

An Empirical Investigation on Business Cycles in Asia: Finding the paths of International Transmission

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Abstract

This paper investigates the paths of international transmission of business cycles among major economies in East Asia. It will be helpful to deduce some policy implications on the macroeconomic management in the region. Firstly, we examine the business cycles by analyzing the monthly data as well as annual data. Next we conduct a Granger-causality test to detect the linkage and the synchronization of the business cycles in the region. Lastly, we examine the impulse responses of these countries to the endogenous shocks in the system.

Of particular interest is the finding that Korea's business cycle progresses in advance of other economies in the region. In a Granger sense, Korea is the cause of the business cycles in Asia. Malaysia also plays an important role in the cause. It is plausible that both countries lead the Asian economy because of their IT-driven industrial structure which is sensitive to the change of demand in the global market.

1. Introduction

It is important for policymakers in Asia to watch carefully the reaction of the domestic economy to the disturbances in economies in geometric proximity. This is the lesson from the Asian Currency Crisis in 1997 and afterwards. Asian countries are vulnerable to sudden shocks in the neighboring countries, which have serious adverse effects on home country. Definitely, we need to know the paths of transmission of economic fluctuations.

At the same time the recent surge of argument on East Asian Community and the optimal currency area in the region has led to a number of studies on business cycle synchronization. Because a currency union depends on, to some extent, to the extent to which participating economies are synchronized.

This paper investigates the international transmission of business cycles among Asian economies by using a monthly business index which has not been previously in the literature. So far the most of the investigation concerning the business cycles in Asia have been conducted by using annual or quarterly GDP statistics because of the availability of the data set.¹ However, it is much more desirable to use monthly data than annual data when we look into carefully the transmission mechanism of business cycles.²

This paper is organized as follows. In the next section we review some related works. Section 2 describes our data and methodology. In section 3 we construct a vector auto-regressive model and show the results of Granger-causality test and impulse-response function. The final section offers our conclusions and refers to the remaining problems which will be dealt in the future study.

Our findings can be summarized as follows. Of particular interest is the finding that Korea's business cycle progresses in advance of other economies in the region. In a Granger sense, Korea is the cause of the business cycles in Asia. Malaysia also plays an important role in the cause. It is plausible that both countries lead the Asian economy because of their IT-driven industrial structure which is sensitive to the changes of demand in the global market.

2. Investigation by Annual Data

2.1 Cross-Country Correlation of Business Cycles

Previously the business cycle is often defined by annual data in Asia, most typically by the annual growth rate of GDP, because of the limitation of the data.

Kawai and Motonishi (2004) computed the international correlation of the growth rate of real GDP by using annual data (1980-2002). The study includes 21 countries: ASEAN10, EU,

¹ Some countries in Asia like Vietnam still do not publish quarterly GDP statistics.

² We usually face a lack of samples when we use annual data in the econometric analysis.

Japan, Korea, China, Taiwan, Hong Kong, US, Australia, New Zealand and India.³

Surveying the international correlations of GDP growth rate, Kawai and Motonishi founded some stylized facts as below.

- ① Strong correlations can be seen among original ASEAN member countries (Thailand, Malaysia, Indonesia, Philippines and Singapore)
- ② Weak correlations can be seen among original ASEAN member and newcomers(Vietnam, Cambodia, Laos and Myanmar)
- ③ Strong correlations can be seen among original ASEAN member and east Asian countries(Japan, Korea, Taiwan and Hong Kong)
- ④ Weak correlations can be seen among China and east Asian countries
- ⑤ Weak correlations can be seen among Australia(India and New Zealand also) and east Asian countries
- ⑥ Weak correlations can be seen among US(EU also) and east Asian countries

2.2 Expanding the Data Period

In this section we adopt the method above and expand the data period (1960-2004) to confirm those findings.⁴ Annual growth rates of real GDP in these countries are available since 1960, except Brazil (since 1970), Korea (since 1971), and Malaysia (since 1971). Although high correlation does not necessarily mean the cause and effect relationship, we can grasp the whole picture of the global trend of business cycles.

We can observe some features below from Table1.

- ① High correlations can be seen among ASEAN countries, except the Philippines
- ② The Philippines has a rather high correlation with Japan and Korea.
- ③ High correlations can be seen among US, Canada and Australia
- ④ India and Russia do not have high correlations with the rest of the world.
- ⑤ China has weak correlation with other countries, sometimes zero or negative
- ⑥ Korea has substantially high correlations with Hong Kong, Malaysia, Indonesia and Thailand.
- ⑦ Taiwan has high correlations with US, Japan, Germany, Hong Kong and Singapore, but does not have high correlations with ASEAN countries except Singapore.
- ⑧ Australia has weak correlations with East Asian counties.
- ⑨ India has weak correlations with East Asian counties.
- ⑩ The correlation between Japan and the US is almost zero.

Above findings are consistent with the result of Kawai-Motonishi. As a conclusion, there

³ Taiwan and Hong Kong are referred to as countries for in this paper.

⁴ Data are obtained from *Trend of the World Economy* (Cabinet Office of Japan) and CEIC

exist high correlations within the ASEAN countries. Apparently Korea has high correlation with ASEAN. On the other hand, China seems to be independent from the rest of the world. Also India and Brazil seems to move independently. US has high correlations with Canada, Australia but weak correlation with Asian countries except Taiwan.

Figure 1. International Business Cycles:
Correlation Matrix (1960-2004)

Data: Trend of the World Economy (Cabinet Office of Japan) and CEIC

	US	Canada	China	Japan	Korea	Taiwan	Hong Kong	Singapore	Indonesia	Thailand	Malaysia	Philippines	India	Australia	Euro Area	Germany	Brazil
US	1.00																
Canada	0.75	1.00															
China	0.16	-0.05	1.00														
Japan	0.35	0.21	-0.13	1.00													
Korea	0.23	0.12	0.04	0.37	1.00												
Taiwan	0.61	0.40	-0.01	0.61	0.42	1.00											
Hong Kong	0.41	0.35	-0.14	0.52	0.50	0.76	1.00										
Singapore	0.22	0.20	-0.05	0.44	0.38	0.56	0.57	1.00									
Indonesia	0.03	0.04	-0.08	0.49	0.56	0.38	0.61	0.60	1.00								
Thailand	0.07	-0.06	0.05	0.49	0.74	0.36	0.47	0.48	0.74	1.00							
Malaysia	0.15	0.07	-0.15	0.39	0.55	0.41	0.60	0.82	0.78	0.68	1.00						
Philippines	-0.05	0.11	-0.52	0.28	0.21	0.23	0.38	0.43	0.36	0.29	0.45	1.00					
India	0.02	-0.05	0.33	-0.19	-0.09	-0.26	-0.34	-0.14	-0.11	0.12	-0.21	0.02	1.00				
Australia	0.54	0.69	0.18	0.07	-0.18	0.12	0.03	0.02	-0.16	-0.13	-0.07	-0.13	0.04	1.00			
Euro Area	0.49	0.51	-0.41	0.58	0.26	0.52	0.43	0.32	0.18	0.18	0.35	0.33	-0.35	0.19	1.00		
Germany	0.47	0.27	-0.28	0.60	0.33	0.53	0.43	0.30	0.23	0.32	0.39	0.13	-0.35	0.07	0.87	1.00	
Brazil	0.22	0.48	-0.17	0.37	0.09	0.49	0.43	0.21	0.37	0.03	0.22	0.23	-0.43	0.24	0.45	0.23	1.00

3. Econometric Methods and Description of the Data

3.1 Asian Business Index

As is shown in the previous section, the business cycle is often defined by annual data or quarterly data at best. In practice, the low frequency of annual data might be insufficient to fully assess the degree of business cycle synchronization and find the transmission paths. Therefore, we complement our analysis with monthly data.

The data in this section consist of the *Monthly Asian Business Index (ABI)* devised by the Japan Center for Economic Research in Tokyo, as well as the *Monthly Business Composite Index (CI)* for Japan, presented by the Cabinet Office of Japan. *Asian Business Index* presents the monthly business index for Korea, Taiwan, Hong Kong, Singapore, Thailand, Malaysia, the Philippines, Indonesia, and China.⁵ *ABI* is calculated based on the same method for preparing *CI*. Therefore, we can consistently integrate these data for our analysis.

The analysis follows the following steps.

1. Data are tested for stationarity using the Phillips-Peron test.
2. A correlation matrix is calculated for ABI and CI.
3. The impact of each series on each other are tested for Granger causality using bi-national VARs. A second set of bi-national VARs is estimated while controlling for the effects of the Asian Currency Crisis.⁶

3.2 Basic Statistics of the Data and Graphs

Figure 1 displays some basic statistics of nine economies. The standard deviation, suggesting the volatility of the economy, is relatively large in Korea, Malaysia, Thailand, and Indonesia: relatively small in China and the Philippines.

Figure2. Basic Statistics

	Korea	Taiwan	Hong Kong	Singapore	Thailand	Malaysia	Indonesia	Philippines	China
Mean	-2.9202	-0.9660	-4.6309	-2.3866	-3.9202	-6.2027	-2.5229	-4.3160	-0.9612
Median	-3.0000	-0.6500	-3.8500	-0.6000	-1.2000	-4.2500	-3.2000	-4.2000	0.3000
maximum	26.1000	31.2000	18.9000	22.1000	23.7000	15.7000	28.0000	16.2000	24.8000
minimum	-44.3000	-32.0000	-33.1000	-29.6000	-43.7000	-44.8000	-30.5000	-27.9000	-17.7000
STD	12.2758	10.6835	10.0964	9.9354	12.7934	13.5710	11.7843	8.1465	7.5924
Skewness	-0.5990	-0.3006	-0.3773	-0.6915	-0.8743	-0.8096	-0.0676	-0.2572	0.0396
Kurtosis	4.5532	3.5273	3.0607	3.1038	3.6366	3.2405	2.8962	3.4752	2.7641

⁵ Monthly data are available since January 1990, except China (since December 1991). As a rule of thumb, the economy is in the good condition when the index goes over 10, and very good condition when the index goes over 20: vice versa.

⁶ Cointegration analysis was not conducted because there was no theoretical reason to expect the business cycles of these economies to be cointegrated.

In the next page displays the graphs of the series of ABI and CI: Korea, Taiwan, Hong Kong, Singapore, Thailand, Malaysia, Indonesia, the Philippines, China, and Japan over the period January 1990-February 2006. We can observe deep troughs in 1998 and 2001 for most of the economies. Obviously they are influenced by the Asian Currency Crisis and the burst of the IT bubble. Looking into the graphs carefully, height of the peaks and the depth of the troughs, timing of the turning points are subtly different from each economies. Below is the case of Japan which shows from the burst of the “bubble economy” in 1991 and “lost decade” until recently.

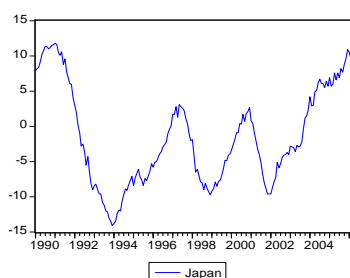


Figure 3 displays the contemporaneous correlations of the above index. It is noteworthy that almost all the correlations are positive; this indicates that the business cycles of sample economies progress in tandem with each other through time. Apparently Japan is the exception, moving independently.

The strongest correlations of the pairs are: Malaysia-Singapore (0.814), Singapore-Thailand (0.795), Malaysia-Thailand (0.779), Malaysia-Korea (0.766), Korea-Thailand (0.763), Malaysia-Hong Kong (0.720), China-Hong Kong (0.708), and Korea-Singapore (0.696). In contrast with Korea, Japan has no countries to go together.

Figure3. Contemporaneous Correlations of the Index

	Korea	Taiwan	Hong Kong	Singapore	Thailand	Malaysia	Indonesia	Philippines	China	Japan
Korea	1.000									
Taiwan	0.535	1.000								
Hong Kong	0.494	0.528	1.000							
Singapore	0.696	0.693	0.675	1.000						
Thailand	0.763	0.512	0.696	0.795	1.000					
Malaysia	0.766	0.606	0.720	0.814	0.779	1.000				
Indonesia	0.400	0.388	0.659	0.645	0.644	0.665	1.000			
Philippines	0.447	0.368	0.458	0.529	0.423	0.613	0.470	1.000		
China	0.386	0.643	0.708	0.674	0.635	0.553	0.502	0.288	1.000	
Japan	0.038	0.236	0.284	0.210	0.192	0.103	0.458	-0.102	0.142	1.000

3.3 Unit Root test

Before moving to the econometric analysis, we first check the stationarity of the business index series using Philips-Peron tests. *Asian Business Index and Composite Index* are used as proxies for business cycles of each country. The sample period covers January 1990 to February 2006. The unit root tests for the levels of all the series in *Asian Business Index* reject the null hypothesis that there exist unit roots in the series.

Results of Philips-Peron test

	Test Statistics	Significant level
Korea	-3.46	Significant at 5% level
Taiwan	-10.75	Significant at 1% level
Hong Kong	-4.83	Significant at 1% level
Singapore	-4.96	Significant at 1% level
Thailand	-4.33	Significant at 1% level
Malaysia	-3.60	Significant at 5% level
Indonesia	-3.60	Significant at 5% level
Philippines	-6.29	Significant at 1% level
China	-8.94	Significant at 1% level

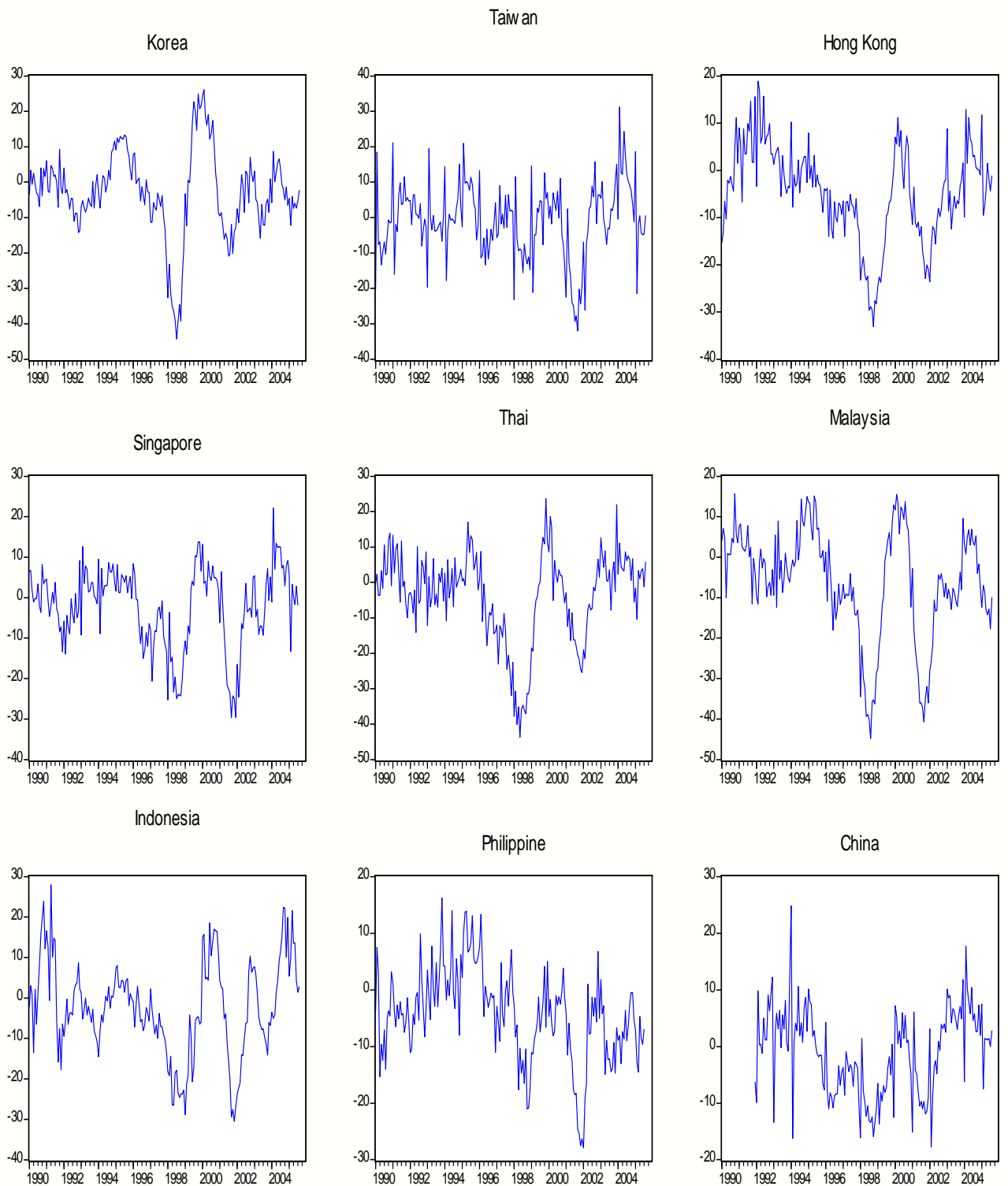
With trend and intercept

Thus, there is no unit root in each of the series in *Asian Business Index*. In the subsequent analysis, we assume the data are level stationary.⁷

However, we can not rule out the possibility of including the unit root in the *CI*. Therefore, we have to exclude Japan from the subsequent analysis.⁸

⁷ The Phillips-Peron test allowing for both an intercept and a time trend is employed to determine if there is a unit root in the data series. The Schwarz Information Criterion is used to determine the lag parameter. Results of applying the PP test to the data are shown in the Appendix.

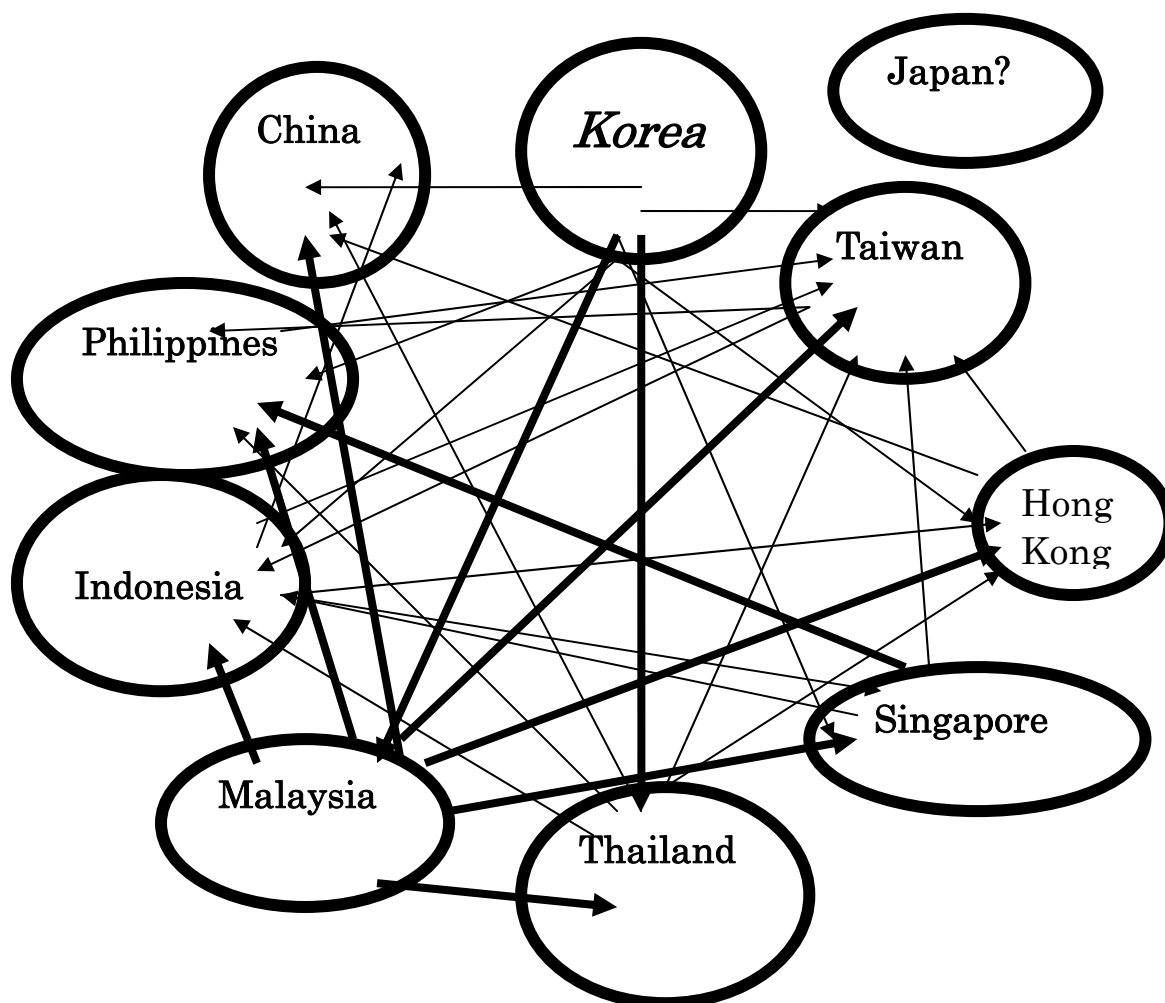
⁸ Monthly GDP statistics for Japan presented by the Japan Center for Economic Research is another candidate for *CI*, which will be tested in the next paper.



5 Results of Granger Causality Tests for Nine Asian Economies

5.1 Illustration

We construct 72 pairs of bi-national VAR model and conducted Granger-causality tests for them. It turned out that 31 pairs out of 72 pairs have strong relationship in the Granger sense (significant at 1% level). Below is the summary chart of the tests. Bold arrow indicates remarkably strong relation ($F\text{-value} > 18$).



5.2 Interpretation

(1) Korea

It is obvious that the Korea is the epicenter of the economic fluctuations in Asia. Korea is the fastest runner and always run in front of other economies, namely leading indicator.

Korea has influence on every other economy but not influenced at all by other economies. In

other words, it is unidirectional causality from Korea to other countries. Strong influence on Thailand and Malaysia from Korea deserves to pay attention.

(2) Malaysia

Malaysia is strongly influenced by Korea. At the same time Malaysia exerts strong influence on other economies, especially on ASEAN countries. This can be interpreted that Malaysia accepts the influence from Korea and propagate it to the neighboring countries, a kind of relay station.

(3) Thailand

Thailand is influenced by Korea and Malaysia. At the same time Thailand exerts strong influence on other economies, especially on Indonesia, the Philippines, China, Taiwan, and Hong Kong. This can be interpreted that Thailand accepts the influence from Korea and Malaysia and propagate it to the neighboring countries.

(4) Singapore

Singapore is influenced by Korea and Malaysia, on the other hand, exerts influence on the Philippines and Taiwan. There exist a bilateral causality between Singapore and Indonesia.

(5) Hong Kong

Hong Kong is influenced by Malaysia, Korea, Thailand, and Indonesia. However, Hong Kong leads Taiwan and China.

(6) Taiwan

Taiwan is influenced by Malaysia. There exist bilateral influence between Taiwan and Indonesia, Taiwan and the Philippines, respectively.

(7) Indonesia

Indonesia is strongly influenced by Malaysia.

(8) The Philippines

The Philippines is strongly influenced by Malaysia and Singapore

(9) China

China does not have any impact on other countries in the granger sense.

As a conclusion, we can say that Korea lies in the “up-stream” of the river if we compared the transmission of business cycles to the flow of water. China, Indonesia, and the Philippines lies in the “down-stream” of the river which never progress in advance. They come last in the flow of economic fluctuation. Malaysia lies in the “mid-stream” of the river, which accepts the impacts from Korea and transmit it to other countries.

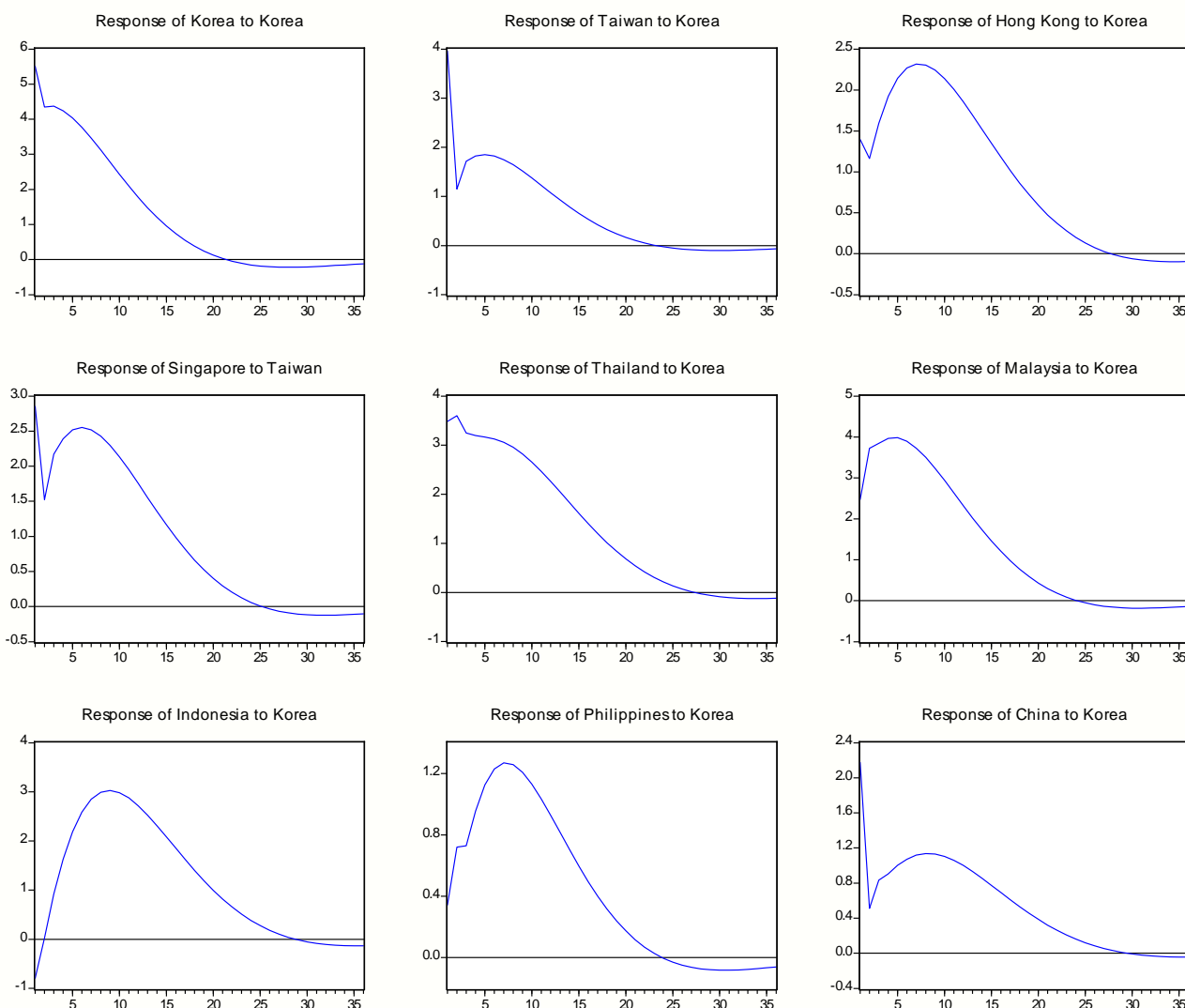
5.3 The response of Asian economies to the shock from Korea

In this section, we employ impulse response function to examine the shocks and its effect based on the VAR model employed in the previous section. Impulse responses trace out the responsiveness of the dependent variables in the VAR to shocks to each of the variables.

As we find out in the previous section, Korea is the “leading indicator” in Asia. Thus, our prime concern is to understand the magnitude of the influence when Korean business condition changes. Next chart illustrates the response of Asian countries when a positive shock (one unit of standard deviation) was given to Korea.

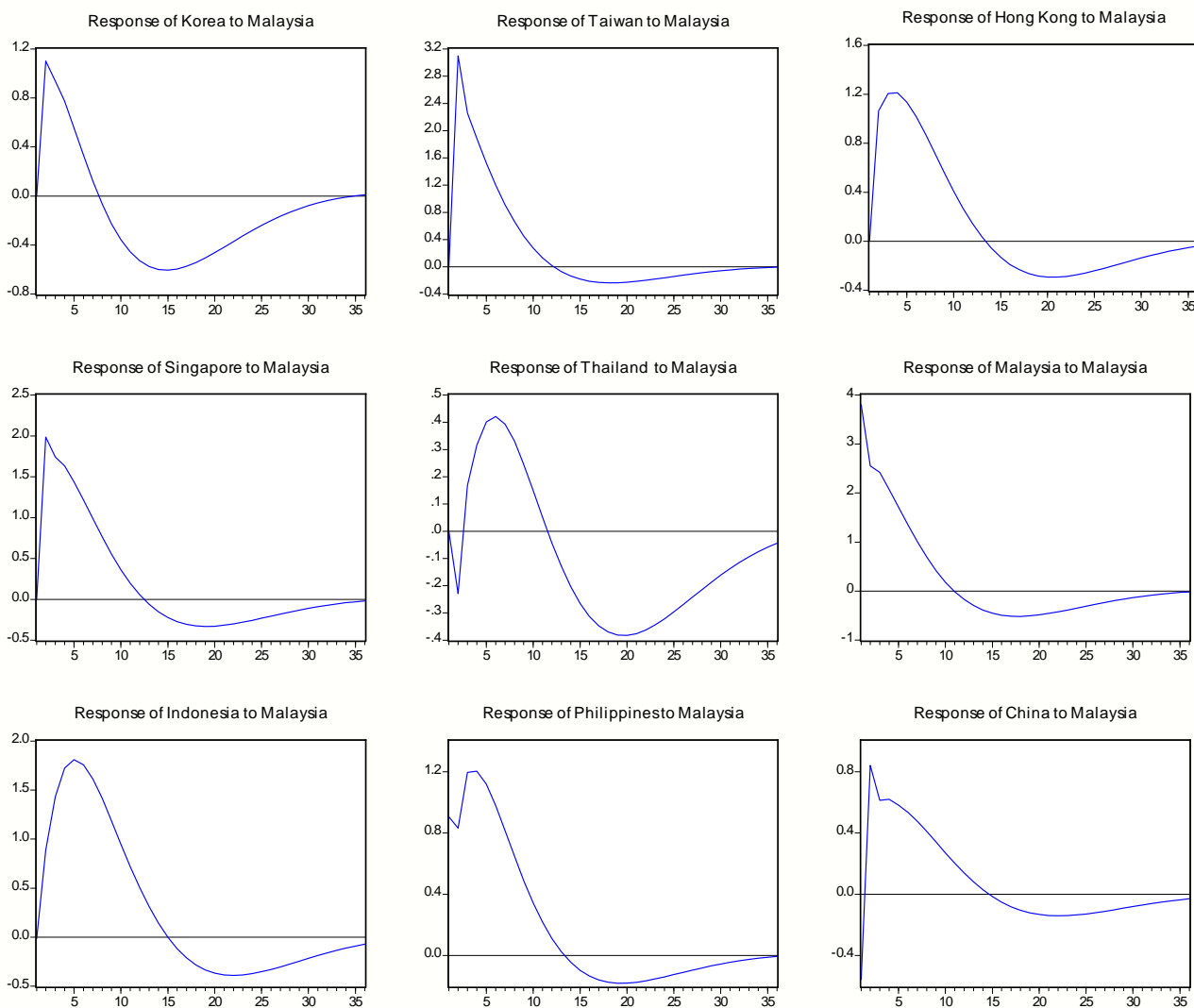
As a whole, most countries respond positively and the effect last for eighteen to twenty-four months.

Response to Cholesky One S.D. Innovations



5.4 The response of Asian economies to the shock from Malaysia

Response to Cholesky One S.D. Innovations

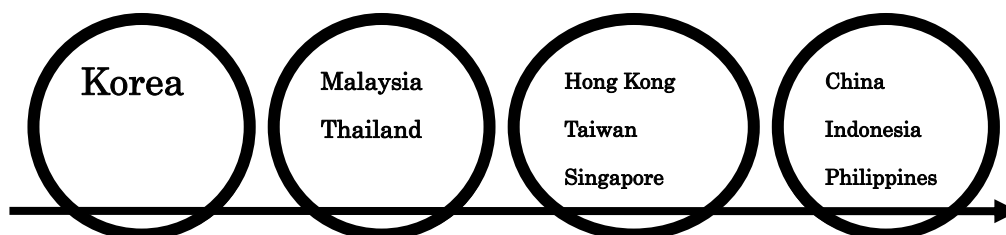


Conclusions

This paper demonstrates the structure of the Asian economy in terms of transmission of business cycles. It turned out that most of Asian economies are preceded by Korea. Korea “granger causes” other economies in the procedure of time order. The influence of Korea toward other economies lasts for more than one year.

Malaysia is also the powerful cause of the fluctuation, next to Korea. China, Indonesia, and the Philippines come in the “down stream” of the transmission paths. Hong Kong, Taiwan, Singapore lies in-between.

Precedence of Transmission of Business Cycles in Time Order



Why Korea and Malaysia lead the Asian economy in the Granger sense? Probably because industrial structure of both countries substantially concentrate on electronics, semi-conductor and other IT related products. It is well known that the demand for these products is highly volatile and unstable. Therefore Korea and Malaysia have to be very sensitive to the changes of demand in the global market.

Some remaining problems should be stated. The influence of Japan and the United States is out of our scope in this paper. Of course we have to construct a comprehensive scheme which covers EU, the United States, Japan, and Asian economies with the acquisition of appropriate data.

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Appendix

Lag	Log L	Appendix1. Lag Structure in the VAR				
		LR	FPE	AIC	SC	HQ
0	-4571.098	NA	1.20e+15	60.26445	60.44349	60.33718
1	-4093.479	892.3937	6.52e+12	55.04577	56.83623*	55.77312
2	-3952.737	246.2984	3.00e+12	54.25970	57.66156	55.64165*
3	-3872.009	131.7133	3.09e+12	54.26328	59.27656	56.29985
4	-3809.461	94.64556	4.15e+12	54.50607	61.13075	57.19724
5	-3726.585	115.5901	4.42e+12	54.48138	62.71748	57.82717
6	-3642.517	107.2977	4.85e+12	54.44101	64.28852	58.44141
7	-3538.027	120.9882	4.32e+12	54.13193	65.59085	58.78694
8	-3426.207	116.2344	3.78e+12	53.72640	66.79673	59.03602
9	-3304.022	112.5383	3.20e+12	53.18450	67.86624	59.14873
10	-3168.510	108.7666	2.61e+12	52.46723	68.76038	59.08607
11	-3020.567	101.2240	2.17e+12	51.58641	69.49096	58.85986
12	-2823.379	111.5670*	1.23e+12*	50.05761*	69.57358	57.98568

Appendix2. Results of Granger causality test

Lags: 1

Null Hypothesis:	Obs	F-Statistic	Probability
Taiwan does not Granger Cause Korea	187	4.84605	0.02895
Korea does not Granger Cause Taiwan		15.2241	0.00013
Hong Kong does not Granger Cause Korea	187	1.10047	0.29554
Korea does not Granger Cause Hong Kong		15.1938	0.00014
Singapore does not Granger Cause Korea	186	0.05589	0.81337
Korea does not Granger Cause Singapore		13.2747	0.00035
Thailand does not Granger Cause Korea	187	0.52653	0.46899
Korea does not Granger Cause Thailand		18.5112	2.7E-05
Malaysia does not Granger Cause Korea	187	5.39612	0.02128
Korea does not Granger Cause Malaysia		28.7049	2.5E-07

Indonesia does not Granger Cause Korea	187	0.29096	0.59026
Korea does not Granger Cause Indonesia		14.8979	0.00016
Philippines does not Granger Cause Korea	186	0.47887	0.48981
Korea does not Granger Cause Philippines		13.9310	0.00025
China does not Granger Cause Korea	164	6.25382	0.01339
Korea does not Granger Cause China		7.36191	0.00739
Hong Kong does not Granger Cause Taiwan	187	9.11936	0.00289
Taiwan does not Granger Cause Hong Kong		2.70101	0.10199
Singapore does not Granger Cause Taiwan	186	11.0604	0.00107
Taiwan does not Granger Cause Singapore		0.81297	0.36843
Thailand does not Granger Cause Taiwan	187	7.13847	0.00822
Taiwan does not Granger Cause Thailand		0.31205	0.57710
Malaysia does not Granger Cause Taiwan	187	36.5542	8.1E-09
Taiwan does not Granger Cause Malaysia		2.84964	0.09309
Indonesia does not Granger Cause Taiwan	187	8.57949	0.00383
Taiwan does not Granger Cause Indonesia		10.7212	0.00127
Philippines does not Granger Cause Taiwan	186	8.27464	0.00450
Taiwan does not Granger Cause Philippines		9.10290	0.00292
China does not Granger Cause Taiwan	164	0.08510	0.77087
Taiwan does not Granger Cause China		1.10688	0.29434
Singapore does not Granger Cause Hong Kong	186	6.38151	0.01238
Hong Kong does not Granger Cause Singapore		0.94064	0.33339
Thailand does not Granger Cause Hong Kong	187	9.16916	0.00281
Hong Kong does not Granger Cause Thailand		0.75972	0.38455
Malaysia does not Granger Cause Hong Kong	187	30.9653	9.2E-08
Hong Kong does not Granger Cause Malaysia		2.26632	0.13393
Indonesia does not Granger Cause Hong Kong	187	7.72099	0.00602
Hong Kong does not Granger Cause Indonesia		5.96065	0.01557
Philippines does not Granger Cause Hong Kong	186	0.83252	0.36275
Hong Kong does not Granger Cause Philippines		4.25826	0.04047
China does not Granger Cause Hong Kong	164	0.08698	0.76843

Hong Kong does not Granger Cause China		15.6215	0.00012
Thailand does not Granger Cause Singapore	186	4.94882	0.02733
Singapore does not Granger Cause Thailand		3.17358	0.07650
Malaysia does not Granger Cause Singapore	186	29.0017	2.2E-07
Singapore does not Granger Cause Malaysia		1.33225	0.24991
Indonesia does not Granger Cause Singapore	186	7.54954	0.00660
Singapore does not Granger Cause Indonesia		15.5503	0.00011
Philippines does not Granger Cause Singapore	186	3.59311	0.05960
Singapore does not Granger Cause Philippines		16.3321	7.8E-05
China does not Granger Cause Singapore	163	3.68477	0.05669
Singapore does not Granger Cause China		6.56553	0.01132
Malaysia does not Granger Cause Thailand	187	16.5707	7.0E-05
Thailand does not Granger Cause Malaysia		4.51771	0.03488
Indonesia does not Granger Cause Thailand	187	6.40872	0.01219
Thailand does not Granger Cause Indonesia		15.3478	0.00013
Philippines does not Granger Cause Thailand	186	0.67539	0.41225
Thailand does not Granger Cause Philippines		7.02504	0.00874
China does not Granger Cause Thailand	164	0.07624	0.78282
Thailand does not Granger Cause China		11.5921	0.00084
Indonesia does not Granger Cause Malaysia	187	0.06343	0.80144
Malaysia does not Granger Cause Indonesia		25.9783	8.5E-07
Philippines does not Granger Cause Malaysia	186	0.00508	0.94325
Malaysia does not Granger Cause Philippines		22.8905	3.5E-06
China does not Granger Cause Malaysia	164	2.26234	0.13451
Malaysia does not Granger Cause China		22.2956	5.1E-06
Philippines does not Granger Cause Indonesia	186	0.33395	0.56405
Indonesia does not Granger Cause Philippines		5.28064	0.02269
China does not Granger Cause Indonesia	164	3.57610	0.06041
Indonesia does not Granger Cause China		15.1206	0.00015
China does not Granger Cause Philippines	163	6.04941	0.01498
Philippines does not Granger Cause China		4.19438	0.04219