Establishing an Exchange Rate Mechanism (ERM) with Chinese Characteristics*: An Option for Taiwan, China and Hong Kong to Prevent the Next Currency Crisis?

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*This title was based on a political slogan proposed by the former Chinese leader Deng Xiaoping (1993): "Establishing the socialistic market economy with Chinese characteristics."

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Abstract

History shows that governments usually rethink their views on international macroeconomic cooperation after the emergence of a crisis. The response of the Asian countries after the speculative attacks occurred in 1997 may be considered as another example after the European ERM crisis in 1992-93. Nevertheless, some new ideas such as the creation of an "Asian Monetary Fund" or an "Asian single currency" may still stay at the stage of political slogans without a realistic executive plan until the next currency crisis occurs. Furthermore, even if a regional exchange rate and monetary cooperative mechanism would be implemented, it is still doubtful whether this would be enough to prevent the occurrence of another currency crisis in Asia or its sub-regional economies. The purpose of this paper is to provide an initial assessment whether an exchange rate mechanism with regional characteristics would be helpful to defend against possible future speculative attacks. We concentrate on the so-called "Chinese Economic Area (CEA)", a good experimental ground due to the cultural similarities and the close but indirect economic ties among the economies in the area. We consider the establishment of a Chinese Exchange Rate Mechanism (CERM) following Robert Mundell's multiple-currency union (2000a, b), in which all CEA members peg their currencies to an international currency in order to achieve the economic convergence and the stability of exchange rates. We apply a dynamic game approach to cooperative and non-cooperative scenarios and simulate the different sources of shocks according to the past experience of currency crises. Under the assumed CERM to induce the conflicts between internal and external economic situations, the values of the loss functions and the crisis indices indicate changes in welfare and the possibility of occurrence of a currency crisis in any of the economies belonging to the CEA. The parameters in the simulation are mainly based on calibration of econometric estimation for the CEA, but some reasonable adjustments are necessary. The simulation results for the CERM are only indicative but are a valuable reference to analyze the value of the regional exchange rates and the monetary cooperation in the policy choice.

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Keywords: Currency crisis, exchange rate mechanism (ERM), international policy coordination.

"…Thus do many calculations lead to victory, and few calculations to defeat: how much more no calculation at all! It is by attention to this point that I can foresee who is likely to win or lose. " (Sun Tzu, *The Art of War*. Chapter 1, Laying Plans)

1. Introduction

It is a difficult task for economists to finish the construction of a "third-generation" model to provide a more complete explanation regarding the main causes and consequences of currency crises. Nevertheless, we can mention three main factors which contribute to the emergence of currency crises: *economic fundamentals*, *external shocks*, and *capital liberalization*.[1] The first two can basically explain the cases observed in Latin American countries in the 1970s and 1980s. Since the second half of the 1980s, people have begun to pay attention to the last one, which causes the volatility in the global financial market.[2] Under free capital mobility, it is believed that currency crises may happen, no matter where and when. In short, a currency crisis is unpredictable and, maybe, inevitable, before we fully understand its nature and find a better way to prevent it.

After experiencing currency crises in the 1990s,[3] countries suffering from speculative attacks seem to be going to "two poles" of exchange rate and monetary policies: *monetary unification* (e.g., European Economic and Monetary Union) and *inflation targeting* (a floating exchange rate system for individual countries, such as the U.K., Sweden, South Korea and Thailand).[4] In spite of the successful case of inflation targeting in New Zealand, it seems that many Asian leaders and economists still prefer the "European Style,"[5] which may be an option to overcome the so-called "impossible trilogy principle.[6]" On the one hand, some politicians and economists believe that the idea of an "Asian Monetary Fund" or an "Asian currency" could be a very useful tool to avoid the threat of currency crises (see Appendix 1), not only because of the great power obtained from the cooperation among countries but also because it would keep the so-called "Asian values" without having to rely on other foreign powers (e.g., IMF). On the other hand, with the experience of the gold standard, the Bretton Woods system, the flexible exchange rate episode

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[1] These factors are mainly based on the so-called "first-generation" (Krugman, (1979)), "second-generation" (Obstfeld, (1996)), and "third-generation" models. See the review made by Yeh (2000a, b).

[2] See also Dornbusch's (2001) review about emerging market crises.

[3] The ERM crisis in 1992-93; the Mexican crisis in 1994-95; the Asian crisis in 1997-98; the Russian crisis in 1998; the Brazilian crisis in 1998-99; the Argentine crisis in 2002.

[4] Obstfeld and Rogoff (1995) and Eichengreen (2000) propose such point of view but Frankel (1999) and Masson (2000) reject it.

[5] Bryant (1995) indicates that, in history, governments usually rethink their views on international macroeconomic cooperation after the crises happened. The response by Asian politicians after 1997 may be considered as another example.

[6] It means that only two of the three following features are mutually compatible: capital mobility, independence of monetary policy, and a fixed exchange rate, (see Wyplosz (1997)).

and the European Monetary Union in the twentieth century, the costs and benefits of different exchange rate and monetary systems have become more evident.

According to the conventional theory of optimum currency areas and their implications, the Asian monetary integration would begin with smaller sub-regions.[7] The so-called **"Chinese Economic Area"** (CEA), which includes Taiwan, China, and Hong Kong,[8] should be the best experimental ground in Asia because not only of linguistic and cultural similarities, but also because of economic complementarities which caused a significant jump in trade and investment within only thirteen years (1987-2000). The main reasons to support the above argument are as follows: first, the "indirect" economic relationships between Taiwan and China keep growing, though the speed of trade dependent growth becomes slow after the missile crisis in 1995 and the "do not haste, be patient" policy valid since 1996.[9] That is, as Chen C.Y. argues, the engine driving the formation of the CEA should not be the governments' policy but instead the people's need.[10] Second, the industrial complementarities (Chinese cheap labor and raw material plus capital, management and skills from Taiwan and Hong Kong)[11] create large amounts of inter-trade and investment in the CEA. Lower-level technical industries move from Taiwan to China mainly via Hong Kong[12], and then build new factories to produce to export to foreign economies (especially to the United States).[13] Hong Kong has become an important intermediate of trade between China and Taiwan, and its market has heavily relied on China.[14] Moreover, 75% of foreign investment (about 220 billion U.S. dollars until 1996) in China is from Taiwan and Hong Kong.[15] China would have no chance to achieve the current economic performance without capitals from Taiwan and Hong Kong. Third, trade surplus of Taiwan in trading with China and Hong Kong is the main resource of Taiwanese foreign reserves. That is why some people are convinced that Taiwan (and Hong

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[7] Bayoumi and Mauro (2001), Artis et al. (1998), Ling (2001), Kohler (2002).

[8] Note that we do not include Macao in our discussion because of its relatively small economic size in the CEA.

[9] "Indirect" means that almost all direct interchanges are illegal at the current stage. A series of publications tried to explore this indirect trade and investment, such as Kau and Soong (1994), Lin (1996), and Liang (1999).

[10] Chen, C.Y., "The fourth pole: Chinese Economic Area," *China Times* (in Chinese), 1998.5.26.

[11] For the historical and current records regarding the structure of the China-Taiwan bilateral trade, see Board of Foreign Trade (Taiwan), *The analysis of cross-strait trade* (monthly report in Chinese, various issues). The above records can be found on http://www.trade.gov.tw.

[12] The Board of Trade, Ministry of Economic Affairs Taiwan, estimates that 70% of Hong Kong exports are, in fact, Chinese exports. See *Taiwanese major trading partner, 2000.1-12*.

[13] The United States is the main export market for China and Taiwan, which means that the U.S. economy is influential not only on the Taiwan-U.S. but also on the Taiwan-China trade. See Ministry of Economic Affairs (Taiwan), *Taiwanese major trading partner, 2000.1-12*.

[14] In 2000 the foreign direct investment (FDI) to Hong Kong amounted to 64 billion U.S. dollars, which is only less than the FDI to the U.S. in the world. It is helpful for Hong Kong in keeping its status of Asian financial center. See *Commercial Times* (in Chinese), 2001.4.2.

[15] The government of Taiwan also imposes restrictions (e.g., amount, items) on the investment in Taiwan. However, it is totally free for the medium and small enterprises to invest in China. The Taiwanese large enterprises may increase their speed to "go west" without the above restrictions.

Kong) cannot survive without a Chinese market.[16] Fourth, as for the economic scale, according to the purchasing power parity (PPP) computation by the World Bank (IBRD) for 1997, the GDP of the CEA is 56% that of the United States, and is 41% higher than that of Japan. The foreign trade volume of the CEA is 60% that of the United States but 25% higher than that of Japan. The foreign reserves of the CEA are 315.2 billion U.S. dollars, which are 42% higher than those of Japan. The above facts, on the one hand, reveal the reason why politicians and economists still advocate in favor of a Chinese economic cooperative mechanism regardless of the current political conflicts. On the other hand, as we learn from the history of European integration, economic cooperation should be a good start to push for political integration in order to eliminate the origins of the conflicts in the CEA.

Due to the above facts, we know that in fact a real but informal economic group has been formed through peculiar indirect economic exchanges. On the one hand, China welcomes foreign direct investment (especially from Taiwan), and Hong Kong became the main financial intermediate, in which China gets capitals not only for foreign direct investments but also for the state-owned enterprise reform. Moreover, Hong Kong is also the main trading and skilled manpower intermediate of China. On the other hand, Taiwan still imposes restrictions on its trade and investment towards China, so Taiwanese small and medium enterprises have to move from Taiwan to China by an indirect way to get cheaper labors and materials. That is why the government of Taiwan is still convinced that the existing restrictions on the Taiwan-China economic exchanges are helpful to finish the process of an industrial upgrade from the labor-intensive to the so-called "knowledge-intensive" industry, such as the semi-conductor industry. Labor mobility is also a one-way movement: Taiwanese easily get permission to go to China but only limited Chinese are allowed to go to Taiwan. From the above discussion we can understand the roles of each economy in the CEA: the vertical integration between Taiwan and China leads not only to a huge volume in trade and investment but also to the acceleration in industrial reallocation. Taiwan has to seek its new comparative advantage when more and more low-skilled industries are transferring its activities to China. Hong Kong will only remain the Asian financial center and the headquarter of the multi-national enterprises if it can keep its advantages in the abundant skilled labor force and operation and management.[17]

According to the theory of economic integration, the free trade area is an important condition to push further economic cooperation. The political problem is still the main handicap to build a formal "Chinese Economic and Monetary Mechanism," though each economy in the CEA is

[16] Note that Taiwanese officials reject this point of view. The official explanation can be found on the website http://www.mac.gov.tw

[17] That is, the advantage of low cost in Shanghai is not a guarantee to replace Hong Kong as the future Asian financial center if Shanghai is not able to create a better environment in operation and management.

willing to do so.[18] Nevertheless, it makes senses that the great China economic cooperation should be easier and more possible than "ASEAN+1" or "ASEAN+3."[19] The ultimate goal of Chinese members are still uncertain, but some unique characteristics in Chinese economies exist, including linguistic and cultural similarities, fast-growing volumes in trade and investment, and consistent goals in preventing the currency crisis. Moreover, all Chinese economies have been members of the World Trade Organization (WTO), which may be helpful to eliminate the rest of the trade handicaps between Taiwan and China to reduce the transaction costs and increase the trade volumes.[20] The above advantages indicate that it should be beneficial for the CEA to strengthen its economic power, including the organization of an "Exchange Rate Mechanism" with Chinese characteristics (Chinese exchange rate mechanism - CERM), to cooperate with other economies with different conditions in Asia.

The cooperation in the CEA is just an incomplete, unofficial, and informal but meaningful idea. Besides political conflicts, one should mention that there are still many unsolved difficulties in order to model the CEA cooperation system. The first and basic one is about the methodology of economic modeling, especially due to the unique "socialistic market mechanism" present in China. The current non-transparent, non-accountable[21] and non-democratic Chinese government may not reflect the real interests of the Chinese people. Moreover, the decentralization between the Chinese central and local governments tends to enhance the above problem. That is, government failure might worsen the final outcome[22] even if the CEA cooperation system becomes a reality. Furthermore, according to some previous publications, a serious problem we do not consider here is about the possible speculative attacks in the transition from individual currencies to an exchange rate and monetary cooperative mechanism. The acceleration of the speed of transition may not necessarily help temper speculative attacks and might simply hasten their occurrence.[23] Another issue is that the welfare of each country may decrease even if policy

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[18] R. Mundell stresses that the political will is another problem that needs to be overcome even if the economies involved have completed all necessary economic conditions to build a monetary union or a single currency. See *Commercial Times* (2001.10.22).

[19] Tung, C.H., chief of executive of Hong Kong SAR, has proposed to organize a free trade area including China, Hong Kong and Macao. His proposal is supported by Mr. Long, the Chinese vice Minister of Foreign Trade. Moreover, Mr. Long believes that Taiwan would be included in the free trade area in the future because of the impact of Taiwan's WTO membership. For details see Wenweipao (2001.11.29, in Chinese) and the website of the 14th general meeting of Pacific Economic Cooperation Council meeting (http://www.peccxiv.org).

[20] China and Taiwan have been members of WTO since 2002. An interesting question is how the indirect economic relationships will be changed after China and Taiwan join WTO at the same time, to which the attitude of Taiwanese government is still uncertain.

[21] However, Chow (1994, pp. 104-105) believes that the quality of the Chinese statistics has been improved a lot according to his personal experience.

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

[23] Froot and Rogoff (1991); Obstfeld and Rogoff (1996), p. 634.

coordination is possible,[24] which would ruin the rationale of the CEA cooperation system. Finally, various types of uncertainties still represent important obstacles to the feasibility of this system. For instance, so far we still do not have a precise estimate regarding the Chinese internal economy and the bilateral economic exchanges between China and Taiwan. We also do not have sufficient information to indicate the objectives and intentions of policy makers of the CEA members (uncertainty regarding the national objectives). We even do not know the actual functioning of the world economy, which also causes difficulties in modeling (model uncertainty).[25] In fact, it seems reasonable to question whether policy makers can actually cooperate without any precise analysis due to the above difficulties.

Nevertheless, we still believe that the economic analysis regarding the CEA cooperation system is not only necessary but also possible. Our arguments are based on not only economic needs but also political willingness of the CEA economies. Two main reasons which constitute the rationale for cooperation among the CEA: first, market failures due to spillover externalities would be serious since the intra-CEA trade and investment is growing rapidly without formal mutual negotiation to solve the problem of legal and structural inconsistency. It may be more important for Taiwan to deal with the externalities, which may reduce the autonomy of Taiwanese economic policies, no matter what their effects are positive or negative for the Taiwanese economy. Second, as we stressed before, governments always have the needs to organize a further cooperative mechanism through negotiation after suffering from crises, which is consistent with the historical experience.[26] It seems too optimistic since, so far, we have no official document or agreement to support this idea except the records of economic exchanges. But from a medium and long term point of view, we believe the three economies are all willing to have the cooperative mechanism, especially China and Taiwan have been fully accepted as new members of the WTO and then follow the rules of the market mechanism: For Taiwan, it is extremely important to have some negotiable issues with China, since it is helpful to decrease the possibility of war. For China, two considerations are imagined. Negotiation and cooperation might avoid Taiwan independent from China. And the possibility of currency and banking crises could be higher and higher if China continues to open its market due to its fast economic growth. As to Hong Kong, a cooperative agreement should be welcome; especially it will further strengthen Hong Kong's currency board since 1980s.

We have to admit that it is impossible to perfectly model the assumed CEA exchange rate

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[24] For instance, Miller and Salmon (1985).

[25] Bryant (1995), Chapter 7

[26] Bryant (1995), p. 113. The government intervention to remedy a market failure can be counterproductive (Bryant (1995), p. 127). But coordination under the principle of subsidiarity may improve the macroeconomic outlook of the CEA significantly. See further discussion below.

mechanism before we are fully aware of all facts in the CEA. The main reason is that our understanding is still not sufficient toward China's economy and economic exchanges in the CEA. However, an advanced assessment based on the current descriptive proposals and available information should be helpful, not only for the academic research but also for the officials to understand possible costs and benefits if the exchange rate mechanism will come true. A solid analytical foundation should be a reliable way to improve the policy debate or even to make the future policy decision.[27] If the CEA cooperation is feasible, the welfare of each CEA member could increase because of the serious market failures present in the current stage. And we could also expect a gradual improvement in the transparency and accountability of the Chinese government once China becomes a member of more international institutions and starts to follow accepted international standards. Furthermore, although the uncertainty problem is still unsolved, one could expect that the degree of uncertainty could be reduced through consultations and information sharing among countries.[28] That is, initial assessments should be helpful to draft feasible steps to establish the CEA exchange rate mechanism. In contrast, nothing can be expected about the mechanism before we have a realistic executive plan.

The dynamic game approach is the main methodology we apply in analyzing the interaction among CEA economies. In the beginning of the 1980s the policy coordination focused on the own and cross border "policy multipliers" of a country. Techniques of game theory have also been used to analyze the policy conflicts under different exchange rate regimes. By mid-1980s the research focus shifted to the intertemporal aspects of economic interdependence, which introduce dynamic game theory in the analysis of policy coordination issues.[29] A series of publications collected in Buiter and Marston (1985), including Miller and Salmon (1985), Oudiz and Sachs (1985), and Currie and Levine (1985), provide a comprehensive analysis of the problems that emerge in such dynamic games. Empirical studies[30] following the dynamic game approach are emerging to explore many important questions, such as the comparison of benefits between coordination and non-coordination, the ranking of regime performance, the effect of uncertainty for policy coordination, and so on. Two main results seem to be widely accepted: First, cooperation is not always beneficial according to the intertemporal and dynamic game

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[27] Communications and through forums and academic activities may be helpful to improve the information exchanges among officials, which may make periodical meeting of policy makers feasible in the future.

[28] Ghosh and Masson (1994) argue that policy makers should engage in Bayesian learning. They suggest "countries would be no worse off by coordinating their macroeconomic policies so long as policy makers do not stick dogmatically to incorrect models (p. 166)." Naturally, consultations and information sharing are also important to reduce the level of uncertainty, (see Bryant (1995), p. 87).

[29] Mckibbin (1997) makes an overview about the relevant theoretical and empirical works since 1950. Recently Daniels and Vanhoose (1998) and Beetsma et al. (2001) concentrate on the policy coordination within the framework of stabilization policy.

[30] For instance, papers collected in Bryant et al. (1993) and Vines and Currie (1995). Bryant (1995) also explains the details in a descriptive way.

approach. Second, the performances of the different regimes depend on the nature of the shocks. It seems that regimes with fixed money stock and fixed exchange rates perform particularly bad, even with asymmetric shocks to the aggregate demand or supply.[31]

The dynamic game approach is still a popular method to analyze the interaction among different policy makers. From 1999 onwards, the EMU countries provide a realistic scenario for the use of this method. Recent works, such as Levine and Brociner (1994), Douven and Plasmans (1996a, b), Engwerda (1998, 2000), Engwerda and Douven (1996), Engwerda et al. (1999, 2002), Weeren (1995), van Aarle, Engwerda and Plasmans. (2000, 2001), van Aarle, Di Bartolomeo, Engwerda and Plasmans (2002a, b), and Di Bartolomeo and Plasmans (2001), explore the convergence issues of the EMU using a dynamic game approach. This approach is analyzed in detail by Başar and Olsder (1999), Petit (1990), and Dockner et al. (2000). This approach should also be appropriate in the Asian situation due to the so-called "decentralized" policy decision process. The main contributions of this paper are twofold. First, in addition to exploring the practical issues regarding the establishment of a Chinese ERM, we analyze the above issue using a new approach, which combines international finance and the dynamic game approach. The common approach of international economics is based on the traditional two-country model. The dynamic game approach allows us to study multi-player interaction, but so far few works extend it to the field of international finance. Under the assumption of a non-cooperative world, it may happen that welfare in each country increases by the introduction of an economic and monetary cooperative mechanism by taking some Chinese and Asian current situations into account.

The main assumptions to establish the Chinese Exchange Rate Mechanism (CERM) according to the literature and the current international situation are as follows:

i. The U.S and Japan are two main markets of Taiwan, China and Hong Kong. Moreover, the Chinese economy is important for Taiwan and Hong Kong due to the industrial vertical integration [32] mentioned above. Regarding the relative competitiveness between Taiwan, Hong Kong and China, we have that on the one hand a Chinese real devaluation might decrease the market share of Taiwanese products in the U.S. and Japan.[33] On the other hand, it might increase the return of

[31] Naturally we always find exceptions. For instance, simulation by Habor et al. (2001) indicates that, under certain conditions, exchange rate targeting seems to be acceptable for the EMU.

[32] Since 1995 the government of Taiwan has executed the plan of the Asia-Pacific Regional Operations Center (APROC). One of the most important goals is to keep Taiwan's advantages in the process of the regional integration by establishing Taiwan as the managerial and financing base of enterprises to invest in China. For details see http://www.cedi.cepd.gov.tw.

[33] The degrees of trade dependence of China on foreign economies (1999): the U.S. (17.03%), Japan (18.33%), EU (15.44%). The degrees of trade dependence of Taiwan on foreign economies (2000): the U.S. (20.79%), Japan (19.12%), EU (14.82%). All information can be found on Ministry of Economic Affairs, Taiwan (http://www.moea.gov.tw) and International Financial Statistics.

Taiwanese investments in China and the need of Chinese imports from Taiwan, which in turns benefits the Taiwanese economy.[34] In this paper, we concentrate on the latter effect by defining the real effective exchange rate of the CEA in terms of the currencies included in the CEA and the three main currencies in the world (the U.S. dollar, the Japanese yen and the euro). The real effective exchange rate of the CEA is also an indicator of the degree of the convergence among all the CEA economies. Besides the G-3 and the CEA exchange rates, other links and transmission channels like trade, capital flows, fiscal policies, interest rates, and national economic growth rates, are all included. Note that we assume that the impact of the EU on the CEA is limited in trade and competitiveness.

ii. Pegging an international currency is a feasible choice for the CEA at the current stage. This assumption is mainly based on Mundell's arguments about Latin America and Asia (2000a, b):

> "…The European model does not exactly fit Mercosur…An alternative approach would be to converge toward an outside currency-either the dollar or the euro or a basket of currency of the three main currencies (the U.S. dollar, Japanese yen and the euro)[35]…Given convergence, it would then be comparatively easy to develop a separate Mercosur currency. "

> "…If all currencies peg and exchange an international currency directly, then all countries can still keep their own currencies and do not need to establish a single currency…some sub-areas in which countries have close economic links to each other can establish international currency systems first. It will be helpful to improve the whole Asian stability and growth. The Great China Economic Area fits the above condition. It will be possible to establish a currency area in which Chinese Renminbi is a central currency, as if Chinese economy keeps growing in the future."[36]

It is controversial whether a peg system is still appropriate for Asian countries after the currency crisis in 1997.[37] Note that the fixed exchange rate system we adopt here

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[34] Liang (1999) finds four factors which matter to the trade relationship between Taiwan and China: (i) the positive correlation between Chinese and Taiwanese exports due to the vertical integration; (ii) the changes in the relative competitiveness among different countries; (iii) the fact that Taiwanese enterprises in China increase their purchasing in the mainland instead of imports from Taiwan; and (iv) the Chinese reform in trade and economic systems.

[35] In his lecture in China, R. Mundell argues that those three currency areas, which are 60% of the world GDP, dominate the world economy. The U.S dollar, Japanese yen and European euro constitute three stable poles in the international economy. See *Commercial Times* (2001.10.17).

[36] See also Appendix 1. This paragraph is translated from the Chinese edition of Mundell's Lecture (2000a) in Taiwan.

[37] In contrast to a common critique (e.g. Fukuda (2000); Hamada (2002)), Ogawa's empirics (2001) proves that the Asian dollar peg system not only stimulated capital inflows to the crisis countries before the crisis, but also stabilized bilateral exchange rates during the post-crisis.

is not a unilateral or a non-cooperative multilateral peg (e.g. European ERM in 1992-93), but a cooperative multi-national peg (see ***assumption iii***). We follow the basic principles proposed by Mundell with one modification. We assume that the CEA economies peg their currencies to the U.S dollar.[38] This assumption fits the current situation since so far all the CEA members choose either a strict peg (Hong Kong and China) or a managerial floating (Taiwan) towards the U.S dollar.

iii. Three Chinese-speaking economies (Taiwan, China and Hong Kong) form a coordination mechanism without loosing their own currencies and policy independence because of the unsolved conflicts about "one China" policy. This assumption is also appropriate for Hong Kong according to the Basic Law of Hong Kong valid from 1997.[39] And they converge with the help of an outside currency or a basket of main currencies in the world.

iv. The CERM will not work if Japan, the most advanced economy in Asia, totally rejects it.[40] Naturally, it we believe it would be better for the CEA if Japan has the willingness to join this CERM. However, the CERM would probably fail in case Japan is not active in adopting a stable exchange rate policy, which may trigger, for example, competitive devaluations in Asia. We assume that three CEA members and Japan cannot fully use their exchange rates as instruments to adjust their macroeconomic situations.[41]

v. In addition to fixing their currencies to the U.S. dollar, in this paper we only consider the case where the economies in the CEA can choose to establish the CERM without a formal coordinating institution.[42] It would be another interesting research topic to

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[38] Williamson (1999) proposes the Pegging to a basket of currencies . In practice it may be difficult for countries to decide their monetary and exchange rate policies according to the basket. Moreover, weights on different currencies sometimes depend on the governments' preferences.

[39] According to *The Basic Law* of Hong Kong (valid since 1997), Hong Kong (HKSAR) has a high degree of autonomy and enjoys executive, legislative and independent judicial power, including that of final adjudication. (BL Article 2). The socialist system and policies shall not be practiced in Hong Kong, and the previous capitalist system and way of life shall remain unchanged for 50 years. (BL Article 5). The HKSAR may on its own, using the name "Hong Kong, China", maintain and develop relations and conclude and implement agreements with foreign states and regions and relevant international organizations in the appropriate fields, including the economic, trade, financial and monetary, shipping, communications, tourism, cultural and sports fields. (BL Article 151). However, The Government of China shall be responsible for the defense and the foreign affairs relating to the HKSAR. (BL Articles 13-14).

[40] R. Mundell firmly believes that the Sino-Japanese cooperation is a necessary condition to establish a single Asian currency. The importance of the Japanese yen comes from the Japanese high savings rate, which is the main source of investment in China. And the Chinese currency would be "the fourth pole" in the international economy under the presumption of its fully convertibility in the future. *Commercial Times* (2001.10.17).

[41] That is, we exclude the possibility of a dirty float. In modeling a dynamic game a country cannot treat the bilateral exchange rate as a fully controlled instrument (Petit, 1990).

[42] An institute like the European System of Central Banks (ESCB in the second stage of EMU) may be a good example. It should be more feasible than a single central bank with a single currency (e.g., like European Central Bank, ECB, in the third and current stage of EMU). The objectives of a common institution may focus on price stability and interest

take into account the possibility of establishing a cooperative mechanism with a common coordination institution in the CEA.

Following the above discussions, we suppose that the future CEA exchange rate and monetary mechanism will still be close to the multiple-currency monetary union,[43] which is defined according to the historical experience mentioned in Figure 1. As Mundell (2000b) argues, this system would work in much the same way as in a single-currency monetary union if its negotiation and coordinating mechanism works well. We have to stress again that the purpose of this paper is not to support the idea of the exchange rate and monetary cooperation in the CEA and disregard other possible options. Alternatively, we try to provide an initial assessment to evaluate whether the CERM, under some reasonable assumptions, would benefit Taiwan, China and Hong Kong by increasing their economic welfares and preventing possible currency crises in the future. The empirical results provided by this paper can only be treated as a reference due to many difficulties in the current political situation and the economic modeling mentioned above.

[Insert Figure 1 here]

This paper is structured as follows. Section 2 presents and explains our modeling. Sections 3 and 4 show how to derive the different outcomes of the CERM if the economies in the CEA are in either a non-cooperative or a cooperative situation. In section 5 the estimation results reveal the current economic situation of the CEA, which will be a reference for the evaluation of a future CERM. Section 6 combines the theories presented in sections 2, 3, 4 and the empirics from section 5 to make a simulation study in which we get an initial idea about the possibility of the CERM in the future. Section 7 concludes our findings in this paper. Some methods concerning mathematical and empirical computations are shown in the appendices.

2. Establishing a Theoretical Framework

In this paper we consider a six-economy model which includes China, Taiwan and Hong Kong in the CEA, and the three major economies of the world, the U.S., Japan and the European Union.[44] The structural-form model is based on Engwerda, van Aarle and Plasmans (2002), van Aarle, Engwerda and Plasmans (2001), and Engwerda and Douven (1996). All these studies extend the conventional Mundell-Fleming open-economy framework. Our approach, however, takes into

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rate convergence of the whole sub-area.

[43] Mundell (2000b) defines four different monetary policy rules related to the fixed exchange rate: Single currency monetary union (e.g. fifty states have the dollar in the U.S.), dollarization (e.g. Panama), political agreement (e.g. the euro under the cooperation between the fiscal authorities and the ECB), and the multiple-currency monetary union (e.g. Hong Kong's currency board).

[44] We only consider three economies outside the CEA since this paper focuses mainly on the issue of currency crises. The U.S. dollar, Japanese yen, and the euro constitute three main blocks in the world of international finance (Mundell, 2000b,c).

consideration important factors ignored by previous studies. One of these factors relates to the interaction between CEA members and the mentioned external economies. Other factors are related to the possible asymmetries within members and the situation of the balance of payments of each economy.

The modeling steps are shown in Figure 2. The main idea is to show the possible conflicts between domestic and international economic objectives[45] under the CERM. Once we determine the economic behavior (aggregate demand and supply) of each country involved, we can then apply the dynamic game approach to analyze the interaction among countries under different scenarios (e.g. cooperative, non-cooperative) and shocks. On the one hand, following a standard approach, we assume that each country tries to minimize its loss function, which includes variables representing the country's economic growth, inflation, interest rate and fiscal policy. This loss function is subject to the real exchange rate of the CEA as a whole, which functions as an indicator of the degree of convergence among the CEA members. One the other hand, the balance of payments, which we use as the main indicator of the exchange rate stability, is also determined for all CEA economies once they decide to adopt a multi-lateral pegging system.[46] Note that it is likely that a country has other objectives besides its loss function minimization (or maximization).[47] We assume that a country has the only objective of minimizing its loss function to achieve domestic stability. The reason is that the balance of payments of the country has been determined after it follows a fixed exchange rate system. Alternatively, a country may have more than two objectives (e.g., minimize its loss function and deficit of the balance of payments at the same time) if it follows a flexible exchange rate system. Furthermore, other tools like interest rate and fiscal policy are also available for each CEA economy to improve its external situation (e.g. decrease the loss in the foreign reserves), but their efficiency for improving the external situations and their side effects on the domestic situations should be taken into account.[48] In this paper we use the **loss function** and the **balance of payments**[49] of each CEA member as two main indicators to evaluate the performance of the CERM. For instance, we expect that any CEA economy would be pressured to abandon the CERM in case both its domestic and external situations cannot be sustained at the same time. In short, the functioning of the CERM under different shocks can be evaluated by both the values of the loss function and the crisis index in each CEA economy. We remind at this point that the CERM is being proposed in this paper as a means to prevent a

[45] Eichengreen and Sussman (2000) point out this in the evolution of the international monetary system in history.

[46] Fukuda's strategic approach (2000) is similar to us. He explores whether the strategic equilibrium of M-East Asian countries in a N-country world can lead to a common currency area when each East Asian country seeks to achieve its own economic stability.

[47] Dockner et al. (2000), p. 12.

[48] This is related to "the principle of effective market classification" proposed by Mundell (1962) and its extensions.

[49] We use the crisis index (see below) to show the situation of the balance of payments of each country.

possible future currency crisis in any of the CEA members.

[Insert Figure 2 here]

According to Walras' law, in an open-economy framework we only need to consider three out of four markets. Therefore, in this paper we model the goods and services, money, and foreign exchange rate markets and skip the bond market. We also follow the recent literature and consider the nominal interest rate as the only instrument of monetary policy, as opposed to a monetary supply aggregate. This allows us not to specify a money market equilibrium condition (e.g., an LM curve).[50]

We present in turn the goods and services, money and foreign exchange markets. Variables with superscript *i=cn*, *tw*, *hk, us, jp, eu, w* represent China, Taiwan, Hong Kong, the United States, Japan, the European Union, and the world, respectively. We define s^{ij} as the logarithmic nominal cross exchange rate between country *i* and *j*, denominated by the currency of country *i*. Since the German mark was the central currency of the European exchange rate mechanism before the launching of the euro in 1999, we use the German currency and the German inflation as representatives of the respective European Union (*eu*) values. 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. We also assume that the interest rate parity condition holds in the long run. Therefore, the nominal interest rate of each country should be equal, in the long run, to the level of international interest rates, which we take as being the U.S. nominal interest rate. A dot above a variable denotes its time derivative. All coefficients are defined to be nonnegative.

Equation (1) presents the aggregate demand for goods and services of five of the economies included in our model. The EU aggregate demand is not presented since, according to ***assumption i***, its impact on the CEA is limited in trade and competitiveness.

$$y^{cn}(t) = \delta_1 q^{CEA}(t) - \gamma_1 r^{cn}(t) + \eta_1 f^{cn}(t) + \rho_1 y^{us}(t) + \rho_2 y^{jp}(t) \quad (1a)$$

$$y^{tw}(t) = \delta_2 q^{CEA}(t) - \gamma_2 r^{tw}(t) + \eta_2 f^{tw}(t) + \rho_3 y^{cn}(t) + \rho_4 y^{us}(t) + \rho_5 y^{jp}(t) \quad (1b)$$

$$y^{hk}(t) = \delta_3 q^{CEA}(t) - \gamma_3 r^{hk}(t) + \eta_3 f^{hk}(t) + \rho_6 y^{cn}(t) + \rho_7 y^{us}(t) + \rho_8 y^{jp}(t) \quad (1c)$$

[50] Di Bartolomeo and Plasmans (2001), Walsh (1998), and Romer (2000). Alternatively, we could have assumed, as in Engwerda et al. (1999), that a monetary targeting strategy is implemented by a central bank. However, according to the experience of the Bundesbank, financial innovation can affect money stock in many ways that have nothing to do with signals of future inflation, (see also De Grauwe (2000), p.190).

$$y^{us}(t) = \delta_1^* q^{us}(t) - \gamma_1^* r^{us}(t) + \eta_1^* f^{us}(t) + \rho_1^* y^{w}(t) \quad (1d)$$

$$y^{jp}(t) = \delta_2^* q^{jp}(t) - \gamma_2^* r^{jp}(t) + \eta_2^* f^{jp}(t) + \rho_2^* y^{us}(t) + \rho_3^* y^{cn}(t) \quad (1e)$$

in which y^i denotes real output, q^i the real effective exchange rate, r the real interest rate, p the price level, and f the real fiscal deficit. Equation (1) expresses output as a function of the real effective exchange rate (or competitiveness) of each country or the CEA, the real interest rate, the domestic fiscal deficit and the foreign output levels. Three points are worth mentioning. First, (1) is helpful to analyze the role of the exchange rate, price convergence, and external impacts on the domestic economy during the process of economic integration. Second, according to ***assumption i*** above, the economies of China, Japan and the U.S. have an impact on Taiwan and Hong Kong but not vice-versa. And the impact of the European economy on other economies only takes place through the exchange rate channel (see below), since Japan and the U.S. are the economies with the most important influence in Asia. Third, the positive δ in (1) implies that an improvement in the competitiveness of the CEA (increase in q^{CEA}) benefits the three economies in the area, since the CEA economies are export-oriented and have established an economic structure of vertical integration. Note that Japan is not included in the CEA according to ***assumption iv***. However, our theoretical argument may not be fully supported by the current empirical evidence and the future development.[51]

The simplified real effective exchange rate of each economy is defined by taking into account its most important trading partners and the long-term purchasing power parity hypothesis (PPP):

$$q^{cn}(t) = \omega^{cnT} e^{cn}(t) \quad (2a)$$

$$q^{tw}(t) = \omega^{twT} e^{tw}(t) \quad (2b)$$

$$q^{hk}(t) = \omega^{hkT} e^{hk}(t) \quad (2c)$$

We define ω is a vector of the trade shares of one country with others, whose values are determined according to the Taiwanese official statistics about the indirect trade among the CEA

[51] We estimate our theoretical model in the following section. Note that Tsai, Y. W., chief of Mainland Affairs Council (Taiwan), stresses that the Taiwan-China economic relationship has changed from a complementary one to a competitive one. (*China Times*, 2001.9.27 (in Chinese))

economies.[52] And vector e^{iT} ($i = cn,tw,hk$), which measures the real exchange rates of country i with respect to countries j ($j = us,jp,eu,cn,tw,hk, \quad i \neq j$), can be defined as $(s^{ij}(t) - p^{i}(t) + p^{j}(t))^{T}$.

For instance, we know that the United States, Japan, the EU, Taiwan, and Hong Kong are the most important trading partners of China, so equation (2a) can be written as

$$q^{cn}(t) = \omega^{cnT} e^{cn}(t) = \begin{bmatrix} \omega_{11} & \omega_{12} & \omega_{13} & \omega_{14} & \omega_{15} \end{bmatrix} \begin{bmatrix} e^{cnus}(t) \\ e^{cnjp}(t) \\ e^{cneu}(t) \\ e^{cntw}(t) \\ e^{cnhk}(t) \end{bmatrix}$$

where

$$e^{cnT} := \begin{bmatrix} e^{cnus}(t) \\ e^{cnjp}(t) \\ e^{cneu}(t) \\ e^{cntw}(t) \\ e^{cnhk}(t) \end{bmatrix} = \begin{bmatrix} s^{cnus}(t) \\ s^{cnjp}(t) \\ s^{cneu}(t) \\ s^{cntw}(t) \\ s^{cnhk}(t) \end{bmatrix} - \begin{bmatrix} p^{cn}(t) \\ p^{cn}(t) \\ p^{cn}(t) \\ p^{cn}(t) \\ p^{cn}(t) \end{bmatrix} + \begin{bmatrix} p^{us}(t) \\ p^{jp}(t) \\ p^{eu}(t) \\ p^{tw}(t) \\ p^{hk}(t) \end{bmatrix}$$

Due to the fact of the economic integration in the CEA, we make the real effective exchange rate of the CEA q^{CEA} and use it as an indicator to measure the degree of convergence of this area.

$$q^{CEA}(t) = \sum_{i}^{cn,tw,hk} v^{i} q^{i}(t) \qquad \sum_{i}^{cn,tw,hk} v^{i} = 1 \tag{2d}$$

in which q^{CEA} is a weighted average of the real effective exchange rate of each country q^{i} (i = *cn, tw, hk*).[53] v_i in (2d) can be interpreted as the contribution in competitiveness due to country i to the whole competitiveness of the CEA. The exchange rate among CEA countries appears in equation (2) since, following ***assumption iii***, those countries still keep their own currencies. The relative prices would be the main factor to decide on the competitiveness among the countries

[52] As we explain above, most trade volumes between China and Taiwan are transported via Hong Kong because the fully direct trade is still not allowed. And the official statistics made by the government of Taiwan are available in our estimation. However, Kau and Soong (1994) have pointed out the estimation bias in official data. In simulation we assume that shares of Taiwan-Hong Kong bilateral trade are zeros.

[53] Remind that currencies of Chinese economies are still fixed to the U.S. dollar because Chinese economies still heavily rely on the U.S. economy. We follow Buiter et al. (1998) to model this and make some modifications.

involved in case there was only a single currency in the world (that is, all s^{ij} equal to zero).

The real effective exchange rates of the U.S. and Japan can be also defined by the similar way.

$$q^{us}(t) = p^{w}(t) - p^{us}(t) \tag{2e}$$

$$q^{jp}(t) = \omega^{jpT} e^{jpj} \qquad j = us, eu, cn \tag{2f}$$

In which we simply assume that the competitiveness of the U.S. depends on the relative price level between the world and the U.S. price levels because of its largest economic scale in the world. And the U.S., the EU, and China are three most important trading partner of Japan.

The real interest rate is defined as the difference between the nominal interest rate and the domestic inflation.

$$r^{i}(t) = i^{i}(t) - \dot{p}^{i}(t) \qquad i = cn, tw, hk, us, jp, eu \tag{3}$$

Note that CPI inflation is consistent with the open-economy framework, which implies a close relationship between foreign prices and domestic production. Given the condition of free capital mobility under floating exchange rate regime we have that:

$$i^{i}(t) = i^{us}(t) + \dot{s}_{e}^{ius}(t) \qquad i = cn, tw, hk, jp, eu \tag{4}$$

where $\dot{s}_{e}^{ius}$ represents the expectation of country *i*'s currency depreciation relative to the U.S. dollar. In the short run, every country still adjusts its monetary policy instrument according to the domestic and international economic situation regardless of (4).[54] However, in a fixed exchange rate regime,($\dot{s}_{e}^{ius}(t) = \dot{s}^{ius}(t) = 0$), the domestic interest rate equals the foreign interest rate (the U.S. interest rate) in the long run.[55]

We construct the aggregate supply (Phillips curve) in the open economy by extending DiNardo and Moore (1999), which follow the strategy proposed by Ashenfelter (1984). The details of the derivation of the Phillips curve are shown in Appendix 2.

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[54] Note by the assumption of "weak consistency" of expectations, $Es^{i}(t) = s_{e}^{i}(t) = s^{i}(t)$, and assuming further that the information set does not change over the period considered, $\dot{s}_{e}^{i}(t) = \dot{s}^{i}(t)$. Petit (1990) follows the assumption by Buiter (1984) to deal with rational expectations in the continuous-time linear quadratic case. The details of rational expectations in the continuous-time case can also be found in Turnovsky (2000), Chapter 3.

[55] This is consistent with Dornbusch's argument (1976b).

$$\dot{p}^i(t) = \tilde{\lambda}_1^i RP^i(t) + \tilde{\lambda}_2^i \dot{p}^w(t) + \tilde{\lambda}_3^i y^i(t) \qquad i = cn, tw, hk, us, jp, eu \tag{5}$$

where the risk premium $RP^i(t) := i^i(t) - i^{us}(t) - \dot{s}^{ius}(t)$ and $\tilde{\lambda}_j^i$ ($j = 1,2,3$) represents coefficients of three items in (5). By construction, the item $RP^{us}(t)$ is equal to zero. In the following it becomes clear that the uncovered interest parity (UIP) condition plays an important role not only in the Phillips curve but also with respect to the capital flows.

The following different points of view related to the Phillips curve in an open-economy are worth mentioning. First, the open economy Phillips curve is explored following not only the traditional Mundell-Fleming model but also the new Keynesian framework proposed by Obstfeld and Rogoff (1996).[56] Second, the degree of capital control may have an impact on the Phillips curve (e.g. the more closed capital market in China).[57] Finally, one should expect that the values of parameters of the CEA economies are different from those in the European countries due to the differences in the structures of labor markets and international trades.

The model (1-5) can be reduced to four output equations in Appendix 3.

$$y^{cn}(t) = D^{cnT} x(t) \tag{6a}$$

$$y^{tw}(t) = D^{twT} x(t) \tag{6b}$$

$$y^{hk}(t) = D^{hkT} x(t) \tag{6c}$$

$$y^{us}(t) = D^{usT} x(t) \tag{6d}$$

$$y^{jp}(t) = D^{jpT} x(t) \tag{6e}$$

where

$$D^{cnT} = \begin{pmatrix} b_1 & b_2 & b_3 & a_1 & 0 & 0 & a_2 & a_3 & -c_1 & 0 & 0 & -c_2 & -c_3 & d_1 & 0 & d_2 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -d_4 & 0 \end{pmatrix}$$

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[56] DiNardo and Moore (1999) provide some empirical evidence regarding the open -economy Phillips curve by testing nine OECD countries from 1970 to 1990. Some recent work derives the open-economy Phillips curve with different styles. For instance, Razin and Yuen (1995) and Loungani, Razin and Yuen (2001) adopt the log-linear Mundell-Fleming framework. Recently, Razin and Yuen (2001) extend the new open economy model by Obstfeld and Rogoff (1996) to get the open-economy Phillips curve.

[57] Fernald and Babson (1999) claim that strong fundamentals with capital controls should be the main reason for China to prevent suffering from the currency crisis in 1997. Moreover, Razin and Yuen (1995, 2001) argue that capital controls reduce the output/employment variations at the expense of bigger variations in inflation rates, which will benefit the policy maker who puts higher weight on stable employment than on stable inflation.

$$D^{wT}=\begin{pmatrix} b_4 & b_5 & b_6 & a_4 & a_5 & 0 & a_6 & a_7 & -c_4 & -c_5 & 0 & -c_6 & -c_7 & d_5 & 0 & d_6 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -d_8 & 0 \end{pmatrix}$$

$$D^{hkT}=\begin{pmatrix} b_7 & b_8 & b_9 & a_8 & 0 & a_9 & a_{10} & a_{11} & -c_8 & 0 & -c_9 & -c_{10} & -c_{11} & d_{10} & 0 & d_{11} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -d_{13} & 0 \end{pmatrix}$$

$$D^{usT}=\begin{pmatrix} 0 & b_{10} & 0 & 0 & 0 & 0 & a_{12} & 0 & 0 & 0 & 0 & -c_{12} & 0 & d_{15} & 0 & d_{16} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{pmatrix}$$

$$D^{jpT}=\begin{pmatrix} b_{11} & b_{12} & b_{13} & a_{13} & 0 & 0 & a_{14} & a_{15} & -c_{13} & 0 & 0 & -c_{14} & -c_{15} & d_{17} & 0 & d_{18} & 0 & 0 & 0 & 0 & 0 & 0 & 0 & -d_{20} & 0 \end{pmatrix}$$

and

$$x^T=\begin{pmatrix} q^{CEA} & q^{us} & q^{jp} & f^{cn} & f^{tw} & f^{hk} & f^{us} & f^{jp} & i^{cn} & i^{tw} & i^{hk} & i^{us} & i^{jp} & y^{w} & y^{eu} & p^{w} & i^{eu} & \dot{s}^{cnjp} & \dot{s}^{cneu} & \dot{s}^{twjp} & \dot{s}^{tweu} & \dot{s}^{hkjp} & \dot{s}^{hkeu} & \dot{s}^{jpus} & \dot{s}^{euus} \end{pmatrix}$$

where all parameters are assumed to be nonnegative. Note that $\dot{s}^{cnus}(t)=\dot{s}^{twus}(t)=\dot{s}^{hkus}(t)=0$ according to ***assumption ii***.

The assumptions we mentioned above are shown again in (6): First, the fiscal (monetary) policy of China and Japan positively (negatively) impact on Taiwan and Hong Kong, though so far China has no well-organized monetary and financial markets.[58] Second, q^{CEA} and y of other economies appear in (6a-d) at the same time because of not only a close economic link has been formed among countries but also foreign economies still matter for the economic growth of this sub-area. It is clear that the external influence still transmits from China and Japan to Taiwan and Hong Kong according to the above assumptions.

q^{CEA} is important not only for the economic growth but also for measuring the degree of the economic convergence in the CEA. Equation (2d) can be re-write as

$$q^{CEA}(t)=\sum_i v^i q^i(t)=\sum_i v^i \omega^{iT} e^i(t) \qquad i=cn,tw,hk \tag{7}$$

Following ***assumption ii***, the three Chinese members agree to fix their currencies to the U.S. dollar

$$\dot{s}^{ij}(t)=0 \qquad i=cn,tw,hk \qquad j=us$$

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[58] Unlike the situations in Japan and the United States, the Chinese monetary policy is to stabilize the economic situation, and its contributions to economic growth are limited. See Mainland Affairs Council (Taiwan), *Mainland and Cross-strait Economic Report*, 1997-98. Chapter 8. In the current stage, as we introduced in Section 1, monetary and financial markets of China and Taiwan have not been fully open to each other, but the situation is expected to improve in the near future.

such that changes in nominal exchange rates with respect to time equal to zero.

$$\dot{s}^{ik}(t) = 0, \quad i;k = cn,tw,hk \quad i \neq k \tag{8}$$

That is, $\dot{s}^{cntw}(t) = \dot{s}^{cnhk}(t) = \dot{s}^{twcn}(t) = \dot{s}^{twhk}(t) = \dot{s}^{hkcn}(t) = \dot{s}^{hktw}(t) = 0$.

Now we can get the derivatives of the real effective exchange rate with respect to time, an important condition for the three economies in the CEA to achieve not only exchange rate stability but also external competitiveness[59] and convergence ($\dot{q}^{CEA}(t) \to 0$).

$$\dot{q}^{CEA}(t) = \sum_i v^i \omega^{iT} \dot{e}^i(t) \qquad i = cn,tw,hk \tag{9a}$$

where vector $\dot{e}^{iT} := (\dot{s}^{ij} - \dot{p}^i + \dot{p}^j)^T$.

Equation (9a) can be simplified as

$$\dot{q}^{CEA}(t) = \pi^T \dot{p}(t) + \phi^T \dot{s}(t) \tag{9b}$$

where

$$\pi^T := \begin{bmatrix} \pi_1 & \pi_2 & \pi_3 & \pi_4 & \pi_5 & \pi_6 \end{bmatrix}$$
$$\phi^T := \begin{bmatrix} \phi_{18} & \phi_{19} & \phi_{20} & \phi_{21} & \phi_{22} & \phi_{23} \end{bmatrix}$$
$$\dot{p}^T(t) := \begin{bmatrix} -\dot{p}^{cn}(t) & -\dot{p}^{tw}(t) & -\dot{p}^{hk}(t) & \dot{p}^{us}(t) & \dot{p}^{jp}(t) & \dot{p}^{eu}(t) \end{bmatrix}$$
$$\dot{s}^T(t) := \begin{bmatrix} \dot{s}^{cnjp} & \dot{s}^{cneu} & \dot{s}^{twjp} & \dot{s}^{tweu} & \dot{s}^{hkjp} & \dot{s}^{hkeu} \end{bmatrix}$$

All parameters are shown in Appendix 4.

In (9b) $\dot{s}^{cnjp}(t)$, $\dot{s}^{cneu}(t)$, $\dot{s}^{twjp}(t)$, $\dot{s}^{tweu}(t)$, $\dot{s}^{hkjp}(t)$, and $\dot{s}^{hkeu}(t)$ are cross exchange rates between the CEA economies and two other advanced blocks of countries (Japan and EU). The stability of inflation rates[60] and exchange rates[61] of the U.S., Japan and the EU contribute to the

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[59] That is, competitive devaluation is not allowed in the sub-area.

[60] Obstfeld (2001) shows evidence that in industrialized countries nominal exchange rates partially determine real exchange rates because of relative price stability. The situations in emerging economies may not be the same as those in developed economies.

[61] The cross rate $s^{cnjp}(t) = s^{cnus}(t) - s^{jpus}(t)$, so that taking account of (8), the cross exchange rate changes satisfy: $\dot{s}^{cnjp}(t) = \dot{s}^{twjp}(t) = \dot{s}^{hkjp}(t) = -\dot{s}^{jpus}(t)$ and $\dot{s}^{cneu}(t) = \dot{s}^{tweu}(t) = \dot{s}^{hkeu}(t) = -\dot{s}^{euus}(t)$.

convergence of the CEA. From equation (9) we can easily understand why Mundell (2000b) argues that inflation and exchange rate stability in other regions are also necessary conditions for economic integration in one region.[62] Besides, exchange rate volatility among industrialized nations is also to blame for the currency crises of the emerging markets, though there is no solid evidence to support the above argument.[63]

Substitute (5) and (6) into (9), then we can rewrite it as

$$\dot{q}^{CEA}(t) = \phi^T x(t) \qquad \phi \in \Re^{25} \tag{10}$$
$$q^{CEA}(0) = q_0^{CEA}$$

The vector ϕ is shown in Appendix 4

The dynamics of the model in (10) are then represented by the first-order linear differential equation with national fiscal deficits and interest rates as control variables, and real effective exchange rates, nominal cross exchange rates, and foreign real incomes as state variables. Note that the income of the EU can be exogenous.

In this paper we use the crisis index as an indicator for the possibility of the currency crisis. Under the assumption of fixing currency values to the U.S. dollar, the crisis index of each CEA country can be written according to either Sachs et al. (1996)

$$IND^i(t) = \Phi_s^i \frac{ds^{ius}(t)}{dt}(-1) + \Phi_{fr}^i \frac{dfr^i(t)}{dt} \tag{11a}$$

where $\Phi_s^i := \dfrac{\frac{1}{V_{s^{ius}}}}{\frac{1}{V_{s^{ius}}} + \frac{1}{V_{fr^i}}}$ and $\Phi_{fr}^i := \dfrac{\frac{1}{V_{fr^i}}}{\frac{1}{V_{s^{ius}}} + \frac{1}{V_{fr^i}}}$

or to Eichengreen et al. (1995):

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[62] According to the past records of cross exchange rates, it is hard to expect that a country can keep all exchange rates unchanged at the same time without a new international monetary system since the Bank of Japan and the European Central Bank may adopt different policies. As Mundell (2000c) says, the exchange rate stability among U.S. dollar, Japanese yen and euro will become "the most important prices in the world economy." If Japan and EU also fix their currencies to the U.S dollar, then $\dot{s}^{cnjp}(t) = \dot{s}^{cneu}(t) = \dot{s}^{twjp}(t) = \dot{s}^{tweu}(t) = \dot{s}^{hkjp}(t) = \dot{s}^{hkeu}(t) = 0$.

[63] Reinhart and Reinhart (2001) agree that keeping G-3 exchange rates in target zones could indeed lead to more stable prices in emerging markets, but their empirical evidence does not support that limiting exchange rate volatility among the G-3 would provide significant benefits for emerging markets.

$$IND^i(t) = \Phi_s^i \frac{ds^{ius}(t)}{dt}(-1) + \Phi_i^i \frac{di^i(t)}{dt}(-1) + \Phi_{fr}^i \frac{dfr^i(t)}{dt} \tag{11b}$$

where $\Phi_s^i := \frac{\frac{1}{V_{s^{ius}}}}{\frac{1}{V_{s^{ius}}} + \frac{1}{V_{i^i}} + \frac{1}{V_{fr^i}}}$, $\Phi_i^i := \frac{\frac{1}{V_{i^i}}}{\frac{1}{V_{s^{ius}}} + \frac{1}{V_{i^i}} + \frac{1}{V_{fr^i}}}$ and $\Phi_{fr}^i := \frac{\frac{1}{V_{fr^i}}}{\frac{1}{V_{s^{ius}}} + \frac{1}{V_{i^i}} + \frac{1}{V_{fr^i}}}$

The rationale for measuring the crisis in this way is that authorities typically respond to an attack by running down reserves, increasing nominal interest rate and depreciating the exchange rate. The weights given to the exchange rate (s), the nominal interest rate (i), and the foreign reserves (fr) deviating from their trends are country-specific, and they are inversely related to the relative variance (V_s, V_i and V_{fr}) of each series.[64] So the crisis indices are weighted averages of the nominal exchange rate, the nominal interest rate, and the international reserves against the U.S. dollar. Following the same definition of Eichengreen et al. to compute the weights in nominal exchange rate, nominal interest rate and foreign reserves, we get weight vectors $[\Phi_s \quad \Phi_i \quad \Phi_{fr}]$: $[6905.94 \quad 16.19 \quad 2096.26]$ for Taiwan, $[75268736 \quad 75.36 \quad 347.59]$ for Hong Kong, and $[857.69 \quad 358.80 \quad 115.72]$ for China, respectively. Note that the weight for Hong Kong's depreciation is extremely high because of the famous currency board. The higher the negative value of *IND* is, the higher is the possibility of a country suffering from speculative attacks. Under the assumptions of the fixed exchange rates and the optimal values of interest rates, in the following context we will know that the values of crisis indices depend on changes in interest rates foreign reserves.

In order to compute the value of the crisis index for each economy, we have to define the change in foreign reserves, which, in principle, is equal to the sum of the current account and capital account. Following Yeh (2000a, b), we define changes in foreign reserves of each member by combining current accounts and capital accounts.[65] Note that foreign reserves are important

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[64] The definition is to compute the inverse of the variances of the rates of changes in the foreign reserves, the rates of changes in the nominal interest rates and depreciation rates during a tranquil period (from January 1987.1 to December 1996). Note that the weight for Hong Kong's foreign reserves is computed by quarterly data since the monthly data is not available before 1996.

[65] Obstfeld (2001) points out two theoretical drawbacks in conventional modeling. First, it is theoretically ad hoc by specifying the capital account as a flow function of interest rate levels. Second, the definition of external balance is in terms of official reserve flows rather than in terms of attaining some satisfactory sustainable paths for domestic consumption and investment. That is, the government can raise the interest rate to get capital inflows without thinking of the crowding out of domestic investment and consumption. We avoid the above drawbacks by including nominal interest rates in the minimized loss functions of each country (equation (15) below).

indicators to show the situation of capital flows.[66]

$$fr^i(t) = ca^i(t) + \dot{k}^i(t) \qquad (12)^{67}$$

First, the current accounts (ca^i) are closely related to changes in exchange rates.[68] We assume that the current account equals to trade account for simplicity. That is, only the real exchange rate variable is included in the right hand side of the current account equation (e.g., Frankel and Rodriguez, 1982).

$$ca^{cn}(t) = \psi_1 q^{CEA} \qquad (13a)$$

$$ca^{tw}(t) = \psi_2 q^{CEA} \qquad (13b)$$

$$ca^{hk}(t) = \psi_3 q^{CEA} \qquad (13c)$$

in which ψ_1, ψ_2 and ψ_3 represent the positive contributions of improving competitiveness. Under the assumptions of the fixed exchange system and unchanged foreign price, the real effective exchange devaluation may be caused by either domestic price goes down individually or other members' prices go down. The former case will cause the increasing domestic competitiveness of domestic economy and the latter one will not. From the assumption of an integrated CEA, the increasing domestic competitiveness may benefit from domestic trade, but decreasing competitiveness in other members may be harmful for their trade performance, which will also negatively contribute to the domestic current account.[69]

We define the capital account ($\dot{k}^i$) following the capital mobility condition and the theory of foreign direct investment (FDI)

$$\dot{k}^i(t) = \sigma^i[i^i(t) - i^{us}(t) - \dot{s}^{ius}(t)] + \xi^i y^i(t) \qquad \sigma > 0 \quad \xi > 0 \qquad (14)$$

Uncovered interest rate parity (UIP) plays an important role in defending speculative attacks:

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[66] Tobin (1978) argues that the basic problem of international finance is not the exchange regime itself but huge private capitals flows.

[67] In theory the balance of payments is a definition equation when the country fixes its exchange rate.

[68] Kouri's acceleration hypothesis (1976) claims that current accounts deficits (surplus) cause exchanges depreciation (appreciation).

[69] Many enterprises move from Taiwan to China mainly via Hong Kong, and then build new factories to produce to export to foreign economies (especially to the United States). That is, the decreasing gains of those firms will reveal in the current account of Taiwan when firms report their operation in China to their headquarters in Taiwan.

First, the theory indicates that raising the interest rate is helpful to prevent capital outflows, but it also causes depreciation expectations in the private sector, which offsets the effort by the government. However, empirical evidence shows that countries adopting the fixed exchange rate regime (recall the assumption $\dot{s}^{iuse}(t)=\dot{s}^{ius}(t)=0 \quad i=cn,tw,hk$) caused UIP works worse, which is a necessary condition for an effective interest rate defense.[70] Furthermore, Flood and Jeanne (2000) argue that the timing of the interest rate defense matters: increasing the domestic interest rate *prior* to a speculative attack will always *hasten* the onset of the speculative attack for fiscal reasons; and committing credibility to increase the domestic interest rate *after* the speculative attack may *block* the speculative attack.[71] In general, a country prefers the FDI to the short-term capital flows.[72] Note that free capital mobility ($\sigma \to \infty$) conflicts with the assumption of full sterilization, because any central bank cannot buy or sell unlimited bonds if assuming the condition of free capital mobility.[73]

According to the theory of currency crises the short-term capital inflows may be closely related to the so-called "lending boom," which is caused by the over-lending of domestic banks to the private sector (Gourinchas, Valdes, and Landerretche, 2001). Empirics have shown the roles of the lending boom and short-term foreign debts in recent crises (e.g., Mexico in 1994-95; Thailand in 1997).

We 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,[74] and fiscal deficit. For simplicity, we do not model possible conflicts between the fiscal authority and the central bank in each country.

$$\underset{f^{cn},i^{cn}}{Min} J^{cn}(t_0=0)=\underset{f^{cn},i^{cn}}{Min}\frac{1}{2}\int_0^{\infty}\{\alpha_1(\dot{p}^{cn}(t))^2+\beta_1(y^{cn}(t))^2+\chi_1(i^{cn}(t))^2+\zeta_1(f^{cn}(t))^2\}e^{-\theta(t-t_0)}dt\} \tag{15a}$$

$$\underset{f^{tw},i^{tw}}{Min} J^{tw}(t_0=0)=\underset{f^{tw},i^{tw}}{Min}\frac{1}{2}\int_0^{\infty}\{\alpha_2(\dot{p}^{tw}(t))^2+\beta_2(y^{tw}(t))^2+\chi_2(i^{tw}(t))^2+\zeta_2(f^{tw}(t))^2\}e^{-\theta(t-t_0)}dt\} \tag{15b}$$

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[70] Flood and Rose (2001).

[71] The most striking result is that the action should be taken after the attack.

[72] Edwards (2001) shows the empirical evidence that an open capital account positively affects economic growth only after a country has achieved a certain degree of economic development. Here we concentrate not only on short-term capital flows but also on long-term foreign direct investment (FDI), which is related to economic development of a country.

[73] Lai, Chang and Chu (1990).

[74] 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.

$$\underset{f^{hk},i^{hk}}{Min} J^{hk}(t_0=0)=\underset{f^{hk},i^{hk}}{Min}\frac{1}{2}\int_0^{\infty}\{\alpha_3(\dot{p}^{hk}(t))^2+\beta_3(y^{hk}(t))^2+\chi_3(i^{hk}(t))^2+\zeta_3(f^{hk}(t))^2\}e^{-\theta(t-t_0)}dt\} \tag{15c}$$

$$\underset{f^{us},i^{us}}{Min} J^{us}(t_0=0)=\underset{f^{us},i^{us}}{Min}\frac{1}{2}\int_0^{\infty}\{\alpha_4(\dot{p}^{us}(t))^2+\beta_4(y^{us}(t))^2+\chi_4(i^{us}(t))^2+\zeta_4(f^{us}(t))^2\}e^{-\theta(t-t_0)}dt\} \tag{15d}$$

$$\underset{f^{jp},i^{jp}}{Min} J^{jp}(t_0=0)=\underset{f^{jp},i^{jp}}{Min}\frac{1}{2}\int_0^{\infty}\{\alpha_5(\dot{p}^{jp}(t))^2+\beta_5(y^{jp}(t))^2+\chi_5(i^{jp}(t))^2+\zeta_5(f^{jp}(t))^2\}e^{-\theta(t-t_0)}dt\} \tag{15e}$$

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

Substitute (6) of the reduced- form equations into (15), then the loss functions are

$$J^{cn}=\frac{1}{2}h_1^{cn}\int_0^{\infty}\{x^T(t)M^{cn}x(t)\}e^{-\theta t}dt \tag{16a}$$

$$J^{tw}=\frac{1}{2}h_1^{tw}\int_0^{\infty}\{x^T(t)M^{tw}x(t)\}e^{-\theta t}dt \tag{16b}$$

$$J^{hk}=\frac{1}{2}h_1^{hk}\int_0^{\infty}\{x^T(t)M^{hk}x(t)\}e^{-\theta t}dt \tag{16c}$$

$$J^{us}=\frac{1}{2}h_1^{us}\int_0^{\infty}\{x^T(t)M^{us}x(t)\}e^{-\theta t}dt \tag{16d}$$

$$J^{jp}=\frac{1}{2}h_1^{jp}\int_0^{\infty}\{x^T(t)M^{jp}x(t)\}e^{-\theta t}dt \tag{16e}$$

The computation of matrices M is shown in Appendix 5.

3. Policy Design in a Non-cooperative Game

The non-cooperative scenario in fact is similar to the situation before the onset of the European ERM in 1992-93 or the Asian currency crisis in 1997. In a non-cooperative case players minimize their loss functions (16) with respect to the dynamic law of motion (9) of the system[75]

[75] In this case we use $\dot{q}^{CEA}(t)$ as the only dynamic law of motion of the model since we include all bilateral differentials of the price levels in $q^{CEA}(t)$, which indicates the convergence of the three CEA economies. In a three-country case by Van Aarle, Di Bartolomeo, Engwerda and Plasmans (2002b), three bilateral inflation differentials are used as three dynamic motions, which can be represented as a dynamic vector with three first-order linear differential equations.

$$Min \quad J^{cn} \quad J^{tw} \quad J^{hk} \quad J^{us} \quad J^{jp} \tag{17}$$

$$st.\dot{q}^{CEA}(t) = \phi^T x(t)$$

$$= Aq^{CEA}(t) + Bu_1 + Cu_2$$

$$q(0) = q_0$$

where u_1^T and u_2^T are the vector of instruments and the vector of non-controlled variables, respectively.

$$B=\left[B_1 \;\; B_2 \;\; B_3 \;\; B_4 \;\; B_5 \;\; B_6 \;\; B_7 \;\; B_8 \;\; B_9 \;\; B_{10}\right]$$

$$C=\left[C_1 \;\; C_2 \;\; C_3 \;\; C_4 \;\; C_5 \;\; C_6 \;\; C_7 \;\; C_8 \;\; C_9 \;\; C_{10} \;\; C_{11} \;\; C_{12} \;\; C_{13} \;\; C_{14}\right]$$

$$u_1^T=\left[f^{cn}(t) \;\; f^{tw}(t) \;\; f^{hk}(t) \;\; f^{us}(t) \;\; f^{jp}(t) \;\; i^{cn}(t) \;\; i^{tw}(t) \;\; i^{hk}(t) \;\; i^{us}(t) \;\; i^{jp}(t)\right]$$

$$u_2^T=\left[y^{w}(t) \;\; y^{eu}(t) \;\; q^{us}(t) \;\; q^{jp}(t) \;\; p^{w}(t) \;\; i^{eu}(t) \;\; \dot{s}^{cnjp}(t) \;\; \dot{s}^{cneu}(t) \;\; \dot{s}^{twjp}(t) \;\; \dot{s}^{tweu}(t) \;\; \dot{s}^{hkjp}(t) \;\; \dot{s}^{hkeu}(t) \;\; \dot{s}^{jpus}(t) \;\; \dot{s}^{euus}(t)\right]$$

The steps to find the non-cooperative Nash solution are shown in Appendix 6. Following Engwerda et al. (1999) and van Aarle, Engwerda and Plasmans. (2001), we get the equilibrium strategies in the non-cooperative open-loop case

$$\begin{bmatrix} f^{cn}(t) \\ f^{tw}(t) \\ f^{hk}(t) \\ f^{us}(t) \\ f^{jp}(t) \\ i^{cn}(t) \\ i^{tw}(t) \\ i^{hk}(t) \\ i^{us}(t) \\ i^{jp}(t) \end{bmatrix} = -G^{-1} \begin{bmatrix} a_1 b_1 + B_1^T \Gamma_1 \\ a_5 b_4 + B_2^T \Gamma_2 \\ a_9 b_7 + B_3^T \Gamma_3 \\ B_4^T \Gamma_4 \\ a_{15} b_{11} + B_5^T \Gamma_5 \\ b_1 (h_9^{cn} - c_1) + B_6^T \Gamma_1 \\ b_4 (h_9^{tw} - c_5) + B_7^T \Gamma_2 \\ b_7 (h_9^{hk} - c_9) + B_8^T \Gamma_3 \\ B_9^T \Gamma_4 \\ b_{11} (h_9^{jp} - c_{15}) + B_{10}^T \Gamma_5 \end{bmatrix} q^{CEA}(t) =: H_{nc} q^{CEA}(t) \tag{18}$$

where Γ_i is a ratio calculated using eigenvalues in Appendix 5.

Then using (16) we obtain players' optimal values of loss functions.

$$J^i = \frac{1}{2} h_1^i \int_0^\infty \{x^T(t) M^i x(t)\} e^{-\theta t} dt \qquad i = cn, \;\; tw, \;\; hk, \;\; jp, \;\; us \tag{19}$$

where

$$x^T := \left(q^{CEA} \quad q^{us} \quad q^{jp} \quad H_{nc}^T q^{CEA} \quad y^w \quad y^{eu} \quad \dot{p}^w \quad i^{eu} \quad \dot{s}^{cnjp} \quad \dot{s}^{cneu} \quad \dot{s}^{twjp} \quad \dot{s}^{tweu} \quad \dot{s}^{hkjp} \quad \dot{s}^{hkeu} \quad \dot{s}^{jpus} \quad \dot{s}^{euus}\right)$$

4. Modeling Cooperation and Coalition

We try to model the possible cooperative outcome by the axiomatic approach by (1950, 1953) according to the current East Asian situation. Recall the ***assumption iv*** above: Japan is not included in the CEA, but it does not mean that Japan is not willing to join the CERM. Here we simply assume two possible cases: **Full cooperation** among the CEA, Japan and the U.S. will be the most optimistic situation. That is, Japan and the U.S keep outside the CERM but they are willing to support it, though it would be naïve to believe that they will do so. Alternatively, **partial cooperation** or **coalition** among the CEA economies may be more feasible than full cooperation. Furthermore, the possible coalition between China and Hong Kong and non-cooperative attitudes held by Japan or the U.S may lead CERM to break down. The CEA full or partial cooperation formation can be analyzed by the partitioned game approach, which reduces a game in normal form to a two-stage game. In the first stage, the CEA economies play non-cooperatively to see the possibility to form a full or a partial CEA cooperative mechanism. In the second stage, the formed (full or partial) cooperative mechanism and the rest of the CEA economies play non-cooperatively in setting their economic policies to face shocks.[76]

In addition to the standard coalitional Nash equilibrium (CNE), there are several different equilibrium concepts for the first stage of the game.[77] We still mainly concentrate on the CNE, in which economies simultaneously make their decisions in a one-shot game. The CNE can be characterized by two properties:

i. **Profitability property**: The losses in the coalition must be lower than or equal to the non-cooperative losses for all coalition economies.

ii. **Stability property**: (a) *internal stability*: the loss of each coalition economy must be lower than or equal to the loss that the same economy faces when it decides to leave the coalition and the other coalition economies do not change their strategies; (b) *external stability*: the loss of each non-coalition economy must be lower than the loss that the same economy faces when it decides to join the coalition. Different assumptions can be made by changing the combination of the above two properties. For instance, the limitation of joining the coalition (exclusive membership) can be described by the profitability and the internal stability properties (i+ii (a)).

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[76] Van Aarle et al. (2002b).

[77] For instance, the Sequential Negotiation Equilibrium is helpful in capturing the importance of historical relationships between economies. And the Farsighted Coalitional Equilibrium replaces the Nash myopic behavior if economies hold long-term points of view. Ibid.

And the profitability only can explain the coalition unanimity, which assumes that the whole coalition collapses when one of its members defects. Of course the above condition may be too simple to be used in thinking more complicated phenomenon.[78]

We model the full cooperation as follows

$$J^{FC} = \tau^{cn} J^{cn} + \tau^{tw} J^{tw} + \tau^{hk} J^{hk} + \tau^{us} J^{us} + \tau^{jp} J^{jp} \qquad \tau^{cn} + \tau^{tw} + \tau^{hk} + \tau^{us} + \tau^{jp} = 1 \qquad (20)$$

Note that τ measures not only bargaining powers between countries but also the degree of "sacrifice". The government of China is convinced that the economic power is the best tool to promote Chinese unification.[79] From the political logic obeyed by China and the performance of Chinese Renminbi in 1997 we may expect that the value of τ may be small at least at the beginning of forming the cooperative mechanism.

Minimizing

$$J^{FC} = \frac{1}{2}\int_0^{\infty} \{x^T(t) M^{FC} x(t)\} e^{-\theta t} dt \qquad (21)$$

which subjects to (9). Note that $M_{FC} = \tau^{cn} M^{cn} + \tau\ M^{tw} + \tau\ M^{hk} + \tau^{us} M^{us} + \tau^{jp} M^{jp}$.

Next, We define the coalition among the CEA economies by rewriting the dynamic low of motion (9) as

$$\dot{q}^{CEA}(t) = \begin{bmatrix} -\phi_1 & -\phi_2 & -\phi_3 & \phi_6 & \phi_7 & \phi_8 \end{bmatrix} \begin{bmatrix} f^{cn}(t) \\ f^{tw}(t) \\ f^{hk}(t) \\ i^{cn}(t) \\ i^{tw}(t) \\ i^{hk}(t) \end{bmatrix} + \tilde{\phi}^T \tilde{x}\ (t) \qquad (22)$$

$$q^{CEA}(0) = q_0^{CEA}$$

where

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[78] Think of a possibility: If unification is the ultimate goal held by the government of China, then how to set the Chinese welfare-loss function? It is a complicated political problem, which may imply the existence of a transfer mechanism (e.g. side-payments) and will not be discussed in this paper for simplicity. However, the problem of side-payments in the CEA would be more feasible than in Europe.

[79] See "Cross-strait relationship and economic policies toward Mainland China" (in Chinese), Mainland Affairs Council, Taiwan. (Http://www.mac.gov.tw)

$$\tilde{\phi} = \left(-\phi_4 \;\; -\phi_5 \;\; \phi_9 \;\; \phi_{10} \;\; -\phi_{11} \;\; -\phi_{12} \;\; -\phi_{13} \;\; -\phi_{14} \;\; \phi_{15} \;\; -\phi_{16} \;\; \phi_{17} \;\; \phi_{18} \;\; \phi_{19} \;\; \phi_{20} \;\; \phi_{21} \;\; \phi_{22} \;\; \phi_{23} \;\; -\phi_{24} \;\; -\phi_{25}\right)$$

and

$$\tilde{x}^T = \left(f^{us} \;\; f^{jp} \;\; i^{us} \;\; i^{jp} \;\; q^{CEA} \;\; q^{us} \;\; q^{jp} \;\; y^{w} \;\; y^{eu} \;\; \dot{p}^{w} \;\; i^{eu} \;\; \dot{s}^{cnjp} \;\; \dot{s}^{cneu} \;\; \dot{s}^{twjp} \;\; \dot{s}^{tweu} \;\; \dot{s}^{hkjp} \;\; \dot{s}^{hkeu} \;\; \dot{s}^{jpus} \;\; \dot{s}^{euus}\right)$$

and then minimize loss functions and subject to (22)

$$J^{CEA} = \tau^{cn} J^{cn} + \tau^{tw} J^{tw} + \tau^{hk} J^{hk} \qquad and \qquad J^{us}, J^{jp} \qquad \tau^{cn} + \tau^{tw} + \tau^{hk} = 1 \qquad (23)$$

The possible China-Hong Kong coalition can be modeled according to the above approach.

The steps to get the cooperative solution are shown in Appendix 7. Note that the Stackelberg solutions are easy to be obtained if we make some changes in the above solution procedures, though they may not be realistic in our case. The details of the general solution of the linear quadratic case can be found in Petit (1990).

5. Understanding the Historical and Current situation in the CEA: An Estimation

In this section we estimate the countries' economic behaviors according to the equations (1a-e) and (5). After we getting the parameters of the structural- form model, we can compute the parameters of the reduced- form model in equation (6). Then we can simulate the model and get the values of the loss functions and the crisis indices, which are main indicators to show the costs and benefits of between with- and without the CERM.

It is well known that it is not easy to do the estimation for the Chinese economy because of its transitional characteristics. Moreover, the data are not sufficient since China opens its market to the world for only twenty years. Another point is that the current situation in the CEA does not mean anything about the future development because CEA has not experienced a long-term integration with well-organized procedures by members in the sub-region. Despite the above difficulties, we still try to do the estimation, which we will treat as a reference to do the simulation in the next section.

The two main advantages of estimation by quarterly data is that Hong Kong can be included in our empirics, and an empirical study by recent observations (most variables are from 1988.II to 2000IV) is also helpful to aware of the current development of the CEA. Alternatively, there are also two shortcomings: first, the number of observations of some variables of Hong Kong is less than 30. Second, the quality of some variables is not satisfied (e.g., Chinese quarterly real output and the government consumption are not available. See Appendix 8), so we should be cautious to interpret the empirical results.

First, we try to estimate equations (1) and (5) by a conventional way, the error correction mechanism (ECM, Douven and Plasmans, 1996).[80]

$$\Delta y_t = \alpha_0 + \alpha_1 y_{t-1} + \sum_{k=1}^{K} \beta_k x_{k,t-1} + \sum_{k=1}^{K} \sum_{l=0}^{L_k} \delta_{k_l} \Delta x_{x_k,t-l} + \sum_{m=1}^{M} \gamma_m \Delta y_{t-m} + \varepsilon_t \tag{24}$$

where y represents the left-hand side variable (the GDP in equation (1) and the CPI inflation in equation (5)) and x represents all right-hand side variables except the lagged term and the first differentiate term of y.

Next, we do the estimation by following the completed theoretical model shown in section 2. We first use the Hodrick-Prescott filter to compute the long-term trends of variables and define all variables, except interest rates and inflation rates, are in logarithms and denote deviations from their long-term equilibrium. Note that the values computed by the Hodrick-Prescott filter are not equal to the long-term equilibrium of variables but are rough trends of variables.

$$\bar{y}_t = \alpha_0 + \alpha_2 \bar{y}_{t-1} + \sum_{k=0}^{K} \beta_k \bar{x}_{t-1} + \varepsilon_t \tag{26}$$

where $\bar{y}$ and $\bar{x}$ represent the values of endogenous (the GDP in (1) and the CPI inflation rate in (5)) and exogenous variables deviating from the trends computed by Hodrick-Prescott filter.

We report the results of full model estimation by OLS and seemingly unrelated regression method (SUR). The necessary seasonal adjustment is made for the variables on the quarterly basis.[81] Here we still only concentrate on the results related to the links among economies in the CEA.

The regressions of economic growth are shown in Tables 1 and 2. First, for the real exchange depreciation, the results are not fully consistent with our theoretical arguments. Chinese real exchange depreciation did not positively contribute on Taiwanese economy, which seems to violate the assumption of vertical industrial integration. Another interesting point is that Hong Kong's real exchange depreciation negatively contributed on its own economy. A possible explanation is related to Hong Kong's intermediate status in the CEA we mentioned in section 1: as a financial operation and trading transportation center of the CEA, Hong Kong's currency stability is helpful for Chinese capital inflows and foreign investment to China via Hong Kong. That is why China did its best to support Hong Kong's currency board during the Asian financial crisis in 1997.

[80] The purpose of the estimation is to get the parameters for the simulation in the next 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)

[Insert Tables 1 and 2 here]

Second, although the factor of Chinese economy is insignificant in our regression analysis by annual data, Chinese industrial growth did positively contribute on Taiwanese economic growth (Table 2). This result is consistent with the vertical industrial integration by large amount of foreign direct investment from Taiwan to China. That is, the government of Taiwan cannot neglect the so-called "Chinese factors" anymore even if the United States will still be the largest trade partner in the future. The data problem may be the reason why Chinese industrial growth is not significant in the equation of Hong Kong: in contrast to the low ratio of services over GDP in China, over 80% of Hong Kong's GDP are from services.

Third, we add an Asian financial crisis dummy (*D97.III*) into four regressions of Asian economies. The result indicates that Taiwan and Hong Kong economies suffered from the crisis in 1997-98. In contrast, Chinese economy was safe due to its capital control. Of course the result may depend on the definition of the dummy.

Note again we have to be prudent to look at the above results because of the quality of the quarterly data. Moreover, our theoretical arguments stress on long-term effects, which may inconsistent with short-term phenomenon.

The regressions of Phillips curves are shown in Tables 3 and 4. Note that in East Asia and the U.S. the labor markets and wage adjustment are more flexible than other developed countries. The risk premiums RP are relatively small in more open economies.

[Insert Tables 3 and 4 here]

We do not include capital flows in our empirics due to the data insufficiency of China and Hong Kong. In simulation studies we will use the appropriate values according to our estimation and relevant literature. [82]

6. Simulation Studies

We have included fundamentals (e.g. governments' policy choice), external shocks (e.g. foreign price or exchange rate shocks, competitive devaluations), and capital flows (balance of payments) in our modeling. However, these factors are closely connected to and influenced by each other. The advantage of the simulation approach is to show the direct and indirect impacts of the above three main causes of the fixed exchange rate regime collapse on each economy. For instance, from the first generation models we know that domestic credit expansion may cause insufficient

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[81] We mainly use the multiplicative method to adjust quarterly time series.

[82] For instance, Reinhart and Reinhart (2001) and Edwards (2001). Wen (1997) reports the difficulty to figure out the degree of capital mobility.

foreign reserves[83] which, in turn, might trigger a currency crisis. On the other hand, high degree of capital mobility[84] is also an important reason to explain why some East Asian countries ran out of foreign reserves during 1997-98, especially those countries that had huge loans from abroad.[85] Besides, the linkage between domestic and foreign interest rates may be a determinant of the domestic monetary policy, including the interest rate defense before the onset of the crisis,[86] which may, in turn, have an impact on the domestic macroeconomic situation.[87] Note that some empirical works develop thresholds for leading indicators based on theory in order to forecast future currency crises.[88] But absolute thresholds do not exist for all indicators and for all countries in the world. Furthermore, as mentioned before, many possible causes are closely related to each other. That is why in theory current account deficits and capital flows can be good representatives of over-consumption, over-investment, and short-term foreign debts.

We can evaluate the relationship among domestic and international economic factors by modeling and simulating the international macroeconomic linkages. However, it is not possible to analyze all the above possible causes in a paper. We provide now the main principles for the simulations performed in this paper:

i.Fundamentals:

In addition to the price shock from China (p^{cn}), we concentrate on the Chinese government's preferences, especially inflation controls and fiscal policies, which are related to the problem of domestic credit expansion. That is, we can simulate changes of the weights (α on inflation controls and ζ on fiscal policies) in its loss function during a certain period of time. The reason to do so comes from the poor record of Chinese economic policy stability, which would be the main handicap in establishing the CEA cooperative mechanism.

ii. External shocks:

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[83] Mundell (1963); Krugman (1979); Flood and Garber (1984).

[84] Proposed by Agenor, Bhandari, and Flood (1992)

[85] Proposed by Buiter (1987).

[86] Flood and Rose (2001); Flood and Jeanne (2001).

[87] In Flood and Garber (1984) the strong response of money demand towards nominal interest rate may also increase the possibility of the fixed exchange rate regime collapse.

[88] Some thresholds of indicators are based on Shen's work (2000), in which he drafts values of indicators according to economic performance of Asian countries before 1997 as follows: Real exchange appreciation caused by CPI inflation, which is over 6% per year; GDP growth is less than 5%; the ratio of fiscal deficit over GDP is less than -3%; domestic credit growth is over 20%, which is mainly caused by domestic bank loans to the private sector; the ratio of current account deficit over GDP less than –4%; changes in capital flows reverse less than -100%; changes in foreign reserves loss is over 25%; external shocks, including foreign (or global) economic growth slowdown, foreign exchange rate policies (the cross-exchange rates) change, and foreign (especially the U.S.) interest rate policies change. Note that most variables worsening may last over one year.

These shocks are derived from changes in the international economic situations, the so-called "monsoonal effects." We simulate three main variables. One is the U.S. price shock (p^{us}). The other is the world-wide nominal interest rate. Recall we assume that the world wide nominal interest rate and the U.S. nominal interest rate are identical. And the last one is changes in the cross-exchange rates (e.g, $\dot{s}^{euus}$, $\dot{s}^{jpus}$), which might be caused by devaluations of countries outside the CEA due to competitiveness issues.

iii. Foreign monetary policy and capital mobility:

Capital flows, especially short-term ones, are usually related to external shocks. Remind that in (14) the short-term capital flow of each country depends not only on the monetary policies between the U.S. and other countries (χ in the loss functions), but also on the degree of capital mobility (σ^i).

iv. Bargaining power:

The above three reasons could be the explanations of the past crises, including the Asian case in 1997. The cooperative scenario is assumed to be helpful for defending against the next speculative attacks. In addition to repeat the above three situations in the cooperative case, the relative bagaining powers (τ^i) between individual countries would be important for a country to decide to cooperate or not. This is not only an economic but also a political arrangement. We have listed some possibilities in Section 4.

We assume six scenarios below, in which different origins of shocks and institutional arrangements are defined. For each scenario we compute solutions of non-cooperation (NC), full cooperation (FC), the CEA cooperation (CEA), and China-Hong Coalition (cn-hk), respectively. [89] And each solution has the standard and robust results. We do the standard simulation by using the values of the structural model parameters and weights in the loss functions shown in Table 5. The values for the parameters are mainly calibrated from our quarterly estimation, but adjustments for some parameters are necessary if the estimation results are not fully consistent with our theoretical arguments. For instance, we arbitrarily define the degrees of capital mobility

[89] We exclude other possible coalitions because they are beyond our discussion. For instance, Lo, Fu-chuan, Taiwan representative in Japan, proposes the Taiwan-Japan coalition. *China Times*, 2002.5.1.

(σ^i) by the common knowledge due to some difficulties with the econometric estimation.[90]

Furthermore, the weights and discount rates in the loss functions are mainly based on the relevant literature. In contrast, only the significant parameters with the right signs in the estimation are chosen in the robust simulation. That is, parameters either insignificant or with the wrong signs in the estimation are set to zero.

[Insert Table 5 here]

As stressed before, the loss function and the crisis index are two main indicators to show a country's domestic and international economic situations, respectively. Since the balance of payments of each CEA economy has been determined, all economies decide their economic policies by taking into account the values of their loss functions.

6.1 Scenario I: Price Shock from the U.S.

In this scenario we assume there is a price shock from the U.S., which means the price level of the U.S. increases 5% with respect to the price level of the other economies. Note that we can expect the impact of the U.S. economy on the CEA due to the fixed exchange rate regime. Table 6 presents the results of our standard and robust numerical simulation for the loss functions (domestic economic situations). Figures 3 and 4 report the adjustment of crisis indices (international economic situations) under the CERM, respectively.

[Insert Table 6 and Figures 3-4 here]

Recall that we will use profitability and stability properties to characterize the coalitional Nash equilibrium (CNE). In our standard simulation the non-cooperative solution, which is similar to the situation before the onset of the Asian financial crisis in 1997, is the only equilibrium. In the robust simulation the China-Hong Kong coalition is profitable, internally and externally stable. This means that the China-Hong Kong coalition is available if the assumption of exclusive membership can be sustained. From the crisis indices of each CEA economy (Figures 3-4 (a) for China, (b) for Taiwan, and (c) for Hong Kong, respectively), we know that the China-Hong Kong coalition is helpful for Hong Kong in keeping the stability of their foreign exchange markets. We can judge it by looking at the values of the crisis indices[91] and their speed of convergence under the U.S. price shock. For China and Taiwan, the China-Hong Kong coalition seems not to be

[90] Wen (1997) estimates the degrees of capital mobility of China and Taiwan by the uncovered interest rate parity and finds that they are very close to zero. This econometric result cannot tell us the difference of capital flows between Taiwan and China.

[91] Remind the higher the negative value of the crisis index is, the higher is the possibility of a country suffering from speculative attacks.

efficient in decreasing the possibility of a currency crisis. For Hong Kong, the full cooperation is the best to defend against the possible currency crisis. Nevertheless, either cooperation or coalition is better than the non-cooperative solution for all economies in the CEA.

The results in Table 6 show that the China-Hong Kong coalition can be the equilibrium for the domestic economic stability. Figures 3-4 (a), (b), and (c) indicate that the cooperation and coalitions could be helpful in defending against currency crises under the CERM and the U.S. price shock. The main reason could be that in the short run all economies could still keep their individual domestic interests, but the CEA external economic situations would be consistent with the U.S. because of the CERM. The interesting finding is that for Hong Kong all four solutions have a positive impact on the foreign exchange market. However, in scenario II we will see that the results depend on the type of shocks.

6.2 Scenario II: Price Shock from China

The shocks may not necessarily originate from outside the CEA but can also come from the CEA itself. The poor record of Chinese unstable economic policy decision and uncertain economic outlook could be one of the main problems of the CEA cooperation. Table 7 and Figures 5-6 (a), (b), and (c) describe the results of domestic and international economic situations where we investigate the price shock from China, which means the price level of China increases 5% with respect to the price levels of the other economies.

[Insert Table 7 and Figures 5-6 here]

The results in this scenario are different from those in scenario I: China-Hong Kong coalition is still profitable in minimizing the loss functions of the two CEA economies, and it is also the second best for the external stability of Hong Kong. Regardless of the domestic equilibrium, the full cooperation would be helpless in stabilizing Hong Kong's international financial market. In the short run, it would happen due to the inconsistency between exchange rate policy and geographical economic relationship.[92] Recall that van Aarle et al. (2002b) argue that the full cooperation may not be preferred by the more open economies due to the existence of asymmetries and externalities. We find the similar results in the following scenarios.

6.3 Scenario III: China's Asymmetric Policy Preference

China's unstable decision making may be another negative factor for the future CEA cooperation. In this scenario we assume that the values of all China's preference weights in the loss function are only a half of the other economies. And the origins of the shocks are the same as those of

[92] For instance, Hong Kong will still keep its currency board under the CERM but strengthen its economic link with China.

scenarios II and I. It is not possible to precisely figure out the policy preference of a country in a quantitative way. Here we just assume that China's attitute toward the stabilization of inflation, output, fiscal policy, and monetary policy is not as strict as that of other economies.

[Insert Table 8 and Figures 7-8 here]

The results from the numerical simulation in this scenario are basically the same as those in scenarios II and I: The China-Hong Kong coalition is still preferred. But its effects for the CEA economies to prevent external imbalances depend on the origin of the shocks. From Figures 7-8 (a), (b), and (c), we know that for Hong Kong the protection provided by the China-Hong Kong coalition is at least as good as the situation in non-cooperation and the CEA cooperation when the price shock is from China.

6.4 Scenario IV: Changes in the Foreign Exchange Rates

Remind that Mundell (2000a, b) stresses the impact of the three main currency blocks on the stability of the CERM. Here we assume that Japanese yen and European euro depreciate 10% at the same time with respect to the U.S. dollar.

[Insert Table 9 and Figures 9-10 here]

In this scenario the China-Hong Kong coalition is still preferred, but it is not different from other solutions, except the full cooperation for Hong Kong, in decreasing the possibility of the speculative attacks. The CEA cooperation cannot be better than the non-cooperative solution to prevent from a currency crisis, which violates the proposals made by some economists and politicians shown in Appendix 1.

6.5 Scenario V: Changes in the U.S. Monetary Policy

Changes in the preference weight of the U.S. monetary policy would change the interest rate differentials between the U.S. and the rest of the economies in the world. And the interest rate differentials, in turn, have impacts on the capital flows of the whole world. In this scenario we still assume the U.S. price shock as in scenario I, but the U.S. preference weight on interest rate (χ_4) in the loss function becomes double. We do so in order to simulate the reactions of the CEA economies when the U.S. adopts a stricter monetary policy.

[Insert Table 10 and Figures 11-12 here]

The results are similar to that in scenario I: the China-Hong Kong coalition could be preferred in stabilizing domestic and external economic situations of China and Hong Kong, respectively. However, regardless of the equilibrium of domestic stabilization, the full cooperation is always better than the non-cooperative solution in stabilizing the balances of payments of the CEA. That

is, the full cooperation can solve the problem of monetary policy inconsistency among economies then alleviate the sharp reverse of capital flows.

6.6 Scenario VI: Asymmetric Bargaining Powers

In this scenario the shock is the same as in scenario I but the bargaining powers are assumed to be asymmetric. We assume that the bargaining powers of the U.S., China, Japan, Taiwan, and Hong Kong are 0.4, 0.2, 0.2, 0.1, and 0.1, respectively. There is no absolute standard to define the bargaining power of each economy,[93] but the asymmetric arrangement as proposed here should be more realistic than the symmetric one.

[Insert Table 11 and Figures 13-14 here]

The results obtained in this scenario are almost the same as those in scenario I. However, we should be aware of the consequences of the asymmetric distribution of bargaining power: the economy with lower bargaining power is unwilling to cooperate, and the whole profit is redistributed among economies in different regimes. Nevertheless, it is hard to imagine that the large economies will give in except some special considerations.

We concentrate on the above two main indicators and just briefly report the adjustment of the other macroeconomic variables.[94] In most cases the cooperation and the coalition can efficiently stabilize their inflation rates, fiscal policies, and interest rates. It explains that on the one hand, as Lau states (2001), fiscal policy instead of interest rate is used for domestic stimulus purpose under the fixed exchange rate system. On the other hand, in an individual (non-cooperative) peg system, the fiscal policy would be more active than in a multilateral peg due to the absence of policy coordination. That is, countries with a unilateral peg system would have to pay the price of having volatile in their economic policies.

7. Concluding Remarks

The financial crises and the European integration in the 1990s gave origin to the discussion regarding a possible Asian regional exchange rate and monetary cooperation. This paper provides an initial assessment whether a CEA cooperation would be effective for Taiwan, China and Hong Kong in preventing the next speculative attack. It can also be treated as a test of returning to the U.S. dollar system different from the past unilateral peg. Due to some difficulties, such as lack of a concrete executive plan of the CERM and the data quality of the cross-strait exchanges, we have to impose some assumptions on our model according to economic theory and

[93] The bargaining power of a country can be assumed to be an increasing function of its relative size. van Aarle et al. (2002b).

[94] All figures are available on request.

current development of the CEA. Therefore, the simulation results based on dynamic game theory and empirics are only indicative. However, they are helpful in verifying the effectiveness of the Asian regional exchange rate arrangements.

Remind that in Figure 2 we assume that all economies try to stabilize their domestic economies by minimizing loss functions, and their balances of payments are determined under the CERM. That is, the types of cooperation depend on the equilibria of five economies' loss functions, then we can evaluate whether the cooperative arrangements those economies would choose are efficient to defend the speculative attacks by looking at the determined crisis indices. Of course we can expect that the results of the numerical simulation would be different if we adopt different assumptions. For instance, an economy may either have two (domestic and international) loss functions and try to stabilize them at the same time, or minimize one loss function, in which the appropriate domestic and international economic variables are included.

From our numerical simulation, three major conclusions related to the CEA cooperation can be derived:

i. In all scenarios the full cooperation and the CEA cooperation are not feasible according to the definition of coalitional Nash equilibrium (CNE). The interesting result is that the CEA cooperation would not be possible because in most cases it violates Taiwan's domestic economic interests. That is, the above two types of cooperation would be difficult to achieve even if they were helpful in stabilizing the crisis indices of the CEA economies.

ii. In most cases the China-Hong Kong coalition is feasible. It can be a good promise for Hong Kong to defend the speculative attacks under different types of shocks. Furthermore, Hong Kong is more willing than Taiwan to cooperate with China, but it is less interested in the full cooperation when compared to Taiwan. The explanation could be derived from the closely economic link between China and Hong Kong, and closer relationships of Taiwan- the U.S. and Taiwan-Japan than the link between Taiwan-China so far.

iii. Hong Kong's international financial situation is sensitive to the type of cooperation and the origin of the shocks (e.g. shocks from non-CEA economies versus the shock from China). The Taiwanese crisis index is always extremely negative after a shock, no matter whether in the non-cooperative or cooperative solution. In most cases China prefers the CEA cooperation or China-Hong Kong coalition, except in the cases where the U.S. changes its preference regarding monetary policy. Due to its strict capital controls, Chinese crisis index is not sensitive to the origin of the shocks and the type of cooperation. However, China would still benefit a lot from the CEA or China-Hong Kong cooperation regardless of political reasons.

It seems that our simulation results do not support the ideas regarding the CEA exchange and

monetary cooperation proposed by R. Mundell (2000a, b), J. Stiglitz (2002), and other politicians and economists (see Appendix 1). Note that, for simplicity, we derive the above results by ignoring the existence of some political problems (e.g. side-payments). However, the side-payments in the CEA would be more feasible than in the rest of regional cooperative mechanisms in the world. For instance, the CEA cooperation, which violates CNE in all scenarios of our numerical simulation, could be achieved if some economies (e.g. Taiwan prefers non-cooperative solution in our most cases) can get some benefits through fair negotiations.

In addition to improve our understanding about the current CEA economic relation, there are two possible ways to improve our modeling. First, a new institutional arrangement will be necessary after the CERM operates. The importance of an independent exchange rate and monetary institute has been widely discussed on the economic literature for the example of the European Monetary Union. If the idea would be also feasible in the CEA, the function of an independent monetary institute should not only be related to the single monetary policy but also to the control of capital flows, which played an important role in the recent financial crises. The second point is about modeling. In our model we assume that the close economic link causes a transmission mechanism from one country to the others. In this regard, it means that Taiwan and Hong Kong are relatively small compared to China, the U.S., and Japan. This implies the Stackelberg equilibrium might also be appropriate. However, as a top 20th economy in the world, Taiwan still owns the status of political and policy independence, which means the Nash equilibrium would still be more realistic than the Stackelberg equilibrium in the current stage. Nevertheless, we cannot ignore the fact that the Chinese economy still keeps growing.[95] Furthermore, to extend a deterministic dynamic game to a stochastic form is an option to deal with the problem of uncertainty.

The model in this paper can be extended as a game of five economies with an exchange and monetary cooperative institute (e.g. an institute similar to the European System of Central Banks, ESCB). This would be the next research topic in the future.

[95] According to the Economists' report (Japanese version, 2000.12.29), in 1990 the GDP of China ranked 10th in the world, and it was 30% of that of Russia, 69% of sum of GDP of ASEAN 5 nations and South Korea, and 12% of that of Japan. After 8 years it became 3.5 times of that of Russia, 1.3 times of sum of GDP of ASEAN 5 nations and South Korea. In 2000 the Chinese economic growth is 8%, and it is the first time the GNP of China is over 1 trillion U.S. dollars. Prime minister, Zhu, Rong-gi, claims that the economic growth rates of China will keep at least 7% in the future five years. See *China Times*, 2001.3.6.

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TABLE 1 ESTIMATION OF ECONOMIC GROWTH (y^i) BY THE ERROR CORRECTION MECHANISM, 1988.II-2000.IV.

Equation	***China***		***Taiwan***		***H.K.***		***Japan***		***U.S.***	
Estimation	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR
Δq_t^{cn}	-0.07	-0.03	**-0.09**	**-0.09****	0.02	0.01				
	(0.08)	(0.05)	(0.05)	(0.03)	(0.09)	(0.05)				
q_{t-1}^{cn}	0.02	0.04	**-0.19****	**-0.18****	-0.07	-0.06				
	(0.09)	(0.06)	(0.05)	(0.03)	(0.08)	(0.05)				
Δq_t^{tw}	0.05	-0.03	**0.19**	**0.19****	0.05	0.05				
	(0.16)	(0.10)	(0.11)	(0.07)	(0.15)	(0.08)				
q_{t-1}^{tw}	-0.00	-0.05	**0.25****	**0.27****	-0.06	-0.04				
	(0.12)	(0.07)	(0.08)	(0.05)	(0.11)	(0.06)				
Δq_t^{hk}	-0.29	-0.16	-0.17	-0.15	**-0.43***	**-0.41****				
	(0.22)	(0.14)	(0.15)	(0.10)	(0.20)	(0.11)				
q_{t-1}^{hk}	0.06	0.13	**-0.30***	**-0.29****	**-0.38***	**-0.36****				
	(0.21)	(0.13)	(0.13)	(0.09)	(0.18)	(0.10)				
Δq_t^{jp}							**0.09****	**0.08****		
							(0.03)	(0.02)		
q_{t-1}^{jp}							**0.04**	**0.04***		
							(0.03)	(0.02)		
Δq_t^{us}									0.01	0.00
									(0.06)	(0.06
q_{t-1}^{us}									-0.00	0.00
									(0.01)	(0.01
Δr_t^i	**1.19****	**1.33****	0.47	**0.52***	-0.00	-0.00	0.04	0.26	**0.32**	**0.31***
	(0.34)	(0.22)	(0.35)	(0.23)	(0.01)	(0.00)	(0.38)	(0.27	(0.18)	(0.16)
r_{t-1}^i	**0.78****	**0.78****	0.74	**0.76***	-0.01	**-0.01***	-0.25	-0.07	-0.11	-0.11
	(0.21)	(0.13)	(0.59)	(0.37)	(0.01)	(0.01)	(0.44)	(0.31	(0.08)	(0.07)
Δf_t^i	-0.01	-0.00	-0.05	-0.06	0.36	**0.30****	0.06	0.17	0.12	0.09
	(0.03)	(0.02)	(0.07)	(0.04)	(0.20)	(0.11)	(0.22)	(0.15	(0.12)	(0.11)
f_{t-1}^i	**0.06***	**0.07****	**-0.19**	**-0.22****	0.44	**0.38***	0.29	**0.42****	-0.05	-0.04
	(0.03)	(0.02)	(0.10)	(0.07)	(0.28)	(0.15)	(0.20)	(0.14	(0.06)	(0.05)
Δy_t^{cn}			0.11	0.13	-0.11	-0.10	0.00	0.01		
			(0.12)	(0.08)	(0.20)	(0.11)	(0.05)	(0.03)		
y_{t-1}^{cn}	-0.01	0.01	**0.20****	**0.21****	-0.18	**-0.17****	-0.00	-0.00		
	(0.08)	(0.05)	(0.05)	(0.03)	(0.11)	(0.06)	(0.02)	(0.01)		
y_{t-1}^{tw}			**-1.06****	**-1.09****						
			(0.20)	(0.13)						
y_{t-1}^{hk}					**-0.67***	**-0.62****				
					(0.26)	(0.14)				
Δy_t^{jp}	0.10	0.33	-0.02	-0.09	0.22	0.11				
	(0.74)	(0.47)	(0.43)	(0.28)	(0.54)	(0.30				
y_{t-1}^{jp}	0.94	**1.38**	**-1.14**	**-1.08****	0.50	0.41	**-0.83****	**-0.85****		
	(1.19)	(0.75)	(0.64)	(0.41)	(0.88)	(0.48)	(0.21)	(0.15)		
Δy_t^{us}	-1.50	**-1.65***	0.45	0.36	-0.59	-0.58	-0.43	**-0.49**		
	(1.06)	(0.67)	(0.71)	(0.46)	(1.23)	(0.67	(0.37)	(0.26		
y_{t-1}^{us}	-0.13	-0.54	-0.00	-0.08	2.36	**2.28****	-0.15	**-0.26**	0.04	0.02
	(0.76)	(0.49	(0.50)	(0.32)	(1.39)	(0.76	(0.22)	(0.16)	(0.05)	(0.04
D97.III	0.03	**0.05**	**-0.05***	**-0.05****	-0.01	-0.01	-0.01	-0.00		
	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.00)		
$\overline{R}^2$	0.82	0.81	0.58	0.56	0.58	0.56	0.43	0.41	0.20	0.19
SE	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
D-W stat.	2.01	2.10	2.30	2.17	2.44	2.41	2.22	2.04	1.71	1.65
Observations	35	35	35	35	28	28	35	35	49	49

Note: Standard errors in parenthesis. The constant is not reported. System observations are 616. ** and * mean coefficients are significant at 1% and 5% level. The coefficients significant at 10% are bolded.

TABLE 2 ESTIMATION OF ECONOMIC GROWTH (y^{i}) BY HODRICK-PRESCOTT FILTER, 1988.II-2000.IV.

Equation	***China***		***Taiwan***		***H.K.***		***Japan***		***U.S.***	
Estimation	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR
q_t^{cn}	-0.07	-0.04	-0.03	-0.03	0.01	-0.00				
	(0.09)	(0.05)	(0.05)	(0.03)	(0.09)	(0.05)				
q_{t-1}^{cn}	0.07	0.07	**-0.10**	**-0.09****	-0.08	-0.07				
	(0.10)	(0.06)	(0.05)	(0.03)	(0.08)	(0.04)				
q_t^{tw}	0.03	-0.08	**0.28***	**0.28****	0.10	0.11				
	(0.19)	(0.12)	(0.11)	(0.07)	(0.15)	(0.08)				
q_{t-1}^{tw}	-0.05	-0.02	-0.01	-0.02	-0.09	-0.09				
	(0.17)	(0.10)	(0.09)	(0.06)	(0.11)	(0.06)				
q_t^{hk}	-0.31	-0.21	-0.13	-0.13	**-0.54****	**-0.50****				
	(0.25)	(0.15)	(0.15)	(0.09)	(0.28)	(0.15)				
q_{t-1}^{hk}	0.17	0.15	-0.12	-0.11	0.06	0.11				
	(0.23)	(0.14)	(0.12)	(0.08)	(0.18)	(0.08)				
q_t^{jp}							**0.09***	**0.09****		
							(0.04)	(0.02)		
q_{t-1}^{jp}							-0.04	**-0.05***		
							(0.03)	(0.02)		
Δq_t^{us}									**0.11**	**0.13***
									(0.06)	(0.05)
q_{t-1}^{us}									**-0.14***	**-0.18****
									(0.06)	(0.05)
r_t^{i}	**1.00***	**1.07****	0.07	0.19	-0.01	-0.01	0.17	0.43	**0.49****	**0.66****
	(0.40)	(0.25)	(0.35)	(0.22)	(0.01)	(0.00)	(0.41)	(0.28)	(0.17)	(0.14)
r_{t-1}^{i}	-0.35	-0.44	-0.15	-0.22	-0.01	**-0.01***	-0.18	-0.07	**-0.50****	**-0.58****
	(0.45)	(0.28)	(0.35)	(0.22)	(0.01)	(0.00)	(0.30)	(0.21)	(0.15)	(0.12)
f_t^{i}	0.02	0.01	-0.01	-0.01	**0.32**	**0.30****	0.06	0.12	0.06	0.05
	(0.04)	(0.02)	(0.06)	(0.04)	(0.18)	(0.10)	(0.24)	(0.17)	(0.11)	(0.09)
f_{t-1}^{i}	0.05	**0.06****	-0.09	**-0.11****	0.10	0.09	0.28	0.29	-0.16	**-0.15**
	(0.04)	(0.02)	(0.06)	(0.04)	(0.18)	(0.10)	(0.26)	(0.18)	(0.10)	(0.09)
y_t^{cn}			**0.26***	**0.28****	-0.18	-0.15	0.02	0.03		
			(0.12)	(0.08)	(0.19)	(0.11)	(0.05)	(0.04)		
y_{t-1}^{cn}	**0.94****	**0.95****	-0.12	**-0.16***	-0.01	-0.06	-0.03	-0.02		
	(0.10)	(0.07)	(0.12)	(0.08)	(0.26)	(0.14)	(0.06)	(0.04)		
y_{t-1}^{tw}			-0.24	-0.21						
			(0.20)	(0.13)						
y_{t-1}^{hk}					0.38	**0.43****				
					(0.25)	(0.13)				
y_t^{jp}	-0.28	-0.07	0.18	0.07	-0.02	-0.05				
	(0.78)	(0.48)	(0.39)	(0.25)	(0.60)	(0.33)				
y_{t-1}^{jp}	0.45	0.74	**-0.99***	**-0.98****	0.03	0.20	0.20	0.17		
	(0.75)	(0.47)	(0.40)	(0.25)	(0.63)	(0.34)	(0.22)	(0.15)		
y_t^{us}	-2.13	**-2.20****	**1.55**	**1.61****	-0.76	-0.86	-0.31	**-0.59**		
	(1.32)	(0.82)	(0.84)	(0.54)	(1.51)	(0.82)	(0.49)	(0.34)		
y_{t-1}^{us}	0.33	-0.20	0.13	-0.01	**2.71***	**2.99****	0.29	0.29	**0.71****	**0.65****
	(1.45)	(0.90)	(0.80)	(0.51)	(1.35)	(0.73)	(0.45)	(0.31)	(0.10)	(0.08)
D97.III	0.02	**0.04***	**-0.04***	**-0.04****	-0.02	**-0.02**	-0.01	-0.00		
	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.00)		
$\overline{R}^2$	0.96	0.95	0.54	0.52	0.83	0.82	0.50	0.45	0.68	0.66
SE	0.02	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
D-W stat.	1.84	1.92	2.22	2.21	2.37	2.40	2.21	1.81	1.70	1.65
Observations	35	35	35	35	28	28	35	35	49	49

Note: Standard errors in parenthesis. The constant is not reported. System observations are 616. ** and * mean coefficients are significant at 1% and 5% level. The coefficients significant at 10% are bolded.

TABLE 3 ESTIMATION OF PHILLIPS CURVES ($\dot{p}^{i}$) BY THE ERROR CORRECTION MECHANISM, 1988.II-2000.IV.

Equation	***China***		***Taiwan***		***H.K.***		***Japan***		***U.S.***	
Estimation	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR
$\dot{p}^{i}_{t-1}$	**-0.27****	**-0.28****	**-1.26****	**-1.22****	**-0.36****	**-0.30****	**-0.92****	**-0.93****	**-0.71****	**-0.75****
	(0.08)	(0.07	(0.13)	(0.10)	(0.14)	(0.11)	(0.14)	(0.12)	(0.12)	(0.11)
ΔRP^{i}_{t}	0.00	0.02	0.05	0.03	0.00	0.00	0.00	-0.00		
	(0.04)	(0.03)	(0.04)	(0.03)	(0.00)	(0.00)	(0.01)	(0.01)		
RP^{i}_{t-1}	0.11	**0.12***	-0.01	0.01	0.00	-0.00	-0.01	-0.01		
	(0.07)	(0.06)	(0.04)	(0.04)	(0.00)	(0.00)	(0.01)	(0.01)		
$\Delta\dot{p}^{w}_{t}$	0.53	0.59	-0.17	-0.15	-0.47	**-0.52**	0.07	0.04	0.06	**0.07**
	(0.46)	(0.37	(0.12)	(0.10)	(0.36)	(0.29)	(0.08)	(0.07)	(0.04)	(0.04)
$\dot{p}^{w}_{t-1}$	**1.58****	**1.66****	0.07	0.06	0.18	0.14	0.05	0.05	0.02	0.01
	(0.22)	(0.19	(0.07)	(0.06)	(0.18)	(0.14)	(0.04)	(0.04)	(0.03)	(0.02)
Δy^{i}_{t}	-0.08	-0.08	**-0.16****	**-0.19****	-0.07	-0.04	**-0.22****	**-0.29****	**-0.26****	**-0.32****
	(0.11)	(0.09)	(0.05)	(0.04)	(0.07)	(0.06)	(0.07)	(0.06)	(0.07)	(0.06)
y^{i}_{t-1}	**0.01**	**0.01****	**-0.02***	**-0.02****	0.07	**0.08***	**-0.05***	**-0.06****	-0.00	-0.00
	(0.01)	(0.00)	(0.01)	(0.01)	(0.05)	(0.04)	(0.02)	(0.02)	(0.01)	(0.01)
$\overline{R}^{2}$	0.62	0.62	0.74	0.73	0.26	0.24	0.55	0.53	0.43	0.41
SE	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00
D-W stat.	1.34	1.38	2.04	2.17	2.48	2.64	1.89	1.85	1.71	1.58
Observations	35	35	49	49	28	28	49	49	49	49

Note: Standard errors in parenthesis. The constant is not reported. System observations are 616. ** and * mean coefficients are significant at 1% and 5% level. The coefficients significant at 10% are bolded.

TABLE 4 ESTIMATION OF PHILLIPS CURVES ($\dot{p}^{i}$) BY HODRICK-PRESCOTT FILTER, 1988.II-2000.IV.

Equation	***China***		***Taiwan***		***H.K.***		***Japan***		***U.S.***	
Estimation	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR	OLS	SUR
$\dot{p}^{i}_{t-1}$	**0.75****	**0.73****	**-0.27***	**-0.21***	-0.10	-0.10	-0.15	**-0.24***	0.01	0.05
	(0.07)	(0.06)	(0.13)	(0.10)	(0.16)	(0.12)	(0.12)	(0.10)	(0.12)	(0.10)
RP^{i}_{t}	-0.01	-0.01	0.05	0.03	**0.003***	**0.003***	0.00	-0.00		
	(0.04)	(0.03)	(0.04)	(0.03)	(0.00)	(0.00)	(0.01)	(0.01)		
RP^{i}_{t-1}	**0.08***	**0.10****	-0.06	-0.04	-0.00	-0.00	0.00	0.00		
	(0.04)	(0.03)	(0.04)	(0.03)	(0.00)	(0.00)	(0.01)	(0.01)		
$\dot{p}^{w}_{t}$	-0.32	-0.22	-0.17	-0.12	**-0.60****	**-0.68****	0.08	0.06	0.02	0.05
	(0.42)	(0.33)	(0.13)	(0.11)	(0.23)	(0.18)	(0.07)	(0.06)	(0.04)	(0.03)
$\dot{p}^{w}_{t-1}$	0.60	0.44	**0.23**	**0.18**	0.25	**0.26**	-0.06	-0.02	-0.02	-0.05
	(0.45)	(0.36)	(0.13)	(0.10)	(0.19)	(0.15)	(0.07)	(0.05)	(0.04)	(0.03)
y^{i}_{t}	-0.04	-0.04	**-0.16****	**-0.19****	-0.07	-0.03	**-0.14***	**-0.18****	**-0.21****	**-0.28****
	(0.08)	(0.07)	(0.06)	(0.05)	(0.05)	(0.04)	(0.06)	(0.05)	(0.06)	(0.05)
y^{i}_{t-1}	0.14	**0.15***	**0.13***	**0.16****	**0.22****	**0.20****	**0.26****	**0.28****	**0.30****	**0.37****
	(0.09)	(0.07)	(0.07)	(0.05)	(0.05)	(0.04)	(0.06)	(0.05)	(0.06)	(0.05)
$\overline{R}^{2}$	0.95	0.95	0.35	0.32	0.60	0.58	0.33	0.30	0.33	0.29
SE	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.00
D-W stat.	1.42	1.32	2.08	2.24	2.51	2.28	2.32	2.15	1.81	1.76
Observations	35	35	49	49	28	28	49	49	49	49

Note: Standard errors in parenthesis. The constant is not reported. System observations are 616. ** and * mean coefficients are significant at 1% and 5% level. The coefficients significant at 10% are bolded.

TABLE 5 VALUES OF PARAMETERS IN THE SIMULATION

	China	Taiwan	Hong Kong	US	Japan
δ	$\delta_1 = 0.5$	$\delta_2 = 0.5$	$\delta_3 = 0.5$	$\delta_1^* = 0.11$	$\delta_2^* = 0.08$
γ	$\gamma_1 = 0.35$	$\gamma_2 = 0.15$	$\gamma_3 = 0.01$	$\gamma_1^* = 0.50$	$\gamma_2^* = 0.07$
η	$\eta_1 = 0.06$	$\eta_2 = 0.01$	$\eta_3 = 0.30$	$\eta_1^* = 0.05$	$\eta_2^* = 0.06$
ρ	$\rho_1 = 0.33$ $\rho_2 = 0.1$	$\rho_3 = 0.26$ $\rho_4 = 0.36$ $\rho_5 = 0.07$	$\rho_6 = 0.01$ $\rho_7 = 2.71$ $\rho_8 = 0.11$	$\rho_1^* = 0.16$	$\rho_2^* = 0.01$ $\rho_3^* = 0.29$
$\tilde{\lambda}$	$\tilde{\lambda}_1^{cn} = 0.08$ $\tilde{\lambda}_2^{cn} = 0.53$ $\tilde{\lambda}_3^{cn} = 0.15$	$\tilde{\lambda}_1^{tw} = 0.03$ $\tilde{\lambda}_2^{tw} = 0.18$ $\tilde{\lambda}_3^{tw} = 0.13$	$\tilde{\lambda}_1^{hk} = 0.003$ $\tilde{\lambda}_2^{hk} = 0.26$ $\tilde{\lambda}_3^{hk} = 0.20$	$\tilde{\lambda}_1^{us} = 0$ $\tilde{\lambda}_2^{us} = 0.07$ $\tilde{\lambda}_3^{us} = 0.3$	$\tilde{\lambda}_1^{jp} = 0.01$ $\tilde{\lambda}_2^{jp} = 0.04$ $\tilde{\lambda}_3^{jp} = 0.26$
ν	$\nu^{cn} = 0.69$	$\nu^{tw} = 0.20$	$\nu^{hk} = 0.11$		
ω	$\omega_{11} = 0.32$ $\omega_{12} = 0.31$ $\omega_{13} = 0.27$ $\omega_{14} = 0.10$ $\omega_{15} = 0$	$\omega_{21} = 0.32$ $\omega_{22} = 0.30$ $\omega_{23} = 0.23$ $\omega_{24} = 0.15$ $\omega_{25} = 0$	$\omega_{31} = 0.19$ $\omega_{32} = 0.12$ $\omega_{33} = 0.16$ $\omega_{34} = 0.53$ $\omega_{35} = 0$		$\omega_{21}^* = 0.5$ $\omega_{22}^* = 0.3$ $\omega_{23}^* = 0.2$
Φ	$\Phi_s^{cn} = 857.69$ $\Phi_i^{cn} = 358.8$ $\Phi_{fr}^{cn} = 115.72$	$\Phi_s^{tw} = 6905.94$ $\Phi_i^{tw} = 16.19$ $\Phi_{fr}^{tw} = 2096.26$	$\Phi_s^{hk} = 752687.36$ $\Phi_i^{hk} = 75.36$ $\Phi_{fr}^{hk} = 347.59$		$\Phi_s^{jp} = 1213.13$ $\Phi_i^{jp} = 201.96$ $\Phi_{fr}^{jp} = 789.39$
ψ	$\psi^{cn} = 0.5$	$\psi^{tw} = 0.5$	$\psi^{hk} = 0.5$		$\psi^{jp} = 0.07$
σ	$\sigma^{cn} = 1$	$\sigma^{tw} = 5$	$\sigma^{hk} = 10$		$\sigma^{jp} = 10$
ξ	$\xi^{cn} = 10$	$\xi^{tw} = 5$	$\xi^{hk} = 1$		$\xi^{jp} = 1$
α	$\alpha_1 = 2$	$\alpha_2 = 2$	$\alpha_3 = 2$	$\alpha_4 = 2$	$\alpha_5 = 2$
β	$\beta_1 = 5$	$\beta_2 = 5$	$\beta_3 = 5$	$\beta_4 = 5$	$\beta_5 = 5$
χ	$\chi_1 = 2.5$	$\chi_2 = 2.5$	$\chi_3 = 2.5$	$\chi_4 = 2.5$	$\chi_5 = 2.5$
ζ	$\zeta_1 = 2.5$	$\zeta_2 = 2.5$	$\zeta_3 = 2.5$	$\zeta_4 = 2.5$	$\zeta_5 = 2.5$
θ	$\theta = 0.15$	$\theta = 0.15$	$\theta = 0.15$	$\theta = 0.15$	$\theta = 0.15$
τ	$\tau^{cn} = 0.2$	$\tau^{tw} = 0.2$	$\tau^{hk} = 0.2$	$\tau^{us} = 0.2$	$\tau^{jp} = 0.2$

Note: $\tilde{\lambda}_1^{eu} = 0.004$ $\tilde{\lambda}_2^{eu} = 0.09$ $\tilde{\lambda}_3^{eu} = 0.10$, respectively according to our OLS estimation. The values of ν^i are based on the ratios of GDP of each CEA economy over the CEA's GDP in 2000.

TABLE 6 OPTIMAL COSTS UNDER THE U.S. PRICE SHOCK (DIVIDED BY 100)

	Non-Cooperative	Full Cooperation	CEA cooperation	China-H.K Coalition
China	0.0513	0.047	0.0658	0.0644
	(0.0998)	(0.1158)	(0.0983)	(0.098)
Taiwan	0.0782	0.06	0.1008	0.1079
	(0.1559)	(0.1559)	(0.1781)	(0.1631)
Hong Kong	0.1826	0.3045	0.1765	0.1423
	(0.1968)	(0.2901)	(0.1903)	(0.1667)
U.S.	0.0724	0.1122	0.0723	0.0728
	(0.0724)	(0.1024)	(0.0724)	(0.0724)
Japan	0.0199	0.0158	0.0249	0.0271
	(0.0069)	(0.0069)	(0.0069)	(0.0110)
Average		0.1079	0.1144	0.1034
		(0.1342)	(0.1556)	(0.1324)

Note: In Tables 8-13, Columns identify policy regimes; rows 2 to 6 indicate the policy-makers' optimal losses while row 7 shows the average optimal loss of each coalition member. Values of the optimal losses in the robust test are shown in parenthesis.

TABLE 7 OPTIMAL COSTS UNDER THE CHINA'S PRICE SHOCK (DIVIDED BY 100)

	Non-Cooperative	Full Cooperation	CEA cooperation	China-H.K Coalition
China	0.5311	0.6177	0.4456	0.4494
	(0.3843)	(0.3986)	(0.3814)	(0.3821)
Taiwan	0.7154	0.7743	0.7611	0.6789
	(0.6039)	(0.6039)	(0.6261)	(0.6111)
Hong Kong	0.4656	0.6546	0.4551	0.4026
	(0.4283)	(0.5642)	(0.4193)	(0.3854)
U.S.	0	0.0083	8.2852e-006	0.0028
	(0)	(0.0051)	(7.6526e-006)	(0)
Japan	0.0333	0.0405	0.0274	0.0340
	(0.0011)	(0.0011)	(0.0011)	(0.0052)
Average		0.4190	0.5539	0.426
		(0.3146)	(0.4756)	(0.3838)

TABLE 8A OPTIMAL COSTS UNDER CHINA'S ASYMMETRIC POLICY PREFERENCE (DIVIDED BY 100)

	Non-Cooperative	Full Cooperation	CEA cooperation	China-H.K Coalition
China	0.0257	0.0235	0.0329	0.0322
	(0.0499)	(0.0579)	(0.0492)	(0.0490)
Taiwan	0.0782	0.0600	0.1008	0.1079
	(0.1559)	(0.1559)	(0.1781)	(0.1631)
Hong Kong	0.1826	0.3045	0.1765	0.1423
	(0.1968)	(0.2901)	(0.1903)	(0.1667)
U.S.	0.0724	0.1122	0.0723	0.0728
	(0.0724)	(0.1024)	(0.0724)	(0.0724)
Japan	0.0199	0.0158	0.0249	0.0271
	(0.0069)	(0.0069)	(0.0069)	(0.0110)
Average		0.1032	0.1034	0.0873
		(0.1226)	(0.1392)	(0.1079)

Note: Assume there is a price shock in the U.S.

TABLE 8B OPTIMAL COSTS UNDER CHINA'S ASYMMETRIC POLICY PREFERENCE (DIVIDED BY 100)

	Non-Cooperative	Full Cooperation	CEA cooperation	China-H.K Coalition
China	0.2655	0.3088	0.2228	0.2247
	(0.1922)	(0.1993)	(0.1907)	(0.1911)
Taiwan	0.7154	0.7743	0.7611	0.6789
	(0.6039)	(0.6039)	(0.6261)	(0.6111)
Hong Kong	0.4656	0.6546	0.4551	0.4026
	(0.4283)	(0.5642)	(0.4193)	(0.3854)
U.S.	0	0.0083	8.2852e-006	0.0028
	(0)	(0.0051)	(7.6526e-006)	(0)
Japan	0.0333	0.0405	0.0274	0.0340
	(0.0011)	(0.0011)	(0.0011)	(0.0052)
Average		0.3573	0.4797	0.3137
		(0.2747)	(0.4120)	(0.2883)

Note: Assume there is a price shock in China

TABLE 9 OPTIMAL COSTS UNDER THE FOREIGN EXCHANGE RATE SHOCK (DIVIDED BY 100)

	Non-Cooperative	Full Cooperation	CEA cooperation	China-H.K Coalition
China	1.5266	1.6617	1.3779	1.3850
	(1.2222)	(1.2382)	(1.2149)	(1.2164)
Taiwan	2.1611	2.2611	2.2227	2.0861
	(1.9241)	(1.9241)	(1.9463)	(1.9313)
Hong Kong	1.3640	1.6797	1.3453	1.2579
	(1.2999)	(1.5333)	(1.2854)	(1.228)
U.S.	0	0.0083	8.2852e-006	0.0028
	(0)	(0.0051)	(7.6526e-006)	(0)
Japan	0.018	0.0226	0.0138	0.0197
	(0.0538)	(0.0538)	(0.0538)	(0.0579)
Average		1.1267	1.6486	1.3215
		(0.9509)	(1.4822)	(1.2222)

TABLE 10 OPTIMAL COSTS UNDER THE U.S. MONETARY POLICY CHANGE (DIVIDED BY 100)

	Non-Cooperative	Full Cooperation	CEA cooperation	China-H.K Coalition
China	0.0513	0.0486	0.0658	0.0644
	(0.0998)	(0.1165)	(0.0983)	(0.098)
Taiwan	0.0782	0.0616	0.1008	0.1079
	(0.1559)	(0.1559)	(0.1781)	(0.1631)
Hong Kong	0.1826	0.2843	0.1765	0.1423
	(0.1968)	(0.2742)	(0.1903)	(0.1667)
U.S.	0.0724	0.1092	0.0723	0.0728
	(0.0724)	(0.0997)	(0.0724)	(0.0724)
Japan	0.0199	0.016	0.0249	0.0271
	(0.0069)	(0.0069)	(0.0069)	(0.0110)
Average		0.1039	0.1144	0.1034
		(0.1306)	(0.1556)	(0.1324)

Note: Assume there is a price shock in the U.S.

TABLE 11 OPTIMAL COSTS UNDER THE ASYMMETRIC BARGAINING POWERS (DIVIDED BY 100)

	Non-Cooperative	Full Cooperation	CEA cooperation	China-H.K Coalition
China	0.0513	0.0480	0.0658	0.0643
	(0.0998)	(0.1072)	(0.0982)	(0.0979)
Taiwan	0.0782	0.0674	0.0986	0.1042
	(0.1559)	(0.1559)	(0.1734)	(0.1591)
Hong Kong	0.1826	0.2387	0.1698	0.1421
	(0.1968)	(0.2335)	(0.1836)	(0.1667)
U.S.	0.0724	0.0923	0.0723	0.0728
	(0.0724)	(0.0861)	(0.0724)	(0.0724)
Japan	0.0199	0.0173	0.0249	0.0255
	(0.0069)	(0.0069)	(0.0069)	(0.0090)
Average		0.0927	0.1114	0.1032
		(0.1179)	(0.1517)	(0.1323)

Note: Assume there is a price shock in the U.S.

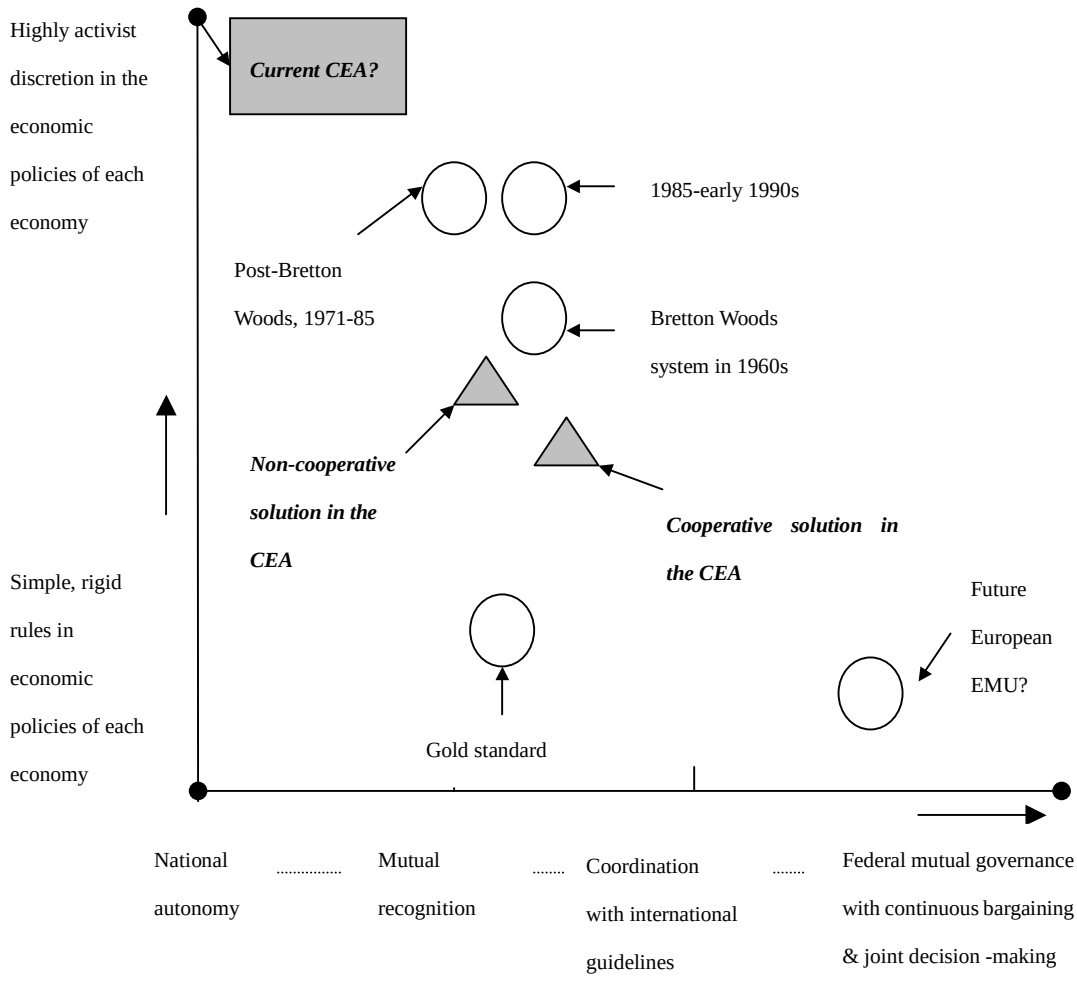


FIGURE 1 DEFINITION OF THE CERM IN THIS PAPER

Source: Bryant (1995); authors' argument

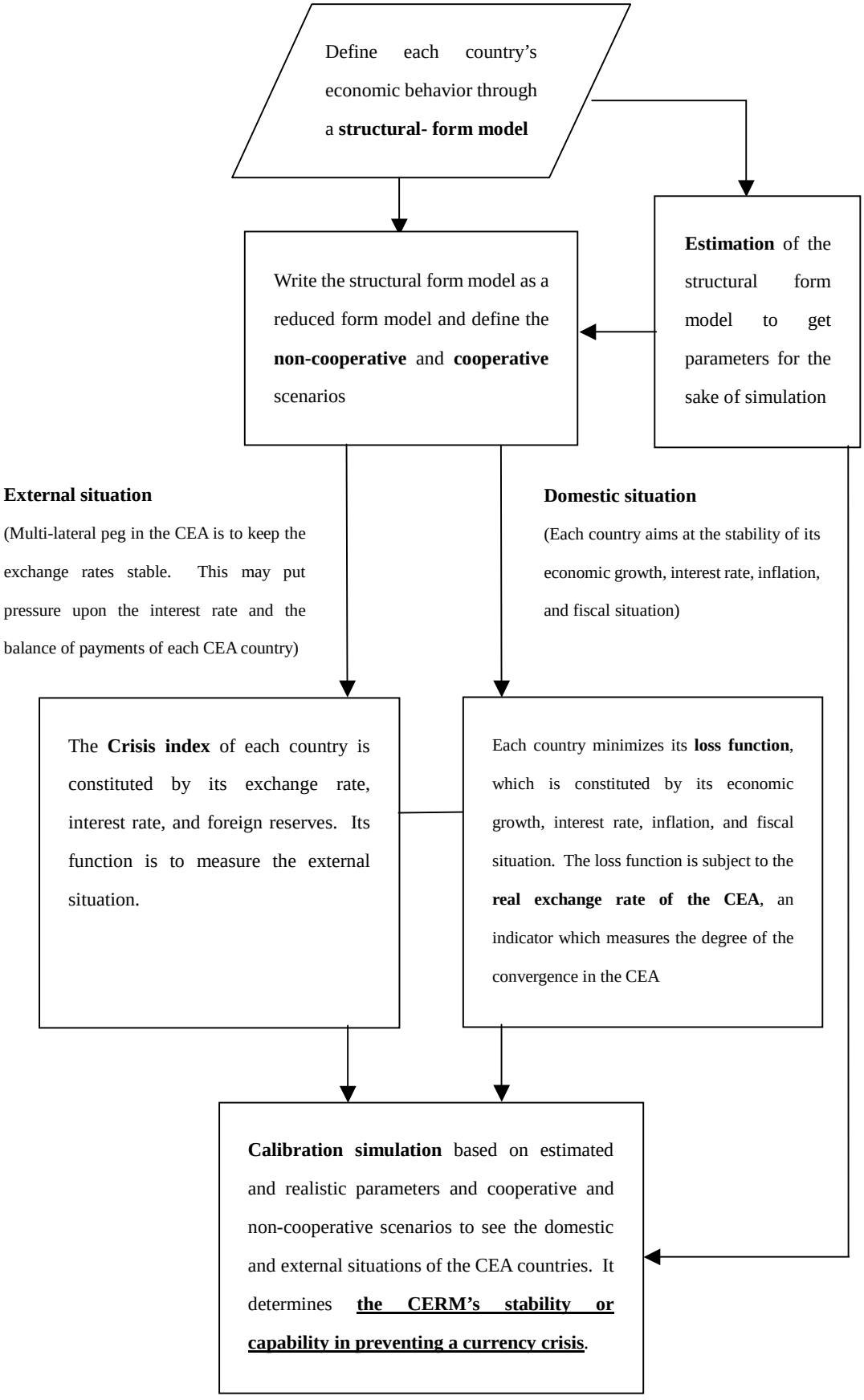
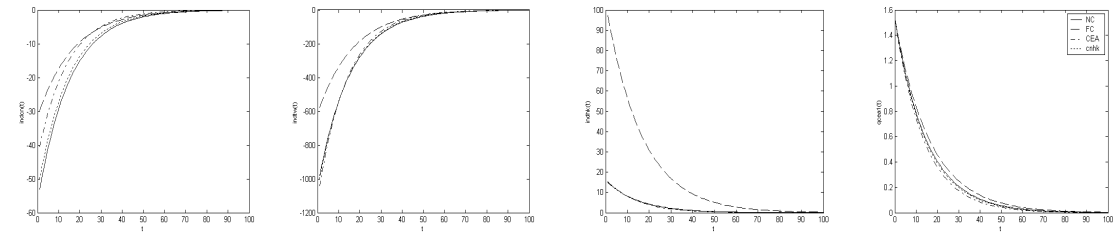


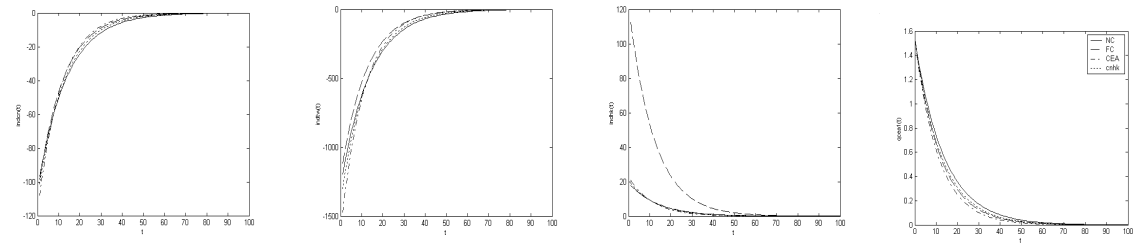
FIGURE 2 THE ECONOMIC MODELING OF THIS PAPER

Note: (a): crisis index of China; (b): crisis index of Taiwan; (c): crisis index of Hong Kong; (d): q^{CEA}



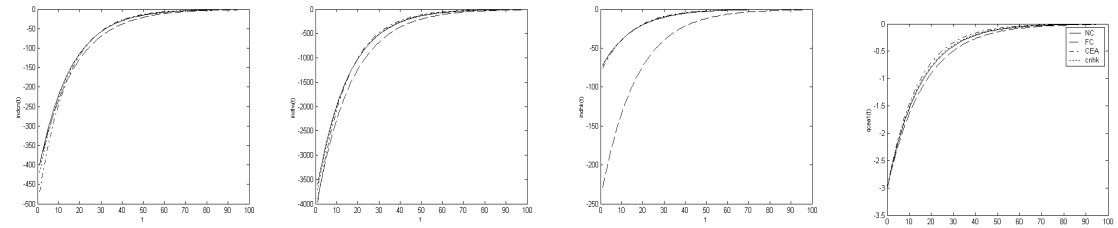
(a) (b) (c) (d)

FIGURE 3 THE PRICE SHOCK FROM THE U.S



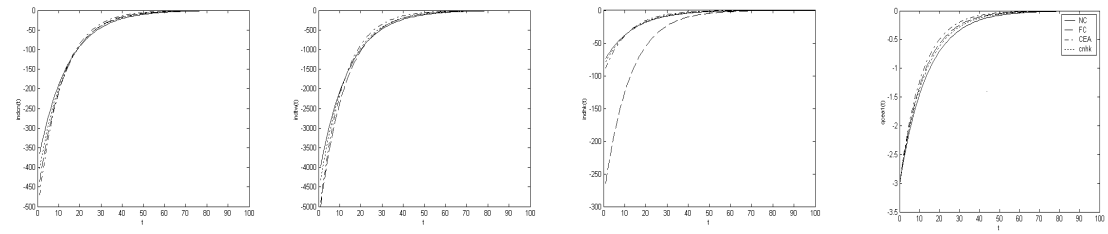
(a) (b) (c) (d)

FIGURE 4 THE PRICE SHOCK FROM THE U.S (ROBUST TEST)



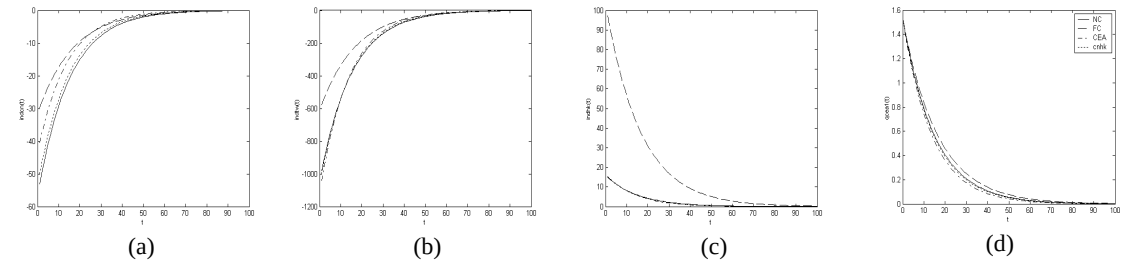
(a) (b) (c) (d)

FIGURE 5 THE PRICE SHOCK FROM CHINA



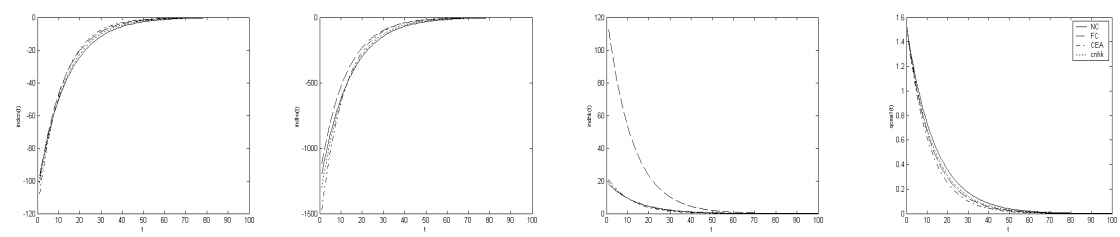
(a) (b) (c) (d)

FIGURE 6 THE PRICE SHOCK FROM CHINA (ROBUST TEST)



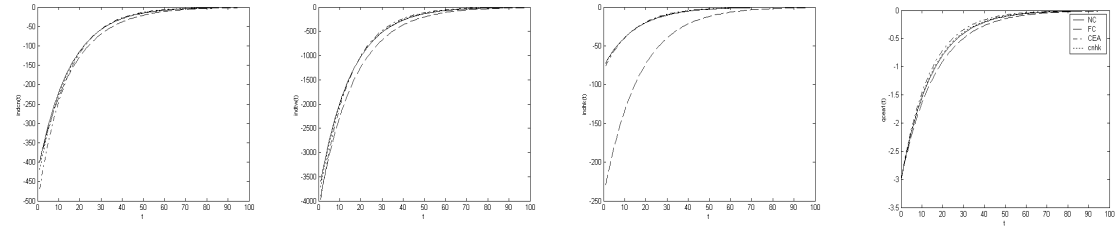
(a) (b) (c) (d)

FIGURE 7A CHINA'S ASYMMETRIC POLICY PREFERENCE (THE U.S. PRICE SHOCK)



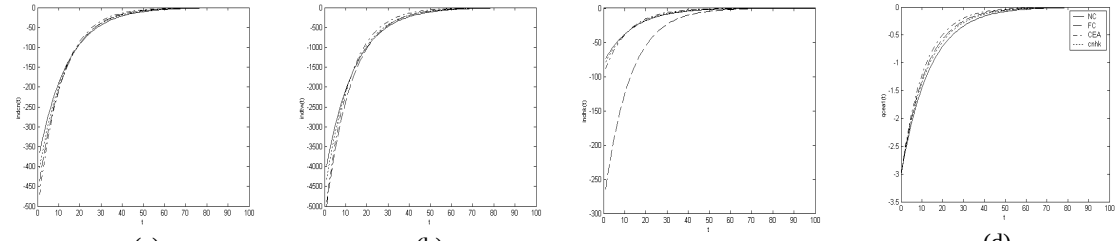
(a) (b) (c) (d)

FIGURE 7B CHINA'S ASYMMETRIC POLICY PREFERENCE (ROBUST TEST OF THE U.S. PRICE SHOCK)



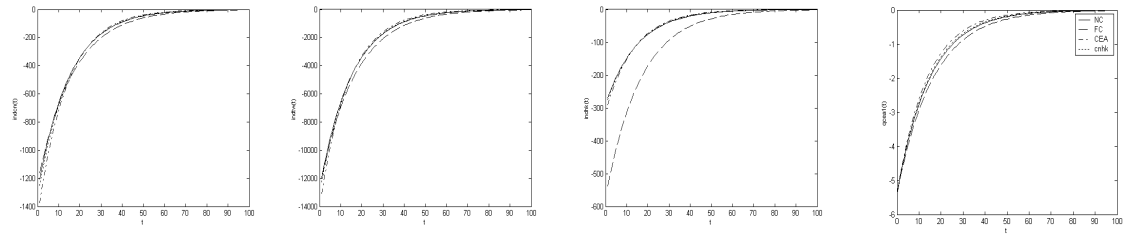
(a) (b) (c) (d)

FIGURE 8A CHINA'S ASYMMETRIC POLICY PREFERENCE (THE CHINA'S PRICE SHOCK)



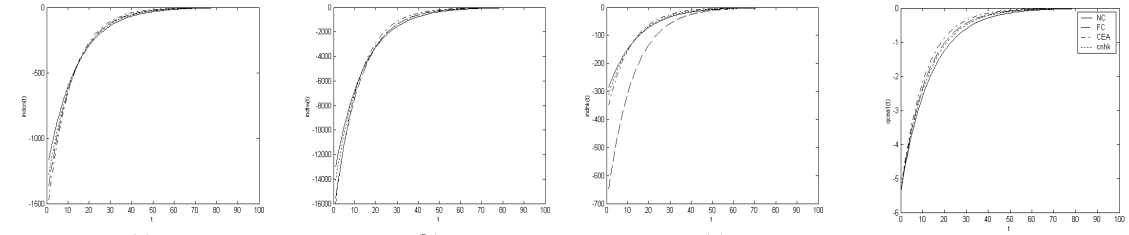
(a) (b) (c) (d)

FIGURE 8B CHINA'S ASYMMETRIC POLICY PREFERENCE (ROBUST TEST OF THE CHINA'S PRICE SHOCK)



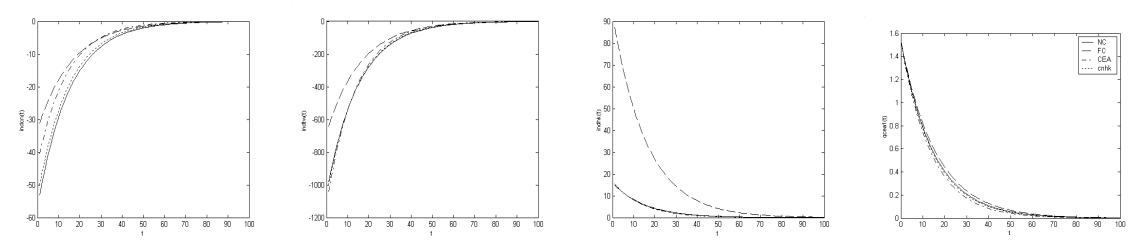
(a) (b) (c) (d)

FIGURE 9 CHANGES IN THE CROSS-EXCHANGE RATES



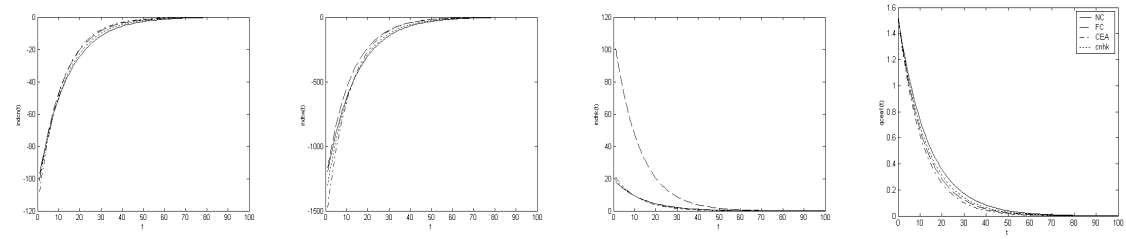
(a) (b) (c) (d)

FIGURE 10 CHANGES IN THE CROSS-EXCHANGE RATES (ROBUST TEST)



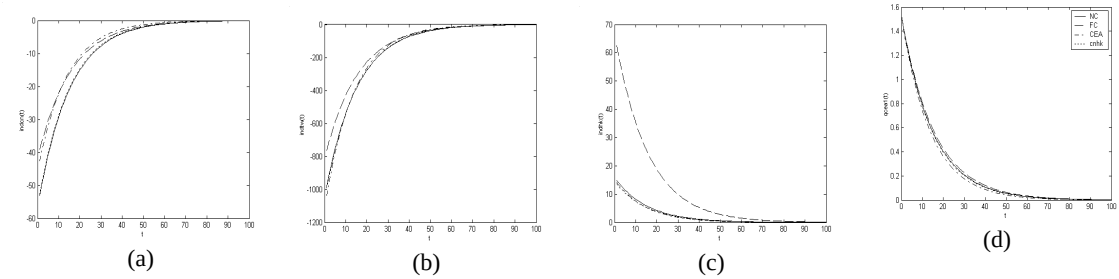
(a) (b) (c) (d)

FIGURE 11 CHANGES IN THE U.S. MONETARY POLICY



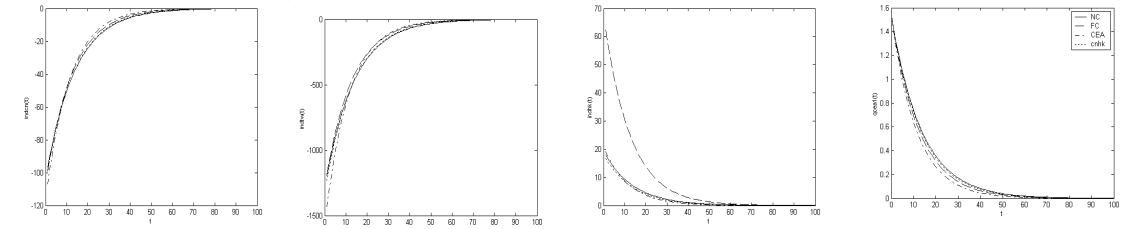
(a) (b) (c) (d)

FIGURE 12 CHANGES IN THE U.S. MONETARY POLICY (ROBUST TEST)



(a) (b) (c) (d)

FIGURE 13 CHANGES IN THE BARGAINING POWERS



(a) (b) (c) (d)

FIGURE 14 CHANGES IN THE BARGAINING POWERS (ROBUST TEST)

Appendix 1 Recent Events and Comments about Asian or Chinese Economic Cooperation

Optimistic

(1) Joseph Stiglitz (RIETI Symposium, Japan, April 22, 2002):

i. Asian monetary integration is the foundation to establish a new global financial system. Asian counties have the ability to start the reform because of their huge foreign reserves.

ii. The idea of Asian Monetary Fund (AMF) was not feasible because of the objection by the United States. Asian countries should be devoted to Asian monetary and trade integration to deal with the problems caused by the current U.S. dominant financial system.

(2) ASEAN+China (10+1):

The Brunei Summit (November 6, 2001): The leaders of ASEAN 10 and China have agreed to establish the "China-ASEAN" free trade area in the next decade. It is estimated that this free trade area will increase the economic growth rates of ASEAN and China to 1% and 0.3%, respectively.

(3) ***Japan***:

i. Katoh (the chief of the Japanese Liberal Democratic Party, 1999.6): In view of the difficult process of European integration, we need more efforts to construct an "**Asian common currency**" due to the huge economic gaps among Asian countries.

ii. Japanese government (1997, 2000.5): Japanese government will advocate an "**Asian currency stability fund**" and cooperate with ASEAN, China, and South Korea in constructing a financing mechanism to avoid currency crises. The Minister of Finance, Miyazawa, claims that the necessary fund may amount to several thousands of millions U.S. dollars.

(4) ***The Philippines***:

The former president J. Estrada (1999.6) says that the **single currency** can not only accelerate regional integration, but also stabilize Asian economies through monetary and fiscal policy coordination among individual governments.

(5) ***Malaysia***:

The prime minister Mahathir Mohammad (1999.6) emphasizes that Asia should not totally follow European or American political and economic systems, but make use of Asia's own advantages. Moreover, although Chinese exchange rate stability benefited other Asian economies during the 1997 Asian financial crises, the **Japanese yen** will be more suitable for the third international currency than the **Chinese Renminbi**, for the latter is impossible to be a financing tool in Asian economies

(6) ***Taiwan***:

i. Peng, Huai-nan (the president of Central Bank of Taiwan, 1999.3, 1999.5): an **Asian single currency** is a good idea in terms of stabilizing Asian financial markets and keeping from financial crises. However, it will be better and feasible if a large economy can play the leading role in realizing this idea.

ii. Dr. Yin, N.P. (1999.5): From a long-term point of view, the idea of an **Asian common currency** is very important since it is closely related to Asian-Pacific competitiveness with European and American countries. Nevertheless, an Asian monetary mechanism and regional integration should be first established before this idea becomes possible.

Pessimistic

(1) ***United States***:

The Secretary of Finance (2000.7) believes that Asian countries should **peg down one single international currency** to prevent the currency crises

(2) ***Japan***:

Mr. Ku (a chief research staff member of Nomura Institute, 1999.5) is convinced that an **Asian common currency is not feasible** in view of the current situations of Asian countries. As is the case of Germany, Japan can be a possible leader of other Asian economies. However, there exist conflicts between Japan and other Asian countries. Moreover, Japan itself depends too heavily on the American market. As to China, it is just an emerging open economy. Too many economic problems still need to be solved in this country.

(3) ***Taiwan***:

The former president Mr. Lee, T.H.(1999.5) points out that an **Asian common currency is extremely dangerous**. He expects that Asia-Pacific Economic Co-operation (APEC) will exert much more influence in the future.

(4) ***China***:

Outlook Weekly (2001.11.5, p.52-55), a periodical sponsored by the Chinese government, enumerates several obstacles to the free trade area between ASEAN, Japan, South Korea, and China: such as nationalism, less open economy of ASEAN, objection from the United States (even Japan and Australia), and lacking mutual trust among members due to the past conflicts. Moreover, ASEAN countries may be unwilling or unable to achieve some necessary conditions of a free trade area. For instance, Mahathir Mohammad rejects an open Malaysian automobile market to foreign countries.

Conditional

(1) ***International Monetary Fund (IMF)*** (2000.3): The key to an "Asian Monetary Fund" (AMF) is **whether it will be consistent with IMF's policies**, no matter what its details are.

(2) ***Robert. Mundell*** (2000a, b; *Commercial Times* (in Chinese), 2001.10.17; 10.21):

i. The idea of an international currency system will be a trend in the next decade. However, it is not the right time for Asia or APEC to have a single currency, since all necessary conditions to establish a monetary union[95] are still not available among Asian countries.

ii. **If all currencies peg down and exchange an international currency directly, then all countries can still keep their own currencies and do not need to establish a single currency**. It seems impossible for Asia to pursue the European-style integration due to various political problems. Some sub-areas in which countries have close economic links to one another can establish international currency systems first. It will be helpful to improve the whole Asian stability and growth. The Great

[95] The necessary conditions include a common acceptable inflation rate, a common formula to compute an inflation index, a common exchange rate, and a common monetary policy.

Chinese Economic Area fits the above condition. **It will be possible to establish a currency area in which the Chinese Renminbi becomes the central currency, as long as the Chinese economy keeps growing in the future**.[96]

iii. An **Asian Monetary Fund** could, however, serve as the catalyst in constructive political development and might eventually pave the way to a viable Asian currency area. The common inflation and inflation target may cause some problems for those Asian countries which have different business cycles. Nevertheless, the contribution of the single currency in stabilizing the economies will exceed its negative impact.

(2) Lau, L. (2001):

i. A stable exchange rate encourages long-term foreign portfolio and direct investment by United States and other investors with currencies pegged to the U.S dollar and promotes economic integration. Taiwan has ample foreign reserves to make dollarization or a currency board work.

ii. Hot money flows as well as political developments can easily disrupt the foreign exchange market in Taiwan. There are lots of advantages for Taiwan to adopt dollarization or a currency board, such as removal of the uncertainty in trade and investment, and the reduction of the exchange rate risk.

(3) Asian Policy Forum (Constituted by 17 institutes in the Asian Development Bank) (1999.7):

i. The best way for Asian countries to keep from currency crises is **to peg down a basket of currencies**[97] which contain the currencies of their main trading partners. **The limited floating exchange rate policy** will be better for Asian countries to maintain their competitiveness and to avoid exchange rate volatility caused by capital flows.

ii. **Establish a "Regional Financial Arrangement, RFA**" and execute relative work in each Asian country. A RFA should be a good complement to the International Monetary Fund.

Sources: Mundell (2000a, 2000b); Lawrence Lau (2001); China Times; Commercial Times, various issues.

Appendix 2 Derivation of the Open Economy Phillips Curve in Equation (5)

Following Ashenfelter (1984) and DiNardo and Moore (1999), we construct the standard open economy Phillips curve in continuous time.

$$\dot{p}_d^i(t) = \upsilon^i \dot{p}^i(t) + \tilde{\xi}^i y^i(t) \tag{A1}$$

where $\dot{p}_d^i$ is defined as domestic inflation. In theory υ and $\tilde{\xi}$ are nonnegative coefficients of CPI inflation and output. The intuition of the standard equation is that the domestic price setting depends on domestic nominal wages, and the latter depend on CPI inflation because workers care about their real consumption wage. Note that we do not take some items into account for simplicity, such as country-specific factors and the common supply shock.

Moreover, assume inflation in non-tradables is equal to the domestic inflation and inflation in tradables is equal to the world CPI inflation, respectively. We can get the CPI of the country by the weighted average

$$\dot{p}^i(t) = \lambda^i \dot{p}_d^i(t) + (1-\lambda^i)\dot{p}^w(t) \qquad 0 < \lambda^i < 1 \tag{A2}$$

[96] The Chinese authorities still hold an optimistic view for the future Chinese economic growth. Mr. Shih, G., the Minister of International Trade, says that Chinese economy will keep a 7% growth rate in the future five years, despite the recession in international trade and the forthcoming problems after China joins the WTO. See *Commercial Times* (in Chinese), 2001. 10.31.

[97] Note that it is consistent with Williamson (1999).

where λ denotes the share of consumption devoted to non-tradables.

Substitute (A2), (3) and uncovered interest rate parity condition $i^i(t)=i^{us}(t)+\dot{s}^{ius}(t)$ into (A1), the relationship between CPI and domestic output can be shown as

$$\dot{p}^i(t)=\frac{1}{1-\upsilon^i\lambda^i}(i^i(t)-i^{us}(t)-\dot{s}^{ius}(t))+\frac{\lambda^i(1-\lambda^i)}{1-\upsilon^i\lambda^i}\dot{p}^w(t)+\frac{\tilde{\xi}^i\lambda^i}{1-\upsilon^i\lambda^i}y^i(t) \qquad \text{(A3)}$$

Note that from (A1), (1) and (3) we know

$$\frac{\partial \dot{p}_d^i(t)}{\partial \dot{p}^i(t)}=\upsilon^i+\frac{\partial y^i(t)}{\partial \dot{p}^i(t)}$$

where $\frac{\partial y^{cn}(t)}{\partial \dot{p}^{cn}(t)}=\gamma_1$, $\frac{\partial y^{tw}(t)}{\partial \dot{p}^{tw}(t)}=\gamma_2$, $\frac{\partial y^{hk}(t)}{\partial \dot{p}^{hk}(t)}=\gamma_3$, $\frac{\partial y^{us}(t)}{\partial \dot{p}^{us}(t)}=\gamma_1^*$,

$$\frac{\partial y^{jp}(t)}{\partial \dot{p}^{jp}(t)}=\gamma_2^*$$

We skip the details and just concentrate on the case of China. From (A2) the partial derivative of CPI inflation with respect to the domestic inflation is

$$\frac{\partial \dot{p}^{cn}(t)}{\partial \dot{p}_d^{cn}(t)}=\lambda^{cn}+(1-\lambda^{cn})\tilde{\varphi}^{cn}=\frac{1}{\upsilon^{cn}+\gamma_1} \qquad \textit{Assume that} \quad \frac{\partial \dot{p}^w(t)}{\partial \dot{p}_d^{cn}(t)}=\tilde{\varphi}^{cn}$$

We can get

$$1-\upsilon^{cn}\lambda^{cn}=\frac{\gamma_1-\tilde{\varphi}^{cn}(1-\upsilon^{cn})(\upsilon^{cn}+\gamma_1)}{(\upsilon^{cn}+\gamma_1)(1-\tilde{\varphi}^{cn})}$$

It is hard to define whether $1-\upsilon^{cn}\lambda^{cn}>0$ or $1-\upsilon^{cn}\lambda^{cn}<0$ without sufficient information. So far empirical work (e.g., DiNardo and Moore, 1999) has not been able to confirm the values and signs of the coefficients in (A3) for each economy. However, we expect that values of $\tilde{\varphi}^i$ in the CEA members are smaller than those of the U.S., Japan and Europe. For instance, assume $\tilde{\varphi}^{cn}\to 0$, $1-\upsilon^{cn}\lambda^{cn}>0$, which promises the coefficients in Chinese open economy Phillips curve are all positive.

Finally, (A3) can be shown with suitable definitions of parameters

$$\dot{p}^i(t)=\tilde{\lambda}_1^i RP^i(t)+\tilde{\lambda}_2^i \dot{p}^w(t)+\tilde{\lambda}_3^i y^i(t) \tag{5}$$

in which we define $RP^i(t) \coloneqq i^i(t)-i^{us}(t)-\dot{s}^{ius}(t)$.

Appendix 3 Parameters of Equation (6)

In this appendix we show how to derive (6). Here we just show the case of China.

$$y^{cn}(t)=\delta_1 q^{CEA}(t)-\gamma_1 r^{cn}(t)+\eta_1 f^{cn}(t)+\rho_1 y^{us}(t)+\rho_2 y^{jp}(t) \tag{1a}$$

First, substitute (3), Chinese, Japanese and the U.S. Phillips curves in (5) into (1a), (1d) and (1e), then substitute (1d) and (1e) into (1a). Define

$$\kappa_1=\frac{1}{1-\gamma_1^*\tilde{\lambda}_3^{us}} \qquad \kappa_2=\frac{1}{1-\gamma_2^*\tilde{\lambda}_3^{jp}} \qquad \kappa_3=\frac{1}{(1-\gamma_1\tilde{\lambda}_3^{cn}-\rho_2\kappa_2\rho_3^*)}$$

After rearranging (1a') we can get (6a')

$$\begin{aligned} y^{cn}(t)=\kappa_3\{&\delta_1 q^{CEA}(t)-\gamma_1(1-\tilde{\lambda}_1^{cn})i^{cn}(t)-[\gamma_1^*(\rho_1\kappa_1+\kappa_1\kappa_2\rho_2\rho_2^*)+\kappa_2\rho_2\gamma_2^*\tilde{\lambda}_1^{jp}+\gamma_1\tilde{\lambda}_1^{cn}]i^{us}(t) \\ &-\gamma_1\tilde{\lambda}_1^{cn}\dot{s}^{cnus}(t)+[\gamma_1^*\tilde{\lambda}_2^{us}(\rho_1\kappa_1+\kappa_1\kappa_2\rho_2\rho_2^*)+\kappa_2\rho_2\gamma_2^*\tilde{\lambda}_2^{jp}+\gamma_1\tilde{\lambda}_2^{cn}]p^w(t) \\ &+\eta_1 f^{cn}(t)+\kappa_2\rho_2\delta_2^* q^{jp}(t)-\gamma_2^*\kappa_2\rho_2(1-\tilde{\lambda}_1^{jp})i^{jp}(t)-\gamma_2^*\kappa_2\rho_2\tilde{\lambda}_1^{jp}\dot{s}^{jpus}(t) \\ &+\eta_2^*\kappa_2\rho_2 f^{jp}(t)+\delta_1^*(\rho_1\kappa_1+\kappa_1\kappa_2\rho_2\rho_2^*)q^{us}(t)+\eta_1^*(\rho_1\kappa_1+\kappa_1\kappa_2\rho_2\rho_2^*)f^{us}(t) \\ &+\rho_1^*(\rho_1\kappa_1+\kappa_1\kappa_2\rho_2\rho_2^*)y^w(t) \end{aligned} \tag{6a'}$$

Following the same steps we get the rest of equations of (6). All parameters in (6) are as follows

$\kappa \coloneqq$

$$\kappa_1=\frac{1}{1-\gamma_1^*\tilde{\lambda}_3^{us}} \quad \kappa_2=\frac{1}{1-\gamma_2^*\tilde{\lambda}_3^{jp}} \quad \kappa_3=\frac{1}{(1-\gamma_1\tilde{\lambda}_3^{cn}-\rho_2\kappa_2\rho_3^*)} \quad \kappa_4=\frac{1}{1-\gamma_2\tilde{\lambda}_3^{tw}} \quad \kappa_5=\frac{1}{1-\gamma_3\tilde{\lambda}_3^{hk}}$$

$a \coloneqq$

$$a_1=\kappa_3\eta_1 \quad a_2=\kappa_3\eta_1^*(\rho_1\kappa_1+\kappa_1\kappa_2\rho_2\rho_2^*) \quad a_3=\kappa_2\kappa_3\rho_2\eta_2^* \quad a_4=\kappa_4(\rho_3 a_1+\rho_5 a_{13}) \quad a_5=\kappa_4\eta_2$$
$$a_6=\kappa_4(\rho_3 a_2+\rho_4 a_{12}+\rho_5 a_{14}) \quad a_7=\kappa_4(\rho_3 a_3+\rho_5 a_{15}) \quad a_8=\kappa_5(\rho_6 a_1+\rho_8 a_{13}) \quad a_9=\kappa_5\eta_3$$
$$a_{10}=\kappa_5(\rho_6 a_2+\rho_7 a_{12}+\rho_8 a_{14}) \quad a_{11}=\kappa_5(\rho_6 a_3+\rho_8 a_{15}) \quad a_{12}=\kappa_1\eta_1^* \quad a_{13}=\kappa_2\rho_3^* a_1$$
$$a_{14}=\kappa_2(\rho_2^* a_{12}+\rho_3^* a_2) \quad a_{15}=\kappa_2(\eta_2^*+\rho_3^* a_3)$$

$b :=$

$b_1 = \kappa_3 \delta_1 \quad b_2 = \kappa_3 \delta_1^* (\rho_1 \kappa_1 + \kappa_1 \kappa_2 \rho_2 \rho_2^*) \quad b_3 = \kappa_2 \kappa_3 \rho_2 \delta_2^* \quad b_4 = \kappa_4 (\delta_2 + \rho_3 b_1 + \rho_5 b_{11})$

$b_5 = \kappa_4 (\rho_3 b_2 + \rho_4 b_{10} + \rho_5 b_{12}) \quad b_6 = \kappa_4 (\rho_3 b_3 + \rho_5 b_{13}) \quad b_7 = \kappa_5 (\delta_3 + \rho_6 b_1 + \rho_8 b_{11})$

$b_8 = \kappa_5 (\rho_6 b_2 + \rho_7 b_{10} + \rho_8 b_{12}) \quad b_9 = \kappa_5 (\rho_6 b_3 + \rho_8 b_{13}) \quad b_{10} = \kappa_1 \delta_1^*$

$b_{11} = \kappa_2 \rho_3^* b_1 \quad b_{12} = \kappa_2 (\rho_3^* b_2 + \rho_2^* b_{10}) \quad b_{13} = \kappa_2 (\rho_3^* b_3 + \delta_2^*)$

$c :=$

$c_1 = \kappa_3 \gamma_1 (1 - \tilde{\lambda}_1^{cn}) \quad c_2 = \kappa_3 [\gamma_1 \tilde{\lambda}_1^{cn} + \rho_2 \kappa_2 \gamma_2^* \tilde{\lambda}_1^{jp} + \gamma_1^* (\rho_1 \kappa_1 + \kappa_1 \kappa_2 \rho_2 \rho_2^*)] \quad c_3 = \kappa_2 \kappa_3 \rho_2 \gamma_2^* (1 - \tilde{\lambda}_1^{jp})$

$c_4 = \kappa_4 (\rho_3 c_1 + \rho_5 c_{13}) \quad c_5 = \gamma_2 \kappa_4 (1 - \tilde{\lambda}_1^{tw}) \quad c_6 = \kappa_4 (\gamma_2 \tilde{\lambda}_1^{tw} + \rho_3 c_2 + \rho_4 c_{12} + \rho_5 c_{14}) \quad c_7 = \kappa_4 (\rho_3 c_3 + \rho_5 c_{15})$

$c_8 = \kappa_5 (\rho_6 c_1 + \rho_8 c_{13}) \quad c_9 = \gamma_3 \kappa_5 (1 - \tilde{\lambda}_1^{hk}) \quad c_{10} = \kappa_5 (\gamma_3 \tilde{\lambda}_1^{hk} + \rho_6 c_2 + \rho_7 c_{12} + \rho_8 c_{14}) \quad c_{11} = \kappa_5 (\rho_6 c_3 + \rho_8 c_{15})$

$c_{12} = \kappa_1 \gamma_1^* \quad c_{13} = \kappa_2 \rho_3^* c_1 \quad c_{14} = \kappa_2 (\gamma_2^* \tilde{\lambda}_1^{jp} + \rho_2^* c_{12} + \rho_3^* c_2) \quad c_{15} = \kappa_2 [\gamma_2^* (1 - \lambda_1^{jp}) + \rho_3^* c_3]$

$d :=$

$d_1 = \kappa_3 \rho_1^* (\rho_1 \kappa_1 + \kappa_1 \kappa_2 \rho_2 \rho_2^*) \quad d_2 = \kappa_3 [\gamma_1 \tilde{\lambda}_2^{cn} + \rho_2 \kappa_2 \gamma_2^* \tilde{\lambda}_2^{jp} + \gamma_1^* \tilde{\lambda}_2^{us} (\rho_1 \kappa_1 + \kappa_1 \kappa_2 \rho_2 \rho_2^*)] \quad d_3 = \kappa_3 \gamma_1 \tilde{\lambda}_1^{cn}$

$d_4 = \kappa_3 \rho_2 \kappa_2 \gamma_2^* \tilde{\lambda}_1^{jp} \quad d_5 = \kappa_4 (\rho_3 d_1 + \rho_4 d_{15} + \rho_5 d_{17}) \quad d_6 = \kappa_4 (\gamma_2 \tilde{\lambda}_2^{tw} + \rho_3 d_2 + \rho_4 d_{16} + \rho_5 d_{18}) \quad d_7 = \kappa_4 (\rho_3 d_3 + \rho_5 d_{19})$

$d_8 = \kappa_4 (\rho_3 d_4 + \rho_5 d_{20}) \quad d_9 = \kappa_4 \gamma_2 \tilde{\lambda}_1^{tw} \quad d_{10} = \kappa_5 (\rho_6 d_1 + \rho_7 d_{15} + \rho_8 d_{17}) \quad d_{11} = \kappa_5 (\gamma_3 \tilde{\lambda}_2^{hk} + \rho_6 d_2 + \rho_7 d_{16} + \rho_8 d_{18})$

$d_{12} = \kappa_5 (\rho_6 d_3 + \rho_8 d_{19}) \quad d_{13} = \kappa_5 (\rho_6 d_4 + \rho_8 d_{20}) \quad d_{14} = \kappa_5 \gamma_3 \tilde{\lambda}_1^{hk} \quad d_{15} = \kappa_1 \rho_1^* \quad d_{16} = \kappa_1 \gamma_1^* \tilde{\lambda}_2^{us}$

$d_{17} = \kappa_2 (\rho_3^* d_1 + \rho_2^* d_{15}) \quad d_{18} = \kappa_2 (\gamma_2^* \tilde{\lambda}_2^{jp} + \rho_3^* d_2 + \rho_2^* d_{16}) \quad d_{19} = \kappa_2 \rho_3^* d_4 \quad d_{20} = \kappa_2 (\gamma_2^* \tilde{\lambda}_1^{jp} + \rho_3^* d_4)$

Note that in economic theory coefficients of nominal interest rates should be nonnegative, which implies κ should be positive.

Appendix 4 Parameters of Equation (10)

The step to get (10) is to substitute (5) into (9), then differentiate q^{CEA} with respect to time.

$$
\begin{aligned}
\dot{q}^{CEA}(t) &= \phi^T x(t) \\
&= -\phi_1 f^{cn}(t) - \phi_2 f^{tw}(t) - \phi_3 f^{hk}(t) - \phi_4 f^{us}(t) - \phi_5 f^{jp}(t) + \phi_6 i^{cn}(t) \\
&\quad + \phi_7 i^{tw}(t) + \phi_8 i^{hk}(t) + \phi_9 i^{us}(t) + \phi_{10} i^{jp}(t) - \phi_{11} q^{CEA}(t) - \phi_{12} q^{us}(t) \\
&\quad - \phi_{13} q^{jp}(t) - \phi_{14} y^{w}(t) + \phi_{15} y^{eu}(t) - \phi_{16} \dot{p}^{w}(t) + \phi_{17} i^{eu}(t) + \phi_{18} \dot{s}^{cnjp}(t) \\
&\quad + \phi_{19} \dot{s}^{cneu}(t) + \phi_{20} \dot{s}^{twjp}(t) + \phi_{21} \dot{s}^{tweu}(t) + \phi_{22} \dot{s}^{hkjp}(t) + \phi_{23} \dot{s}^{hkeu}(t) \\
&\quad - \phi_{24} \dot{s}^{jpus}(t) - \phi_{25} \dot{s}^{euus}(t)
\end{aligned}
$$

Define

$$\pi_1 := v^{cn}(\omega_{11}+\omega_{12}+\omega_{13}+\omega_{14}+\omega_{15}) - v^{tw}\omega_{24} - v^{hk}\omega_{34}$$
$$\pi_2 := v^{tw}(\omega_{21}+\omega_{22}+\omega_{23}+\omega_{24}+\omega_{25}) - v^{cn}\omega_{14} - v^{hk}\omega_{35}$$
$$\pi_3 := v^{hk}(\omega_{31}+\omega_{32}+\omega_{33}+\omega_{34}+\omega_{35}) - v^{cn}\omega_{15} - v^{tw}\omega_{25}$$
$$\pi_4 := v^{cn}\omega_{11} + v^{tw}\omega_{21} + v^{hk}\omega_{31}$$
$$\pi_5 := v^{cn}\omega_{12} + v^{tw}\omega_{22} + v^{hk}\omega_{32}$$
$$\pi_6 := v^{cn}\omega_{13} + v^{tw}\omega_{23} + v^{hk}\omega_{33}$$

All parameters in (10) are as follows

$$\phi_1 = \pi_1\tilde{\lambda}_3^{cn}a_1 + \pi_2\tilde{\lambda}_3^{tw}a_4 + \pi_3\tilde{\lambda}_3^{hk}a_8 - \pi_5\tilde{\lambda}_3^{jp}a_{13} \qquad \phi_2 = \pi_2\tilde{\lambda}_3^{tw}a_5 \qquad \phi_3 = \pi_3\tilde{\lambda}_3^{hk}a_9$$
$$\phi_4 = \pi_1\tilde{\lambda}_3^{cn}a_2 + \pi_2\tilde{\lambda}_3^{tw}a_6 + \pi_3\tilde{\lambda}_3^{hk}a_{10} - \pi_4\tilde{\lambda}_3^{us}a_{12} - \pi_5\tilde{\lambda}_3^{jp}a_{14} \qquad \phi_5 = \pi_1\tilde{\lambda}_3^{cn}a_3 + \pi_2\tilde{\lambda}_3^{tw}a_7 + \pi_3\tilde{\lambda}_3^{hk}a_{11} - \pi_5\tilde{\lambda}_3^{jp}a_{15}$$
$$\phi_6 = \pi_1(\tilde{\lambda}_3^{cn}c_1 - \tilde{\lambda}_1^{cn}) + \pi_2\tilde{\lambda}_3^{tw}c_4 + \pi_3\tilde{\lambda}_3^{hk}c_8 - \pi_5\tilde{\lambda}_3^{jp}c_{13} \qquad \phi_7 = \pi_2(\lambda_3^{tw}c_5 - \tilde{\lambda}_1^{tw}) \qquad \phi_8 = \pi_3(\lambda_3^{hk}c_9 - \tilde{\lambda}_1^{hk})$$
$$\phi_9 = \pi_1(\tilde{\lambda}_3^{cn}c_2 + \tilde{\lambda}_1^{cn}) + \pi_2(\tilde{\lambda}_3^{tw}c_6 + \tilde{\lambda}_1^{tw}) + \pi_3(\tilde{\lambda}_3^{hk}c_{10} + \tilde{\lambda}_1^{hk}) - \pi_4\tilde{\lambda}_3^{us}c_{12} - \pi_5(\tilde{\lambda}_3^{jp}c_{14} + \tilde{\lambda}_1^{jp}) - \pi_6\tilde{\lambda}_1^{eu}$$
$$\phi_{10} = \pi_1\tilde{\lambda}_3^{cn}c_3 + \pi_2\tilde{\lambda}_3^{tw}c_7 + \pi_3\tilde{\lambda}_3^{hk}c_{11} + \pi_5(\tilde{\lambda}_1^{jp} - \tilde{\lambda}_3^{jp}c_{15}) \qquad \phi_{11} = \pi_1\tilde{\lambda}_3^{cn}b_1 + \pi_2\tilde{\lambda}_3^{tw}b_4 + \pi_3\tilde{\lambda}_3^{hk}b_7 - \pi_5\tilde{\lambda}_3^{jp}b_{11}$$
$$\phi_{12} = \pi_1\tilde{\lambda}_3^{cn}b_2 + \pi_2\tilde{\lambda}_3^{tw}b_5 + \pi_3\tilde{\lambda}_3^{hk}b_8 - \pi_4\tilde{\lambda}_3^{us}b_{10} - \pi_5\tilde{\lambda}_3^{jp}b_{12} \qquad \phi_{13} = \pi_1\tilde{\lambda}_3^{cn}b_3 + \pi_2\tilde{\lambda}_3^{tw}b_6 + \pi_3\tilde{\lambda}_3^{hk}b_9 - \pi_5\tilde{\lambda}_3^{jp}b_{13}$$
$$\phi_{14} = \pi_1\tilde{\lambda}_3^{cn}d_1 + \pi_2\tilde{\lambda}_3^{tw}d_5 + \pi_3\tilde{\lambda}_3^{hk}d_{10} - \pi_4\tilde{\lambda}_3^{us}d_{15} - \pi_5\tilde{\lambda}_3^{jp}d_{17} \qquad \phi_{15} = \pi_6\tilde{\lambda}_3^{eu}$$
$$\phi_{16} = \pi_1(\tilde{\lambda}_3^{cn}d_2 + \tilde{\lambda}_2^{cn}) + \pi_2(\tilde{\lambda}_3^{tw}d_6 + \tilde{\lambda}_2^{tw}) + \pi_3(\tilde{\lambda}_3^{hk}d_{11} + \tilde{\lambda}_2^{hk}) - \pi_4(\tilde{\lambda}_3^{us}d_{16} + \tilde{\lambda}_2^{us}) - \pi_5(\tilde{\lambda}_3^{jp}d_{18} + \tilde{\lambda}_2^{jp}) - \pi_6\tilde{\lambda}_2^{eu}$$
$$\phi_{17} = \pi_6\tilde{\lambda}_1^{eu} \qquad \phi_{18} = v^{cn}\omega_{12} \qquad \phi_{19} = v^{cn}\omega_{13} \qquad \phi_{20} = v^{tw}\omega_{22} \qquad \phi_{21} = v^{tw}\omega_{23} \qquad \phi_{22} = v^{hk}\omega_{32} \qquad \phi_{23} = v^{hk}\omega_{33}$$
$$\phi_{24} = -\pi_1\tilde{\lambda}_3^{cn}d_4 - \pi_2\tilde{\lambda}_3^{tw}d_8 - \pi_3\tilde{\lambda}_3^{hk}d_{13} + \pi_5(\tilde{\lambda}_1^{jp} + \tilde{\lambda}_3^{jp}d_{20}) \qquad \phi_{25} = \pi_6\tilde{\lambda}_1^{eu}$$

Appendix 5 Matrices *M* of the Equation (16)

Here we just show the case of China. From (15a) we know

$$J^{cn}(t_0 = 0) = \frac{1}{2}\int_{t_0}^{\infty}\{\alpha_1(\dot{p}^{cn}(t))^2 + \beta_1(y^{cn}(t))^2 + \chi_1(i^{cn}(t))^2 + \zeta_1(f^{cn}(t))^2\}e^{-\theta(t-t_0)}dt\}$$

Substitute Phillips curve of China in (5) and the reduced- form of Chinese output in (6a) into (15a), we get

$$\alpha_1(\dot{p}^{cn}(t))^2 + \beta_1(y^{cn}(t))^2 + \chi_1(i^{cn}(t))^2 + \zeta_1(f^{cn}(t))^2$$
$$= h_1^{cn}[(y^{cn}(t))^2 + h_2^{cn}(i^{cn}(t))^2 + h_3^{cn}(f^{cn}(t))^2 + h_4^{cn}(i^{us}(t))^2 + h_5^{cn}(\dot{p}^{w}(t))^2 + 2h_6^{cn}i^{cn}(t)i^{us}(t)$$
$$+ 2h_7^{cn}i^{cn}(t)\dot{p}^{w}(t) + 2h_8^{cn}i^{us}(t)\dot{p}^{w}(t) + 2h_9^{cn}i^{cn}(t)y^{cn}(t) + 2h_{10}^{cn}i^{us}(t)y^{cn}(t) + 2h_{11}^{cn}\dot{p}^{w}(t)y^{cn}(t)]$$

where

$$h_1^{cn}=\alpha_1(\tilde{\lambda}_3^{cn})^2+\beta_1 \qquad h_2^{cn}=\frac{\alpha_1(\tilde{\lambda}_1^{cn})^2+\chi_1}{h_1^{cn}} \qquad h_3^{cn}=\frac{\zeta_1}{h_1^{cn}} \quad h_4^{cn}=\frac{\alpha_1(\tilde{\lambda}_1^{cn})^2}{h_1^{cn}} \quad h_5^{cn}=\frac{\alpha_1(\tilde{\lambda}_2^{cn})^2}{h_1^{cn}}$$

$$h_6^{cn}=-\frac{\alpha_1(\tilde{\lambda}_1^{cn})^2}{h_1^{cn}} \qquad h_7^{cn}=\frac{\alpha_1\tilde{\lambda}_1^{cn}\tilde{\lambda}_2^{cn}}{h_1^{cn}} \quad h_8^{cn}=-\frac{\alpha_1\tilde{\lambda}_1^{cn}\tilde{\lambda}_2^{cn}}{h_1^{cn}} \quad h_9^{cn}=\frac{\alpha_1\tilde{\lambda}_1^{cn}\tilde{\lambda}_3^{cn}}{h_1^{cn}}$$

$$h_{10}^{cn}=-\frac{\alpha_1\tilde{\lambda}_1^{cn}\tilde{\lambda}_3^{cn}}{h_1^{cn}} \qquad h_{11}^{cn}=\frac{\alpha_1\tilde{\lambda}_2^{cn}\tilde{\lambda}_3^{cn}}{h_1^{cn}}$$

Define

$$J^{cn}(t_0=0)=\frac{1}{2}\int_0^{\infty}\{\alpha_1(\dot{p}^{cn}(t))^2+\beta_1(y^{cn}(t))^2+\chi_1(\dot{i}^{cn}(t))^2+\zeta_1(\dot{f}^{cn}(t))^2\}e^{-\theta(t-t_0)}dt\}=\frac{1}{2}h_1^{cn}\int_0^{\infty}\{x^T(t)M^{cn}x(t)\}e^{-\theta t}dt,$$

we can get M^{cn} a 25×25 matrix.

Appendix 6 Steps of Computing the Non-cooperative Nash Solution

Following Engwerda et al. (1999) and van Aarle, Engwerda and Plasmans (2001), the non-cooperative Nash solution can be found by following steps:

From Appendix 5 we can factorize $M^i\in\Re^{25}$, and then calculate $G\in\Re^{10}$ using entries from M^i

$$G=\begin{bmatrix}
a_1^2+h_3^{cn} & 0 & 0 & a_1a_2 & a_1a_3\\
a_4a_5 & a_5^2+h_3^{tw} & 0 & a_5a_6 & a_5a_7\\
a_8a_9 & 0 & a_9^2+h_3^{hk} & a_9a_{10} & a_9a_{11}\\
0 & 0 & 0 & a_{12}^2+h_3^{us} & 0\\
a_{13}a_{15} & 0 & 0 & a_{14}a_{15} & a_{15}^2+h_3^{jp}\\
a_1(h_9^{cn}-c_1) & 0 & 0 & a_2(h_9^{cn}-c_1) & a_3(h_9^{cn}-c_1)\\
a_4(h_9^{tw}-c_5) & a_5(h_9^{tw}-c_5) & 0 & a_6(h_9^{tw}-c_5) & a_7(h_9^{tw}-c_5)\\
a_8(h_9^{hk}-c_9) & 0 & a_9(h_9^{hk}-c_9) & a_{10}(h_9^{hk}-c_9) & a_{11}(h_9^{hk}-c_9)\\
0 & 0 & 0 & -a_{12}c_{12} & 0\\
a_{13}(h_9^{jp}-c_{15}) & 0 & 0 & a_{14}(h_9^{jp}-c_{15}) & a_{15}(h_9^{jp}-c_{15})
\end{bmatrix}$$

$$\begin{bmatrix}
a_1(h_9^{cn}-c_1) & 0 & 0 & a_1(h_{10}^{cn}-c_2) & -a_1c_3\\
-a_5c_4 & a_5(h_9^{tw}-c_5) & 0 & a_5(h_{10}^{tw}-c_6) & -a_5c_7\\
-a_9c_8 & 0 & a_9(h_9^{hk}-c_9) & a_9(h_{10}^{hk}-c_{10}) & -a_9c_{11}\\
0 & 0 & 0 & -a_{12}c_{12} & 0\\
-a_{15}c_{13} & 0 & 0 & a_{15}(h_{10}^{jp}-c_{14}) & a_{15}(h_9^{jp}-c_{15})\\
c_1^2+h_2^{cn}-2c_1h_9^{cn} & 0 & 0 & c_1c_2+h_6^{cn}-c_2h_9^{cn}-c_1h_{10}^{cn} & c_3(c_1-h_9^{cn})\\
c_4(c_5-h_9^{tw}) & c_5^2+h_2^{tw}-2c_5h_9^{tw} & 0 & c_5c_6+h_6^{tw}-c_6h_9^{tw}-c_5h_{10}^{tw} & c_7(c_5-h_9^{tw})\\
c_8(c_9-h_9^{hk}) & 0 & c_9^2+h_2^{hk}-2c_9h_9^{hk} & c_9c_{10}+h_6^{hk}-c_{10}h_9^{hk}-c_9h_{10}^{hk} & c_{11}(c_9-h_9^{hk})\\
0 & 0 & 0 & c_{12}^2+h_2^{us} & 0\\
c_{13}(c_{15}-h_9^{jp}) & 0 & 0 & c_{14}c_{15}+h_6^{jp}-c_{14}h_9^{jp}-c_{15}h_{10}^{jp} & c_{15}^2+h_2^{jp}-2c_{15}h_9^{jp}
\end{bmatrix}$$

Note that all h are from M^i.

The 6×6 matrix M is defined as

$$M = \begin{bmatrix} \phi_{11} & 0 & 0 & 0 & 0 & 0 \\ b_1^2 & -\phi_{11}^T & 0 & 0 & 0 & 0 \\ b_4^2 & 0 & -\phi_{11}^T & 0 & 0 & 0 \\ b_7^2 & 0 & 0 & -\phi_{11}^T & 0 & 0 \\ 0 & 0 & 0 & 0 & -\phi_{11}^T & 0 \\ b_{11}^2 & 0 & 0 & 0 & 0 & -\phi_{11}^T \end{bmatrix} + \begin{bmatrix} B \\ -\tilde{U}^{cn} \\ -\tilde{U}^{tw} \\ -\tilde{U}^{hk} \\ -\tilde{U}^{us} \\ -\tilde{U}^{jp} \end{bmatrix} G^{-1} \begin{bmatrix} a_1 b_1 & B_1^T & 0 & 0 & 0 & 0 \\ a_5 b_4 & 0 & B_2^T & 0 & 0 & 0 \\ a_9 b_7 & 0 & 0 & B_3^T & 0 & 0 \\ 0 & 0 & 0 & 0 & B_4^T & 0 \\ a_{15} b_{11} & 0 & 0 & 0 & 0 & B_5^T \\ b_1 (h_9^{cn} - c_1) & B_6^T & 0 & 0 & 0 & 0 \\ b_4 (h_9^{cn} - c_5) & 0 & B_7^T & 0 & 0 & 0 \\ b_7 (h_9^{cn} - c_9) & 0 & 0 & B_8^T & 0 & 0 \\ 0 & 0 & 0 & 0 & B_9^T & 0 \\ b_{11} (h_9^{cn} - c_{15}) & 0 & 0 & 0 & 0 & B_{10}^T \end{bmatrix}$$

Note that $\tilde{U}^i$ ($i = cn, tw, hk, us, jp$) is a row vector from $M^i(1,4:13)$, which means elements from columns 4 to 13 of the first row in M^i.

Second, calculate the positive eigenvalue(s) of M. If $a_{cl,nc}$ is a positive eigenvalue and ϑ is defined as $\vartheta = \begin{bmatrix} \vartheta_0 & \vartheta_1 & \vartheta_2 & \vartheta_3 & \vartheta_4 & \vartheta_5 \end{bmatrix}^T$, a corresponding eigenvector. Then the equilibrium strategies are

$$\begin{bmatrix} f^{cn}(t) \\ f^{tw}(t) \\ f^{hk}(t) \\ f^{us}(t) \\ f^{jp}(t) \\ i^{cn}(t) \\ i^{tw}(t) \\ i^{hk}(t) \\ i^{us}(t) \\ i^{jp}(t) \end{bmatrix} = -G^{-1} \begin{bmatrix} a_1 b_1 + B_1^T \Gamma_1 \\ a_5 b_4 + B_2^T \Gamma_2 \\ a_9 b_7 + B_3^T \Gamma_3 \\ B_4^T \Gamma_4 \\ a_{15} b_{11} + B_5^T \Gamma_5 \\ b_1 (h_9^{cn} - c_1) + B_6^T \Gamma_1 \\ b_4 (h_9^{tw} - c_5) + B_7^T \Gamma_2 \\ b_7 (h_9^{hk} - c_9) + B_8^T \Gamma_3 \\ B_9^T \Gamma_4 \\ b_{11} (h_9^{jp} - c_{15}) + B_{10}^T \Gamma_5 \end{bmatrix} q^{CEA}(t) \qquad \text{(A4)}$$

where $\Gamma_i = \frac{\vartheta_i}{\vartheta_0}$.

Using the equilibrium strategies the resulting closed-loop system is described by

$$\dot{q}^{CEA}(t) = -a_{cl,nc} \cdot q^{CEA}(t) \qquad q(0) = q_0$$

Appendix 7 Steps of Computing the Cooperative Nash Solution and Coalition

The unique equilibrium strategies can be obtained by following steps:

First, factorize matrix M_{FC} by removing uncontrolled variables

$$\tilde{M}_{FC} = \begin{bmatrix} Q & W \\ W^T & X \end{bmatrix}$$

where Q is a scalar, W a 1×10 vector containing instrumental variables, and X a 10×10 matrix containing instrumental variables.

Second, following Lancaster and Rodman (1995) and van Aarle, Engwerda and Plasmans (2001), We calculate the Hamiltonian matrix

$$Ham = \begin{bmatrix} -(A - BX^{-1}W^T) & BX^{-1}B^T \\ Q - WX^{-1}W^T & (A - BX^{-1}W^T)^T \end{bmatrix}$$

Third, determine the positive eigenvalue $a_{cl,FC}$ of Ham and its corresponding eigenvector $\vartheta = \begin{bmatrix} \vartheta_0 & \vartheta_1 \end{bmatrix}^T$ $\Gamma = \frac{\vartheta_1}{\vartheta_0}$. Calculate $\Gamma = \frac{\vartheta_1}{\vartheta_0}$.

Finally, the equilibrium strategies are

$$\begin{bmatrix} f^{cn}(t) \\ f^{tw}(t) \\ f^{hk}(t) \\ f^{us}(t) \\ f^{jp}(t) \\ i^{cn}(t) \\ i^{tw}(t) \\ i^{hk}(t) \\ i^{us}(t) \\ i^{jp}(t) \end{bmatrix} = -X^{-1}(W^T + B^T\Gamma)q(t) = H_{FC}q^{CEA}(t) \tag{A5}$$

And the resulting closed-loop system satisfies

$$\dot{q}^{CEA}(t) = -a_{cl,FC} \cdot q^{CEA}(t) \qquad q(0) = q_0$$

As to the solution of the CEA coalition, we redefine of $x(t)$ corresponding the above coalition form

$$x(t) = (P^{CEA})^{-1} \tilde{x}(t)$$

Then, with

$$M^{i}_{CEA} = ((P^{CEA})^{-1})^{T} M^{i} (P^{CEA})^{-1}$$

Introducing $M_{PC} = \tau^{cn} M^{cn}_{CEA} + \tau^{tw} M^{tw}_{CEA} + \tau^{hk} M^{hk}_{CEA}, \quad \tau^{cn} + \tau^{tw} + \tau^{hk} = 1$, so

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

Minimize J_{PC}, J^{jp} and J^{us} we can determine the equilibrium controls

$$\begin{bmatrix} f^{cn}(t) \\ f^{tw}(t) \\ f^{hk}(t) \\ f^{us}(t) \\ f^{jp}(t) \\ i^{cn}(t) \\ i^{tw}(t) \\ i^{hk}(t) \\ i^{us}(t) \\ i^{jp}(t) \end{bmatrix} = H_{PC} q^{CEA}(t) \qquad \text{(A6)}$$

Using these optimal controls, the dynamic closed-loop expression of the system is described by

$$\dot{q}^{CEA}(t) = -a_{(cn,hk)} \cdot q^{CEA}(t) \qquad q^{CEA}(0) = q_0^{CEA}$$

Where $a_{(cn,hk)}$ is obtained as the eigenvalue of some matrix.

Appendix 8 Data Description

The quarterly data of 6 economies (China, Taiwan, Hong Kong, Japan, USA, and Germany (European Union)) and world CPI from 1988.II to 2000.IV are included in our estimation. The

main data sources of this paper are *IFS* CD-ROM, *IFS monthly report* (March 2001), *Direction of Trade Statistics (various issues), World Economic Outlook* (May 2001). The main data sources of Taiwan are *Taiwan Financial Statistics* by IFS format (Central Bank of Taiwan, various issues), *Statistical Yearbook*, and *Monthly Bulletin of Statistics* (Executive Yuan, various issues). We also use *China's Key Indicators* (World Bank, 2000), *China's Statistical Yearbook* (National Statistical Bureau, 2000), and the data provided by websites of Ministry of Finance, Taiwan (http://www.mof.gov.tw) and Central Bank of Taiwan (http://www.cbc.gov.tw) as supplements because of the data insufficiency of China before 1985.

All variables, except interest rates and inflation rates, are in logarithms and denote deviations from their long-term equilibrium (balance growth path). There are two ways to represent the long-term equilibrium trends: one is by the error correction mechanism (ECM), the other is computed by Hodrick-Prescott filter. All variables denominated in foreign currency are transformed into domestic currency in this empirical test.

Variables	Definition	Data sources
Real GDP (y)	$y_t^i = log\ (\frac{GDP_t^i}{CPI_t^i})$. The nominal value of GDP is adjusted by CPI index. In the estimation by quarterly base we use 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)	$s_t^i = logEx_t^i$, $q_t^i = \sum_{i=1}^{n} \omega_t^i (s_t^i - p_t^i + p_t^*)$. The weighted average of the bilateral real exchange rates, which was computed by using CPI, was calculated with respect to the Japanese yen, the U.S. dollar, and the Deutsche mark. These weights (ω_t^i) total one and are proportional to the relative bilateral trade shares with Japan, the U.S., and the E.U. The negative (positive) value of changes in real effective exchange rate means real appreciation (depreciation). The formula is consistent with our theoretical model.	IFS line rf, 64 IMF, *Direction of trade statistics*
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)	$r_t^i = i_t^i - p_t^i$ Real interest rate is equal to the nominal interest rate minus consumer price index, which is consistent with our theoretical model.	IFS line 60b, 60l, 64
Fiscal policy (f)	$f_t^i = \log (\frac{GC_t^i}{CPI_t^i})$ We use government consumption (GC) in this paper. We do not use the government deficit because of the data insufficiency of Japan. The nominal government consumption is adjusted by CPI index. In the quarterly estimation we use the claims on the central government of China to replace the Chinese government consumption because not only the latter is not available but also the former we suppose is closely related to government consumption in China.	IFS line 91f, line 64, line 32a

Consumer price index (*p*)	$p_t^i = log(CPI_t^i)$ The base year of all economies is 1995. Note that the CPI data of China is not available before 1985, so Wholesale Price Index (WPI) of China is also used.	IFS line 64, *China's Statistical Yearbook*
Real money supply, M2 (*m*)	$m_t^i = log\left(\frac{M2_t^i}{CPI_t^i}\right)$ The normal definition of M2 is that the money (IFS line 34) plus the quasi money (IFS line 35), which is adopted by empirical work. The nominal money supply is adjusted by CPI index.	IFS line 34, line 35, line 64
Foreign Reserves (*R*)	$R_t^i = log\left(\frac{Res_t^i \times S_t^i}{CPI_t^i}\right)$ Foreign reserves minus the values of gold reserves (*Res*), which reveals the liquidity of reserves. The foreign reserves are denominated by domestic currency and adjusted by CPI index.	IFS line 1l.d, line64
Current account (*ca*) and capital account ($\dot{k}$)	The trade account is used to replace the current account. Note that data of China are not available. And data of Hong Kong are not sufficient.	IFS line 78acd, line78bcd
Asian financial crisis dummy (*D97.III*)	D97.III=1 for the quarterly data after the third quarter 1997, otherwise D97.III=0. Note that Thailand was the first country to be attacked by speculators in July 1997.	