Current Account, Capital Formation and Terms of Trade Shocks: A Revisit of the Harberger-Laursen-Metzler Effect

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Paper for the APEA Conference, 2005.

Presenter: Chen-Min Hsu

ABSTRACT

This paper extends the Blanchard's model of a closed-economy to a three-good (exportable, importable and non-tradable goods) open-economy model with capital accumulation to study the impacts of terms of trade on the current account. We find that when capital goods are imported into a production economy, the Harberger-Laursen-Metzler effect is discernible for temporary or permanent terms of trade shocks. Furthermore, our simulation results show that the steady state is a saddle point and the speed of convergence of capital and consumption is quite low.

Keywords: Terms of trade, Current account, Harberger-Laursen-Metzler effect.

JEL Classification: F11, F32, F47.

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We thank Henry Wan (Cornell University) and several seminar participants at the Institute of Economics, Academia Sinica in Taiwan for their comments and suggestions. All errors are our responsibility.

INTRODUCTION

Small open economies tend to be easily disturbed by external shocks through international trade. The change of terms of trade would have great influences on the economic performance (such as output, savings and current account) of those export-orientated countries like Japan, South Korea and Taiwan. The fluctuation of output caused by the terms of trade shocks differs from the traditional real business cycle model since the shocks come from demand shocks instead of supply shocks.

Numerous works have been dedicated to study the impacts of deteriorations in terms of trade faced by small open economies. The early studies by Harberger (1950) and Laursen and Metzler (1950) showed that a decrease in current income arising from an adverse terms of trade shock would lower both private savings and the current account balance. Using an intertemporal optimization framework with infinitely-lived households, Obstfeld (1982a) revisited the issue of terms of trade and found that the Harberger-Laursen-Metzler effect failed to hold when there was a permanent deterioration in terms of trade. However, Obsteld (1982b, 1983) showed that a temporary worsening of terms of trade led to a current account deficit, but that when terms of trade reverted to their original level, the current account would move into surplus and ultimately back to its initial steady-state level.[1]

Svesson and Razin (1983) adopted a two-period, two-good (importable and exportable goods) framework to reexamine Obstfeld's propositions and found that there were deteriorations in the current account and savings as a result of temporary deterioration in terms of trade, but that this might go either way as a result of any permanent deterioration. The study by Sen and Turnovsky (1989) indicated that the

[1] In Obstfeld (1982a), there was a varying rate of time preference while in Obsfeld (1982b, 1983), the rate of was a constant rate of time preference.

Harberger-Laursen-Metzler effect depended on whether or not that income effect dominated the substitution effect during the deterioration of terms of trade. A representative individual intertemporal model was adopted by Mendoza (1995) and Kose (2002) to investigate the impact of terms-of-trade shocks on current account. Mendoza (1995) found that there was a temporary Harberger-Laursen-Metzler effect, but there was no permanent Harberger-Laursen-Metzler effect in industrialized countries while Kose (2002) found that about 95 per cent of fluctuations in the trade balance was positively accounted for by terms-of-trade shocks in developing countries.

Extending Engel and Kletzer (1990) and the Blanchard-style (1985) overlapping generations model to a three-good (exportable, importable and non-tradable goods) open economy in which the production structure is similar to that of Mendoza (1995), this paper attempts to revisit the Harberger-Laursen-Metzler effect of terms of trade shocks. Instead of adopting a representative agent model as the real business cycle model usually does, we use an overlapping generations model to allow for different types of agents to live in the economy at the same time. Based on the study by Chen et al. (2005) of a two-good (exportable and importable goods) open economy, we continue with the analysis of a three-good model with capital accumulation in this paper. In this paper, capital formation and non-tradable goods are incorporated into the framework, where we assume that capital is only used to produce tradable goods (exportable and importable goods) and installation costs are involved.[2] This assumption allows us to simplify the analytical framework since it disposes of the requirement to consider the capital reallocation effect between tradable and non-

[2] Models with costly investment can be found in Brock (1988), Sen and Turnovsky (1989a, 1989b) and Morshed and Turnovsky (2000), and the nature of investment is important for the dynamics. In the absence of any installation costs, capital stock adjustment occurs instantaneously.

tradable sectors.[3]

Our numerical results show that a steady-state solution does exist, and that it is a saddle point. We also find that a temporary or permanent deterioration in terms of trade implies a worsening of the trade balance; that is, we observe the presence of the Harberger-Laursen-Metzler effect. Our results further show that, as demonstrated by Barro and Sala-i-Martin (2004), the speed of convergence of capital and consumption is quite low.

The remainder of this paper is organized as follows. An open economy with capital accumulation to study firms' investment behavior is developed in the next section, followed, in the subsequent section, by a computational analysis of the terms of trade shocks. The final section presents the conclusions drawn from this study.

THE PRODUCTION MODEL

Firms

In this section, we endogenize production and capital accumulation into an open economy, basically following the neoclassical Solow model to specify the production sector. In contrast to the two-good open economy model, as in Sen and Turnovsky (1989a, 1989b) and Engel and Kletzer (1990), we continue to incorporate non-tradable goods and examine the additional effects of terms of trade shocks stemming from changes in the real exchange rate. Hence, goods are categorized into exportable, importable and non-tradable goods. It is assumed that capital goods are imported from foreign countries, and indeed, this is the case for most developing countries in the real

[3] Detailed analysis of the real exchange rate dynamics and their interaction with capital accumulation in a two-sector dependent economy was provided by Brock (1996) and Morshed and Turnovsky (2000), with the latter showing that by incorporating the inter-sectoral adjustment costs of capital movement, both the dynamics of capital accumulation and real exchange rate were sensitive to the degree of adjustment costs.

world.[4] Following Mendoza (1995), importable goods are taken as the numeraire. The relative price of exportable goods, i.e. terms of trade, is denoted by P_X.[5] The relative price of non-tradable goods is P_N, which is defined as the real exchange rate. Exportable goods (*X*) and importable goods (*M*) are produced using both capital and labor, whilst non-tradable goods (*N*) are produced using only labor. Capital is assumed to be installed with adjustment costs, and the supply of labor in the tradable sector is assumed to be inelastic, whilst in the non-tradable sector, it is assumed to be elastic.[6] The optimal behavior of the representative firm in the tradable sector can be described as follows:

$$V_t = \max \int_t^{\infty} [P_X X(K_X, L_X) + M(K_M L_M) - W_X L_X - W_M L_M$$

$$- I(1 + J(I/K))] e^{-r(v-t)} dv, \qquad (1)$$

s.t. $$K_X + K_M = K, \qquad (2)$$

$$\dot{K} = I, \qquad (3)$$

where time notation is omitted without confusion. Variables K_i and L_i ($i = X, M$) respectively represent capital and labor employed to produce good *i*, and we assume that K_X and K_M are perfect substitutes. Depreciation of capital goods is ignored here. The global real interest rate is denoted as *r*, which is constant for a small open economy. Production functions of *X* and *M* are presented by *X* (.) and *M* (.). The respective wage rates of L_X and L_M are W_X and W_M. Investment is represented by *I*, and

4 Although domestic firms also produce importable goods, we assume that there are only sufficient domestically-produced importable goods for consumption, and that all capital goods used for production are imported.
5 The three sector (exportable, importable and non-tradable goods) model was also used by Ostry (1988), Ostry and Reinhart (1992) and Cashin and McDermott (2003) to discuss the effects of terms of trade shocks on economic performance.
6 In addition to the setting that labor was 'inelastically' supplied to the traded sector, Mendoza (1995) similarly assumed that capital was 'inelastically' supplied to the non-traded sector.

$J(.)$ is an installment cost function with $J(0) = 0$ and $J' > 0$.

The optimality conditions for Equation (1) are:

$$P_X X_K = M_K , \tag{4}$$

$$\rho = 1 + J'(I/K) \cdot (I/K) , \tag{5}$$

$$\dot{\rho} = r\rho - [M_K + J'(I/K) \cdot (I/K)^2] , \tag{6}$$

where X_K and M_K are the marginal product of capital of exportable and importable goods, ρ is the shadow price of capital goods, and the production function is assumed to be linearly homogeneous in capital and labor. Solving Equations (2) and (4), we have:

$$K_X = K_X(K, P_X) , \tag{7}$$

$$K_M = K_M(K, P_X) , \tag{8}$$

with: $$K_X^{'} = \frac{M_{KK}}{M_{KK} + P_X X_{KK}} > 0 , \qquad K_M^{'} = \frac{P_X X_{KK}}{M_{KK} + P_X X_{KK}} > 0 ,$$

where $K_X^{'}$ and $K_M^{'}$ are the first-order derivatives of K_X (.) and K_M (.) with respect to K; and M_{KK} and X_{KK} denote the second-order derivatives of M and X with respect to K_M and K_X. By Equation (5), the optimal investment function is:

$$I = \phi(\rho - 1) \cdot K , \quad \text{where} \quad \phi(0) = 0 \quad \text{and} \quad \phi'(0) > 0 . \tag{9}$$

Dynamic equations can be obtained from Equations (3), (6) and (9):

$$\dot{K} = \phi(\rho - 1)K , \tag{10}$$

$$\dot{\rho} = r\rho - [M_K + J'(\phi(\rho - 1)) \cdot \phi^2(\rho - 1)] . \tag{11}$$

We assume that labor is the only input in the non-tradable sector. The optimal behavior of the representative non-tradable goods firm can thus be described as:

$$\max\int_{t}^{\infty}[P_N G(L_N)-W_N L_N]e^{-r(v-t)}dv\,, \tag{12}$$

where $G(.)$ is the production function of non-tradable goods (which is assumed to have constant returns to scale), L_N is the labor allocation for the production of the non-tradable goods, and W_N is the wage rate of L_N. The optimality condition is therefore:

$$P_N G_L = W_N\,, \tag{13}$$

where G_L is the marginal productivity of L_N.

Households

We assume that the economy comprises of identical households with constant life expectancy, and that there is no population growth.[7] At each instant, a new cohort of size β is born so that the size of the total population at any given time is normalized as one.

Assuming that there exist perfect annuity markets, in the absence of bequest motive and with negative bequest prohibited, individuals will contract to pay non-human wealth a to insurance companies contingent on their death to receive βa per unit of time. Thus the effective rate of return on non-human wealth is $r+\beta$. As a result of uncertain lifetime expectancy, each household's effective subjective discount rate is $\alpha+\beta$, where α is the positive pure rate of time preference. For

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[7] Let β be the constant instantaneous probability of death and assume that the random variable 'time until death' has an exponential distribution; then expected lifetime is equal to the expected value of the random variable which is $1/\beta$; in other words, $1/\beta$ can be thought of as an index of the effective horizon of individuals. As β goes to zero, the horizon becomes infinite, and we have the Ramsey-Cass-Koopmans model.

agents born at time s, we define total household expenditure as $c(s,t) = P_X c_X(s,t) + c_M(s,t) + P_N c_N(s,t)$.

We assume that households consume exportable goods (c_X), importable goods (c_M), non-tradable goods (c_N) and leisure (L). Starting from the current time t, the household at time s maximizes expected utility, given by

$$\max \int_t^{\infty} U(c_X(s,v), c_M(s,v), c_N(s,v), L(s,v)) e^{-\alpha(v-t)} dv .$$

Conditioned on being alive at the earlier time t, the probability of being alive at time v is $e^{-\beta(v-t)}$. Hence, the expected lifetime utility becomes:

$$\max E_t [\int_t^{\infty} U(c_X(s,v), c_M(s,v), c_N(s,v), L(s,v)) e^{-(\alpha+\beta)(v-t)} dv] . \tag{14}$$

The budget constraint for the household is

$$\int_t^{\infty} c(s,v) e^{-(r+\beta)(v-t)} dv \le a(s,t) + h(s,t) , \tag{15}$$

where: $$c(s,t) = P_X c_X(s,t) + c_M(s,t) + P_N c_N(s,t) , \tag{16}$$

$$h(s,t) = \int_t^{\infty} (y(v) - \tau(v)) e^{-(r+\beta)(v-t)} dv$$

$$= \int_t^{\infty} [W_X(v) L_X + W_M(v) L_M + W_N(v) L_N(s,v) - \tau(v)] e^{-(r+\beta)(v-t)} dv , \tag{17}$$

where $a(t)$ and $h(t)$ represent non-human wealth and human wealth and $L(s,v)$ is leisure and $L_N(s,v)$ is the labor allocation for the production of the non-tradable goods, with $L_X + L_M + L_N + L = 1$. The labor income and the lump-sum tax are denoted by $y(t)$ and $\tau(t)$, respectively. The consolidated lifetime budget constraint of Equation (15) implies that:

$$\dot{a}(s,t) = (r+\beta)a(s,t) + W_X(t)L_X + W_M(t)L_M + W_N(t)L_N(s,t) - \tau(t) - c(s,t)\,. \quad (18)$$

Hence, Equation (17) can be rewritten as:

$$h(s,t) = \int_t^\infty [W_X(v)L_X + W_M(v)L_M + W_N(v)(1-L_X-L_M) - \tau(v)]e^{-(r+\beta)(v-t)}dv$$

$$-\int_t^\infty W_N(v)L(s,v)e^{-(r+\beta)(v-t)}dv\,, \quad (17')$$

$$\equiv \int_t^\infty y^f(v)\, e^{-(r+\beta)(v-t)}dv - \int_t^\infty W_N(v)L(s,v)e^{-(r+\beta)(v-t)}dv\,,$$

$$\equiv h^f(s,t) - \int_t^\infty W_N(v)L(s,v)e^{-(r+\beta)(v-t)}dv\,,$$

where $y^f(v) \equiv W_X(v)L_X + W_M(v)L_M + W_N(v)(1-L_X-L_M) - \tau(v)$ is the full post-tax income of an individual, and $h^f(s,t) \equiv \int_t^\infty y^f(v)\, e^{-(r+\beta)(v-t)}dv$ is 'full' post-tax human wealth. From Equations (15) and (17'), we can obtain:

$$\int_t^\infty [c(s,v) + W_N(v)L(s,v)]e^{-(r+\beta)(v-t)}dv \le a(s,t) + h^f(s,t)\,. \quad (19)$$

Let the instantaneous utility function $U(c_X, c_M, c_N, L)$ be in log form and additively separable for consumption and leisure. That is:

$$U(c_X, c_M, c_N, L) = \theta \sum_i \mu_i \log c_i + (1-\theta)\log L\,, \quad i = X, M, N\,, \quad (20)$$

where θ is the contribution of consumption to utility, μ_i is the contribution of good i to consumption, and $\sum_i \mu_i = 1$. Solving the household's optimization problem from Equations (14), (16), (17), (19) and (20), we have:

$$c(s,t) = \theta(\alpha + \beta)[a(s,t) + h^f(s,t)], \tag{21}$$

$$L(s,t) = \frac{1-\theta}{\theta}\frac{c(s,t)}{W_N(s,t)}, \tag{22}$$

$$P_X(t)c_X(s,t) = \mu_X c(s,t), \tag{23}$$

$$c_M(s,t) = \mu_M c(s,t), \tag{24}$$

$$P_N(t)c_N(s,t) = \mu_N c(s,t). \tag{25}$$

By aggregation, we obtain:

$$C(t) = \beta\int_{-\infty}^{t} c(s,t)e^{\beta(s-t)}ds = \theta(\alpha + \beta)[A(t) + H^f(t)], \tag{26}$$

$$L(t) = \beta\int_{-\infty}^{t} L(s,t)e^{\beta(s-t)}ds = \frac{1-\theta}{\theta}\frac{C(t)}{W_N(t)}, \tag{27}$$

where:

$$A(t) = \beta\int_{-\infty}^{t} a(s,t)e^{\beta(s-t)}ds, \tag{28}$$

$$H^f(t) = \beta\int_{-\infty}^{t} h^f(s,t)e^{\beta(s-t)}ds. \tag{29}$$

The dynamics of ‘full’ human and non-human wealth thus become:

$$\dot{A}(t) = rA(t) + Y^f(t) - C(t) - W_N(t)L(t), \tag{30}$$

$$\dot{H}^f(t) = (r + \beta)H^f(t) - Y^f(t), \tag{31}$$

where:

$$Y^f(t) \equiv \beta\int_{-\infty}^{t} y^f(s)e^{\beta(s-t)}ds.$$

The dynamics of consumption can be written as:

$$\dot{C}(t) = (r-\alpha)C(t) - \theta\beta(\alpha+\beta)A(t)\,. \tag{32}$$

Linear homogeneity of production and the convexity of adjustment cost function ensure that the value of the firm is equal to ρK.[8] Thus, non-human wealth comprises of foreign assets and equity, i.e.:

$$A = F + \rho K\,. \tag{33}$$

The Government

In this section, we assume that the government also consumes non-tradable goods and finances its consumption by means of taxation. Hence, the government budget constraint can be rewritten as:

$$G(t) = P_X(t)G_X(t) + G_M(t) + P_N(t)G_N(t) = T(t)\,, \tag{34}$$

where $G_N(t)$ is government expenditure on non-tradable goods. From Equations (10), (11), (33), (34) and the market clearing condition for non-tradable goods, $P_N N(L_N) = (1-\mu_X-\mu_M)C(t) + G_N(t)$, we can obtain:

$$\begin{aligned}\dot{F} &= rF + P_X X + M - (\mu_X+\mu_M)C \\ &+ [J'(\phi(\rho-1))\cdot\phi^2(\rho-1) - \rho\cdot\phi(\rho-1)]K - (G_M + P_X G_X)\,.\end{aligned} \tag{35}$$

Equations (10), (11), (32) and (35) describe the entire dynamic system. Linearizing the system around the steady state, we obtain:

[8] See Hayashi (1982) for the derivation.

$$\begin{bmatrix} \dot{K} \\ \dot{\rho} \\ \dot{C} \\ \dot{F} \end{bmatrix} = \begin{bmatrix} 0 & \phi'(0)K^* & 0 & 0 \\ -M_{KK}K_M^{'}(K^*) & r & 0 & 0 \\ -\theta\beta(\alpha+\beta) & \theta\beta(\alpha+\beta)K^* & r-\alpha & -\theta\beta(\alpha+\beta) \\ r & -\phi'(0)K^* & -(\mu_X+\mu_M) & r \end{bmatrix} \begin{bmatrix} K-K^* \\ \rho-1 \\ C-C^* \\ F-F^* \end{bmatrix} \quad (36)$$

where the asterisked variables denote the steady-state values. Since the characteristic matrix in the system (36) is block recursive, there is little difficulty in obtaining the eigenvalues. Detailed analysis of the dynamic system is provided in Appendix. Four eigenvalues are roots of the following characteristic equations:

$$f_1(\lambda) = \lambda^2 - r\lambda + \phi'(0)M_{KK}K_M^{'}(K^*)K^* = 0\,, \quad (37)$$

$$f_2(\lambda) = \lambda^2 - (2r-\alpha)\lambda + [r(r-\alpha) - \theta\beta(\alpha+\beta)(\mu_X + \mu_M)] = 0\,. \quad (38)$$

SIMULATIONS

This subsection provides details of the calibration of the parameter values used for our simulations. We begin by considering an economy where the non-tradable sector uses only labor for production, choosing Taiwan to represent the small open economy in our model, and calibrating the remainder of the parameter values to the data for the year 1990.[9] The birth rate in Taiwan in 1990 was 1.66 per cent; thus, in our model setting, which enables each individual to give birth to one child, β is set at 3.32 per cent. The real interest rate and the rate of time preference are set at 0.04 and 0.03, respectively.

We assume that tradable sectors adopt Cobb-Douglas production functions to produce their exportable and importable goods. That is, $X(K_X, L_X) = K_X^{\xi_1} L_X^{1-\xi_1}$ and $M(K_M, L_M) = K_M^{\xi_2} L_M^{1-\xi_2}$. In 1990, 28.9 per cent of all exported goods from Taiwan were classified as high capital-intensity goods, whilst the proportion of all imports

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[9] Data source: Taiwan Statistical Data Book (2000).

regarded as high capital-intensity goods was 46.4 per cent. Hence, we set $\xi_1 = 0.3$ and $\xi_2 = 0.35$ so that the importable goods sector is more capital intensive than the exportable goods sector.

The adjustment cost function of investment is set at $J(I/K) = \dfrac{bI}{2K}$, and since the parameter value of b only affects the speed of convergence, and has no impact on the steady state (K^*, ρ^*, C^*, F^*), we assign $b = 10$. For simplicity, we assume that there is no government spending.[10]

Following Hansen and Imrohoroglu (1992), we assume that, after subtracting time spent on eating, sleeping and other personal care, agents will have a total of 98 hours per week available to them. By assuming that individuals spend 45 hours per week working[11] and that the labor inputs of the exportable, importable and non-tradable goods sectors are equal, we can then calculate that L_X and L_M are approximately equal to 0.15. The parameter value of θ is calibrated to 0.4766, so that at steady state private consumption is 10 per cent of non-human wealth. Assuming that non-human wealth comprises of the same weight of foreign assets and equity at steady state, then $\mu_X + \mu_M$ is calibrated to 0.8085.

According to the parameter values calibrated above, the steady-state equilibrium is characterized by $K^* = 6.8882$, $\rho^* = 1$, $C^* = 1.377$ and $F^* = 6.882$. Using Equations (37) and (38) to solve for the four eigenvalues -0.0354, 0.0754, -0.0071, 0.0571, implies that the steady-state equilibrium is, as expected, a saddle point, since there are two jumping variables (p and C) and two stock variables (K and F).

Numerical Results

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10 The inclusion of government spending on exportable and importable goods does not change our simulation results.

11 According to Monthly Bulletin of Earnings and Productivity Statistics (2000), the average monthly working hours for employees in non-agricultural industries in Taiwan ranges from 189 and 204.

Figures 1 and 2 present the simulation results on the effects of terms of trade shocks on the economy, respectively illustrating an unanticipated temporary appreciation in terms of trade and a permanent appreciation in terms of trade (that is, an increase in the relative price of exportable goods), with changes in consumption, capital, foreign assets and shadow price reacting differently in either case.[12]

Figure 1 illustrates the case of a temporary increase, of 5 per cent, in the relative price of exportable goods, demonstrating that consumption, capital and foreign assets increase immediately after the appreciation of terms of trade, and then move back to their original steady-state equilibrium. The speed of convergence is quite slow because the absolute values of the negative eigenvalues are small.

Figure 2 describes the dynamic effects of a permanent (5 per cent) increase in the relative price of exportable goods. The new steady state is: $K^* = 7.0808$, $\rho^* = 1$, $C^* = 1.421$ and $F^* = 7.1294$, which demonstrates that, following appreciation in terms of trade, there is a sudden rise in consumption which then continues to rise gradually until it reaches the new steady state.

As the figure shows, capital also increases over time and will eventually converge to the value of the new steady-state; however, there is a discernible fall in foreign assets immediately after the shock, but thereafter, these assets gradually rise to the higher value of the new steady state. This differs from the case of a temporary increase, where there is no negative change in the value of foreign assets. Furthermore, when the shock is permanent, a portfolio substitution effect is also discernible between capital and foreign assets in the medium term.

[12] We adopt the GEMPACK economic modelling software (Harrison and Pearson (1996)) to carry out our simulations; see Dixon et al. (1992) and Codsi et al. (1992) for an explanation of the algorithm.

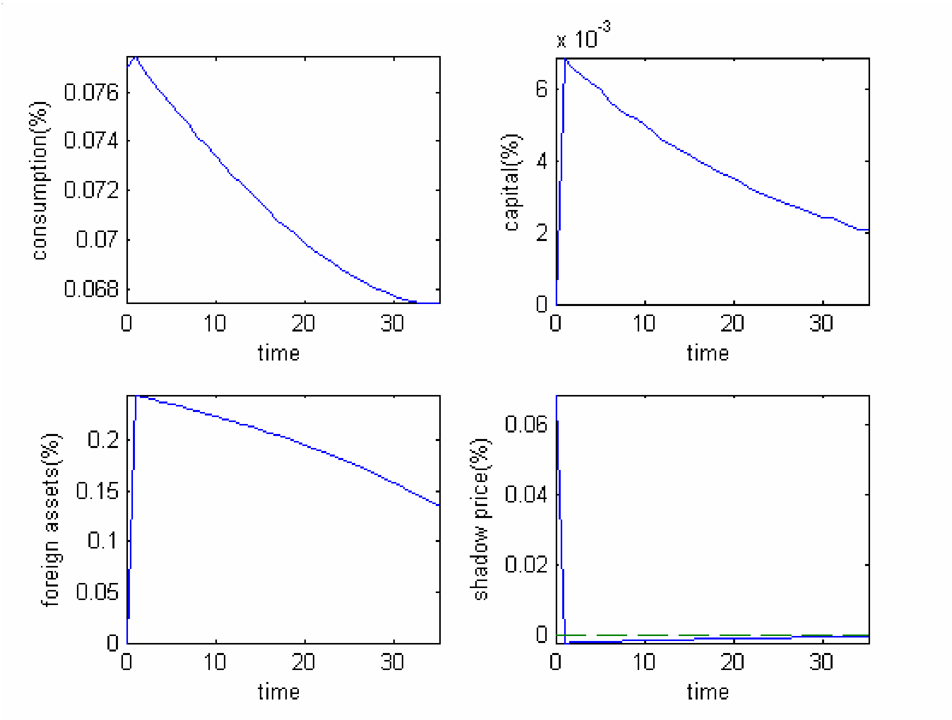

Figure 1 The effects on the economy from a temporary appreciation in terms of trade

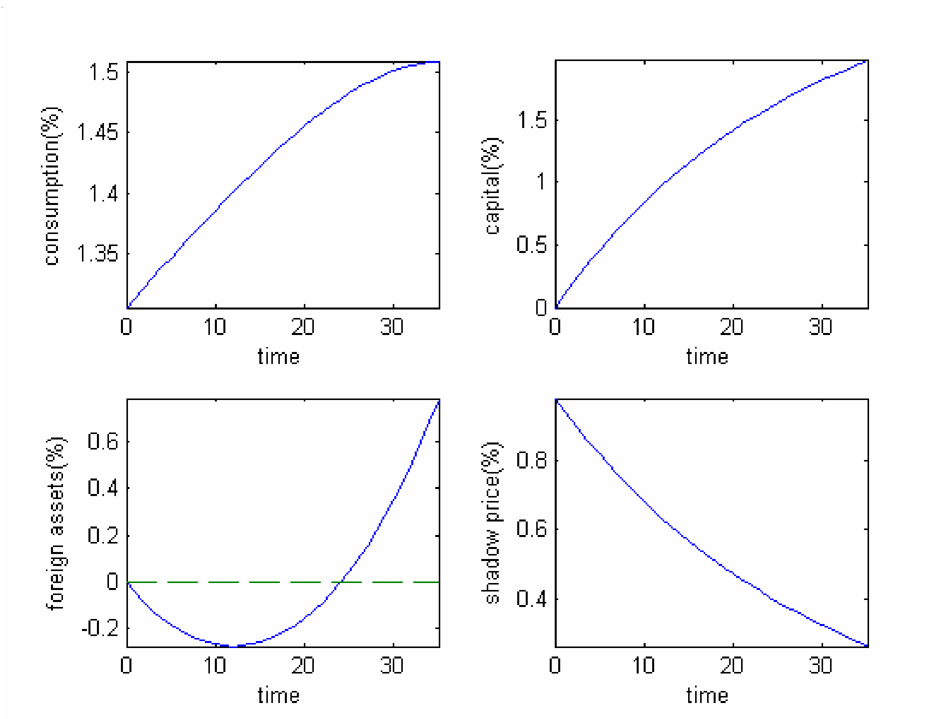

Figure 2 The effects on the economy from a permanent appreciation in terms of trade

We conduct a sensitivity analysis in order to determine how dependent the speed of convergence is upon the parameters. Let λ_1 and λ_2 represent the negative eigenvalues, respectively corresponding to Equations (37) and (38), and note that, according to Equation (37), λ_1 depends upon the assigned value of *b*. As Table 1 shows, with a rise in the value of *b*, there is a reduction in the absolute value of λ_1; hence, when investment becomes more costly, there is deceleration in the speed of convergence for K_t, ρ_t, C_t and F_t.

Table 1 The relationship between b and λ_1

b	0.1	0.5	1.0	5.0	10.0	20.0	50.0
λ_1	-0.4975	-0.2121	-0.1447	-0.0558	-0.0354	-0.0217	-0.0106

We find from the simulation results that the Harberger-Laursen-Metzler effect is present for temporary and permanent shocks in terms of trade, although these effects are quite weak.[13] This is similar to the finding by Mendoza (1995) of a weak positive correlation between net exports and terms of trade in an open-economy real business cycle model. It is also interesting to note that, as suggested by Barro and Sala-i-Martin (2004), the speed of convergence can be reduced by the presence of adjustment costs in capital formation and imperfect capital mobility.

CONCLUSIONS

In this paper, we study the effects of changes in terms of trade on private spending, capital accumulation and the current account of a small open economy with capital accumulation, utilizing the Blanchard-type uncertain lifetime overlapping generations framework.

[13] We also develop a model where capital is used as an input in the non-tradable sector. The simulation results demonstrate that the Harberger-Laursen-Metzler effect can be obtained in an economy as long as non-tradable goods are more capital intensive than exportable goods.

It has been clearly demonstrated by Persson and Svensson (1985), Brock (1988, 1996), Matsuyama (1987, 1988), Buiter (1989) and Sen and Turnovsky (1989a, 1989b), that both investment behavior and savings behavior are crucial to the understanding of different exogenous shocks on the current account; thus, we extend the simple model by introducing production and capital accumulation functions into the model.

Assuming that capital goods are imported from foreign countries, the simulation results show that the Harberger-Laursen-Metzler effect will always be present for both temporary and permanent terms of trade shocks. However, capital and foreign assets react differently when faced with different degrees of shock; indeed, in the case of permanent shocks, a transitional portfolio substitution effect is discernible between capital and foreign assets. We also find that in the finite-horizon model with investment adjustment costs and imperfect capital mobility, the speed of convergence of capital and consumption is quite low.

As a concluding note, the nature of capital accumulation is relevant to the dynamics. Brock and Turnovsky (1994) and Brock (1996) showed that if investment is in the form of non-traded goods, then even in the absence of any adjustment costs associated with investment, non-degenerate dynamics are obtained. Moreover, non-recursive dynamics are dependent upon the relative capital intensities of the traded goods and non-traded goods sectors only when the capital is in the form of non-traded goods.

In this paper, we have assumed that the investment goods are both traded and imported; however, this does not allow us to analyze the dynamics of the interaction between terms of trade and the real exchange rate, whilst the capital intensity of the two sectors of importable and exportable goods are also, essentially, irrelevant to the dynamics. In a planned future work, we aim to try out alternative specifications for investment expenditure in the form of non-traded goods.

REFERENCES

Barro, R.J. and X. Sala-i-Martin (2004), *Economic Growth*, New York: McGraw-Hill Inc.

Blanchard, O.J. (1985), 'Debt, Deficit and Finite Horizons', *Journal of Political Economy*, **93**: 223-47.

Brock, P.L. (1988), 'Investment, the Current Account and the Relative Price of Non-Traded Goods in a Small Open Economy', *Journal of International Economics*, **24**: 235-53.

Brock, P.L. (1996), 'International Transfers, the Relative Price of Non-traded Goods and the Current Account', *Canadian Journal of Economics*, **29**: 306-25.

Brock, P.L. and S.J. Turnovsky (1994), 'The Dependent Economy Model with Both Traded and Non-traded Capital Goods', *Review of International Economics*, **3**: 306-25.

Buiter, W.H. (1989), *Budgetary Policy, International and Intertemporal Trade in the Global Economy* , Amsterdam: Elsevier Science Publishers B.V.

Cashin, P. and C.J. McDermott (2002), 'Terms of Trade Shocks and the Current Account: Evidence from Five Industrial Countries', *Open Economies Review*, **13**: 219-35.

CEPD (2000), *Taiwan Statistical Data Book*, Taipei: Council for Economic Planning and Development.

Chen, H.-J., C.-M. Hsu and K.-S. Lian (2005), 'Terms of Trade Shocks and Current Account in a Finite-Horizon Economy', mimeo, National Taiwan University.

Codsi, G., K.R. Person and P.J. Wilcoxen (1992), 'General Purpose Software for Intertemporal Economic Models', *Computer Science in Economics and Management*, **5**: 57-79.

DGBAS (2000), *Monthly Bulletin of Earnings and Productivity Statistics, Taiwan Area*, Taipei: Directorate-General of Budget, Accounting and Statistics.

Diamond, P.A. (1965), 'National Debt in a Neoclassical Growth Model', *American Economic Review*, **55**: 1126-50.

Dixon, P.B., B.R. Parmenter, A.A. Powell and P.J. Wilcoxen (1992), *Notes and Problems in Applied General Equilibrium Economics*, Amsterdam: North-Holland.

Engel, C. and K. Kletzer (1990), 'Tariffs and Saving in a Model with New Generations', *Journal of International Economics*, **28**: 71-91.

Frenkel, J.A. and A. Razin (1987), *Fiscal Policies and the World Economy*, Cambridge, MA.: MIT Press.

Hayashi, F. (1982), 'Tobin's Marginal q and Average q: A Neoclassical Interpretation', *Econometrica*, **50**: 213-24.

Hansen, G..D. and A. Imrohoroglu (1992), 'The Role of Unemployment Insurance in an

Economy with Liquidity Constraints and Moral Hazard', *Journal of Political Economy*, **100**: 118-142.

Harberger, A.C. (1950), 'Currency Depreciation, Income and the Balance of Trade', *Journal of Political Economy*, **58**: 47-60.

Harrison, W.J. and K.R. Pearson (1996), 'Computing Solutions for Large General Equilibrium Models Using GEMPACK', *Computational Economics*, **9**: 83-127.

Laursen, S. and L.A. Metzler (1950), 'Flexible Exchange Rates and the Theory of Employment', *Review of Economics and Statistics*, **32**: 281-99.

Klundert, T.V. and F. Ploeg (1989), 'Fiscal Policy and Finite Lives in Interdependent Economies with Real and Nominal Wage Rigidity', *Oxford Economic Papers*, **41**: 459-89.

Kose, M.A. (2002), 'Explaining Business Cycles in Small Open Economies: How Much Do World Prices Matter?", *Journal o f International Economics*, **56**: 299-327.

Morshed, A.K.M. and S.J. Turnovsky (2000), *Sectoral Adjustment Costs and Real Exchange Rate Dynamics in a Two-Sector Dependent Economy*, Seattle: University of Washington.

Matsuyama, K. (1987), 'Current Account Dynamics in a Finite Horizon Model', *Journal of International Economic*s, **23**: 299-313.

Matsuyama, K. (1988), 'Terms of Trade, Factor Intensities and the Current Account in a Life Cycle Model', *Review of Economic Studies*, **55**: 247-62.

Mendoza, E.G. (1995), 'Terms of Trade, the Real Exchange Rate and Economic Fluctuations', *International Economic Review*, **36**: 101-37.

Obstfeld, M. (1982a), 'Aggregate Spending and Terms of Trade: Is There a Laursen-Metzler Effect?', *Quarterly Journal of Economics*, **97**: 251-70.

Obstfeld, M. (1982b), 'Transitory Terms of Trade Shocks and the Current Account: the Case of Constant Time Preference', *NBER Working Paper Series*, No. 834.

Obstfeld, M. (1983), 'Intertemporal Price Speculation and the Optimal Current Account Deficit', *Journal of International Money and Finance*, **2**: 135-45.

Ostry, J.D. (1988), 'Balance of Trade, Terms of Trade and the Real Exchange Rate: An Intertemporal Optimizing Framework', *IMF Staff Papers*, **35**: 541-73.

Ostry, J.D. and C.M. Reinhart (1992), 'Private Saving and Terms of Trade Shocks: Evidence from Developing Countries', *IMF Staff Papers*, **39**: 495-517.

Otto, G. (2003), 'Terms of Trade Shocks and the Balance of Trade: There Is a Harberger-Laursen-Metzler Effect', *Journal of International Money and Finance*, **22**: 155-84.

Persson, T. and L. Svensson (1985), 'Current Account Dynamics and the Terms of Trade: Harberger-Laursen-Metzler Two Generations Later', *Journal of Political Economy*, **93**:

43-65.

Sen, P. and S.J. Turnovsky (1989a), 'Deterioration of Terms of Trade and Capital Accumulation: A Re-Examination of the Laursen-Metzler Effect', *Journal of International Economics*, **26**: 227-50.

Sen, P. and S.J. Turnovsky (1989b), 'Tariffs, Capital Accumulation and the Current Account in a Small Open Economy', *International Economic Review*, **30**: 811-31.

Yaari, M.E. (1965), 'Uncertain Lifetime, Life Insurance and the Theory of the Consumer', *Review of Economic Studies*, **32**: 137-50.

Appendix

Analysis of Dynamic Systems

In this appendix, we study the dynamic system presented in the penultimate section of the paper. We should begin by noting that the dynamic system (36) is block recursive. There are two predetermined variables, *K* and *F*, and two jumping variables, p and *C*. Let λ_1 and λ_2 represent negative eigenvalues which respectively correspond to Equations (37) and (38). The number of predetermined variables is equal to the number of negative eigenvalues. The unique stable path to the steady state is thus:

$$K_t - K^* = V_{11} e^{\lambda_1 t}\,, \tag{A1}$$

$$\rho_t - 1 = V_{21} e^{\lambda_1 t}\,, \tag{A2}$$

$$C_t - C^* = V_{31} e^{\lambda_1 t} + V_{32} e^{\lambda_2 t}\,, \tag{A3}$$

$$F_t - F^* = V_{41} e^{\lambda_1 t} + V_{42} e^{\lambda_2 t}\,, \tag{A4}$$

where λ_1 and λ_2 are negative roots of Equations (37) and (38). Solving for V_{11}, V_{21}, V_{31}, V_{32}, V_{41} and V_{42}, we obtain:

$$V_{11} = K_0 - K^*\,,$$

$$V_{21} = \pi(\lambda_1 - r)^{-1}(K_0 - K^*)\,,$$

$$V_{31} = \theta\beta(\alpha+\beta)\pi K^* \Delta^{-1}(K_0 - K^*)\,,$$

$$V_{32} = \theta(\mu_X + \mu_M)^{-1}(r - \lambda_2)V_{42}$$

$$V_{41} = -V_{11} - (\mu_X + \mu_M)\theta\beta(\alpha+\beta)\pi K^* \Delta^{-1}(\lambda_1 - r)^{-1}(K_0 - K^*)\,,$$

$$V_{42} = F_0 - F^* - V_{41}\,,$$

where $\pi = -M_{KK} K_M^{'}(K^*)$, $\Delta = \begin{vmatrix} r-\alpha-\lambda_2 & -\theta\beta(\alpha+\beta) \\ \mu_X + \mu_M & \lambda_2 - r \end{vmatrix}$.

Hence, we can rewrite Equations (A1), (A2), (A3) and (A4) as:

$$K_t - K^* = (K_0 - K^*)e^{\lambda_1 t}, \tag{A1'}$$

$$\rho_t - 1 = \pi(\lambda_1 - r)^{-1}(K_0 - K^*)e^{\lambda_1 t}, \tag{A2'}$$

$$C_t - C^* = \theta\beta(\alpha+\beta)\pi K^* \Delta^{-1}\left(\frac{r-\lambda_2}{\lambda_1 - r}e^{\lambda_2 t} + e^{\lambda_1 t}\right)$$

$$+ (A_0 - A^*)(\mu_X + \mu_M)^{-1}(r - \lambda_2)e^{\lambda_2 t}, \tag{A3'}$$

$$F_t - F^* = (K_0 - K^*)[(\mu_X + \mu_M)\theta\beta(\alpha+\beta)\pi K^* \Delta^{-1}(\lambda_1 - r)^{-1}(e^{\lambda_2 t} - e^{\lambda_1 t}) - e^{\lambda_1 t}]$$

$$+ (A_0 - A^*)e^{\lambda_2 t}. \tag{A4'}$$

* Note that the model reduces to Matsuyama's (1987) model when $\mu_X + \mu_M = 1$ and $\theta = 1$.