DISCUSSION PAPERS IN ECONOMICS

Working Paper No. 03-05

The Impact of the US Economy on the Asia-Pacific Region: Does it Matter?

Frank S.T. Hsiao
Department of Economics, University of Colorado at Boulder
Boulder, Colorado

Mei-Chu W. Hsiao
Department of Economics, University of Colorado at Denver
Denver, Colorado

Akio Yamashita
Department of Economics, Ryukoku University
Kyoto, Japan

April 2003

Center for Economic Analysis
Department of Economics

University of Colorado at Boulder
Boulder, Colorado 80309

The Impact of the US Economy on the Asia-Pacific Region: —Does it Matter?

Frank S.T. Hsiao
University of Colorado at Boulder, U.S.A.

Mei-Chu W. Hsiao
University of Colorado at Denver, U.S.A.

Akio Yamashita
Ryukoku University, Japan

Forthcoming in
Journal of Asian Economics, Vol. 14 No. 2, March/April 2003

Frank S.T. Hsiao*
Professor of Economics
Department of Economics
University of Colorado at Boulder
Boulder, CO 80309-0256

Office: (303)492-7908, 6396
FAX: (303)492-8960 (Dep't)
e-mail: hsiao@spot.colorado.edu

Mei-Chu W. Hsiao
Professor of Economics
Department of Economics, Campus Box 181
University of Colorado at Denver
1380 Lawrence St., Suite 460
Denver, CO 80204

Office: (303)556-8322, 4413
FAX: (303)556-3547
e-mail: mhsiao@carbon.cudenver.edu

Akio Yamashita
Professor of Economics
67 Tsukamoto-cho
Fukakusa, Fushimi-ku
Ryukoku University, Kyoto 612-8577 Japan

e-mail: yamasita@biz.ryukoku.ac.jp

*Corresponding author

The Impact of the US Economy on the Asia-Pacific Region: Does It Matter?

Frank S.T. Hsiao[a,*], Mei-chu W. Hsiao[b], and Akio Yamashita[c]

a. Department of Economics, University of Colorado at Boulder, CO 80309-0256, USA
b. Department of Economics, University of Colorado at Denver, CO 80204, USA
c. Department of Economics, Ryukoku University, Kyoto, 612-8577, Japan

----

Abstract

We first confirm the interdependence of the United States and the Asia-Pacific region, and explore the real linkage through trade and investment, and the financial linkage through stock markets. These linkages are strengthened by the recent IT revolution. The pairwise and VAR model are used to test the Granger causality of real linkage in terms of GDP and the financial linkage in terms of the daily stock price indexes among these countries. Impulse response functions and variance decomposition from VAR are illustrated. Our results show that there is no significant unidirectional causality from the US GDP to Japan, Taiwan, Korea, and China. But the slump in the US stock price indexes will Granger cause the stock market recession in Japan, Korea, and Taiwan, but not China.

JEL classification: F41; C32; E32; E44; O53.

Keywords: US and Asia Pacific, Regional Interdependence, IT Revolution, VAR, Causality

- -------------------------------

1. Introduction

Since the mid-1980s, the United States and the Asia-Pacific countries have increasingly formed a new international division of labor in the new economy of information technology (IT), defined as computer hardware, software, and telecommunication equipment (IMF, 2001, 105). The Asia-Pacific countries here include the Asian Developed Countries (ADCs): South Korea

*Corresponding author. Tel.: 303-492-7908; fax: 303-492-8960.
E-mail address: hsiao@spot.colorado.edu

(hereafter Korea), Taiwan, Singapore, and Japan, and the ASEAN4+: that is, Indonesia, Malaysia, Philippines, Thailand and China. When Hong Kong, which is increasingly integrated with China, is included in the ADCs, we denote them separately as the ADCs+. By 2000, about 30 to 50 percent of total exports of these two groups consisted of IT products, or about 10% of their GDP (IMF, 2001, 107, 122, 126). As the United States, along with Japan, is a significant investor in this region, and a majority of their products are exported to the United States (see below), the economic relation between these Asian countries and the United States is becoming much closer than ever. This paper examines the interdependence between the United States and some selected countries in these two groups of Asian countries, and assesses the impact of the recent US recession on this regional economy.

After a prolonged prosperity, the recovery of the Asian economies from the 1997 Asian financial crisis (Hsiao and Hsiao, 2001a) was swift, thanks to the booming IT markets in the United States from 1999 to 2000. However, since mid-2000s, a decrease in the demand for IT products and the subsequent worsening of the US economy (IMF, 2001, 79), aggravated by the 9/11 terrorist attack and over-investment in the IT sectors in the United States and the Asian countries, led to a sharp decrease in exports and slower GDP growth in these Asian countries (ibid., 33). The slump in the US IT markets transmitted quickly to the Asia-Pacific region through trade and foreign investment as well as stock markets. The transmission has been fast and devastating.

The reason is that the United States is not only the largest economy in the world, it is also an important trading partner and a major supplier of technology and capital. Thus, in Section II, we first discuss the role of the United States as a major trading partner, investor, and capital lender to the countries in the Asia-Pacific region. We also examine the importance of the ADCs as exporters and importers to and from the United States. In Section III, we then discuss the impact of the IT revolution on the United States and these two groups of the Asia-Pacific region, which have successfully specialized in producing and exporting IT products. We explore the real linkage between them through trade and investment and the financial linkage through stock markets. The strengthening of the real and financial linkages arising from the IT revolution and the increased vulnerability of these countries to international macroeconomic fluctuations are noted. We then, in Section IV, select five countries, the United States, and Japan, Korea, Taiwan (the major ADCs+), and China (the major ASEAN4+), to test the causality of the GDP series.

We first check the pairwise Granger causality for ten pairs of the countries, and then use the vector autoregression (VAR) model to test Granger causality. Impulse response functions and variance decomposition of each variable are derived and illustrated. Similar methods are used in Section V to test the causality of the stock indexes of the five countries. Section VI concludes.

2. The interdependence of the United States and the Asia-Pacific region

Figure 1 shows the share of GDP of the world's 174 countries[1] in year 2000 (WB, 2002). The US GDP alone accounted for almost 31% of world GDP. Japan at 15.2% was a distant second, followed by China, 3.4%. In contrast, the NIEs (Korea, Taiwan, Singapore, and Hong Kong) had a 3.2% share, and the ASEAN4 had about a 1.4% share. Thus, the difference is so enormous that the US economy could be expected to exert significant influence over the individual countries in the region economically and politically.[2]

Place Figure 1 here

In fact, this is the case. Part (a) of Table 1 shows the merchandise trade with the United States as a percent of the total merchandise trade for each country in the region. In 1999, except in Hong Kong, the weight of the US trade is over 10%, and in the Philippines, China, and Japan even as high as 28% to 30% of their total trade. Generally speaking, the weight of the US decreased in the ADCs+ in the 1990s and increased in ASEAN4+ countries, indicating the success of diversification of the direction of trade in the ADCs+ economies. Nevertheless, for all these countries, trade with the US is still predominant.

Place Table 1 here

----

[1] Taiwan's GDP data in current US$ (US$ 309 billion) is taken from ICSEAD (2002), and added to the world total of US$ 31.5 trillion to calculate percentage. EMU+ includes 12 countries in the European Monetary Union (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain) and United Kingdom (WB, 2002).

[2] In the original version of this paper, we presented the purchasing power parity share weight of GDP. In that case, the US GDP accounted for 22% of the world GDP, China, 11.5%, Japan, 7.5%, NIEs, 3.4%, ASEAN4, 3.6%. Since we are interested in the impact (instead of welfare) of the current US GDP on the GDPs of the Asia-Pacific countries, we decided to use GDP in current US dollars.

A more direct impact of trade volume on economic activity may be measured by taking the proportion of US trade as a percentage of GDP in each country, as shown in Part (b) of Table 1. The percentage apparently varies inversely with the size of the economy, as indicated in Figure 1: only 4% in China and 10% in Japan. Other countries range from 13% in Korea to a whopping 42% in Singapore. Thus, the transmission of macroeconomic fluctuations from the US to smaller countries through trade relations alone may be expected to be substantial.

Part (c) in the last two columns shows that the IT products hold the bulk of exports: Most are exported to the US, and the rest to other inter- or intra-regional countries. Except for Japan, which shows a slight decrease, the proportion of IT products in the total merchandise trade increased considerably from 1990 to 1999, at least 30% for all countries. Among them, the ratio of Indonesia increased almost thirteen times and that of the Philippines three times. In 1999, the proportion of IT products in the total trade of the Philippines was 63%, followed by Singapore at 53%. As we will see in the next section, this increase renders these countries quite vulnerable to the IT-induced business cycle.

As well as by trade, US economic conditions may influence its trading partners through its foreign direct and portfolio investment flows[3] and threw stock markets. Part (a) of Table 2 presents the shares of US and Japanese foreign direct investment (FDI) in the Asia-Pacific region. We added the share of Japanese FDI, since Japan is another large investor in the area, competing with the United States. The first row of each country shows the total inward foreign direct investment,[4] in billions of US dollars, but in some cases in the domestic currency, converted to US dollars. The percentage shares of US FDI and Japanese FDI are then calculated. Exceptions to the designated year are shown in the parentheses.

Place Table 2 here

[3] In studying the relative impact of the US and Japanese business cycles on the Australian economy in terms of real GDP from 1959:3 to 1996:4, Lee, et al. (2003) found that the main transmission channel of the US business cycle to the Australian business cycle was FDI (that is, what they call the financial market), while that of Japan was trade. They also found that the US output had a stronger impact than the Japanese output. They did not consider the stock market linkage.

[4] Different country has different method of interpreting and collecting FDI data. For example, inward flow data of Indonesia "are based on approvals and exclude foreign direct investment in the oil and gas industry, banking, non-bank financial institution, insurance and leasing. Reported data include cancellations, expansions, mergers, net value of alterations and shifting of projects from foreign to domestic investment or vice versa" (UNCTAD, 2000). Thus, Indonesia' FDI may be under-reported.

In general, the grand total of FDI investment in the nine countries increased considerably in the 1990s: 4 times in ADCs and 5 times in the ASEAN+, 4.6 times overall, indicating the rapidly increasing openness of the Asia-Pacific region. Most of the increased FDI came from the USA, as the proportion of US investment in the total FDI in the countries increased in both groups, especially in the ADCs, while that of overall Japanese investment in the eight countries decreased considerably over the decade, the largest decrease occurring in the ADCs.

Compared with 1990, FDI in China increased 13 times in 1998, consisting of 54% of FDI in the ASEAN4+ or 40% of FDI in grand total. Interestingly, the proportion of FDI in China from both the USA and Japan decreased five to six percent, indicating the increase of FDI in China from Taiwan, Korea, and other countries. China is followed by Korea, which increased 11 times, the Philippines, 4.5 times, Indonesia, 3.8 times, and Singapore, 3.2 times. Malaysia is the only country that shows a slight decrease in FDI. The US proportion of FDI has increased in all the countries, except Korea and China, suggesting the increase of economic influence of the United States in this region. Note that, although the proportion of US investment in Korea has decreased, the US still contributes 34% of the total FDI in Korea; thus, US economic conditions may still exert considerable impact on the Korean economy.

Part (b) of Table 2 shows that the US banks are far smaller lenders to these countries, than the Japanese banks (Callen and McKibbin, 2001). The US share of lending to the ADCs remains almost the same and small, less than 10%, while that to the ASEAN4+ tends to be decreasing and also small, also less than 10%. Thus, US monetary policy, especially changes in interest rate, has a limited effect on these Asia-Pacific countries.

We have seen the dominance of the US role in Asian exports and direct investment. On the other hand, the United States also increasingly depends on trade with the Asia-Pacific region, especially with the ADCs. The left-hand side of Figure 2 shows that, in 2000, the U.S. exports to the ADC+ consisted of about 20% of its total exports. In fact, among the ten leading exporting partners of the United States in 2000, Japan ranked third, Korea sixth, Taiwan seventh, and Singapore tenth, and the trend in Korea and Taiwan is increasing (SAUS, 2001). At a lesser scale, 6% of the United States exports went to the ASEAN4+ countries, a total of 25% to both areas. On the import side, the United States also relies more on Asia. It imported 21% from the ADC+ and 14% from the ASEAN4+, a total of 35%. Among them, Japan ranked second, China fourth, Taiwan seventh, Korea eight, and Malaysia tenth. Thus, a change in economic conditions in the Asia-Pacific area will have an impact on the US economy.

Place Figure 2 here

It may be interesting to point out that among the US patents granted to residents of areas outside the United States and its territories, the three major ADCs alone had 54% of the total patents granted in 1999: Japan, 32,513 patents, ranked first, Taiwan, 4,526, ranked third, only after Germany, and Korea, 3,679, ranked sixth, after France and the United Kingdom (SAUS, 2001, 846). Few people are aware that the vigorous inventive and innovative activities of these three countries, especially Taiwan and Korea, have exceeded most of the OECD countries, and are comparable to Germany, France, and the United Kingdom. Thus, the US recession, and the subsequent decrease in revenue from the massive use of patented products in the United States also sends a blow to these countries.

3. The IT revolution and the global real and financial linkages

The recent IT revolution has contributed several new features to the interdependence between the United States and the Asia-Pacific countries.

The core of the IT revolution is semiconductors, the power of which has doubled every 18 to 24 months (Moor's Law) and the prices of which have decreased steadily and rapidly. The fast technological obsolescence and turnover, low cost of learning, externality of networking, and the combination of high-tech and labor- intensive manufacturing process in this field, has enabled a vertical division of labor between computer producers in the United States and developing countries like the ASEAN4+, for offshore sourcing of IT peripherals (EPA, 2000). Specialization in IT products in Asia-Pacific countries has enhanced the interdependence between the United States and these countries through trade and foreign direct investment. At the same time, this specialization has exposed these countries to the recent IT shock originating from the slump in demand for IT products in the United States.

The governments in this region place a top priority on developing the IT industry. Singapore has a national initiative for an "Intelligent Island," Taiwan for a "Green Silicon Island," and Malaysia for a "Multimedia Super Corridor." Other ASEAN4+ countries are also establishing special IT enclaves (ADB, 2000). As most of the IT products are exported, as shown in Part (c) of Table 1, strong international linkages may be expected to continue in the near future.

Furthermore, the governments of the ADCs have devoted large resources to R&D in the development of IT industries, facilitating technology absorption and adaptation, and further technological and managerial innovations, as evidenced by the patents granted in the United States mentioned above. Taiwan is now the world's third largest producer of IT products, next to the US and Japan, and Korea is the world's third largest producer of semiconductor chips, and is in the forefront of mobile-phone technology (ADB, 2000). This also implies that IT products in the ADCs are related horizontally to industries in other advanced countries like the United States and the OECD countries in Europe, and thus the ADCs' domestic business cycle of boom and bust in the IT industries is inevitably linked to the international business cycle, increasing the vulnerability of their economies (IMF, 2001, 123).

In addition to the supply side of production and exports, the rapidly falling prices of IT products and new services have also stimulated domestic demand for the products within these countries. Table 3 presents the degree of penetration of some IT products in the ADCs+ and the ASEAN4+ countries. While there is a very clear "digital divide" among the two groups, the popularity of IT products, like telephone main lines, mobile telephones, personal computers (PC), internet hosts, in the former NIEs (Korea, Taiwan, Singapore, and Hong Kong) is either almost as great, or has already exceeded their popularity in Japan, and even in the United States-with the notable exception of the IT R&D scientists and engineers in the US.

In fact, Part (b) of Table 3 shows that, according to the IT indexes compiled by the Japan's Economic Planning Agency (EPA, 2000), the differences of the IT infrastructure index[5] and the IT knowledge index of the NIEs and ASEAN4+ from those of Japan are much closer than expected. Although the total value of IT outputs of the two groups in terms of US dollars are still far behind that of Japan and the USA, the per capita output of IT products among the NIEs has already exceeded that of the United States by 1997, indicating the potential of further

---

[5] The output index and the per capita output index include the outputs of data and office machinery, communication and household audio equipment. The infrastructure index includes the first four items in part (a) of Table 3, and nine other items, like number of cable TV, credit card usage, etc. The knowledge index considers the numbers of IT scientists, patents granted, high school and college enrollments, students studying in the United States, science paper citation index, etc.

development in these countries. The expansion of domestic markets for IT products may help to offset the volatility of exports, but at the same time, it makes consumers and investors more vulnerable to changes in international macroeconomic conditions.

Place Table 3 here

The IT revolution strengthened financial linkages across the countries (IMF, 2001, 121, 128). Since new IT firms tend to be younger, smaller, and riskier, the IT sector relies more on equity financing (ibid. 131). This characteristic has been observed in a variety of economies, in both developed and developing countries. In Taiwan, for example, 44% of the total manufacturing capital in 2000 was invested by the IT industry, and almost 38% of the IT investment was financed through the stock market (Cheng, 2002).

Greater reliance on equity finance, and so on the stock markets across the countries, makes the IT sector and the economies in the Asia-Pacific region vulnerable to international stock price movements. Parts (a) and (b) of Table 4 present the correlation coefficients among the US NASDAQ index, Tokyo Nikkei-Dow-Jones average index, Singapore Straight Times Price Index, and Taiwan Weighted Stock Indexes (ibid). They show clearly that, compared with 1995-1999, the correlation coefficients increased dramatically in 2000-2001, especially the coefficients between the US stock price index and the stock price indexes in other countries. Thus, the close ties between the US stock market and other countries caused the slump in the US market to be reflected rapidly in the stock prices of other countries.

Place Table 4 here

How does the international linkage of stock markets influence domestic macroeconomic fluctuations? If the IT stocks are held only by a small number of people, and have little weight in the national income, then international financial linkages should not have much effect on domestic consumption or business cycles. However, this is not the case in most of the Asia-Pacific countries. The many boom years in the IT industry in this region, before the recent slump boosted the local stock market prices, stimulated stock ownership in the IT-producing and

IT-exporting countries. The last two columns of Table 3 show stock market capitalization relative to GDP as a proxy for the stock ownership in each country.

Except for Korea, the ADCs had capitalization ratios above 50% of GDP in 2000. Their equity capitalization ranked from second to nineteenth in the world[6], indicating the predominance of equity assets in these societies. Except for Malaysia, the ASEAN4+ countries had lower capitalization ratios, ranging from 20% to 60%, but still high in the world rankings, from twenty-second to twenty-fifth. This implies that sharp changes in equity prices will change individuals' wealth (the wealth effect in these societies), and since wealth is a key factor determining consumption, household consumption will also change (Edison and Slok, 2001; Bertaut, 2002), and therefore the growth of the economies will be affected. Thus, the IT revolution has strengthened international dependence and the real and financial linkages.

Parts (c) to (f) of Table 4 present the correlation coefficients of GDP time series, the growth rates of GDP from 1979 to 2000, 270 recent common transaction days' stock price indexes and their growth rates from September 18, 2001 to December 13, 2002 for the five countries. The correlation coefficients of GDP among the five countries are very high (0.81 to 0.98), but are low for GDP growth rates (-0.32 to 0.59). In terms of the growth rates, the correlation coefficients between the United States and all other countries are generally low, especially with Korea and China. Korea and Taiwan have higher correlation with Japan (0.56 and 0.58). Korea and Taiwan also have high correlation coefficient (0.59). There seems to have much similarity among the three countries in terms of the GDP levels and their growth rates (Hsiao and Hsiao, 2003). China's GDP growth rate consistently has negative correlation coefficients with all other countries. This may be due to China's high GDP growth rates during the past two decades and the slowdown of the GDP growth in the United States and ADCs.

Similarly, the correlation coefficients of daily stock indexes are generally higher than their growth rates. The stock indexes of Japan and the USA are highly correlated (0.72). Similar to the GDP levels and growth rates, the stock indexes of Korea, Taiwan, and Japan have higher correlation coefficients (0.56 and 0.60) than with other countries, especially between Korea and Taiwan (0.90). Again China is different. The correlation coefficients of stock indexes between China, the United States, and Japan, are low (0.21 and 0.32), and China and Korea along with

---

[6] The world ranking is taken from Kurian (2001), which is also based on EIU data but does not mark the year the statistics are taken.

Taiwan even have small negative correlation coefficients. This may be due to the government control of the stock markets in China. In terms of the growth rates of the stock indexes, the movements among countries seem random, and no trend seems to exist, except that Japan and the United States (0.23), and Taiwan and Korea (0.25) show some correlations.

4. Causality tests on the GDP series

There are several methods of testing international interdependence and linkages. Arora and Vamvakidis (2001) apply usual growth regression to study the impact of the US economic growth on the rest of the world, without considering the financial linkages. Callen and McKibbin (2001) use a G-Cubed (Asia-Pacific) model to examine the effect of changes in Japanese policy on the Asia-Pacific region. Watanabe (1996) examines the impact of US stock prices and volatility on the Asia-Pacific region, using an exponential autoregressive conditionally heteroskedastic (EGARCH) model, a variety of regression analysis. In view of our empirical observations in the previous sections, however, we submit that in this interdependent world the best order of analysis would be to first test the causality of the linkages, and after we have found that cause and effect, then apply impulse response analysis. In this section, therefore, we test the causality and dynamics of the GDP time series, and in the next section, we test the stock price index time series.

In this paper we choose to test the causality of the US and the major ADCs, Japan, Korea, and Taiwan. China is also chosen from the ASEAN+ countries for the size of its economy and its growing importance in the Asia-Pacific regional economy. The annual GDP in current US dollars for these countries from 1979 to 2000, except for Taiwan, were obtained from the World Bank's World Development Indicators (WB, 2002). Taiwan's data were taken from the ICSEAD (2002). The GDP time series are chosen to test the real linkage since the rapid economic growth of Japan, Korea, Taiwan, and China are due to their openness through trade and inward foreign direct investment, especially with the United States (Sachs and Warner, 1995, 1996; Coe, Helpman, and Hoffmaister, 1995; Hsiao and Hsiao, 2001b).

Before analyzing the causal relations among the five GDP time series, we have used the Augmented Dickey-Fuller (ADF) unit-root test to examine the stationarity of each GDP series (Greene, 2003). The ADF test results show that all five level series (in log values) of GDP are nonstationary at the 10% level of significance, and their first-difference series (i.e., the growth rates of GDP) are all stationary at the 5% or 10% level of significance. Hence, we use the GDP growth rate series in the causality analysis. In addition, we have also applied the Johansen test of cointegration to the five GDP level series. The test results indicate no cointegration at the 1% level of significance. Therefore, the vector autoregression model (VAR) can be used in testing the causality relationship among the five GDP growth rate series.

A. Pairwise Granger causality tests

The annual GDP data set, however, is adequate for examining pairwise Granger causality relationship among the five countries using stationary first-difference series of GDP (Greene, 2003). The test involves in estimating the following two equations:

$$\Delta x_t = \alpha + \sum_{i=1}^{m} \beta_i \Delta x_{t-i} + \sum_{j=1}^{m} \gamma_j \Delta y_{t-j} + \mu_t \ , \quad (1)$$

$$\Delta y_t = \delta + \sum_{i=1}^{m} \lambda_i \Delta x_{t-i} + \sum_{j=1}^{m} \theta_j \Delta y_{t-j} + \nu_t \ , \quad (2)$$

where Δx_t and Δy_t are the first-difference series of GDP for a pair of countries, respectively, e.g., Japan and China, the USA and Japan, etc. From five countries, we have a total of ten pairs of Granger causality tests. Δx_{t-i} and Δy_{t-j} are lagged dependent variables. μ_t and v_t are the random error terms in the equations. The causal relationship in equation (1) is seen from the Wald's coefficient F-test on the joint significance of the coefficients γ_j's of Δy_{t-j}'s, and that in equation (2) is seen from the joint significance of the coefficients λ_i's of Δx_{t-i}'s. In this bivariate case, we do not include the other variables' influence on the pair of variables in the equations. Thus, the causality relationship is due to the direct influence of the two variables.

Since we only have a small sample of annual data, we have tried to estimate the model with the lag length m = 1 and m = 2. In both cases, we obtained the same causality results. Therefore, we choose to present the results from the lag length m = 2 in Table 5. From the ten pairwise Granger causality tests, we have found two unidirectional causality relationships: Japan's GDP growth rate causes Korea's GDP growth rate at the 5% level of significance, and Japan's GDP growth rate also causes Taiwan's GDP growth rate at the 1% level of significance. These results show the strong dependency of the growth of Taiwanese and Korean economies on the Japanese economic growth, but not vise versa. The testing results also show the US's GDP growth rate unidirectionally causes Japan's GDP growth rate at the 25% level of significance.

Place Table 5 here

B. VAR Granger causality tests

To take into account the interactions among the five countries, we take one step further by formulating the GDP growth rate series into a system of vector autoregression (VAR) model (Greene, 2003), to examine the Granger causality relationships among the five countries. The VAR(p) model involves the estimation of the following equation system:

$$y_t = \mu + \Gamma_1 y_{t-1} + \ \ldots \ + \Gamma_p y_{t-p} + \varepsilon_t \ , \qquad (3)$$

where y_t is a (5 x 1) vector of the endogenous variables, i.e., y_t = ($DLKOR_t$ $DLTWN_t$ $DLCHN_t$ $DLHPN_t$ $DLUSA_t$)', the GDP growth rate series of Korea, Taiwan, China, Japan, and the USA. The μ is a (5 x 1) constant vector, Γ_i , i = 1, 2, …, p, the order of lags, is a (5 x 5) coefficient matrix, y_{t-i} is a (5 x 1) vector of the ith lagged endogenous variables, ε_t is a (5 x 1) vector of the random error terms. In this case, the data set allows us to estimate the VAR model at i = 1 or i = 2. We then select the optimal lag length at i = 1 by the minimum AIC of the VAR system.

Place Table 6 here

Table 6 presents the estimations from VAR(1) moodel. The Granger causality is examined using the Wald's coefficient F-test on each variable in each equation. The last row presents the summary of the testing results. In this VAR model, we include the other country variables to take into account the indirect influence from other countries. We have found three unidirectional causality relations: Japan's GDP growth rate causes Korea's GDP growth rate and also causes Taiwan's GDP growth rate. These results are consistent with the results of the pairwise Granger causality test above. Furthermore, we have also found that Korea's GDP growth rate causes China's GDP growth rate, as evidenced from recent closer economic relation between the two countries.

Figure 3 illustrates the combined impulse response functions of each endogenous variable to trace the effects of injecting a shock into the estimated VAR(1) system due to a policy change and/or external stimuli to an economy, i.e., a one-time shock of one standard deviation of the error term. Especially, we have found that Korea and Taiwan have very strong positive responses to a change in Japan' GDP growth rate, and China also has positive response to a change in Korea's GDP growth rate. They peaked in the second periods, and lasted about four periods.

Place Figure 3 here

Figure 4 depicts the variance decomposition of each endogenous variable in the estimated VAR(1) system. We have found that a change in Japan's GDP growth rate has played a relative important role in explaining the variance (about 20%) of Korea's GDP growth rate and the variance (about 40%) of Taiwan's GDP growth rate. The changes in the GDP growth rate of Taiwan and Korea have played an important role in explaining the variance of China's GDP growth rate, about 30% and 10%, respectively. In the case of Japan, Taiwan and Korea have played a relatively important role (15% and 20%, respectively) than the United States (about 5%).

.--------------------------

Place Figure 4 here

----

5. Causality tests on the stock price index series

The daily stock price indexes for China (Shanghai Composite, SSEC), Korea (Seoul Composite, KS11), Japan (Nikkei 225, N225), Taiwan (Taiwan Weighted, TWII), and the USA (S&P 500, GSPC) were retrieved[7] from the Major World Indices (finance.yahoo.com, on 12/15/2002). We have selected 270 recent common transaction days' stock indexes at the closing of the market[8] for each of the five countries, from September 18, 2001 to December 13, 2002. The period is chosen to eliminate the immediate effect of the September 11, 2001 tragic event in the New York City.

---

[7] We have chosen S&P 500 instead of NASDAQ since the latter consists of 5000 or so technology stocks, while S&P 500 index consists of major stocks in both technology and non-technology, similar to the stock indexes of other countries.

[8] We first compare the US index and the Japanese index, and choose the stock indexes which have the common transaction days in both countries. We then compare these indexes with those of other three countries, one by one, and select the indexes which have the common transaction days as the US and Japan. Note that, since Cheng (2002) did not specify how the data were selected , the results of Part (a)(b) and Part (e)(f) may not be comparable.

We apply the same econometric procedures as in analyzing the GDP series above to examine the causality relationships among the stock index series of the five countries. The Augmented Dickey-Fuller (ADF) unit-root tests show that all five level series (in log values) of the stock indexes are nonstationary at the 1% level of significance, and their first-difference series (i.e., the growth rates of stock indexes) are all stationary at the 10% level of significance. In addition, the Johansen test of cointegration for the five stock index series shows that they are not cointegrated. Hence, we use the first-difference series of the stock indexes in testing their Granger causality relationships.

A. Pairwise Granger causality tests

We apply the pairwise Granger causality tests to the five stationary first-difference series of stock indexes. In this case, Δx_t and Δy_t in equations (1) and (2) are the first-difference series of stock indexes for a pair of countries, respectively, and the other notations remain the same.

Place Table 7 here

Table 7 presents the estimations of the ten pairwise Granger causality tests, and the last column shows the summary of the test results. We have found the following interesting Granger causality relationships:

1. The USA's stock index growth rate unidirectionally causes Japan's stock index growth rate (at the 1% level of significance), and causes Korea's stock index growth rate (at the 5% level of significance), as well as Taiwan's stock index growth rate (at the 1% level of significance).
2. Japan's stock index growth rate unidirectionally causes Taiwan's stock index growth rate (at the 1% level of significance).
3. There is bidirectional causality between Korea's stock index growth rate and Taiwan's stock index growth rate (at 1% and 10% level of significance, respectively).

B. VAR Granger causality tests

When we formulate the five stock index growth rate series into a system of vector autoregression (VAR) to examine the Granger causality relationships among the five countries, the y_t in equation (3) is a (5 x 1) vector of the endogenous variables, i.e., y_t = ($DLKSID_t$

$DLTSID_t$ $DLCSID_t$ $DLJSID_t$ $DLUSID_t$)', the stock index growth rate series of Korea, Taiwan, China, Japan, and the USA. In this case, the optimal lag length i = 1 is selected by the minimum AIC of the VAR system.

Place Table 8 here

Table 8 presents the estimations from the VAR(1) model on stock index growth rate series for the five countries, and the last row shows the summary of Granger causality test results. We have found the following causality relationships:

1. Like the pairwise Granger causality tests above, the USA's stock index growth rate unidirectionally causes Japan's stock index growth rate (at the 1% level of significance), Korea's stock index growth rate (at the 5% level of significance), as well as Taiwan's stock index growth rate (at a low, 15%, level of significance).
2. Korea's stock index growth rate unidirectionally causes Taiwan's stock index growth rate (at the 1% level of significance).
3. Compared with pairwise Granger causality tests, we see two results: One is that Japan's stock index growth rate unidirectionally causes China's stock index growth rate (at a low, 15%, level of significance) with a negative coefficient. Another is that China's stock index growth rate unidirectionally causes the USA's stock index growth rate (at the 10% level of significance). It is not clear why this is the case.[9]

Figure 5 illustrates the combined impulse response functions of each endogenous variable, to trace the effects of injecting a shock into the estimated VAR(1) system due to a policy change and/or external stimuli in a financial market. We have found that Japan, Korea and Taiwan's stock index growth rates have relatively strong positive responses to a change in the USA's financial market, peaked at the second period, and lasted about three to four periods. Furthermore, Taiwan's response to Korea's change is positive and strong.

Place Figure 5 here

[9] There are two groups of stock transactions in China, some are open to foreigners, some are only for local people, and its stock markets are not as free as other countries. This may distort the causality relationship with other countries.

Figure 6 depicts the variance decomposition of each endogenous variable in the estimated VAR(1) system. We have found that a change in the USA's financial market has played a relatively important role in explaining (about 17%) the variance of Japan's stock index growth rate, and a change in Korea's financial market has played a relatively important role in explaining (about 15%) the variance of Taiwan's stock index growth rate. For the case of the USA, only Japan has played some role in explaining the variance of the USA's stock index growth rate. The effects of other countries on Korea and China are almost negligible.

Place Figure 6 here

----

6. Conclusions

Given the size of its economy and resources, one would expect that the United States would exert enormous influence on the stability and growth of closely allied countries in the Asia-Pacific region. This view is popular and intuitive. However, to our knowledge, the literature is still wanting in quantitative assessment of the role of the United States in this region. This paper attempts to fill this gap by first confirming the mutual dependence of the United States and the Asia-Pacific region, which includes the ADCs and the ASEAN4+ countries. We have pointed out that, while the United States is a predominant force in trade and investment in the region, it also relies on the countries in this region for its trade. The IT revolution enhanced the interdependence between the United States and the countries in this region through real and financial linkages.

Our study of linkages also highlights the possible routes of the transmission of the US recession, and more generally, the international business cycle, in the Asia-Pacific region. The impact of the US recession, and for that matter, of Japan and other countries, should be transmitted through trade, foreign direct investment, and stock markets. With this understanding, we then performed Granger causality tests on the time series data of five countries: The United States, Japan, Korea, Taiwan, and China. The results are quite unexpected. The pairwise Granger causality tests show that the GDP growth rates have unidirectional causality from the Japan to Taiwan and Korea. Surprisingly, we didn't find significant causality relationships between the United States and any other four countries.

In a larger VAR model in which the influence of other countries are included, the VAR Granger causality tests confirm again the same unidirectional causality of the GDP growth rates from Japan to Taiwan and Korea, and additionally, the unidirectional causality from Korea to China. Apparently, so far as GDP growth is concerned, despite the apparent dominance of the US economy and its increasing interdependence with the Asia-Pacific region, the recent US recession has minimal impact on the GDP growth of the Asia-Pacific region. The recent recession in Taiwan and Korea is more likely influenced by Japan rather than the United States. These results may be due to the fact that the annual GDP time series data are too short for causality analysis. A further study is called for.

We had no sample problems on the stock price indexes, and the results are much more illuminating. The pairwise Granger causality tests of the stock indexes show that, other things being equal, there is a very strong unidirectional causality from the United States to Japan, Korea and Taiwan, and also from Japan to Taiwan. In addition, there is a bidirectional causality between Korea and Taiwan. When our analysis is extended to the VAR model, we still obtain the same unidirectional causality from the United States to the three major ADCs, but not to China. Whether the case of China can be found similarly in the ASEAN countries will be our next project of study. We have also found very strong unidirectional causality from Korea to Taiwan, and weak unidirectional causality from Japan to China, as well as from China to the United States, a finding that is not intuitive.

In general, based on our data set, so far as the GDP real linkage is concerned, we have not found the significant unidirectional causality from US GDP growth to the growth of Japan, Korea, and Taiwan, or China. On the other hand, from the financial point of view, the recent US IT recession in the stock market during the past two years have shown a significant unidirectional causality from the United States to Japan, Korea and Taiwan, but not to China. This shows that the impact of the US recession is transmitted only through the stock markets, or more generally, the financial linkage. In short, the US recession does matter for Japan, Korea, and Taiwan through the financial linkage. Our empirical results seem to confirm the current economic experience between the United States and the Asia-Pacific region.

Acknowledgements:

The initial research of this paper was done while the first two authors were visiting researchers at the International Centre for the Study of East Asian Development (ICSEAD), Kitakyushu, Japan, in the summer of 2002. It was presented at the AEA/ACAES Session at the 2003 ASSA Annual Meeting at Washington, D.C. January, 2003. We are grateful to the hospitality at the ICSEAD, and to Professors Steve Beckman, Martin Boileau, Richard Hooley, Hyun-Hoon Lee, Robert McNown, Eric Ramstetter, and James T.H. Tsao for helpful discussions or data collection. All errors of omission and commission are the authors'.

References

Arora, V. and A. Vamvakidis, (2001). The impact of U.S. economic growth on the rest of the world: How much does it matter? IMF Working Paper, WP/01/119.

Asia Development Bank (ADB) (2000). *Asian development outlook 2000 update*, Manila: ADB

Bertaut, C. C. (2002). Equity prices, household wealth, and consumption growth in foreign industrial countries: Wealth effects in the 1990s, *International Finance Discussion Papers*, No. 724, Board of Governors of the Federal Research System.

Callen, T. and W. J. McKibbin (2001). Policies and prospects in Japan and the implications for the Asia-Pacific region, *IMF Working Paper*, WP/01/131.

Cheng, Y. C. (2002), A Study of the IT business cycle and the Taiwanese economy (in Chinese), *Industry of Free China*, 49-73.

Coe, D.T., E. Helpman, A.W. Hoffmaister (1995), North-South R&D spillovers, *NBER Working Paper Series*, No. 5048, March.

Economic Intelligence Units (EIU). available at website: www.viewwire.com/index.asp

Economic Planning Agency (EPA) (2000*), Asian Economies 2000* (*Azia Keizai 2000*, in Japanese) Tokyo: Economic Planning Agency, Government of Japan.

Edison, H. and T. Slok (2001). Wealth effects and the new economy, *IMF Working Paper* WP/01/77.

Finance.yahoo.com (2002). Major world indices-Daily stock indexes, 12/15/2002.

Greene, W. H. (2003). *Econometric analysis*, Upper-Saddle River: NJ: Prentice-Hall.

Hsiao, F. S.T. and M. C. W. Hsiao (2001a), Capital flows and exchange rates: Recent Korean and Taiwanese experience and challenges, *Journal of Asian Economics*, 12, 2001, 353-381.

Hsiao, F.S.T., & Hsiao, M. C. W. (2001b), Diminishing returns and Asian NIEs – How they overcome the iron law. In Institute of Economics (Eds), *Conference proceeding on Economic Development in memory of Professor Mo-Huan Hsiang,* Taipei, Taiwan: Academia Sinica. 239-288.

Hsiao, F. S.T. and M. C. W. Hsiao (2003), "Miracle Growth" in the twentieth Century-international comparisons of East Asian development, *World Development*, *31 (2)*, 227-257.

International Centre for the Study of East Asian Development (ICSEAD) (2002), Recent trends and prospects for major Asian economies, *East Asian Economic Perspectives* (EAEP), 13.

International Monetary Fund (IMF) (2001), *World economic outlook, The information technology revolution,* October.

Japan Statistical Yearbook (JSY) (1994, 2000). Statistics Bureau, Management and Coordination Agency, Government of Japan.

Kurian, G. T. (2001). *The illustrated book of world rankings*, 5th ed., NY: M.E. Sharpe.

Taiwan Statistical Data Book (TSDB) (2002). Council for Economic Planning and Development, Executive Yuan, Taiwan.

Lee, H. H., H.S. Huh, and D. Harris (2003). The relative impact of the US and Japanese business cycles on the Australian economy, *Japan and the World economy*, 15, 111-129.

Sachs, J.D. and A. Warner (1995), Economic reform and the process of global integration, *Brookings Papers on Economic Analysis, 25th Anniversary Issue.* 1-118.

Sachs, J.D. and A. Warner (1996), Achieving rapid growth in the transition economies of Central Europe, *Harvard Institute for International Development*, Harvard University, January.

US Census Bureau (2001). *Statistical abstract of the United States: 2001* (SAUS), 121 edition. Washington, D.C.: Economics and Statistics Administration, U.S. Department of Commerce.

United Nations Conference on Trade and Development (UNCTAD) (2000). *World investment directory, foreign direct investment, and corporate debt*, Volume VII. Asia and the Pacific. New York: United Nations.

Watanabe, T. (1996). Time series snalysis of stock prices and international linkages (in Japanese), Chapter 8 in Masahiro Kawai, ed., *Finance and capital markets in Asia*, Nihon Keizai Shinbunsha.

World Bank (WB) (2002). *World development indicators, 2002*, Washington, D.C.: The World Bank.

World Trade Organization (WTO) (2000). *International trade statistics, 2000*.

Table 1. Merchandise Trade with the United States and in IT Products

	(a) Trade with USA % Total Trade			(b) Trade with USA % GDP			(c) IT Exports % Total Trade	
	1980	1990	1999	1980	1990	1999	1990	1999
World Avg	12.2	13	15.5	4	4	5.7	8.8	14.1
ADC+								
Korea	23	26	21	15	13	13	22.1	29.7
Taiwan	29	28	22	28	21	18	21.0	37.1
Singapore	12	16	16	43	49	42	36.5	52.8
Japan	21	29	28	2	5	10	23.3	21.8
HK	18	10	7	27	23	15	15.6	22.0
ASEAN-4+								
Indonesia	21	11	14	8	5	9	0.5	6.1
Malaysia	17	16	21	16	20	39	27.9	52.4
Philippines	29	30	30	12	14	26	22.7	63.0
Thailand	14	15	19	7	10	16	15.3	26.1
China	14	22	28	5	5	4	...	15.4
United States							13.1	18.1

Sources: (a), (b) from Arora and Vamvakidis (2001), which is based on IMF Direction of Trade Statistics and World Economic Outlook. Taiwan's data are calculated from TSDB (2002) in nominal US dollars. (c) WTO (2000). Table IV. 57. Exports of office machines and telecom equipment of selected economies, 1990-99

Table 2. Share of FDI flow and Stock of Lending (in US$ billions, %)

Country	(a) FDI	1990	1995	1998	Notes	(b) Lending 1990	1995	2000
1 Korea	Total	0.8	1.9	8.9	a	28.7	77.5	58.8
	% **US**	**40**	**33**	**34**		**14**	**10**	**11**
	% *Japan*	*29*	*22*	*6*		*32*	*28*	*18*
2 Taiwan	Total	2.3	2.9	3.7	a	10.0	22.5	18.1
	% **US**	**25**	**45**	**25**		**18**	**12**	**12**
	% *Japan*	*36*	*20*	*14*		*29*	*14*	*17*
3 Singapore	Total	2.6	3.1	8.5		140.6	192.5	100.0
	% **US**	**33**	**41**	**53**	(97)	**3**	**3**	**3**
	% *Japan*	*36*	*38*	*10*		*56*	*40*	*27*
4 Japan*	Total	2.8	3.9	10.2	a			
	% **US**	**24**	**48**	**60**				
Total	ADCs	9	12	31		179	293	177
Average	% **US**	**30**	**42**	**43**		**12**	**8**	**8**
Average	% *Japan*	*34*	*26*	*10*		*39*	*27*	*20*
5 Indonesia	Total	8.8	39.9	33.8	a	24.7	44.5	40.2
	% **US**	**2**	**7**	**3**	(97)	**5**	**6**	**8**
	% *Japan*	*26*	*9*	*16*		*61*	*47*	*25*
6 Malaysia*	Total	1.7	2.3	1.5		7.3	16.8	20.8
	% **US**	**6** (91)	**22**	**15**		**5**	**9**	**5**
	% *Japan*	*37*	*23*	*18*		*61*	*44*	*27*
7 Philippines	Total	0.2	0.8	0.9		9.3	8.3	16.5
	% **US**	**27**	**7**	**28**		**34**	**35**	**11**
	% *Japan*	*28*	*30*	*17*		*32*	*12*	*18*
8 Thailand*	Total	2.5	2.0	2.8		13.6	62.8	26.6
	% **US**	**10**	**13**	**22**	(97)	**9**	**7**	**4**
	% *Japan*	*43*	*28*	*36*		*55*	*59*	*37*
9 China	Total	3.5	37.5	45.3		22.3	48.4	58.2
	US	**13**	**8**	**7**	(97)	**1**	**4**	**2**
	Japan	*14*	*8*	*10*		*54*	*36*	*18*
Total	ASEAN4	17	83	84		77	181	162
Average	% **US**	**11**	**11**	**15**		**11**	**12**	**6**
Average	% *Japan*	*30*	*20*	*19*		*52*	*40*	*25*
GrdTotal	9 countries	25	94	116		256	473	339
GrdAvg	% **US**	**20**	**25**	**27**		**11**	**11**	**7**
GrdAvg	% *Japan*	*31*	*22*	*16*		*48*	*35*	*23*

Notes: a = on approval base

Sources: UNCTAD (2000). * Originally given in local currency and converted to US$ by average yearly exchange rate from ICSEAD (2002). For Japan, JSY (1994, 2001),

Table 3. Use of IT Products and Capitalization in Asia-Pacific Region

Items	IT Products (a)					IT Indicators (b)				Stock Markets (c)	
Items	Tele main lines	Mobile tele	PCs	Internet hosts	Sci,Eng in R&D	Total output	Per capita	Infra-structure	Know-ledge	(c)Equity Capital'n	(d)
unit	per 1000 people	per 1000 people	per 1000 people	per 10000 people	per mil people	US$ billions	US$ 1000	index %	index %	% of GDP	Wld rkg
year	1998	1998	1998	Jul-99	1987-97	1997	1997	97-99	96-98	End of 2000	
USA	661	256	459	1509	3676	267	100	66.8	66.5	114.9 *	1
ADCs+											
Japan	503	374	237	164	4,909	218	173	56.5	60.6	66.3	2
Korea	433	302	157	56	2193	48	105	50.7	55.1	34.4 **	19
Taiwan	526	216	–	–	3532	31	145	53.3	51.8	79.9	12
Singapore	562	346	458	322	2318	43	1156	55.9	48.5	168.3	18
HK	558	475	254	143	–	8	130	55.3	45.1	406.4	7
Avg NIEs	520	335	290	174	2681	33	384	53.8	50.1	172	
ASEAN4+											
Indonesia	27	5	8	1	182	6	3	42.5	45.0	20.1	25
Malaysia	198	99	59	24	93	29	135	46.9	43.7	128.1	11
Philippines	37	22	15	1	157	7	9	42.4	48.1	60.0 **	26
Thailand	84	32	22	5	103	12	20	45.1	44.2	24.3	24
China	70	19	9	1	454	7	3	42.5	49.4	50.7	22
AvgASEAN4+	83	35	22	6 #	198	12	34	44	46	57	22

Sources: (a) ADB (2000, 65). (b) EPA (2000) Table 2-3-3. (c) From Economist Intellegent Unit, Country Finance. (d) World ranking is based on equity capitalization (not on % of GDP) given in Kurian (2001).
*NYSE. **End of September 2000.

Table 4. Correlation Coefficients

Stock Price Indexes, GDP, and Growth Rates

a **1995-1999**

Countries	USA(Nasdaq)	Japan	Taiwan
Japan	0.200		
Taiwan	0.133	0.438	
Singapore	0.024	0.448	0.098

b **2000-2001**

Countries	USA(Nasdaq)	Japan	Taiwan
Japan	0.772		
Taiwan	0.744	0.812	
Singapore	0.717	0.713	0.712

Correlation coefficients among five countries

c **GDP 1979 - 2000**

	USA	Japan	Korea	Taiwan
Japan	0.92			
Korea	0.92	0.97		
Taiwan	0.98	0.97	0.97	
China	0.95	0.81	0.86	0.91

d **Growth rates of GDP 1980 - 2000**

Japan	0.04			
Korea	0.01	0.56		
Taiwan	0.31	0.58	0.59	
China	-0.04	-0.32	-0.01	-0.29

e **Daily stock indexes 9/18/01 - 12/13/02**

	USA(S&P500)	Japan	Korea	Taiwan
Japan	0.72			
Korea	0.19	0.56		
Taiwan	0.43	0.60	0.90	
China	0.21	0.32	-0.18	-0.14

f **Growth rates of daily stock indexes 9/19/01 - 12/13/02**

Japan	0.23			
Korea	-0.01	0.11		
Taiwan	0.04	0.01	0.25	
China	0.02	0.08	-0.10	0.03

Sources: (a), (b) Cheng (2002). (c)-(f) Authors' calculations.
(c), (d) WB (2002). (e), (f) Finance.Yahoo.com (2002)

Table 5. Pairwise Granger causality tests: growth rates of GDP, 1980 - 2000, lag:2

Pair	Test result	F-stat	p-value	Causality direction
1	Japan does not cause China	0.449	0.65	
	China does not cause Japan	0.493	0.62	
2	Korea does not cause China	0.150	0.86	
	China does not cause Korea	1.533	0.25	
3	Taiwan does not cause China	0.014	0.99	
	China does not cause Taiwan	0.456	0.64	
4	USA does not cause China	0.567	0.58	
	China does not cause USA	1.250	0.32	
5	Korea does not cause Japan	1.530	0.25	
	Japan does cause Korea	5.369	0.02 **	Unidirectional
6	Taiwan does not cause Japan	1.092	0.36	
	Japan does cause Taiwan	9.584	0.002 ***	Unidirectional
7	USA does not cause Japan	1.542	0.25	
	Japan does not cause USA	0.041	0.96	
8	Taiwan does not cause Korea	0.929	0.42	
	Korea does not cause Taiwan	0.024	0.98	
9	USA does not cause Korea	0.185	0.83	
	Korea does not cause USA	0.063	0.94	
10	USA does not cause Taiwan	1.415	0.28	
	Taiwan does not cause USA	0.257	0.78	

Note: *** (**) denotes significant at the 1% (5%) level.

Table 6. Vector autoregression estimates, VAR(1): growth rates of GDP, 1980 - 2000

	Eq. Number	1	2	3	4	5
	Country	Korea	Taiwan	China	Japan	USA
Country	Dep. Var.	DLKOR	DLTWN	DLCHN	DLJPN	DLUSA
Korea	DLKOR(-1)	-0.141	-0.169	0.367	-0.346	-0.039
		[0.66]	[0.22]	[0.07] *	[0.20]	[0.42]
Taiwan	DLTWN(-1)	0.109	0.234	-0.445	0.115	0.089
		[0.85]	[0.35]	[0.22]	[0.82]	[0.33]
China	DLCHN(-1)	-0.101	0.085	0.044	-0.048	0.045
		[0.82]	[0.64]	[0.86]	[0.89]	[0.49]
Japan	DLJPN(-1)	0.661	0.561	-0.137	0.497	0.005
		[0.10] *	[0.004] ***	[0.56]	[0.14]	[0.94]
USA	DLUSA(-1)	-0.668	-0.895	0.129	-1.035	0.073
		[0.71]	[0.25]	[0.90]	[0.49]	[0.79]
	Constant	0.104	0.100	0.096	0.129	0.048
		[0.40]	[0.07] *	[0.20]	[0.22]	[0.02] **
Unidirect. causality:		JPN--->KOR	JPN--->TWN	KOR--->CHN		

Notes:
DLKOR is the first-difference of log-values (growth rates) of Korea's GDP used in the analysis, same notations apply to other countries.
The p-value is in the parentheses. *** (**, or *) denotes the test is significant at the 1% (5%, or 10%) level, respectively.

Table 7. Pairwise Granger causality tests: stock indexes, lags: 2

Pair		Test result		F-stat	p-value		Causality direction
1	Japan	does not cause	China	1.997	0.14		
	China	does not cause	Japan	0.943	0.39		
2	Korea	does not cause	China	0.465	0.63		
	China	does not cause	Korea	1.337	0.26		
3	Taiwan	does not cause	China	1.596	0.20		
	China	does not cause	Taiwan	0.468	0.63		
4	USA	does not cause	China	0.244	0.78		
	China	does not cause	USA	2.128	0.12		
5	Korea	does not cause	Japan	0.053	0.95		
	Japan	does not cause	Korea	0.242	0.78		
6	Taiwan	does not cause	Japan	0.019	0.98		
	Japan	does cause	Taiwan	5.287	0.01	***	Unidirectional
7	USA	does cause	Japan	20.436	0	***	Unidirectional
	Japan	does not cause	USA	1.484	0.23		
8	Taiwan	does cause	Korea	2.915	0.06	*	Bidirectional
	Korea	does cause	Taiwan	8.858	0	***	
9	USA	does cause	Korea	2.982	0.05	**	Unidirectional
	Korea	does not cause	USA	1.686	0.19		
10	USA	does cause	Taiwan	7.230	0	***	Unidirectional
	Taiwan	does not cause	USA	1.141	0.32		

Note: *** (** or *) denotes significant at the 1% (5% or 10%) level.

Table 8. Vector autoregression estimates, VAR(1): growth rates of stock indexes, sample: 270

	Eq. Number	1	2	3	4	5
	Country	Korea	Taiwan	China	Japan	USA
Country	Dep Variable	DLKSID	DLTSID	DLCSID	DLJSID	DLUSID
Korea	DLKSID(-1)	-0.001	0.235	-0.029	0.002	-0.055
		[0.99]	[0.00] ***	[0.55]	[0.96]	[0.24]
Taiwan	DLTSID(-1)	0.026	0.006	0.005	-0.004	-0.041
		[0.71]	[0.92]	[0.92]	[0.93]	[0.43]
China	DLCSID(-1)	0.099	-0.003	-0.033	0.081	0.106
		[0.23]	[0.97]	[0.59]	[0.17]	[0.08] *
Japan	DLJSID(-1)	-0.038	0.003	-0.091	-0.137	-0.084
		[0.64]	[0.96]	[0.14]	[0.02] **	[0.16]
USA	DLUSID(-1)	0.203	0.112	-0.016	0.393	-0.002
		[0.02] **	[0.13]	[0.80]	[0.00] ***	[0.98]
	Constant	0.001	0.001	-0.001	-0.001	-0.001
		[0.31]	[0.47]	[0.29]	[0.58]	[0.57]
Unidirect. causality:		USA--->KOR	KOR--->TWN		USA--->JPN	CHN--->USA

Notes:
DLKSID is the first-difference of log-values (growth rates) of Korea's stock index (daily) used in the analysis.
The same notations apply to other countries. Other notes are the same as Table 6.

Figure 1. World Share of GDP, 2000 (in current US$)

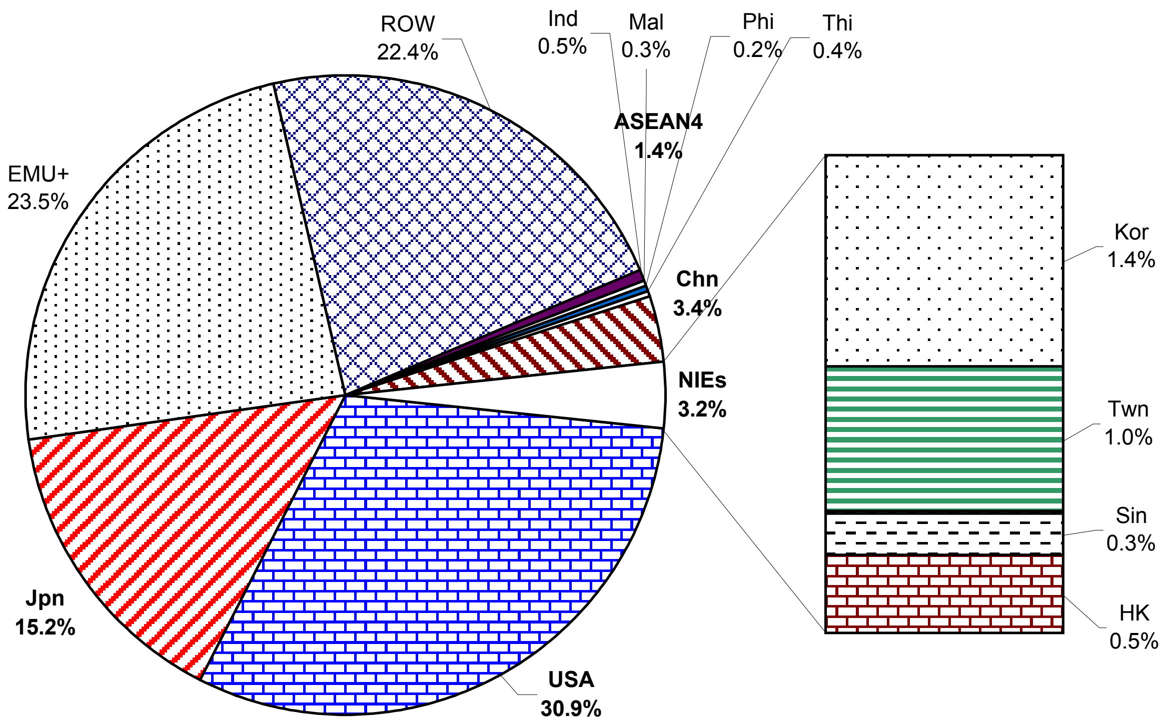

Figure 2. US Exports and Imports from Asia-Pacific Region
Ratios to Total Exports and Imports

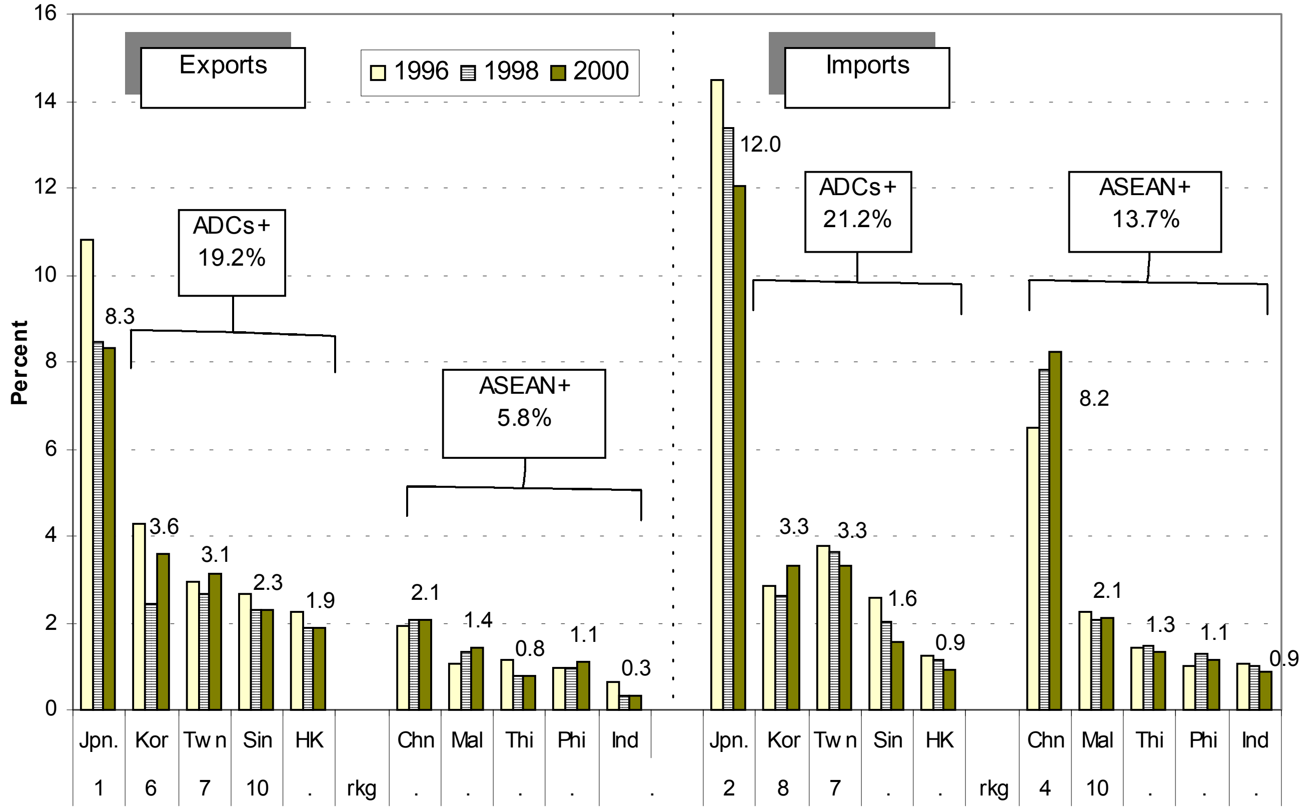

Figure 3. Impulse Response Functions: Growth Rates of GDP

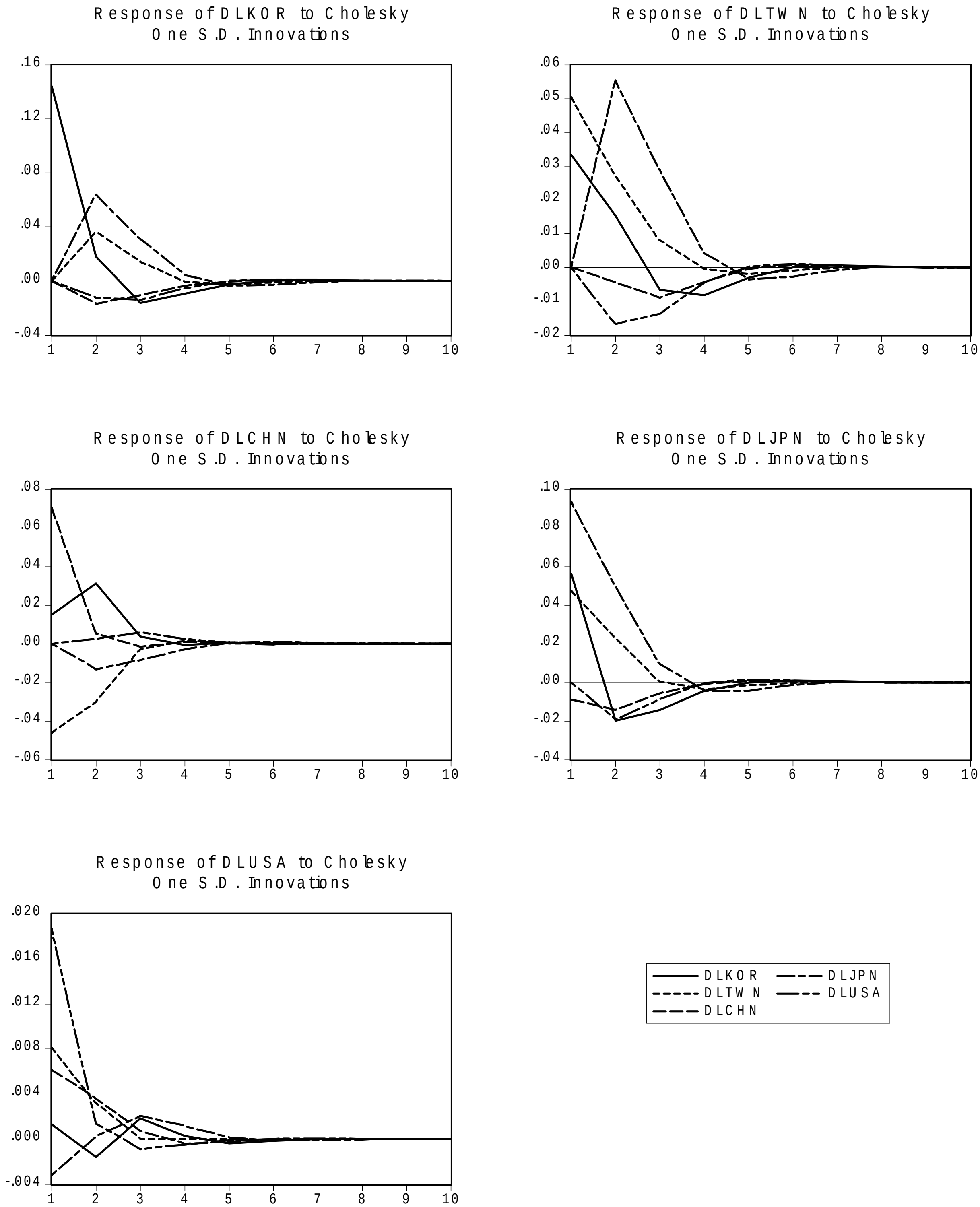

Figure 4. Variance Decomposition: Growth Rates of GDP

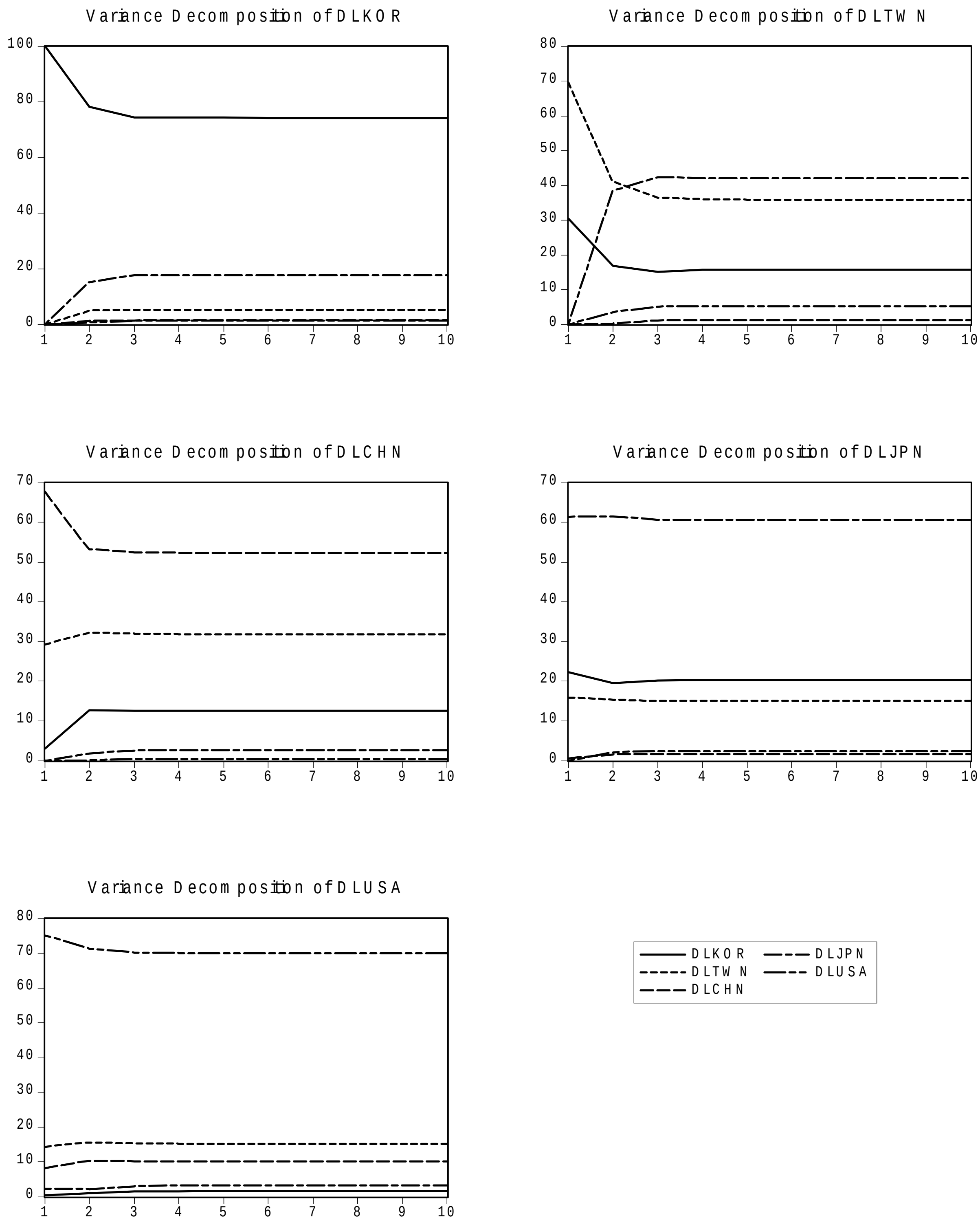

Figure 5. Impulse Response Functions: Growth Rates of Stock Price Indexes.

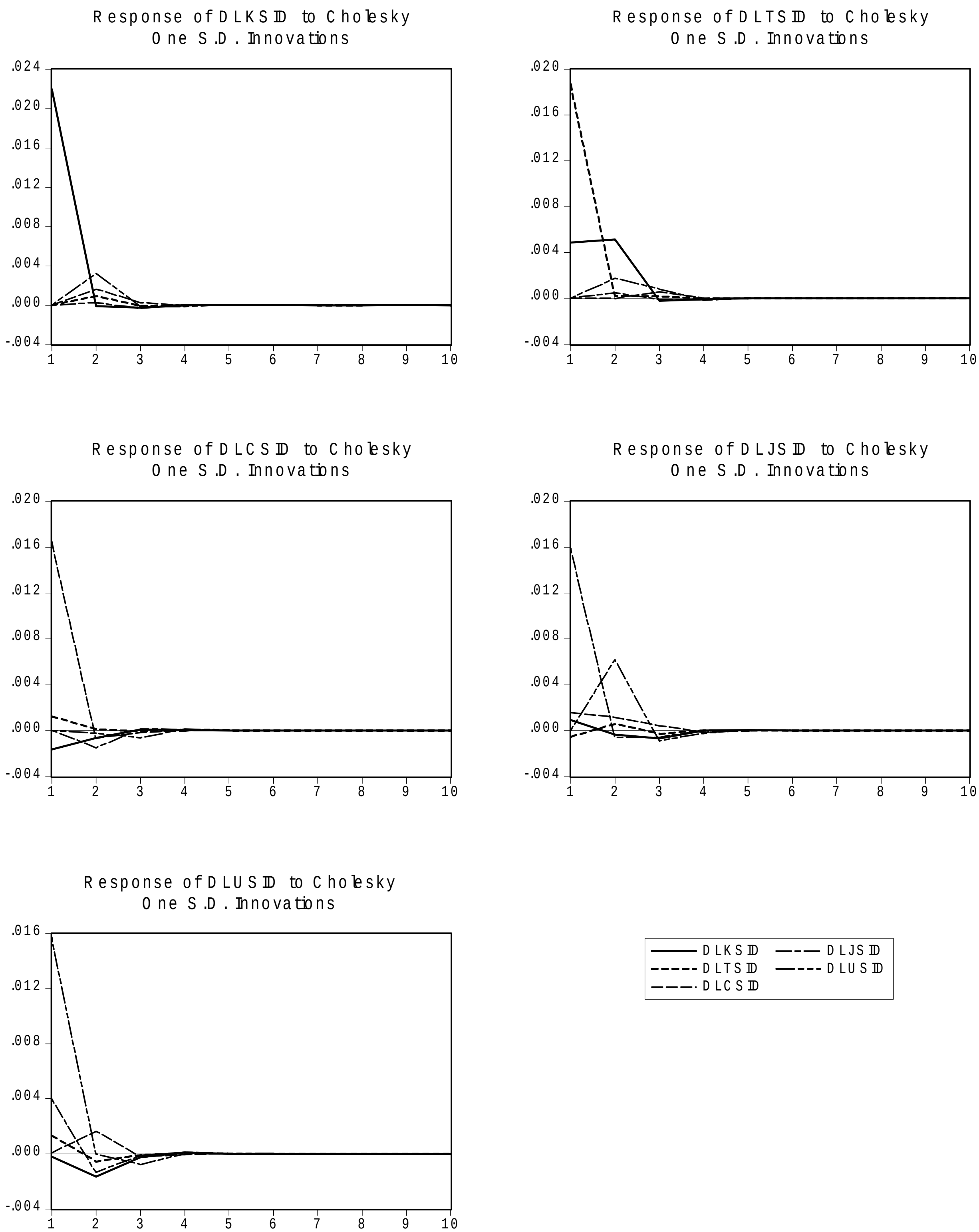

Figure 6. Variance Decomposition: Growth Rates of Stock Price Indexes