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ANALOGOUS CYCLES WITH LAGGED CO-MOVEMENT: U.S. AND EAST ASIAN BUSINESS CYCLES

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I. INTRODUCTION

THE spectacular economic growth of the East Asian economy since World War II has attracted the attention of economists worldwide. Some literature related to economic growth was motivated by the difference in the economic performance between the East Asian economies and other developing countries, for example Lucas (1993). In 1997, the East Asian economies attracted public attention again, because of their economic crisis. Vulnerable financial institutions and mismanagement in foreign exchange control may have caused this severe recession in the East Asian economies. Some economists fear that this collapse of the East Asian economy will affect considerably the world economy. Nowadays not only economic growth but also fluctuations in the short and medium term of the East Asian economy tend to affect the field of both business and academic research.

Basic facts of the U.S. business cycles have been elaborately examined by economists, and many models were developed in order to explain the facts. However, some critical features of the U.S. business cycles, e.g., volatile hours, long-lasting propagation mechanism, procyclical productivity, etc., still fit only partially to economic models. On the other hand, basic facts of the U.S. business cycles need not be completely applicable to the East Asian economy. It is worth analyzing East Asian business cycles in order to devise stabilization policies for these economies, which are now suffering from unprecedented economic turmoil.

In this paper basic features of business cycles in the East Asian economies are examined. Here I define business cycles as fluctuations of the period of the cycle of less than eight years. I use the Hodrick-Prescott filter to single business cycles out from whole fluctuations. As is usually done for analyzing the U.S. business cycles in quarterly frequency, the second moments of macroeconomic aggregates will be mainly used to investigate the East Asian business cycles. Features of quarterly U.S. data, which are worth comparing with those of East Asia, are as follows:[1]

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[1] These features are cited from Cooley and Prescott (1995, p. 32), Kydland and Prescott (1990), Prescott (1995), and Cooley and Hansen (1995).

(1) Consumption fluctuates procyclically and less than output.
(2) Investment is procyclical and fluctuates much more than output.
(3) Government consumption is acyclical.
(4) Trade balance is counter-cyclical.
(5) The magnitude of fluctuations in output and aggregate hours of work are nearly equal. Hours of work are highly procyclical.
(6) Employment fluctuates almost as much as output and total hours of work, while workweeks fluctuate less.
(7) Hourly real wage is slightly procyclical.
(8) Productivity, whether it is defined as total factor productivity or labor productivity, is weakly procyclical.
(9) Monetary aggregates are procyclical, and lead the cycle.
(10) Prices are counter-cyclical after World War II.
(11) All macroeconomic variables are serially positively correlated.

It may be premature to state that these features have already been stylized, because discussions still continue.[2] However, we can use the above features of the U.S. economy as criteria to look into business cycles of the East Asian economies, and compare observed features of the East Asian business cycles with those of the U.S. economy.

Among the above features I pay most attention to (8) and (11), i.e., procyclical productivity and positive autocorrelation in macroeconomic variables. These features are consistent with increasing-returns-to-scale technology. Some people argue that models incorporating increasing-returns-to-scale technology describe U.S. business cycles very well.[3] Increasing-returns-to-scale technology often suggests that the government should intervene in the economy, whether it is carried out with externality or market power. Therefore, it is important to determine whether procyclical productivity and positive serial correlation are observed in the East Asian economies, in order to consider the role of the government in East Asia. In fact, I estimated returns to scale of manufacturing industries in Japan, the Republic of Korea, Taiwan, and the Philippines in my companion papers.[4] As a result, the sources of procyclical productivity and positive serial correlation in macroeconomic variables are not attributed to increasing-returns-to-scale technology but to other factors, e.g., cyclical unobserved factor utilization, etc.[5]

The main conclusion of this comparative analysis is that most of the above features of the U.S. business cycles are common to selected East Asian economies. In terms of frequency, the U.S. business cycles are similar to the East Asian business

[2] For example, Kraay and Ventura (1997) argue that creditor countries tend to exhibit a procyclical trade balance.
[3] See Farmer (1993), Farmer and Guo (1995), and Rotemberg and Woodford (1995).
[4] See Yamagata (1997a, 1997b).
[5] See Basu (1996), Basu and Kimball (1997), Bils and Cho (1994), Burnside and Eichenbaum (1996), and Burnside, Eichenbaum, and Rebelo (1993), for research on unobserved factor utilization.

cycles so that a high coherence between U.S. GDP and that of the East Asian economies is observed. However, macroeconomic variables of the selected East Asian economies tend to be more volatile than those of the United States. Co-movements between detrended U.S. GDP and that of the East Asian economies are not necessarily strong, while East Asian consumption tends to co-move more with lagged U.S. and Japanese consumption.

In this paper, I will analyze the business cycles of the United States and seven East Asian economies, i.e., Japan, Hong Kong, Korea, the Philippines, Singapore, Taiwan, and Thailand, which were selected because of the diversity of the characteristics of their economies. In the next section, business cycles of each of the East Asian economies are described. The similarity and co-movement in business cycles between the U.S. and the East Asian economies are investigated in Section III. In Section III, a test of differences in moments of the U.S. and the East Asian economies will first be undertaken. Then, the coherence between U.S. GDP and that of the East Asian economies will be estimated. Finally, international co-movements in GDP and consumption among the U.S. and the East Asian economies will be explored. Concluding remarks are given in the final section.

II. BUSINESS CYCLES OF EAST ASIAN ECONOMIES

Most of the macroeconomic variables of the U.S. economy are available for quarterly periods, so quarterly data are used in most business cycle research for the U.S. economy. By contrast, it is often difficult to obtain quarterly real national accounts data in East Asia. Therefore, I used only annual data in this paper. In Japan, Korea, and Taiwan, many data on industrial production, inputs to industrial sectors, money, and price series are available in monthly frequency. I did not use these series here, but I did use them in a companion paper (Yamagata 1997a).

I used the Penn World Table, Mark 5.5, for national accounts data in most parts of this paper. In most economies, real national accounts series running from the early 1950s through 1990 are available from the Penn World Table. Data on money and price levels are cited from *International Financial Statistics* of the International Monetary Fund (IMF), except for Hong Kong. For Japan, Korea, the Philippines, Singapore, and Thailand, I used labor input data from the International Labour Organisation (ILO), *Yearbook of Labour Statistics*. For Taiwan, labor input series for manufacturing industries were obtained from Taiwan data sources. The generalized method of moments is used to estimate the moments.

Since I used the Hodrick-Prescott filter (hereafter H-P filter) for detrending, fluctuations of a period of less than eight years remain.[6] Before detrending, all the vari-

[6] For the H-P filter, refer to King and Rebelo (1993) and Cooley and Prescott (1995). The smoothing parameter for annual series is set at 100.

ables except for trade balance were logged. Since the trade balance can be negative, linear approximation of the logarithm is used for the trade balance, instead of the logarithm.

1. *The United States*

The second moments of U.S. annual macroeconomic variables are represented as a benchmark for comparison with those of the East Asian economies (see Table

TABLE I

MOMENTS OF MACROECONOMIC VARIABLES DETRENDED WITH THE H-P FILTER ($\lambda = 100$): THE UNITED STATES, 1950–90

	Standard Deviation		First-Order Serial Correlation	Correlation between x_t and GDP_{t+i}				
	sd(x)	sd(x)/ sd(GDP)		$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$
GDP	0.027	1.00	0.435	–0.04	0.43	1.00	0.43	–0.04
	(0.002)		(0.065)	(0.14)	(0.06)		(0.06)	(0.14)
Private consumption	0.017	0.71	0.500	–0.00	0.37	0.84	0.50	–0.03
	(0.002)		(0.085)	(0.18)	(0.07)	(0.07)	(0.12)	(0.11)
Investment	0.072	3.00	0.294	–0.31	0.19	0.88	0.44	–0.01
	(0.009)		(0.045)	(0.13)	(0.09)	(0.05)	(0.05)	(0.11)
Government consumption	0.070	2.92	0.343	0.14	0.20	0.25	0.08	0.18
	(0.025)		(0.114)	(0.11)	(0.08)	(0.04)	(0.09)	(0.07)
Balance of trade	0.603	25.13	0.643	0.50	0.20	–0.32	–0.47	–0.37
	(0.160)		(0.054)	(0.24)	(0.08)	(0.10)	(0.14)	(0.19)
M1[a]	0.027	1.14	0.463	–0.07	0.08	0.26	0.26	–0.01
	(0.007)		(0.051)	(0.08)	(0.07)	(0.06)	(0.10)	(0.25)
M2[a]	0.029	1.23	0.528	–0.62	–0.43	0.24	0.67	0.36
	(0.004)		(0.058)	(0.05)	(0.07)	(0.06)	(0.11)	(0.14)
WPI	0.043	1.79	0.721	0.13	–0.10	–0.40	–0.65	–0.45
	(0.007)		(0.099)	(0.15)	(0.10)	(0.07)	(0.07)	(0.12)
CPI	0.027	1.13	0.747	0.12	–0.21	–0.54	–0.65	–0.35
	(0.006)		(0.093)	(0.14)	(0.09)	(0.09)	(0.09)	(0.13)
GDP deflator	0.019	0.82	0.826	0.01	–0.33	–0.52	–0.66	–0.40
	(0.004)		(0.057)	(0.12)	(0.08)	(0.09)	(0.09)	(0.13)

Sources: Per capita GDP, private consumption, investment, government consumption, and balance of trade (tb) are calculated by the author based on the Penn World Table, Mark 5.5. M1, M2, WPI, CPI, and GDP deflator are based on IMF (1994).

Note: Since the balance-of-trade data contain negative values, logarithms are approximated by

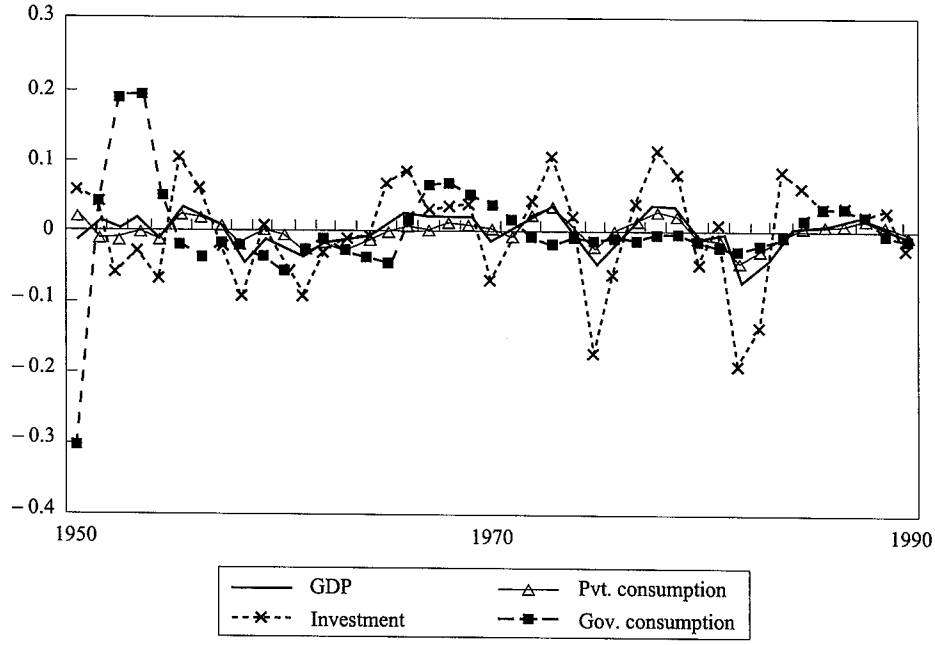
$$\ln(tb_t) \approx \frac{tb_t}{|\,\text{mean}(tb)|} - 1.$$

The standard deviation of the detrended log per capita GDP for 1959–90 is 0.023.

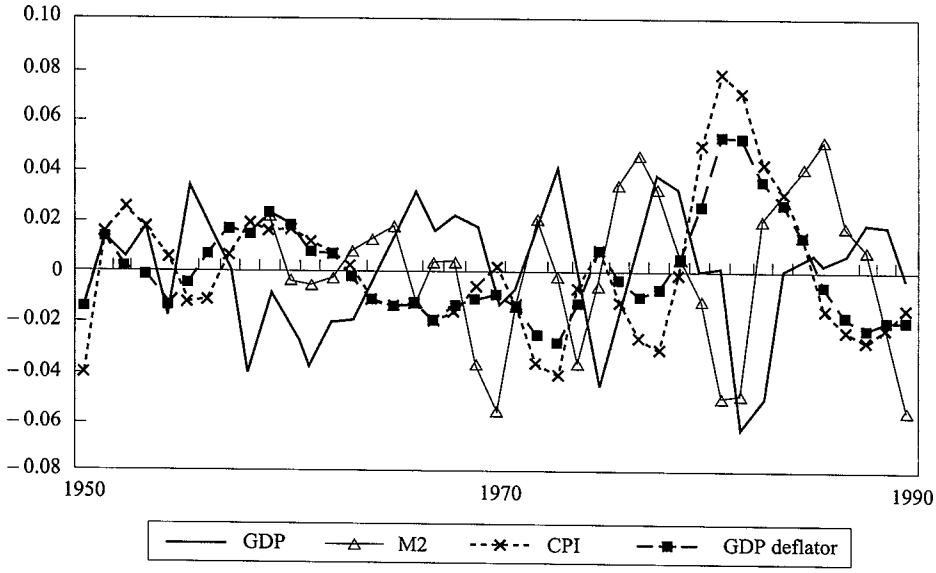
[a] 1959–90.

Fig. 1

A. Business Cycles in the United States (1)



B. Business Cycles in the United States (2)



I and Figure 1). Overall tendencies of the moments of the annual macroeconomic variables are the same as those of the quarterly variables in the United States. Private consumption and investment are procyclical while prices are counter-cyclical. Correlation coefficients of GDP with private consumption and investment are 0.84 and 0.88, respectively, while those with the world price index (WPI), consumption price index (CPI), and GDP deflator are –0.40, –0.54, and –0.52, respectively. Private consumption is less volatile than GDP, i.e., the former is 0.71 times as volatile as the latter, while investment is three times more volatile. Correlation coefficient of government consumption is not particularly high, i.e., 0.25, though it is significantly far from zero. The balance of trade is highly volatile and counter-cyclical. Money (M) is moderately procyclical and leads output. It is notable that one-year-lagged M2 is highly and significantly correlated with current GDP. It is apparent that M2 has led GDP since the late 1960s (Figure 1-B). Most variables, with the exception of government consumption, show a high degree of persistence.

Though labor and labor productivity series do not appear in Table I, it is known that labor productivity and per capita income at a lower frequency tend to be highly correlated in the United States.[7]

2. *Japan*

The Japanese economy follows the features of business cycles of the U.S. economy in quarterly frequency as indicated in the Introduction (see Table II and Figure 2). The standard deviation of logged GDP of Japan is as high as that of the United States. Private consumption is less volatile and investment is more volatile than GDP. Both private consumption and investment are significantly procyclical, though the correlation coefficient between current private consumption and GDP is not as high as in the United States.

Volatility of labor input is considerably lower than that of GDP in Japan. The values of relative volatility of the number of workers, hours per worker, and total hours to GDP are 0.29, 0.36, and 0.54. It is notable that hours per worker are more volatile than the number of workers in Japan. These two features are distinct from those of U.S. business cycles. The number of workers and total hours are significantly procyclical, while hours per worker are only weakly procyclical, as in the United States.

Output per worker and output per hour are both markedly procyclical. The correlation coefficient between GDP and output per worker is higher than that between GDP and output per hour. Procyclical hours per worker seem to cause this reduction in correlation between output and labor productivity. Both output per worker and output per hour are as volatile as GDP.

An interesting aspect indicated in Table II is that government consumption and

[7] See Romer (1989, p. 58).

TABLE II

MOMENTS OF MACROECONOMIC VARIABLES DETRENDED WITH THE H-P FILTER ($\lambda = 100$): JAPAN, 1950–90

	Standard Deviation		First-Order Serial Correlation	Correlation between x_t and GDP_{t+i}				
	sd(x)	sd(x)/ sd(GDP)		$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$
GDP	0.028	1.00	0.654	0.28	0.65	1.00	0.65	0.28
	(0.004)		(0.056)	(0.09)	(0.06)		(0.06)	(0.09)
Private consumption	0.021	0.75	0.538	0.43	0.60	0.68	0.29	–0.00
	(0.004)		(0.062)	(0.08)	(0.07)	(0.10)	(0.17)	(0.15)
Investment	0.084	2.97	0.357	0.00	0.30	0.76	0.52	0.20
	(0.011)		(0.140)	(0.18)	(0.22)	(0.10)	(0.06)	(0.07)
Government consumption	0.030	1.06	0.203	0.17	0.30	0.14	0.13	0.13
	(0.095)		(0.254)	(0.17)	(0.23)	(0.13)	(0.11)	(0.08)
Balance of trade	0.892	31.46	0.615	–0.09	–0.21	–0.29	–0.09	0.07
	(0.233)		(0.084)	(0.17)	(0.23)	(0.13)	(0.11)	(0.08)
Number of workers[a]	0.008	0.29	0.481	–0.02	0.23	0.41	0.28	0.20
	(0.001)		(0.069)	(0.08)	(0.14)	(0.18)	(0.18)	(0.26)
Hours per worker[a]	0.010	0.36	0.656	–0.51	–0.22	0.29	0.47	0.36
	(0.001)		(0.069)	(0.10)	(0.15)	(0.14)	(0.09)	(0.10)
Total hours[a]	0.015	0.54	0.640	–0.37	–0.03	0.40	0.45	0.36
	(0.002)		(0.053)	(0.09)	(0.16)	(0.16)	(0.13)	(0.16)
Real wage[b]	0.033	1.17	0.822	0.61	0.31	–0.05	–0.33	–0.55
	(0.004)		(0.071)	(0.11)	(0.10)	(0.10)	(0.11)	(0.13)
Output per worker[c]	0.025	0.93	0.636	0.37	0.64	0.94	0.58	0.18
	(0.004)		(0.058)	(0.12)	(0.08)	(0.02)	(0.07)	(0.08)
Output per hour[c]	0.026	0.95	0.705	0.58	0.73	0.79	0.37	0.03
	(0.004)		(0.046)	(0.11)	(0.06)	(0.05)	(0.07)	(0.08)
M1[d]	0.052	1.81	0.671	0.39	0.33	0.19	–0.06	–0.44
	(0.005)		(0.058)	(0.14)	(0.13)	(0.20)	(0.17)	(0.16)
M2[d]	0.031	1.07	0.712	0.39	0.24	0.06	–0.15	–0.53
	(0.004)		(0.063)	(0.12)	(0.11)	(0.15)	(0.16)	(0.16)
WPI	0.060	2.12	0.512	–0.08	–0.16	–0.32	–0.55	–0.50
	(0.010)		(0.124)	(0.15)	(0.16)	(0.25)	(0.14)	(0.08)
CPI	0.043	1.50	0.678	0.02	–0.14	–0.35	–0.51	–0.43
	(0.005)		(0.108)	(0.28)	(0.32)	(0.34)	(0.18)	(0.07)
GDP deflator[b]	0.033	1.19	0.760	–0.26	–0.32	–0.53	–0.66	–0.52
	(0.007)		(0.066)	(0.13)	(0.16)	(0.22)	(0.13)	(0.09)

Sources: The data on labor are calculated by the author based on ILO (various years). The sources of the other data are the same as in Table I.

Note: Logarithms of the balance of trade are approximated as in Table I. The standard deviation of the detrended log per capita GDP for 1953–90 is 0.028. Those for 1955–90, 1956–90, and 1953–92 are 0.029, 0.028, and 0.027, respectively. Real wage is deflated with GDP deflator.

[a] 1953–90.

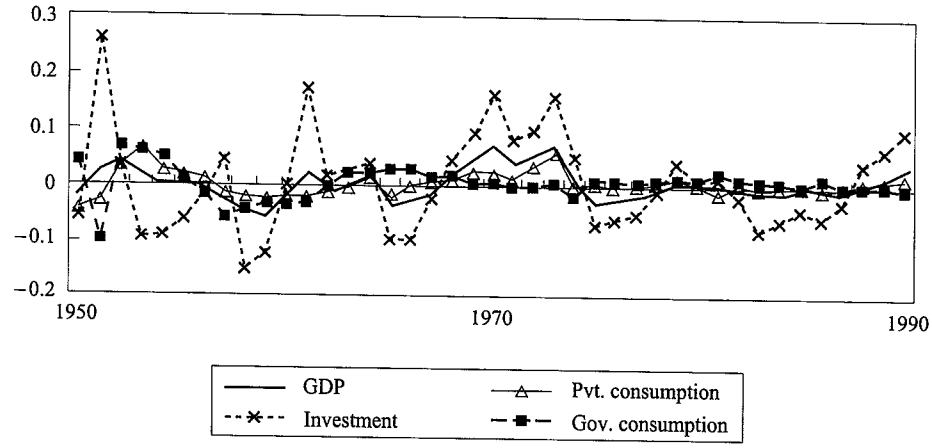
[b] 1956–90.

[c] 1953–92.

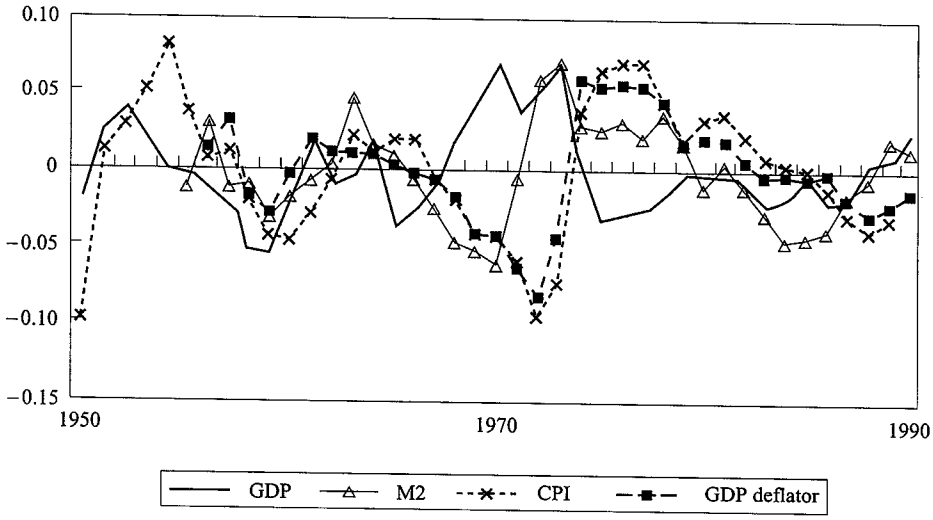
[d] 1955–90.

Fig. 2

A. Business Cycles in Japan (1)



B. Business Cycles in Japan (2)



money are less procyclical in Japan. The correlation coefficients of GNP with government consumption, M1, and M2 are 0.14, 0.19, and 0.06, respectively and these coefficients are not significant. Moreover, government consumption is less volatile and its persistence is not remarkable. Price levels are counter-cyclical, as in the case of the United States, and the negative correlation is significant for two price level variables out of three.

3. *Hong Kong*

Tendencies in most of the moments of macroeconomic variables of Hong Kong

TABLE III

MOMENTS OF MACROECONOMIC VARIABLES DETRENDED WITH THE H-P FILTER ($\lambda = 100$): HONG KONG, 1960–90

	Standard Deviation		First-Order Serial Correlation	Correlation between x_t and GDP_{t+i}				
	sd(x)	sd(x)/ sd(GDP)		$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$
GDP	0.036	1.00	0.413	–0.24	0.41	1.00	0.41	–0.24
	(0.003)		(0.040)	(0.08)	(0.04)		(0.04)	(0.08)
Private consumption	0.037	1.02	0.413	–0.04	0.48	0.80	0.22	–0.35
	(0.007)		(0.073)	(0.08)	(0.07)	(0.09)	(0.09)	(0.10)
Investment	0.108	2.97	0.651	–0.28	0.21	0.75	0.60	0.11
	(0.013)		(0.049)	(0.10)	(0.06)	(0.04)	(0.08)	(0.11)
Government consumption	0.219	6.05	0.449	0.00	0.28	0.45	0.24	0.13
	(0.082)		(0.101)	(0.09)	(0.06)	(0.15)	(0.12)	(0.10)
Balance of trade	0.513	14.18	0.503	–0.31	–0.35	–0.30	–0.36	–0.15
	(0.079)		(0.102)	(0.18)	(0.16)	(0.15)	(0.09)	(0.09)
M1[a]	0.083	2.24	0.410	–0.63	–0.15	0.42	0.62	0.15
	(0.010)		(0.149)	(0.12)	(0.13)	(0.07)	(0.07)	(0.11)
M2[a]	0.080	2.16	0.509	–0.16	–0.12	0.04	0.08	–0.22
	(0.012)		(0.076)	(0.16)	(0.08)	(0.23)	(0.24)	(0.13)
CPI	0.041	1.12	0.673	0.41	0.19	–0.28	–0.63	–0.39
	(0.004)		(0.071)	(0.16)	(0.10)	(0.07)	(0.08)	(0.13)
GDP deflator[a]	0.035	0.95	0.663	0.36	0.28	–0.04	–0.23	–0.15
	(0.003)		(0.045)	(0.26)	(0.17)	(0.09)	(0.12)	(0.19)

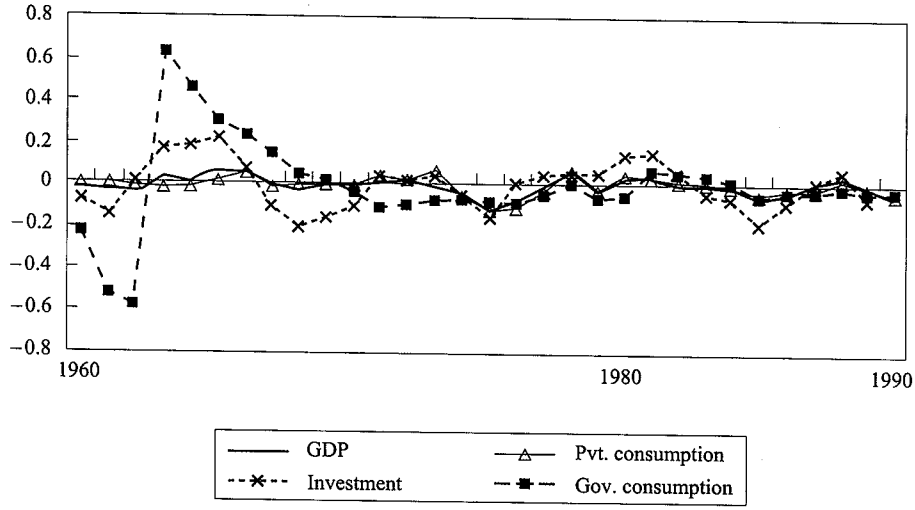
Sources: Per capita GDP, private consumption, investment, government consumption, and balance of trade are calculated by the author based on the Penn World Table, Mark 5.5. CPI is based on IMF (1994). M1 and M2 are based on: the Census and Statistics Department, *Hong Kong Statistics, 1947–1967* (1969); idem, *Hong Kong Social and Economic Trends*, 1964–1974 and 1967–1977 editions.; and idem, *Hong Kong Annual Digest of Statistics*, 1981, 1985, and 1993 editions. GDP deflator of Hong Kong is based on the Census and Statistics Department, *Revised Estimates of Gross Domestic Product, 1961 to First Quarter 1994* (1994). The data on labor are based on ILO (various years).

Note: Logarithms of the balance of trade are approximated as in Table I. The standard deviation of the detrended log per capita GDP for 1961–90 is 0.037.

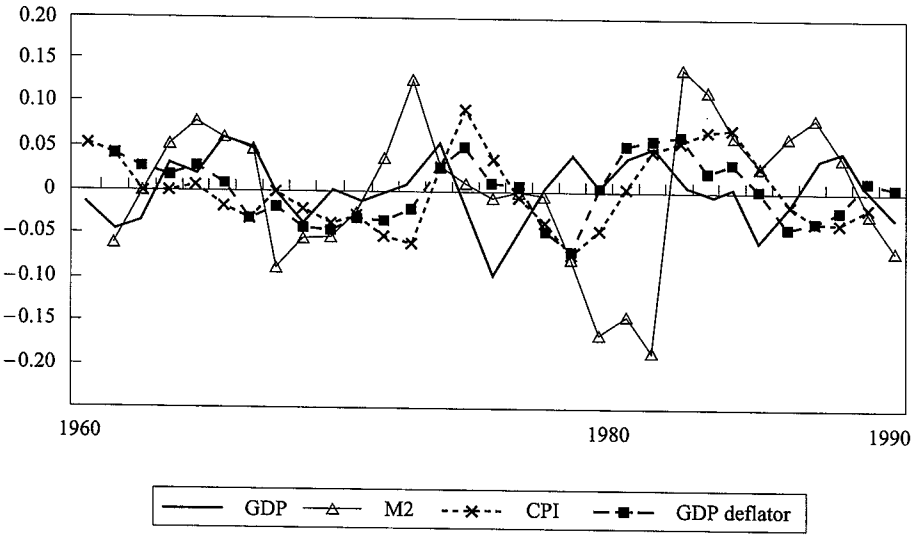
[a] 1961–90.

Fig. 3

A. Business Cycles in Hong Kong (1)



B. Business Cycles in Hong Kong (2)



are similar to U.S. and Japanese ones (see Table III and Figure 3). Private consumption and investment are highly procyclical. M1 is significantly procyclical though M2 is less correlated to GDP. In Figure 3-B, M2 appears to lead GDP except for the period from the middle of the 1970s to the middle of the 1980s. Thus, M2 is basically procyclical if we rule out the period after the oil shock and the period during which worldwide recession was dominant. While CPI in Hong Kong is significantly counter-cyclical, the negative correlation between the GDP deflator and output is low.

It is noticeable that most of the macroeconomic variables in Hong Kong are more volatile than in the United States and Japan. For example, the standard deviations of per capita GDP in the United States and Japan are 2.7 per cent and 2.8 per cent, respectively, while that in Hong Kong is 3.6 per cent. It seems that private consumption is slightly more volatile than GDP because private consumption includes durable consumption goods. As we see below, macroeconomic variables in most of the East Asian economies are evidently more volatile than in the United States with the exception of Japan and Taiwan.

Laissez-faire is the basic principle of economic policy of the Hong Kong government. From that point of view, it is interesting to note that the correlation between output and government consumption in Hong Kong is higher than in Japan and the United States. Moreover, government consumption is about three times more volatile than in the United States. The standard deviation in detrended log government consumption in Hong Kong is 0.219 while that in the United States is 0.070. The standard deviation in government consumption is six times more volatile than that in GDP.

The period since labor-inputs series for the Hong Kong economy have been available is too short to be used for the purpose of analyzing business cycles.

4. *Korea*

The moments of macroeconomic variables in Korea shown in Table IV and Figure 4 display different features from those in the U.S. and the other East Asian economies. First of all, investment is less cyclical, i.e., the correlation with GDP is 55 per cent, and more volatile than in the other economies. Second, government consumption is more cyclical and shows a higher degree of persistence. Government shocks may explain the low correlation between GDP and investment and the high correlation between GDP and government consumption, because positive government shocks raise output and interest rates, and at the same time crowd out investment to a certain extent.[8]

[8] Aiyagari, Christiano, and Eichenbaum (1992) analyze the effects of a permanent and temporary government shock on output, employment, and interest rates both analytically and numerically. Christiano and Eichenbaum (1992) show that government consumption shocks lead to benchmark real business cycle models that conform more to the U.S. economy.

TABLE IV

MOMENTS OF MACROECONOMIC VARIABLES DETRENDED WITH THE H-P FILTER ($\lambda = 100$): KOREA, 1953–89

	Standard Deviation		First-Order Serial Correlation	Correlation between x_t and GDP_{t+i}				
	sd(x)	sd(x)/ sd(GDP)		$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$
GDP	0.041	1.00	0.626	0.25	0.63	1.00	0.63	0.25
	(0.003)		(0.069)	(0.13)	(0.07)		(0.07)	(0.13)
Private consumption	0.038	0.92	0.554	0.35	0.64	0.83	0.42	0.15
	(0.003)		(0.067)	(0.17)	(0.09)	(0.28)	(0.09)	(0.10)
Investment	0.159	3.87	0.249	–0.12	0.16	0.55	0.35	0.22
	(0.022)		(0.104)	(0.13)	(0.18)	(0.11)	(0.06)	(0.17)
Government consumption	0.045	1.10	0.593	0.58	0.69	0.63	0.45	0.12
	(0.003)		(0.074)	(0.10)	(0.07)	(0.08)	(0.08)	(0.10)
Balance of trade	1.088	26.42	0.122	–0.19	–0.36	–0.31	0.19	0.31
	(0.341)		(0.156)	(0.10)	(0.08)	(0.06)	(0.14)	(0.19)
Number of workers[a]	0.017	0.42	0.720	0.49	0.40	0.49	0.41	0.09
	(0.002)		(0.042)	(0.07)	(0.13)	(0.17)	(0.17)	(0.13)
Hours per worker[a]	0.025	0.63	0.613	–0.46	–0.56	–0.44	–0.07	0.15
	(0.005)		(0.071)	(0.10)	(0.07)	(0.06)	(0.09)	(0.18)
Total hours[a]	0.026	0.65	0.515	–0.13	–0.28	–0.11	0.20	0.20
	(0.005)		(0.049)	(0.16)	(0.20)	(0.21)	(0.13)	(0.12)
Real wage[b]	0.063	1.51	0.162	0.09	0.36	0.53	0.03	–0.33
	(0.013)		(0.152)	(0.10)	(0.12)	(0.04)	(0.09)	(0.08)
Output per worker[c]	0.031	0.76	0.372	–0.01	0.47	0.84	0.35	0.02
	(0.003)		(0.065)	(0.13)	(0.07)	(0.05)	(0.08)	(0.08)
Output per hour[c]	0.049	1.21	0.486	0.23	0.59	0.76	0.26	–0.07
	(0.006)		(0.055)	(0.15)	(0.06)	(0.08)	(0.11)	(0.14)
M1	0.130	3.15	0.477	0.20	0.31	0.44	0.43	0.11
	(0.029)		(0.104)	(0.14)	(0.10)	(0.10)	(0.12)	(0.16)
M2[d]	0.185	4.38	0.629	–0.04	–0.08	–0.01	0.15	0.08
	(0.048)		(0.076)	(0.16)	(0.09)	(0.11)	(0.20)	(0.24)
WPI	0.134	3.25	0.625	0.01	–0.04	–0.14	–0.17	–0.10
	(0.023)		(0.069)	(0.13)	(0.17)	(0.34)	(0.29)	(0.17)
CPI[e]	0.074	1.80	0.757	0.19	–0.21	–0.62	–0.63	–0.40
	(0.010)		(0.067)	(0.15)	(0.10)	(0.09)	(0.10)	(0.13)
GDP deflator	0.107	2.60	0.658	0.08	0.11	0.09	–0.02	–0.12
	(0.024)		(0.077)	(0.14)	(0.13)	(0.28)	(0.28)	(0.22)

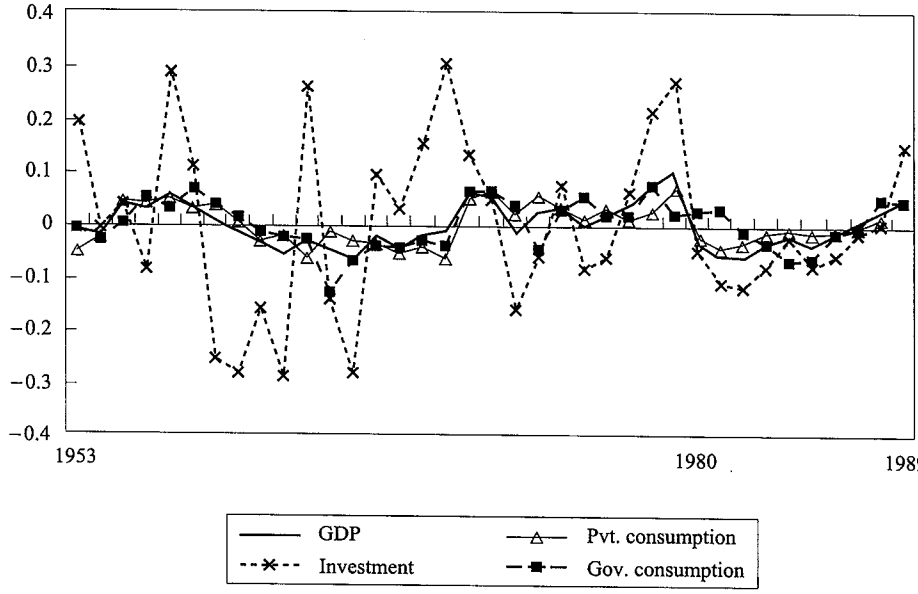
Sources: The same as in Table II.

Note: Logarithms of the balance of trade are approximated as in Table I. The standard deviation of the detrended log per capita GDP for 1960–89 is 0.042. Those for 1967–89, 1963–89, 1969–89, and 1963–91 are 0.040, 0.043, 0.042, and 0.040, respectively. Real wage is deflated with GDP deflator.

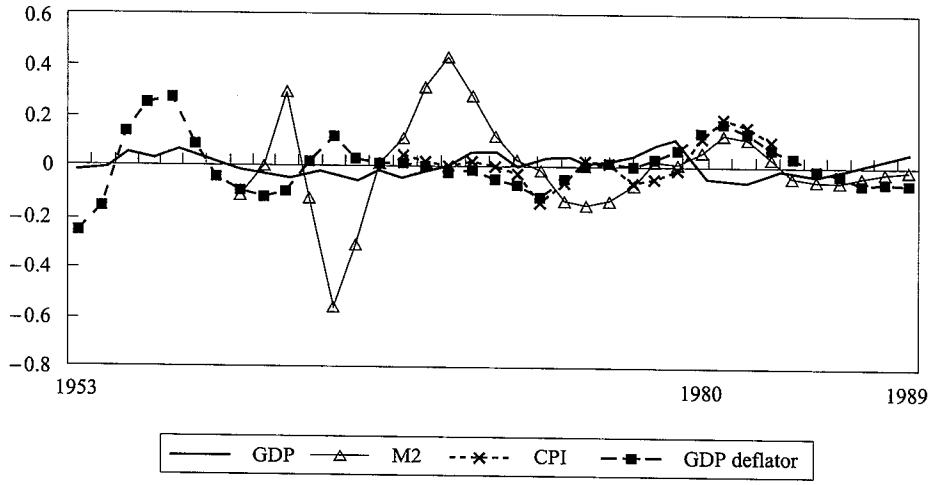
[a] 1963–89.
[b] 1969–89.
[c] 1963–91.
[d] 1960–89.
[e] 1967–89.

Fig. 4

A. Business Cycles in Korea (1)



B. Business Cycles in Korea (2)



Third, it is noteworthy that money and prices are highly volatile in Korea. Korea is one of the countries which have experienced high inflation after the two oil price hikes in the 1970s. The volatility suggests that Korea experienced not only hyper-inflation and high money growth but also great fluctuations within the prevailing price levels and money trend.

Fourth, hours per worker are more volatile than employment, in contrast to the U.S. and Japanese economies. It is puzzling that the number of workers is remarkably procyclical, hours per worker significantly counter-cyclical, and total hours seem acyclical as a result.

Real wage is one and a half times as volatile as GDP, and highly procyclical. Both output per worker and output per hour are also highly procyclical. The correlation coefficient between current GDP and labor productivity decreases when we use total hours as labor inputs, as in the case of Japan.

5. *The Philippines*

The Philippine economy also follows the same pattern as those of the U.S. and the other East Asian economies in general (see Table V and Figure 5). Private consumption and investment are highly procyclical, i.e., correlations are 85 per cent and 83 per cent, respectively. Private consumption is less volatile while investment is more volatile. Investment seems to have been more volatile in the 1970s and the 1980s (see Figure 5-B). The balance of trade is highly volatile and significantly counter-cyclical. Price levels are counter-cyclical and the negative correlations of all three price indicators are significant. All variables show a high degree of persistence.

Employment is only moderately serially correlated, and acyclical. Output per worker at 4.5 per cent is markedly volatile and highly procyclical.

As for the volatility in money and price levels, the standard deviations themselves in these variables are less pronounced than those in Korea, while relative volatility in these variables is comparable to that in Korea. The Philippines also suffered from hyper-inflation. This examination of the moments of macroeconomic variables clearly shows that high inflation is accompanied by higher frequency variation in money and price levels in the Philippines, too.

6. *Singapore*

Some moments of the macroeconomic variables of Singapore behave differently from those of the U.S. and the other East Asian economies. The most notable difference lies in the correlation between current price level and GDP (see Table VI and Figure 6). The correlation coefficients for WPI, CPI, and GDP deflator are all positive and some are large in scale. This positive correlation between current GDP and GDP deflator might cause a negative correlation between GDP and real wage, because the denominator of this real wage is the GDP deflator.

TABLE V

MOMENTS OF MACROECONOMIC VARIABLES DETRENDED WITH THE H-P FILTER ($\lambda = 100$): THE PHILIPPINES, 1950–90

	Standard Deviation		First-Order Serial Correlation	Correlation between x_t and GDP_{t+i}				
	sd(x)	sd(x)/ sd(GDP)		$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$
GDP	0.040	1.00	0.719	0.20	0.72	1.00	0.72	0.20
	(0.011)		(0.061)	(0.10)	(0.06)		(0.06)	(0.10)
Private consumption	0.033	0.83	0.593	0.05	0.51	0.85	0.70	0.26
	(0.004)		(0.095)	(0.08)	(0.09)	(0.05)	(0.08)	(0.08)
Investment	0.139	3.48	0.630	0.27	0.74	0.83	0.50	0.02
	(0.036)		(0.071)	(0.11)	(0.07)	(0.12)	(0.14)	(0.10)
Government consumption	0.056	1.39	0.713	0.00	0.44	0.75	0.63	0.32
	(0.007)		(0.068)	(0.07)	(0.08)	(0.11)	(0.10)	(0.08)
Balance of trade	0.704	17.56	0.410	0.02	–0.36	–0.59	–0.49	–0.15
	(0.053)		(0.062)	(0.07)	(0.09)	(0.15)	(0.15)	(0.11)
Number of workers[a]	0.028	0.71	0.293	0.14	0.03	0.08	0.10	–0.06
	(0.004)		(0.076)	(0.06)	(0.06)	(0.09)	(0.11)	(0.11)
Output per worker[a]	0.045	1.16	0.571	0.10	0.60	0.79	0.56	0.22
	(0.008)		(0.092)	(0.07)	(0.08)	(0.12)	(0.14)	(0.07)
M1[b]	0.065	3.39	0.446	0.06	0.20	0.22	–0.02	0.00
	(0.005)		(0.073)	(0.06)	(0.19)	(0.28)	(0.30)	(0.23)
M2[b]	0.055	2.91	0.417	0.04	0.06	–0.05	–0.26	–0.31
	(0.009)		(0.108)	(0.10)	(0.10)	(0.24)	(0.30)	(0.10)
WPI	0.086	2.14	0.459	0.08	–0.22	–0.53	–0.50	–0.13
	(0.017)		(0.041)	(0.12)	(0.10)	(0.22)	(0.20)	(0.15)
CPI	0.068	1.69	0.517	0.16	–0.26	–0.60	–0.49	–0.10
	(0.013)		(0.056)	(0.12)	(0.08)	(0.19)	(0.21)	(0.16)
GDP deflator	0.066	1.64	0.570	0.00	–0.35	–0.65	–0.54	–0.10
	(0.015)		(0.062)	(0.12)	(0.10)	(0.19)	(0.18)	(0.13)

Sources: The same as in Table II.

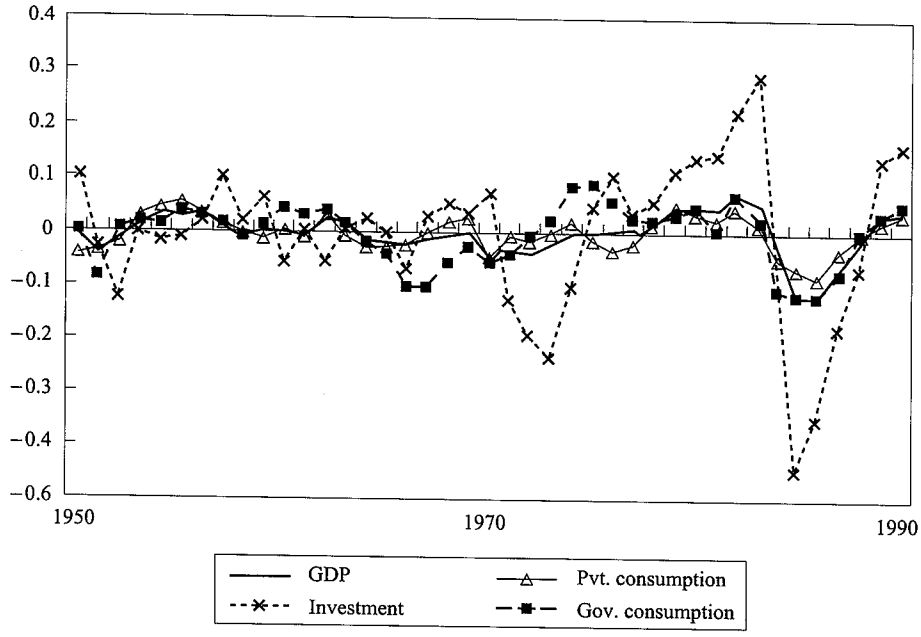
Note: Logarithms of the balance of trade are approximated as in Table I. Since the money data of the *International Financial Statistics* (IMF 1994) show a discrepancy between those before 1983 and those after 1982, the data after 1982 are not used. The standard deviation of the detrended log per capita GDP for 1950–82 is 0.019. That for 1957–92 is 0.039.

[a] 1957–92.

[b] 1950–82.

Fig. 5

A. Business Cycles in the Philippines (1)



B. Business Cycles in the Philippines (2)

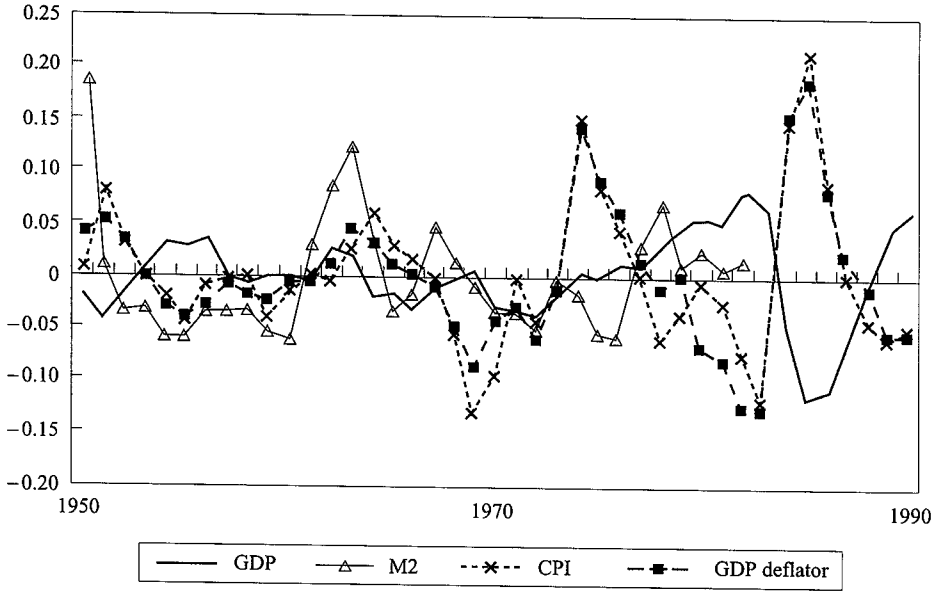


TABLE VI

MOMENTS OF MACROECONOMIC VARIABLES DETRENDED WITH THE H-P FILTER ($\lambda = 100$): SINGAPORE, 1960–90

	Standard Deviation		First-Order Serial Correlation	Correlation between x_t and GDP_{t+i}				
	sd(x)	sd(x)/ sd(GDP)		$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$
GDP	0.046	1.00	0.706	0.31	0.71	1.00	0.71	0.31
	(0.006)		(0.041)	(0.10)	(0.04)		(0.04)	(0.10)
Private consumption	0.050	1.08	0.805	0.30	0.60	0.91	0.74	0.46
	(0.008)		(0.037)	(0.20)	(0.13)	(0.05)	(0.04)	(0.09)
Investment	0.115	2.47	0.647	0.32	0.60	0.59	0.32	0.02
	(0.008)		(0.052)	(0.16)	(0.09)	(0.06)	(0.11)	(0.22)
Government consumption	0.075	1.61	0.696	0.32	0.40	0.31	0.20	0.17
	(0.008)		(0.087)	(0.15)	(0.21)	(0.37)	(0.35)	(0.23)
Balance of trade	0.758	16.32	0.425	–0.38	–0.47	–0.27	–0.14	–0.03
	(0.070)		(0.105)	(0.17)	(0.07)	(0.13)	(0.25)	(0.24)
Number of workers[a]	0.045	0.84	0.745	0.09	0.24	0.29	0.27	0.22
	(0.005)		(0.043)	(0.17)	(0.27)	(0.31)	(0.23)	(0.12)
Hours per worker[a]	0.010	0.18	0.434	0.21	0.36	0.40	0.17	–0.07
	(0.001)		(0.082)	(0.26)	(0.23)	(0.09)	(0.17)	(0.19)
Total hours[a]	0.046	0.87	0.715	0.13	0.31	0.37	0.29	0.20
	(0.003)		(0.031)	(0.12)	(0.21)	(0.30)	(0.24)	(0.14)
Real wage	0.033	0.60	0.560	–0.01	–0.40	–0.62	–0.76	–0.65
	(0.002)		(0.064)	(0.17)	(0.16)	(0.05)	(0.06)	(0.08)
Output per worker[a]	0.033	0.62	0.469	0.05	0.23	0.41	0.28	0.20
	(0.008)		(0.101)	(0.13)	(0.19)	(0.16)	(0.14)	(0.14)
Output per hour[a]	0.031	0.59	0.518	0.00	0.14	0.31	0.23	0.20
	(0.007)		(0.070)	(0.12)	(0.17)	(0.21)	(0.20)	(0.14)
M1[b]	0.064	1.44	0.451	0.27	0.47	0.76	0.41	–0.01
	(0.008)		(0.104)	(0.10)	(0.06)	(0.05)	(0.20)	(0.20)
M2[b]	0.063	1.41	0.572	0.01	0.46	0.81	0.47	0.03
	(0.063)		(0.091)	(0.12)	(0.07)	(0.06)	(0.10)	(0.06)
WPI[c]	0.082	2.09	0.629	0.29	0.69	0.76	0.47	0.11
			(0.243)					
CPI	0.056	1.21	0.672	0.43	0.40	0.17	–0.13	–0.28
	(0.012)		(0.089)	(0.07)	(0.11)	(0.11)	(0.11)	(0.08)
GDP deflator	0.040	0.86	0.735	0.53	0.59	0.40	0.08	–0.28
	(0.005)		(0.055)	(0.06)	(0.11)	(0.15)	(0.12)	(0.07)

Sources: The same as in Table II.

Note: The standard deviation of the detrended log per capita GDP for 1965–90 is 0.045. Those for 1976–90 and 1960–92 are 0.040 and 0.053, respectively. The moments for WPI are not estimated with the Generalized Method of Moments, but are instead estimated by Ordinary Least Squares method, due to the small number of observations.

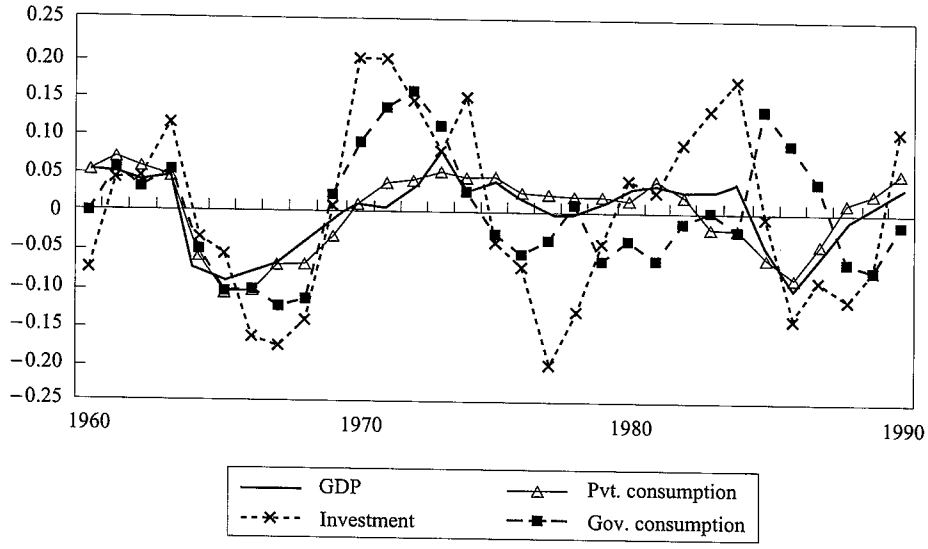
[a] 1960–92.

[b] 1965–90.

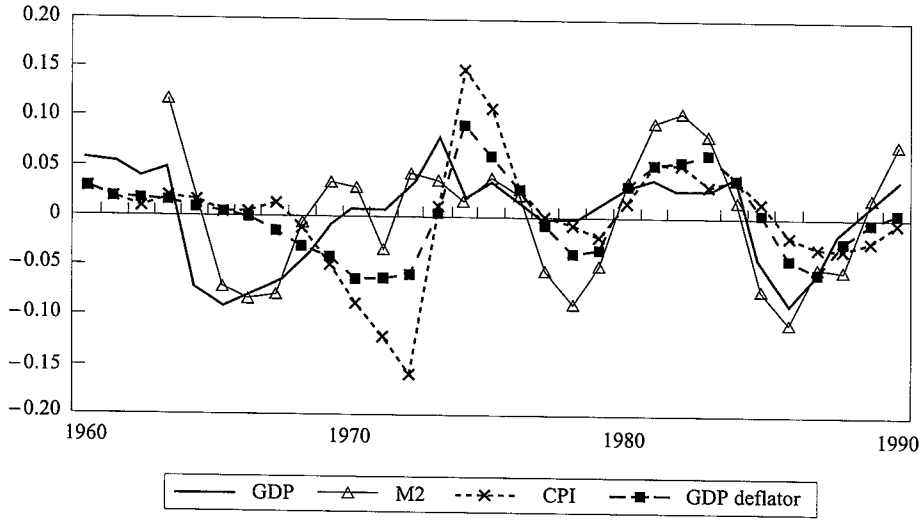
[c] 1976–90.

Fig. 6

A. Business Cycles in Singapore (1)



B. Business Cycles in Singapore (2)



Second, it is conspicuous that both M1 and M2 are highly procyclical. Moreover, the correlation between monetary aggregates and GDP which are both one-year lagged and ahead, is also significantly positive and considerable in terms of scale.

Third, per capita GDP is most volatile among the economies examined in this paper. The standard deviation of per capita GDP is 4.6 per cent. Other variables are remarkably volatile as a whole.

In contrast, the moments of labor inputs and labor productivity are in agreement with the features of U.S. business cycles indicated in the Introduction. The variation in total hours is mostly explained by the variation in employment. Employment is only weakly procyclical, however. Labor productivity is procyclical, and again, the correlation coefficient between current GDP and output per hour is lower than that between GDP and output per worker.

7. *Taiwan*

Per capita GDP in Taiwan is as volatile as in the United States and Japan (see Table VII). The volatility of Taiwanese business cycles is less appreciable than that in the other small open economies in general. In contrast, the balance of trade is highly volatile.

As a whole, features of the moments are similar to those of the United States. Private consumption and investment are procyclical. Government consumption is weakly but significantly procyclical. Both M1 and M2 are procyclical, and one-year-lagged monetary aggregates are positively correlated with current GDP. Price levels and the balance of trade are counter-cyclical (see Figure 7).

Total hours in manufacturing industries are less volatile than output of manufacturing industries in Taiwan. As in the U.S. macro economy, the number of workers fluctuates more than hours per worker in annual frequency in the Taiwanese manufacturing industries. Labor productivity is highly procyclical as well as labor inputs, whether labor inputs are estimated as employment or total hours. Labor productivity is half as volatile as output. Real wage is volatile and weakly procyclical.

8. *Thailand*

The Thai economy shows similar features of the moments of macroeconomic variables to those in the U.S. and the other East Asian economies (see Table VIII and Figure 8). Private consumption and investment are highly procyclical, while balance of trade and price levels are counter-cyclical, though all negative correlations between prices and output are extremely weak and insignificant. Investment and balance of trade are as volatile as in the U.S. and the other East Asian economies. The only distinctive features of the Thai economy are that M2 is less volatile than the output and that the correlation between M2 and output is negative.

Employment and output per worker are as volatile as per capita GDP. Both are quite procyclical and only weakly serially correlated.

TABLE VII

MOMENTS OF MACROECONOMIC VARIABLES DETRENDED WITH THE H-P FILTER ($\lambda = 100$): TAIWAN, 1951–90

	Standard Deviation		First-Order Serial Correlation	Correlation between x_t and GDP_{t+i}				
	sd(x)	sd(x)/ sd(GDP)		$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$
GDP	0.029	1.00	0.580	0.07	0.58	1.00	0.58	0.07
	(0.002)		(0.059)	(0.10)	(0.06)		(0.06)	(0.10)
Private consumption	0.031	1.08	0.580	0.17	0.60	0.89	0.49	0.07
	(0.003)		(0.084)	(0.08)	(0.09)	(0.03)	(0.07)	(0.11)
Investment	0.098	3.45	0.424	0.08	0.46	0.63	0.22	–0.02
	(0.011)		(0.114)	(0.22)	(0.24)	(0.14)	(0.14)	(0.15)
Government consumption	0.038	1.31	0.483	0.26	0.19	0.23	0.13	–0.11
	(0.003)		(0.074)	(0.31)	(0.27)	(0.10)	(0.19)	(0.14)
Balance of trade	1.196	41.87	0.582	–0.53	–0.61	–0.27	0.13	0.26
	(0.407)		(0.082)	(0.14)	(0.16)	(0.12)	(0.09)	(0.09)
Number of workers[a]	0.039	0.69	0.613	–0.22	0.42	0.77	0.37	0.15
	(0.003)		(0.120)	(0.08)	(0.07)	(0.04)	(0.13)	(0.17)
Hours per worker[a]	0.012	0.21	0.166	–0.31	–0.08	0.62	0.60	0.14
	(0.002)		(0.075)	(0.09)	(0.14)	(0.05)	(0.10)	(0.08)
Total hours[a]	0.045	0.79	0.586	–0.27	0.34	0.83	0.48	0.16
	(0.003)		(0.096)	(0.08)	(0.06)	(0.04)	(0.09)	(0.14)
Real wage[a]	0.059	1.04	0.580	–0.13	–0.11	0.25	0.32	0.04
	(0.005)		(0.130)	(0.23)	(0.13)	(0.17)	(0.30)	(0.22)
Output per worker[a]	0.036	0.65	0.367	0.16	0.18	0.73	0.23	–0.23
	(0.007)		(0.073)	(0.09)	(0.10)	(0.14)	(0.19)	(0.15)
Output per hour[a]	0.032	0.56	0.393	0.30	0.24	0.62	0.05	–0.32
	(0.004)		(0.082)	(0.09)	(0.09)	(0.20)	(0.19)	(0.14)
M1[b]	0.107	3.70	0.568	–0.09	0.26	0.61	0.56	0.11
	(0.016)		(0.075)	(0.11)	(0.07)	(0.06)	(0.19)	(0.24)
M2[b]	0.049	1.69	0.602	–0.30	–0.07	0.29	0.50	0.28
	(0.006)		(0.079)	(0.13)	(0.12)	(0.07)	(0.11)	(0.24)
WPI[c]	0.076	2.75	0.638	0.38	0.21	–0.24	–0.62	–0.53
	(0.014)		(0.086)	(0.18)	(0.21)	(0.13)	(0.08)	(0.11)
CPI[c]	0.070	2.52	0.583	0.40	0.11	–0.40	–0.62	–0.40
	(0.010)		(0.100)	(0.20)	(0.18)	(0.08)	(0.06)	(0.14)
GDP deflator[c]	0.057	2.06	0.512	0.35	0.09	–0.31	–0.56	–0.46
	(0.006)		(0.104)	(0.19)	(0.21)	(0.08)	(0.07)	(0.10)

Sources: Per capita GDP, private consumption, investment, government consumption, and balance of trade are calculated by the author based on the Penn World Table, Mark 5.5. M1, M2, WPI, CPI, and GDP deflator are based on Council for Economic Planning and Development, *Taiwan Statistical Data Book* (various years).

Note: The standard deviations of the detrended log per capita GDP for 1952–90 and 1961–90 are 0.028 and 0.029, respectively.

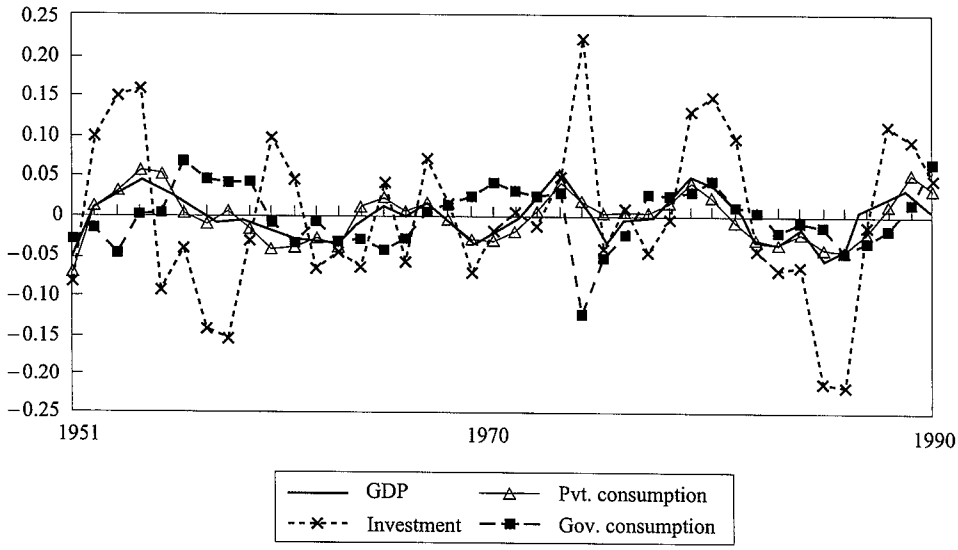
[a] 1973–96: Manufacturing industries data. Relative volatility is calculated as a ratio of the standard deviation of each variable to that of manufacturing output, which is 0.057.

[b] 1961–90.

[c] 1952–90.

Fig. 7

A. Business Cycles in Taiwan (1)



B. Business Cycles in Taiwan (2)

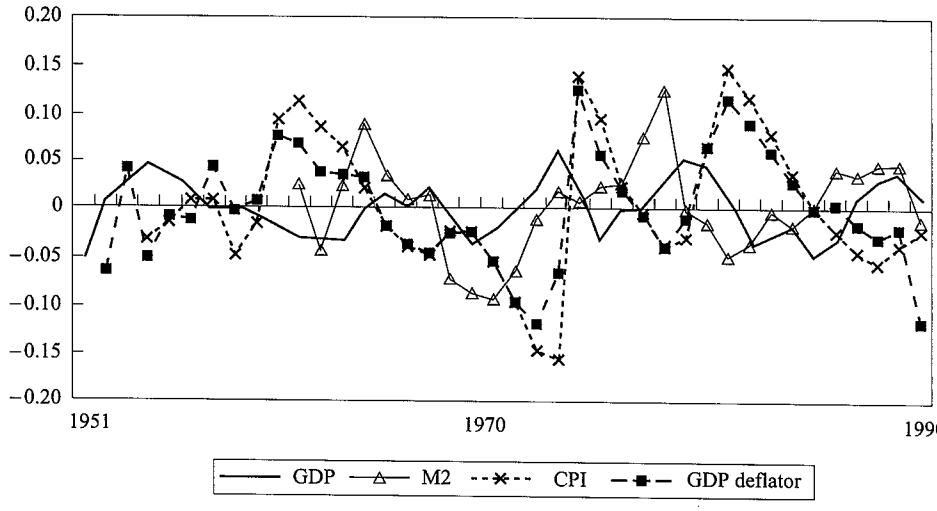


TABLE VIII

MOMENTS OF MACROECONOMIC VARIABLES DETRENDED WITH THE H-P FILTER ($\lambda = 100$): THAILAND, 1950–90

	Standard Deviation		First-Order Serial Correlation	Correlation between x_t and GDP_{t+i}				
	sd(x)	sd(x)/ sd(GDP)		$i=-2$	$i=-1$	$i=0$	$i=1$	$i=2$
GDP	0.043	1.00	0.470	0.16	0.47	1.00	0.47	0.16
	(0.007)		(0.051)	(0.05)	(0.09)		(0.09)	(0.05)
Private consumption	0.045	1.05	0.405	0.08	0.36	0.93	0.48	0.17
	(0.007)		(0.079)	(0.09)	(0.06)	(0.03)	(0.08)	(0.11)
Investment	0.096	2.25	0.321	0.02	0.41	0.70	0.33	0.08
	(0.010)		(0.069)	(0.09)	(0.09)	(0.10)	(0.07)	(0.05)
Government consumption	0.062	1.44	0.572	0.46	0.25	0.17	–0.13	–0.27
	(0.008)		(0.075)	(0.11)	(0.08)	(0.14)	(0.17)	(0.14)
Balance of trade	0.358	8.36	0.205	0.01	–0.15	–0.38	–0.11	0.21
	(0.047)		(0.077)	(0.07)	(0.13)	(0.28)	(0.14)	(0.05)
Number of workers[a]	0.032	0.94	0.316	–0.33	0.14	0.51	0.58	0.40
	(0.003)		(0.085)	(0.10)	(0.07)	(0.05)	(0.08)	(0.11)
Output per worker[a]	0.034	0.99	0.280	0.48	0.53	0.57	0.13	–0.17
	(0.003)		(0.220)	(0.09)	(0.20)	(0.17)	(0.18)	(0.12)
M1	0.066	1.54	0.552	–0.17	0.07	0.14	0.20	0.02
	(0.007)		(0.080)	(0.09)	(0.15)	(0.29)	(0.26)	(0.17)
M2	0.037	0.87	0.367	–0.14	–0.01	–0.07	–0.14	–0.36
	(0.003)		(0.100)	(0.13)	(0.20)	(0.26)	(0.12)	(0.14)
WPI	0.068	1.58	0.585	–0.07	0.07	–0.06	–0.05	0.05
	(0.009)		(0.092)	(0.19)	(0.14)	(0.15)	(0.07)	(0.09)
CPI[b]	0.051	1.37	0.694	0.03	0.00	–0.16	–0.18	–0.07
	(0.008)		(0.066)	(0.26)	(0.18)	(0.09)	(0.07)	(0.17)
GDP deflator	0.047	1.10	0.625	–0.00	0.02	–0.13	–0.26	–0.16
	(0.007)		(0.095)	(0.20)	(0.15)	(0.18)	(0.14)	(0.08)

Sources: The same as in Table II.

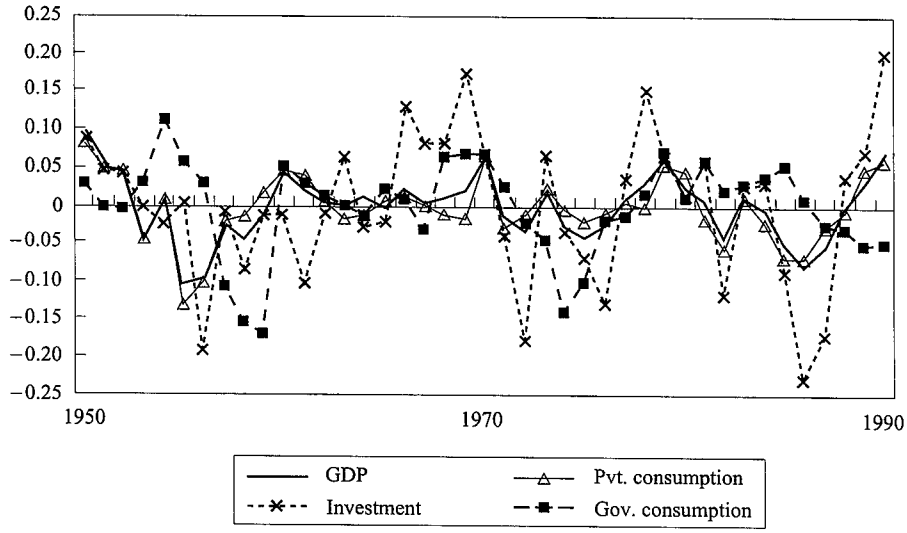
Note: Logarithms of the balance of trade are approximated as in Table I. The standard deviation of the detrended log per capita GDP for 1955–90 is 0.037. That for 1971–92 is 0.034.

[a] 1971–92.

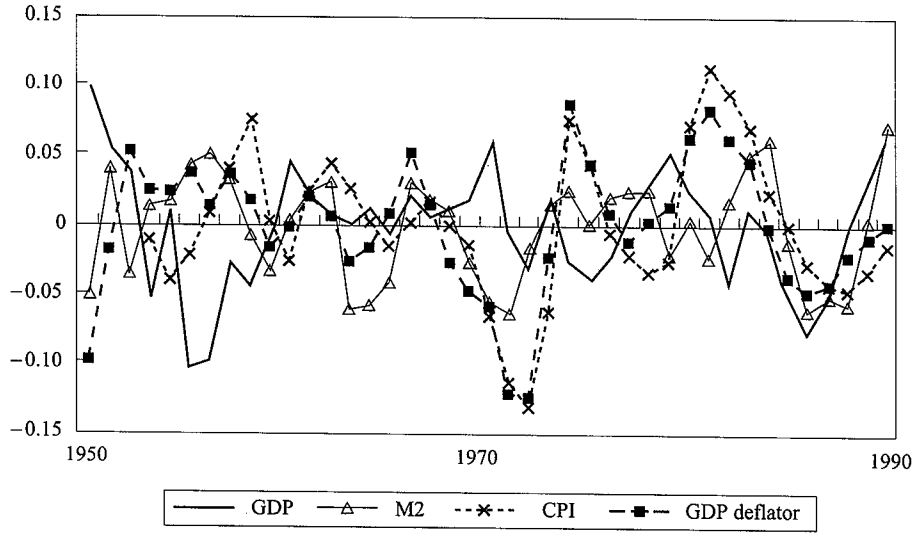
[b] 1955–90.

Fig. 8

A. Business Cycles in Thailand (1)



B. Business Cycles in Thailand (2)



III. INTERNATIONAL COMPARISON OF BUSINESS CYCLES

While business cycles in the U.S. economy have been examined thoroughly, those in Asian economies have not been fully investigated. Thus, it is meaningful to compare business cycles in Asia with those in the United States and to consider economic mechanisms and environments in the East Asian economies selected in this paper. First of all, I will test the similarity in moments of macroeconomic variables between the U.S. and the East Asian economies, using the *t*-values of the differences in the moments. Second, coherence of GDP between the U.S. and the East Asian economies is estimated. Finally, international co-movements of business cycles are studied and compared with those among developed countries in Backus, Kehoe, and Kydland (1992).

A. *Similarity in Moments of Macroeconomic Variables*

Tables IX, X, and XI show the *t*-values of the difference between the U.S. and the East Asian economies in the standard deviation, the first-order serial correlation of the macroeconomic variables, and the correlation between current GDP and the other current macroeconomic variables, respectively.

TABLE IX

t-VALUES OF DIFFERENCE IN MOMENTS BETWEEN THE UNITED STATES AND EAST ASIA: STANDARD DEVIATION

	Japan	Hong Kong	Korea	Philip-pines	Singa-pore	Taiwan	Thailand
GDP	–0.89	–3.33	–4.71	–1.43	–3.48	–0.71	–2.61
Private consumption	–0.89	–2.75	–5.82	–3.58	–4.00	–3.88	–3.85
Investment	–0.84	–2.28	–3.66	–1.81	–3.57	–1.82	–1.78
Government consumption	0.41	–1.74	0.99	0.54	–0.19	1.27	0.30
Balance of trade	–1.02	0.50	–1.29	–0.60	–0.89	–1.36	1.47
M1	–2.91	–4.59	–3.45	–4.42	–3.48	–4.58	–3.94
M2	–0.35	–4.03	–3.24	–2.64	–0.54	–0.49	–1.60
WPI	–1.39	N.A.	–3.79	–2.34	N.A.	–2.11	–2.19
CPI	–2.05	–1.94	–4.03	–2.86	–2.16	–3.69	–2.40
GDP deflator	–1.74	–3.20	–3.62	–3.03	–3.28	–5.27	–3.47

Note: *t*-values are obtained as follows;

$$t_{US\text{-}i} \equiv \frac{Z_{US} - Z_i}{\sqrt{\mathrm{Var}(Z_{US}) + \mathrm{Var}(Z_i)}}.$$

It is assumed that the moments of the United States and *i*th economy (Z_{US} and Z_i) are mutually independent.

TABLE X

t-VALUES OF DIFFERENCE IN MOMENTS BETWEEN THE UNITED STATES AND EAST ASIA: FIRST-ORDER SERIAL CORRELATION

	Japan	Hong Kong	Korea	Philip-pines	Singa-pore	Taiwan	Thailand
GDP	–2.55	0.29	–2.01	–3.19	–3.53	–1.65	–0.42
Private consumption	–0.36	0.78	–0.50	–0.73	–3.29	–0.67	0.82
Investment	–0.43	–5.37	0.40	–4.00	–5.13	–1.06	–0.33
Balance of trade	0.28	1.21	3.16	2.83	1.85	0.62	4.66
M1	–2.69	0.34	–0.12	0.19	0.10	–1.16	–0.94
M2	–2.15	0.20	–1.06	0.91	–0.41	–0.76	1.39
WPI	1.32	N.A.	0.80	2.45	0.35	0.63	1.01
CPI	0.48	0.63	–0.09	2.12	0.58	1.20	0.46
GDP deflator	0.76	2.24	1.75	3.04	1.15	2.65	1.81

Note: The same as in Table IX.

TABLE XI

t-VALUES OF DIFFERENCE IN MOMENTS BETWEEN THE UNITED STATES AND EAST ASIA: CORRELATION WITH CURRENT GDP

	Japan	Hong Kong	Korea	Philip-pines	Singa-pore	Taiwan	Thailand
Private consumption	1.31	0.35	0.03	–0.12	–0.81	–0.66	–1.18
Investment	1.07	2.03	2.73	0.38	3.71	1.68	1.61
Government consumption	0.81	–1.29	–4.25	–4.27	–0.16	0.19	0.55
Balance of trade	–0.18	–0.11	–0.09	1.50	–0.30	–0.32	0.20
M1	0.34	–1.74	–1.54	0.14	–6.40	–4.12	0.41
M2	1.11	0.84	2.00	1.17	–6.72	–0.54	1.16
WPI	–0.31	N.A.	–0.75	0.56	N.A.	–1.08	–2.05
CPI	–0.54	–2.28	0.63	0.29	–5.00	–1.16	–2.99
GDP deflator	0.04	–3.77	–2.07	0.62	–5.26	–1.74	–1.94

Note: The same as in Table IX.

It is noticeable that the variables tend to be more volatile in the East Asian developing economies than in the United States (see Table IX). Thirty-nine *t*-values of differences between the United States and the Asian developing economies out of the sixty-eight figures available are smaller than –2 and no *t*-value exceeds 2. Those of government consumption and balance of trade in the East Asian economies, however, are not significantly different from those of the United States. The estimated standard deviations in Japan are not appreciably different from those in the United States, though most of them are larger than the corresponding U.S. standard

deviations. As a whole, these results suggest that macroeconomic variables of smaller economies tend to be more volatile than those of larger economies.

There is no pronounced tendency in the difference in the case of the first-order serial correlation as we found in the comparison of standard deviation (see Table X). Twenty *t*-values out of sixty-nine exceed 2 in terms of absolute value, though the signs of the differences are either positive or negative.

The correlation between current GDP and current macroeconomic variables of the East Asian economies is much more similar to that of the United States than the above two moments (see Table XI). Sixteen *t*-values out of sixty-one exceed 2 in terms of the absolute value and five out of the sixteen *t*-values are found for Singapore whose price levels are procyclical. The moments of Japan are not significantly different from those of the United States.

B. *Coherence of Output between the U.S. and Asian Economies*

Economic fluctuations of the selected East Asian economies are similar to those of the United States from the viewpoint of the spectral analysis, too (see Figure 9).[9] Except for the Philippines, the coherence of GDP between the U.S. and each of the East Asian economies exceeds 90 per cent at any frequency. The output of the United States and that of the East Asian economies are jointly influenced by cycles at each frequency to a significant degree. Even in the Philippines, the coherence at higher frequencies, i.e., frequencies corresponding to the period from four to two years, exceeds 90 per cent.

The coherence in most of the Asian economies shares the same pattern of change as the frequency increases. At both lowest and highest frequencies, the coherence tends to be high while it is relatively low in the middle range of frequency, with the exception of Taiwan. Thus, both very long and very short waves of GDP in the United States and most of the Asian economies are highly linearly related. The coherence of Thailand's GDP with U.S. GDP is by and large high at every frequency.

C. *International Co-movements of Business Cycles*

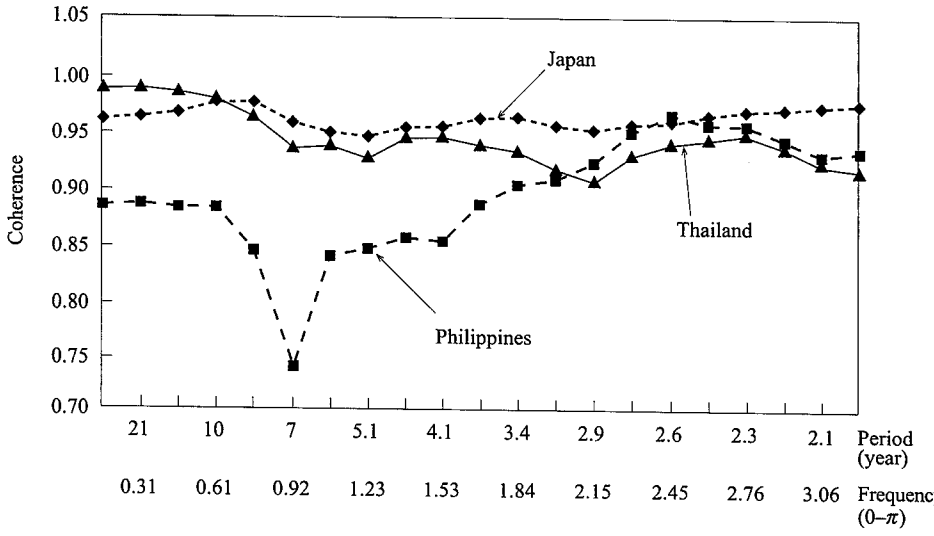
It is generally recognized that output and private consumption in most developed countries tend to be positively correlated with those of the U.S. economy and that the international co-movements in output are stronger than those in private consumption.[10] From the theoretical point of view, consumption should be more syn-

[9] Notice that the original series which have not been detrended with the H-P filter are used in this section. The coherence values shown in Figure 9 are smoothed with the modified Bartlett kernel whose bandwidth parameter is 4. Namely, the population coherence is estimated with the 4 frequencies moving average of the sample coherence. See Hamilton (1994, pp. 276–78). The patterns shown in Figure 9 did not change dramatically even when different bandwidth parameters, i.e., 2, 3, or 5, were used.

[10] See Backus, Kehoe, and Kydland (1992, 1995).

Fig. 9. Coherence of Output
(with U.S. output: bandwidth parameter=4)

A. Japan, the Philippines, and Thailand



B. Hong Kong and Singapore

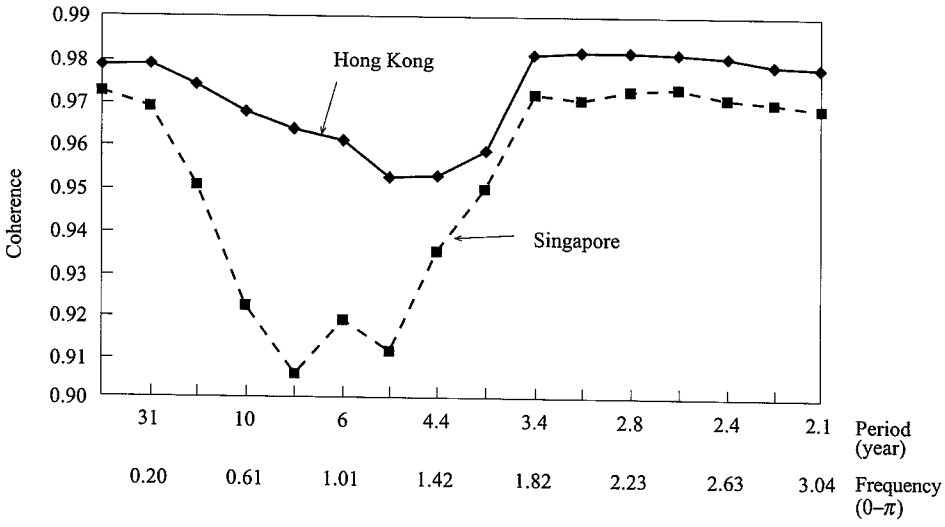
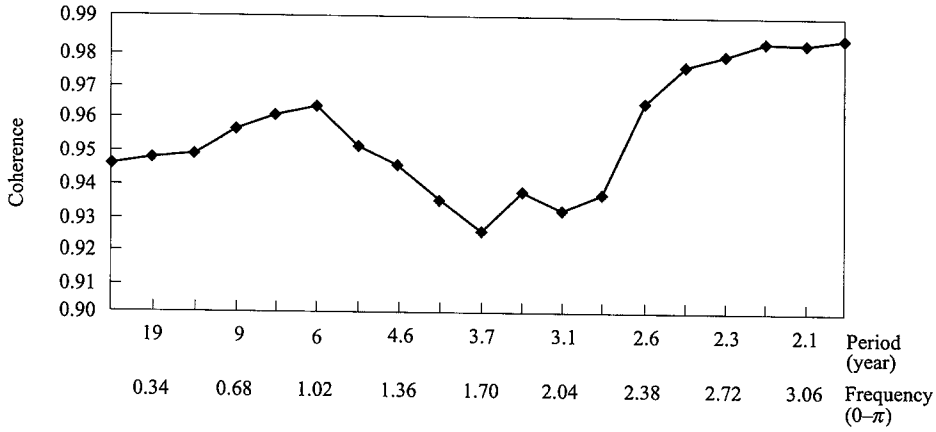


Fig. 9 (Continued)

C. Korea



D. Taiwan

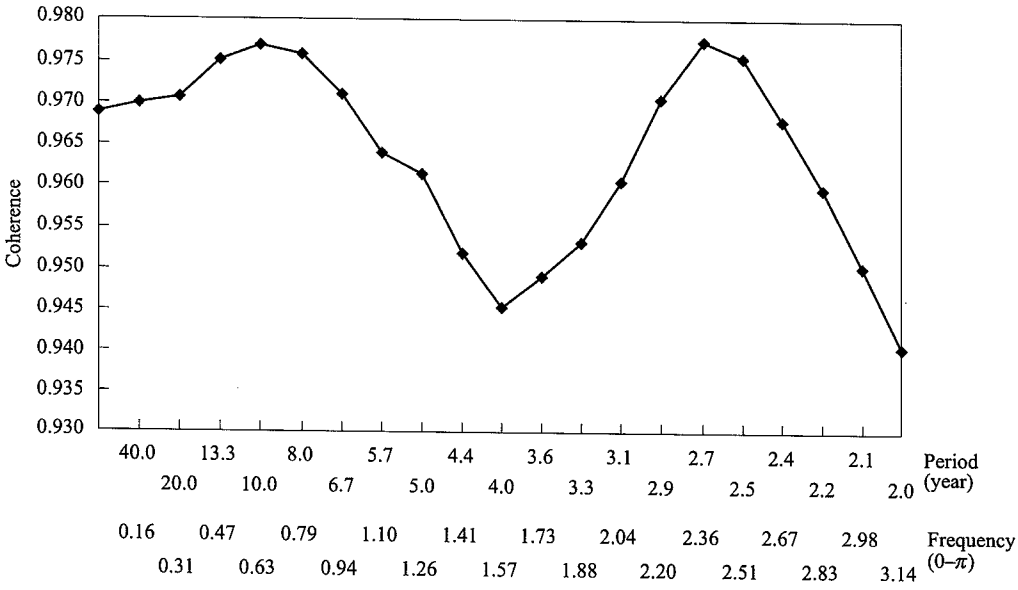


TABLE XII

CO-MOVEMENTS IN U.S. AND JAPANESE PER CAPITA GDP

	Current		Lagged	
	USA	Japan	USA	Japan
USA	1.000 [0.000]	0.266 [0.085]	0.430 [0.004]	0.050 [0.753]
Japan	0.266 [0.085]	1.000 [0.000]	0.272 [0.081]	0.633 [0.000]
Hong Kong	0.509 [0.003]	0.086 [0.634]	0.166 [0.355]	0.037 [0.839]
Korea	0.331 [0.039]	0.071 [0.669]	0.295 [0.069]	0.091 [0.584]
Philippines	–0.176 [0.259]	–0.064 [0.684]	0.059 [0.711]	0.011 [0.945]
Singapore	–0.324 [0.066]	0.202 [0.260]	–0.252 [0.157]	0.235 [0.188]
Taiwan	0.537 [0.000]	0.078 [0.629]	0.441 [0.004]	0.216 [0.181]
Thailand	–0.033 [0.834]	0.254 [0.100]	0.069 [0.663]	–0.026 [0.871]

Note: Figures are correlation coefficients, and p-values under the null hypothesis of no correlation are listed in brackets.

TABLE XIII

CO-MOVEMENTS IN U.S. AND JAPANESE PER CAPITA CONSUMPTION

	Current		Lagged	
	USA	Japan	USA	Japan
USA	1.000 [0.000]	0.159 [0.309]	0.516 [0.001]	0.144 [0.362]
Japan	0.159 [0.309]	1.000 [0.000]	0.103 [0.518]	0.549 [0.000]
Hong Kong	0.249 [0.162]	0.302 [0.088]	0.233 [0.192]	0.063 [0.728]
Korea	0.391 [0.014]	0.075 [0.650]	0.398 [0.012]	0.206 [0.208]
Philippines	–0.091 [0.561]	0.321 [0.036]	0.113 [0.477]	0.343 [0.026]
Singapore	–0.140 [0.438]	0.068 [0.707]	0.099 [0.585]	0.103 [0.568]
Taiwan	0.382 [0.015]	0.465 [0.003]	0.203 [0.208]	0.553 [0.000]
Thailand	0.015 [0.924]	–0.157 [0.314]	0.260 [0.097]	–0.223 [0.156]

Note: The same as in Table XII.

chronized across country through capital movement than output which is influenced by idiosyncratic technology shocks. Therefore, this discrepancy between the fact and theory is puzzling and is referred to as the "quantity anomaly" in Backus, Kehoe, and Kydland (1995).

In the case of the East Asian economies, co-movements in output with U.S. and Japanese economies are not necessarily strong (Table XII).[11] Output of Hong Kong,

[11] See Yamagata (1998) for details. Here I use the Penn World Table data to analyze international co-movements in GDP and consumption. The international co-movements are brought about through price signals, for instance exchange rate. The Penn World Table data do not reflect the direct effect of change in the exchange rate, though they are expressed in U.S. dollar. Someone might want to consider the same co-movements in GDP and consumption in terms of the currency of each country because people in the country take account of prices which they experience every day.

Korea, and Taiwan significantly co-moves with U.S. output. Though the GDP of other East Asian economies does not co-move with U.S. GDP, the GDP of Singapore and Thailand co-moves with the Japanese GDP considerably.[12] Except for the Philippines, the GDP of the East Asian economies seems to co-move with either U.S. or Japanese GDP. Co-movements in consumption appear to be similar to those in GDP (Table XIII).

However, once we examine the correlation between the current East Asian consumption and one-year-lagged U.S. and Japanese consumption, our impression on co-movements changes (Table XIII). It appears that these correlation coefficients are larger in general than those between the current East Asian consumption and that of the United States and Japan. The correlation coefficients of the current consumption of Korea, the Philippines, and Singapore with the lagged consumption of the United States and Japan are all higher than those with current U.S. and Japanese consumption. Hong Kong is the only exception such that the coefficients with lagged U.S. and Japanese consumption are both smaller than those of the current counterparts, respectively. Incidentally, lagged U.S. and Japanese GDP is not systematically correlated with current GDP of other East Asian economies (Table XII).

A possible interpretation of this positive correlation between lagged U.S. and Japanese consumption and consumption of other East Asia is that consumption synchronization which is supported by macroeconomic models is materialized between the United States and East Asia with one-year lag. Consumption synchronization takes place due to risk averse preference and is realized by capital movements in order to offset idiosyncratic technology shocks delivered to each economy. This process may take time. And influences from a large country on a small country might be more apparent than reverse influences.

[12] In the case of Singapore and Thailand, the share of exports and imports associated with the United States has been smaller than that of Japan with the United States. For example, exports to the United States as a percentage of the total exports of Singapore accounted for 11.1 per cent in 1970 and 21.3 per cent in 1990, while the same figure from Japan towards the United States was 31.1 per cent in 1970 and 31.7 per cent in 1990 [see Yamagata (1995) and Naya (1988) among others]. Exports of Thailand accounted for 13.4 per cent in 1970 and 22.7 per cent in 1990, respectively. In addition, the import share of the United States as a percentage of the total imports of Japan is also larger than that of Singapore and Thailand. Therefore the low correlations of the Singapore and Thai business cycles with U.S. business cycles may be understandable.

On the other hand, the economic relations of the Philippines have been closer to the United States than to the other Asian economies as a result of historical ties since the colonization period. In fact, the share of Philippine exports and imports associated with the United States is in general larger than or roughly equal to that of Japan.

Exports to the United States as a percentage of total Philippine exports accounted for 41.7 per cent in 1970 and 42.6 per cent in 1990. Imports accounted for 31.6 per cent in 1970 and 19.9 per cent in 1990, while the corresponding import share of the United States in the total imports of Japan was 25.4 per cent in 1970 and 20.9 per cent in 1990. It is surprising that such a close economic relationship does not result in positive co-movement of business cycles between the Philippines and the United States.

IV. CONCLUDING REMARKS

The behavior of most of the detrended macroeconomic variables in the East Asian economies was found to be similar to that observed in the U.S. economy. Consumption and investment are highly procyclical in East Asia, while the balance of trade and the price level are counter-cyclical with some exceptions. The magnitude of the correlations between GDP and other variables of these economies tends to be similar to that of the U.S. economy, though the macroeconomic variables of the East Asian developing economies are in general more volatile than in the U.S. economy. Furthermore, most macroeconomic variables show a significant positive serial correlation. In sum, the features of U.S. business cycles seen in the U.S. quarterly data, from (1) through (4) and from (9) through (11), as indicated in the Introduction, seem to be applicable to most East Asian economies. Moreover, the high coherence between the U.S. GDP and that of the East Asian economies shows that business cycles in terms of frequency are also similar between the United States and East Asia.

As for labor series, the volatility of labor inputs tends to be less conspicuous than that of GDP, and hours per worker fluctuate more than employment in Japan and Korea. Therefore, the features of U.S. business cycles (6) do not generally apply to East Asia. Procyclical real wage is not common in East Asia, either. However, procyclical labor productivity is seen in all the economies where labor-input series are available. In theory, increasing-returns-to-scale technology may cause procyclical productivity. Increasing-returns-to-scale technology is also able to explain the strong propagation mechanism, which is reflected in the high first-order serial correlation of macroeconomic variables of the U.S. and East Asian economies. In my companion papers, I determined whether increasing-returns-to-scale technology gives rise to the procyclical productivity and high serial correlation for the Philippine, Japanese, Korean, and Taiwanese manufacturing industries (Yamagata 1997a, 1997b).

These similarities in business cycles between the United States and East Asia in both time and frequency do not result in co-movements in business cycles of the United States and East Asia. Though GDP and consumption of some East Asian economies, e.g., Hong Kong, Korea, and Taiwan, co-move with those of the United States, those of Singapore and Thailand co-move with Japan more. Some show a high correlation in consumption with the United States, but consumption synchronization is never apparent. However, one-year-lagged U.S. and Japanese consumption is correlated with the consumption of other East Asian economies so that consumption synchronization might take place between the United States and East Asia with one-year lag. Obviously, more evidence is needed to elucidate the mechanism of this consumption synchronization with the lag between the United States and East Asia.

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