On the Possibility of a Common Currency Area in East Asia : A Strategic Approach under Uncertainty by a Multicountry Model*

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Abstract

The purpose of this paper is to explore whether the strategic equilibrium can lead to a common currency area in East Asia when each East Asian country seeks to achieve its own economic stability. The analysis is based on a N-country world economy model where M East Asian countries form a common currency area. By using the system decomposition method, the model solution is derived explicitly. It generally depends on the relative variabilities of various exogenous shocks whether the East Asian countries tend to join a common currency area or not.

The Nash equilibrium in our model can be classified into four cases. In one of four cases, the interactions of exogenous shocks are "strategic complementary" in the common currency area. In this case, the model has two Nash equilibria. In the Pareto superior equilibrium, all East Asian countries join the common currency area. However, the model also has the Pareto inferior equilibrium in which all East Asian countries adopt the flexible exchange rate regime and the common currency area is never formed in East Asia.

In another of four cases, the interactions of exogenous shocks are "strategic substitute" in the common currency area. In this case, the Nash equilibrium is always the Pareto optimal, although the model cannot decide which East Asian countries will join the common currency area. However, the integer constraint can lead to smaller entry to the common currency area than the optimal level. As a result, the model can cause uneven losses between member countries and non-member countries, even if these countries are completely symmetric ex ante.

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1. Introduction

During the past decades, intra-regional linkage among the East Asian economies has increased remarkably. In particular, in terms of international trade, each East Asian country has now become one of the biggest trading partners for other East Asian countries. However, despite these growing roles of intra-regional linkage, most East Asian countries linked their currencies solely to the U.S. dollar before the crisis.[1] To the extent that reducing exchange rate volatility can reduce trade risk, it is natural to suppose that East Asian governments will reduce the weight of the US dollar in their currency basket unless a costless hedge through a perfect forward/futures market is possible. However, this was not the case in East Asian countries before the crisis and that the U.S. dollar had the dominant weight in East Asian currency baskets before the currency crisis in 1997.[2]

Several lessons from the 1997 East Asian crisis taught us that the dollar dominant exchange rate regime was not desirable for the stability of the East Asian economies. As a result, we now have a large number of arguments, particularly among policy makers, on what will be the desirable exchange rate regime for the future East Asia. For a future exchange rate regime in East Asia, the flexible exchange rate regime is a possible alternative. In fact, Korea, Thailand, and Indonesia have moved to the flexible exchange rate regime after the crisis. However, forming a common currency area like the European monetary union is another alternative for the future East Asian exchange rate regime.

The purpose of this paper is to explore the possibility of having a common currency area in East Asia where several East Asian countries share a common currency. We theoretically study whether the strategic equilibrium can lead to a common currency area in East Asia when each East Asian country seeks to achieve its own income stability. The analysis is based on a N-country world economy model where M countries among H East Asian countries form a common currency area. After solving the model explicitly, we investigate what exchange rate regime is chosen by each East Asian countries in the Nash equilibrium. It generally depends on the relative variabilities of various exogenous shocks whether the countries tend to join a common currency area or not.

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[1] Strictly speaking, Hong Kong was the only economy which fixed its exchange rate to the U.S. dollar before the crisis. However, Frankel (1991) and Frankel and Wei (1994) showed that even the other East Asian governments placed the dominant weight on the U.S. dollar in their currency baskets before the crisis.

[2] Before the crisis, the U.S. dollar was also dominant among various types of foreign transactions and asset holdings in East Asian countries. See, among others, Tavlas and Ozeki (1992), Kawai (1996), Ito (1993) Fukuda and Ji (1994) for the evidence.

When each East Asian country strategically chooses the exchange rate regime to achieve its own income stability, the Nash equilibrium in our model can be classified into four cases. In any of the Nash equilibria, the equilibrium regime is stable in the sense that neither policy maker has an incentive to switch unilaterally from the regime. In addition, for two cases, we can derive the definitive answer on what exchange regime the Nash equilibrium will lead to in East Asia. However, when each East Asian policy maker is confronted with a tradeoff in reducing the fixed costs and the output stability, the Nash equilibria in our model can be indeterminate in the sense that the model cannot predict which East Asian countries will join the common currency area.

In particular, for some reasonable parameter set, the interactions of exogenous shocks can be "strategic complementary" in the common currency area. In this case, the model has two Nash equilibria: the equilibrium where the common currency area is never formed in East Asia and the equilibrium where all East Asian counties join the common currency area. The Pareto superior equilibrium exchange rate regime is the regime where all East Asian countries join the common currency area. However, the model also has the Pareto inferior equilibrium in which all East Asian countries adopt the flexible exchange rate regime and the common currency area is never formed in East Asia. This Pareto inferior equilibrium is stable in the sense that neither policy maker has an incentive to switch unilaterally from the flexible exchange rate regime. Thus, once the economy is stuck in the inferior equilibrium, it is difficult for the East Asian region to form the desirable common currency area without coordination of East Asian policy makers.

For another reasonable parameter set, the interactions of exogenous shocks can be "strategic substitute" in the common currency area. In this case, the Nash equilibrium is always the Pareto optimal, although the model cannot decide which East Asian countries will join the common currency area. However, the integer constraint can lead to smaller entry to the common currency area than the optimal level. As a result, the model can cause uneven losses between member countries and non-member countries, even if these countries are completely symmetric ex ante.

The main focus of our analysis is to study whether the strategic equilibrium can lead to a common currency area in East Asia when each East Asian country seeks to achieve its own income stability. In treating the income stability, the approach is similar to a large number of studies on the exchange rate management under uncertainty.[3] However, by using the decomposition method developed by Fukuda (1993), the following analysis investigates a general N-country model in which M out of H East Asian countries form a common currency

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[3] These studies include Aizenman and Frenkel (1985) and Turnovsky (1984) for small open economy models, and Buiter and Eaton (1985), Canzoneri (1982), Miller and Williamson (1988), and Fukuda and Hamada (1988) for multicountry models.

area.[4] More importantly, we study the strategic choice of the exchange rate regime under uncertainty where non-cooperative policy makers in East Asia decide whether they should join the common currency area or not.

Beginning with early work by Hamada (1976), a large number of studies have analyzed strategic monetary policy.[5] Our study is a sort of extension of Turnovsky and d'Orey (1989) who investigated the strategic choice of monetary instrument in two interdependent economies under uncertainty. However, since we consider the N-country world where M countries form a common currency area, our analysis is far more general than any previous studies. In particular, two noteworthy cases in our Nash equilibria derive several important policy implications which no previous study discussed seriously.

In the following model, we do not incorporate the approach of Obstfeld (1996) and Hamada (1998) who investigated the strategic choice of the exchange rate regime when time-consistent policy makers have an incentive to cause a surprise inflation. Needless to say, the surprise inflation model is generally important in considering the choice of the exchange regime in developing countries. However, it seems less relevant in East Asia because various statistical data show that East Asian governments have had less incentive to cause the surprise inflation. In fact, not a few studies pointed out that in the pre-crisis East Asian countries, the budget was in surplus or in negligible deficit and that unemployment rates were at the low level.[6] After the crisis, some East Asian countries experienced significant budget deficits and high unemployment rates. However, as the economy recovered rapidly, the budget deficits declined and unemployment rates went down to the low level in these East Asian countries.

In international finance, the theory of optimal currency areas is one of the classic issues, dating back to the work of Mundell (1961). In particular, with Europe's attempt to institute a common currency, the question of common currency areas or currency unions has come to the forefront of international economic policy in recent years. It is beyond the scope of this paper to compare our results with a large number of previous contributions on optimal currency areas. However, focusing on the strategic equilibrium where each policy maker seeks to achieve its own income stability, our analysis would present one possible scenario which the East Asian countries may be confronted with in forming a common currency area in the future.

The paper is organized as follows. Section 2 describes our N-country world in which M

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[4] The decomposition method was derived by extending the method used by Aoki (1981), Buiter (1986), and Turnovsky (1986).

[5] For example, Canzoneri and Gray (1985) and Canzoneri and Henderson (1991).

[6] For example, Corsetti, Pesenti, and Roubini (1998), Krugman (1998), and Radelet and Sachs (1998).

out of H East Asian countries form a common currency area. Section 3 derives the explicit solution of the output for each East Asian country. Section 4 defines the loss function which each policy maker minimizes. After examining the incentive to join the common currency in section 5, section 6 shows that the Nash equilibria can be classified into four cases. Section 6 discusses two interesting cases in the Nash equilibria and section 7 considers their implications for East Asia. Section 7 summarizes our main results and discusses their possible extensions.

2. The Model

To illustrate the choice of exchange rate regime by multiple East Asian countries, we consider a simple N-country world in which there exist H East Asian countries (where H $\ll$ N). Every parameter is assumed to be symmetric among countries, although disturbances and policy instruments may differ among countries. All variables are defined as deviations from the long-run equilibrium so that the mean of each variable is zero. Variables in country j are indexed by superscript j (j =1,2, ..., N), and subscripts refer to time periods. The model of country j (j =1,2, ..., N) is described by the following four equations.

(1) $m_t^j - p_t^j = ay_t^j - bi_t^j + v_t^j,$

(2) $y_t^j = c(p_t^j - E_{t-1}p_t^j) + w_t^j,$

(3) $y_t^j = -\alpha(i_t^k - E_{t-1}p_t^j + p_t^j) + \beta \sum_{k \neq j}\left(e_t^{jk} - p_t^j + p_t^k\right) + \gamma y_t^k + \delta \sum_{k \neq j} y_t^k + u_t^j,$

(4) $i_t^j = i_t^k + E_t e_{t+1}^{jk} - e_t^{jk},$ for all j$\neq$k,

where y = the log of real output, p = the log of price level, m = the log of nominal money supply, e^{jk} = the log of country j's exchange rate in terms of country k's currency, and i = nominal interest rate. $E_{t-1}x_t$ is the conditional expectations of x_t based on the information set at time t-1. The term $\sum_{k \neq j} x_t^k$ in (3) denotes the summation of x_t^k for k = 1,2, ..., N but k$\neq$j.

Equations of the model are standard in traditional macroeconomic literature. Equation (1) is the money demand function. The disturbance term v_t^j denotes monetary shocks in country j. Equation (2) is the aggregate supply function. $E_{t-1}p_t$ is the wage setter's conditional expectations of p_t based on the information set at time t-1. The disturbance term w_t^j denotes supply shocks in country j. Equation (3) describes aggregate demand equation, which depends negatively on domestic real interest rate and positively on real exchange rates as well as domestic and foreign incomes. The disturbance term u_t^j denotes demand shocks in country j. For analytical simplicity, we assume that the elasticities of real exchange rates and

foreign incomes are symmetric for all foreign countries. Equation (4) is the uncovered interest parity condition between country j and k for all $j \neq k$.

Throughout this paper, all stochastic disturbances are assumed to be serially uncorrelated over time and be independent of other types of disturbances. However, we allow that the same type of stochastic disturbances may have the cross-country correlations, particularly among the East Asian economies, in the following analysis.

In our model, the total number of the East Asian countries is H. We suppose that among these H countries, M countries ($M \leqq H$) form a common currency area in East Asia. Since the order of country is arbitrarily chosen, we define that country j is an East Asian country when j = 1, 2, ..., H and is a non-East Asian country when j = H+1, H+2, ..., N. We also define that country j is a member of the East Asian common currency area when j = 1, 2, ..., M but is a non-member when j = M+1, M+2, ..., H.

For analytical tractability, we assume that non-member East Asian countries and non-East Asian countries adopt the flexible exchange rate regime and keep the money supply constant over time. We also assume that the total amount of the money supply in the East Asian common currency area is kept constant over time. Under these assumptions, it holds that $\sum_{i=1}^{M} m_t^i = 0$, $e_t^{jk} = 0$ for $1 \leqq j, k \leqq M$ and $j \neq k$, and $m_t^j = 0$ for j = M+1, M+2, ..., N.

3. The Explicit Solution

Our N-country model consists of 4*N-1 interdependent equations. Thus, without the assumption of symmetric parameters, it is very difficult to derive the explicit solutions in general. However, under the assumption of symmetric parameters, the decomposition method by Fukuda (1993) can orthogonalize these equations into three independent groups and derive the explicit solution. The solution procedure by the decomposition method is briefly explained in the appendix. It derives the following explicit forms of output for each country.

When country j is a member of the East Asian common currency, that is, when j = 1, 2, ..., M, the output in country j is solved as

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\begin{aligned}
(5) \quad y_t^j = {} & (1/\Omega)[bcu_t^a - \alpha c v_t^a + \alpha(1+b)w_t^a] \\
& + (1/\Psi)[c(u_t^j - \frac{1}{M}\sum_{i=1}^{M} u_t^i) + (\alpha + \beta N)(w_t^j - \frac{1}{M}\sum_{i=1}^{M} w_t^i)] \\
& + (1/\Gamma)[bc\frac{1}{M}\sum_{i=1}^{M} u_t^{di} - (\alpha + \beta N)c\frac{1}{M}\sum_{i=1}^{M} v_t^{di} + (\alpha + \beta N)(1+b)\frac{1}{M}\sum_{i=1}^{M} w_t^{di}],
\end{aligned}
$$

where three parameters, , Ω, Ψ, and Γ, are defined as

$$\Omega \equiv \alpha(1+ac)+[\alpha+c\{1-\gamma-\delta(N-1)]b,$$
$$\Psi \equiv (\alpha+\beta N)+c(1-\gamma+\delta),$$
$$\Gamma \equiv (\alpha+\beta N)(1+ac)+[(\alpha+\beta N)+c(1-\gamma+\delta)]b.$$

Disturbance terms with superscript *a* denote world-average stochastic disturbances defined by:

$$u_t^a \equiv \frac{1}{N}\sum_{j=1}^{N} u_t^j,\ v_t^a \equiv \frac{1}{N}\sum_{j=1}^{N} v_t^j, \text{ and } w_t^a \equiv \frac{1}{N}\sum_{j=1}^{N} w_t^j,$$

and those with superscript *dj* are country-specific disturbances defined by:

$$u_t^{dj} \equiv u_t^j - u_t^a,\ v_t^{dj} \equiv v_t^j - v_t^a, \text{ and } w_t^{dj} \equiv w_t^j - w_t^a.$$

Equation (5) states that when country j is a member of the East Asian common currency area, its domestic output is affected by three types of stochastic shocks. The first type of shocks are world-average stochastic disturbances, u_t^a, v_t^a, and w_t^a These disturbances affect the domestic output through changing world average interest rate, world average price level, and world average income level.

The second type of shocks are country-specific disturbances in the region, $u_t^j - \frac{1}{M}\sum_{i=1}^{M} u_t^i$ and $w_t^j - \frac{1}{M}\sum_{i=1}^{M} w_t^i$. These stochastic shocks are deviations of country-specific shocks, u_t^j and w_t^j, from their regional average, $\frac{1}{M}\sum_{i=1}^{M} u_t^i$ and $\frac{1}{M}\sum_{i=1}^{M} w_t^i$. These disturbances appear in the equation because country-specific stochastic disturbances in the region call for the adjustment of domestic price level to keep the intra-regional exchange rates fixed. It is worthwhile to note that no country-specific monetary shock in the region, $v_t^j - \frac{1}{M}\sum_{i=1}^{M} v_t^i$, appear in the equation. This reflects the fact that the money market is endogenously cleared under the fixed exchange rate regime.

The third type of shocks are region-specific stochastic disturbances, $\frac{1}{M}\sum_{i=1}^{M} u_t^{di}$, $\frac{1}{M}\sum_{i=1}^{M} v_t^{di}$, and $\frac{1}{M}\sum_{i=1}^{M} w_t^{di}$. They are the average of country-specific shocks, u_t^{dj} ($\equiv u_t^j - u_t^a$), v_t^{dj} ($\equiv v_t^j$

- v_t^a), and w_t^{dj} ($\equiv w_t^j - w_t^a$), in the region. The shocks appear in the equation because the exchange of the common currency area is flexible against the currencies outside the common currency area.

On the other hand, when country j adopts the flexible exchange rate regime, that is, when j = M+1, M+2, ..., N, the output in country j is solved as

$$(6) \quad y_t^j = (1/\Omega)[bcu_t^a - \alpha cv_t^a + \alpha(1+b)w_t^a] + (1/\Gamma)[bcu_t^{dj} - (\alpha + \beta N)cv_t^{dj} + (\alpha + \beta N)(1+b)w_t^{dj}].$$

Equation (6) implies that the solution under the flexible exchange regime is much simpler than that of the common currency area. In general, when country j adopts the flexible exchange rate regime, the domestic output is affected by two types of stochastic shocks: world-average stochastic disturbances, u_t^a, v_t^a, and w_t^a, and country-specific shocks, u_t^{dj} ($\equiv u_t^j - u_t^a$), v_t^{dj} ($\equiv v_t^j - v_t^a$), and w_t^{dj} ($\equiv w_t^j - w_t^a$). It is noteworthy that the output level of non-member East Asian countries does not depend on how many foreign countries form the common currency area in East Asia. This reflects the fact that putting aside the effects through world average shocks, the output level is autonomously determined under the flexible exchange rate.

Since N can be arbitrarily large, we assume that country specific disturbances, u_t^{dj}, v_t^{dj}, and w_t^{dj}, are independent of world average disturbances, u_t^a, v_t^a, and w_t^a. However, we allow that a country specific disturbance in country j is correlated with that in country k ($j \neq k$). In particular, we assume that when both j and k countries are East Asian countries, u_t^{dj} and u_t^{dk}, v_t^{dj} and v_t^{dk}, and w_t^{dj} and w_t^{dk} respectively have a positive correlation which is constant over time and does not depend on the combination of j and k.

In the following analysis, we respectively denote the variances of u_t^a, v_t^a, and w_t^a by σ_{ua}^2, σ_{va}^2, and σ_{wa}^2, and the variances of u_t^{dj}, v_t^{dj}, and w_t^{dj} by σ_{uj}^2, σ_{vj}^2, and σ_{wj}^2. We also respectively denote the covariances of u_t^{dj} and u_t^{dk}, v_t^{dj} and v_t^{dk}, and w_t^{dj} and w_t^{dk} by cov_u, cov_v, and cov_w when both j and k countries are East Asian countries.

4. The Loss Function

In the following sections, we study the strategic equilibrium when each East Asian country seeks to achieve its own economic stability. We assume that the policy makers in the economies take as benchmarks the level of output in a frictionless economy, where wages and prices are fully flexible and the labor market clears. Assuming that labor is immobile internationally, the output in such an economy responds only to its own supply shocks (see

Turnovsky and d'Orey (1989)). In terms of the present notation, this adjustment can be expressed as

(7) $y_t^j = q\, w_t^j$, for all j, and $q \equiv (1+n)/(1+n+\gamma) < 1$,

where n is the elasticity of labor supply.

In the following analysis, we determine the equilibrium exchange rate regime as a two-stage game; the exchange rate regime is chosen in the first stage and the private agents clear the market under the chosen regime in the second stage. We thus suppose that the policy maker in country j chooses its exchange rate regime so as to minimize the following loss function

(8) $L_t = E_{t-1}(y_t - y_t^*)^2 + C$,

The loss function in (8) is standard except for a supplementary cost term C. The supplementary cost term reflects the extra fixed costs which arise under each exchange rate regime. The fixed costs may capture the costs of international transactions, say, costs from currency conversion, under each exchange rate regime. They may also be viewed as the political costs of committing on a specific exchange rate regime.

In the following analysis, we assume that $C = C_1$ when the country joins the common currency area, whereas $C = C_2$ when the country adopts the flexible exchange rate regime. Then, equations (5) and (6) respectively lead to the following loss functions for two alternative exchange rate regimes.

When country j is a member of the East Asian common currency, that is, when j = 1, 2, ..., M, the loss function in country j is

(9) $$L^A = C_1 + L^a + \left[\left(\frac{c}{\Psi}\right)^2\left(1-\frac{1}{M}\right)+\left(\frac{bc}{\Gamma}\right)^2\frac{1}{M}\right]\sigma_u^2 - \left[\left(\frac{c}{\Psi}\right)^2-\left(\frac{bc}{\Gamma}\right)^2\right]\left(1-\frac{1}{M}\right)cov_u$$

$$+ \left[\frac{(\alpha+\beta N)c}{\Gamma}\right]^2\left[\frac{1}{M}\sigma_v^2+\left(1-\frac{1}{M}\right)cov_v\right]$$

$$+ \left[\left(\frac{\alpha+\beta N}{\Psi}-q\right)^2\left(1-\frac{1}{M}\right)+\left\{\frac{(\alpha+\beta N)(1+b)}{\Gamma}-q\right\}^2\frac{1}{M}\right]\sigma_w^2$$

$$- \left[\left(\frac{\alpha + \beta N}{\Psi} - q \right)^2 - \left\{ \frac{(\alpha + \beta N)(1+b)}{\Gamma} - q \right\}^2 \right] \left(1 - \frac{1}{M} \right) cov_w ,$$

where $L^a \equiv (1/\Omega)^2[(bc)^2 \sigma_{ua}^2 + (\alpha c)^2 \sigma_{va}^2 + \{\alpha(1+b) - q\Omega\}^2 \sigma_{wa}^2]$.

On the other hand, when country j adopts the flexible exchange rate regime, that is, when j = M+1, M+2, ..., N, the loss function in country j is

$$(10) \quad L^B = C_2 + L^a + (1/\Gamma)^2[(bc)^2 \sigma_u^2 + \{(\alpha + \beta N)c\}^2 \sigma_v^2 + \{(\alpha + \beta N)(1+b)\}^2 \sigma_w^2].$$

The loss functions generally depend on the relative variabilities of various exogenous shocks. The loss function in the common currency area also depends on the number of the common currency members, M. The latter characteristic implies the existence of a strategic interaction among East Asian countries which affects the incentive of each East Asian country to join or withdraw the common currency area.

5. The Incentive to Join the Common Currency

In the strategic equilibrium, each East Asian policy maker chooses its own exchange regime so as to minimize its loss function at the first stage of the game. In particular, in the non-cooperative Nash equilibrium, each policy maker chooses its regime taking the behavior of the other policy maker as given.

In this section, we first consider what is the best response of country M given that M-1 countries (from country 1 to country M-1) form a common currency area in East Asia. When M-1 countries form a common currency area, the loss function of country M is equal to L^A when it joins the common currency area and is equal to L^B when it adopts the flexible exchange rate regime. Thus, country M has an incentive to adopt the common currency if and only if $L^B > L^A$.

Because

$$(11) \quad \triangle L \equiv L^B - L^A = C_2 - C_1 - \left[\left(\frac{c}{\Psi} \right)^2 - \left(\frac{bc}{\Gamma} \right)^2 \right] \left(1 - \frac{1}{M} \right) \left(\sigma_u^2 - cov_u \right)$$

$$+\left[\frac{(\alpha+\beta N)c}{\Gamma}\right]^2\left(1-\frac{1}{M}\right)\left(\sigma_v^2-cov_v\right)$$

$$+\left[\left\{\frac{(\alpha+\beta N)(1+b)}{\Gamma}-q\right\}^2-\left(\frac{\alpha+\beta N}{\Psi}-q\right)^2\right]\left(1-\frac{1}{M}\right)\left(\sigma_w^2-cov_w\right),$$

the incentive generally depends on the relative variabilities of various exogenous shocks. For example, since $c/\Psi > bc/\Gamma$, the country j has more incentive to adopt the common currency when the variance of country specific demand shocks, σ_u^2, is small and when the variance of country specific monetary shocks, σ_v^2, is large. The effect of country specific supply shocks on the incentive is ambiguous. If $1-\gamma+\delta > (\alpha+\beta N)a$, the incentive to adopt the common currency increases as the variance of country specific supply shocks, σ_w^2, increases. However, if $1-\gamma+\delta < (\alpha+\beta N)a$, the incentive decreases as σ_w^2 increases.

The incentive also depends on the cross-country correlations of three types of country specific disturbances. For example, the country has a larger incentive to form a common currency area when their demand shocks have larger cross-country correlations but less incentives when their monetary shocks have larger cross-country correlations. The effect of cross-country correlations of supply shocks on the incentive depends on the parameter values. If $1-\gamma+\delta > (\alpha+\beta N)a$, the incentive decreases as the cross-country correlation, cov_w, increases. However, if $1-\gamma+\delta < (\alpha+\beta N)a$, the incentive increases as cov_w, increases.

6. The Strategic Equilibrium

Given the results in the last section, we now explore what exchange rate regime is chosen by the East Asian countries in the strategic Nash equilibrium. Define

$$(12)\qquad \Pi \equiv -\left[\left(\frac{c}{\Psi}\right)^2-\left(\frac{bc}{\Gamma}\right)^2\right]\left(\sigma_u^2-cov_u\right)+\left[\frac{(\alpha+\beta N)c}{\Gamma}\right]^2\left(\sigma_v^2-cov_v\right)$$

$$+\left[\left\{\frac{(\alpha+\beta N)(1+b)}{\Gamma}-q\right\}^2-\left(\frac{\alpha+\beta N}{\Psi}-q\right)^2\right]\left(\sigma_w^2-cov_w\right).$$

Then, since $\triangle L = C_2 - C_1 + \Pi(1-1/M)$, the Nash equilibrium in our model can be classified into four cases depending on the relative magnitude of Π and $C_2 - C_1$.

The first is the case where $C_1 < C_2$ and $\Pi > [H/(H-1)](C_1 - C_2)$. In this case, we can show that $\triangle L > 0$ for all $M \leqq H$. When $\triangle L > 0$ for all $M \leqq H$, each East Asian country has an incentive to join the common currency area regardless of the number of its participants. This implies that when $C_2 > C_1$ and $\Pi > [H/(H-1)](C_1 - C_2)$, all East Asian counties join the common currency area in the Nash equilibrium. Since this case tends to happen when C_2 is much larger than C_1, the result holds true reflecting an obvious fact that the common currency area tends to be formed when its fixed costs under the common currency area are much smaller than those under the flexible exchange rate.

The second case arises when $C_1 > C_2$ and $\Pi < [H/(H-1)](C_1 - C_2)$. In this case, it holds that $\triangle L < 0$ for all $M \leqq H$. When $\triangle L < 0$ for all $M \leqq H$, no East Asian country has an incentive to join the common currency area regardless of the number of its participants. Thus, contrary to the first case, the common currency area is never formed in the Nash equilibrium when $C_1 > C_2$ and $\Pi < [H/(H-1)](C_1 - C_2)$. However, since this case tends to happen when C_1 is much larger than C_2, the result is a mirror image of the first case reflecting an obvious fact that it is difficult to form the common currency area when its fixed costs are much larger than the costs under the flexible exchange rate.

Less obvious and more interesting results are derived in the third and fourth cases. The third is the case where $0 < [H/(H-1)](C_1 - C_2) < \Pi$. In this case, we can show that $\triangle L \geqq 0$ if and only if $M \geqq \Pi/(\Pi + C_2 - C_1)$. The case is quite noteworthy because each East Asian country has an incentive to join the common currency area if and only if the number of the other participants is greater than some threshold number. A simple algebra (that is, $\Pi/(\Pi + C_2 - C_1) - 1$) verifies that the threshold number is equal to $(C_1 - C_2)/(\Pi + C_2 - C_1)$ which is always positive. In other words, when $0 < [H/(H-1)](C_1 - C_2) < \Pi$, the model has two Nash equilibria: the equilibrium where the common currency area is never formed in East Asia and the equilibrium where all East Asian counties join the common currency area.

The fourth case arises when $0 > [H/(H-1)](C_1 - C_2) > \Pi$. In this case, it can be shown that $\triangle L \geqq 0$ if and only if $M \leqq \Pi/(\Pi + C_2 - C_1)$. The result implies that when $0 > [H/(H-1)](C_1 - C_2) > \Pi$, each East Asian country has an incentive to join the common currency area if and only if the other participants is smaller than the threshold number, i.e., $(C_1 - C_2)/(\Pi + C_2 - C_1)$. If we define M* as the maximum integer such that $M^* \leqq \Pi/(\Pi + C_2 - C_1)$, the Nash equilibirum is thus the equilibrium where M* East Asian countries join the common currency area but H-M* East Asian countries do not. It is noteworthy that H East Asian countries can take two different exchange rate regimes although their economic structures are completely symmetric. In fact, when $0 > [H/(H-1)](C_1 - C_2) > \Pi$, our model cannot decide which East Asian countries will join the common currency area and which East Asian countries will adopt the flexible exchange rate regime.

7. Implications of the Indeterminate Nash Equilibria

In the last section, we have shown that when each East Asian country strategically seeks to achieve its own economic stability, the Nash equilibrium in our model can be classified into four cases depending on the relative magnitude of Π and $C_1 - C_2$. In any of the Nash equilibria, the equilibrium regime is stable in the sense that neither policy maker has an incentive to switch unilaterally from the regime. In particular, among four cases, the first two cases are straightforward and derive the definitive answer on whether the Nash equilibrium can lead to a common currency area in East Asia or not. However, the Nash equilibria in the third and fourth cases are indeterminate in the sense that the model cannot predict which East Asian countries will join the common currency area. The source of indeterminacy in these equilibria comes from the fact that the loss function L^A in (9) (or equivalently $\triangle L$ in (11)) depends on the number of countries in the common currency area, M. Because of the dependency, the incentive to join or withdraw the common currency area is generally affected by how many countries will join the common currency area.

The purpose of this section is to explore the economic implications of these two types of indeterminate Nash equilibria in details. In general, it depends on the parameter values and variances and covariances of exogenous shocks when the third and four cases will happen in our model. But, when $C_1 > C_2$ (that is, when the fixed costs under the flexible exchange rate are smaller than those under the common currency area), the third case tends to happen when the variance of demand shocks is small, the variance of monetary shocks is large, and the variance of supply shocks is large (small) if $1 - \gamma + \delta$ is larger (smaller) than $(\alpha + \beta N)a$. In this case, each East Asian policy maker is confronted with a tradeoff such that the common currency area is not desirable in reducing the fixed costs but is desirable in reducing the output stability.

In the third case, the Pareto superior equilibrium exchange rate regime is the regime where all East Asian countries join the common currency area. In fact, we can show that the loss function of each East Asian country is minimized when M = H. However, in addition to this Pareto superior equilibrium, the model also has the Pareto inferior equilibrium in which all East Asian countries adopt the flexible exchange rate regime and the common currency area is never formed in East Asia. This Pareto inferior equilibrium is stable in the sense that neither policy maker has an incentive to switch unilaterally from the flexible exchange rate regime. Thus, once the economy is stuck in the inferior equilibrium, it is difficult for the East Asian region to form the desirable common currency area without coordination of East Asian policy makers.

The reason why the inferior equilibrium can exist is that the interactions of exogenous shocks in the common currency area are "strategic complementary" in stabilizing monetary shocks for any parameter set and in stabilizing supply shocks if $1 - \gamma + \delta > (\alpha + \beta N)a$. For

example, since the variance of $\frac{1}{M}\sum_{i=1}^{M} v_t^{di}$ decreases as M increases, equation (5) states that the output instability caused by the monetary shocks is more diversified out as the number of participants increases in the common currency area. This implies that when either monetary or supply shocks are large, the strategic complementary may deter non-cooperative policy makers from forming a common currency area in East Asia even if it is desirable in terms of economic stability in the region.

On the other hand, when $C_1 < C_2$ (that is, when the fixed costs under the flexible exchange rate are larger than those under the common currency area), the fourth case tends to happen when the variance of demand shocks is large, the variance of monetary shocks is small, and the variance of supply shocks is small (large) if $1-\gamma+\delta$ is larger (smaller) than $(\alpha+\beta N)a$. In this case, each East Asian policy maker is confronted with a tradeoff such that the common currency area is more desirable in reducing the fixed cost but less desirable in reducing the output stability.

In the fourth case, we can show that the loss function of each East Asian country is minimized when $M = \Pi/(\Pi+C_2-C_1)$ which is smaller than H. In addition, when $M = \Pi/(\Pi+C_2-C_1)$, East Asian countries are indifferent between joining the common currency area and keeping the flexible exchange rate regime. Thus, the Nash equilibrium is the Pareto optimal in the fourth case, although the model cannot decide which East Asian countries will join the common currency area.

However, since the value of $\Pi/(\Pi+C_2-C_1)$ is not integer in general, the integer constraint can lead to smaller entry to the common currency area than the optimal level and can cause the loss difference between member countries and non-member countries. For example, suppose that $a = b = \alpha = \beta N = 1$, $c = 2$, $1-\gamma+\delta = 0.5$, $C_1 = 8/9$, $C_2 = 28/9$, $\sigma_{ua}^2 = \sigma_{va}^2 = \sigma_{wa}^2 = \sigma_v^2 = \sigma_w^2 = cov_v = cov_w = 0$, $\sigma_u^2 = 18$, and $cov_u = 9$. Then, since $\Pi/(\Pi+C_2-C_1) = 8/3$, two countries form the common currency area among H East Asian countries in the Nash equilibrium. In this example, it holds that $L^A = 32/9$ and $L^B = 4$ and the countries outside the common currency area have larger losses than countries inside the common currency area by $L^B - L^A = 4/9$.

Although the difference of losses exists among symmetric East Asian countries, the Nash equilibrium is stable in the sense that no policy maker with larger losses has an incentive to switch from the flexible exchange rate regime. This is because when a new country enters the common currency area, the loss under the common currency area becomes larger than the loss under the flexible exchange rate.

The Nash equilibrium with uneven loss functions arises when the strategic interactions among East Asian policy makers are "strategic substitute" in stabilizing demand shocks for any parameter set and in stabilizing supply shocks if $1-\gamma+\delta < (\alpha+\beta N)a$. For example, since the variance of $u_t^j - \frac{1}{M}\sum_{i=1}^{M} u_t^i$ increases as M increases, equation (5) states that the output

instability caused by the demand shocks is magnified as the number of participants increases in the common currency area. This implies that when either demand or supply shocks are large, the integer constraint may lead to uneven welfare losses among H East Asian countries although their economic structures are completely symmetric.

8. Implications for the East Asian economies

In previous sections, we have investigated what exchange rate regime is realized in the Nash equilibrium when each East Asian country strategically seeks to achieve its own income stability. The noteworthy findings were derived when each East Asian policy maker is confronted with a tradeoff in reducing the fixed costs and the output stability. In this case, the interactions of exogenous shocks in the common currency area become either "strategic complementary" or "strategic substitute" in stabilizing exogenous shocks. As a result, the equilibrium exchange rate regime is not necessarily determinate in this case.

Because of growing roles of intra-regional linkage among the East Asian economies, the approach focusing on the interactions of exogenous shocks is probably relevant in considering the possibility of the common currency area among the future East Asian countries. However, our model has different implications depending on whether the interactions are "strategic complementary" or "strategic substitute".

When the interactions of shocks are "strategic complementary" in the common currency area, our model implies that there can exist two Nash equilibria. In such a case, although forming a common currency area is desirable for all East Asian countries, both the flexible exchange rate regime and the common currency area can be the equilibrium regime even for reasonable parameters and exogenous shocks. In particular, if the initial exchange regime is the flexible exchange rate regime, it may be difficult to switch the regime to the desirable common currency area unless some big push or some drastic expectation changes occur in the region.

After the crisis, Thailand, Korea, and Indonesia switched their regimes to the flexible exchange rate regime under the supervision of IMF. Because the regime switch in these countries was not necessarily voluntarily chosen, the sustainability of the regime is not clear at the current stage. However, if the interactions of shocks are "strategic complementary", the (non-optimal) flexible exchange rate regime can be sustainable given the behavior of the other countries. Thus, even if the involuntary regime switch happens, the regime switch can have permanent (undesirable) effects on the future exchange rate regime not only for these three countries but also for other East Asian economies.

On the other hand, when the interactions of exogenous shocks are "strategic substitute" in the common currency area, our model implies that a relatively small number of East countries will

form a common currency area in the future. This will be true even if all East Asian countries have similar economic structures. In particular, when the integer constraint exists, the symmetric East Asian countries can have different welfare losses depending on whether they become a member of the common currency area or not.

Of course, all East Asian countries are not symmetric in the real world. In such a case, some East Asian countries have more incentive to join the common currency area and others do not. However, even in this case, the integer constraint may have uneven welfare consequences on member countries and non-member countries. If so, policy coordination among the East Asian countries is called for to make redistributions from member countries to non-member countries for the true stability in the region.

9. Conclusions

Before the crisis, most East Asian countries linked their currencies solely to the U.S. dollar. Lessons from the crisis, however, taught us that the dollar dominant exchange rate regime was not desirable for the stability of the East Asian economies. In this paper, we have investigated whether the strategic equilibrium can lead to a common currency area in East Asia when each East Asian country seeks to achieve its own income stability. Several noteworthy results were derived when each East Asian policy maker is confronted with a tradeoff in reducing the fixed costs and the output stability. In such a case, the Nash equilibria in our model can be indeterminate in the sense that the model cannot predict which East Asian countries will join the common currency area. In the paper, we made extensive discussions on these indeterminate Nash equilibria and derived several implications which may be useful in considering the future exchange rate regime in East Asia.

Needless to say, because of our limited model analysis, we need several reservations to apply our theoretical results to the actual policy implementations in East Asia. In particular, our N-country model with symmetric structures is too simple to derive general economic implications for the future currency system in East Asia. Although the extension complicates our analysis, we can point out several directions for our future researches.

First, in defining the loss function of each East Asian countries, we included an exogenous supplementary cost term C to capture the fixed costs arising under each exchange rate regime. The fixed cost term is plausible in the sense that the output stability is not the only goal in choosing the exchange rate regime. However, strictly speaking, the costs are not exogenous. For example, suppose that the fixed costs capture the costs of international transactions under each exchange rate regime. In this case, if there exists some network externality in reducing the costs of international transactions, the costs may vary depending on how many countries

join the common currency area. Making the fixed cost term endogenous is a possible remained topic for our researches.

Second, in considering the future exchange rate regime in East Asia, we implicitly assumed that the East Asian countries need to choose one of the flexible exchange rate regime and the common currency area. However, generally speaking, there are several alternative choices for the future East Asian exchange rate regime, including the currency basket peg system, the managed floating system, and the dollar peg system. Although expanding the choices complicates the analysis, it is desirable to check the robustness of our theoretical results.

Finally, our model was based on simple log-linear equations without profound microfoundations. Although the model was standard in traditional studies, we can also investigate alternative models with some microfoundation of money, say, the model of cash-in-advance or the model of Matsuyama et al. (1993). It is also our remained future research topic to study whether the strategic equilibrium can lead to a common currency area in East Asia in these alternative models.

Appendix

In this appendix, we derive the explicit solution of our N-country model where M countries form a common currency area. The solution method is based on the decomposition method by Fukuda (1993), which orthogonalizes the N interdependent systems into three independent system.

The solution method first decomposes the N interdependent subsystems into the N independent subsystems. For any vector $X = (x^1, x^2, ..., x^N)$, define

(A1) $x_t^a \equiv \frac{1}{N}\sum_{j=1}^{N} x_t^j$,

(A2) $x_t^{d(q)} \equiv \frac{1}{q}\sum_{j=1}^{q} x_t^j - x_t^{q+1}$.

Then, we can transform equations (1)-(4) for j =1,2, ..., N into the following equations:

(A3) $m_t^a - p_t^a = ay_t^a - bi_t^a + v_t^a$,

(A4) $y_t^a = c(p_t^a - E_{t-1}p_t^a) + w_t^a$,

(A5) $y_t^a = -\alpha(i_t^a - E_{t-1}p_t^a + p_t^a) + \{\gamma + \delta(N-1)\}y_t^a + u_t^a$,

For q = 1, 2, ..., M,

(A6) $y_t^{d(q)} = c(p_t^{d(q)} - E_{t-1}p_t^{d(q)}) + w_t^{d(q)}$,

(A7) $y_t^{d(q)} = -\alpha(i_t^{d(q)} - E_{t-1}p_t^{d(q)} + p_t^{d(q)}) + \beta N(e_t^{d(q)} - p_t^{d(q)}) + (\gamma - \delta)y_t^{d(q)} + u_t^{d(q)}$,

(A8) $e_t^{d(q)} = i_t^{d(q)} = 0$,

For q = M+1, M+2, ..., M,

(A9) $-p_t^{d(q)} = ay_t^{d(q)} - bi_t^{d(q)} + v_t^{d(q)}$,

(A10) $y_t^{d(q)} = c(p_t^{d(q)} - E_{t-1}p_t^{d(q)}) + w_t^{d(q)}$,

(A11) $y_t^{d(q)} = -\alpha(i_t^{d(q)} - E_{t-1}p_t^{d(q)} + p_t^{d(q)}) + \beta N(e_t^{d(q)} - p_t^{d(q)}) + (\gamma - \delta)y_t^{d(q)} + u_t^{d(q)}$,

(A12) $i_t^{d(q)} = E_t e_{t+1}^{d(q)} - e_t^{d(q)}$.

When $1 \leqq j \leqq M$, country j is a member of the common currency area. Thus, its monetary policy has no autonomy in order to fix the exchange rate among the member countries and to keep their interest rate differentials zero. As a result, (A6) - (A8) hold when q = 1, 2, ..., M. On the other hand, when $j \geqq M+1$, country j keeps its money supply constant over time under the flexible exchange rate regime. Noting that the total money of the common currency is also kept fixed, it holds that $m_t^{d(q)} = 0$ for q = M+1, M+2, ..., N and that (A9) - (A12)

are derived.

Three groups of equations (A3) - (A5), (A6) - (A8), and (A9) - (A12) are respectively self-contained systems. Thus, three groups lead to the following three independent solutions.

(A13) $y_t^a = (1/\Omega)[bcu_t^a - \alpha cv_t^a + \alpha(1+b)w_t^a]$,

(A14) $y_t^{d(q)} = (1/\Psi)[cu_t^{d(q)} + (\alpha + \beta N)w_t^{d(q)}]$, for q = 1, 2, ..., M,

(A15) $y_t^{d(q)} = (1/\Gamma)[bcu_t^{d(q)} - (\alpha + \beta N)cv_t^{d(q)} + (\alpha + \beta N)(1+b)w_t^{d(q)}]$, for q $\geqq$ M+1.

Transforming N orthogonalized systems into the original N-country world, we can obtain the explicit solution in our N-country model. The retransformation formula is:

(A16) $x_t^1 \equiv \frac{1}{N}x_t^a + \sum_{q=1}^{N-1}\left(\frac{1}{q(q+1)}x_t^{d(q)}\right)$,

(A17) $x_t^k \equiv \frac{1}{N}x_t^a - \frac{1}{k}x_t^{d(k-1)} + \sum_{q=k}^{N-1}\left(\frac{1}{q(q+1)}x_t^{d(q)}\right)$, when 2 $\leqq k \leqq N$-1,

(A18) $x_t^N \equiv \frac{1}{N}\left(x_t^a - x_t^{d(N-1)}\right)$.

Applying (A16) - (A18) to (A13) - (A15), we obtain equations (5) and (6) in the text.

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