Preliminary draft

Exchange Rate Changes and Income Redistribution*

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May 9, 2007

Abstract

Changes in exchange rates certainly have profound effects on redistribution of income between owners of different production factors. This paper investigates the income redistribution effects of exogenous exchange rate changes (devaluations) in a dynamic specific factors model of a small open economy that produces traded and non-traded goods. Workers are assumed to move freely between the sectors with a flexible wage rate while installed capital is sector-specific and new capital goods are constructed by combining non-traded inputs with imported machines. Keeping the results of static specific factors model in mind, I trace fully articulated dynamic paths of real factor incomes after devaluation. In so doing, the paper intends to measure the extent to which real return on capital in both sectors would change over time, and to see which direction real wages would move on impact and over time after devaluation with different sets of parameter values. Various simulation results show that real return on capital in the nontradables sector always falls on impact following devaluation while that in the tradables sector invariably jumps up on impact. On the other hand, real wage jumps up, stay unchanged or falls on impact following a devaluation depending mainly on factor intensity of each sectors and the share of imported capital goods in production of capital goods. In the long run, of course, real factor incomes return to their new steady-state levels that are same as their pre-devaluation levels.

Key Words: devaluation, income redistribution, real factor income
JEL Classification: F41, O11

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* Prepared for the Spring seminar for the Korea Money and Finance Association.

1. Introduction

Changes in exchange rates certainly have profound effects on redistribution of income between owners of different production factors. However, though, research on the effects of exchange rate changes has so far focused mainly on their effects on employment and output as well as on the balance of payments.[1)] More interesting question in a socio-economic sense would be the effects of exchange rate changes on redistribution of income between owners of different production factors. It is especially so in less developed countries (LDCs) that should pursue economic development, maintaining social stability at the same time.

Important contributions have been made by several authors, including Alexander(1952), Diaz Alejandro(1963), Cooper(1971), Krugman and Taylor(1978), Barbone and Rivera-Batiz(1987). By assuming fixed money wage at least in the short run, however, they simply see the redistributive effects of devaluation as transferring income always from fixed wage earners to capitalists, and only as a part of aggregate demand changes in a class of static models. Moreover, they pay little attention to the consequences of sectoral difference by assuming a single aggregate production sector. Buffie(1992), on the other hand, analyzes the income redistribution effects of commercial policies in a dynamic trade model. However, his model is not a macroeconomic but a real model, having little to do with money or inflation. Moreover, as acknowledged by himself, he didn't take into account different sectoral responses either, mainly due to the complexity of dynamic equations system.

Taking this strand of previous literature into consideration, the paper investigates the income redistribution effects of exchange rate changes in a dynamic specific factors model of a small open economy that produces traded and non-traded goods. Workers are assumed to move freely between the sectors with a flexible wage rate while installed capital is sector-specific and new capital goods are constructed by combining non-traded inputs with imported machines. Keeping the results of static specific factors model in mind, the paper traces fully articulated dynamic paths of real factor incomes after devaluation. In so doing, the paper intends to measure the extent to which real returns on capital in both sectors would change over time, and to see which direction and how far real wage would move on impact and over time after devaluation with different sets of parameter values.

Various simulation results with different sets of parameter values show that real return on capital in the nontradables sector always falls on impact following devaluation while that in the tradables sector invariably jumps up on impact. On the other hand, real wage jumps up, stays unchanged or falls on impact following devaluation depending mainly on factor intensity of each sectors and the share of imported machines in production of capital goods. In the long run, of course, real factor incomes return to their steady-state levels that are same as their pre-devaluation levels.

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1) In particular, there have heated debates among development economists regarding whether devaluation is expansionary or contractionary in the context of LDCs. [see, for example, Hirschman(1949), Hanson(1983), Gylfason and Schmid (1983), Buffie(1986), Risager(1988), Montiel and Lizondo(1989), Buffie and Won(2001), Won(2005), and Tovar(2005)]

The paper proceeds as follows. In section 2, I 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 (6×6) dynamic equations system, I rely on numerical methods to characterize the economy's dynamics. Section 3 describes how I calibrate the model with different sets of parameter values that reflect various economic characteristics of LDCs. Section 4 provides the results of calibrations in detail, interpreting them in economically sensible ways. Section 5 concludes the paper.

2. 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 specification of the capital good 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, I 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, or vice versa.

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. More specifically, to simplify the analysis without limiting the possibility of various elasticities of factor substitution, I assume that both goods are produced according to a constant elasticity of substitution(CES) technology. Therefore, the production relation in each sector can be described as

$$Q_T = [a_1 L_T^{(\sigma_T - 1)/\sigma_T} + a_2 K_T^{(\sigma_T - 1)/\sigma_T}]^{\sigma_T/(\sigma_T - 1)} \qquad (1)$$

$$Q_N = [a_3 L_N^{(\sigma_N - 1)/\sigma_N} + a_4 K_N^{(\sigma_N - 1)/\sigma_N}]^{\sigma_N/(\sigma_N - 1)}, \qquad (2)$$

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.

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

where a_1-a_4 are constants determined by technology and subscripts T and N denote the tradables and the nontradables sectors, respectively. σ_i, Q_i, K_i and L_i denote the elasticity of factor substitution, the output, the sector-specific capital and labor inputs used in sector i, respectively.

Since I 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, I assume that the foreign currency price of a unit of tradables is unity for analytical simplicity. 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 P_i denotes the domestic price of good i, and α and $1-\alpha$ represent the shares of the nontradables and the tradables in aggregate consumption expenditure, respectively.[4)]

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

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

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

where $c_i(\cdot)$, r_i, w denote the unit cost function, capital rental rate in sector i, and the nominal wage rate, 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 and its percentage change are determined as

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

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

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 a percentage change (i.e., $\hat{X} = dX/X$).

2.1.2. Factors and the nontradables markets

The labor market clears continuously via the flexible wage rate in both sectors 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

$$L_T = a_1 (w/e)^{-\sigma_T} Q_T \tag{8}$$

$$L_N = a_3 (w/P_N)^{-\sigma_N} Q_N\ . \tag{9}$$

4) That is, $\alpha = (P_N D_N)/E$ 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.

Labor supply is assumed to be fixed at $\overline{L}$. Therefore, the labor market equilibrium can be defined as

$$L_T + L_N = \overline{L} \tag{10}$$

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

$$D_N(e, P_N, E) + b_N[I_T + \Psi_T(I_T - \delta K_T) + I_N + \Psi_N(I_N - \delta K_N)] = Q_N(L_N, K_N), \tag{11}$$

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 $\Psi'_i(\cdot) \gtrless 0$ as $I \gtrless \delta K$, $\Psi''_i(\cdot) > 0$ and $\Psi(0) = \Psi'(0) = 0$.[5]

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.[6] 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

$$\dot{M} = R(e, P_N, K_T, K_N) - E - P_K[I_T + \Psi(I_T - \delta K_T)] - P_K[I_N + \Psi(I_N - \delta K_N)] \tag{12}$$

$$\dot{K}_T = I_T - \delta K_T \tag{13}$$

$$\dot{K}_N = I_N - \delta K_N, \tag{14}$$

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 a usual indirect utility function such as $V_i = \partial V / \partial P_i < 0, V_E = \partial V / \partial E > 0$ 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 the facilitation of transactions. On the right-hand side of (12), $R(\bullet)$ is the revenue function of the family firm which equals $eQ_T + P_N Q_N$. The revenue function also has the usual properties such as

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5) 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), 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.

6) This specification is convenient in that demand for each good depends only on prices and aggregate expenditure, but not on real money balances.

$$R_1(\cdot) = Q_T,\ R_2(\cdot) = Q_N,\ R_3(\cdot) = r_T,\ R_4(\cdot) = r_N, \tag{15}$$

where the subscript j means the partial differentiation of the revenue function, $R(\bullet)$ with respect to the jth argument.

The budget constraint, (12) 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, (12) can be interpreted as the domestic excess supply of the tradables, and thus as the trade balance surplus as in Dornbusch (1973). (13) and (14) 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 : Solution Procedure

The present value Hamiltonian function for this problem is specified as

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

where the co-state variables $\lambda_i, (i = 1,2,3)$ 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)[7] for the family firm's maximization problem are thus given as

$$V_E(e, P_N, E) = \lambda_1 \tag{16}$$

$$V_E P_K [1 + \Psi'_T (I_T - \delta K_T)] = \lambda_2 \tag{17}$$

$$V_E P_K [1 + \Psi'_N (I_N - \delta K_N)] = \lambda_3, \tag{18}$$

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. (16) states that the shadow price of money is equal to the marginal utility of a one dollar increase in consumption expenditure. (17) and (18) 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.

$$\dot{\lambda}_1 = \lambda_1 \rho - \frac{\Phi'(M/P)}{P} \tag{19}$$

7) It is assumed that the transversality conditions for three assets are met.

$$\dot{\lambda}_2 = \lambda_1[(\rho+\delta)P_K - r_T + \rho P_K \Psi'_T] \tag{20}$$

$$\dot{\lambda}_3 = \lambda_1[(\rho+\delta)P_K - r_N + \rho P_K \Psi'_N], \tag{21}$$

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

The first task is to get rid of the unobservable shadow prices from the dynamic system, making use of the information on the FONCs. This can be done by differentiating (16) with respect to time and substituting for (19). Simple manipulations, making use of Roy's Identity, give

$$\tau^{-1}\frac{\dot{E}}{E} = \frac{\Phi'}{PV_E} - \rho + (\tau^{-1}-1)\alpha\frac{\dot{P}_N}{P_N}, \tag{22}$$

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. Similar manipulations involving (17) and (20), and then (18) and (21) yield, respectively

$$\Psi''_T\dot{I}_T = (1+\Psi'_T)\frac{\Phi'}{PV_E} + \delta\Psi''_T(I_T - \delta K_T) + \delta - \frac{r_T}{P_K} - \beta(1+\Psi'_T)\frac{\dot{P}_N}{P_N} \tag{23}$$

$$\Psi''_N\dot{I}_N = (1+\Psi'_N)\frac{\Phi'}{PV_E} + \delta\Psi''_N(I_N - \delta K_N) + \delta - \frac{r_N}{P_K} - \beta(1+\Psi'_N)\frac{\dot{P}_N}{P_N}. \tag{24}$$

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

$$\widehat{P_N} = (P_N Q_N J)^{-1}\ \{\alpha dE + \beta P_K[(1+\Psi'_T)dI_T + (1+\Psi'_N)dI_N] + \Theta_T dK_T + \Theta_N dK_N\} \tag{25}$$

$$\frac{\dot{P}_N}{P_N} = (P_N Q_N J)^{-1}\ \{\alpha\dot{E} + \beta P_K[(1+\Psi'_T)\dot{I}_T + (1+\Psi'_N)\dot{I}_N] + \Theta_T\dot{K}_T + \Theta_N\dot{K}_N\}\ , \tag{26}$$

where $\Theta_T \equiv (\frac{kr_N}{\theta_K^N})(\frac{\sigma_N\theta_L^N}{\theta_K^N})\omega_3 - \beta\delta\Psi_T{}'$, $\Theta_N \equiv (\frac{r_N}{\theta_K^N})[(\frac{\sigma_N\theta_L^N}{\theta_K^N})\omega_4 - 1] - \beta\delta\Psi_N{}'$, $k \equiv \frac{K_N}{K_T}$, $J \equiv \frac{D_N}{Q_N}(\epsilon+\alpha) + \frac{\omega_1\sigma_N\theta_L^N}{\theta_K^N}$ and ϵ is the compensated own price elasticity of demand. θ_j^i 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, (10) give a percentage change of nominal equilibrium wage rate as[8)]

$$\hat{w} = \omega_1\hat{e} + \omega_2\widehat{P_N} + \omega_3\widehat{K_T} + \omega_4\widehat{K_N}, \tag{27}$$

where $\omega_1 = \Omega^{-1}(\frac{\sigma_T}{\theta_K^T})$, $\omega_2 = \Omega^{-1}(\frac{L_N}{L_T})(\frac{\sigma_N}{\theta_K^N})$, $\omega_3 = \Omega^{-1}$, $\omega_4 = \Omega^{-1}(\frac{L_N}{L_T})$ and $\Omega = \frac{\sigma_T}{\theta_K^T} + (\frac{\sigma_N}{\theta_K^N})(\frac{L_T}{L_N})$.

Making use of (27), zero profit condition for the tradables sector, (4) gives

$$\widehat{r_T} = s_1\hat{e} - s_2\widehat{P_N} - s_3\widehat{K_T} - s_4\widehat{K_N}, \tag{28}$$

8) In equation (27), homogeneity property can be seen by noting that the sum of the coefficients of the nominal variables, e and P_N equals 1.

where $s_1 = (\frac{1}{\theta_K^T})(1-\omega_1\theta_L^T)$, $s_2 = \omega_2(\frac{\theta_L^T}{\theta_K^T})$, $s_3 = \omega_3(\frac{\theta_L^T}{\theta_K^T})$, $s_4 = \omega_4(\frac{\theta_L^T}{\theta_K^T})$.

Likewise, combining (5) and (27) gives[9)]

$$\widehat{r_N} = v_1\hat{e} - v_2\widehat{P_N} - v_3\widehat{K_T} - v_4\widehat{K_N}, \quad (29)$$

where $v_1 = (\frac{1}{\theta_K^N})(1-\omega_2\theta_L^N)$, $v_2 = \omega_1(\frac{\theta_L^N}{\theta_K^N})$, $v_3 = \omega_3(\frac{\theta_L^N}{\theta_K^N})$, $v_4 = \omega_4(\frac{\theta_L^N}{\theta_K^N})$.

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

The final task is to obtain dynamic expressions for the three choice variables. Linearizing (22), (23) and (24), and evaluating them around steady-state[10)], and then substituting (25) and (28) into them yield a three simultaneous differential equations system regarding $\dot{I}_T, \dot{I}_N$, and $\dot{E}$ as in <Appendix 1>.[11)12)] In addition, linearizing (12), and evaluating it around the steady-state, and substituting (25) in it yield the complete expression for $\dot{M}$ as

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

(A.1), (A.2), (A.3) in <Appendix 1>, (15), (16) and (30) form the complete system of dynamic equations appropriate for the calibration as

$$\begin{bmatrix} \dot{M} \\ \dot{E} \\ \dot{I}_T \\ \dot{I}_N \\ \dot{K}_T \\ \dot{K}_N \end{bmatrix} = \begin{bmatrix} 0 & X_1 & X_2 & X_2 & X_{22} & X_3 \\ -X_4 & X_5 & X_6 & X_7 & X_8 & X_9 \\ -X_{10} & X_{11} & X_{12} & X_{13} & X_{14} & X_{15} \\ X_{16} & X_{17} & X_{18} & X_{19} & X_{20} & X_{21} \\ 0 & 0 & 1 & 0 & -\delta & 0 \\ 0 & 0 & 0 & 1 & 0 & -\delta \end{bmatrix} \begin{bmatrix} M-M^* \\ E-E^* \\ I_T - I_T^* \\ I_N - I_N^* \\ K_T - K_T^* \\ K_N - K_N^* \end{bmatrix}, \quad (31)$$

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>.

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9) Basic homogeneity property appears again in (29) by $v_1 - v_2 = 1$, and in (28) by $s_1 - s_2 = 1$.

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

11) In order to get the complete solutions, I need to pin down the Ψ_i'' terms. Log-differentiating (17) and evaluating it at the steady-state where $\Psi_T'(\cdot) = 0$, yield $\Psi_T'' I_T \widehat{I_T} = \widehat{\lambda_2} - \widehat{\lambda_1} - \widehat{P_K}$. 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, I can get the expressions for Ψ_i'' evaluated at a steady-state as $\Psi_T'' = (1/z\delta K_T)$, $\Psi_N'' = (1/z\delta K_N)$.

12) In obtaining the solutions, we assume that the income elasticity of money demand, η, equals to 1. That is, $\eta \equiv \frac{\widehat{M}}{\hat{E}} = \frac{\Phi' V_{EE} E}{\Phi''(M/P) V_E} = -\frac{\Phi'}{\Phi''(M/P)\tau} = 1$.

3. 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, I need to obtain the eigenvalues of the coefficient matrix, X, and associated eigenvectors. Finding the eigenvalues of 6×6 matrix involves solving a 6^{th} order polynomial equation, which is, as known well, generally no way to get explicit solutions analytically. Therefore, I 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, I should be able to assign the coefficient matrix, X, real number values. In fact, I can set plausible values for $\alpha, \beta, \sigma_i, \theta_j^i, \gamma, \rho, \tau, \mu$ and ϵ from the existing literature. But, I 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 I exploit the information in the budget constraint and the market clearing condition. Note first that when evaluated at the steady-state where $r_T = r_N$,

$$\frac{L_N}{L_T} = (\frac{\theta_L^N}{\theta_L^T})(\frac{P_N Q_N}{e Q_T}) = (\frac{\theta_L^N}{\theta_L^T})(\frac{VA_N}{1 - VA_N}), \tag{32}$$

$$k(\equiv \frac{K_N}{K_T}) = \frac{\theta_K^N}{\theta_K^T}\frac{VA_N}{1 - VA_N}, \tag{33}$$

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, I obtain

$$VA_N = \Gamma^{-1}[\alpha + \frac{\delta(\beta - \alpha)\theta_K^T}{(\rho + \delta)}], \tag{34}$$

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

where $\quad \Gamma = 1 + [\frac{(\theta_N^T - \theta_K^{T)}\delta(\beta - \alpha)}{(\rho + \delta)}],$

$$(K/Y) = (\rho + \delta)^{-1}[\theta_K^T + (\theta_K^N - \theta_K^T)VA_N].$$

Now once I assign sensible values for the parameters, VA_N is determined by (34). The values for (L_N/L_T), k and (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, I am now ready to solve the differential equations system, (31) numerically. In all 36 sets of parameter values tested, I obtained three negative and three positive distinctive real roots. Therefore, there exists a unique convergent saddle point solution for each set of parameter values. The complete solutions for the convergent saddle paths of the variables of interest over time in the forms of elasticity with respect to devaluation are derived as

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

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

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

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

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

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

where λ_i and $v_{ji}(i,j=1,\ldots,6)$ are the corresponding i^{th} eigenvalues and eigenvectors, respectively. Here I assume that $\lambda_2, \lambda_5, \lambda_6$ are negative eigenvalues. The h_is associated with the negative eigenvalues are constants determined by the initial conditions of state variables,[13] and $h'_i \equiv (h_i/M^0\hat{e})$. Superscript "0" denotes the initial steady-state, or pre-jump values.

3.3. Equilibrium paths of the real factor incomes

Changes in real factor incomes over time following devaluation can also be shown in the form of elasticity with respect to devaluation. First of all, subtracting CPI inflation rate from (27) and dividing it by the percentage change in exchange rate gives the change of real wage rate in the form of its elasticity with respect to devaluation as

$$\frac{(\widehat{\frac{w}{P}})}{\hat{e}} = \frac{(\hat{w}-\widehat{P})}{\hat{e}} = (\alpha-\omega_2)(1-\frac{\widehat{P_N}}{\hat{e}}) + \omega_3\frac{\widehat{K_T}}{\hat{e}} + \omega_4\frac{\widehat{K_N}}{\hat{e}}, \tag{36}$$

Similar manipulations of (28) and (29) make it possible to trace the change of real return on capital in each sector as

$$\frac{(\widehat{\frac{r_T}{P}})}{\hat{e}} = \frac{(\widehat{r_T}-\widehat{P})}{\hat{e}} = (\alpha+s_2)(1-\frac{\widehat{P_N}}{\hat{e}}) - s_3\frac{\widehat{K_T}}{\hat{e}} - s_4\frac{\widehat{K_N}}{\hat{e}}, \tag{37}$$

$$\frac{(\widehat{\frac{r_N}{P}})}{\hat{e}} = \frac{(\widehat{r_N}-\widehat{P})}{\hat{e}} = (\alpha-v_1)(1-\frac{\widehat{P_N}}{\hat{e}}) - v_3\frac{\widehat{K_T}}{\hat{e}} - v_4\frac{\widehat{K_N}}{\hat{e}}, \tag{38}$$

Manipulating (25) to get the elasticity of price of nontradables ($\widehat{P_N}$) with respect to devaluation

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13) The h_is associated with positive eigenvalues are set to be zero on the convergent saddle paths.

over time, and plugging it and the solution paths of the variables of interest into (36) - (38) yield the complete paths of real factor incomes over time.

3.4. Parameterization of the model

With the model ready for calibration, I 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 below in <Table 1>. Here I investigate the effects of devaluation with 36 different sets of parameter values that reflect different economic structures of LDCs.

<Table 1> Parameter values used to calibrate the model

Parameters that vary in simulation	$\beta = .25,\ .50,\ .75$ $\tau = .20,\ 1.0,$ $\theta_L^T = .30,\ .50,\ .70$ $z = .50,\ 1.5$
Parameters that are fixed in simulation	$\alpha = .50,\ \gamma = .50,\ \rho = .10,\ \delta = .06, \sigma_i = .50$ $\theta_L^N = .50,\ \theta_K^N = .50,\ \epsilon = .20,\ \mu = .1$

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, I use .20 following Llunch, Powell and Williams(1973) and Blundell(1988). For the intertemporal elasticity of substitution, τ, Summers(1984) 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, I try .2 and 1.0 for low and high ends. Regarding the *q*-elasticity of investment, *z*, I 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, I fix it at .50 following White(1978), Khatkhate(1980) and Ahluwalia(1974). For the cost share of labor(capital) in the tradables sector, I 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, I consider a neural case where they have the same shares because I intend to focus on how different factor intensities in the tradables sector affect the outcome. Pure time preference rate, ρ, is assumed to be .10. The rate of depreciation, δ, and the consumption share of the nontradables, α 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 to income, μ, is set to be .10 as in Buffie(1992).

4. Results

Under the parameterization of the economy given in the previous section, I trace the transitional dynamics of real factor incomes. <Table 2> summarizes the part of simulation results about the impact effects of the devaluation on real factor incomes. In what follows, I present and interpret the simulation results, and take a closer look at three typical model economies.

4.1. General observations

Devaluation is neutral in the long run. Thus, all the real variables should remain unchanged in the long run after devaluation regardless of their transitional dynamics. Various simulation results show that real factor incomes return to their initial levels in the long run in all cases considered.

However, short run dynamics differs strikingly among real factor incomes. <Table 2> shows that capital owners in the tradables sector clearly benefit while capital owners in the nontradables sector lose on impact following a devaluation in all cases considered. On the other hand, workers either benefit or lose depending mainly on parameter values. This result should be nothing strange to international economists, conforming with the conclusions of the famous specific factors model.

What is interesting is that the extent to which each factors of production benefits or lose depends on several key variables of interest that reflect an economy's peculiar structure. Real return on capital in the tradables sector (r_T/P) jumps up on impact following devaluation in all cases considered, and then approaches the new steady-state where the real return remains the same as its initial level. During the transitional period, real return on capital in the tradables sector always remains above its long-run equilibrium level. However, it generally increases more on impact as the cost share of the nontradables in the production of capital good, β, rises. Moreover, real return on capital in the tradables sector generally increases more on impact as the intertemporal elasticity of substitution, τ, gets smaller and the *q*-elasticity of investment demand, *z*, becomes bigger. With lower τ (=.2), its initial increase tends to be smaller as the tradables sector becomes more labor intensive. On the contrary, its initial increase tends to be bigger as the tradables sector becomes more labor intensive with higher τ (=1.0).

Meanwhile, real return on capital in the nontradables sector, (r_N/P) falls immediately after devaluation in all cases considered, and then approaches the new steady-state where the real return remains the same as its initial level. During the transitional period, real return on capital in the nontradables sector almost always remains below its long-run equilibrium level. It falls more on impact with lower intertemporal elasticity of substitution, τ, and higher *q*-elasticity of investment demand, z. Unlike real return on capital in the tradables sector, I cannot find a consistent relationship between real return on capital in the sector and the cost share of the nontradables in the production of capital good, β. With lower τ (=.2), on the other hand, its initial drop tends to be smaller as the tradables sector becomes more labor intensive except two

<Table 2> Impact effects of devaluation on real factor incomes

$\tau = 0.2,\ z = 0.5$

β	Real wage rate	Real return on capital in T-sector	Real return on capital in N-sector	Factor Intensity
.25	−.030736	.159992	−.174811	$\theta_L^T = .30,\ \theta_K^T = .70$
	.007828	.159168	−.174824	$\theta_L^T = .50,\ \theta_K^T = .50$
	.032720	.160780	−.174959	$\theta_L^T = .70,\ \theta_K^T = .30$
.50	−.049215	.196862	−.196862	$\theta_L^T = .30,\ \theta_K^T = .70$
	0.	.193482	−.193482	$\theta_L^T = .50,\ \theta_K^T = .50$
	.031796	.190778	−.190778	$\theta_L^T = .70,\ \theta_K^T = .30$
.75	−.066247	.221990	−.204791	$\theta_L^T = .30,\ \theta_K^T = .70$
	−.009954	.222303	−.202395	$\theta_L^T = .50,\ \theta_K^T = .50$
	.028631	.219132	−.200194	$\theta_L^T = .70,\ \theta_K^T = .30$

$\tau = 1.0,\ z = 0.5$

β	Real wage rate	Real return on capital in T-sector	Real return on capital in N-sector	Factor Intensity
.25	−.022753	.118437	−.129407	$\theta_L^T = .30,\ \theta_K^T = .70$
	.006068	.123379	−.135514	$\theta_L^T = .50,\ \theta_K^T = .50$
	.026329	.129328	−.140787	$\theta_L^T = .70,\ \theta_K^T = .30$
.50	−.032013	.128053	−.128053	$\theta_L^T = .30,\ \theta_K^T = .70$
	0.	.133389	−.133389	$\theta_L^T = .50,\ \theta_K^T = .50$
	.023160	.138961	−.138961	$\theta_L^T = .70,\ \theta_K^T = .30$
.75	−.039109	.131053	−.120899	$\theta_L^T = .30,\ \theta_K^T = .70$
	−.006249	.139566	−.127068	$\theta_L^T = .50,\ \theta_K^T = .50$
	.019153	.146586	−.133918	$\theta_L^T = .70,\ \theta_K^T = .30$

$\tau = 0.2,\ z = 1.5$

β	Real wage rate	Real return on capital in T-sector	Real return on capital in N-sector	Factor Intensity
.25	−.033576	.174776	−.190964	$\theta_L^T = .30, \theta_K^T = .70$
	.008415	.171104	−.187934	$\theta_L^T = .50,\ \theta_K^T = .50$
	.034398	.168959	−.183930	$\theta_L^T = .70,\ \theta_K^T = .30$
.50	−.058823	.235291	−.235291	$\theta_L^T = .30,\ \theta_K^T = .70$
	0.	.232361	−.232361	$\theta_L^T = .50,\ \theta_K^T = .50$
	.037769	.226612	−.226612	$\theta_L^T = .70,\ \theta_K^T = .30$
.75	−.078721	.263790	−.243353	$\theta_L^T = .30,\ \theta_K^T = .70$
	−.012192	.272291	−.247907	$\theta_L^T = .50,\ \theta_K^T = .50$
	.035530	.271927	−.248427	$\theta_L^T = .70,\ \theta_K^T = .30$

$\tau = 1.0$, z =1.5

β	Real wage rate	Real return on capital in T-sector	Real return on capital in N-sector	Factor Intensity
.25	−.022574	.117503	−.128387	$\theta_L^T = .30$, $\theta_K^T = .70$
	.006031	.122639	−.134701	$\theta_L^T = .50$, $\theta_K^T = .50$
	.026156	.128473	−.139857	$\theta_L^T = .70$, $\theta_K^T = .30$
.50	−.033084	.132337	−.132337	$\theta_L^T = .30$, $\theta_K^T = .70$
	0.	.138295	−.138295	$\theta_L^T = .50$, $\theta_K^T = .50$
	.023998	.143988	−.143988	$\theta_L^T = .70$, $\theta_K^T = .30$
.75	−.039101	.131026	−.120874	$\theta_L^T = .30$, $\theta_K^T = .70$
	−.006394	.142788	−.130001	$\theta_L^T = .50$, $\theta_K^T = .50$
	.019884	.152184	−.139032	$\theta_L^T = .70$, $\theta_K^T = .30$

extreme cases (β=.25, z=.5 and β=.75, z=1.5). On the contrary, its initial drop tends to be larger as the tradables sector becomes more labor intensive with higher τ(=1.0).

Of particular interest is the response of real wage rate following devaluation. Real wage rate falls on impact after devaluation when the tradables sector is relatively capital intensive while jumping up when the tradables sector becomes more labor intensive. And then, it moves toward the new steady-state where it is equal to its initial level. Its initial drop tends to be larger or initial jump-up tends to be smaller under a given factor intensity in the tradables sector with some exceptions. It falls more on impact with lower intertemporal elasticity of substitution, τ, and higher q-elasticity of investment demand, z. With lower τ(=.2), it drops or jumps up more as the q-elasticity of investment demand, z becomes larger. On the contrary, with higher τ (=1.0), such consistent relationship between real wage and the q-elasticity of investment demand, z is not detected.

Increasing or decreasing, real wage changes less than expected, and varies much than real returns on capital. For example, a 100% devaluation brings a mere 3.1% decrease in real wage on impact while real returns on capital in tradables sector increases by 11.8% and that in nontradables sector falls by 12.8% when $\tau = 0.2$, $z = 0.5$, $\beta = .25$, $\theta_L^T = .30$, $\theta_K^T = .70$. Therefore, it seems that devaluation may hit capitalists in nontradables sector harder than workers when the both are affected adversely.[14)]

4.2. Model economies

In order to take a closer look at how real factor incomes in different economies respond to devaluation, I discuss three model economies, typical LDC economies with different cost share of

14) In reality, however, workers may feel hit harder because they are less able to smooth their consumption facing adverse shocks.

the nontradables in the production of capital good, β and different factor intensities in the tradables sector. Model economy I is the most labor-intensive in the tradables sector and very dependent on imported machines in the production of an aggregate capital good ($\beta = .25$) while Model economy III is the most capital-intensive in the tradables sector and the least dependent on imported machines in the production of an aggregate capital good ($\beta = .75$). Model economy II is in between and can be considered a neutral case for reference. Parameterization for the three economies are as in <Table 3>. Impact effects of devaluation on real factor incomes and their transitional paths are shown below as in <Figure 1>～<Figure 3>.

<Table 3> Parameter values for the model economies

<table>
<tr><th>Model Economy</th><th>Common parameter values</th><th>Varying parameter values</th></tr>
<tr><td>I</td><td rowspan="3">$\alpha = .50,\ \gamma = .50,\ \rho = .10,\ \delta = .06,$
$\sigma_i = .50,\ \theta_L^N = .50,\ \theta_K^N = .50,\ \epsilon = .20,$
$\mu = .1,\ z = 1.5,\ \tau = .20$</td><td>$\theta_L^T = .7,\ \theta_K^T = .3,\ \beta = .25$</td></tr>
<tr><td>II</td><td>$\theta_L^T = .5,\ \theta_K^T = .5,\ \beta = .5$</td></tr>
<tr><td>III</td><td>$\theta_L^T = .3,\ \theta_K^T = .7,\ \beta = .75$</td></tr>
</table>

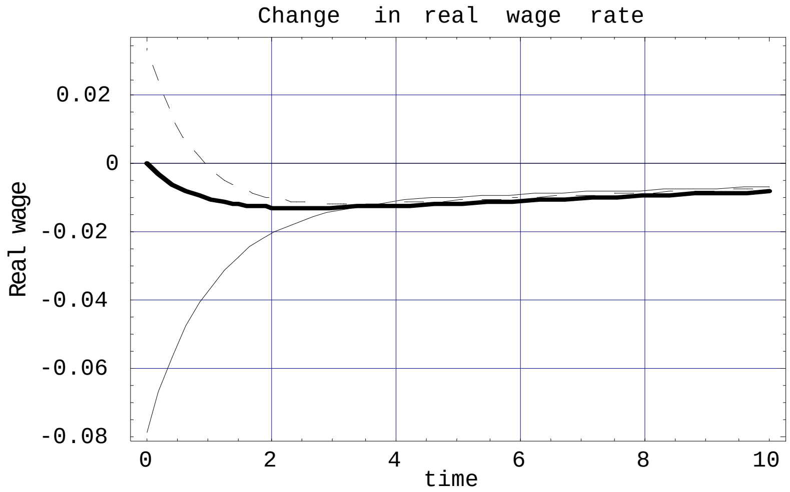
<Figure 1> shows that real wage rate jumps up by .034% per percent devaluation immediately after devaluation in model economies I while it drops by .079% per percent devaluation in model economies III. However, in the both cases, real wage rate returns to its new steady state level in 2-3 years. No significant real wage rate change is observed in model economy II.

<Figure 2> shows that real return on capital in the tradables sector increases immediately after devaluation by .169%, .232% and .264% per percent devaluation in model economies I, II and III respectively. Since then, real return on capital in the tradables sector decreases sharply for 3-4 years toward the new steady-state where it is same as the initial level.

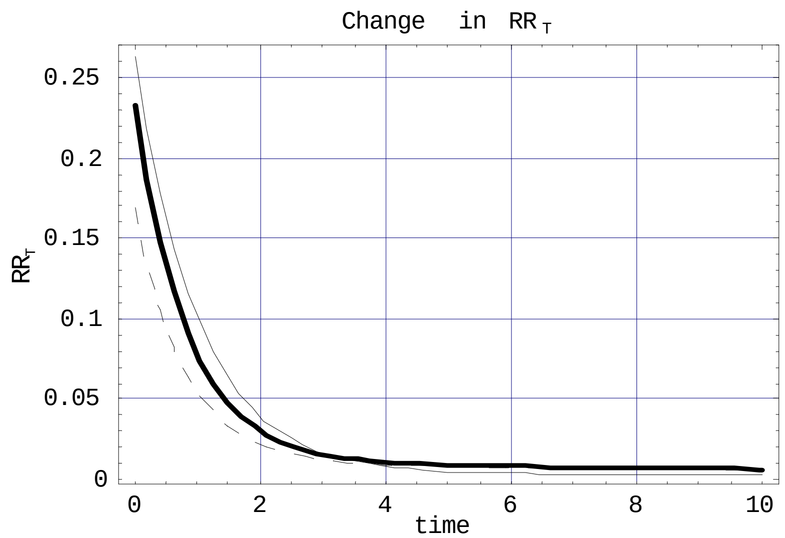
<Figure 3> indicates that real return on capital in the nontradables sector drops sharply on impact following devaluation by .184%, .232% and .243% per percent devaluation in model economies I, II and III respectively. Since then, real return on capital in the nontradables sector rebounds sharply for 3-4 years toward the new steady-state where it is same as the initial level.

In sum, both workers and capitalist of the tradables sector gain in the short to medium run following devaluation in the economies similar to model economy I. On the contrary, workers lose while capitalists of the tradables sector gain in the economies similar to model economy III. In the economies like model economy II, workers are neutral. Capitalists of the nontradables sector always lose while capitalists in the tradables sector invariably benefits in the short to medium run from devaluation.

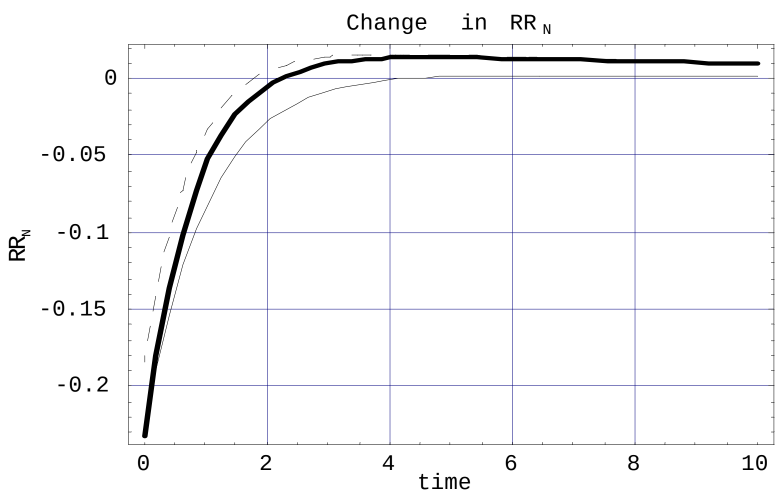
<Figure 1> Transitional dynamics of real wage rate



<Figure 2> Transitional dynamics of real return on capital in T-sector



<Figure 3> Transitional dynamics of real return on capital in N-sector



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

5. Concluding remarks

This paper has vividly shown that using a general equilibrium dynamic optimization model, devaluation adversely affects capitalists in the nontradables sector in the short run while benefiting capitalists in the tradables sector. More importantly, the paper has demonstrated that workers may or may not benefit from devaluation in the short to medium run depending mainly on factor intensities in the production sectors and the share of imported machines in production of capital goods. With neutral assumption on factor intensity in the nontradables sector, workers benefit more from devaluation in the short run as the tradables sector becomes more labor intensive while they lose more as the tradables sector becomes more capital intensive.

For the future research, it would be desirable to extend the representative agent model used here to a model with heterogeneous agents.

References

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.

Bahmani-Oskoosee, M. (1998), "Are Devaluations Contractionary in LDCs?" *Journal of Economic Development*, 23:131-145.

Barbone, L. and F. Rivera-Batiz(1987), “Foreign Capital and the Contractionary Impact of Currency Devaluation, with an Application to Jamaica,” *Journal of Development Economics*, 26: 1-15.

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

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

__________ 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.

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.(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.

Gould,J.(1968), "Adjustment Costs in the Theory of Investment of the Firm," *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.

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

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.

Morley,S.A.(1992), "On the Effect of Devaluation During Stabilization Programs in LDCs," *Review of Economics and Statistics*, 74: 21-27.

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

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

Tovar,C.E.(2005), "The Mechanics of Devaluations and the Output Response in a DSGE Model: How Relevant is the Balance Sheet Effect?" *BIS Working Papers*, no. 192.

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

Won, Yongkul(2005), "Devaluation and the Role of Voluntary Unemployment," *Seoul Journal of Economics*, vol. 18, no. 3: 217-247.

<Appendix 1> Solutions for $\dot{I}_{T,}\dot{I}_N$ and $\dot{E}$

$$
\begin{aligned}
G\dot{I}_T = \ & A_1 \ \{B_4(dI_T - \delta dK_T) + \rho B_3(dE - \frac{dM}{\mu}) + B_6[\alpha dE + \beta(dI_T + dI_N) \\
& \quad + \Theta_T dK_T + \Theta_N dK_N] + s_3(\rho+\delta)dK_T + \frac{s_4(\rho+\delta)}{k}dK_N \\
& \quad - A_4\Theta_N(dI_N - \delta dK_N)\} \\
& + B_7 \ \{[(dI_T - \delta dK_T) - \frac{1}{k}(dI_N - \delta dK_N)] + A_2[\alpha dE + \beta(dI_T + dI_N) \\
& \quad + \Theta_T dK_T + \Theta_N dK_N] + z\delta(s_3 - v_3)dK_T + \frac{z\delta(s_4 - v_4)}{k}dK_N\} \\
& - A_3 \ \{\rho(dE - \frac{dM}{\mu}) + \frac{H}{\alpha}[\Theta_T(dI_T - \delta dK_T) + \Theta_N(dI_N - \delta dK_N)]\}
\end{aligned} \tag{A.1}
$$

$$
\begin{aligned}
G\dot{I}_N = \ & A_1 \ \{B_5(dI_N - \delta dK_N) + \rho B_3 k(dE - \frac{dM}{\mu}) + B_8[\alpha dE + \beta(dI_T + dI_N) \\
& \quad + \Theta_T dK_T + \Theta_N dK_N] + k(\rho+\delta)v_3 dK_T + (\rho+\delta)v_4 dK_N \\
& \quad - kA_4\Theta_T(dI_T - \delta dK_T)\} \\
& + B_7 \ \{[(dI_T - \delta dK_T) - \frac{1}{k}(dI_N - \delta dK_N)] + A_2[\alpha dE + \beta(dI_T + dI_N) \\
& \quad + \Theta_T dK_T + \Theta_N dK_N] + z\delta(s_3 - v_3)dK_T + \frac{z\delta(s_4 - v_4)}{k}dK_N\} \\
& - kA_3 \ \{\rho(dE - \frac{dM}{\mu}) + \frac{H}{\alpha}[\Theta_T(dI_T - \delta dK_T) + \Theta_N(dI_N - \delta dK_N)]\}
\end{aligned} \tag{A.2}
$$

$$
\begin{aligned}
G\dot{E} = \ & F \ \{\rho(dE - \frac{dM}{\mu}) + \frac{H}{\alpha}[\Theta_T(dI_T - \delta dK_T) + \Theta_N(dI_N - \delta dK_N)]\} \\
& + A_6 \ \{[(\rho+\delta) - (\frac{A_3}{\alpha})\Theta_T](dI_T - \delta dK_T)] + z\delta\rho(1+k)B_3(dE - \frac{dM}{\mu}) \\
& \quad + B_1[\alpha dE + \beta(dI_T + dI_N) + \Theta_T dK_T + \Theta_N dK_N] \\
& \quad + z\delta(\rho+\delta)s_3 dK_T + \frac{z\delta(\rho+\delta)s_4}{k}dK_N - \frac{A_3}{\alpha}\Theta_N(dI_N - \delta dK_N) \\
& \quad + [(\rho+\delta) - (\frac{kA_3}{\alpha})\Theta_N](dI_N - \delta dK_N) + B_2[\alpha dE + \beta(dI_T + dI_N) \\
& \quad + \Theta_T dK_T + \Theta_N dK_N] + z\delta k(\rho+\delta)v_3 dK_T \\
& \quad + z\delta(\rho+\delta)v_4 dK_N - k(\frac{A_3}{\alpha})\Theta_T(dI_T - \delta dK_T)\}
\end{aligned} \tag{A.3}
$$

<Appendix 2> Expressions for X_i's

$X_1 = \alpha A_5 - 1,\ X_2 = \beta A_5 - 1,\ X_{22} = \Theta_T A_5 + (\rho+\delta),\ X_3 = \Theta_N A_5 + (\rho+\delta),$

$X_4 = (\frac{\rho}{\mu G})[F + A_6 B_3 z\delta(1+k)],\ X_5 = (\frac{1}{G})[\rho F + A_6 B_3 z\delta\rho(1+k) + (B_1 + B_2)\alpha],$

$X_6 = (\frac{1}{G})[F(\frac{H}{\alpha})\Theta_T + A_6[(\rho+\delta) - (\frac{A_3}{\alpha})\Theta_T - A_3(\frac{k}{\alpha})\Theta_T] + (B_1 + B_2)\beta],$

$X_7 = (\frac{1}{G})[F(\frac{H}{\alpha})\Theta_N + A_6[(\rho+\delta) - (\frac{A_3}{\alpha})\Theta_N - A_3(\frac{k}{\alpha})\Theta_N] + (B_1 + B_2)\beta],$

$X_8 = (\frac{1}{G})[(B_1 + B_2)\Theta_T + A_6(\rho+\delta)\delta[z(s_3 + kv_3) - 1] + A_6(\frac{A_3}{\alpha})\delta\Theta_T(1+k) - F(\frac{H}{\alpha})\Theta_T\delta],$

$$X_9 = (\frac{1}{G})[(B_1+B_2)\Theta_N + A_6(\rho+\delta)\delta[z(\frac{s_4}{k}+v_4)-1] + A_6(\frac{A_3}{\alpha})\delta\Theta_N(1+k) - F(\frac{H}{\alpha})\Theta_N\delta],$$

$$X_{10} = (\frac{\rho}{\mu G})[A_1B_3 - A_3],\ X_{11} = (\frac{1}{G})[A_1(\rho B_3+\alpha B_6)+\alpha A_2B_7-\rho A_3],$$

$$X_{12} = (\frac{1}{G})[A_1(B_4+\beta B_6)+B_7(1+\beta A_2)-A_3(\frac{H}{\alpha})\Theta_T],$$

$$X_{13} = (\frac{1}{G})[A_1(\beta B_6 - A_4\Theta_N)+B_7(\beta A_2-\frac{1}{k})-A_3(\frac{H}{\alpha})\Theta_N],$$

$$X_{14} = (\frac{1}{G})[A_1[B_6\Theta_T+s_3(\rho+\delta)-B_4\delta]+B_7[A_2\Theta_T+z\delta(s_3-v_3)-\delta]+A_3(\frac{H}{\alpha})\Theta_T\delta],$$

$$X_{15} = (\frac{1}{G})[A_1[B_6\Theta_N+\frac{s_4(\rho+\delta)}{k}+A_4\Theta_N\delta]+B_7[\frac{\delta}{k}+A_2\Theta_N+\frac{z\delta(s_4-v_4)}{k}]+A_3(\frac{H}{\alpha})\Theta_N\delta],$$

$$X_{16} = (\frac{\rho k}{\mu G})(A_3-A_1B_3),\ X_{17} = (\frac{1}{G})[A_1(\rho B_6k+\alpha B_8)-\alpha B_7A_2-\rho A_3k],$$

$$X_{18} = (\frac{1}{G})[A_1(\beta B_6 - A_4k\Theta_T)-B_7(1+\beta A_2)-A_3(\frac{H}{\alpha})k\Theta_T],$$

$$X_{19} = (\frac{1}{G})[A_1(B_5+\beta B_8)-B_7(\beta A_2-\frac{1}{k})-A_3(\frac{H}{\alpha})k\Theta_N],$$

$$X_{20} = (\frac{1}{G})[A_1[B_8\Theta_T+k(\rho+\delta)v_3+A_4\Theta_Nk\delta]-B_7[A_2\Theta_T+z\delta(s_3-v_3)-\delta]+kA_3(\frac{H}{\alpha})\Theta_T\delta],$$

$$X_{21} = (\frac{1}{G})[A_1[B_8\Theta_N+(\rho+\delta)v_4-B_5\delta]-B_7[\frac{\delta}{k}+A_2\Theta_N+\frac{z\delta(s_4-v_4)}{k}]+kA_3(\frac{H}{\alpha})\Theta_N\delta],$$

where $A_1 = z\delta(1+H),\ A_2 = \frac{z\delta\theta_K^N(v_1+s_2)}{J(\rho+\delta)k},\ A_3 = z\delta\alpha A_4,\ A_4 = \frac{\beta\theta_K^N}{J(\rho+\delta)k},\ A_5 = \frac{(D_N/Q_N)}{J},$

$$A_6 = \beta(1-\tau)A_5,\ B_1 = z\delta A_6B_6,\ B_2 = z\delta A_6B_8,\ B_3 = \frac{\alpha\theta_K^N}{\tau k(\rho+\delta)(D_N/Q_N)},$$

$$B_4 = [\frac{(\rho+\delta)}{z\delta}-A_4\Theta_T],\ B_5 = [\frac{(\rho+\delta)}{z\delta}-kA_4\Theta_N],\ B_6 = \frac{(\beta+s_2)\theta_K^N}{Jk},\ B_7 = \frac{z\delta\beta^2\theta_K^N}{J},$$

$$B_8 = \frac{(\beta-v_1)\theta_K^N}{J},\ F = 1+z\delta(1+k)\beta A_4,\ H = \alpha(\tau-1)A_5,\ G = F+H.$$