Devaluation and the Role of Voluntary Unemployment

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This paper analyzes the effects of devaluation on investment as well as the other macroeconomic variables of interest in the small open developing economy producing traded and nontraded goods. In so doing, the paper makes use of a perfect foresight dynamic optimizing model emphasizing the role of imported capital good and the labor market distortions that are prevalent in most developing countries. A particular attention is paid to the nontradables sector where labor market is rigid by workers' reservation wage and thus voluntary unemployment is possible. The paper intends to see how much the results differ from those of the standard full employment model. Various simulation results reveal that the introduction of voluntary unemployment in the nontradables sector significantly changes the consequences of devaluation. The situation following devaluation in typical developing countries is likely to be worse than that of the full employment model. While devaluation improves the balance of payments on impact in all cases considered, both sectoral and aggregate investment fall larger than in the full employment model. Moreover, real output of the economy as well as employment in the nontradables sector falls in all cases considered, and falls larger than in the full employment model. The results show that devaluation may turn out to be quite a harsh experience for developing economies, especially those with labor market rigidity.

Keywords: Devaluation, Investment, Voluntary unemployment, Developing countries

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I. Introduction

The contactionary effects of devaluation have drawn renewed attention among development economists since a seminal paper by Krugman and Taylor (1978). Following and extending Hirschman (1949), Diaz Alejandro (1963), and Cooper (1971), they show that devaluation can lead to a reduction in national output if i) imports initially exceed exports, ii) there are differences in consumption propensities from profits and wages, iii) government revenues are increased by devaluation. Since then, numerous theoretical or empirical literature examines the validity of the contractionary devaluation (see, for example, Hanson (1983), Gylfason and Schmid (1983), Buffie (1986), Risager (1988), Montiel and Lizondo (1989), Faini and de Melo (1990), de Melo *et al.* (1991), Bahmani-Oskooee (1998), and most recently, Buffie and Won (2001))

Among others, Buffie (1986) investigates the impact of devaluation on aggregate investment spending for the first time in a serious manner. He shows that under an extremely weak condition devaluation lowers 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 a capital good. 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 a capital good in the sector producing traded goods. A recent paper by Buffie and Won (2001) overcomes the shortcoming and provides more general analysis in a two-sector small open economy model. Capturing the critical tension between tradables and nontradables sectors, they show that both sectoral and aggregate investments fall on impact after devaluation in most plausible cases considered and remain almost always below their long-run equilibrium levels during the transitional period.

However, full employment assumption - one of the main assumptions on which their model relies - is subject to criticism that it falls short of reality, especially in the context of less developed countries (LDCs). Considering the sizable wage differential and considerable costs of moving between the two sectors in LDCs, it is hard to believe that immediately after devaluation, workers who are released from higher-paying nontradables sector are willing to move to tradables sector, accepting lower wage. Expecting the fall in labor demand in the nontradables sector to be temporary and thus anticipating to be rehired in the sector later, they instead are likely to choose to remain unemployed voluntarily.

In this regard, this paper intends to improve on Buffie and Won (2001) by introducing the possibility of voluntary unemployment that is prevalent in most LDCs and analyzing after-devaluation transitional dynamics. Sharing the main features of their model, the paper investigates the effects of devaluation on the variables of interest such as sectoral and aggregate investment, the balance of payments, real output and sectoral employment in the small open economy producing traded and nontraded goods. Various simulation results reveal that typical LDC economies are likely to face more adverse consequences after devaluation than in the full employment model of Buffie and Won (2001), experiencing a larger fall in investment and a larger decline in real output. The introduction of voluntary unemployment in the model, therefore, strengthens the robustness of the contractionary effects of devaluation in typical LDC economies.

The paper proceeds as follows. Section II lays out the model and derives the system of differential equations that govern the paths of the variables of interest. Due to high dimensionality of the system, numerical methods are used to characterize the economy's dynamics. Section III describes how to calibrate the model with different sets of parameter values that reflect the various economic structures of LDCs. Section IV provides the results of calibrations in detail, interpreting them in economically sensible ways and comparing them with those of the full employment model. Section V 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 addition, real money balances enter the utility function explicitly to take the nonpecuniary services money yields into account in the spirit of Sidrauski (1967).[1]

[1] 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

Most importantly, the two-gap specification of the capital good is adopted and plays a critical role in the model.[2] 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.

A. *The Economy*

a) Technology

Two types of composite goods, traded and nontraded goods, are produced and consumed domestically. The tradables sector can be considered 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, while land is used only for the tradables sector. 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

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

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

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 while $\overline{T}$ denotes the fixed land supply used only in production of the tradables. The cost share of land reflects the weight of primary products in production of the tradables. More specifically, to simplify the analysis without limiting the possibility of various elasticities of factor substitution, both goods are assumed to be produced according to a constant elasticity of

functionally equivalent.

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

substitution (CES) technology.

In 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, the foreign currency price of a unit of tradables is assumed to be unity for analytical simplicity. Therefore, the domestic price of the traded good is specified as

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

where P_i denotes the domestic price of good i. The general price level (CPI) of the economy is constructed according to a geometric average of the prices of the two 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.[3]

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

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

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

where $c_i(\cdot)$, w_i, r_i denote a unit cost function, nominal wage rate and capital rental rate in sector i, respectively and v is the rental rate of land.

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.[4] Denoting b_T and b_N as the input-output coefficients for the noncompetitive imported input and

[3] That is, $\alpha = (P_N D_N)/E$ and $(1-\alpha) = (e D_T)/E$, where D_i denotes the consumption demand for good i and E denotes the nominal aggregate consumption expenditure on both goods.

[4] This fixed proportion assumption is not critical. See Buffie and Won (2001) for details.

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

$$\hat{P}_K = (1-\beta)\hat{e} + \beta\hat{P}_N, \tag{7}$$

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.*, $\hat{X} = dX/X$.

b) Factors and the Nontradables Markets

Considering the labor market distortion in LDCs, two different wage setting procedures are assumed for the two sectors. That is, the nontradables sector adopts 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.[5] Therefore, the nominal wage in the nontradables sector is specified as

$$\hat{w}_N = \gamma \hat{P}_N + (1-\gamma)\hat{e}, \tag{8}$$

where γ and $1-\gamma$ are the indexation weights attached to the price of the nontradables and the price of the tradables, respectively.[6]

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

[5] 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).

[6] Since real consumption wage is assumed to be institutionally fixed, γ is equal to α.

denotes the elasticity of factor substitution in sector i. Labor supply is assumed to be fixed at $\bar{L}$. Unlike Buffie and Won (2001) that assumes full employment even with real wage rigidity in the nontradables sector, we here introduce the possibility of voluntary unemployment, especially in the nontradables sector. There are two possible reasons why workers choose to remain unemployed voluntarily: high costs of moving between the two sectors and high reservation wage of the workers in the higher-paying nontradables sector. With voluntary unemployment, the labor market situation can be defined as

$$L_T+L_N \leqq \bar{L} \tag{11}$$

However, the land market clears continuously via a flexible land rental rate, v. Demand for land in the tradables sector is determined by the instantaneous profit maximization for a CES production function as

$$T=c(v/e)^{-\sigma_T}Q_T, \tag{12}$$

where c is a constant determined by technology. Therefore, the land market equilibrium is specified as

$$T=\bar{T}, \tag{13}$$

where T and $\bar{T}$ denote the demand for, and the supply of land, respectively.

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

$$D_N(e, P_N, E)+b_N[I_T+\Psi_T(I_T-\delta K_T)+I_N+\Psi_N(I_N-\delta K_N)]=Q_N(L_N, K_N), \tag{14}$$

where I_i and δ denote the gross investment in sector i and the constant depreciation rate of a capital good 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 $I>\delta K$, $\Psi_i''(\cdot)>0$, $\Psi(0)=\Psi'(0)=0$.[7]

[7] A convex adjustment costs function is introduced to make the model

B. The Representative Agent's Optimization Problem

a) 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.[8] 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

$$\dot{M} = R(e, P_N, K_T, K_N, L_N) - E - P_K[I_T + \Psi(I_T - \delta K_T)] - P_K[I_N + \Psi(I_N - \delta K_N)] \quad (15)$$

$$\dot{K}_T = I_T - \delta K_T \quad (16)$$

$$\dot{K}_N = I_N - \delta K_N, \quad (17)$$

where ρ is the constant time discount rate, and an overdot denotes the time derivatives $(\dot{X} = dX/dt)$. $V(e, P_N, E)$ is the indirect utility function and retains all the properties of a 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 a 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 facilitation of transactions. On the right-hand side of (15), $R(\cdot)$ is the revenue function of the family firm which equals $eQ_T + P_N Q_N$. Using the envelope theorem, we get

consistent with the assumption of sector-specific capital as well as to reflect real world phenomena. See Gould (1968), 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.

[8] 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.

$$R_1(\cdot)=Q_T,\ R_2(\cdot)=Q_N,\ R_3(\cdot)=r_T,\ R_4(\cdot)=r_N,\ R_5(\cdot)=w_N, \tag{18}$$

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 employment in the nontradables sector (L_N), and an increase in employment in the nontradables sector raises the revenue by w_N per worker.[9] This result comes from voluntary unemployment in the nontradables sector. Since workers laid off from the nontradables sector wouldn't take jobs in the tradables sector, either a decrease or an increase in employment in the nontradables sector changes the family firm's revenue by w_N per worker.

The budget constraint in (15) defines the evolution of domestic nominal money balances which are accumulated as revenue exceeds the sum of consumption expenditure and investment spending in the two sectors. With the nontradables market cleared continuously, (15) can be interpreted as domestic excess supply of the tradables, and thus as trade balance surplus as in Dornbusch (1973). (16) and (17) 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, $\{K_N, K_T, M\}$.

b) 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, $(i=1, 2, 3)$ represent the current shadow prices of money, capital in the tradables sector, and capital

[9] In the full employment model, $R_5(\cdot)=w_N-w_T$. This result comes from both a sectoral wage differential and full employment assumption. Because of full employment, nontradables sector employment (L_N) crowds out tradables sector employment (L_T) on a one for one basis.

in the nontradables sector, respectively. Time subscripts attached to the variables are omitted for notational simplicity.

The first-order necessary conditions (FONCs)[10] for the family firm's maximization problem are thus given as

$$V_E(e, P_N, E) = \lambda_1 \tag{19}$$

$$V_E P_K[1 + \Psi'_T(I_T - \delta K_T)] = \lambda_2 \tag{20}$$

$$V_E P_K[1 + \Psi'_N(I_N - \delta K_N)] = \lambda_3, \tag{21}$$

where these three conditions are obtained by maximizing H with respect to the three choice variables, $\{E, I_T, I_N\}$ respectively. These intertemporal no arbitrage conditions can be interpreted in a standard way. (19) states that the shadow price of money is equal to the marginal utility of a one dollar increase in consumption expenditure. (20) and (21) 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.

$$\dot{\lambda}_1 = \lambda_1 \rho - \frac{\Phi'(M/P)}{P} \tag{22}$$

$$\dot{\lambda}_2 = \lambda_1[(\rho+\delta)P_K - r_T + \rho P_K \Psi'_T] \tag{23}$$

$$\dot{\lambda}_3 = \lambda_1[(\rho+\delta)P_K - r_N + \rho P_K \Psi'_N], \tag{24}$$

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

Making use of (19), (22) and Roy's Identity, we obtain

$$\tau^{-1}\frac{\dot{E}}{E} = \frac{\Phi'}{PV_E} - \rho + (\tau^{-1} - 1)\alpha\frac{\dot{P}_N}{P_N}, \tag{25}$$

where $\tau\,(\equiv -(V_E/V_{EE}E))$ is the intertemporal elasticity of substitution that is defined as the inverse of relative risk aversion. Similarly,

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

combining (20) and (23) yields

$$\Psi''_T \dot{I}_T = (1+\Psi'_T)\frac{\Phi'}{PV_E} + \delta \Psi''_T (I_T - \delta K_T) + \delta - \frac{r_T}{P_K} - \beta(1+\Psi'_T)\frac{\dot{P}_N}{P_N} \tag{26}$$

Symmetric manipulations involving (21) and (24) give

$$\Psi''_N \dot{I}_N = (1+\Psi'_N)\frac{\Phi'}{PV_E} + \delta \Psi''_N (I_N - \delta K_N) + \delta - \frac{r_N}{P_K} - \beta(1+\Psi'_N)\frac{\dot{P}_N}{P_N} \tag{27}$$

Turning to the market clearing condition in the nontradables sector, we obtain the expression for $\hat{P}_N$ and $\dot{P}_N$ over the transitional period where $\dot{e}=0$ as

$$\begin{aligned}\hat{P}_N = (P_N Q_N J)^{-1}\{ &\alpha dE + \beta P_K[(1+\Psi'_T)dI_T + (1+\Psi'_N)dI_N - \delta \Psi'_T dK_T] \\ &- (\frac{r_N}{\theta_K^N} + \beta P_K \delta \Psi'_N) dK_N \}\end{aligned} \tag{28}$$

$$\begin{aligned}\frac{\dot{P}_N}{P_N} = (P_N Q_N J)^{-1}\{ &\alpha \dot{E} + \beta P_K[(1+\Psi'_T)\dot{I}_T + (1+\Psi'_N)\dot{I}_N - \delta \Psi'_T \dot{K}_T] \\ &- (\frac{r_N}{\theta_K^N} + \beta P_K \delta \Psi'_N) \dot{K}_N \}\end{aligned} \tag{29}$$

where $J \equiv (D_N/Q_N)(\varepsilon+\alpha) + (\sigma \theta_L^N (1-\gamma)/\theta_K^N)$ and ε is the compensated own price elasticity of demand while θ_j^i denotes the cost share of input j in sector i ($i=T, N, j=K, L, T$).

Since labor supply in the tradables sector wouldn't change even after devaluation, equation (9) determines the wage rate in the tradables sector as

$$\hat{w}_T = \frac{\theta_K^T}{\sigma_T}\hat{K}_T + \hat{e} \tag{30}$$

Likewise, equations (12) and (13) determine the land rental rate as

$$\hat{v} = \frac{\theta_K^T}{\sigma_T}\hat{K}_T + \hat{e} \tag{31}$$

From the zero profit condition for the tradables sector in (4) and making use of (30) and (31), we obtain

$$\hat{r}_T = \frac{(1-\theta_K^T)}{\sigma_T}\hat{K}_T + \hat{e} \tag{32}$$

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

Finally, linearizing (25), (26) and (27) around the steady-state,[11] and substituting (28) and (32) into them yield a three simultaneous differential equations system as[12,13]

$$
\begin{aligned}
G\dot{I}_T = {} & z\delta(1+\alpha B)\Big\{\frac{\rho+\delta}{z\delta}(dI_T-\delta dK_T)+\frac{\rho\,\theta_K^N\alpha}{\tau k(\rho+\delta)(D_N/Q_N)}\Big(dE-\frac{dM}{\mu}\Big) \\
& +\frac{\theta_K^N\beta}{Jk}\Big[\alpha dE+\beta(dI_T+dI_N)-\frac{\tau_N}{\theta_K^N}dK_N\Big] \\
& +\frac{(\rho+\delta)(1-\theta_K^T)}{\sigma_T}dK_T+\frac{\beta}{Jk}(dI_N-\delta dK_N)\Big\} \\
& +\frac{z\delta\beta^2\theta_K^N}{J}\Big\{(dI_T-\delta dK_T)-\frac{1}{k}(dI_N-\delta dK_N) \\
& +\frac{z\delta(1-\theta_L^N\gamma)}{J(\rho+\delta)k}\Big[\alpha dE+\beta(dI_T+dI_N)-\frac{(\rho+\delta)}{\theta_K^N}dK_N\Big] \\
& +\frac{z\delta(1-\theta_K^T)}{\sigma_T}dK_T\Big\}+\beta\alpha z\delta\theta
\end{aligned}
\tag{33}
$$

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

[12] In order to get the complete solutions, we need to pin down the Ψ_i'' terms. Log-differentiating (20) and evaluating it at the steady-state where $\Psi_T'=0$, 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 $\Psi_T''=1/z\delta K_T$, $\Psi_N''=1/z\delta K_N$.

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

$$G\dot{I}_N = z\delta(1+\alpha B)\{\frac{\rho+\delta}{z\delta}(dI_N - \delta dK_N) + \frac{\beta}{J}(dI_N - \delta dK_N) \tag{34}$$

$$+\frac{\rho\theta_K^N\alpha}{\tau(\rho+\delta)(D_N/Q_N)}(\alpha dE - \frac{dM}{\mu}) + \frac{\theta_K^N}{J}[\beta - \frac{(1-\theta_L^N\gamma)}{\theta_K^N}][\alpha dE +$$

$$+\beta(dI_T + dI_N) - FdK_N]\} - \frac{\beta\alpha z\delta F}{J}[\rho dE - \frac{\rho}{\mu}dM + BF(dI_N - \delta dK_N)]$$

$$-\frac{z\delta\beta^2\theta_K^N}{J}\{(dI_T - \delta dK_T) - \frac{1}{k}(dI_N - \delta dK_N)$$

$$+\frac{z\delta(1-\theta_L^N\gamma)}{J(\rho+\delta)k}[\alpha dE + \beta(dI_T + dI_N) - FdK_N] + \frac{z\delta(1-\theta_K^T)}{\sigma_T}dK_T\}$$

$$G\dot{E} = [1 + \frac{\beta^2(1+k)z\delta}{JFk}][\rho dE - \frac{\rho}{\mu}dM + BF(dI_N - \delta dK_N)] \tag{35}$$

$$-\beta B\{(\rho+\delta)(dI_T + dI_N - \delta dK_T - \delta dK_N)$$

$$+\frac{z\delta\alpha\rho(1+k)}{\tau k(D_N/Q_N)F}(dE - \frac{dM}{\mu}) + \frac{z\delta\theta_K^N}{Jk}[\beta(1+k)$$

$$-\frac{(1-\theta_L^N)\gamma k}{\theta_K^N}][\alpha dE + \beta(dI_T + dI_N) - FdK_N]$$

$$+\frac{(\rho+\delta)z\delta(1-\theta_K^T)}{\sigma_T}dK_T + \frac{z\delta\beta(1+k)}{Jk}(dI_N - \delta dK_N)\},$$

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

In addition, linearizing (15) around the steady-state and substituting (28) yield the complete expression for $\dot{M}$ as

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

$$+(\rho+\delta)dK_T-dE-dI_T-dI_N+\frac{(\rho+\delta)}{\theta_K^N}dK_N \qquad (36)$$

Equations (33), (34), (35), (16), (17) and (36) form the complete system of dynamic equations appropriate for calibration as

$$\begin{bmatrix}\dot{M}\\ \dot{E}\\ \dot{I}_T\\ \dot{I}_N\\ \dot{K}_T\\ \dot{K}_N\end{bmatrix}=\begin{bmatrix}0 & X_1 & X_2 & X_2 & \rho+\delta & X_3\\ X_4 & X_5 & X_6 & X_7 & X_8 & X_9\\ X_{10} & X_{11} & X_{12} & X_{13} & X_{14} & X_{15}\\ X_{16} & X_{17} & X_{18} & X_{19} & X_{20} & X_{21}\\ 0 & 0 & 1 & 0 & -\delta & 0\\ 0 & 0 & 0 & 1 & 0 & -\delta\end{bmatrix}\begin{bmatrix}M-M^*\\ E-E^*\\ I_T-I_T^*\\ I_N-I_N^*\\ K_T-K_T^*\\ K_N-K_N^*\end{bmatrix}, \qquad (37)$$

where an asterisk (*) denotes a new steady-state equilibrium, and X_i's are the coefficients of the corresponding variables in each equation.

III. Calibration of the Model

In order to see whether the system in (37) has a unique convergent solution path, and to find the path if one exists, we need to obtain the eigenvalues of the coefficient matrix in (37) and associated eigenvectors. Finding the eigenvalues of a 6×6 matrix involves solving a 6th order polynomial equation, which is, in general, impossible. Therefore, numerical method are used to get the eigenvalues and the associated eigenvectors.

A. Determination of Undetermined Parameters

Before calibrating the model, we should be able to assign the coefficient matrix real number values. In fact, we can set plausible values for $\alpha, \beta, \sigma_i, \theta_j^i, \gamma, \rho, \tau, \mu$ and ε from existing literature. But we still have three parameters undetermined, L_N/L_T, k and 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 $r_T = r_N$,

$$\frac{L_N}{L_T} = \frac{\theta_L^N}{\theta_T^N} \frac{P_N Q_N}{e Q_T} = \frac{\theta_L^N}{\theta_T^N} \frac{VA_N}{1 - VA_N}, \tag{38}$$

$$k(\equiv \frac{K_N}{K_T}) = \frac{\theta_K^N}{\theta_K^T} \frac{VA_N}{1 - VA_N}, \tag{39}$$

where $VA_N \equiv P_N Q_N / Y$, $Y = e Q_T + P_N Q_N$.
From the nontradables market clearing condition and the budget constraint evaluated at a steady-state, we obtain

$$VA_N = H^{-1}\Big[\alpha + \frac{\delta(\beta - \alpha)\theta_K^T}{(\rho + \delta)}\Big], \tag{40}$$

$$\frac{D_N}{Q_N} = \frac{(P_N/E)(E/Y)}{(P_N Q_N/Y)} = (\frac{\alpha}{VA_N})(\frac{E}{Y}) = (\frac{\alpha}{VA_N})[1 - \delta(\frac{K}{Y})], \tag{41}$$

where $H = 1 + [(\theta_N^T - \theta_K^T)\delta(\beta - \alpha)/(\rho + \delta)]$,
$K/Y = (\rho + \delta)^{-1}[\theta_K^T + (\theta_K^N - \theta_K^T)\ VA_N]$.
Once we assign sensible values for the parameters, VA_N is determined by (40). The values for L_N/L_T, k and D_N/Q_N are subsequently determined by (38), (39) and (41), respectively.

B. Solution Paths of the Variables of Interest

With all the parameters observable and determined consistently, we are now ready to solve the differential equations system in (37) numerically. In all 18 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[15]

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

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

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

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

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

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

where $h'_i \equiv h_i/M^0\hat{e}$. The h_i's are constants determined by the initial conditions, and λ_i and $v_{ji}(i,j=1,\cdots,6)$ are the corresponding ith eigenvalues and eigenvectors, respectively. The above equations depict the reactions of the variables of interest in the forms of cumulative elasticity with respect to devaluation. Superscript 0 denotes the initial steady-state or pre-jump values. On the other hand, change in the balance of payments over time is measured by the ratio of the balance of payments to initial expenditure and

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

[15] Here we assume that $\lambda_2, \lambda_5, \lambda_6$ are negative eigenvalues.

derived as

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

For calibration, we use the case where $\hat{e}=0.1$. That is, a 10% devaluation is assumed.

The responses of the other interesting variables are traced as

$$\frac{\hat{I}}{\hat{e}} = \left(\frac{1}{1+k}\right)\frac{\hat{I}_T}{\hat{e}} + \left(\frac{k}{1+k}\right)\frac{\hat{I}_N}{\hat{e}},$$

$$\frac{\hat{K}}{\hat{e}} = \left(\frac{1}{1+k}\right)\frac{\hat{K}_T}{\hat{e}} + \left(\frac{k}{1+k}\right)\frac{\hat{K}_N}{\hat{e}},$$

$$\frac{\hat{L}_N}{\hat{e}} = \frac{\sigma_N(1-\gamma)}{\theta_K^N}\left(\frac{\hat{P}_N}{\hat{e}} - 1\right) + \frac{\hat{K}_N}{\hat{e}},$$

$$\frac{\hat{Q}}{\hat{e}} = \theta_K^T(1-VA_N)\frac{\hat{K}_T}{\hat{e}} + VA_N\frac{\hat{K}_N}{\hat{e}} + \theta_L^N VA_N\left[\frac{\sigma_N(1-\gamma)}{\theta_K^N}\right]\left(\frac{\hat{P}_N}{\hat{e}} - 1\right),$$

where I and K denote aggregate investment and aggregate capital stock, respectively while Q denotes real output and thus $\hat{Q}$ is obtained by differentiating the revenue function at constant prices.[16]

C. Parameterization of the Model

With the model ready for calibration, we finally should be able to

[16] Notice that the responses of the price of the nontradables and the real exchange rate after a devaluation are traced as

$$\frac{\hat{P}_N}{\hat{e}} = 1 + \left(\frac{(D_N/Q_N)}{J}\right)\left(\frac{\hat{E}}{\hat{e}} - 1\right) + \frac{\beta\delta\theta_K^N}{J(\rho+\delta)k}\frac{\hat{I}_T}{\hat{e}} + \frac{\beta\delta\theta_K^N}{J(\rho+\delta)}\frac{\hat{I}_N}{\hat{e}} - J^{-1}\frac{\hat{K}_N}{\hat{e}},$$

$$\frac{(\hat{e}/P_N)}{\hat{e}} = \frac{(\hat{e}-\hat{P}_N)}{\hat{e}} = 1 - \frac{\hat{P}_N}{\hat{e}}, \text{ respectively.}$$

TABLE 1
PARAMETER VALUES USED TO CALIBRATE THE MODEL

Parameters that vary in simulation	β=0.25, 0.50, 0.75 τ=0.20, 1.0, 2.0 θ_U^T=0.10, 0.40
Parameters that are fixed in simulation	α=0.50, γ=0.50, ρ=0.10, z=1.5, δ=0.06 θ_L^N=0.30, θ_K^N=0.70, ε=0.20, μ=0.1, σ_i=0.50
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. γ= Weight of the nontradables in wage indexation. ρ= Pure time preference rate. μ= Ratio 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.

assign plausible values for the parameters from existing literature. The parameter values used to calibrate the model are summarized in Table 1. Here we investigate the effects of devaluation with 18 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 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 0.50-0.80. For the compensated own price elasticity of demand for the nontradables, ε, we use 0.20 following Llunch, Powell, and Williams (1977) and Blundell (1988). For the intertemporal elasticity of substitution, τ, Summers (1981) 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 0.20. Blundell (1988) also shows that it is small and probably less than

0.50. Attanasio and Weber (1989) obtains a little higher. Here, we try 0.2 and 2.0 for low and high ends and 1.0 for the middle. Regarding the q-elasticity of investment, z, we use 0.5 and 1.5. Abel (1980) shows that it is on the order of 0.50-1.1. Blanchard and Wyplosz (1981) estimates it as 0.43, while Hayashi (1982) puts it at around 0.67. 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 0.50 following White (1978), Khatkhate (1980), and Ahluwalia *et al.* (1974). For the cost share of primary factor (land) in the tradables sector, we try two different cases, $\theta_v^T=0.10$ for low dependence on primary factor case, and $\theta_v^T=0.40$ for high dependence on primary factor case. For θ_L^N and θ_K^N, we consider a neutral case where they have the same shares because we intend to see how different dependence on primary factor in the tradables sector affect the outcome. Pure time preference rate, ρ, is assumed to be 0.10. The rate of depreciation, δ, and the consumption share of the nontradables, α (and thus wage indexation parameter, γ) are set to be 0.06 and 0.50, respectively to focus on the other important variables such as θ_v^T, β, and τ. The ratio of money demand, μ, is set to be 0.10 as in Buffie (1992).

IV. Results

Under the parameterization of the economy given in the previous section, we trace the impact effects and 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. Table 2 summarizes a part of simulation results about the impact effects of devaluation. For the sake of comparison, we include the corresponding results of the full employment model (FEM) in parentheses. In what follows, we first provide and interpret the simulation results from general perspectives, comparing them with the results of the full employment model. And then, we discuss three typical model economies to see the transitional dynamics in detail.

TABLE 2

IMPACT EFFECTS OF DEVALUATION

$\theta_v^T = 0.10$

β	BOP	E	I_T	I_N	I	L_N	Q	τ
0.25	0.01234	0.80866	-0.32708	-0.38001	-0.35658	-0.10388	-0.01394	0.20
	(0.01278)	(0.81569)	(-0.31612)	(-0.36929)	(-0.34576)	(-0.10020)	(-0.00672)	
	0.00643	0.86500	-0.08868	-0.14895	-0.12227	-0.06579	-0.00883	1.0
	(0.00669)	(0.87026)	(-0.08217)	(-0.14241)	(-0.11574)	(-0.06312)	(-0.00424)	
	0.00479	0.89317	-0.04736	-0.10559	-0.07981	-0.05108	-0.00685	2.0
	(0.00499)	(0.89729)	(-0.04198)	(-0.10025)	(-0.07446)	(-0.04898)	(-0.00329)	
0.50	0.00988	0.76677	-0.22268	-0.30379	-0.27205	-0.13149	-0.01972	0.20
	(0.01053)	(0.77989)	(-0.21053)	(-0.28978)	(-0.25877)	(-0.12433)	(-0.00932)	
	0.00547	0.84833	-0.02383	-0.09678	-0.06823	-0.07276	-0.01091	1.0
	(0.00581)	(0.85644)	(-0.01882)	(-0.09067)	(-0.06256)	(-0.06863)	(-0.00515)	
	0.00417	0.87977	**0.00505**	-0.06239	-0.03600	-0.05555	-0.00833	2.0
	(0.00444)	(0.88593)	**(0.00894)**	(-0.05775)	(-0.03165)	(-0.05241)	(-0.00393)	
0.75	0.00819	0.74493	-0.12213	-0.22601	-0.19070	-0.14079	-0.02345	0.20
	(0.00898)	(0.76375)	(-0.11267)	(-0.21227)	(-0.17841)	(-0.13071)	(-0.01089)	
	0.00514	0.84107	**0.03297**	-0.04167	-0.01629	-0.06947	-0.01157	1.0
	(0.00553)	(0.85055)	**(0.03519)**	(-0.03865)	(-0.01355)	(-0.06501)	(-0.00541)	
	0.00415	0.87209	**0.05062**	-0.01522	**0.00715**	-0.05230	-0.00871	2.0
	(0.00445)	(0.87904)	**(0.05217)**	(-0.01353)	**(0.00881)**	(-0.04909)	(-0.00409)	

$\theta_v^T = 0.40$

β	BOP	E	I_T	I_N	I	L_N	Q	τ
0.25	0.01167	0.80692	-0.34659	-0.40092	-0.38248	-0.10260	-0.01400	0.20
	(0.01201)	(0.81404)	(-0.33464)	(-0.38942)	(-0.37083)	(-0.09893)	(-0.00675)	
	0.00624	0.86274	-0.08957	-0.15152	-0.13050	-0.06614	-0.00902	1.0
	(0.00650)	(0.86817)	(-0.08286)	(-0.14485)	(-0.12381)	(-0.06345)	(-0.00433)	
	0.00469	0.89165	-0.04710	-0.10666	-0.08644	-0.05141	-0.00701	2.0
	(0.00488)	(0.89592)	(-0.04163)	(-0.10128)	(-0.08104)	(-0.04929)	(-0.00336)	
0.50	0.00960	0.76783	-0.23870	-0.31912	-0.29499	-0.12891	-0.01934	0.20
	(0.01022)	(0.78045)	(-0.22579)	(-0.30480)	(-0.28110)	(-0.12211)	(-0.00916)	
	0.00542	0.84766	-0.02375	-0.09727	-0.07521	-0.07286	-0.01093	1.0
	(0.00576)	(0.85561)	(-0.01863)	(-0.09129)	(-0.06949)	(-0.06887)	(-0.00517)	
	0.00416	0.87949	**0.00561**	-0.06258	-0.04212	-0.05591	-0.00839	2.0
	(0.00442)	(0.88558)	**(0.00959)**	(-0.05803)	(-0.03775)	(-0.05286)	(-0.00396)	
0.75	0.00811	0.74630	-0.13214	-0.23462	-0.20791	-0.13895	-0.02287	0.20
	(0.00886)	(0.76416)	(-0.12213)	(-0.22091)	(-0.19517)	(-0.12946)	(-0.01065)	
	0.00514	0.84043	**0.03542**	-0.04038	-0.02062	-0.07052	-0.01161	1.0
	(0.00552)	(0.84970)	**(0.03773)**	(-0.03737)	(-0.01780)	(-0.06617)	(-0.00545)	
	0.00414	0.87174	**0.05312**	-0.01456	**0.00308**	-0.05367	-0.00884	2.0
	(0.00443)	(0.87868)	**(0.05477)**	(-0.01277)	**(0.00483)**	(-0.05048)	(-0.00415)	

Note: For the sake of comparison, corresponding figures of the FEM are included in parentheses.

A. 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.

Of interest is the response of investment at both sectoral and aggregate levels. Investment in the nontradables sector, I_N, falls on impact after 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. 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 production of capital good and the intertemporal elasticity of substitution are very high, the investment in the tradables sector jumps up on impact after a devaluation, and then approaches the new steady-state where the investment remains the same as its initial level.

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] which causes the demand for labor in the nontradables sector to fall. As a result, the marginal productivity of capital falls in the sector, which makes the q-ratio smaller. In addition, a devaluation makes q-ratio in the nontradables sector smaller by raising the relative price of the capital

[17] $\left(\frac{\hat{w}_N}{P_N}\right) = \hat{w}_N - \hat{p}_N = \gamma \hat{P}_N + (1-\gamma)\hat{e} - \hat{P}_N = (1-\gamma)(\hat{e} - \hat{P}_N) > 0$

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 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. On the contrary, 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

[18] $$(\frac{\hat{P}_K}{P_N}) = \hat{P}_K - \hat{p}_N = \beta\hat{P}_N + (1-\beta)\hat{e} - \hat{P}_N = (1-\beta)(\hat{e} - \hat{P}_N) > 0$$

[19] $$(\frac{\hat{P}_K}{e}) = \hat{P}_K - \hat{e} = \beta\hat{P}_N + (1-\beta)\hat{e} - \hat{e} = -\beta(\hat{e} - \hat{P}_N) < 0$$

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, and the weaker the competing asset effect. On the other hand, the q-effect depends on the cost share of the nontradables in 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 good measured in terms of tradables becomes larger, and the initial increase in the price of the capital good 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, on the other hand, 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 almost all cases considered except one extreme case.

Employment in the nontradables sector, L_N, falls on impact after devaluation in all cases considered. This can be explained by the fact that the product wage in the nontradables sector increases on impact. The released workers from the nontradables sector are not absorbed by the tradables sector under the assumption of voluntary unemployment in the model. However, employment in the nontradables sector, L_N, finally approaches the new steady-state where L_N remains the same as its initial level.

Real output, Q, falls on impact in all cases considered after devaluation. This is because the workers who are released from the nontradables sector choose to stay out of production process. However, real output is restored to the initial level at the new steady-state as the other variables adjust.

B. Comparison with the Full Employment Model (FEM)

A devaluation improves the balance of payments on impact in all cases considered as in the full employment model (FEM). However, the size of improvement in the balance of payments is smaller than in the FEM. As noticed before, the domestic excess supply of the tradables matches the balance of payments surplus. With voluntary unemployment in the nontradables sector, the negative real income effect of devaluation is larger than in the FEM. This could increase the excess supply of the tradables. But at the same time, the domestic production of the tradables would be unchanged on impact unlike in the FEM, since workers who are released from the nontradables would remain unemployed instead of moving and working in the tradables sector. Therefore, even considering a larger fall in demand for the tradables, the domestic excess supply of the tradables would decrease in the model with voluntary unemployment than in the FEM. This explains why the balance of payments improves less in the model with open unemployment. During the transitional period, as in the FEM, 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.

The initial increase in nominal expenditure is smaller than in the FEM, which implies that real expenditure falls on impact more than in the FEM. Facing both a sudden fall in real money balances and a larger decline in real income after a devaluation, the representative family firm that wants to restore real money balances to the desired level, should reduce real expenditure more and save more than in the FEM. This leads to a larger fall in real consumption expenditure.

The response of investment at both sectoral and aggregate levels is more interesting. Sectoral investments and therefore, aggregate investment show qualitatively same behaviors after a devaluation as in the FEM. But quantitatively, they show a distinct pattern which is different from the FEM. That is, they decrease more when they decrease, and increase less when they increase. Recall the three prominent effects operating when investment decision in each sector is made following a devaluation. First, consider the nontradables sector in which investment falls more on impact than in the FEM in all cases considered. Both the q-effect and the competing asset effect pull in direction of lower investment as in the FEM. But facing a larger fall in real income with voluntary unemployment, the representative family firm that wants to smooth consumption decrease investment in the sector more, *i.e.*, the consumption smoothing effect pull in direction of much lower investment in the sector than in the FEM. Therefore, the three prominent effects operate so that investment in the nontradables sector decreases more than in the FEM.

Next, consider the tradables sector in which investment falls more with relatively low β and τ, and increases less with relatively high β and τ than in the FEM. A devaluation lowers the product wage in the tradables sector, which raises demand for labor in the sector. However, the marginal productivity of capital wouldn't increase since labor supply to the tradables sector is assumed to be fixed. Therefore, even if a fall in the relative price of capital good in terms of the tradables makes the q-ratio larger, the overall increase in the q-ratio is smaller than in the FEM. In addition, by the same reason as in the nontradables sector, the consumption smoothing effect decreases investment in the tradables sector more than in the FEM. The competing asset effect again pull in direction of lower investment in the sector. Therefore, the positive effect on investment in the sector, the q-effect, becomes smaller, while the negative effects, the competing asset effect and the consumption smoothing effect, become larger with voluntary unemployment. Consequently, investment in the tradables sector falls more, or increases less with voluntary unemployment than in the FEM. Aggregate investment, therefore, falls more, or increases less on impact after a devaluation than in the FEM.

Employment in the nontradables sector, L_N, falls on impact after a devaluation in all cases considered as in the FEM due to the fact that the product wage in the nontradables sector increases on impact. But, L_N decreases more than in the FEM. This has to do with a smaller increase in the price of the nontradables on impact, which is, in turn, due to a larger fall in investment and a less increase in nominal consumption expenditure following a devaluation. The released workers from the nontradables sector choose to be unemployed until they get rehired in the sector.

Real output, Q falls on impact in all cases more than in the FEM. This is because workers who are released from the nontradables sector choose to remain unemployed voluntarily instead of moving to the tradables sector. Simulation results show that the fall in real output on impact is about two times larger than in the FEM. Real

TABLE 3
PARAMETER VALUES FOR THE MODEL ECONOMIES

Model Economy	Common Parameter Values	β, τ
I	$\alpha=0.50$, $\gamma=0.50$, $\rho=0.10$, $\delta=0.06$	$\beta=0.25$, $\tau=0.2$
II	$\sigma_l=0.50$, $\theta_L^N=0.30$, $\theta_K^N=0.70$, $\varepsilon=0.20$, $\mu=0.1$, $z=1.5$, $\theta_L^T=0.45$, $\theta_K^T=0.45$,	$\beta=0.5$, $\tau=1$
III	$\theta_v^T=0.10$	$\beta=0.75$, $\tau=2$

output, however, is restored to the initial level at the new steady-state as the other variables adjust.

C. 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 degrees of dependence on imported machines and different intertemporal elasticity of substitution. The model economy I is highly dependent upon imported machines, with a representative family firm which has a low intertemporal elasticity of substitution, and thus prefers very smooth consumption. This specification is most appropriate for low income LDC economies such as sub-Saharan African nations that produce and export rudimentary manufacturing goods. The model economy III is, on the other hand, less dependent upon imported machines, with a representative family firm which has a very high intertemporal elasticity of substitution, and thus reluctant to smooth consumption. This specification may be close to high income LDC economies, such as Korea, Hong Kong and Taiwan. The model economy II is in between.

Parameterization for the three economies are as in Table 3. Impact effects of devaluation on the variables of interest and their transitional paths are shown as Figure 1-6.

Figure 1 shows that a 10% of devaluation improves the balance of payments on impact as much as 1.23%, 0.55% and 0.42% of the initial nominal consumption expenditure in the model economies I, II and III, respectively. However, the initial improvement gradually fades away, and finally the balance of payments surplus disappears about in 4-5 years. Devaluation is neutral in the long run as in the typical monetary model.

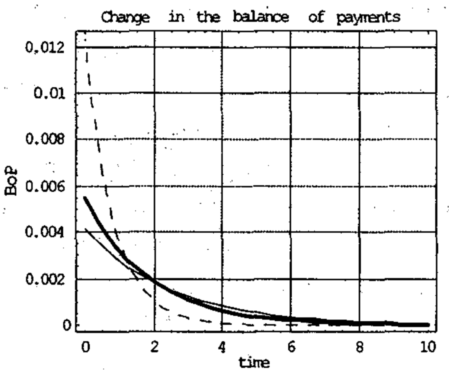

FIGURE 1

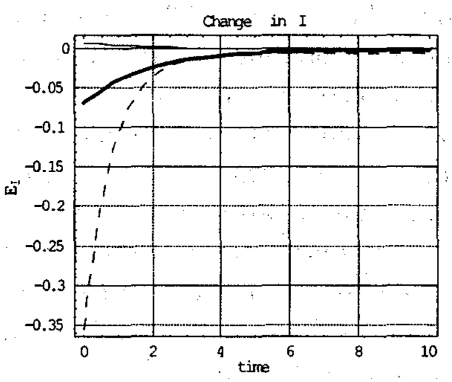

FIGURE 4

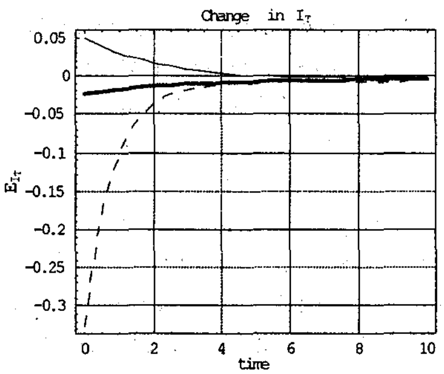

FIGURE 2

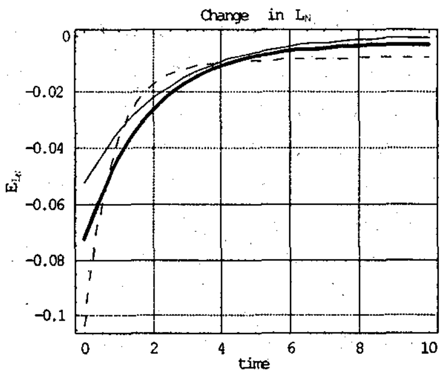

FIGURE 5

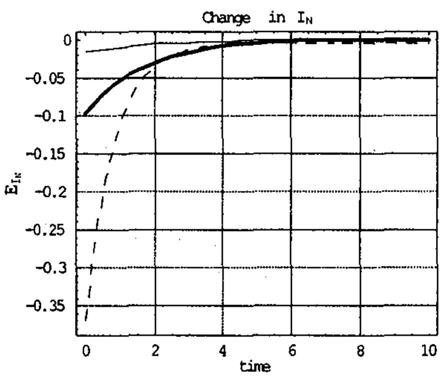

FIGURE 3

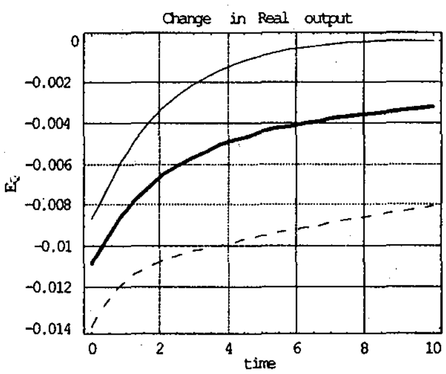

FIGURE 6

Note: Model Economies I, II, and III are depicted by dotted, thick, and thin lines respectively.

Figure 2 shows that investment in the tradables sector falls immediately by 0.33% and 0.02% per percent devaluation in the model economies I and II, respectively but increases 0.05% in the model economy III. Since then, it quickly approaches toward the new steady-state where it is same as the initial level. Figure 3 indicates that investment in the nontradables sector drops in all cases immediately after devaluation, by 0.38%, 0.10%, and 0.02% per percent devaluation in the model economies I, II, and III, respectively. Following the initial jump-down, it rebounds sharply for the first 3 years, approaching toward the new steady-state where it is same as the initial level.

Combining Figure 2 and Figure 3, Figure 4 shows that aggregate investment drops immediately by 0.36%, 0.07% per percent devaluation in the model economies I and II, respectively, but increases less than 0.01% in the model economy III. Since then, it approaches toward the new steady-state where it is same as the initial level. Figure 5 shows that employment in the nontradables sector falls on impact following a devaluation by 0.104%, 0.073% and 0.052% per percent devaluation in the model economies I, II, and III, respectively. After the initial decrease, it increases sharply for the first 3-4 years before approaching steadily toward its long-run equilibrium level. Finally, Figure 6 describes that real output drops immediately after a devaluation by 0.014%, 0.011% and 0.009% per percent devaluation in model economies I, II, and III, respectively. Thereafter, it rises slowly toward its long-run equilibrium level.

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 those LDC economies which depend heavily on imported machines in capital formation, especially for those with voluntary unemployment. That is, 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 devaluation, typical LDC economies will suffer a severe recession, experiencing a fall in investment and in real output. Moreover, typical LDC economies with voluntary unemployment are likely to face more adverse consequences than in the standard full employment model, experiencing a larger fall in investment and a larger decline in real output. Therefore, the introduction of voluntary unemployment in the model strengthens the robustness of the contractionary effects of devaluation in typical LDC economies.

The results clearly give a warning signal to those governments that implement stabilization programs recommended by IMF-World Bank in exchange for adjustment loans. When devaluation is implemented, the other policy measures such as tight monetary and fiscal policies and high interest rates policy in the programs 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. In addition, our results suggest that the program should include the measures to get rid of voluntary unemployment, such as measures to improve labor market flexibility.

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