THE KOREAN ECONOMIC REVIEW
Volume 19, Number 1, Summer 2003

DEVALUATION, INVESTMENT AND FACTOR INTENSITY IN TWO-SECTOR TWO-FACTOR SMALL OPEN ECONOMY*

YOUNGKUL WON**

This paper analyzes the impact of devaluation on the balance of payments, sectoral investment, aggregate investment, sectoral employment and real output in a perfect foresight dynamic optimizing model of a small open economy with two sectors and two factors of production. We emphasize the role of imported capital goods, and the labor market distortions that are prevalent in most developing countries. In particular, we trace the impact effect and the transitional dynamics of devaluation when factor intensity varies in the tradables sector. Our simulation results show that devaluation improves the balance of payments on impact in all cases considered. The more labor-intensive the tradables sector is, the smaller is the initial improvement in the balance of payments. Surprisingly, investment in the tradables sector falls in most plausible cases. Aggregate investment as well as investment in the nontradables sector always drops on impact regardless of parameter values, and it drops more as the tradables sector becomes more labor-intensive. Employment in the nontradables sector and real output of the economy fall in all cases considered. The results of the paper show that devaluation may turn out to be quite a harsh experience for developing economies, especially those with more labor-intensive tradables sector.

JEL Classification: F41, O11
Keywords: Devaluation, Investment, Factor Intensity

I. INTRODUCTION

Conventional wisdom says that devaluation improves external balances, and thus stimulates the economy by increasing real income and output at least in the

Received for publication: Feb. 20, 2003. *Revision accepted:* April 18, 2003.
* This paper was supported by a Research Promotion Fund in 2002 from the University of Seoul.
** Department of Economics, University of Seoul. I would like to thank two anonymous referees of this Review for their very insightful comments which have greatly improved this paper. I remain, of course, responsible for any errors.

short-run. In line with the conventional wisdom, devaluation has long been recommended as a part of stabilization policy package supported by the IMF and World Bank. However, there has been a concern that devaluation may be contractionary, especially in the context of less developed countries (LDCs). [see Hirschman(1949), Diaz Alejandro(1963), Cooper(1971), Krugman and Taylor (1978), Buffie(1986), Montiel and Lizondo(1989) and de Melo et al.(1991)][1] The traditional literature on contractionary devaluation relies either on contraction in aggregate demand caused by income redistribution, or on contraction in aggregate supply due to imported inputs.

One potentially important source of contractionary effects that used to be neglected is a fall in investment spending. The impact of devaluation on aggregate investment spending has been analyzed in Buffie(1986) and Risager(1988). Buffie(1986) shows that under an extremely weak condition, devaluation will lower aggregate investment, emphasizing that any favorable indirect effects working through a rise in product price are always dominated by the direct contractionary effect devaluation exerts by raising the supply price of capital goods. However, a feature of his model, namely a high level of aggregation, is open to criticism for ignoring a potential stimulus to investment resulting from a decrease in the relative price of capital goods in sectors producing traded goods in a small open economy. Risager(1988) shares the same shortcoming by focusing only on a one-sector, large economy.

Recently, Buffie and Won(2001) provides a more general analysis in a two-sector small open economy model. They investigate the effects of devaluation in a rigorous intertemporal model consistent with optimizing behavior and rational expectation. Capturing the critical tention between tradables and nontradables sectors, they show that both sectoral and aggregate investments fall on impact after a devaluation in most plausible cases considered, and remain almost always below their long-run equilibrium levels during the transitional period. Their model is, however, specified to describe a situation most appropriate for sub-Saharan LDCs with a land-using tradables sector and a capital-intensive nontradables sector, thus losing a lot in generality. Moreover, their paper focuses mainly on the impact effects of devaluation on investment, leaving the other important variables of interest largely untouched and mostly neglecting the transitional dynamics of devaluation.

Keeping the limitations of their model in mind, we improve on Buffie and Won(2001). Sharing the main feature of their model, this paper investigates the effects of devaluation on variables of interest such as the balance of payments, sectoral and aggregate investment, real output and sectoral employment, in a more general two-sector, two-factor small open economy model. Moreover, a full

[1] Gylfason and Schmid (1983) among others, on the other hand, shows that devaluation tends to increase domestic real income and output for a group of ten industrial and developing countries, thus supporting the traditional view.

general equilibrium perfect foresight dynamic optimization is adopted, thus providing complete characterizations of the transitional paths of the variables of interest. In particular, special attention is paid to the effects of devaluation with different factor intensities in the tradables sector to capture the situations of various manufacturing exporting countries.

Our simulation results reveal that the balance of payments unambiguously improves immediately after devaluation, and the economy accumulates foreign reserves before the balance of payments returns to its initial level. The initial improvement in the balance of payments, however, gets smaller as the tradables sector becomes more labor-intensive. Employment in the nontradables sector and real output fall on impact in all cases considered. Aggregate investment falls on impact following devaluation in all cases considered and remains almost always below its long-run equilibrium level during the transitional period. The economy suffers more substantial decrease in aggregate investment on impact with more labor-intensive tradables sector. Sectoral investment also falls on impact in most cases, and falls more with more labor-intensive tradables sector. Only under some extreme assumptions on the key parameters, such as very low dependence on imported capital goods in domestic capital formation and high reluctance to smooth consumption, investment in the tradables sector increases a little immediately after a devaluation. In such cases, investment in the tradables sector increases more on impact with higher labor intensity in the sector. However, in all cases considered, investment in the nontradables sector falls on impact after a devaluation, and falls generally more with labor-intensive tradables sector.

The paper proceeds as follows. In section 2, we lay out the model and derive the system of differential equations that govern the paths of variables of interest. Due to high dimensionality of the system(6×6), we are forced to rely on numerical methods to characterize the economy's dynamics. Section 3 describes how we calibrate the model with different sets of parameter values that reflect the various economic structures of LDCs. Section 4 provides the results of calibrations in detail, interpreting them in economically sensible ways. Section 5 concludes the paper.

II. THE MODEL

The model developed in the paper is in line with the monetary approach to the balance of payments in that the balance of payments is essentially a monetary phenomenon in the model. In addition, real money balances enter the utility function explicitly to take the nonpecuniary services money yields into account in the spirit of Sidrauski(1967).[2] Most importantly, the two-gap

[2] There has been a series of debates about the validity of money-in-utility function formulation. However, Feenstra(1986) convincingly demonstrates that using real balance as an argument of the utility function and entering money into liquidity costs that appear in the budget constraint are functionally equivalent.

specification of the capital goods is adopted and plays a critical role in the model.[3] In order to highlight the private sector's response to devaluation and maintain the tractability, we deliberately put the government sector behavior aside. The role of the government, or the central bank, is to simply convert foreign exchanges into domestic currency.

2.1. The Economy

2.1.1. Technology

Two types of composite goods are produced and consumed domestically, traded goods and nontraded goods. The tradables sector can be considered as the sectors which produce rudimentary manufacturing or natural resource-related products. The nontradables sector includes services and import-competing manufacturing sectors which are highly protected by trade barriers, such as import quotas and tariffs, for fostering domestic production.

Capital and labor are factors of production in both sectors. Capital is assumed, even in the long run, to be sector-specific. Once installed, it evolves over time according to a law of motion defined later. Labor, on the other hand, is intersectorally mobile. Therefore, the production relation in each sector can be described as

$$Q_T = Q_T(L_T, K_T), \tag{1-a}$$

$$Q_N = Q_N(L_N, K_N), \tag{1-b}$$

where subscripts " T " and " N " denote the tradables and the nontradables sectors, respectively. Q_i, K_i and L_i denote the output, the sector-specific capital and labor inputs used in sector i, respectively. More specifically, to simplify the analysis without limiting the possibility of various elasticities of factor substitution, we assume that both goods are produced according to a constant elasticity of substitution(CES) technology.

Since we investigate a small open economy, the domestic price of the traded good is determined solely by the exchange rate, e, the domestic currency price of a unit of foreign currency. As usual, we assume that the foreign currency price of a unit of tradables is unity for analytical simplicity. Therefore, the domestic price of the traded good is specified as

$$P_T = e, \tag{2}$$

[3] See Chenery and Bruno(1962) and McKinnon(1964) for the two-gap specification.

where P_i denotes the domestic price of good i. The general price level of the economy (CPI) is constructed according to a geometric average of the prices of nontraded goods and traded goods with their expenditure shares,

$$P = P_N^{\alpha} e^{1-\alpha}, \tag{3}$$

where α and $1-\alpha$ represent the shares of the nontradables and the tradables in aggregate consumption expenditure respectively, *i.e.*, $\alpha = (P_N D_N)/E$ and $(1-\alpha) = (eD_T)/E$, where D_i denotes the consumption demand for good i and E denotes the nominal aggregate consumption expenditure on both goods.

Constant - returns - to - scale technology, coupled with a competitive market assumption gives the following zero - profit conditions which link product prices and factor prices as

$$e = c_T(w_T, r_T) \tag{4}$$

$$P_N = c_N(w_N, r_N), \tag{5}$$

where $c_i(\cdot)$, w_i and r_i denote the unit cost function, the nominal wage rate and the capital rental rate in sector i, respectively. Following the two-gap specification, capital is assumed to be a composite good produced by combining a noncompetitive imported input such as machines, and a nontraded component such as construction services, in a fixed proportion. Denoting b_T and b_N as the input-output coefficients for the noncompetitive imported input and the nontraded components respectively, the price of an aggregate capital good, P_K, is determined as

$$P_K = b_T e + b_N P_N \tag{6}$$

For later use, it is useful to rewrite (6) in percentage changes as

$$\widehat{P_K} = (1-\beta)\hat{e} + \beta\widehat{P_N} \tag{7}$$

where $\beta(\equiv b_N P_N/P_K)$ is the cost share of the nontradables in production of an aggregate capital good, and a circumflex(^) denotes the percentage change of a variable, *i.e.*, $\hat{X} = dX/X$.

2.1.2. Factors and the nontradables markets

Considering the labor market distortion in LDCs, we assume two different wage setting procedures for the two sectors. That is, the nontradables sector is assumed to adopt a wage indexation rule to have the real consumption wage fixed, due to labor contracts or social norms, while the tradables sector follows the market-determined wage rate. The wage rate in the nontradables sector is determined so as to be higher than that of the tradables sector[4]. Therefore, the nominal wage in the nontradables sector is specified as

$$\widehat{w_N} = \gamma \widehat{P_N} + (1-\gamma)\hat{e}, \tag{8}$$

where γ and $1-\gamma$ are the indexation weights attached to the price of the nontradables and the price of the tradables, respectively.[5] The labor market, however, clears continuously via the flexible wage rate in the tradables sector so that full employment prevails at any given moment in the economy. Demand for labor in each sector can be obtained by the instantaneous profit maximization for a CES production function as:

$$L_T = a(w_T/e)^{-\sigma_T} Q_T \tag{9}$$

$$L_N = b(w_N/P_N)^{-\sigma_N} Q_N, \tag{10}$$

where a and b are constants determined by technology, and σ_i denotes the elasticity of factor substitution in sector i. Labor supply is assumed to be fixed at $\overline{L}$. Therefore, the labor market equilibrium can be defined as

$$L_T + L_N = \overline{L} \tag{11}$$

The nontradables market clears continuously via a flexible P_N. Therefore, P_N should adjust instantaneously to satisfy the following nontradables market clearing condition.

$$D_N(e, P_N, E) + b_N[I_T + \Psi_T(I_T - \delta K_T) + I_N + \Psi_N(I_N - \delta K_N)] = Q_N(L_N, K_N), \tag{12}$$

where I_i and δ denote the gross investment in sector i and the constant depreciation rate of capital goods assumed to be common in both sectors, respectively. $\Psi_i(\cdot)$ is a strictly convex adjustment costs function of net investment in sector i so that $\Psi'_i(\cdot) > 0$ as $I > \delta K$, $\Psi''_i(\cdot) > 0$ and $\Psi(0) = \Psi'(0) = 0$.[6]

[4] Several studies show that there exists a significant degree of wage differential between the two sectors in LDCs. For example, see World Development Report(1993).

[5] Since we assume that a real consumption wage is institutionally fixed, γ is, in fact, equal to α.

[6] A convex adjustment costs function is introduced to make the model consistent with the assumption of sector-specific capital as well as to reflect real world phenomena. See Gould(1968) and Lucas(1967) for classical treatment of adjustment costs function. Gould considers adjustment cost as a function of gross investment, while Lucas thinks of it as a function of net investment.

2.2. The Representative Agent's Optimization Problem

2.2.1. The optimization problem

Consumption and investment decisions are made by an infinitely-lived representative family firm having homothetic preferences. The family firm possesses perfect foresight, and selects the investment plans on both sectors and the consumption plans on both goods(expenditure) that maximize the additively separable utility function in which real money balances are included.[7] Therefore, the representative family firm's maximization problem can be stated as

$$\max_{E, I_T, I_N} \int_0^{\infty} [V(e, P_N, E) + \Phi(M/P)] \exp(-\rho t) dt$$

subject to

$$\begin{aligned} \dot{M} &= R(e, P_N, K_T, K_N, L_N) - E - P_K[I_T + \Psi(I_T - \delta K_T)] \\ &\quad - P_K[I_N + \Psi(I_N - \delta K_N)] \end{aligned} \tag{13}$$

$$\dot{K}_T = I_T - \delta K_T \tag{14}$$

$$\dot{K}_N = I_N - \delta K_N, \tag{15}$$

where ρ is the constant time discount rate, and an overdot denotes the time derivatives, *i.e.*, $\dot{X} = dX/dt$. $V(e, P_N, E)$ is the indirect utility function and retains all the properties of usual indirect utility function where $V_i = \partial V/\partial P_i < 0$, $V_E = \partial V/\partial E > 0$ and $V_{EE} < 0$. $\Phi(\cdot)$ also retains the usual properties of utility function, such as $\Phi' > 0, \Phi'' < 0$. M denotes nominal money balances. Real money balances are included in the utility function for taking into account the nonpecuniary services yielded by money holding, such as the facilitation of transactions. On the right-hand side of (13), $R(\cdot)$ is the revenue function of the family firm which equals $eQ_T + P_N Q_N$. Thus, using the envelope theorem, we get

$$\begin{aligned} &R_1(\cdot) = Q_T, \; R_2(\cdot) = Q_N, R_3(\cdot) = r_T, \; R_4(\cdot) = r_N, \\ &R_5(\cdot) = w_N - w_T, \end{aligned} \tag{16}$$

where the subscript j means the partial differentiation of the function, $R(\cdot)$, with respect to the jth argument. Notice that the revenue function depends on

[7] This specification is convenient in that demand for each good depends only on prices and aggregate expenditure, but not on real money balances. See Buffie(1993) for example.

employment in the nontradables sector (L_N), and an increase in employment in the nontradables sector raises the revenue by $w_N - w_T$ per worker. This result comes from both a sectoral wage differential and full employment in the economy. Because of full employment, nontradables sector employment (L_N) crowds out tradables sector employment (L_T) on a one for-one-basis.

The budget constraint, (13) defines the evolution of domestic nominal money balances which are accumulated as the revenue exceeds the sum of consumption expenditure and investment spending in the two sectors. With the nontradables market cleared continuously, (13) can be interpreted as the domestic excess supply of the tradables, and thus as the trade balance surplus as in Dornbusch(1973). (14) and (15) specify the capital's law of motion in each sector as usual. The representative family firm now chooses the sequences of investment in each sector and expenditure, $\{I_T, I_N, E\}$, to maximize its utility based on the expectation on the evolutions of capital in each sector and money balance, $\{K_N, K_T, M\}$.

2.2.2. Solving the maximization problem

The present value Hamiltonian function for this problem is specified as

$$\begin{aligned} H = \exp(-\rho t) \ \{ & V(e, P_N, E) + \Phi(M/P) + \lambda_1 [R(e, P_N, K_T, K_N, L_N) \\ & - E - P_K(I_T + \Psi_T(I_T - \delta K_T)) - P_K(I_N + \Psi_N(I_N - \delta K_N))] \\ & + \lambda_2 [I_T - \delta K_T] + \lambda_3 [I_N - \delta K_N]\}, \end{aligned}$$

where the co-state variables λ_i, is not necessary $(i = 1, 2, 3)$ represent the current shadow prices of money, capital in the tradables sector, and capital in the nontradables sector, respectively. Time subscripts attached to the variables are omitted for notational simplicity.

The first-order necessary conditions(FONCs)[8] for the family firm's maximization problem are thus given as

$$V_E(e, P_N, E) = \lambda_1 \tag{17}$$

$$V_E P_K [1 + \Psi'_T(I_T - \delta K_T)] = \lambda_2 \tag{18}$$

$$V_E P_K [1 + \Psi'_N(I_N - \delta K_N)] = \lambda_3, \tag{19}$$

where these three conditions are obtained by maximizing H with respect to the

[8] It is assumed that the transversality conditions for three assets are met.

three choice variables, $\{E, I_T, I_N\}$ respectively. These intertemporal, no arbitrage conditions can be interpreted in a standard way. (17) states that the shadow price of money is equal to the marginal utility of a dollar increase in consumption expenditure. (18) and (19) imply that capital's shadow price in each sector is equal to a decrease in utility that is due to a unit increase in the capital good away from consumption expenditure.

The remaining FONCs are comprised of the following co-state equations that show the optimal changes in shadow prices over time, and thus must be satisfied along the optimal path of each variable of interest:

$$\dot{\lambda}_1 = \lambda_1 \rho - \frac{\Phi'(M/P)}{P} \tag{20}$$

$$\dot{\lambda}_2 = \lambda_1[(\rho + \delta)P_K - r_T + \rho P_K \Psi'_T] \tag{21}$$

$$\dot{\lambda}_3 = \lambda_1[(\rho + \delta)P_K - r_N + \rho P_K \Psi'_N], \tag{22}$$

where we omitted the argument of the adjustment cost function for notational simplicity.

The next task is to obtain dynamic expressions for three choice variables from the information on the FONCs. Making use of (17), (20) and Roy's Identity, we obtain

$$\tau^{-1}\frac{\dot{E}}{E} = \frac{\Phi'}{PV_E} - \rho + (\tau^{-1} - 1)\alpha\frac{\dot{P}_N}{P_N}, \tag{23}$$

where $\tau (\equiv -\frac{V_E}{V_{EE}E})$ is the intertemporal elasticity of substitution that is, in turn, defined as the inverse of relative risk aversion. Similarly, combining (18) and (21) yields

$$\Psi'_T \dot{I}_T = (1 + \Psi'_T)\frac{\Phi'}{PV_E} + \delta\Psi'_T(I_T - \delta K_T) + \delta - \frac{r_T}{P_K} - \beta(1 + \Psi'_T)\frac{\dot{P}_N}{P_N} \tag{24}$$

Symmetric manipulations involving (19) and (22) give

$$\Psi'_N \dot{I}_N = (1 + \Psi'_N)\frac{\Phi'}{PV_E} + \delta\Psi'_N(I_N - \delta K_N) + \delta - \frac{r_N}{P_K} - \beta(1 + \Psi'_N)\frac{\dot{P}_N}{P_N} \tag{25}$$

We now turn to the market clearing condition in the nontradables sector, obtaining the expression for $\widehat{P_N}$ and $\dot{P}_N$ over the transitional period where $\dot{e} = 0$ as

$$\widehat{P_N}=(P_N Q_N J)^{-1}\ \{\alpha dE+\beta P_K[(1+\Psi'_T)dI_T+(1+\Psi'_N)dI_N-\delta\Psi'_T dK_T] - (\frac{r_N}{\theta^N_K}+\beta P_K\delta\Psi'_N)dK_N\} \tag{26}$$

$$\frac{\dot{P}_N}{P_N}=(P_N Q_N J)^{-1}\ \{\alpha\dot{E}+\beta P_K[(1+\Psi'_T)\dot{I}_T+(1+\Psi'_N)\dot{I}_N-\delta\Psi'_T\dot{K}_T] - (\frac{r_N}{\theta^N_K}+\beta P_K\delta\Psi'_N)\dot{K}_N\} \tag{27}$$

where $J\equiv\frac{D_N}{Q_N}(\varepsilon+\alpha)+\frac{\sigma\theta^N_L(1-\gamma)}{\theta^N_K}$ and ε is the compensated own price elasticity of demand. θ^i_j denotes the cost share of input j in sector $i(i=T,N,j=K,L)$.

On the other hand, manipulations of the labor market clearing condition, (11), give[9]

$$\widehat{w_T}=\zeta_1\widehat{K_T}+\zeta_2\widehat{K_N}+\zeta_3\hat{e}+\zeta_4\widehat{P_N}, \tag{28}$$

where

$$\zeta_1=\frac{\theta^T_K}{\sigma_T}>0, \qquad \zeta_2=\frac{L_N(1-\theta^T_L)}{L_T\sigma_T}>0,$$

$$\zeta_3=1-(\frac{1-\theta^T_L}{\theta^N_K})(\frac{L_N\sigma_N(1-\gamma)}{L^T\sigma_T}),\ \zeta_4=(\frac{1-\theta^T_L}{\theta^N_K})(\frac{L_N\sigma_N(1-\gamma)}{L_T\sigma_T})>0$$

From the zero profit condition for the tradables sector, (4), and making use of (28), we obtain[10]

$$\widehat{r_T}=s_1\hat{e}-s_2\widehat{P_N}-s_3\widehat{K_T}-s_4\widehat{K_N}. \tag{29}$$

where

$$s_1=1+\frac{L_N\sigma_N(1-\gamma)}{L_T\sigma_T}\frac{\theta^T_L}{\theta^N_K}>0,\ s_2=\frac{L_N\sigma_N(1-\gamma)}{L_T\sigma_T}\frac{\theta^T_L}{\theta^N_K}>0,\ s_3=\frac{1-\theta^T_L}{\sigma_T}>0,$$

$$s_4=\frac{L_N}{L_T}\frac{\theta^T_L}{\sigma_T}>0.$$

From now on, without loss of generality, we choose units so that P_K equals to 1.

Finally, linearizing (23), (24) and (25) around the steady-state,[11] and substituting (26) and (29) into them yield a three simultaneous differential equations

[9] In equation (28), we can see the homogeneity property by noting that the sum of the coefficients of the nominal variables, e and P_N equals 1.

[10] Basic homogeneity property appears again by $s_1-s_2=1$.

system regarding $\dot{I}_T$, $\dot{I}_N$, and $\dot{E}$ as in <Appendix 1>.[12 13] In addition, linearizing (13) around the steady-state, and substituting (26) yield the complete expression for $\dot{M}$ as

$$\dot{M}= \Gamma^{-1}[(\frac{D_N}{Q_N})+(1-g)\frac{\theta_L^N}{\theta_K^N}\sigma_N(1-\gamma)][\alpha dE+\beta(dI_T+dI_N)-\frac{(\rho+\delta)}{\theta_K^N}dK_N] + (\rho+\delta)dK_T-dE-dI_T-dI_N+(\rho+\delta)[1+(1-g)\frac{\theta_L^N}{\theta_K^N}]dK_N \tag{30}$$

Equations (A1), (A2) and (A3) in <Appendix 1>, and (16), (17) and (30) form the complete system of dynamic equations appropriate for the calibration as

$$\begin{bmatrix} \dot{M} \\ \dot{E} \\ \dot{I}_T \\ \dot{I}_N \\ \dot{K}_T \\ \dot{K}_N \end{bmatrix} = \begin{bmatrix} 0 & X_1 & X_2 & X_2 & \rho+\delta & X_3 \\ -X_4 & X_5 & X_6 & X_7 & X_8 & -X_9 \\ -X_{10} & X_{11} & X_{12} & X_{13} & X_{14} & X_{15} \\ X_{16} & X_{17} & X_{18} & X_{19} & X_{20} & X_{21} \\ 0 & 0 & 1 & 0 & -\delta & 0 \\ 0 & 0 & 0 & 1 & 0 & -\delta \end{bmatrix} \begin{bmatrix} M-M^* \\ E-E^* \\ I_T-I_T^* \\ I_N-I_N^* \\ K_T-K_T^* \\ K_N-K_N^* \end{bmatrix}, \tag{31}$$

where an asterisk(*) denotes a new steady-state equilibrium, and X_i's are the coefficients of the corresponding variables in each equation. Exact expressions for X_i's are stated in <Appendix 2>.

Ⅲ. CALIBRATION OF THE MODEL

In order to see whether the system in (31) has a unique convergent solution path, and to find the path if one exists, we need to obtain the eigenvalues of the coefficient matrix, X, and the associated eigenvectors. Finding the eigenvalues of 6×6 matrix involves solving a 6^{th} order polynomial equation, which is, as

---

[11] Note that $\Psi_T=\Psi_N=\Psi_T'=\Psi_N'=0$, $I_i=\delta K_i$, $r_i=(\rho+\delta)P_K$, $\frac{\Phi'(M/P)}{PV_E}=\rho$ at the steady-state.

[12] In order to get the complete solutions, we need to pin down the Ψ_i'' terms. Log-differentiating (18) and evaluating it at the steady-state where $\Psi_T'(\cdot)=0$ yield $\Psi_T''I_T\hat{I}_T=\hat{\lambda}_2-\hat{\lambda}_1-\hat{P}_K$. The RHS of the expression is, in fact, the percentage change in Tobin's q-ratio. Defining z to be the elasticity of investment with respect to q-ratio, and assuming that the q-elasticity of investment is the same in both sectors, we then get the expressions for Ψ_i'' evaluated at a steady-state as $\Psi_T''=\frac{1}{z\delta K_T}$, $\Psi_N''=\frac{1}{z\delta K_N}$.

[13] In obtaining the solutions, we make use of the zero profit condition in the nontradables sector, (5), giving $\hat{r}_N=\frac{(1-\theta_L^N\gamma)}{\theta_K^N}\hat{P}_N$ and the demand for labor in the nontradables sector, (10), yielding $\hat{L}_N=\frac{\sigma_N(1-\gamma)}{\theta_K^N}(\hat{P}_N-\hat{e})+\hat{K}_N$. Furthermore, we assume that the income elasticity of money demand, η, equals to 1. That is, $\eta\equiv\frac{\hat{M}}{\hat{E}}=\frac{\Phi' V_{EE}E}{\Phi''(M/P)V_E}=-\frac{\Phi'}{\Phi''(M/P)\tau}=1.$

known well, generally no way to get explicit solutions analytically. Therefore, we resort to a numerical method, using *mathematica* program, to get the eigenvalues and the associated eigenvectors.

3.1. Determination of Undetermined Parameters

Before doing the calibrations, we should be able to assign the coefficient matrix, X, to real number values. In fact, we can set plausible values for $\alpha, \beta, \sigma_i, \theta^i_j, \gamma, \rho, \tau, \mu$ and ε from the existing literature. But, we still have three parameters undetermined, $\frac{L_N}{L_T}$, k and $\frac{D_N}{Q_N}$. These three parameters have to be set in an internally consistent way. This requires that we exploit the information in the budget constraint and the market clearing condition. Note first that when evaluated at the steady-state where $r_T = r_N$,

$$\frac{L_N}{L_T} = \frac{\theta^N_L}{\theta^N_T} g \frac{P_N Q_N}{eQ_T} = \frac{\theta^N_L}{\theta^N_T} g \frac{VA_N}{1-VA_N}, \tag{32}$$

$$k(\equiv \frac{K_N}{K_T}) = \frac{\theta^N_K}{\theta^T_K} \frac{VA_N}{1-VA_N}, \tag{33}$$

where $VA_N \equiv \frac{P_N Q_N}{Y}$, $Y = eQ_T + P_N Q_N$.

From the nontradables market clearing condition and the budget constraint evaluated at a steady-state, we obtain

$$VA_N = H^{-1}[\alpha + \frac{\delta(\beta-\alpha)\theta^T_K}{(\rho+\delta)}], \tag{34}$$

$$\frac{D_N}{Q_N} = \frac{(P_N/E)(E/Y)}{(P_N Q_N/Y)} = (\frac{\alpha}{VA_N})(\frac{E}{Y}) = (\frac{\alpha}{VA_N})[1-\delta(\frac{K}{Y})], \tag{35}$$

where
$$H = 1 + [\frac{(\theta^T_N - \theta^T_K)\delta(\beta-\alpha)}{(\rho+\delta)}],$$
$$\frac{K}{Y} = (\rho+\delta)^{-1}[\theta^T_K + (\theta^N_K - \theta^T_K) VA_N].$$

Now once we assign sensible values for the parameters, VA_N is determined by (34). The values for $\frac{L_N}{L_T}$, k and $\frac{D_N}{Q_N}$ are subsequently determined by (32), (33) and (35), respectively.

3.2. Solution Paths of Variables of Interest

With all the parameters observable and determined consistently, we are now ready to solve the differential equations system (31) numerically. In all 36 sets of parameter values tested, we obtained three negative and three positive distinctive real roots. Therefore, there exists a unique convergent saddle point solution for each set of parameter values[14]. The complete solutions for the convergent saddle paths of the variables of interest are derived as

$$\frac{\hat{M}}{\hat{e}} = \frac{(M(t)-M^0)}{\hat{e}} = 1+[v_{12}h'_2\exp(\lambda_2 t)+v_{15}h'_5\exp(\lambda_5 t)+v_{16}h'_6\exp(\lambda_6 t)],$$

$$\frac{\hat{E}}{\hat{e}} = \frac{(E(t)-E^0)}{\hat{e}} = 1+\mu[v_{22}h'_2\exp(\lambda_2 t)+v_{25}h'_5\exp(\lambda_5 t)+v_{26}h'_6\exp(\lambda_6 t)],$$

$$\frac{\hat{I}_T}{\hat{e}} = \frac{(I_T(t)-I_T^0)}{\hat{e}} = (\frac{\mu}{\delta})[\frac{k(\rho+\delta)}{\theta_K^N VA_N(Y/E)}][v_{32}h'_2\exp(\lambda_2 t)+v_{35}h'_5\exp(\lambda_5 t) + v_{36}h'_6\exp(\lambda_6 t)],$$

$$\frac{\hat{I}_N}{\hat{e}} = \frac{(I_N(t)-I_N^0)}{\hat{e}} = (\frac{\mu}{\delta})[\frac{(\rho+\delta)}{k\theta_K^N(1-VA_N)(Y/E)}][v_{42}h'_2\exp(\lambda_2 t) + v_{45}h'_5\exp(\lambda_5 t)+v_{46}h'_6\exp(\lambda_6 t)],$$

$$\frac{\hat{K}_T}{\hat{e}} = \frac{(K_T(t)-K_T^0)}{\hat{e}} = \mu[\frac{k(\rho+\delta)}{\theta_K^N VA_N(Y/E)}][v_{52}h'_2\exp(\lambda_2 t)+v_{55}h'_5\exp(\lambda_5 t) + v_{56}h'_6\exp(\lambda_6 t)],$$

$$\frac{\hat{K}_N}{\hat{e}} = \frac{(K_N(t)-K_N^0)}{\hat{e}} = \mu[\frac{(\rho+\delta)}{k\theta_K^N(1-VA_N)(Y/E)}][v_{62}h'_2\exp(\lambda_2 t) + v_{65}h'_5\exp(\lambda_5 t)+v_{66}h'_6\exp(\lambda_6 t)],$$

where $h'_i \equiv \frac{h_i}{M^0\hat{e}}$. The h_i's are constants determined by the initial conditions, and λ_i and $v_{ji}(i,j=1, ..., 6)$ are the corresponding i^{th} eigenvalues and eigenvectors, respectively. Here we assume that $\lambda_2, \lambda_5, \lambda_6$ are negative eigenvalues. The above equations depict the reactions of the variables of interest in the forms of the elasticity of each variable of interest with respect to devaluation. Superscript "0" denotes the initial steady-state, or pre-jump values. Change in the balance of payments is measured by the ratio of the balance of payments to initial expenditure, and is derived as

$$\frac{\dot{M}(t)}{E^0} = \mu[\lambda_2 v_{12}h'_2\exp(\lambda_2 t)+\lambda_5 v_{15}h'_5\exp(\lambda_5 t)+\lambda_6 v_{16}h'_6\exp(\lambda_6 t)]\hat{e}$$

[14] See Buiter (1984) for the condition of existence of a unique convergent saddle point solution.

For the calibrations, we use the case where $\hat{e}=.1$, *i. e.*, a 10% devaluation is assumed.

The responses of the other interesting variables are traced as

$$\frac{\widehat{P_N}}{\hat{e}}=1+(\frac{(D_N/Q_N)}{J})(\frac{\hat{E}}{\hat{e}}-1)+\frac{\beta\delta\theta_K^N}{J(\rho+\delta)k}\frac{\widehat{I_T}}{\hat{e}}+\frac{\beta\delta\theta_K^N}{J(\rho+\delta)}\frac{\widehat{I_N}}{\hat{e}}-J^{-1}\frac{\widehat{K_N}}{\hat{e}},$$

$$\frac{(\widehat{\frac{e}{P_N}})}{\hat{e}}=\frac{(\hat{e}-\widehat{P_N})}{\hat{e}}=1-\frac{\widehat{P_N}}{\hat{e}},$$

$$\frac{\widehat{L_N}}{\hat{e}}=\frac{\sigma_N(1-\gamma)}{\theta_K^N}(\frac{\widehat{P_N}}{\hat{e}}-1)+\frac{\widehat{K_N}}{\hat{e}},$$

$$\frac{\hat{I}}{\hat{e}}=(\frac{1}{1+k})\frac{\widehat{I_T}}{\hat{e}}+(\frac{k}{1+k})\frac{\widehat{I_N}}{\hat{e}},$$

$$\frac{\hat{K}}{\hat{e}}=(\frac{1}{1+k})\frac{\widehat{K_T}}{\hat{e}}+(\frac{k}{1+k})\frac{\widehat{K_N}}{\hat{e}},$$

$$\frac{\hat{Q}}{\hat{e}}=\theta_K^T(1-VA_N)\frac{\widehat{K_T}}{\hat{e}}+VA_N\frac{\widehat{K_N}}{\hat{e}}+\theta_L^N VA_N[\frac{\sigma_N(1-\gamma)}{\theta_K^N}](\frac{\widehat{P_N}}{\hat{e}}-1).$$

3.3. Parameterization of the Model

With the model ready for calibration, we finally should be able to assign plausible values for the parameters from the existing literature. The parameter values used to calibrate the model are summarized in <Appendix 3>. Here we investigate the effects of devaluation with 36 different sets of parameter values that reflect different economic structures of LDCs.

The justification of particular choices of parameter values may be in order. For the cost share of the nontradables in the production of an aggregate capital good, β, Krueger(1978) gives 40% share of construction in fixed capital formation as a normal case. Also, NBER studies find the share of domestic output in total investment generally to be on the order of .50~.80. For the compensated own price elasticity of demand for the nontradables, ε, we use .20 following Llunch, Powell and Williams(1973) and Blundell(1988). For the intertemporal elasticity of substitution, τ, Summers(1982) puts it around 1. According to Hansen and Singleton(1983), it would be on the order of 0~2.0. Hall(1988), criticizing the previous two papers, argues that it is close to zero, and is probably not above .20. Blundell(1988) also shows that it is small and probably less than .50. Attanasio and Weber(1989) obtains a little higher. Here, we try .2 and 1.0 for low and high ends. Regarding the q-elasticity of investment, z, we use .5 and 1.5. Abel(1980) shows that it is on the order of .50~1.1. Blanchard and Wyplosz(1981) estimates it as .43, while Hayashi(1982) puts it at around .67. Summers(1981) argues that it is about 1.5 in case of the U.S.A. For the elasticity of factor substitution, σ_i, we fix it at .50 following

White(1978), Khatkhate(1980) and Ahluwalia(1974). For the sectoral wage gap, g, we set it at .75, implying that the nontradables sector pays 33% more than the tradables sector does, which is not uncommon in LDCs. For the cost share of labor(capital) in the tradables sector, we try three different cases, θ_L^T=.30(θ_K^T =.70) for capital-intensive tradables sector case, θ_L^T=.50(θ_K^T=.50) for neutral case, θ_L^T=.70(θ_K^T=.30) for labor-intensive tradables sector case. For θ_L^N and θ_K^N, we consider a neutral case where they have the same shares because we intend to focus on how different factor intensities in the tradables sector affect the outcome.[15] Pure time preference rate, ρ, is assumed to be .10. The rate of depreciation, δ, and the consumption share of the nontradables, α(and, thus wage indexation parameter, γ) are set to be .06 and .50, respectively to focus on the other important variables like θ_L^T, β, and τ. The ratio of money demand, μ, is set to be .10 as in Buffie(1992).

Ⅳ. RESULTS

Under the parameterization of the economy given in the previous section, we trace the transitional dynamics of several variables of interest. These include the balance of payments, investment at both sectoral and aggregate levels, capital stock at both sectoral and aggregate levels, employment in the nontradables sector, and real output. <Appendix 4> summarizes the part of simulation results about the impact effects of the devaluation. In what follows, we interpret the simulation results from general perspectives, and then take a closer look at three typical model economies.

4.1. General Observations

We have nothing new to say about the balance of payments. A devaluation improves the balance of payments on impact in all cases considered. However, as other variables, especially P_N, begin to adjust to devaluation, the balance of payments surplus gradually disappears, and the economy moves toward the new steady-state in which the balance of payments surplus is zero. Following devaluation, a fall in real money balance, coupled with a decrease in real income results in a drop in overall demand for goods and services produced by both sectors. The contraction in demand, when combined with an increase of supply in the tradables sector, induces the excess supply of the tradables, which implies that a devaluation improves the balance of payments on impact. The

---

[15] Notice from (32) and (33) that $\frac{K_T/L_T}{K_N/L_N}=\frac{g\theta_K^T}{\theta_L^T}$. The capital-labor ratio in the tradables sector is 75% higher than that in the nontradables sector when θ_L^T =.30(θ_K^T=.70), and 75%, 32% of that in the nontradables sector when θ_L^T=.50(θ_K^T=.50), θ_L^T=.70(θ_K^T=.30) respectively.

more labor-intensive the tradables sector becomes, the smaller is the initial improvement in the balance of payments.

Of interest is the response of investment at both sectoral and aggregate levels. Investment in the nontradables sector, I_N, falls on impact after a devaluation in all cases of parameter choices considered, and then moves toward the new steady-state where I_N is equal to its initial level. The initial drop in I_N is larger as the tradables sector becomes more labor-intensive, except some cases where the cost share of the nontradables in the production of capital good, β, and the intertemporal elasticity of substitution, τ, are very high. During the transitional period, I_N remains below its long-run equilibrium level.

Investment in the tradables sector, I_T, also falls on impact in most cases considered. Only in some exceptional cases where the cost share of the nontradables in the production of capital goods and the intertemporal elasticity of substitution are very high, the investment in the tradables sector, in fact, jumps up on impact after a devaluation, and then approaches the new steady-state where the investment remains the same as its initial level. When τ is low, the initial drop in I_T gets larger with more labor-intensive tradables sector. However, with a high τ, the initial decrease or increase in I_T becomes magnified. The q-elasticity of investment demand, z, also plays a role as a magnifier.[16] With a higher z, investment response in each sector becomes larger. What is interesting is that aggregate investment always drops on impact regardless of parameter values, and it drops more as the tradables sector becomes more labor-intensive.

As noticed in (33), the ratio of capital stock in the nontradables sector to that in the tradables sector, k, gets larger as the tradables sector becomes more labor-intensive. Considering that aggregate investment is a weighted average of the two sectoral investment, therefore, the weight attached to investment in the nontradables sector becomes larger. Because it is the nontradables sector that is hit harder by devaluation, aggregate investment should fall more with more labor intensive tradables sector. This also explains why aggregate investment falls more on impact even when sectoral investment decreases less (or increases more) in some cases with larger τ and larger β as the labor intensity in tradables sector becomes higher.

In order to understand sectoral investment behavior of the representative family firm, we need to notice that there are three prominent effects occurring when the investment decision in each sector is made following a devaluation. First, a devaluation raises the product wage in the nontradables sector on impact,[17]

[16] z has to do with the degree of convexity of adjustment costs function. As z gets larger, the adjustment costs of investment become smaller.

[17] $\widehat{\left(\frac{w_N}{P_N}\right)} = \widehat{w_N} - \widehat{p_N} = \gamma \widehat{P_N} + (1-\gamma)\hat{e} - \widehat{P_N} = (1-\gamma)(\hat{e} - \widehat{P_N}) > 0$

which causes the demand for labor in the nontradables sector to fall. As a result, the marginal productivity of capital also falls in the sector, which makes the q-ratio smaller. Also, a devaluation makes q-ratio in the nontradables sector smaller by raising the relative price of the capital in terms of the nontradables.[18] Consequently, investment in the nontradables sector, I_N, falls on impact following a devaluation. We call this effect the q-effect. Secondly, devaluation decreases real balances by raising the general price level. The drop in real balances, however, increases the marginal utility of money. Considering this increase in marginal utility of money, the representative family firm would hold more of its assets in the form of money rather than capital. Therefore, investment demand in each sector falls on impact following a devaluation. We call this effect the competing asset effect. Finally, devaluation lowers real income in the economy on impact by reallocating workers from the high wage nontradables sector to the low wage tradables sector. Therefore, a risk averse representative family firm has an incentive to smooth consumption by lowering investment following a devaluation. We call this effect the consumption smoothing effect.

All these three effects pull in the direction of lower investment in the nontradables sector. This explains why investment in the nontradables sector decreases on impact following a devaluation in all cases of parameter choices considered. In the tradables sector, devaluation lowers the relative price of the capital good measured in terms of the tradables on impact.[19] This makes the q-ratio for the sector larger. In addition, a devaluation lowers the product wage in the sector on impact, which causes the demand for labor in the sector to rise. As a result, the marginal productivity of capital also increases, which makes the q-ratio larger. Therefore, the q-effect in the tradables sector pulls in the direction of higher investment in the sector. Alternatively, the consumption smoothing and the competing asset effects pull in the direction of lower investment in the tradables sector, as in the nontradables sector. Therefore, the direction of investment in the tradables sector depends on the relative strength between two contractionary effects, the consumption smoothing and the competing asset effects, and one expansionary effect, the q-effect.

The strength of the two contractionary effects depends on the intertemporal elasticity of substitution, τ. The inverse of the intertemporal elasticity of substitution, $1/\tau$, is, in fact, the elasticity of the marginal utility of real balances because we assume that the income elasticity of money demand is equal to unity. Therefore, the larger τ is, the smaller the elasticity of the marginal utility of real balances is, and the weaker the competing asset effect is.

---

[18] $(\widehat{\frac{P_K}{P_N}}) = \widehat{P_K} - \widehat{p_N} = \beta \widehat{P_N} + (1-\beta)\hat{e} - \widehat{P_N} = (1-\beta)(\hat{e} - \widehat{P_N}) > 0$

[19] $(\widehat{\frac{P_K}{e}}) = \widehat{P_K} - \hat{e} = \beta \widehat{P_N} + (1-\beta)\hat{e} - \hat{e} = -\beta(\hat{e} - \widehat{P_N}) < 0$

On the other hand, the q-effect depends on the cost share of the nontradables in the production of capital goods, β. As shown in footnotes (18) and (19), as β becomes larger, the initial decrease in the price of the capital goods measured in terms of tradables becomes larger, and the initial increase in the price of the capital goods measured in the nontradables sector becomes smaller. Therefore, the larger β is, the positive q-effect is stronger in the tradables sector while the negative q-effect is weaker in the nontradables sector.

Thus, in some cases where β and τ are large enough so that the stronger q-effect dominates the weakened competing asset and consumption smoothing effects, investment in the tradables sector increases on impact following a devaluation. The increase in either β or τ also works for investment in the nontradables sector favorably so that it decreases less than otherwise. But in the reasonable range of parameter values considered, it is not enough to reverse the direction of investment in the nontradables sector. Aggregate investment, therefore, falls on impact in all cases considered.

Employment in the nontradables sector, L_N, falls on impact after devaluation in all cases considered. This could be explained by the fact that the product wage in the nontradables sector increases on impact. The released workers from the nontradables sector are absorbed by the tradables sector under the assumption of full employment in the model. This movement explains the behavior of real output after devaluation.

Real output, Q, falls on impact in all cases considered after devaluation. The movement of workers from the nontradables sector, which is higher in productivity, to the tradables sector, which is lower in productivity, decreases real output on impact. However, real output is restored to the initial level at the new steady-state as the other variables adjust. In cases of L_N and Q, differences in factor intensity seem to induce little change on impact. However, the transitional dynamics of, in particular, Q shows a significant difference depending on factor intensity as will be seen in model economies.

4.2. Model Economies

In order to take a closer look at how different economies respond to devaluation, we discuss three model economies, typical LDC economies with different factor intensities in the tradables sector. The model economies are very dependent on imported machines in the production of an aggregate capital goods ($\beta = .25$) as most low income LDC economies are.[20] Model economy I is the most capital-intensive in the tradables sector while Model economy III is the most labor-intensive in the tradables sector. Model economy II is considered as a neutral case for reference. Parameterization for the three economies are as in

[20] The basic features of the results presented here do not change with a larger β unless it is unreasonably high.

[Table 1]. Impact effect of devaluation on the variables of interest and their transitional paths are shown as [Figure 1]~[Figure 7] in <Appendix 5>.

[Table 1] Parameter values for the model economies

Model Economy	Common parameter values	Factor Intensity in the tradables sector
I	$\alpha=.50,\ \gamma=.50,\ \rho=.10,\ \delta=.06,\ \sigma_i=.50,$	$\theta_L^T=.30,\ \ \theta_K^T=.70$
II	$\theta_L^N=.50,\ \theta_K^N=.50,\ \epsilon=.20,\ \mu=.1,\ g=.75,$	$\theta_L^T=.50,\ \ \theta_K^T=.50$
III	$\beta=.25,\ z=1.5,\ \tau=.20$	$\theta_L^T=.70,\ \ \theta_K^T=.30$

[Figure 1] shows that 10% of devaluation improves the balance of payments on impact as much as 1.42%, 1.31% and 1.21% of the initial nominal consumption expenditure in model economies I, II and III respectively. However, the initial improvement gradually fades away, and finally the balance of payments surplus disappears in 4-5 years or so. Devaluation is neutral in the long run as in typical monetary model.

[Figure 2] shows that investment in the tradables sector falls immediately by .32%, .35% and .37% per percent devaluation on impact in model economies I, II and III respectively. Since then, increasing sharply for the first 3 years, the investment in the tradables sector rises slowly toward the new steady-state where it is the same as the initial level. [Figure 3] indicates that investment in the nontradables sector also drops immediately after a devaluation by .37%, .40% and .43% per percent devaluation on impact in model economies I, II and III respectively. Following the initial jump-down, investment in the nontradables sector rebounds sharply for the first 3 years, and then increases steadily toward the new steady-state.

Combining [Figure 2] and [Figure 3], [Figure 4] shows that aggregate investment drops immediately by .34%, .37% and .41% per percent devaluation on impact in model economies I, II and III respectively. After rebounding sharply for the first 3 years, aggregate investment rises steadily toward the new steady-state. Reflecting [Figure 4], aggregate capital stock decreases sharply during the first 3 years after a devaluation, and then rises slowly toward a new steady-state as in [Figure 5]. However, the transitional dynamics of capital stock differs significantly across the model economies. The fall in capital stock is the deepest in model economy III, an economy with the most labor-intensive tradables sector while it is the least in model economy I.

[Figure 6] shows that employment in the nontradables sector falls on impact following a devaluation by .101%, .099% and .098% per percent devaluation in model economies I, II and III respectively. After the initial decrease, employment in the nontradables sector increases sharply for the first 3 years before it approaches steadily toward its long-run equilibrium level. Unlike the other variables of interest, employment in the nontradables sector shows little difference among the model economies. Finally, [Figure 7] describes that real output drops immediately after a devaluation by .0055%, .0056% and .0057% per percent devaluation in model economies I, II and III respectively. Thereafter, real output keeps on falling for the first 2 years as much as .009% per percent devaluation in case of model economy III, and then rises slowly toward its long-run equilibrium level. As shown vividly, the more labor-intensive the tradables sector is, the larger is the fall in real output following devaluation.

V. CONCLUDING REMARKS

This paper has demonstrated that devaluation, which has widely been considered as a useful policy measure to boost the economy, may turn out to be quite a harsh experience for LDC economies, especially for those with more labor-intensive tradables sector. Devaluation may improve the external balances, but only when other domestic economic indicators have suffered.

All the simulation results have shown that during the short-run period immediately after a devaluation, typical LDC economies having labor-intensive tradables sector will suffer a recession, experiencing a larger fall in investment and in real output than others. These results clearly give a warning signal to those governments that implement stabilization programs recommended by IMF-WB in exchange for adjustment loans as several real world examples do. Even though the programs include other policy measures, such as tight monetary and fiscal policies and high interest rates policy, they may make things worse in the short run as far as a recession is concerned since they are, by nature, contractionary in demand. The question, then, boils down to whether and for how long the government, facing political pressures, is able to tolerate the short-run economic harshness for the expected long-run gains which may be uncertain.

That being said, it may be in order to point out some qualifications of the paper. First of all, we did not take into account the possible income redistribution effects of devaluation. It would be desirable to extend the representative agent model employed here to a model with heterogeneous agents.[21] Secondly, stabilization package adopted in LDCs includes, in general, more than devaluation. For example, austerity policies such as tight fiscal and monetary policies, real wage reduction are, in general, implemented with devaluation. It needs to analyze the effect of devaluation when the austerity policies are implemented simultaneously, which would be much difficult to deal with, though. Finally, labor market situations vary greatly among different LDCs so that various wage rate determination mechanisms could be considered in the model.

Despite the qualifications mentioned above, we believe that the paper has

[21] See Kirman(1993) for criticism on the representative agent model.

provided some theoretical explanations for investment slump following the IMF-WB sponsored stabilization program in many developing countries. Contractionary devaluation is more than remote possibility, having deep roots in the structural characteristics of LDC economies. Therefore, policy suggestions, before delivered, should carefully take the structural characteristics of a specific economy into consideration.

<Appendix 1> Solutions for $\dot{I_T}$, $\dot{I_N}$ and $\dot{E}$

$$
\begin{aligned}
G\dot{I_T} = & \ z\delta(1+\alpha B)\ \{\frac{\rho+\delta}{z\delta}(dI_T - \delta dK_T) \\
& + \frac{\rho\theta_K^N \alpha}{\tau k(\rho+\delta)(D_N/Q_N)}(dE - \frac{dM}{\mu}) + \frac{\theta_K^N \beta}{Jk}[\alpha dE \\
& + \beta(dI_T + dI_N) - \frac{r_N}{\theta_K^N} dK_N] + \frac{(\rho+\delta)(1-\theta_K^T)}{\sigma_T} dK_T \\
& + \frac{\beta}{Jk}(dI_N - \delta dK_N)\} \ + \frac{z\delta\beta^2\theta_K^N}{J} \ \{(dI_T - \delta dK_T) \\
& - \frac{1}{k}(dI_N - \delta dK_N) + \frac{z\delta(1-\theta_L^N\gamma)}{J(\rho+\delta)k}[\alpha dE + \beta(dI_T + dI_N) \\
& - \frac{(\rho+\delta)}{\theta_k^N} dK_N] + \frac{z\delta(1-\theta_K^T)}{\sigma_T} dK_t\ \} \ + \frac{\beta\alpha z_k^N \delta\theta}{J(\rho+\varepsilon)k}[\frac{\rho}{\mu} dM \\
& - \rho dE + \frac{B(\rho+\delta)}{\theta K_N}(dI_N - \delta dK_N)],
\end{aligned}
\tag{A-1}
$$

$$
\begin{aligned}
G\dot{I_N} = & \ z\delta(1+\alpha B)\ \{\frac{\rho+\delta}{z\delta}(dI_N - \delta dK_N) + \frac{\beta}{J}(dI_N - \delta dK_N) \\
& + \frac{\rho\theta_K^N \alpha}{\tau(\rho+\delta)(D_N/Q_N)}(\alpha dE - \frac{dM}{\mu}) + \frac{\theta_K^N}{J}[\beta \\
& - \frac{(1-\theta_L^N\gamma)}{\theta_K^N}][\alpha dE + \beta(dI_T + dI_N) - F dK_N]\} \\
& - \frac{\beta\alpha z\delta F}{J}[\rho dE - \frac{\rho}{\mu} dM + BF(dI_N - \delta dK_N)] \\
& - \frac{z\delta\beta^2\theta_K^N}{J} \ \{(dI_T - \delta dK_T) - \frac{1}{k}(dI_N - \delta dK_N) \\
& + \frac{z\delta(1-\theta_L^N\gamma)}{J(\rho+\delta)k}[\alpha dE + \beta(dI_T + dI_N) - F dK_N] + \frac{z\delta(1-\theta_K^T)}{\sigma_T} dK_T\} \ ,
\end{aligned}
\tag{A-2}
$$

$$
\begin{aligned}
G\dot{E} = & \ [1 + \frac{\beta^2(1+k)z\delta}{JFk}]\rho dE - \frac{\rho}{\mu} dM \\
& + BF(dI_N - \delta dK_N) - \beta B\ \{\ (\rho+\delta)(dI_T + dI_N - \delta dK_T - \delta dK_N) \\
& + \frac{z\delta\alpha\rho(1+k)}{\tau k(D_N/Q_N)F}(dE - \frac{dM}{\mu}) + \frac{z\delta\theta_K^N}{Jk}[\beta(1+k) \\
& - \frac{(1-\theta_L^N)\gamma k}{\theta_K^N}][\alpha dE + \beta(dI_T + dI_N) - F dK_N] \\
& + \frac{(\rho+\delta)z\delta(1-\theta_K^T)}{\sigma_T} dK_T + \frac{z\delta\beta(1+k)}{Jk}(dI_N - \delta dK_N)\ \}\ ],
\end{aligned}
\tag{A-3}
$$

where $G \equiv 1 + \alpha B + \dfrac{\beta^2(1+k)z\delta\theta_K^N}{J(\rho+\delta)k}$, $\quad B = \dfrac{(\tau-1)(D_N/Q_N)}{J}$, $\quad k \equiv \dfrac{K_N}{K_T}$,

$F \equiv \dfrac{(\rho+\delta)}{\theta_K^N}$.

<Appendix 2> Expressions for X_i's

$$X_1 = \frac{\alpha}{J}[(D_N/Q_N) + (1-g)\frac{\theta_L^N}{\theta_K^N}\sigma_N(1-\gamma)] - 1$$

$$X_2 = \frac{\beta}{J}[(D_N/Q_N) + (1-g)\frac{\theta_L^N}{\theta_K^N}\sigma_N(1-\gamma)] - 1$$

$$X_3 = \frac{(\rho+\delta)}{\theta_K^N}\ \{\theta_K^N + \theta_L^N(1-g) - J^{-1}[(D_N/Q_N) + \frac{\theta_L^N}{\theta_K^N}\sigma_N(1-\gamma)]\}$$

$$X_4 = \frac{\rho}{\mu G}[F_1 + \frac{(1-\tau)\beta z\delta\theta_K^N\alpha(1+k)}{J\tau(\rho+\delta)k}],\ \textit{where}\ F_1 = 1 + \frac{\beta^2 z\delta\theta_K^N(1+k)}{J(\rho+\delta)k}$$

$$X_5 = \frac{1}{G}[\rho F_1 + \frac{(1-\tau)\beta\rho z\delta\theta_K^N\alpha(1+k)}{J\tau(\rho+\delta)k} + B_1\alpha],$$

$$\textit{where}\ B_1 = \frac{(1-\tau)\beta z\delta\theta_K^N(D_N/Q_N)}{J^2 k}[\beta(1+k) - \frac{(1-\theta_L^N\gamma)k}{\theta_K^N}]$$

$$X_6 = \frac{1}{G}[\frac{(1-\tau)\beta(D_N/Q_N)(\rho+\delta)}{J} + B_1\beta]$$

$$X_7 = X_6 + \frac{F_1(\tau-1)\beta(D_N/Q_N)(\rho+\delta)}{J\theta_K^N G} + \frac{(1-\tau)\beta^2 z\delta(1+k)(D_N/Q_N)}{J^2 kG}$$

$$X_8 = \frac{(1-\tau)\beta(D_N/Q_N)}{JG}[(\rho+\delta)\delta(zs_3-1)]$$

$$X_9 = \frac{(\rho+\delta)}{G}[\frac{F_1(1-\tau)(D_N/Q_N)\delta}{J}(\frac{zs_4}{k}-1) - \frac{B_1}{\theta_K^N} - \frac{F_1(\tau-1)\delta(D_N/Q_N)}{J\theta_K^N}]$$
$$- \frac{(1-\tau)\beta^2 z\delta^2(1+k)(D_N/Q_N)}{J^2 kG}$$

$$X_{10} = \frac{\rho}{\mu G}[\frac{A_1\theta_K^N\alpha}{\tau(\rho+\delta)k(D_N/Q_N)} - A_3],$$

$$\textit{where}\ A_1 = z\delta[1 + \frac{(\tau-1)\alpha(D_N/Q_N)}{J}],\ A_3 = \frac{z\delta\theta_K^N\alpha\beta}{J(\rho+\delta)k}$$

$$X_{11} = \mu X_{10} + \frac{\alpha\theta_K^N}{JG}[\frac{A_1(\beta+s_2)}{k} + \beta^2 z\delta A_2],$$

$$\textit{where}\ A_2 = \frac{z\delta\theta_K^N}{J(\rho+\delta)k}[\frac{(1-\theta_L\gamma)}{\theta_K^N} + s_2]$$

$$X_{12} = \frac{A_1}{G}[\frac{(\rho+\delta)}{z\delta} + \frac{\theta_K^N\beta(\beta+s_2)}{Jk}] + \frac{\beta^2\theta_K^N z\delta}{JG}[1 + A_2\beta]$$

$$X_{13} = \frac{1}{JG}[\frac{A_1\beta(1+\theta_K^N(\beta+s_2))}{k} + \frac{\beta^2\theta_K^N z\delta(A_2\beta k-1)}{k}$$
$$+ \frac{A_3(1-\tau)(D_N/Q_N)(\rho+\delta)}{\theta_K^N}]$$

$$X_{14} = \frac{(zs_3-1)}{G}[\frac{A_1(\rho+\delta)}{z} + \frac{z\delta^2\theta_K^N\beta^2}{J}]$$

$$X_{15}= \frac{1}{G}\ \{\frac{A_1(\rho+\delta)}{k}[s_4-\frac{(\beta+s_2)}{J}]-\frac{A_1\beta\delta}{Jk}+$$
$$\frac{\beta^2 z\delta\theta_K^N}{Jk}[z\delta s_4+\delta-\frac{A_2(\rho+\delta)k}{\theta_K^N}]-\frac{A_3(1-\tau)(D_N/Q_N)(\rho+\delta)\delta}{J\theta_K^N}\}$$

$$X_{16}=\frac{\rho}{\mu G}[A_3-\frac{A_1\theta_K^N\alpha}{\tau(\rho+\delta)(D_N/Q_N)}],$$

$$X_{17}= \frac{1}{G}\ \{A_1\alpha[\frac{\rho\theta_K^N}{\tau(\rho+\delta)(D_N/Q_N)}+A_4]-A_3\rho-\frac{\beta^2\theta_K^N z\delta}{J}A_2\alpha\}$$
$$\text{where}\quad A_4=\frac{\theta_K^N}{J}[\beta-\frac{(1-\theta_L^N\gamma)}{\theta_K^N}]$$

$$X_{18}=\frac{\beta}{G}[A_1A_4-\frac{\beta\theta_K^N z\delta}{J}(1+A_2\beta)]$$

$$X_{19}= \frac{1}{G}\ \{A_1[\frac{(\rho+\delta)}{z\delta}+A_4\beta+\frac{\beta}{J}]-\frac{A_3(\tau-1)(D_N/Q_N)(\rho+\delta)}{J\theta_K^N}$$
$$-\frac{\beta^2\theta_K^N z\delta}{J}(A_2\beta-\frac{1}{k})\}$$

$$X_{20}=\frac{\beta^2\theta_K^N z\delta^2}{JG}(1-zs_3)$$

$$X_{21}= \frac{1}{G}\ \{\frac{A_3(\tau-1)(D_N/Q_N)(\rho+\delta)\delta}{J\theta_K^N}-A_1(\rho+\delta)(\frac{1}{z}+\frac{A_4}{\theta_K^N})-\frac{A_1\beta\delta}{J}$$
$$-\frac{\beta^2\theta_K^N z\delta}{Jk}[z\delta s_4+\delta-\frac{A_2(\rho+\delta)k}{\theta_K^N}]\}$$

<Appendix 3> Parameter values used to calibrate the model

A. Parameter values

Parameters that vary in simulation	β = .25, .50, .75 τ = .20, 1.0, θ_L^T = .30, .50, .70 z = .50, 1.5
Parameters that are fixed in simulation	α = .50, γ= .50, ρ= .10, δ= .06, σ_i= .50 θ_L^N = .50, θ_K^N= .50, ε= .20, μ= .1, g= .75

B. Notations

α = Share of the nontradables in aggregate consumption expenditure.

β = Cost share of the nontradables in production of an aggregate capital good.

δ = Depreciation rate of capital in both sectors.

ε = Compensated own price elasticity of demand for the nontradables.

g = Sectoral wage differential $(\equiv \frac{w_T}{w_N})$

γ = Weight of the nontradables in wage indexation.

ρ = Pure time preference rate.

μ = Ration of nominal money demand to nominal expenditure.

σ_i = Elasticity of factor substitution in sector i.

τ = Intertemporal elasticity of substitution.

θ_j^i = Cost share of factor j in sector i.

z = Elasticity of investment with respect to q-ratio.

<Appendix 4> Impact effects of devaluation

$\tau = .20$

β	BOP	I_T	I_N	I	L_N	Q	z	Factor Intensity
.25	.010609	-.150387	-.170661	-.157726	-.091539	-.005065	.50	$\theta_L^T = .30$ $\theta_K^T = .70$
	.014169	-.321398	-.371102	-.339390	-.101050	-.005592	1.5	
	.010078	-.156476	-.177795	-.166136	-.091908	-.005206	.50	$\theta_L^T = .50$ $\theta_K^T = .50$
	.013104	-.346438	-.398861	-.370192	-.099470	-.005634	1.5	
	.009593	-.162279	-.184741	-.175528	-.092285	-.005343	.50	$\theta_L^T = .70$ $\theta_K^T = .30$
	.012078	-.372804	-.428439	-.405620	-.097980	-.005673	1.5	
.50	.009904	-.127269	-.152717	-.137872	-.102679	-.006417	.50	$\theta_L^T = .30$ $\theta_K^T = .70$
	.012072	-.246673	-.320471	-.277423	-.125166	-.007823	1.5	
	.009552	-.132417	-.158289	-.145353	-.101785	-.006362	.50	$\theta_L^T = .50$ $\theta_K^T = .50$
	.011482	-.267711	-.342260	-.304985	-.122344	-.007647	1.5	
	.009215	-.137614	-.163919	-.154054	-.100745	-.006296	.50	$\theta_L^T = .70$ $\theta_K^T = .30$
	.010877	-.291221	-.366407	-.338213	-.118915	-.007432	1.5	
.75	.009344	-.102685	-.132591	-.116781	-.107459	-.007458	.50	$\theta_L^T = .30$ $\theta_K^T = .70$
	.010543	-.172459	-.266357	-.216718	-.133018	-.009217	1.5	
	.009117	-.106867	-.136779	-.123225	-.106567	-.007285	.50	$\theta_L^T = .50$ $\theta_K^T = .50$
	.010224	-.187742	-.281309	-.238912	-.131261	-.008973	1.5	
	.008891	-.111400	-.141243	-.131101	-.105382	-.007089	.50	$\theta_L^T = .70$ $\theta_K^T = .30$
	.009887	-.206144	-.298835	-.267334	-.128668	-.008656	1.5	

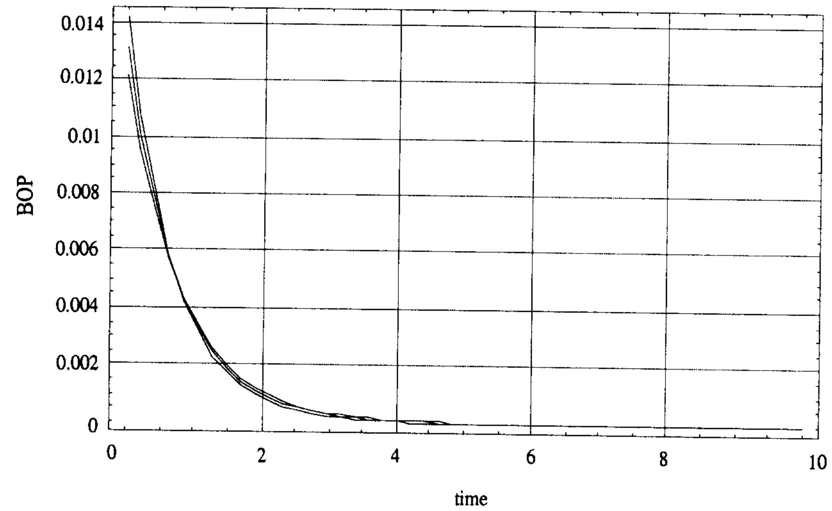
<**Appendix 4**> Impact effects of devaluation (continued)

$\tau = 1.0$

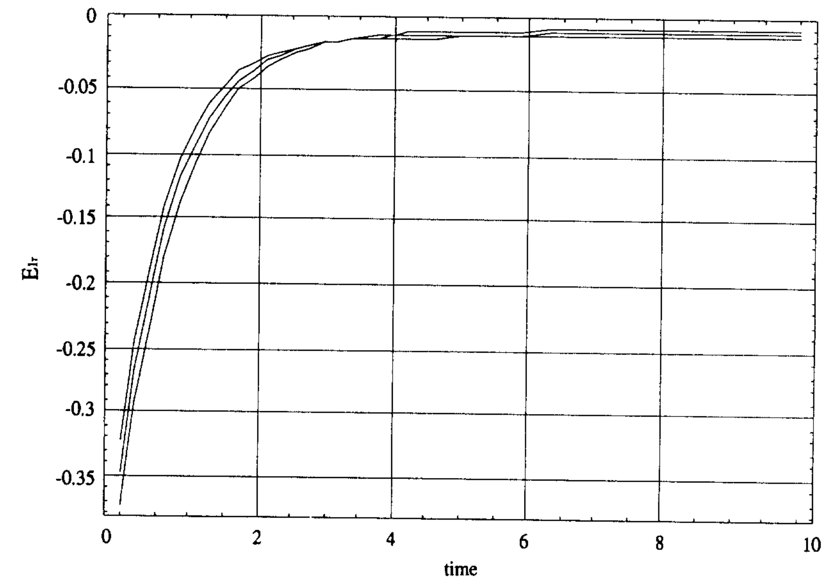
β	BOP	I_T	I_N	I	L_N	Q	z	Factor Intensity
.25	.006758	-.032123	-.055049	-.040422	-.068208	-.003774	.50	$\theta_L^T = .30$ $\theta_K^T = .70$
	.007580	-.080772	-.138835	-.101789	-.067200	-.003718	1.5	
	.006628	-.031972	-.055729	-.042737	-.069083	-.003913	.50	$\theta_L^T = .50$ $\theta_K^T = .50$
	.007291	-.081389	-.142322	-.108999	-.067943	-.003848	1.5	
	.006514	-.031781	-.056331	-.046262	-.069863	-.004045	.50	$\theta_L^T = .70$ $\theta_K^T = .30$
	.007035	-.081787	-.145466	-.119348	-.068606	-.003972	1.5	
.50	.006549	-.014729	-.039150	-.024905	-.067903	-.004244	.50	$\theta_L^T = .30$ $\theta_K^T = .70$
	.006798	-.032365	-.099823	-.060473	-.070486	-.004405	1.5	
	.006472	-.014330	-.039394	-.026862	-.068962	-.004310	.50	$\theta_L^T = .50$ $\theta_K^T = .50$
	.006681	-.031963	-.101084	-.066523	-.071188	-.004449	1.5	
	.006401	-.013931	-.039626	-.029990	-.069982	-.004374	.50	$\theta_L^T = .70$ $\theta_K^T = .30$
	.006573	-.031513	-.102286	-.075746	-.071865	-.004492	1.5	
.75	.006488	.001110	-.023790	-.010627	-.064860	-.004501	.50	$\theta_L^T = .30$ $\theta_K^T = .70$
	.006488	.009568	-.060867	-.023632	-.066661	-.004626	1.5	
	.006430	.001969	-.023530	-.011976	-.066419	-.004540	.50	$\theta_L^T = .50$ $\theta_K^T = .50$
	.006430	.011878	-.060081	-.027475	-.068227	-.004664	1.5	
	.006374	.002862	-.023258	-.014381	-.068041	-.004578	.50	$\theta_L^T = .70$ $\theta_K^T = .30$
	.006376	.014289	-.059162	-.034153	-.069928	-.004705	1.5	

<**Appendix 5**> Transitional dynamics in the model economies

[Figure 1] Change in the balance of payments



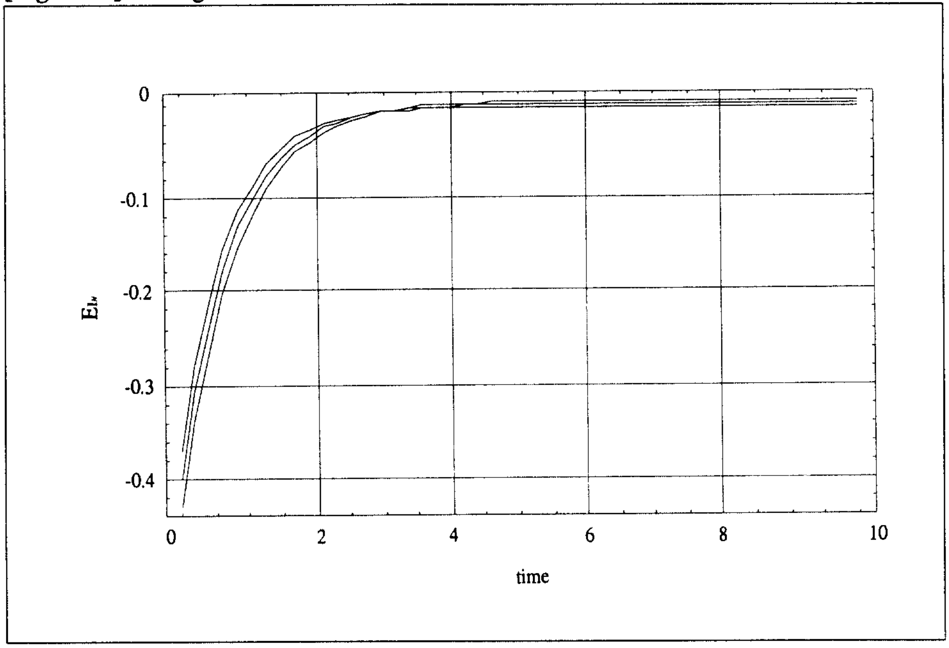
[Figure 2] Change in I_T



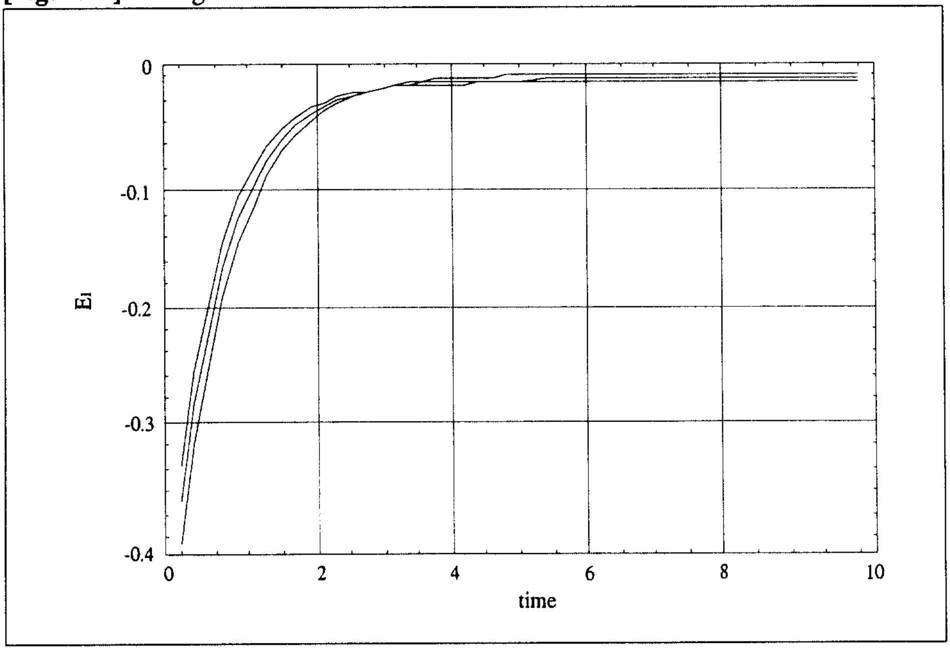
* Note : Model economies I, II, and III are depicted from the above, respectively.

<**Appendix 5**> Transitional dynamics in the model economies (continued)

[Figure 3] Change in I_N



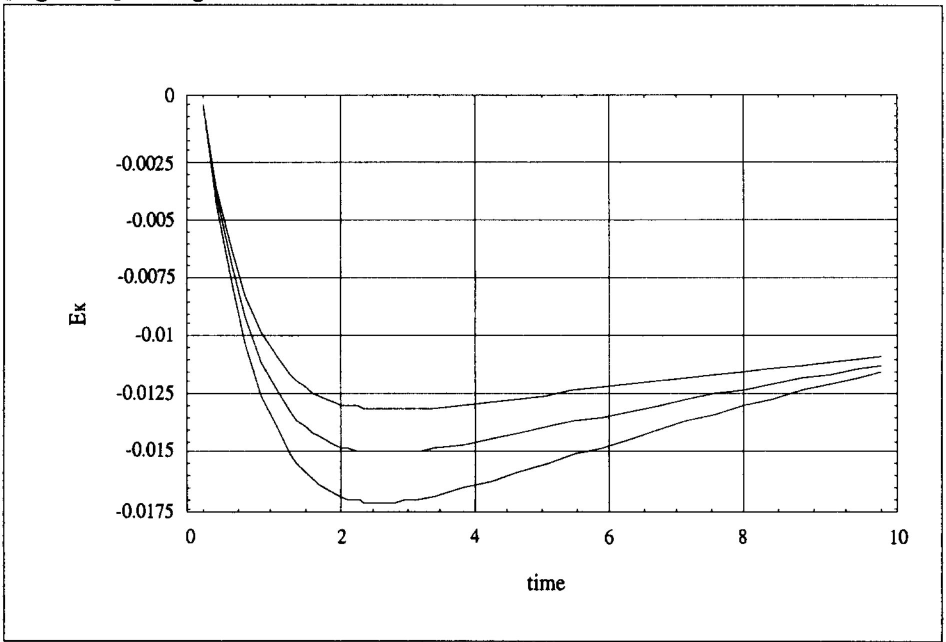
[Figure 4] Change in I



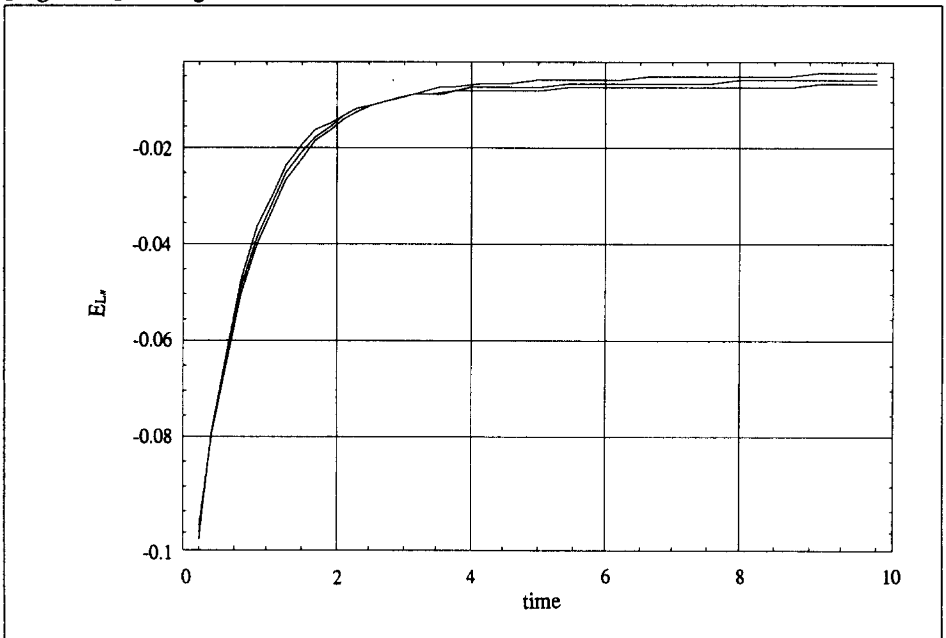
* Note : Model economies I, II, and III are depicted from the above, respectively

<Appendix 5> Transitional dynamics in the model economies (continued)

[Figure 5] Change in K



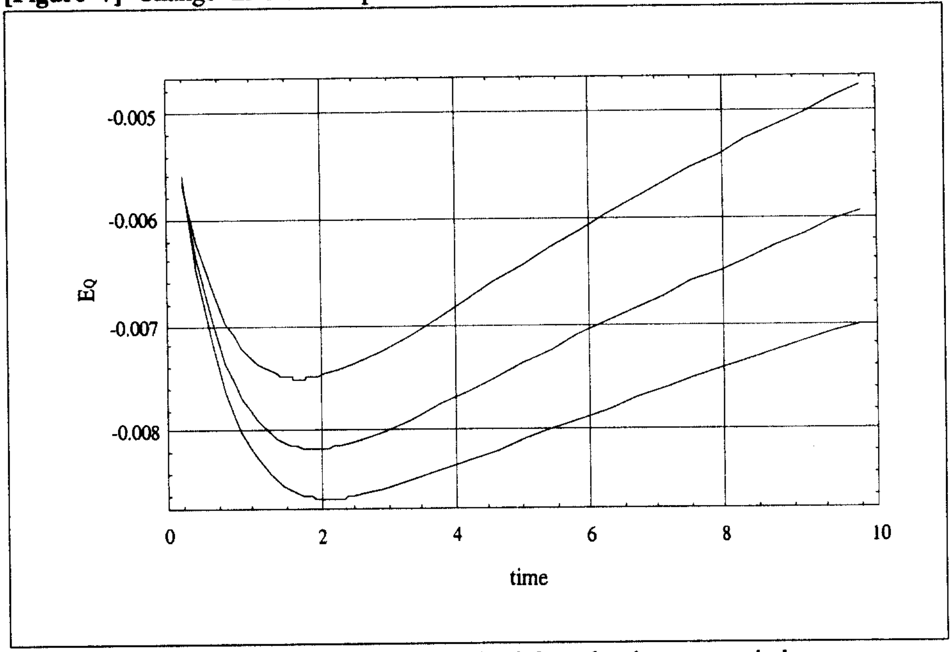
[Figure 6] Change in L_N



* Note : Model economies I, II, and III are depicted from the above, respectively.

<Appendix 5> Transitional dynamics in the model economies (continued)

[Figure 7] Change in Real output



* Note : Model economies I, II, and III are depicted from the above, respectively.

REFERENCE

Abel, A. B.(1980), "Empirical Investment Equations:An Integrated Framework," in: K. Brunner and A.H. Meltzer, eds., On the State of Macroeconomics, Vol.12 of the *Carnegie-Rochester Conference Series on Public Policy*, a *supplementary series to Journal of Monetary Economics*(1980): 39-91.

Attanasio, O. P. and G. Weber(1989), "Intertemporal Substitution, Risk Aversion and the Euler Equation for Consumption," *Economic Journal*, supplement, 99: 59-73.

Blanchard, O. and C. Wyplosz(1981), "An Empirical Structural Model of Aggregate Demand," *Journal of Monetary Economics*, 7: 1-28.

Blundell, R(1988), "Consumer Behavior:Theory and Empirical Evidence-A Survey," *Economic Journal*, 98: 16-65.

Buffie, E .F.(1993), "Quotas vs. Devaluation in the Small Open Economy," *Economica*, 58: 299-316.

________ (1992), "Commercial Policy, Growth and the Distribution of Income in a Dynamic Trade Model," *Journal of Development Economics*, 37: 1-30.

________ (1989), "Imported Inputs, Real Wage Rigidity and Devaluation in the Small Open Economy," *European Economic Review*, 33: 1345-1361.

________ (1986), "Devaluation, Investment and Growth in LDCs," *Journal of Development Economics*, 20: 361-371.

________ (1984), "The Macroeconomics of Trade Liberalization," *Journal of International Economics*, 17: 121-137.

________ and Y. Won(2001), "Devaluation and Investment in an Optimizing model of the Small Open Economy," *European Economic Review*, 45: 1461-1500.

Buiter, W.(1984), "Saddlepoint Problems in Continuous Time Rational Expectations Models:A General Method and Some Macroeconomic Examples," *Econometrica*, 52: 665-680.

Cooper, R.(1971), *Currency Devaluation in Developing Countries*, Princeton Essays on International Finance, no. 86.

De Melo, J., R. Faini, A. Senhadji and J. Stanton(1991), "Growth-oriented Adjustment Programs:A Statistical Analysis," *World Development*, 19: 957-967.

Deaton, A. and J. Muellbauer(1980), *Economics and Consumer Behavior*, Cambridge University Press, Cambridge.

Diaz Alejandro, C. F.(1963), "A Note on the Impact of Devaluation and the Redistribution Effect," *Journal of Political Economy*, 71: 577-580.

Dornbusch, R.(1980), *Open Economy Macroeconomics*, Basic Books, New York.

__________ (1973), "Devaluation, Money, and Nontraded Goods," *American Economic Review*, 63: 871-883.

Feenstra, R.(1986), "Functional Equivalence between Liquidity Costs and the

Utility of Money," *Journal of Monetary Economics*, 17: 271-291.

Frenkel, J. A. and H. G. Johnson, eds.(1976), *The Monetary Approach to the Balance of Payments*, Allen and Urwin, London.

Gylfason, T. and M. Schmid(1983), "Does Devaluation Cause Stagflation?," *Canadian Journal of Economics*, 16: 641-654.

Gould, J.(1968), "Adjustment Costs in the Theory of Investment of the Firmm," *Review of Economic Studies*, 35: 47-56.

Hirschman, A. O.(1949), "Devaluation and the Trade Balance:A Note," *Review of Economics and Statistics*, 31: 50-53.

Hall, R. E.(1988), "Intertemporal Substitution in Consumption," *Journal of Political Economy*, 96: 957-967.

Hansen, L. P. and K. J. Singleton(1983), "Stochastic Consumption, Risk Aversion and the Temporal Behavior of Asset Returns," *Journal of Political Economy*, 91: 249-265.

Hanson, J. A.(1983), "Contractionary Devaluation, Substitution in Production and Consumption, and the Role of the Labor Market," *Journal of International Economics*, 14: 179-189.

Hayashi, F.(1982), "Tobin's Marginal and Average q:A Neoclassical Interpretation," *Econometrica*, 50: 213-224.

Kamin, M. and N. L. Schwarz(1991), *Dynamic Optimization*, North-Holland, Amsterdam.

Khan, M. S., P. Montiel, and N. U. Haque(1990), "Adjustment with Growth: Relating the Analytical Approaches of the IMF and the World Bank," *Journal of Development Economics*, 32: 155-179.

Khatkhate, D.(1980), "Capital Scarcity and Factor Proportions in Less Developed Countries," *Journal of Post Keynesian Economics*, 155-180.

Kirman, A. P.(1993), "Whom or What Does the Representative Individual Represent?," *Journal of Economic Perspectives*, 8: 117-136.

Krueger, A.(1978), *Liberalization Attempts and Consequences*, NBER, New York.

Krugman, P. and L. Taylor(1978), "Contractionary Effects of Devaluation," *Journal of International Economics*, 8: 445-456.

Llunch, C., A. Powell and R. Williams(1977), *Patterns in Household Demand and Saving*, Oxford University Press, London.

Lucas, R. E.(1967), "Adjustment Costs and the Theory of Supply," *Journal of Political Economy*, 75:321-334.

Montiel, P. J. and J. S. Lizondo(1989), "Contractionary Devaluation in Developing Countries," *IMF Staff Papers*, 36: 182-227.

Risager, O.(1988), "Devaluation, Profitability and Investment," *Scandinavian Journal of Economics*, 90: 125-140.

Sidrauski, M.(1967), "Rational Choice and Patterns of Growth in a Monetary Economy," *American Economic Review*, 57: 534-544.

Summers, L. H.(1984), "The After-tax Rate of Return Affects Private Savings," *American Economic Review Papers and Proceedings*, 74: 243-253.

________ (1981), "Taxation and Corporate Investment:A q-theory Approach," *Brookings Papers on Economic Activity*, 1: 67-127.

White, L. J.(1978), "Evidence of Appropriate Factor Proportions for Manufacturing in Less Developed Countries," *Economic Development and Cultural Change*, 27: 27-59.

World Bank(1986, 1993), *World Development Report*, Washington, D.C.