Should Taiwan Worry About "Marginalization?" A Dynamic Game Theoretical Analysis

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Abstract

In Taiwan, economic marginalization has been a main concern due to the imbalanced cross-strait economic and political relations, the country's failure to participate in main international organizations, and the endorsement of the Closer Economic Partnership Arrangement (CEPA) between Hong Kong and China in 2003. The question can be considered in two aspects: On the one hand, marginalization means that Taiwan may not be able to play a key role in regional economic integration, which in turns may put the country to the next Asian currency speculative attacks without protection under a regional macroeconomic cooperative mechanism. On the other hand, is a regional cooperative mechanism, such as CEPA and its further extensions, the best choice for Taiwan's future economic development? On the basis of a dynamic game framework by Yeh and Plasmans (2002), I will analyze some options and their possible outcomes according to the current development of four main economic blocks of the world (the U.S., Japan, the EMU, and the Chinese Economic Area), and to the principles of macroeconomic and international economic stabilization: (1) Taiwan does its best to participate regional cooperative mechanisms, putting aside the independence issue; (2) Taiwan keeps its independent political status and economic policy. A comparative analysis of the above options is preliminary but may be helpful in considering of Taiwan's future economic and cross-strait policies.

JEL codes: C70, F33, F42, F47.

Keywords: Marginalization, Economic integration, currency crisis, dynamic (differential) game

1. Introduction

The idea "marginalize"[1] or "marginalization" is widely used in literacy, cultural criticism, and sociology. It describes the process in which a person, a group, or an activity is deprived as a symbol of a central power.[2] Recently, the same idea has been used to discuss Taiwan's future economic situation due to the imbalanced cross-strait economic and political relations, the country's failure to participate in main international organizations, and the endorsement of the Closer Economic Partnership Arrangement (CEPA) between Hong Kong and China in 2003. Whether Taiwan should participate CEPA or not has become a hot issue. To clarify the above viewpoints, Mr. CHEN Shui-bian (2004), the president of Taiwan, stressed the necessity for Taiwan and China to establish a dynamic "peace and stability framework" for interactions through consultation, which is under the presumption of national sovereignty, security, and dignity. However, some foreign observers state that the possible "self-marginalization" is rapidly becoming a reality, since the lack of direct links between Taiwan and China has become a symbol of Taiwan's self-isolation from Asia's fastest growing market.[3] That is, the problem of Taiwan's marginalization derives not only from China's economic and diplomatic blockades but also from Taiwan's own policy choice.

The question can be considered in two aspects: On the one hand, some regional cooperative arrangements, such as CEPA, can be a beginning of a further international economic policy coordination mechanism.

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[1] *Merrianm Webster's Collegiate Dictionary and Thesaurus* explains the verb "to relegate to a marginal position within a society or a group."

[2] Childers and Hentzi (1995), pp.174-75.

[3] American Chamber of Commerce in Taipei (2004), p.8.

Marginalization means that Taiwan may not be able to play a key role in regional economic integration, which in turns put the country to the next Asian currency speculative attacks without protection under a regional macroeconomic cooperative mechanism.[4] On the other hand, according to research literature, many difficulties, such as asymmetries and spillover externalities within economies, and the problem of governments' failure,[5] plague the process of creating a viable international cooperation. Moreover, the welfare of each country may decrease even if policy coordination is possible.[6] In other words, regional cooperative mechanism may not be appropriate for all economies. In Taiwan's case, it depends on many conditions and national considerations.

The purpose of this paper is to analyze whether a regional cooperative mechanism, such as CEPA and its further extensions, is the best choice for Taiwan's future economic development. An analysis related to Taiwan's marginalization according to current information and possible options is of course very preliminary but may be helpful in considering Taiwan's future economic and cross-strait policies. A dynamic game approach is adopted to study the interaction among Chinese economies and the main economic blocks of the world. A series of publications collected in Buiter and Marston (1985) provide a comprehensive analysis of the problems that emerge in such dynamic games. From 1999 onwards, the European Monetary Union (EMU) provides a realistic scenario for the use of this method. Recent works, such as Levine and Brociner (1994), Douven and Plasmans (1996a, b), Engwerda, van Aarle, and Plasmans (1999, 2002), van Aarle, Engwerda and

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[4] For instance, the central bank of Taiwan (*China Times,* 2000.12) comments that Taiwan and China should cooperate to push an East Asia financial cooperative mechanism after both joining WTO, under condition that individual countries keep monetary policy independence.

[5] Bryant (1995), p.72.

[6] Miller and Salmon (1985).

Plasmans (2000, 2001), van Aarle et al. (2002a, b), Di Bartolomeo and Plasmans (2001), and Di Bartolomeo et al. (2002), explore the convergence issues of the EMU. This approach should also be appropriate in the Asian situation due to the so-called "decentralized" policy decision process.

This paper is structured as follows. Section 2 presents and explains our modeling. Section 3 shows how to derive the different macroeconomic and international financial outcomes if Taiwan is in either a non-cooperative or a cooperative situation. Here we assume that the non-cooperative situation can be the consequence of marginalization or self-isolation. Section 4 combines the theories and the empirics presented in sections 2 and 3 to make a simulation study in which we get an initial idea about the possibility of the CEMU in the future. Section 5 concludes our findings of this paper.

2. Establishing a Theoretical Framework

In this paper we consider a five-economy model that includes China, Taiwan, and the three major economies of the world: the U.S., Japan and the EMU.[7] The structural-form model is based on Yeh and Plasmans (2002), which extends the conventional Mundell-Fleming open-economy framework. All variables are expressed in natural logarithms, except for the interest rate, which is in percentages. Most importantly, all variables denote deviations from their long-term equilibrium (balanced growth path), which is normalized to zero. Variables with superscript *i=1*, *2*, *3, 4, 5,* represent China, Taiwan, the United States, Japan, and the EMU, respectively.

[7] We only consider three economies outside the Chinese Economic Area since the U.S. dollar, Japanese yen, and the euro constitute the three main blocks in the world of international finance (Mundell, 2000a,b).

$$y_i(t) = \sum_{j \in \overline{N}/i} \delta_{ij} q_{ij}(t) + \sum_{j \in \overline{N}/i} \rho_{ij} y_j(t) + \eta_i f_i(t) - \gamma_i r_i \qquad (\overline{N} := 1,2,3,4,5) \tag{1a}$$

$$q_{ij}(t) = s_{ij}(t) - p_i(t) + p_j(t) \qquad (\text{superscript} \quad i \neq j) \tag{1b}$$

$$r_i(t) = i_i(t) - \dot{p}_i^e(t) \qquad (\text{superscript} \quad i := 1,2,3,4,5) \tag{1c}$$

$$\dot{p}_i(t) = \lambda_i \Theta_i(t) + \sum_{j \in \overline{N}/i} \varsigma_{ij} \dot{p}_j(t) + \xi_i y_i(t), \qquad p_i(0) = p_i^0 \qquad (\overline{N} := 1,2,3,4,5) \tag{2a}$$

$$\Theta_i(t) := i_i(t) - i_3(t) - \dot{s}_{i3}(t) \tag{2b}$$

Equations (1a), (1b) and (1c), in which y denotes real output, q_{ij} the real exchange rate of country *i* with respect to country *j*, s_{ij} the nominal exchange rate of country *i* with respect to country *j*, *r* the real interest rate, *i* the nominal interest rate, p the price level, and f the real fiscal deficit, express the aggregate demand for goods and services of five of the economies included in our model. Four points are worth mentioning. First, equations (1a), (1b) and (1c) help analyze the roles of the exchange rate, price convergence, and international impact on the domestic economy during the process of economic integration. Second, the economy of the U.S. has an impact on China, Japan, the EMU, and Taiwan, but not vice-versa. The other two economic powers, Japan and the EMU, have impact on China and Taiwan, but not vice-versa. Moreover, we assume China has impact on Taiwan, but not vice versa. Third, the real exchange rate of country *i* on the right side of (1a), $\sum_{j \in \overline{N}/i} \delta_{ij} q_{ij}$, takes into account its most important trading partners and the long-term purchasing power parity hypothesis (PPP). The nominal exchange rates s_{ij} among five countries also appear in equations (1a) and (1b), because those countries keep their own currencies.[8] Finally, the expected real interest rate of each country is defined as in (1c). Henceforth, perfect myopic foresight is assumed in this paper, so that, in our deterministic

[8] The relative prices would be the main factor to decide on the competitiveness among the countries involved in case there was only a

context $\dot{p}_i^e(t) = \dot{p}_i(t)$.

Equation (2) constructs the aggregate supply (Phillips curve) in the open economy by extending DiNardo and Moore (1999).[9] Here the empirical risk premium is defined as $\Theta_i(t)$, in which the nominal interest rate of the U.S. is assumed to be close to the level of the world interest rate. Under the above definition, the U.S. risk premium in equation (2) is zero ($\Theta_3(t) = 0$).

Equations (1) and (2) can be reduced to five output equations

$$y_i(t) = D_i^T x(t) \tag{3}$$

where D_i^T is the vector of the parameters in the reduced-form model. And $x^T = \begin{pmatrix} q & f & i & \dot{s} \end{pmatrix}$, where $q \in \Re^{1\times 10}$, $f \in \Re^{1\times 5}$, $i \in \Re^{1\times 5}$, and $\dot{s} \in \Re^{1\times 10}$.

q, f, i, and $\dot{s}$ of country *i* appear in the output of country *j* at the same time (though some parameters equal to zero), because a close economic link has been formed among countries. It is clear that the external influence still transmits from the U.S., Japan, and the EMU to China and Taiwan according to the above assumptions.

Now we can get the derivatives of the real exchange rates with respect to time.

$$\dot{q}_{ij}(t) = \dot{s}_{ij}(t) - \dot{p}_i(t) + \dot{p}_j(t) \tag{4}$$

By substituting (2) and (3) into (4), it can be rewritten as

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single currency in the world (that is, all s_{ij} equal to zero).

[9] Appendix 2 in Yeh and Plasmans (2002) shows the derivation.

$$\dot{q}_{ij}(t) = \phi^T x(t) \qquad \phi \in \Re^{30} \qquad i \neq j$$
$$q_{ij}(0) = q_{ij}^0 \tag{5}$$

The dynamics of the model in (5) are then represented by ten first-order linear differential equations with national fiscal deficits and interest rates as controlled variables, and real exchange rates, nominal cross exchange rate changes, and foreign real incomes as state variables.

Assume that the authorities control their policy instruments such as to minimize the following quadratic loss functions, which feature the domestic inflation, output, nominal interest rate,[10] and fiscal deficit.

$$\underset{f_i, i_i}{Min} J_i = \underset{f_i, i_i}{Min} \frac{1}{2} \int_{t_0}^{\infty} \{\alpha_i (\dot{p}_i(t))^2 + \beta_i (y_i(t))^2 + \chi_i (i_i(t))^2 + \omega_i (f_i(t))^2\} e^{-\theta(t-t_0)} dt\} \qquad i = 1,2,3,4,5 \tag{6}$$

in which θ denotes the rate of time preference and α, β, χ and ω represent preference weights that are attached to the stabilization of inflation, output, nominal interest rate and fiscal deficit, respectively.

Substitute the reduced- form equation (3) into (6), these loss functions become:

$$J_i = \frac{1}{2} \int_0^{\infty} \{x^T(t) M_i x(t)\} e^{-\theta t} dt \qquad i = 1,2,3,4,5 \tag{7}$$

where $M_i \in \Re^{30 \times 30}$.

3. Policy Designs in the Non-cooperation, Full Cooperation, and Partial Coalition

There can be three possible situations in Taiwan's marginalization: One is the non-cooperation scenario (NC), and the other two are the U.S.-Japan-EMU coalition (G3) and the China-U.S.-Japan-EMU coalition

[10] In van Aarle, Engwerda and Plasmans (2001) the nominal interest rate is not included in the loss function. However, it matters in some emerging markets because of the serious lending boom problem in the private sector.

(G4). The second is not similar to the current G8. Mundel (2000a, b) proposes it because he believes that the three main currencies of the world (the U.S. dollar, Japanese yen and the euro) should be pegged to achieve international financial stability. In theory, it is possible for the three main currency blocks to coordinate their macroeconomic policies. As to the third one, after 2004 G8 Summit in Georgia of the U.S., some comment that China can be invited to participate G8 in the near future. On this account, Taiwan's marginalization may be due to the cooperation among the main economic powers of the world.

There are also some options available to get rid of isolation. Taiwan-China coalition (TW-CN) and full cooperation of five economies (FC) can be two of them. The former means that Taiwan should do its best to be a member of CEPA and then do macroeconomic coordination with China and Hong Kong, regardless of political considerations. The latter seems to be difficult not only for Taiwan but also for the rest of the four economies. Note that I exclude other possible combinations among the five economies not because they are not feasible, but because I focus only on the options related to my research topic.[11]

In the case of NC, each country minimize their loss functions (6) independently with respect to the dynamic laws of motion (5) of the system

$$\begin{aligned} &Min \quad J_i \qquad i = 1,2,3,4,5 \\ &s.t. \quad \dot{q}_{ij}(t) = Aq_{ij}(t) + Bu_1(t) + Cu_2(t) \qquad j = 1,2,3,4,5 \qquad i \neq j \\ &q_{ij}(0) = q_{ij}^0 \end{aligned} \tag{8}$$

where u_1^T is the 1×10 vector of instruments (f_i and i_i),[12] and u_2^T is the vector of non-controlled variables

[11] For instance, Lo, F., former Taiwan's representative in Japan, proposes the Taiwan-Japan coalition (*China Times*, 2002.5.1).

[12] For simplicity we exclude other monetary policy rules (e.g., monetary targeting), which may not be consistent with some countries' situations.

($\dot{s}_{ij}$), respectively. A, B, and C are 10×10 matrices of coefficients.

Next, the full cooperation can be solved by the following open-loop Nash equilibrium.

$$J_{FC} = \sum_{i=1}^{5} \tau_i J_i \qquad \sum_{i=1}^{5} \tau_i = 1 \tag{9}$$

Note that τ measures not only bargaining powers between countries but also the degree of "sacrifice. Values of τ are even if we assume five economies can have a fair negotiation. That is, in the FC, G3, G4, and TW-CN cases, τ of each participating economy is 1/5, 1/3, 1/4, and 1/2, respectively.

Minimize

$$J_{FC} = \frac{1}{2} \int_0^{\infty} \{x^T(t) M_{FC} x(t)\} e^{-\theta t} dt \tag{10}$$

subject to (5). Note that $M_{FC} = \sum_{i=1}^{5} \tau_i M_i$.

The steps to find the non-cooperative and coalitional Nash solutions are shown in Appendix 1.

4. Numerical Simulation

In this section I estimate economic behaviors of five economies according to the equations (1) and (2). The purpose to do so is to get the parameters for the simulations in this section. I try to estimate the model in a conventional way, i.e. utilizing an error correction mechanism (ECM, Douven and Plasmans, 1996a, b). [13] Here I define the mode in a discrete time and go to a different notation.

[13] The purpose of the estimation is to get the parameters for the simulations in this section. For efficiency reasons we do not apply the two-step procedure in which the long-term path is estimated first (e.g. Engle and Granger, 1987).

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum_{k=1}^{K} \beta_k x_{k,t-1} + \sum_{k=1}^{K} \sum_{l=0}^{L_k} \delta_{k_l} \Delta x_{x_k,t-l} + \sum_{m=1}^{M} \gamma_m \Delta y_{t-m} + \varepsilon_t \quad (11)$$

where y represents the left-hand side variable (the GDP in (1) and the CPI inflation in (2)) and x represents all right-hand side variables except the lagged left-hand side term and the differenced terms of all relevant lags of y, and the first differenced terms of all lags of x. ε is a white noise error term.

The estimation based on quarterly data (most variables are from the first quarter in 1992 to the fourth quarter in 2003) helps increase awareness of the current development of the five economies. Two things are worth mentioning: First, similar econometric work can be found in literature. In addition to our estimation results, previous work can be a reference (e.g., Douven and Plasmans, 1996b; Yeh and Plasmans, 2002). Second, values of structural parameters are set to be close to zero in order to avoid the problem of singular matrix if they are insignificant in 1%, 5%, or 10% level and are unavailable in literature. Values of parameters are reported in Table 1, and data description is shown in Appendix 2.

[Insert Table 1 here]

4.1 Values of the loss functions: A case of Chinese deflation

Deflations in China and the U.S. and their consequences to the rest of the world have been the main economic issues since the recent two years. On the one hand, political leaders of the industrial countries believe that China should be responsible for world deflation and asked for RMB appreciation. On the other hand, some economists (e.g., Mundell, 2003a, b) argue that RMB appreciation will not be helpful in solving world deflation, but harmful to Chinese economic reform and long-term growth. In this simulation study, we

assume the price levels of China and the U.S. are lower than 10% and 5% those of the rest economies in our model. Furthermore, we assume that the bilateral nominal exchange rates among the five economies are unchanged. By doing so, we can make a comparison among different scenarios (NC, FC, G3, G4, and TW-CN) under the above shocks, and then we can see whether participating in regional cooperative mechanism is better for Taiwan than isolating from international policy coordination with other economies (especially with China).

We base the simulation on profitability property, which means that the losses in the coalition must be lower than or equal to the non-cooperative losses for all economy members of the coalition. The results of the loss function computation are shown in Table 2.

[Insert Table 2 here]

The fourth and fifth columns of Table 2 are empty, since we get less than ten eigenvalues in our computation according to the steps in Appendix 1.[14] That is, FC and G4 seems to be infeasible on the basis of current information evaluation.

Multiple equilibria, on the other hand, arise in NC, TW-CN, and G3, respectively. In Table 2 we only report a representative equilibrium from each of the three scenarios. With the benchmark of NC, we can find G3 and TW-CN are feasible, since values of the coalitional members' loss functions are not larger than those in NC. Three points can be made from Table 2: First, in G3 the U.S. and Japan can get more benefits than the EMU can. Besides, G3 will cause great negative impact on the welfare of the two Chinese-speaking

[14] If matrix *M* shown in Appendix 1 has more than ten positive eigenvalues multiple equilibria arise, whereas if this matrix has less than ten positives eigenvalues no equilibrium exists (for more details see Engwerda, 1998).

economies. Second, values of Taiwan's and China's loss functions in TW-CN are equal to those in NC, which implies that the two economies cannot get benefits from the coalition of two Chinese-speaking economies.[15] The idea "the fourth pole" proposed by the World Bank (1993) seems impossible for the time being. Finally, on the issue of Taiwan's marginalization, we find no evidence to support the country's cooperation with China (e.g., TW-CN). Also, at this moment China will not be able to isolate Taiwan by cooperating with the main economic powers of the world (e.g., G4 has no equilibrium).

4.2 Macroeconomic adjustments

Macroeconomic adjustments of the five economies under different scenarios are shown in Figures1, 2, and 3. Here we concentrate just on the comparison of Taiwan's situations between NC and TW-CN in order to discuss the question of Taiwan's marginalization. Taiwan's competitiveness, inflation, fiscal and interest rate controls, and output adjustment, are shown in graphs (1), (5), (9), (14), (19), and (24) of the following three figures.

[Insert Figures 1, 2, and 3 here]

Graphs (1) and (5) show Taiwan's relative competitiveness with respect to China and the U.S. is decreasing due to their deflation. Although graph (9) indicates deflation transmits to Taiwan, we can find that adjustments are different in NC and TW-CN. The most interesting part is that opposite controls of fiscal and interest rate policies in the two scenarios, will lead to different adjustments of outputs.

[15] In another equilibrium of TW-CN, a value of Taiwan's loss function is 0.0341 instead of 0.0337, which will cause the coalition impossible.

The main reason may be that in TW-CN Taiwan has to coordinate with China to solve its deflation. This forces Taiwan to adopt the same fiscal and monetary policies as China does (see graphs (13) and (18)), which will in turn cause Taiwan's output recession.

4.3 Balances of payments of Taiwan and China

The institutional arrangement will have impact on macroeconomic adjustments of coalitional members, which in turn will influence their balances of payments. Here changes of the foreign reserves are used to measure the possibility of a country suffering from a currency crisis. Now we use a structural equation (12) to estimate China's and Taiwan's balances of payments, respectively.

$$\Delta fr_i = \kappa_i \Theta_i(t) + \sum_{j \in \overline{N}/i} \psi_{ij} q_{ij}(t) + \sum_{j \in \overline{N}} o_j y_j(t) \qquad (\overline{N} := 1,2,3,4,5) \tag{12}$$

Equations (13) and (14) report the estimation results:

$$\Delta^2 fr_1(t) = \underset{(0.21)}{-0.73} - \underset{(0.10)}{1.63}\Delta\Theta_1(t) + \underset{(0.08)}{0.23}\Delta q_{13}(t) + \underset{(0.03)}{0.09} y_1(t-1) \qquad \overline{R}^2 = 0.94 \qquad DW = 1.93 \tag{13}$$

$$\Delta^2 fr_2(t) = \underset{(0.09)}{-0.28} - \underset{(0.14)}{0.70} fr_2(t-1) + \underset{(0.03)}{0.09}\Delta q_{23}(t-1) + \underset{(0.44)}{0.91}\Delta y_5(t) \qquad \overline{R}^2 = 0.35 \qquad DW = 1.87 \tag{14}$$

We use the same way to simulate the changes of China's and Taiwan's foreign reserves under the same shock and scenarios. The graphs are shown in (28)-(29) of Figures 1, 2, and 3, respectively. The most important finding is that both Chinese-speaking economies can have positive foreign reserves accumulation in TW-CN. Yet in NC and G3, the results are opposite, which means higher possibility of the next currency speculative attack. Putting aside the stabilization of the loss function, Taiwan may re-consider TW-CN if foreign reserves accumulation really matters.

5. Concluding Remarks

In this paper, we adopt a dynamic game approach to explore the so-called “Taiwan’s marginalization” problem. The purpose of the work is to know whether a regional cooperative mechanism, such as CEPA and its further extensions, will be the best choice for Taiwan’s future economic development. The model and information of the analysis are very preliminary, but may be helpful in considering Taiwan’s future economic and cross-strait policies.

The important results of this research can be concluded as follows. First, no evidence can be found to support Taiwan’s macroeconomic policy cooperation with China (e.g., TW-CN). Second, at this moment China will not be able to isolate Taiwan by cooperating with the main economic powers of the world. Therefore, Taiwan does not need to worry about either the pressure of marginalization from China or the criticism from many observers on self-marginalization.

However, many limitations exist in this research: information (including econometric data and modeling) update, robust and sensitivity tests of the simulation results, simulation under different origins of shocks and policy preferences, and so on. Future research may need to deal with all these factors.

TABLE 1 VALUES OF PARAMETERS IN THE SIMULATION

	China	**Taiwan**	**US**	**Japan**	**Germany (EMU)**
δ	$\delta_{13} = 1.18$ $\delta_{14} = 0.0001$ $\delta_{15} = 0.0001$	$\delta_{21} = 0.11$ $\delta_{23} = 0.0001$ $\delta_{24} = 0.15$ $\delta_{25} = 0.0001$		$\delta_{43} = 0.06$ $\delta_{45} = 0.0001$	$\delta_{53} = 0.08$ * $\delta_{54} = 0.0001$
γ	$\gamma_1 = 0.35$ ***	$\gamma_2 = 0.55$	$\gamma_3 = 0.30$	$\gamma_4 = 0.07$ ***	$\gamma_5 = 0.09$ *
η	$\eta_1 = 0.15$ **	$\eta_2 = 0.11$ **	$\eta_3 = 0.29$	$\eta_4 = 0.26$	$\eta_5 = 0.36$
ρ	$\rho_{13} = 0.0001$ $\rho_{14} = 0.0001$ $\rho_{15} = 0.0001$	$\rho_{21} = 0.02$ $\rho_{23} = 1.50$ $\rho_{24} = 0.47$ $\rho_{25} = 0.0001$		$\rho_{43} = 0.0001$ $\rho_{45} = 0.09$ *	$\rho_{53} = 0.06$ * $\rho_{54} = 0.02$ *
λ	$\lambda_1 = 0.14$	$\lambda_2 = 0.07$		$\lambda_4 = 0.02$	$\lambda_5 = -0.02$
ς	$\varsigma_{13} = 1.28$ $\varsigma_{14} = 0.0001$ $\varsigma_{15} = 0.0001$	$\varsigma_{21} = 0.04$ ** $\varsigma_{23} = 0.0001$ $\varsigma_{24} = 0.0001$ $\varsigma_{25} = 0.0001$		$\varsigma_{43} = 0.0001$ $\varsigma_{45} = 0.0001$	$\varsigma_{53} = 0.45$ $\varsigma_{54} = 0.0001$
ξ	$\xi_1 = 0.02$	$\xi_2 = 0.0001$	$\xi_5 = 0.14$	$\xi_4 = 0.11$	$\xi_5 = 0.04$ *
α	2	2	2	2	2
β	5	5	5	5	5
χ	2.5	2.5	2.5	2.5	2.5
ω	2.5	2.5	2.5	2.5	2.5
θ	0.15	0.15	0.15	0.15	0.15
τ	1/2 (TW-CN)	1/2 (TW-CN)	1/3 (G3)	1/3 (G3)	1/3 (G3)

Note: Values of structural parameters are set to be 0.0001 in order to avoid the problem of singular matrix if they are insignificant in 1%, 5%, or 10% level. *Values of parameters are based on Douven and Plasmans (1996); **values are given by the long-run elasticities of our estimation; ***values of parameters are based on Yeh and Plasmans (2002).

TABLE 2 OPTIMAL COSTS UNDER THE U.S. & CHINA'S PRICE SHOCKS

	NC	TW-CN	G3	G4	FC
China	0.1205	**0.1205**	1.08e+005	--	--
Taiwan	0.0337	**0.0337**	6.25e+007	--	--
US	0.0267	0.0279	**0.0214**	--	--
Japan	0.0280	0.0346	**0.0212**	--	--
EMU (Germany)	0.0271	**0.0157**	**0.0266**	--	--

Note: NC: Non-cooperation; TW-CN: Taiwan-China coalition; G3: The US-Japan-EMU coalition; G4: The China-US-Japan-EMU coalition; FC: Full cooperation. Columns identify policy regimes; rows 2 to 6 indicate the policy-makers' optimal losses (divided by 10^6). Values are bolded if they are consistent with the profitability condition.

Note: Countries 1, 2, 3, 4, and 5 represent China, Taiwan, the U.S., Japan, and EMU (Germany), respectively. (1)-(7): Bilateral real exchange rates; (8)-(12): CPI inflation; (13)-(17): Fiscal adjustments; (18)-(22): Interest rate adjustments; (23)-(27): Output adjustments. (28)-(29): Foreign reserves of countries 1 (China) and 2 (Taiwan), respectively.

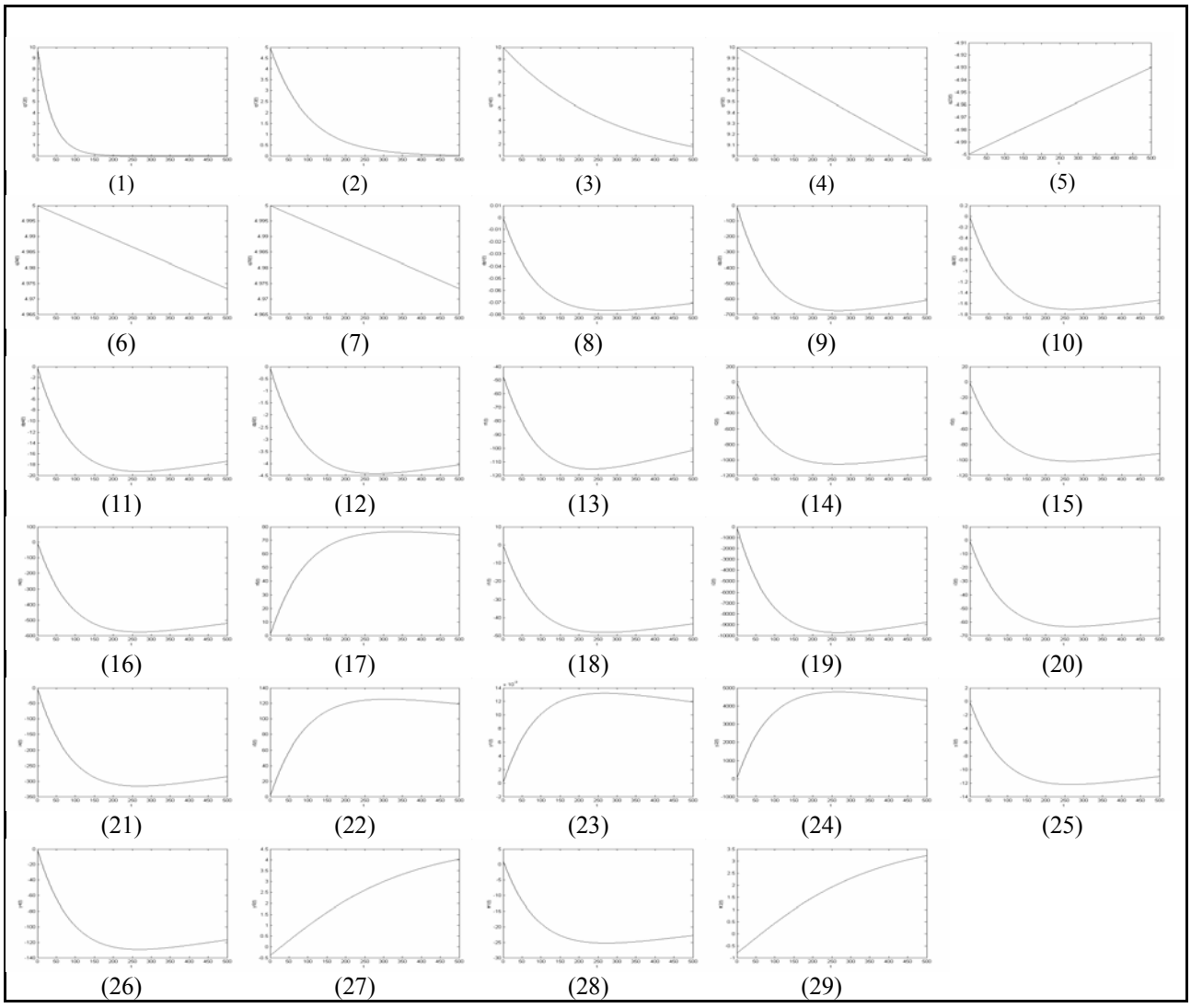
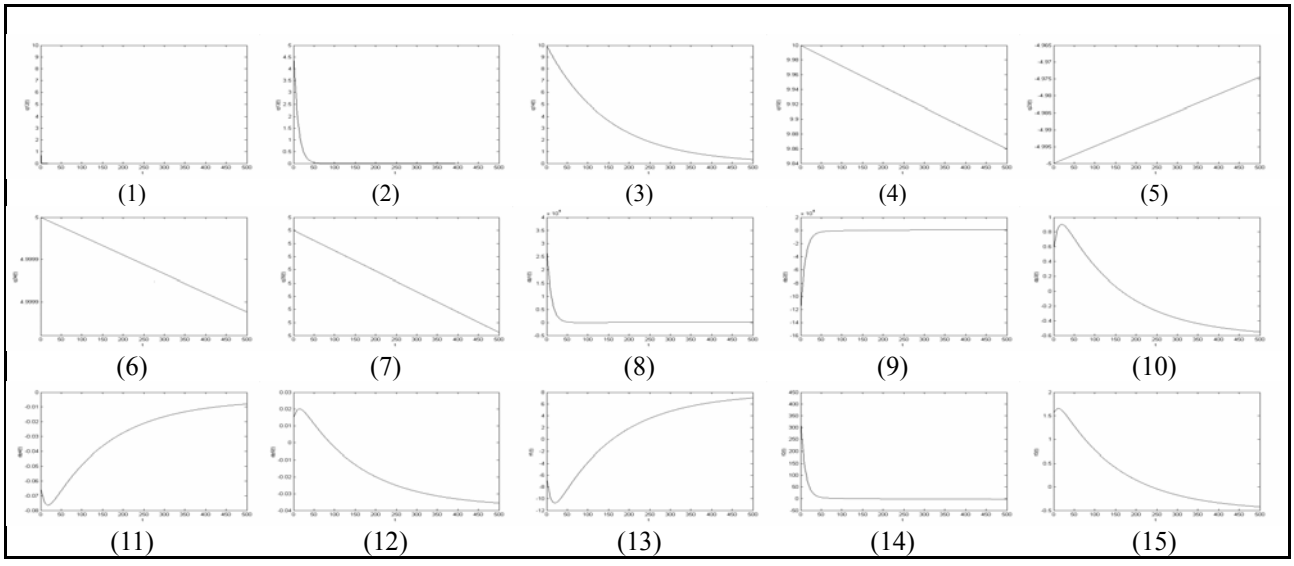


FIGURE 1 MACROECONOMIC ADJUSTMENTS: THE NONCOOPERATION CASE



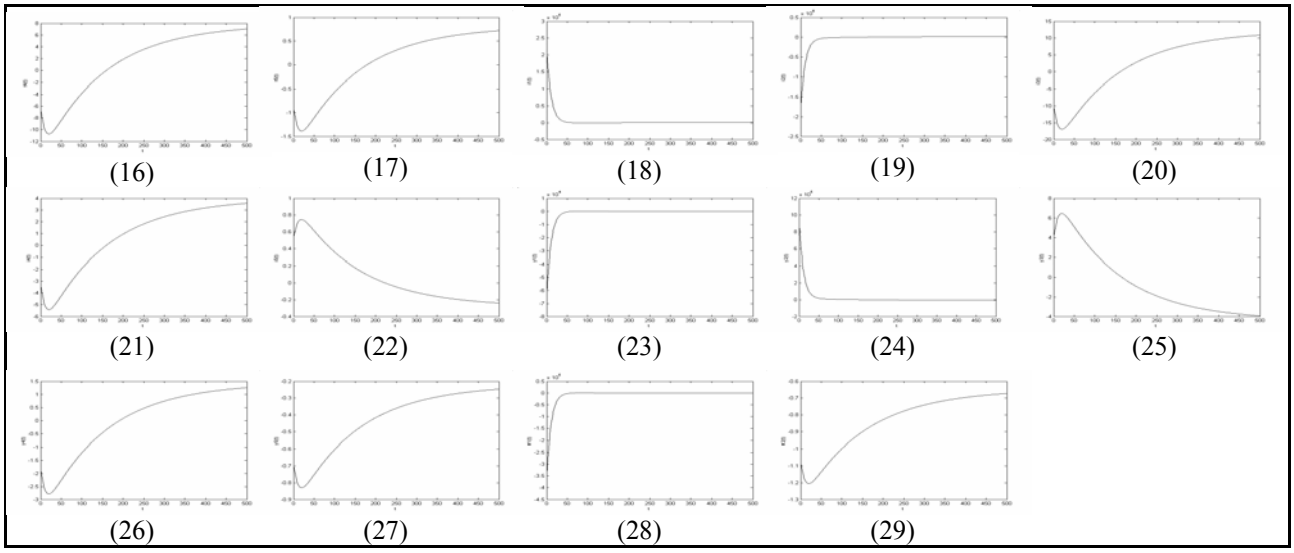


FIGURE 2 MACROECONOMIC ADJUSTMENTS: G3 COALITION

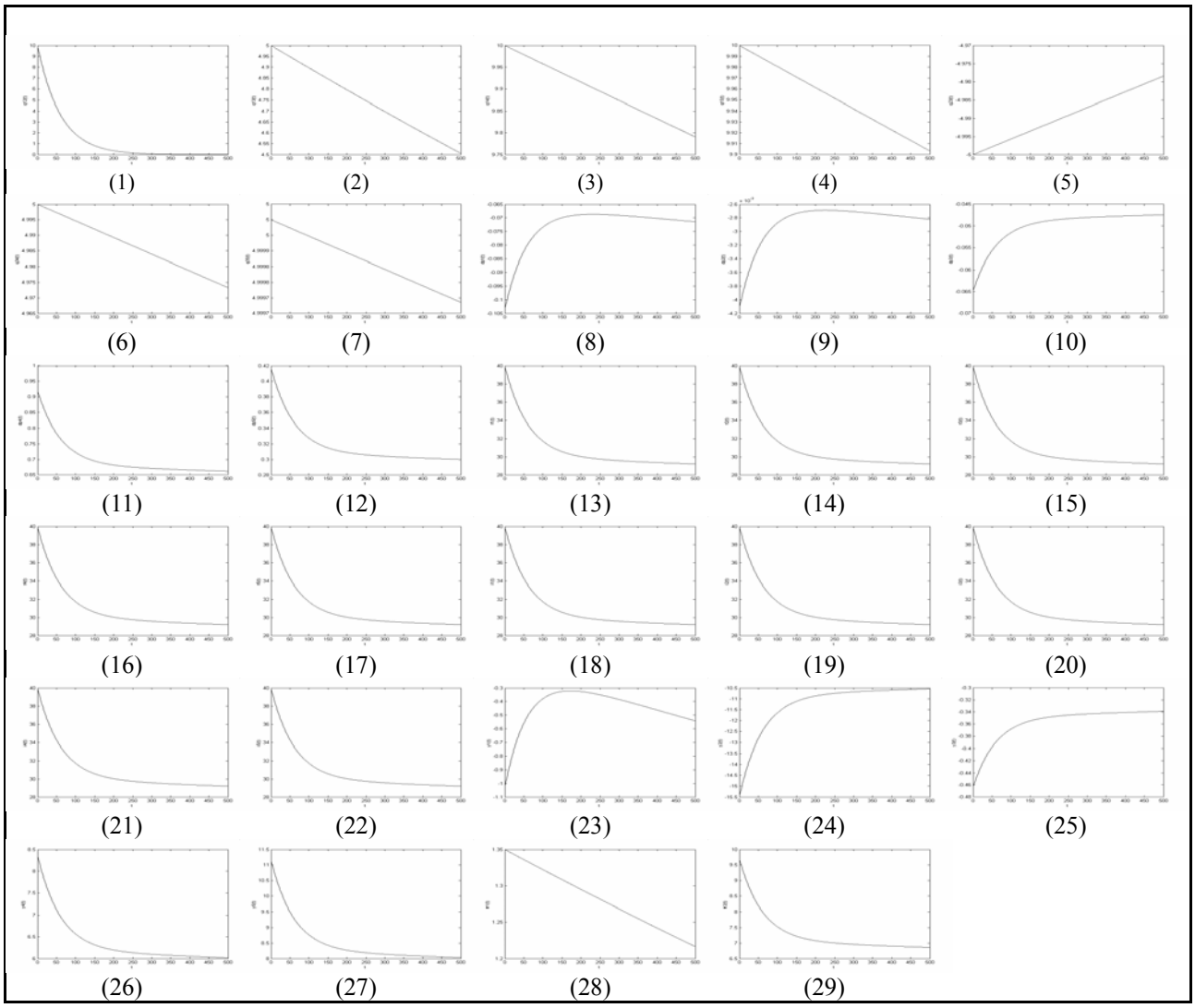


FIGURE 3 MACROECONOMIC ADJUSTMENTS: TAIWAN-CHINA COALITION

Appendix 1 The basic algorithm to derive the game solutions

The basic algorithm is mainly based on van Aarle et al. (2002b), Di Bartolomeo et al. (2002), and Yeh and Plasmans (2002). It is described by the following steps:

1. Factorize matrices $M_i \in \Re^{30\times 30}$ as

$$M_i = \begin{pmatrix}
Q_i & P_{1i} & P_{2i} & P_{3i} & P_{4i} & P_{5i} & L_{1i} & L_{2i} & L_{3i} & L_{4i} & L_{5i} & \cdots & S_{1i} \\
P_{1i}^T & R_{1i} & K_{1i} & K_{2i} & K_{3i} & K_{4i} & K_{5i} & K_{6i} & K_{7i} & K_{8i} & K_{9i} & \cdots & S_{2i} \\
P_{2i}^T & K_{1i}^T & R_{2i} & N_{1i} & N_{2i} & N_{3i} & N_{4i} & N_{5i} & N_{6i} & N_{7i} & N_{8i} & \cdots & S_{3i} \\
P_{3i}^T & K_{2i}^T & N_{1i}^T & R_{3i} & H_{1i} & H_{2i} & H_{3i} & H_{4i} & H_{5i} & H_{6i} & H_{7i} & \cdots & S_{4i} \\
P_{4i}^T & K_{3i}^T & N_{2i}^T & H_{1i}^T & R_{4i} & T_{1i} & T_{1i} & T_{1i} & T_{1i} & T_{1i} & T_{1i} & \cdots & S_{5i} \\
P_{5i}^T & K_{4i}^T & N_{3i}^T & H_{2i}^T & T_{1i}^T & R_{5i} & F_{1i} & F_{2i} & F_{3i} & F_{4i} & F_{5i} & \cdots & S_{6i} \\
L_{1i}^T & K_{5i}^T & N_{4i}^T & H_{3i}^T & T_{2i}^T & F_{1i}^T & R_{6i} & V_{1i} & V_{2i} & V_{3i} & V_{4i} & \cdots & S_{7i} \\
L_{2i}^T & K_{6i}^T & N_{5i}^T & H_{4i}^T & T_{3i}^T & F_{2i}^T & V_{1i}^T & R_{7i} & W_{1i} & W_{2i} & W_{3i} & \cdots & S_{8i} \\
L_{3i}^T & K_{7i}^T & N_{6i}^T & H_{5i}^T & T_{4i}^T & F_{3i}^T & V_{2i}^T & W_{1i}^T & R_{8i} & O_{1i} & O_{2i} & \cdots & S_{9i} \\
L_{4i}^T & K_{8i}^T & N_{7i}^T & H_{6i}^T & T_{5i}^T & F_{4i}^T & V_{3i}^T & W_{2i}^T & O_{1i}^T & R_{9i} & Z_{1i} & \cdots & S_{10i} \\
L_{5i}^T & K_{9i}^T & N_{8i}^T & H_{7i}^T & T_{6i}^T & F_{5i}^T & V_{4i}^T & W_{3i}^T & O_{2i}^T & Z_{1i}^T & R_{10i} & \cdots & S_{11i} \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \ddots & \vdots \\
S_{1i}^T & S_{2i}^T & S_{3i}^T & S_{4i}^T & S_{5i}^T & S_{6i}^T & S_{7i}^T & S_{8i}^T & S_{9i}^T & S_{10i}^T & S_{11i}^T & \cdots & R_{20i}
\end{pmatrix}$$

for $i \in \{1,2,3,4,5\}$, where $Q_i \in \Re^{10\times 10}$, $P_{ji}, L_{ji}, S_{1i} \in \Re^{10\times 1}$, and the other coefficients are scalars.

2. Computing the following matrices:

$$M_i = \begin{pmatrix}
R_{11} & K_{11} & K_{21} & K_{31} & K_{41} & K_{51} & K_{11} & K_{21} & K_{31} & K_{41} \\
K_{12}^T & R_{22} & N_{12} & N_{22} & N_{32} & N_{42} & N_{52} & N_{62} & N_{72} & N_{82} \\
K_{23}^T & N_{13}^T & R_{33} & H_{13} & H_{23} & H_{33} & H_{43} & H_{53} & H_{63} & H_{73} \\
K_{34}^T & N_{24}^T & H_{14}^T & R_{44} & T_{14} & T_{24} & T_{34} & T_{44} & T_{54} & T_{64} \\
K_{45}^T & N_{35}^T & H_{25}^T & T_{15}^T & R_{55} & F_{15} & F_{15} & F_{15} & F_{15} & F_{15} \\
K_{51}^T & N_{41}^T & H_{31}^T & T_{21}^T & F_{11}^T & R_{61} & V_{11} & V_{21} & V_{31} & V_{41} \\
K_{62}^T & N_{52}^T & H_{42}^T & T_{32}^T & F_{22}^T & V_{12}^T & R_{72} & W_{12} & W_{22} & W_{32} \\
K_{73}^T & N_{63}^T & H_{53}^T & T_{43}^T & F_{33}^T & V_{23}^T & W_{13}^T & R_{83} & O_{13} & O_{23} \\
K_{84}^T & N_{74}^T & H_{64}^T & T_{54}^T & F_{44}^T & V_{34}^T & W_{24}^T & O_{14}^T & R_{94} & Z_{14} \\
K_{95}^T & N_{85}^T & H_{75}^T & T_{65}^T & F_{55}^T & V_{45}^T & W_{35}^T & O_{25}^T & Z_{15}^T & R_{105}
\end{pmatrix}$$

$$H_1 = \begin{pmatrix} -A & 0 & 0 & 0 & 0 & 0 \\ Q_1 & A^T & 0 & 0 & 0 & 0 \\ Q_2 & 0 & A^T & 0 & 0 & 0 \\ Q_3 & 0 & 0 & A^T & 0 & 0 \\ Q_4 & 0 & 0 & 0 & A^T & 0 \\ Q_5 & 0 & 0 & 0 & 0 & A^T \end{pmatrix}$$

$$H_2 = \left(B; -M_1(1:10,11:20); -M_2(1:10,11:20); -M_3(1:10,11:20); -M_4(1:10,11:20); -M_5(1:10,11:20)\right)$$

$$\begin{aligned} H_3 = [&M_1(11,1:10) \quad B(1:10,1)^T \quad zeros(1,40); \\ &M_2(12,1:10) \quad zeros(1,10) \quad B(1:10,2)^T \quad zeros(1,30); \\ &M_3(13,1:10) \quad zeros(1,20) \quad B(1:10,3)^T \quad zeros(1,20); \\ &M_4(14,1:10) \quad zeros(1,30) \quad B(1:10,4)^T \quad zeros(1,10); \\ &M_5(15,1:10) \quad zeros(1,40) \quad B(1:10,5)^T; \\ &M_1(16,1:10) \quad B(1:10,6)^T \quad zeros(1,40); \\ &M_2(17,1:10) \quad zeros(1,10) \quad B(1:10,7)^T \quad zeros(1,30); \\ &M_3(18,1:10) \quad zeros(1,20) \quad B(1:10,8)^T \quad zeros(1,20); \\ &M_4(19,1:10) \quad zeros(1,30) \quad B(1:10,9)^T \quad zeros(1,10); \\ &M_5(20,1:10) \quad zeros(1,40) \quad B(1:10,10)^T] \end{aligned}$$

$$M = H_1 + H_2 G^{-1} H_3$$

4. Take ten positive eigenvalues of *M* and the corresponding eigenvectors υ_i to write the following expression:

$$\begin{pmatrix} X \\ Y_1 \\ Y_2 \\ Y_3 \\ Y_4 \\ Y_5 \end{pmatrix} = \left(\upsilon_1 \quad \upsilon_2 \quad \upsilon_3 \quad \upsilon_4 \quad \upsilon_5 \quad \upsilon_6 \quad \upsilon_7 \quad \upsilon_8 \quad \upsilon_9 \quad \upsilon_{10}\right) := z \in \Re^{60\times 10}$$

from which we can derive the optimal controls:

$$\begin{pmatrix} f_1 \\ f_2 \\ f_3 \\ f_4 \\ f_5 \\ i_1 \\ i_2 \\ i_3 \\ i_4 \\ i_5 \end{pmatrix} = -G^{-1} \begin{pmatrix} M_1(11,1:10) + B(1:10,1)^T Y_1 X^{-1} \\ M_2(12,1:10) + B(1:10,2)^T Y_2 X^{-1} \\ M_3(13,1:10) + B(1:10,3)^T Y_3 X^{-1} \\ M_4(14,1:10) + B(1:10,4)^T Y_4 X^{-1} \\ M_5(15,1:10) + B(1:10,5)^T Y_5 X^{-1} \\ M_6(16,1:10) + B(1:10,6)^T Y_1 X^{-1} \\ M_7(17,1:10) + B(1:10,7)^T Y_2 X^{-1} \\ M_8(18,1:10) + B(1:10,8)^T Y_3 X^{-1} \\ M_9(19,1:10) + B(1:10,9)^T Y_4 X^{-1} \\ M_{10}(20,1:10) + B(1:10,10)^T Y_5 X^{-1} \end{pmatrix} q =: CLs$$

5. Rewrite the loss functions of the countries and the dynamics of the model as

$$J_i = \frac{1}{2}\int_0^\infty \begin{pmatrix} q^T & q^T & \dot{s}^T \end{pmatrix} \left(ICL^T M_i \, ICL \right) \begin{pmatrix} q \\ q \\ \dot{s} \end{pmatrix} dt$$

where $ICL =: \begin{pmatrix} ones(10,30); ones(10,10) & CL & ones(10,10); ones(10:30) \end{pmatrix}$, and

$\dot{q} = (-A + BCL)s$

Cooperative and coalitional solutions are achieved by using the same algorithm and factorizing Mi matrix in a similar way as in van Aarle et al. (2002b), Di Bartolomeo et al. (2002), and Yeh and Plasmans (2002).

Appendix 2 Data Description

The quarterly data of 5 economies (China, Taiwan, Japan, USA, and Germany) are included in our estimation. All variables denominated in foreign currency are transformed into domestic currency and are seasonally adjusted in this empirical test.

Variables	Definition	Data sources
Real GDP (y)	$y=log(GDPsa*100/CPIsa)$. In the estimation by quarterly base we use the Chinese industrial production index to compute the value of Chinese industrial production because Chinese quarterly GDP is not available.	IFS line 99b, line 64, line 63.
Nominal exchange rate (s) and Real exchange rate (q)	$s=log(e)$; $q=(e+CPIsaus/CPIsa)$,. The negative (positive) value of changes in real exchange rate means real appreciation (depreciation).	IFS line rf, 64
Nominal interest rate (i)	We mainly use the federal fund rate and money market rate (IFS line 60b) here. But we use deposit rate (IFS 60l) of China and inter-bank loan rate of Taiwan since Chinese discount rate is not available and Taiwanese money market rate is not completed.	IFS line 60b, 60l
Real interest rate (r)	$r=i-\Delta p$ Real interest rate is equal to the nominal interest rate minus consumer price inflation, which is consistent with our theoretical model.	IFS line 60b, 60l, 64
Fiscal policy (f)	$f=log(GCsa*100/CPIsa)$. We use government consumption (GC) in this paper.	IFS line 91f, line 64, line 32a
Consumer price index (p)	$p=log(CPIsa)$. The base year of all economies is 1995. .	IFS line 64
Foreign Reserves (fr)	$fr=log(R*e)$. Foreign reserves minus the values of gold reserves (R), which reveals the liquidity of reserves.	IFS line 1l.d

Source: IFS CD-ROM (2004); *Taiwan Financial Statistics* by IFS format (Central Bank of Taiwan, various issues).

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