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Monetary Policy Coordination between Large and Small Countries: An Empirical Study*

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Using a simple Mundell-Fleming-Dornbusch model, we compare gains and losses from monetary policy coordination and non-coordination between a large developed country (the United States or Japan) and a small open developing country (Taiwan or South Korea). It is shown by simulation that the large countries may gain slightly but are practically indifferent whether they cooperate with smaller countries or not. However, the small open economies may lose from coordinating their policy with the large countries. This may explain the difficulties of policy coordination and economic integration in the real world.

I. Introduction

In recent years, international macroeconomic policy coordination has been one of the major concerns among policy makers and

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economists. It aims at enhancing the economic welfare by coordinating each country's macroeconomic policy, like monetary, fiscal, andor trade policies, to achieve common targets such as economic growth, control of inflation, exchange rate stability, etc. In the world of interdependent economies, each country's economic policy affects the other country's policy objective. Thus coordination seems desirable, especially for some politicians. In fact, the needs of international policy coordination arise from practical problems of changing international financial market.

During the past two decades, the position of the U.S. dollar as the medium of international exchange and reserve currency has been continuously weakening. On the other hand, the economy of the United States is no longer the dominant force to defend the dollar (Hsiao, 1990). The world is divided into the consistently trade surplus countries like Germany and Japan and the chronically trade deficit countries like the United States. Thus, the major industrial countries have held economic summits and talks to deal with international financial problems. For examples, at the Bonn Summit in November 1978, the United States, Germany, Japan, and Switzerland agreed to adopt tight monetary policy and intervene in the foreign exchange market to defend the dollar. The advantage of international policy coordination was confirmed in 1985 Williamsburg Summit. In the Plaza Accord of September 1985, the five major industrial countries agreed to eliminate the trade imbalance of engaging in some specific macroeconomic policies to orderly devaluating the dollar (Rivera-Batiz and Rivera-Batiz, 1985).

Thus in the real world, the industrial countries play the major role in international policy coordination. The theoretical and empirical studies in this area by economists also emphasize exclusively on the policy coordination among major industrial countries, especially among the United States, Japan, and Germany.

To some extent, international policy coordination by major powers has been successful in maintaining the stability of the international financial market. However, after many years of G-7 summit meetings, trade imbalances among the industrial countries still exist, and policy coordination does not seem to be welfare improving. Similar mixed results also appear in the studies by economists. In some simple symmetric models of industrial countries, policy coordination does improve the economic welfare (McKibbon, 1988; Cooper, 1985). However, some empirical studies show that the gains from cooperation are considerably small (Oudiz and Sachs, 1984).

The purpose of this paper is to extend the analysis of international policy coordination to include industrial countries and small open developing economies. Here, the players are not identical and economies are not symmetric. More specifically, using a simple two-country macroeconomic model, we investigate whether international policy coordination between Taiwan and the United States, South Korea (hereafter, Korea) and the United States, Taiwan and Japan, and also Korea and Japan will improve the economic welfare for each country. We also measure the gains from policy coordination in terms of the units in country's real GDP.

In Section II, we summarize and compare some basic statistics of Taiwan, Korea, the United States, and Japan for a recent year. These four countries have very close economic and political relations since the World War II. A more detailed exposition of country comparisons may be found in Hsiao (1990), Hsiao and Hsiao (1983; 1989; 1995), and Kuark (1995). In Section III, a Mundell-Fleming-Dornbusch type two-country model (Cooper, 1985; McKibbin, 1988) is specified. The home country is small, and the foreign country is large. The conventional symmetric model applied to international policy coordination in industrial countries has been illustrated in details in our previous paper (Hsiao and Hsiao, 1994a) and elsewhere (McKibbin, 1988; McKibbin and Sachs, 1991).

In Section IV, in view of our simulation results in a previous paper, we review briefly the recent controversy on uncertain unit root in time series related to the choice between the trend and difference stationary models (DeJong, et al. 1992; Rudebusch, 1993). Using the time series data of Taiwan, Korea, the United States, and Japan, the regression equations of the trend stationary model are estimated by using log-linear form. The regression coefficients derived in this section are then used in the derivation of various equilibria in our general model in Section V. Since well-defined fiscal policy, especially the tax system, has not been established in Taiwan or Korea in the past, we assume monetary policy as the policy variable in the model. The detailed derivations of the simulation results using regression coefficients are shown in Appendix A. In this paper, we compare the cases of Nash equilibrium and the cooperative equilibrium. We then implement the model empirically and measure the size of gains or losses from policy coordination. Section VI presents some interpretations of the simulation results.

II. Some Economic Background

As in the previous paper (Hsiao and Hsiao, 1994a), we have shown that the United States is a large country with 8.67% of the world land, 5.2% of the world population, and 28.48% of the world GDP in 1988. Japan has 0.35% of the world land, 2.59% of the world population, and 16.71% of the world GDP in 1988. In contrasts, Taiwan and Korea are much smaller countries. Taiwan has only 0.03% of the world land, 0.42% of the world population, and 0.73% of the world GDP in 1988. Similarly, Korea has 0.09% of the world land, 0.89% of the world population, and 1.01% of the world GDP in 1988.

In terms of 1988 per capita GNP, the United States, Japan, Taiwan, and Korea ranked 4th, 2nd, 24th, and 33rd among 122 reporting countries and areas by the World Bank (Taiwan is added in by the authors). From 1978 to 1988, while the United States doubled her per capita GNP, Japan, Taiwan, and Korea almost tripled their per capita GNP in the same decade. Both Taiwan and Korea are maintaining rapid growth throughout the past three decades at the average annual rates of 7.3% and 6.8%, respectively.

Table 1 shows international trade interactions among Taiwan, Korea, the United States, and Japan. In 1989, for the United States and Japan, the trade with Taiwan and Korea constitutes only small fractions of their GNP. In contrast, this is not the case for Taiwan and Korea. The Taiwanese exports to the U.S. amounted almost 16% of her GNP, and Taiwan's imports from the U.S. also had 8% of her GNP. Similarly, Korean exports to the U.S. amounted 10% of her GNP, and Korean imports from the U.S. also had 7.6% of her GNP. These yields the

Table 1

EXPORTS AND IMPORTS AS SHARE OF COUNTRY'S GNP, 1989 (%)

Country		USA	Japan	Taiwan	Korea
USA:	Exports to	—	0.86	0.22	0.26
	Imports from	—	1.87	0.49	0.39
Japan:	Exports to	3.45	—	0.56	0.61
	Imports from	1.77	—	0.33	0.47
Taiwan:	Exports to	15.82	5.97	—	0.75
	Imports from	7.91	10.57	—	0.82
Korea:	Exports to	10.11	6.50	0.62	—
	Imports from	7.62	8.48	0.64	

Sources: DTS, 1990. TSDB, 1990, GNP data are from IFS, Dec. 1990.

trade surpluses for both Taiwan and Korea with the United States. On the other hand, Taiwanese exports to Japan amounted about 6% of her GNP, and Taiwan's imports from Japan also had almost 11% of her GNP. Similarly, Korean exports to Japan amounted 6.5% of her GNP, and Korean imports from Japan also had 8.5% of her GNP. These produced the trade deficits for both Taiwan and Korea with Japan.

In general, both Taiwan and Korea are small countries compared with the United States and Japan. The trade of both Taiwan and Korea depends heavily on the United States and Japan, but not visa versa. The gains or losses from international policy coordination among the four countries should reflect these asymmetries. In the following discussions of the two-country model of policy coordination, these facts have been reflected in our model structure.

III. The Model

A game theoretic approach to the problem of international policy coordination can be attributed to a series of pioneering articles by Hamada (1974, 1985). A survey of his contribution and subsequent development by others is given in Currie and Levine (1993). This paper adopts Hamada's game theoretic approach to what is generally known as the Mundell-Fleming-Dornbusch two-country macroeconomic model. Thus, our model is the same as that in Cooper (1985) and McKibbin (1988). In this model, it is assumed that each country has the knowledge of other country's economic structure, but not the information on future policy decisions. The economies are given as follows:

Small country

(1) $q = \phi q^* + \gamma(e + p^* - p) - \lambda i$

(2) $m - p = \alpha p - \beta i$

(3) $p_c = \mu(e + p^*) + (1 - \mu)p$

(4) $i = i^*$

Large country

(1)* $q^* = \gamma^*(p - e - p^*) - \lambda^* i^*$

(2)* $m^* - p^* = \alpha^* q^* - \beta^* i^*$

(3)* $p_c^* = \mu^*(p-e) + (1-\mu^*)p^*$

where

- q = real gross domestic product (GDP)
- e = exchange rate (domestic currency price of a unit of foreign currency).
- p = price index of domestic output (wholesale prices)
- m = the supply of money (M1)
- p_c = consumer price index
- i = rate of interest.

The asterisk denotes the variables and parameters for a large country. All variables except the rate of interest are measured in logarithm.

Equations (1) and (1)* are the IS curves. The small country's gross domestic product (GDP) is a function of the large country's GDP (Argy, et al., 1989), the real exchange rate, and the interest rate. The LM curves are shown in equations (2) and (2)*. The real money supply is a function of GDP and the interest rate i. Equations (3) and (3)* specify that the consumer prices are the weighted geometric average of the import price and the domestic price. The last equation, (4), shows the interest rate parity between the small and large countries. It assumes free capital movement between the two countries. The interest rates are equalized in the world market through foreign investment and perfect substitution between foreign and domestic assets. The simplified expression of (4) also implies zero expected depreciation of home currency and zero risk premium of holding assets.

We assume sticky prices, that is, p and p* do not change in our model. Each government has limited number of instruments, in our case, the money supply m and m*, to achieve its policy objective. As shown in equations (10) to (12) below, the policy objective is to maximize separately or jointly each country's social welfare function (or negative loss function) which penalizes output and price instabilities.

We keep our model as simple as possible, so that we may obtain some definite results without being bogged down by the data and computational problems. We are interested only in the short-run effects of strategic policy coordination.

The model may be solved as follows. From (1) and (1)*, we first solve for e and i as

(5) $e = D_e/D, \; i = D_i/D$

where

$$D_e = \lambda^* q - (\phi\lambda^* + \lambda)q^* + (\gamma\lambda^* - \lambda\gamma^*)p + (\lambda\gamma^* - \gamma\lambda^*)p^*$$

$$D_i = -\gamma^* q + (\gamma^*\phi - \gamma)q^* - 2\gamma\gamma^*(p - p^*)$$

$$D = \gamma\lambda^* + \lambda\gamma^*$$

Thus, the exchange rate e and interest rate i are functions of the outputs and wholesale prices of both small and large countries.

Substituting i in (5) into the LM equations (2) and (2)*, we have

$$(D\alpha + \beta\gamma^*)q - \beta(\gamma^*\phi - \gamma)q^* = Dm - Dp$$

$$\beta^*\gamma^* q + [D\alpha^* - \beta^*(\gamma^*\phi - \gamma)]q^* = Dm^* - Dp^*$$

These two equations may be solved for q and q* as

(6) $\quad q = am + bm^* + cp + dp^*$

(7) $\quad q^* = a^*m + b^*m^* + c^*p + d^*p^*$

where a, b, c, d, a*, b*, c*, d*, are elasticities in terms of the original parameters in (1) to (3)*. Form (5), it can be seen that the values of home and foreign money supplies determine the exchange rate e and the interest rate i in (5) indirectly and simultaneously through home and foreign GDP.

Substituting e in (5) into (3) and (3)*, p_c and p_c^* may also be expressed as functions of the same policy instruments:

(8) $\quad p_c = am + bm^* + cp + dp^*$

(9) $\quad p_c^* = a^*m + b^*m^* + c^*p + d^*p^*$

where a, a*, etc. are constant coefficients depending on the original parameters in (1) to (3)*.

Let the utility function of the small country be

(10) $\quad U = -(1/2)[w_1(q - q^{\#})^2 + w_2(p_c - p_c^{\#})^2]$

where $q^{\#}$ is the target or desired GDP, and $p_c^{\#}$ is the target or desired consumer price index. Parameters w_1 and w_2 are the weights, $w_1 + w_2 = 1$, that the policy makers assign to the two targets.

Similarly, the utility function for the large country is

$$(11) \qquad U^* = -(1/2)[w_1^*(q^* - q^{*\#})^2 + w_2^*(p_c^* - p_c^{*\#})^2]$$

where $w_1^* + w_2^* = 1$.

For Nash non-cooperative equilibrium, the policy makers in each country maximize the utility function U or U*, that is, minimize the loss function $-U$ or $-U^*$, for given weights between the GDP deviation and consumer price deviation from the target values. For cooperative equilibrium, the policy makers in both countries jointly choose money supplies m and m* to maximize the world community welfare:

$$(12) \qquad W = hU + h^*U^*$$

where h and h* are weights assigned to the small and the large countries, respectively. Note that, since the variables are converted to logarithm, the deviations are measured in percentage changes from the targets. As the utilities are measured in pure numbers, they are well-defined and comparable among the countries.

Equations (6) to (9) show interdependence of the world economy. Since prices are sticky, a country's policy changes can exert externalities, or spillovers, on other countries. Thus, in this model, each country's GDP and consumer price, and so the policy objective of each country, depend not only on its own policy instrument, but also on other country's. Clearly, the flexible exchange-rate regime does not insulate a country from the foreign disturbances. Because of externalities, it can be shown theoretically that, under the assumption of symmetric countires, Nash non-cooperative equilibrium is not Pareto-efficient, and the countries may gain through policy coordination (Cooper, 1985).

In recent years, more and more countries assign improvement of trade deficits as one of the policy objectives. If this is the case, fiscal policy is generally assigned to achieve this objective.[1] We do not follow this method in our model. First, fiscal policy, say, government expenditure, cannot be included in the IS curve as a policy instrument. Otherwise, the model will have two policy objectives and two instruments, and by the Tinbergen Theorem (Cooper, 1985), any policy targets can be attained instantly even under non-cooperative equilibrium. There will be

[1] In his earlier paper, Hamada (1974, p. 16), using Mundell's model, takes national income and the balanced of payments as the targets. His policy variable is domestic assets of the banking system (or the "Demand of Money").

no externalities and no policy conflicts, and international policy coordination is not necessary. In fact, this is one of the criticisms on the theory of international policy coordination, which requires that the number of instruments must be less than the number of targets to make a room for coordination. Second, our model assumes perfect mobility of capital under flexible exchange rate regime. The government generally cannot control capital flow directly to improve the balance of trade.

In this paper, when all the coefficients of (6) to (9) are estimated without restriction, we call the model *a general case.* In this case, the distinction between small and large countries comes from the differences in the magnitude of the coefficients, instead of inclusion or exclusion of variables. When we explicitly impose the conditions that the small country's economic variables do not affect the large country's economy, that is, when $a^* = c^* = \bar{a}^* = \bar{c}^* = 0$, then we call the model *a restricted case.* However, large country's variables could influence the small country's economy. This is generally true, as economic development of a small country requires raw materials and intermediate and capital goods from the large countries. As we will see below, our data justify both interpretations. In both cases, in the process of simulation, the weight h^* of the large country in the world welfare function is assumed to be much larger than the small country's weight, h.

IV. The Estimation

The general procedure of solving the model is to assume that the parameters of the model in both countries are equal ($\lambda = \lambda^*$, $\mu = \mu^*$, etc.). Such assumptions may be allowed among the developed countries like the United States, Japan, and the European Community. However, as we have seen in Section II, it is unrealistic to assume symmetry between Taiwan (or Korea) and the United States (or Japan). Thus, in this paper, we assume that two countries are asymmetric.

In an asymmetric model, the reduced form of the original model as shown in equations (6) to (9) depends on very complicated relations among the eight parameters. The usual simulation method and computable general equilibrium analysis simply assign some plausible values to the parameters, either based on intuition or on some historical observations. In this paper, however, we estimate the coefficients of the four reduced form equations in (6) to (9) by the ordinary least squares method using the data of each country for 16 years from 1975 to 1990.

The summary statistics of the data for the target variables $T = (q, p_c, q^*, p_c^*)'$ (the apostrophe denotes the transpose of a row vector), and the instrument variables $y=(x, z)'=(m, m^*, p, p^*)'$, for the United States, Japan, Taiwan, and Korea are shown in Table 2. The numbers are measured in the domestic currency to avoid distortion due to fluctuation in the U.S. dollar during this period. Due to data availability, all q's for Taiwan, Korea, and the United States are measured in real GDP, and the q for Japan is measured in real GNP. Since Taiwan and Korea are fast growing countries, we also listed the latest 1990 statistics, along with their 16-year averages, in Table 2. For comparison, the average and the standard deviation of the data for each variable from 1975 to 1990 are listed. They are then converted into logarithmic form, and their average, standard deviation, maximum, and minimum are computed.

We then group the equations by the small and then the large countries. The regression coefficients are estimated and presented in Table 3 when the U.S. is the large country and Table 4 when Japan is the large country. The regression equations are in log-linear form. This is a major difference between this paper and the previous one (Hsiao and Hsiao, 1994a). In the previous paper, we have shown that when the variables are in logarithms, we found that the null hypothesis of the time series being non-stationary could not be rejected by the Augmented Dickey-Fuller (ADF) unit root test. Furthermore, the null hypothesis of these variables being no-cointegrated could not be rejected by using the Engle-Granger cointegration test. Thus, in accordance with the current practice in macroeconometrics methods, we were forced to use the percentage changes of the variables, that is, the first difference of the log-values, to estimate the regression coefficients. The simulation results, however, were not convincing. The money supplies at Nash and cooperative equilbria turned out to be growing at 17% and 16% per annum, respectively, for Taiwan, and growing at −17% and −16% per annum, respectively, for the United States (see Table 7, Hsiao and Hsiao, 1994a).

In recent years, the power of ADF unit root test in time series has been challenged. It has been found that the classical unit root tests could not discriminate between a trend stationary model and a difference stationary model, and the test results may be considered uncertain at best (DeJong, et al., 1992; Rudebusch, 1993), or even of little practical value (Sims and Uhlig, 1991). Besides, our regression results are used for simulation of the model, rather than for forecasting of the dependent variables. Thus we submit that the use of log-linear model may be justified in this study. This also implies that the possibility of spurious regression due to non-stationary time series may not be excluded. Thus, our simulation results, especially the estimated reaction equations in the following section, should be interpreted cautiously.

Table 2

SUMMARY STATISTICS OF VARIABLES, 1975-1990

		q	p_c	m	p
USA	Unit	'87 pr US$b	'85=100	US$b	'85=100
1990		4884.9	121.0	828.0	113.0
avg		4046.0	86.5	539.9	89.0
std		499.9	22.3	183.4	17.8
avg	in log	8.3	4.4	6.2	4.5
std	in log	0.1	0.3	0.3	0.2
max	in log	8.5	4.8	6.7	4.7
min	in log	8.1	3.9	5.7	4.0
Japan	unit	'85 pr yen b	'85=100	yen b	'85=100
1990		404820.0	106.9	114800.0	90.6
avg		291481.1	90.4	78760.7	91.1
std		57497.4	13.0	19546.0	9.0
avg	in log	12.6	4.5	11.2	4.5
std	in log	0.2	0.2	0.3	0.1
max	in log	12.9	4.7	11.7	4.6
min	in log	12.2	4.1	10.8	4.3
Taiwan	unit	'86 pr NT$b	'86=100	NT$b	'86=100
1990		3883.6	110.7	1931.9	94.3
avg		2327.3	87.1	824.7	91.7
std		847.3	19.3	661.1	14.6
avg	in log	7.7	4.4	6.4	4.5
std	in log	0.4	0.2	0.9	0.2
max	in log	8.3	4.7	7.6	4.7
min	in log	7.0	4.0	4.9	4.2
Korea	unit	'85 pr Won b	'85=100	Won b	'85=100
1990		131263.0	130.0	13952.0	108.0
avg		74334.8	82.9	6114.8	81.1
std		28419.6	30.5	3943.9	26.1
avg	in log	11.1	4.3	8.5	4.3
std	in log	0.4	0.4	0.7	0.4
max	in log	11.8	4.9	9.5	4.7
min	in log	10.5	3.5	7.0	3.6

Notes and Data Sources: The data for USA, Japan, and Korea, 1975-89, are from IFS Tape-1990. The 1990 data are from IFS, May 1992. The data for Taiwan are from TSDB, 1992, pp. 25, 135, 167, '87 pr, etc. means that the variable is in the 1987 prices, etc. b stands for billions.

In Table 3 and 4, we present the estimated coefficients of the restricted and the general cases. The absolute values of the t-statistic, R^2, and the Durbin-Watson statistic (DW) are also reported in the tables. The coefficients of the equations are shown as matrix R in equation (A2) of Appendix A (the letter A before the number indicates that the equation is referred to the one in Appendix A). More specifically, for the restricted case for Taiwan and the United States, the regression coefficients are estimated as follows.

$$(13)\quad R = \left[\begin{array}{cc:cc} a & b & c & d \\ \bar{a} & \bar{b} & \bar{c} & \bar{d} \\ \hdashline a^* & b^* & c^* & d^* \\ \bar{a}^* & \bar{b}^* & \bar{c}^* & \bar{d}^* \end{array}\right] = \left[\begin{array}{cc:cc} 0.175 & 0.309 & -0.579 & 0.905 \\ -0.054 & 0.247 & 0.298 & 0.738 \\ \hdashline 0 & 0.374 & 0 & -0.050 \\ 0 & 0.333 & 0 & 0.780 \end{array}\right]$$

which are slope coefficients of equations (1) to (4) in Table 3.

Similarly, for the general case for Taiwan and the United States, the coefficient matrix consists of the slope coefficients of the equations (1), (2), (5) and (6) in Table 3. For the relation between Korea and the United States, the coefficient matrices for the restricted and general cases are listed in the lower part of Table 3. By the same method, the relation between Taiwan (or Korea) and Japan, the coefficient matrices for the restricted and general cases are listed in Table 4.

Generally speaking, our regression method of estimating coefficients of equations (6) to (9) seems to be more realistic and natural, and relieve us from the burden of assiging "reasonable," often rather arbitrary, values to the 12 parametes in the model. The trade-off is that the structural information linking domestic and foreign goods and money markets may be lost. Thus, it is conceivable that the transmission mechanism of money supply without structural information may give erratic results.[2] Fortunately, this does not seem to be a problem for our data, as we explain below.

a. The transmission mechanism is shown by the sign and magnitude of the coefficients of m and m* in Tables 3 and 4. The coefficients in the m and m* columns show the money supply elasticities of the dependent variable listed on the left hand side. From these tables, we see that the expansion of domestic money supply increases domestic output (q) in all cases, as we might expect.

[2] This is one of the points raised by a referee.

Table 3

REGRESSION COEFFICIENTS FOR REAL OUTPUT AND CONSUMER PRICES — TAIWAN, KOREA, AND THE U.S.A.

Dependent Variable		Constant	m	m*	p	p*	R^2	DW
I. Taiwan-USA: Restricted Case								
1.	q	3.212	0.175	0.309	−0.579	0.905	0.998	1.783
		(7.75)	(3.25)$^{+}$	(2.84)$^{++}$	(4.00)	(4.59)		
2.	p_c	−1.397	−0.054	0.247	0.298	0.738	0.994	1.294
		(3.06)	(0.91)	(2.06)*	(1.87)	(3.40)		
3.	q*	6.189	0	0.374	0	−0.050	0.958	0.878
		(43.5)	(0)	(7.84)$^{+}$	(0)	(0.66)		
4.	p_c^*	−1.134	0	0.333	0	0.780	0.999	1.264
		((26.2)	(0)	(22.9)$^{+}$	(0)	(33.8)		
II. Taiwan-USA: General Case Same as Equations (1) and (2) above, plus								
5.	q*	7.117	0.061	0.114	−0.303	0.323	0.982	1.237
		(18.1)	(1.20)	(1.10)	(2.20)	(1.73)		
6.	p_c^*	−1.457	−0.045	0.413	−0.064	0.868	0.9995	1.728
		(9.66)	(2.29)$^{++}$	(10.5)$^{+}$	(1.21)	(12.1)		

Table 3 (Continued)

Dependent Variable	Constant	m	m*	p	p*	R^2	DW
III. Korea-USA: Restricted Case							
7. q	2.342	0.155	0.821	−0.887	1.391	0.997	2.191
	(2.47)	(1.85)★	(6.91)+	(5.53)	(3.59)		
8. p_c	−2.188	0.119	0.143	0.451	0.599	0.999	2.034
	(4.05)	(2.48)++	(2.10)★	(4.91)	(2.71)		
plus Equations (3) and (4) above.							
IV. Korea-USA: General Case							
Same as Equations (7) and (8) above, plus							
9. q*	4.803	0.005	0.315	−0.388	0.710	0.983	1.358
	(7.06)	(0.08)	(3.68)+	(3.36)	(2.55)		
10. p_c^*	−1.061	−0.005	0.344	0.028	0.731	0.999	1.317
	(3.33)	(0.18)	(8.59)+	(0.52)	(5.61)		

Notes: 1. q, m, p, and p_c are variables for Taiwan or Korea.
2. q*, m*, p*, and p_c* are for the USA.
3. Number of observations N = 16, 1975-1990. df = 11.
4. The absolute value of the t-ratio is in the parentheses.
In Columns m and m*, significance at 1% level = +; at 5% level = ++, at 10% level = ★.

On the other hand, the expansion of foreign money supply also has a positive effect on domestic output in all cases, indicating the "locomotive" effects, rather than the "beggarthy-neighbor" effects (negative coefficients), of externalities. (Kawai, 1994).

b. For all general cases (Cases II and IV in Tables 3 and 4), a large country exerts larger influence on the output of a small country (m* on q) than a small country on the output of a larger country (m on q*).

c. Furthermore, the cross supply elasticities of output are highly significant from large countries to small countries, except equation 7 in Table 4. On the other hand, the cross elasticities are generally not statistically significant from small countries to large countries in all cases.

d. If we eliminate the effects of small countries on large countries by restricting the coefficients to zero as in our restricted cases, the own money supply elasticities of output in large countries become highly statistically significant (equation 3 in Table 3 and 4).

e. A similar effects may be observed on the equations of consumer prices. All own money supply elasticities of domestic consumer prices are positive and statistically significant, as expected, except Taiwan's money supply in equation 2 in Table 3. The Taiwan-U.S. case has a negative coefficient, it is insignificant. Similarly, the Taiwan-Japan case in equation 2 in Table 4, although has an expected positive sign, the coefficient is small and insignificant. Both cases may reflect rather stable price movement in Taiwan as compared with her money supply.

f. Theoretically, the cross country money supply elasticities of consumer prices may be positive or negative. Our regression results show that large country money supply generally exerts larger and significant influence on the small country's consumer prices (m* on p_c), except the case of Taiwan-Japan in equation 2 in Table 4, in which the coefficient is statistically insignificant.

On the other hand, the small countries generally have smaller elasticities and statistically insignificant influence on the large counties (m on p_c*). Our regression results also show that the two small countries have different cross relation with the large countries. The money supply elasticities of the consumer prices of Taiwan and Korea in relation to the United States are negative (equations 6 and 10 in Table 3), but, with Japan, they are positive (equations 6 and 10 in Table 4). Furthermore, all these coefficients are small and statistically insignificant, except the case of Taiwan-U.S.A. (equation 6 in Table 3), in which the coefficient is small but significant.

Table 4

REGRESSION COEFFICIENTS FOR REAL OUTPUT AND CONSUMER PRICES — TAIWAN, KOREA, AND THE JAPAN

Dependent Variable		Constant	m	m*	p	p*	R^2	DW
I. Taiwan-Japan: Restricted Case								
1.	q	0.877	0.290	0.527	−0.213	0.389	0.996	1.450
		(0.42)	$(3.77)^{+}$	$(2.24)^{++}$	(0.83)	(1.08)		
2.	p_c	−3.167	0.084	0.264	0.623	0.289	0.989	1.035
		(1.38)	(0.98)	(1.01)	(2.20)	(0.72)		
3.	q*	3.700	0	0.765	0	0.059	0.983	1.326
		(9.73)	(0)	$(25.3)^{+}$	(0)	(0.77)		
4.	p_c^*	−3.452	0	0.493	0	0.532	0.99	1.245
		(14.7)	(0)	$(26.5)^{+}$	(0)	(11.2)		
II. Taiwan-Japan: General Case								
Same as Equations (1) and (2) above, plus								
5.	q*	6.260	0.127	0.413	−0.310	0.498	0.987	1.142
		(3.22)	(1.76)	(1.87)★	(1.29)	(1.48)		
6.	p_c^*	−2.869	0.005	0.452	0.099	0.401	0.99	1.235
		(2.16)	(0.10)	$(2.99)^{++}$	(0.60)	(1.74)		

Table 4 (Continued)

Dependent Variable		Constant	m	m*	p	p*	R^2	DW
III. Korea-Japan: Restricted Case								
7.	q	5.771	0.324	0.530	0.085	−0.821	0.992	1.42
		(1.34)	(2.56)++	(1.41)	(0.42)	(1.99)		
8.	p_c	−4.134	0.103	0.377	0.694	0.079	0.999	1.148
		(2.64)	(2.23)++	(2.76)++	(9.54)	(0.53)		
plus Equations (3) and (4) above.								
IV. Korea-Japan: General Case								
Same as Equations (7) and (8) above, plus								
9.	q*	7.394	0.112	0.411	0.040	−0.128	0.986	1.19
		(2.47)	(1.27)	(1.57)	(0.29)	(0.45)		
10.	p_c*	−1.707	0.051	0.329	0.022	0.439	0.991	1.178
		(0.89)	(0.90)	(1.97)*	(0.25)	(2.39)		

Notes: 1. Same as notes 1, 3, and 4 in Table 3.
2. q*, m*, p*, and p_c* are for Japan.

g. It may be interesting to note that the U.S. price index consistently exerting very strong and statistically significant influence on outputs and consumer prices of the small countries, while the influence of the Japanese price index are generally weak and statistically insignificant (Column p* of Tables 3 and 4). This may be a manifestation of the fact that both small countries rely heavily on the United States for their major export markets during this period, as we have seen in Table 1.

In general, large countries exert larger and significant influences on the small countries, as we have expected. This justify the use of regression methods to estimate the coefficients for simulation. Furthermore, in this two-country world, the coefficients of the small countries are generally small and statistically insignificant in influencing the large country variables. If the small country money supply variable is eliminated from the regression in restricted cases, the large country money supply elasticities of output (or prices) increases, and the coefficients become highly statistically significant. This may justify the use of restricted cases as one of the criteria to distinguish between large and small countries.

V. The Simulation

The eight sets of regression coefficients, like R in (13), are then used in the model to find the equilibrium money supplies, consumer price indexes, and utility levels under Nash and cooperative equilibria for each pair of large and small countries. From the past performance of the Taiwanese and Korean economies, we conjecture that the output growth policy is probably more important than the price stabilization policy. Thus, we have assigned $w_1=0.8$ to the output growth policy and $w_2=0.2$ to the price policy. Due to the lack of specific information about the relative importance of GDP and price policies in the United States and Japan, we assume that the large country weights the GDP policy and the price policy equally ($w_1^*=w_2^*=0.5$). As explained in Section II, there are differences in size of land, population, GDP between Taiwan and Korean on the one hand and the United States and Japan on the other. Hence we have given Taiwan and Korea a weight of 0.1 ($=h$) and the United States and Japan a weight of 0.9 ($=h^*$) in the world welfare function in (12). The influence of these weights on the numerical results in rather quantitative than qualitative. Even if the weights are changed, our qualitative conclusions would still hold.

A. Policy Coordination between Taiwan and the United States

The target (or desirable) values for Taiwan and the United States, $T^{\#}=(q^{\#}, p_c^{\#}, q^{*\#}, p_c^{*\#})'=(7.7, 4.4, 8.3\ 4.4)'$, and the domestic prices $z=(p, p^*)'=(4.5, 4.5)'$, all in logarithm, are taken from the averages in the first and the third part of Table 2.

For the restricted case, the reaction curve in (A5) for the small country, Taiwan, is derived as

(14) $0.02508m+0.04059m^*=0.87545$

The reaction curve in (A6) for the large country, the United States, is derived as

(15) $0.12538m^*=1.74236$

Hence, the Nash equilibrium is calculated from (A7) as

(16) $x^N=(m^N, m^{*N})'=(12.413, 13.896)'$

Now from equation (A8), or equivalently, the first and the second equations in Table 3, we obtain the target values at the Nash equilibrium as $T_1^N=(q^N, p_c^N)'=(7.933, 7.424)'$. Taiwan's utility at the Nash equilibrium in (A9) is computed as $U^N=-0.936$. They are summarized in Column (3) of Table 5.

Similarly, using the Nash equilibrium x^N in (16), we may calculate the target values of the United States at the Nash equilibrium as $T_1^{*N}=(q^{*N}, p_c^{*N})'=(4.972, 8.137)'$, and the Nash utility as $U^{*N}=-6.261$. They are listed in Column (6) of Table 5.

Next, we calculate the cooperative equilibrium. Given the world's utility function in quadratic form as shown in (A1), the cooperative equilibrium is the solution of equation (A10). We have

(17) $x^C=(m^C, m^{*C})'=(12.704, 13.717)'$.

From the cooperative equilibrium, we derive the cooperative equilibrium targets in (A12) as

(18) $$T^C=(q^c, p_C^C, q^{*c}, p_c^{*C})'$$
$$=(7.929, 7.364, 4.905, 8.078)'$$

and the cooperative utility in (A13) for both countries as

Table 5

GAINS FROM COORDINATION — TAIWAN AND USA, THE RESTRICTED CASE

h = 0.1		**Taiwan p = 4.5**			**USA p* = 4.5**	
Instrument: (1)	Target# (2)	Nash (3)	Coop. (4)	Target# (5)	Nash (6)	Coop. (7)
Money Supply	(avg)	m^N	m^C	(avg)	m^{*N}	m^{*C}
(m)	6.4	12.413	12.704	6.2	13.896	13.717
GDP		q^N	q^C		q^{*N}	$q^{*\#}$
(q)	7.7	7.933	7.929	8.3	4.972	4.905
CPI		pc^N	pc^C		pc^{*N}	pc^{*C}
(pc)	4.4	7.424	7.364	4.4	8.137	8.078
Utilities (U)		−0.936	−5.726		−6.261	−5.726
Change in Util★ (%)			−511.612			8.534
Gain, in ln			(3.235)			0.338
Gain, in antilog			(25.409)			1.403

Note: ★ Change in util $\equiv (W^C - U^N)*100/\text{abs}(U^N)$.

(19) $W^{C} = -5.726.$

These results are also summarized in Columns (4) and (7) in Table 5.

Lastly, we measure the welfare gains or losses (losses are shown in the parentheses) of Taiwan from cooperation, as compared with the Nash non-cooperative equilibrium, in terms of GDP. The method is expounded by Oudiz and Sachs (1984) to measure "welfare gain from cooperation measured in units of GNP." From equation (A14), it can be shown that the welfare gains or losses, Δ, can be calculated from formula (A16) as the smallest absolute value of the roots, $\Delta = 3.235$. This is shown in Column 4 of Table 5. Thus for Taiwan, the welfare loss is 512% when she moves from Nash equilibrium to cooperative equilibrium. The loss in logarithm is 3.235, or NT$25.409 billion.

For the general case, the reaction curve in (A5) for Taiwan is the same as (14). For the United States, it is calculated from (A6) as

$$-0.00582m + 0.09178m^* = 0.62945$$

Hence, the Nash equilibrium is given as

(20) $x^{N} = (m^{N}, m^{*N})' = (21.590, 8.226)'$

Now, from equation (A8), $T_1^{N} = (q^{N}, p_c^{N})' = (7.787, 5.528)'$. Taiwan's utility at Nash equilibrium in (A9) is computed as $U^{N} = -0.130$. They are summarized in Column (3) of Table 6.

Similarly, using the Nash equilibrium x^{N} in (20), we may calculate the target values of the United States at the Nash equilibrium as $T_1^{*N} = (q^{*N}, p_c^{*N})' = (2.345, 6.044)'$, and the Nash utility as $U^{*N} = -9.542$. They are listed in Column (6) of Table 6.

The cooperative equilibrium is the solution of equation (A10). From (A11), we have

(21) $x^{C} = (m^{C}, m^{*C})' = (60.310, 8.639)'$.

From the cooperative equilibrium, we derive the cooperative equilibrium targets in (A12) as

(22) $T^{C} = (q^{C}, p_c^{C}, q^{*C}, p_c^{*C})'$

$$= (14{,}691,\ 3.539,\ 4.754,\ 4.472)'$$

and the cooperative utility in (A13) for both countries as

Table 6

GAINS FROM COORDINATION — TAIWAN AND USA, THE GENERAL CASE

h = 0.1	**Taiwan p = 4.5**			**USA p* = 4.5**		
Instrument:	Target#	Nash	Coop.	Target#	Nash	Coop.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Money Supply	(avg)	m^N	m^C	(avg)	m^{*N}	m^{*C}
(m)	6.4	21.590	60.310	6.2	8.226	8.639
GDP		q^N	q^C		q^{*N}	$q^{*\#}$
(q)	7.7	7.787	14.691	8.3	2.345	4.754
CPI		pc^N	pc^C		pc^{*N}	pc^{*C}
(pc)	4.4	5.528	3.539	4.4	6.044	4.472
Utilities (U)		−0.130	−4.793		−9.542	−4.793
Change in Util★ (%)			−3579.326			49.769
Gain, in ln			(3.328)			1.897
Gain, in antilog			(27.890)			6.666

Note: ★ Change in util $\equiv (W^C - U^N)*100/abs(U^N)$.

(23) $W^C = -4.793.$

These results are also summarized in Columns (4) and (7) in Table 6.

B. Policy Coordination between Korea and the United States

For the restricted case, the Korean reaction function is calculated as

(24) $0.02205m + 0.10521m^* = 1.06520$

and the U.S. reaction curve is given as

(25) $0.12538m^* = 1.74236$

which is the same as (15). The utility and gains or losses for Nash and cooperative equilibria are shown in Table 7.

For the general case, the Korean reaction function is the same as the restricted case. The U.S. reaction curve is given as

(26) $-0.000072m + 0.10878m^* = 1.23710$

The utility and gains or losses for Nash and cooperative equilibria are reported in Table 8.

C. Policy Coordination between Taiwan and Japan, Korea and Japan

For comparison, we also take Japan as the large country and apply the same analytical methods and computation procedures to calculate the utilities and gains or losses for Nash and cooperative equilibria. The results for Taiwan and Japan's restricted case and general case are shown in Tables 5J and 6J, respectively. The results for Korea and Japan restricted are shown in Tables 7J and 8J, respectively. As expected, we found that the numerical results in the cases of Japan as the large country indicate the same qualitative implications as in the cases of the United States as the large country.

Instead of choosing the average of past data as the target values, we also used the minimum and the maximum values of the previous data as the target values. The results are qualiltatively similar to Tables 5 to 8, and also to Tables 5J to 8J.

Table 7

GAINS FROM COORDINATION — KOREA AND USA, THE RESTRICTED CASE

h = 0.1	Korea p = 4.3			USA p* = 4.5		
Instrument: (1)	Target# (2)	Nash (3)	Coop. (4)	Target# (5)	Nash (6)	Coop. (7)
Utilities (U)		−0.004	−5.635		−6.261	−5.635
Change in Util★ (%)			−150233.810			9.994
Gain, in ln			(3.718)			0.400
Gain, in antilog			(41.163)			1.492

Table 8

GAINS FROM COORDINATION — KOREA AND USA, THE GENERAL CASE

h = 0.1	Korea p = 4.3			USA p* = 4.5		
Instrument: (1)	Target# (2)	Nash (3)	Coop. (4)	Target# (5)	Nash (6)	Coop. (7)
Utilities (U)		−0.181	−4.255		−4.771	−4.255
Change in Util★ (%)			−2257.175			10.814
Gain, in ln			(2.960)			0.338
Gain, in antilog			(19.299)			1.402

Note: ★ Change in util≡$(W^C - U^N)*100/abs(U^N)$.

Table 5J

GAINS FROM COORDINATION — TAIWAN AND JAPAN, THE RESTRICTED CASE

h = 0.1		**Taiwan p = 4.5**			**Japan p* = 4.5**	
Instrument: (1)	Target# (2)	Nash (3)	Coop. (4)	Target# (5)	Nash (6)	Coop. (7)
Money Supply	(avg)	m^N	m^C	(avg)	m^{*N}	m^{*C}
(m)	6.4	0.079	0.113	11.2	12.646	12.628
GDP		q^N	q^C		q^{*N}	q^{*C}
(q)	7.7	7.479	7.479	12.6	9.940	9.926
Inflation		p_c^N	p_{cC}		p_c^N	p_c^C
(p_c)	4.4	7.449	7.447	4.5	8.628	8.619
Utilities (U)		−0.949	−5.522		−6.030	−5.522
Change in Util★(%)			−481.771			8.427
Gain, in ln			(3.168)			0.414
Gain, in antilog			(23.751)			1.513

Note: ★ Change in Util≡$(W^C - U^N)$*100/abs(U^N).

Table 6J

GAINS FROM COORDINATION — TAIWAN AND JAPAN, THE GENERAL CASE

h = 0.1	Taiwan p = 4.5			Japan p* = 4.5		
Instrument:	Target#	Nash	Coop.	Target#	Nash	Coop.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Money Supply	(avg)	m^N	m^C	(avg)	m^{*N}	m^{*C}
(m)	6.4	−7.506	38.864	11.2	16.758	7.726
GDP		q^N	q^C		q^{*N}	q^{*C}
(q)	7.7	7.447	16.134	12.6	6.814	8.972
Inflation		p_c^N	p_c^C		p_c^{*N}	p_c^C
(p_c)	4.4	7.898	9.408	4.5	9.787	5.936
Utilities (U)		−1.249	−6.521		−15.358	−6.521
Change in Util★(%)			−422.120			57.540
Gain, in ln			(3.386)			4.420
Gain, in antilog			(29.548)			83.061

Note: ★ Change in Util≡$(W^C - U^N)*100/\text{abs}(U^N)$.

Table 7J

GAINS FROM COORDINATION — KOREA AND JAPAN, THE RESTRICTED CASE

h = 0.01	**Korea p = 4.3**			**Japan p* = 4.5**		
Instrument: (1)	Target# (2)	Nash (3)	Coop. (4)	Target# (5)	Nash (6)	Coop. (7)
Utilities (U)		−3.826	−5.809		−6.030	−5.809
Change in Util★ (%)			−51.815			3.669
Gain, in ln			(1.793)			0.172
Gain, in antilog			(6.008)			1.188

Table 8J

GAINS FROM COORDINATION — KOREA AND JAPAN, THE GENERAL CASE

h = 0.1	**Korea p = 4.3**			**Japan p* = 4.5**		
Instrument: (1)	Target# (2)	Nash (3)	Coop. (4)	Target# (5)	Nash (6)	Coop. (7)
Utilities (U)		−5.885	−7.237		−8.768	−7.237
Change in Util★ (%)			−22.988			17.454
Gain, in ln			(1.333)			0.949
Gain, in antilog			(3.792)			2.582

Note: ★ Change in Util ≡ $(W^C - U^N) * 100/\text{abs}(U^N)$.

VI. Some Interpretations

Some interesting patterns appear from our simulation results. As in the previous paper when the variables are taken as percentage changes, the money supply is consistently erratic, although it is not as unrealistic compared with the previous results as we have mentioned in Section IV. While the actual money supply on average is 6.4 per year for Taiwan, and 11.2 per year for the United States, our simulation shows that, for the restricted case, the Nash equilibrium money supply is 12.4 for Taiwan and 13.9 for the United States. The cooperative equilibrium money supply is 12.7 for Taiwan and 13.7 for the United States. For the general case, the discrepancy for Taiwan is even larger, as shown in the (m) row in Table 6.

The values for the optimal GDP and consumer price index seem much more reasonable. For all four countries the values are closer to the average of the corresponding data, especially for both Taiwan and Korea. For Taiwan, compared with the average of 7.7, Nash equilibrium GDP is 7.9, and is almost the same as that in the cooperative equilibrium. For the United States, compared with the average of 8.3, Nash equilibrium GDP is 5.0. It is also almost the same as that in the cooperative equilibrium. For both countries, the consumer price index is 4,4, the equilibrium consumer price index is about 7.4 for Taiwan and 8.1 for the United States for both equilibria. There are striking similarity in the patterns of the utilities and gains from policy coordination. This is shown in the last four rows of Tables 5 to 8 and Tables 5J to 8J.

In Table 5, the "Utilities" row shows the level of utilities for the Nash equilibrium solution and the cooperative equilibrium solution. They are computed from (A9) and (A13). The "Change in Util" row shows the percentage change in utility by moving from Nash equilibrium to cooperative equilibrium,[3] and is calculated from

(27) $(W^{C}-U^{N})*100/|U^{N}|$.

It is negative ($W^{C}<U^{N}$) if the move is utility-losing, and is positive ($W^{C}>U^{N}$)if the move is utility-gaining. For example, in Table 5, Taiwanese welfare loses 512 percent by moving from Nash equilibrium to cooperative equilibrium, while the United States gains 8.5 percent by doing so.

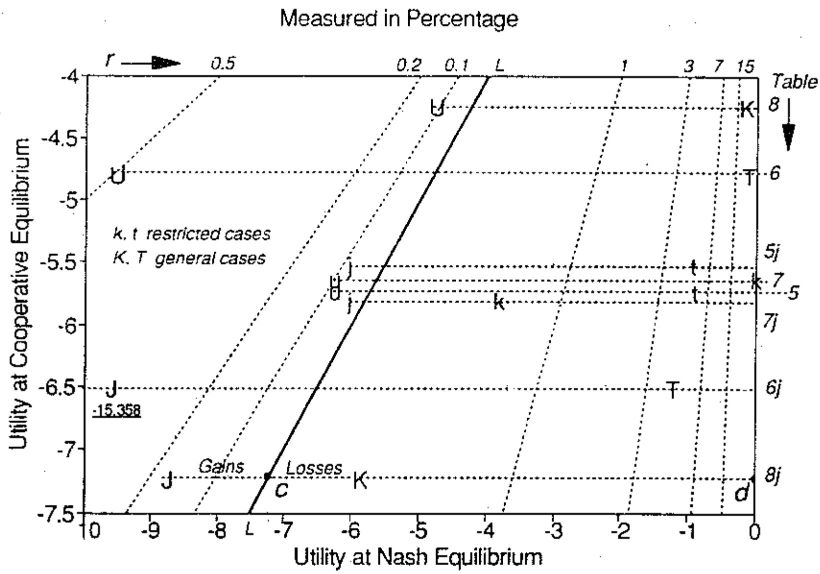
[3] Since $|U^{N}|=-U^{N}$, (27) is equivalent to $(U^{N}-W^{C})*100/U^{N}$.

The utilities and the percentage changes in utilities of Tables 5 to 8 and also Tables 5J to 8J are summarized in Figure 1. The origin of the diagram is located well above the upper right corner of the diagram which is not shown. The diagram shows only a lower part of the third quadrant of the utility space. Line LL is the 45-degree line from the hidden origin. A point on LL represents utility at cooperative equilibrium. Given a cooperative equilibrium utility of small and large countries, their corresponding Nash equilibrium utilities, one for the small country and another for the large country, may be located horizontally.

The corresponding table number is shown at the right margin of the diagram. For example, the horizontal dotted line at the bottom of the diagram illustrate the results of Table 8J. It shows the Nash utility for Korea (K = −5.885%) and that of Japan (J = −8.768%), along with their cooperative utility (c = −7.237%). If the Nash utility is located on the right of the LL line, as shown by point K, then the country loses by moving to the cooperative equilibrium at point c on the LL line. Similarly, if the Nash utility is located on the left of the LL line, then there is a

Figure 1

Gains or Losses from Cooperation



gain, as shown by moving point J to point c. Some distinct patterns appear in the diagrma.[4]

a. All Nash utilities of the small countries are located on the right of the LL line, and mostly cluster near zero, indicating small countries seem to be much better-off with Nash non-cooperative equilibrium. They will lose greatly by moving toward cooperative equilibrium.

b. All Nash utilities of the large countries are located on the left side of the LL line, and cluster near the LL line, indicating large countries are only slightly worse-off at Nash non-cooperative equilibrium as compared with cooperate equilibrium. In other words, they will gain slightly by moving toward cooperative equilibrium.

c. The above characteristics of the scatter diagram are most clearly demonstrated in the restricted cases (Tables 5, 7, 5J, 7J. Shown by small letters in Figure 1). The variation in the general cases (shown by capital letters) is much larger than the restricted cases. Thus, the restricted cases seem to characterize our observations better.

d. There is a discrepancy between the restricted cases and the general cases in the gains from coordination for Japan and the United States. For the restricted cases, Japan's gains are slightly less than the U.S. gains, as can be seen from the "gain distance" in the diagram. However, for the general cases, the Japan's gains are about twice larger than those of the United States. If this is any indication about the difference between the two large countries, we may say that Japan seems to gain more than the United States by cooperating with these small countries.

For the small countries, the restricted and general cases are almost the same in the losses from cooperation with the large countries. However, there seems to have a slight edge that the small country would lose less by cooperating with Japan than with the United States. This is rather inconsistent with our regression finding in Section IV, where we see that the United States exerts more influence on the small countries than Japan (see part g of Section IV). It is not clear whether this reflects closer historic and geographic affinity between Japan and Taiwan and Korea (Hsiao and Hsiao, 1989).

The percentage change in utility by moving from Nash equilibrium to cooperative equilibrium, as calculated by equation (27), may also be

[4] For convenience, Japan's Nash utility (-15.358) is Table 6J is truncated at $J = -10$ in the diagram. The actual J should be located on the left outside the diagram.

read from Figure 1. For example, for Table 8J, the percentage loss from cooperation for Korea with Japan is shown by Kc/Kd = −23%, and the percentage gain from cooperation for Japan with Korea is Jc/Jd = 17%. The numbers on the upper margin of the diagram are these ratios, r's, which should be changed into percentages by multiplying 100. In the diagram, the percentages range from 10% to 1500%. The vertical dotted lines divide the area of the diagram based on these percentages. Clearly, in most cases, the small countries would lose more than 500% and the large countries would gain less than 10% of Nash utilities by moving toward cooperative equilibrium.

In Tables 5 to 8, and 5J to 8J, the "Gain, in ln" row measures the percentage change in utilities in terms of 1990 logarithmic real GDP. The gains or losses are calcualted from Oudiz-Sachs formula in (A16), as described in the previous section. When these numbers are converted into real GDP in the "Gain, in antilog" row by taking anti-logarithm. Table 9 shows the magnitude of these gains or losses in terms of the percentage of 1990 real GDP (real GNP for Japan). Each country's 1990 real GDP is listed in Table 2. In each cell of Table 9, the first number shows the restricted case, and the second, the general case, which is inside the square brackets. For example, in Table 5, moving from Nash equilibrium to cooperative equilibrium will increase United States' GDP by US$1.403 billion. This amounts is 0.0287% of the U.S. 1990 GDP in the restricted case, as shown in the first row (USA) in Table 9. We have also seen in Table 5 that the same move will decrease Taiwan's GDP by NT$25.409 billion. This is about 0.6542% of Taiwan's 1990 GDP, as shown in the third row (Taiwan) in Table 9.

In general, we see that for small countries like Taiwan and Korea, although the losses due to cooperation are quite large compared to the gains of the large countries, the losses in terms of percentage in real GDP are consistently much less than 0.8%. On the other hand, Table 9 also shows that the gains from policy coordination for the large countries are very small, and in terms of percentage in 1990 real GDP, they are generally negligible, no more than 0.1%.

Hence we may conclude that, while we can identify that there are welfare losses of policy coordination for the small countries and small gains for the large countries, the gains or losses are very small in terms of real GDP, and both are practically negligible.

These results are consistent with the results obtained in the previous paper (Hsiao and Hsiao, 1994a) when the percentage changes of the variables are used in the analysis. We may repeat our previous observations here. For the United States, the country is so large that it is indif-

Table 9

GAINS OR LOSSES FROM POLICY COORDINATION AS PERCENTAGE OF 1990 REAL GDP

(Unit: %)

In Coop. with Country	USA	Japan	Taiwan	Korea
USA	—	—	0.0287	0.0305
	—	—	[0.1365]	[0.0287]
Japan	—	—	0.0004	0.0003
	—	—	[0.0205]	[0.0006]
Taiwan	−0.6452	−0.6116	—	—
	[−0.7181]	[−0.7608]	—	—
Korea	−0.0314	−0.0046	—	—
	[−0.0147]	[−0.0029]		

Note: In each cell, the upper number is for the restricted case; the lower number in brackets is for the general case.

ferent whether the United States cooperates with Taiwan and Korea or not. However, for the small open economies like Taiwan and Korea, our results show that, Taiwan and Korea might not have benefits of coordinating their monetary policy with the United States.

The above results are also generally consistent with the empirical findings in a model of policy coordination among industrial countries in the literature. Oudiz and Sachs (1984, pp 45-46) found that the gain would range from 0.03% to 0.99% of GNP of the United States, Germany, or Japan during 1984 to 1986. Coordination may even not pay (Canzoneri and Minford, 1988; Miller and Salmon, 1990). Later, using larger models in dynamic settings, researchers have found the percentage could be slightly higher, between 0.5% to 1.5% of GNP (Currie and Levine, 1993, p. 62). Generally speaking, among the symmetric developed countries, "the gains from coordination are likely to be fairly small, but not insignificant." Thus, "coordination in the sense of *information exchange,* rather than detailed coordination across all variables, may supply part of the improvements available from policy coordination." (ibid., p. 63).

Our findings are also congruous with the general fear among the small countries that any regional economic integration probably would not benefit, or even would work against, the small countries. The fear of "big fish eats small fish," as a proverb says, always presents if they are too close to each other.

In economics term, an interpretation may be given as follows. The price elasticity of exports of a small country is in general larger than that of a large country. This is so because a small country exports labor-intensive products which can be replaced easily by exports from other developing countries. On the other hand, the price elasticity of imports of a small country is in general smaller than that of a large country, since the former imports raw materials and capital goods from the latter. The output elasticity of exports of a small country, on the other hand, is usually lower than that of a large country since the production capacity of a small country is usually limited. Thus for a small country, the result of economic integration, say, an agreement in tariffs reduction, with a large country may have larger negative trade diversion effect, as they have to buy more from the specific large cooperative country than from third countries with cheaper prices. The positive trade creation effect for a small country might be small to limitation of the output elasticity, thus resulting in losses of welfare. Conversely, for a large country, the elasticity situation is reversed. The positive trade creation effect might outweigh the negative trade diversion effect and thus might gain in utilities. Whether similar interpretation can be applied to the case of strategic monetary policy coordination in our model is an open question which requires more sophisticated model simulation.

VII. Conclusions

In this paper, we have investigated gains or losses from monetary policy coordination between two groups of physically and economically different countries. We have found that the small country losses and the large country gains when both countries move from Nash non-cooperative equilibrium to cooperative equilibrium. However, the gain of the large country is minuscule in terms of the percentage of its national income. Similarly, the loss of the small country is also not significant. This may be one of the reasons why policy coordination does not exist between large and small countries, although there are more than 60 free trade agreements in the world since the end of the Second World War (Jones, et al., 1992).

Our simulation results that small and large countries are most likely indifferent about coordination, although basically consistent with the results from other more sophisticated static and dynamic models in the literature, are rather surprising. A caution should be taken in generalization of this conclusion in the context of this paper.

In order to obtain some clear and interesting results, the model we use is a simple, static, and once-and-for-all policy coordination. It ignores several important long-run and other issues. It may be expected that a cooperative dynamic game model may lead to welfare improvement relative to the Nash non-cooperative game model through a reduction in conflicts of interests and benefits from system-wide dynamic optimization. Unlike a dynamic model, the variables in the static objective function are separable, and the world welfare function is the weighted average of individual objective functions. This implies that there is no trade-off or complementary relationship among the targets, a rather unrealistic assumption.

Furthermore, in this fixed price Keynesian frame work with perfect capital mobility, each country's nominal interest rate is the same as the real interest rates, and so the interest rate parity condition (4) also implies the equality between the real interest rates (Hamada, 1974) among the small and the large countries. While there is some evidence of comovements of the interest rates among small and large countries in Pacific Rim, there seems no strong empirical evidence of equality in (4) in terms of either nominal interest rates (Chinn and Frankel, 1994a), or real interest rates (Chinn and Frankel, 1994b).[5] Persistent interest rate differentials between these countries may distort our simulation results.[6]

In Nash equilibrium, both countries are assumed to take other country's monetary policy as given, without recognizing that the other country reacts to its own policy. The model may be extended to the case when the United States (or Japan) acts as the dominant player (the Stackelberg leader) by anticipating Taiwan's or Korea's reaction function. The dominant player may also take into account the follower's policy in the future. This suggests a dynamic framework with rational expectation. Our preliminary results elsewhere (Hsiao and Hsiao, 1994b) shows that the conclusion we have obtained in this paper is the

5 Covered interest differentials declined substantially from 1982 to 1992 among the countries with well-developed forward markets (not including Taiwan and Korea). On the other hand, uncovered interest parity does not hold among the Pacific countries (Chinn and Frankel, 1994a, pp. 30, 34). Chinn and Frankel (1994b) also found that real interest rates among Japan and Korea, and among United States, Taiwan and Korea, are pair-wise cointegrated. This finding might contradict the equality in (4).

6 This has been pointed out to us by Professor Wendy Dobson and a referee of this Journal.

same whether United States or Japan acts as dominant player or not.

Our model may also be extended in several ways. The expected rate of depreciation in the interest rate parity condition may be introduced, non-linear terms, external demand and supply shocks, model uncertainty, economies of scale, market imperfection, institutional enforcement and overseeing mechanism for international cooperation, etc., may also be examined. Clearly, one cannot include all these features in a single simulation model. One or more of these extensions are already applied to some of the symmetric models of international policy coordination among developed countries. However, the theoretical and empirical works on their applications to asymmetric models of policy coordination among small and large countries, or among the developing countries, seem not having been explored.

Naturally, the problems of international policy coordination are too important to rely only on the simple model as expounded in this paper. A large model simulation, however, requires a team work by an institute which is beyond our access. We hope that the results obtained from our simple model are sufficiently robust to the consideration of more sophisticated features. Our study is a first step toward this direction.

Appendix A

To facilitate computation, we rewrite the world welfare functions (10) in matrix form.

$$\text{(A1)} \quad W = -(1/2)(T - T^{\#})' \hat{W}(T - T^{\#})$$

where

$$T = (q,\ p_c;\ q^*,\ p_c^*)' = (T_1,\ T_2)'$$

$$T^{\#} = (q^{\#},\ p_c^{\#};\ q^{*\#},\ p_c^{*\#})' = (T_1^{\#},\ T_2^{\#})'.$$

$$\hat{W} = \begin{bmatrix} hw_1 & & & 0 \\ & hw_2 & & \\ \cdots & \cdots & \cdots & \cdots \\ & & h^*w_1^* & \\ 0 & & & h^*w_2^* \end{bmatrix} = \begin{bmatrix} \hat{W}_1 & \vdots & 0 \\ \cdots & \cdots & \cdots \\ 0 & \vdots & \hat{W}_2 \end{bmatrix}$$

T is the target variables, $T^{\#}$ is the target (or desired) values, and $\hat{W}$ is a diagonal matrix consisting of national and international weights (or importance) of policies (w) and countries (h). "′" denotes transpose.

Write the reduced form equation (6) to (9) as $T = Ry$, or

$$\text{(A2)} \qquad \begin{bmatrix} T_1 \\ T_2 \end{bmatrix} = \begin{bmatrix} R_{11} & R_{12} \\ R_{21} & R_{22} \end{bmatrix} \begin{bmatrix} x \\ z \end{bmatrix}$$

where

$$R \equiv [R_1 : R_2] = \begin{bmatrix} a & b & : & c & d \\ \bar{a} & \bar{b} & : & \bar{c} & \bar{d} \\ \cdots & \cdots & \cdots & \cdots & \cdots \\ a^* & b^* & : & c^* & d^* \\ \bar{a}^* & \bar{b}^* & : & \bar{c}^* & \bar{d}^* \end{bmatrix} = \begin{bmatrix} R_{11} & : & R_{12} \\ \cdots & \cdots & \cdots \\ R_{21} & : & R_{22} \end{bmatrix}$$

$$(x,\ z)' = (m,\ m^*;\ p,\ p^*)'$$

R is the multiplier matrix, x is the policy variables (m, m^*), and $z = (p, p^*)$ is what Tinbergen calls "irrelevant variables."

(i) Nash Equilibrium

Nash equilibrium is derived as follows. For the first (small) country, we choose m such that,

$$\text{(A3)} \qquad U = -(1/2)\,(T_1 - T_1^{\#})'\hat{W}_1(T_1 - T_1^{\#})$$

is maximized, subject to $h = 1$, $T_1 = R_{11}x + R_{12}z$. The first order condition is,

$$\text{(A4)} \qquad \frac{\partial U}{\partial m} = -\left(\frac{\partial T_1}{\partial m}\right)'\ \hat{W}_1(T_1 - T_1^{\#}) = 0$$

where $\partial(T_1 - T_1^{\#})'/\partial m = (\partial T_1/\partial m)' = (\partial q/\partial m,\ \ \partial p_c/\partial m)' = (a,\ \bar{a})'$. Substituting T_1 into the above equation, we have the reaction function of the small country:

$$\text{(A5)} \qquad (a,\ \bar{a})\hat{W}_1 R_{11}\ x = (a,\ \bar{a})\hat{W}_1(T_1^{\#} - R_{12}\ z)$$

which is estimated in (14).

Similarly, the reaction function for the large country is given by

$$\text{(A6)} \qquad (b^*,\ \bar{b}^*)\hat{W}_2 R_{21}\ x = (b^*,\ \bar{b}^*)\hat{W}_2(T^{\#}_2 - R_{22}\ z)$$

which is estimated in (15).

The Nash equilibrium is then given by solving the combined expression of (A5) and (A6) for $h = h^* = 1$,

$$\text{(A7)} \quad \begin{bmatrix} a & \bar{a} & 0 & 0 \\ 0 & 0 & b^* & \bar{b}^* \end{bmatrix} \hat{W} R_1 x = \begin{bmatrix} a & \bar{a} & 0 & 0 \\ 0 & 0 & b^* & \bar{b}^* \end{bmatrix} \hat{W}(T^{\#} - R_2 z)$$

Denote the solution as $x^N = (m^N, m^{*N})'$, which is in (16). Substituting into the constraint, we have

$$\text{(A8)} \quad T_1{}^N = R_{11} x^N + R_{12} z$$

Hence, for the small country,

$$\text{(A9)} \quad U^N = -(1/2)(T_1{}^N - T^N - T^{\#}) \hat{W}_1 (T^N - T^{\#})$$

Similarly, we obtain the Nash equilibrium target values and utility for the large country, $T_2{}^N$ and U^{*N}.

(ii) Cooperative Equilibrium

The cooperative equilibrium is derived as follows. Differentiating the world welfare function (A1) with respect to the policy variables $x = (m, m^*)$, we have

$$\frac{\partial W}{\partial x} = -\left(\frac{\partial T}{\partial x}\right)' \hat{W}(T - T^{\#}) = 0$$

where the derivative $\partial T/\partial x$ is the 4×2 Jacobian matrix, which is R_1. Substituting $T = R_1 x + R_2 z$ of (A2) into the above equation and rearranging, we have

$$\text{(A10)} \quad R_1' \hat{W} R_1 x = R_1' \hat{W}(T^{\#} - R_2 z)$$

The cooperative equilibrium is then

$$\text{(A11)} \quad x^C = (R_1' \hat{W} R_1)^{-1} R_1' \hat{W}(T^{\#} - R_2 z)$$

which is (17). The corresponding optimal targets are

$$\text{(A12)} \quad T^C = R_1 x^C + R_2 z$$

and the corresponding optimal welfare is

(A13) $W^C = -(1/2)(T^C - T^{\#})' W(T^C - T^{\#})$

These are estimated in (18) and (19).

(iii) Gains

Let $W^C \equiv W(T^C) = W(q^C, p_c^C)$, and $U^N \equiv U(q^N, p_c^N)$. Then the "welfare gain from cooperation measured in units of GNP" (see Oudiz and Sachs (1984)) is defined as quantity Δ such that

(A14) $W^C = U(q^N + \Delta, p_c^N)$.

where Δ is positive, since, in general, $W^C > U^N$. Because of the data, we use GDP in this paper.

In our quadratic utility function (A1), the gain Δ is the smallest absolute value of the root of

(A15) $\Delta^2 + 2f\Delta + 2g = 0$

where $f \equiv q^N - q^{\#}$, and $g \equiv (W^C - U^N)/w_1$. The two roots are

(A16) $\Delta_1, \Delta_2 = -f \pm \sqrt{f^2 - 2g}$

The gain for the first country is defined as min $(|\Delta_1|, |\Delta_2|)$.

Similarly, we may calculate Δ^* such that

$$W^C = U^{*N}(q^{*N} + \Delta^*, p_c^{*N}).$$

References

Argy, V., W. McKibbin and E. Siegloff, *Exchange-Rate Regimes for a Small Economy in a Multi-Country World,* Princeton Studies in International Finance, 67, December 1989.

Canzoneri, M.B. and P. Minford, "When International Policy Coordination Matters: An Empirical Analysis," *Applied Economics,* 20, 1988, 1137-1154.

Chinn, M.D. and J.A. Frankel, "Financial Links around the Pacific Rim, 1982-1992," Chapter 2 in R. Glick and M.M. Hutshion (eds.), *Exchange Rate Policy and*

Interdependence, Perspectives from the Pacific Basin, Cambridge University Press, 1994a.

______, "The Relative Influence of US and Japan on Real Interest Rates Around the Pacific Rim," Working Paper, 284, Department of Economics, University of California, Santz Cruz, 1994b.

Cooper, R., "Economic Interdependence and Coordination of Economics Policies," in R.W. Jones and P.B. Kenne (eds.), *Handbook of International Economics,* Vol. II, Amsterdam, Elsevier Science Publishers, B.V. 1985, 1195-1234.

Currie, D. and P. Levine, *Rules, Reputation and Macroeconomic Coordination,* Cambridge, UK, Cambridge University Press, 1993.

DeJong, D.N., J.C. Nankervis, N.E. Savin and C.H. Whiteman, "Integration versus Trend Stationarity in Time Series," *Econometrica,* 60, 2, March 1992, 423-433.

Hamada, K., "Alternative Exchange Systems and the Interdependence of Monetary Policies," in R.Z. Aliber (ed.), *National Monetary Policies and the International Financial System,* Chicago, Illinois, The University of Chicago Press, 1974.

______, *The Political Economy of International Monetary Interdependence,* translated by C.Y. Horioka and C.H. Kwan, Cambridge, MA, The MIT Press, 1985.

Hsiao, F.S.T., "Globalization of the Japanese Economy and the Asian NICs — Toward the Asian Economic Community," in *The Globalization of Japanese Economy,* International Symposium, The 40th Anniversary of Economics Faculty, Komazawa University, Tokyo, Japan, 1990, 129-164.

______, and M.C.W. Hsiao, "Some Development Indicators of Taiwan: A Comparative Study," *Journal of Economic Development,* 8, 1, July 1998, 45-58.

______ and ______, "Japanese Experience of Industrialization and Economic Performance of Korea and Taiwan: Tests of Similarity," in *Taiwan's Foreign Investment, Exports and Financial Analysis, Advances in Financial Planning and Forecasting,* Supplement 1, Greenwich, Connection, JAI Press, Inc., 1989, 157-190.

______ and ______, "Gains from Policy Coordination between Taiwan and the United States — On the Games Government Play," *Research in Asian Economic Studies,* 5, *Asian-Pacific Economies: 1990s and Beyond* eds., M. Dutta and R. Shiratori, eds. Greenwich, Connecticut, JAI Press, Inc., 1994a, 239-264.

______ and ______, "International Policy Coordination with a Dominant Player — The Case of the United States, Japan, Taiwan, and Korea," Paper presented at the Sixth Biennial Conference on United States-Asia Economic Relations, sponsored by the American Committee on Asian Economic Studies and Brandeis University, Brandeis University, Waltham, MA, May 1994b.

_____ and _____, "Taiwanese Economic Development and Foreign Trade," in J.Y.K. Kuark (ed.), 1995.

(IFS) *International Finance Statistics,* International Monetary Fund, Washington, D.C. 1990, 1992.

Jones, R., R. King and M. Klein, "The Chinese Economic Area: Economic Integration without a Free Trade Arrangement," Economic Department Working Paper, 124, OECD, Paris, 1992.

Kawai, M., *Studies in International Finance* (in Japanese), Tokyo, Japan, Tokyo University Press, 1994.

Kurak, J.Y.K., (ed.) *Comparative Asian Economies,* Greenwich, Connecticut, JAI Press, Inc., 1995.

McKibbin, W.J., "The Economics of International Policy Coordinnation," *Economic Record,* December 1988, 241-253.

_____ and J.D. Sachs, *Global Linkages: Macroeconomic Interdependence and Cooperation in the World Economy,* The Brookings Institution, Washington, D.C., 1991.

Miller, M. and M. Salmon, "When Does Coordination Pay?," *Journal of Economic Dynamics and Control,* 14, July-October 1990, 553-569.

Oudiz, G. and J. Sachs, "Macroeconomic Policy Coordination among the Industrial Economies," *Brookings Papers on Economic Activities,* 1, 1984, 1-75.

Rivera-Batiz, F.L. and L. Rivera-Batiz, *International Finance and Open Economy Macroeconomics,* Macmillan, New York, 1985.

Rudebusch, G.D., "The Uncertain Unit Root in Real GNP," *American Economic Review,* 83, 1, March 1993, 264-272.

Sims, C.A. and H. Uhlig, "Understanding Unit Rooters: A Helicopter Tour," *Econometrica,* 59, 6, November 1991, 1591-1599.

(TSDB) *Taiwan Statistical Data Book,* Council for Planning and Development, Executive Yuan, Republic of China, 1992.