Delta m_t = \Delta p_t^d = \Delta p_t = \Delta e_t$.

The results which we have reported above although depend upon the choice of our parameter values but, do not change qualitatively when a different set of parameter values is used. More importantly, we do not get contractionary effects of devaluation for any reasonable parameter values. It is seen that devaluation has more expansionary effects both in the short and the medium run for high values of a_2, c_2, γ, while devaluation is less expansionary for high values of a_1, c_1, f, and h.

Figure 1

Output Effect

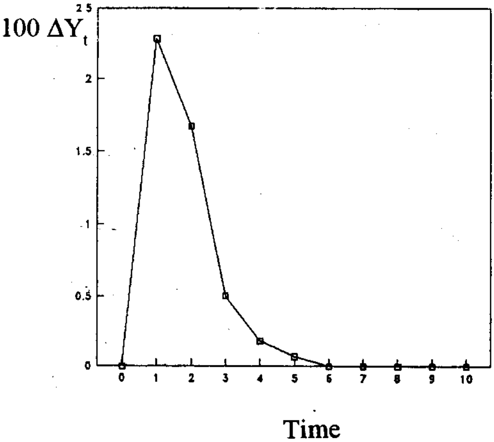


Figure 2

Price Effect

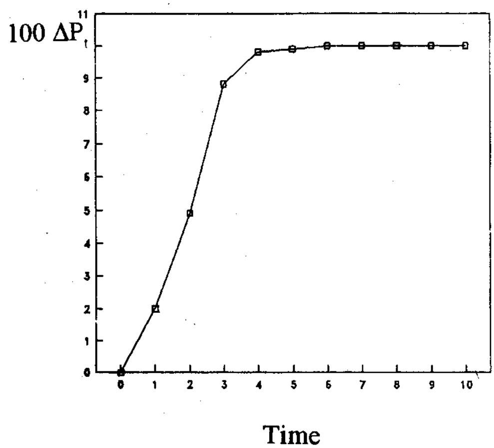
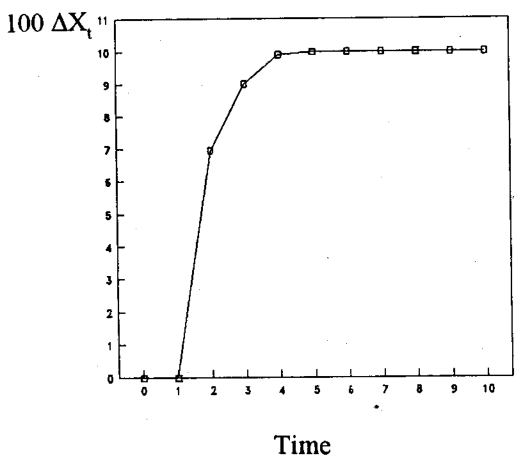


Figure 3

Wage Effect



VI. CONCLUDING REMARKS

In this paper we studied the effects of devaluation on output in a model in which partly sticky wages exist in the form of a two-period wage contract. Due to the nature of these wage contracts, half of the labour force cannot adjust their wage rate in response to a change in the CPI and output. The main finding of the paper is that for stable economies and for plausible sets of parameter values, devaluation exerts a positive impact upon output both in the short and the medium run. The scope of our study, however, is more of a theoretical nature. The model which we have developed in this paper could be considered as an approximation of a developed small open economy such as Canada. The results of our study, therefore, should not apply to less developed countries. For a less developed country we need a model which should allow a lesser degree of capital mobility. Furthermore, we should allow direct supply-side effects of the exchange rate through the inclusion of imported inputs in the model. Because in less developed countries a large fraction of the total output is produced with the combination of both domestic resources and the imported inputs. In this new model the elasticity of substitution between imported inputs and domestic inputs will play a crucial role in determining the net effect of devaluation upon the nominal and real variables of the economy.

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