Bank of Japan Working Paper Series

Evolution of Output Multipliers: An Analysis with a Particular Emphasis on Asia

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No.04-E-12
September 2004

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Abstract

A shock to one country affects output growth in other countries not only through bilateral trade channels but also via output fluctuations in third countries. This paper attempts to quantify the impact of external shocks on growth rates and show how it has evolved over time. In order to capture a shock's international transmission mechanism, a structural VAR model is constructed in which cross-country trade relations influence output growth in major countries. Abeysinghe and Forbes [2001] first introduced such a model and this paper attempts to extend the model by incorporating the influence of changes in trade openness and country specific input-good prices. A series of impulse response analyses indicate an important transmission channel across countries, namely the output-multiplier effect, that has been overlooked in models using only bilateral trade relationships. This paper also contends that output multipliers have changed over time, reflecting an increasing interdependency of the global economy as well as expanding influences of autonomous growth in the Chinese and the U.S. economies.

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[*] A preliminary version of this paper was presented at the European Central Bank Workshop, "the Importance of the External Dimension for the Euro Area: Trade, Capital Flows, and International Macroeconomic Linkages," held on March 29-30, 2004. I would like to thank Lawrence Schembri (Bank of Canada) and other workshop participants for their valuable comments and suggestions. I also would like to extend thanks to Akinari Horii, Ryo Kato, Hitoshi Mio, Akira Otani, Toshitaka Sekine, and many other officials of the Bank of Japan. I would like to thank Tomoko Mori for her insightful research assistance. Any remaining errors my own. The views expressed here are solely those of the author and not necessarily those of the Bank of Japan.

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1. Introduction

During the past decade, economic interdependency across major countries has strengthened. In addition, there have been significant changes in trade flows as well as increases in most countries' trade volume. Closer economic and trade linkages lead to stronger demand linkages, which in turn lead to more synchronized business cycles. For example, an increase in U.S. demand for audio-visual products in the 1980s induced a rise in exports from Japan to the U.S. In the present economic environments, a similar demand shock tends to increase finished product exports from China to the U.S. as well as those of semiconductors or other electronic parts from Korea and Japan to China, against a backdrop of developing international product chains and the increasing tendency of local specialization. An increase in Chinese exports also raises Chinese workers' incomes, which in turn induces an increase in finished good exports from Korea and Japan to China, e.g., mobile phones and automobiles. As such, a positive shock to the U.S. economy is transmitted not only to China via bilateral trade linkage, but also to Korea and Japan via multilateral trade chains and via income effects working on the Chinese economy. In other words, there are two transmission channels through trade linkages. The first channel is bilateral trade flows. The second is an indirect transmission mechanism through supply chains of tradable goods as well as the impact on output in third countries. This paper attempts to capture the international transmission mechanisms through these channels and quantify the impact of external shocks on major countries and regions.

A number of studies have been conducted to measure the importance of trade in the international transmission mechanism of shocks. Based on such studies, there are many multi-country macroeconomic models that focus on interdependency across countries and incorporate trade linkages as a key transmission mechanism of international business cycles. Notable examples are the IMF's MULTIMOD and Global Economic Model (GEM), and the FRB's FRB/Global. Kamada, et al.[2002] also present such a macro-econometric model to quantify the influences that deepening interdependence between Asia and the U.S. has on economic activities in these regions. Forbes [2001] provides a survey of international transmission mechanisms with a particular emphasis on crisis cases. Empirical results of earlier works are mixed, partly because most studies use aggregate trade data.

Abeysinghe and Forbes [2001] developed a structural VAR model to estimate the international transmission mechanism of business cycles, focusing on two types of cross-country linkages: direct effects through bilateral trade and indirect effects via third countries' output fluctuations. Their methodology constructs a model in which trade flows work as linkages of output growths across countries and relative importance of each linkage is allowed to vary over time. Their estimates suggest that indirect effects through third countries' output are so large that a shock to one country significantly affects countries that have relatively minor bilateral trading relations with the country in question.

There are a number of works that discuss the importance of such indirect effects. For example, Isogai, et al.[2002] point out as one of their main findings that there are quantitatively significant transmission channels of country-specific shocks in line with product chains. Kozu, et al.[2002] examine changes in Japan's trade structure and conclude that both Japanese and U.S. economic influences on East Asia strengthened between the pre-1995 and the post-1995 periods, reflecting an increase in interdependency of these countries. Ahearne, et al.[2003] find that China and other emerging Asian countries are "both comrades and competitors" in terms of export- and income-growth correlations. Their conclusion implies that China and other emerging Asian countries can be affected by a shock in a third country, say, the U.S., via both bilateral trade linkage and indirect effects.

This paper follows the above-mentioned literature, especially Abeysinghe and Forbes [2001] (hereafter "AF"). It quantitatively gauges the influence on a country's growth rate of other countries' output fluctuation by the methodology developed by AF. This paper refers to such influence as the "output-multiplier effect." The output-multiplier effect is composed of the direct effect via bilateral trade linkages and the indirect effect from other countries' output fluctuations. One contribution of this paper is the presentation of empirical extension. It attempts to incorporate two important elements that influence the dynamics of international trade patterns, namely changes in trade openness and those in country specific input-good prices. Although the extension of the former element seems intuitive and fruitful, in the end, it leaves its empirical application for future study, because the model specification presented in this paper fails to statistically outperform AF's original model. This paper, however, applies the model incorporating input-good prices, since its performance exceeds that of AF's model. The other contribution of this paper is the quantitative measurements of the evolution of output-multiplier effects between the periods before and after the 1997 Asian economic crisis[1]. The multipliers estimated in the full sample (1980Q1-2003Q2) are largely greater than those in the pre-Asian economic crisis sample (1980Q1-1996Q4).

The remainder of this paper is organized as follows. Section 2 examines AF's model as well as extended models. Section 3 introduces data to measure the output-multiplier effects. Section 4 provides estimates of the AF and extended models and discusses the appropriateness of specifications for empirical analyses. Section 5 presents a series of impulse response analyses, including those of the evolution of output multipliers. Section 6 concludes the paper.

2. Model

2-1. A Structural VAR model of AF (Baseline Model)

This subsection briefly introduces a structural VAR model formulated by AF[2] (hereafter "baseline model"). To measure both direct and indirect effects through multilateral trade linkages, AF developed a structural VAR model simultaneously equating outputs of all countries in the world. Assume there are n countries in the world. Total output of country i can be formulated[3]:

$$Y_i = \sum_{j}^{n} X_{ij} + A_i \tag{1}$$

where Y_i is total output of country i, X_{ij} is exports from country i to country j ($i \neq j$) and A_i is the non-export components of country i's output. A reduced form of export function is specified:

$$X_{ij} = X_{ij}\left(Y_j\right) \tag{2}$$

Inserting equation (2) into equation (1) and converting equation (1) in terms of growth rate yield

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[1] This paper uses the Asian economic crisis as a break of sample period, because during the Asian economic crisis, many researchers recognized that the increasing regional interdependency had worked as a transmission mechanism of a shock in a country to other countries in the same region.

[2] Here, we follow the explanation and terminology of AF. Please refer to AF or Abeysinghe [2001a] for details.

[3] We drop the time subscript t for simplification.

equation (3) with some rearrangement:

$$\frac{dY_i}{Y_i} = \frac{X_i}{Y_i}\sum_{j=1}^{n} h_{ij}\frac{X_{ij}}{X_i}\frac{dY_j}{Y_j} + \frac{dA_i}{Y_i} \tag{3}$$

where $h_{ij} = (\partial X_{ij}/\partial Y_j)(Y_j/X_{ij})$ is the income elasticity of exports with respect to country j's income. AF assumed for simplification that income elasticities are equal across countries, i.e. $h_{ij} = h_i$. Let $a_i = h_i(X_i/Y_i)$ and assumed that a_i is time invariant. Using lower-case letters to indicate growth rates, equation (3) can be transformed:

$$y_{it} = a_i y_{it}^f + u_{it} \tag{4}$$
$$y_{it}^f = \sum_{j=1}^{n}(X_{ijt}/X_{it})y_{jt}$$

where y_{it}^f is an export-weighted average of country j's output growth rates ($i \neq j$) and u_{it} serves as a variable for factors other than export linkages. To capture both the direct and indirect impacts on country i of a shock in country j, assume that country i's growth correlates to simultaneous output growth in country j. Since u_{it} is a variable for anything not captured by export linkage, it is likely to be serially correlated and correlated across equations. Thus, u_{it} is assumed to follow an ARMA process. This is a key assumption in transforming equation (4) into an autoregressive distributed lag model with white noise errors:

$$y_{it} = l_i + \sum_{t=1}^{p} f_{ti} y_{it-t} + \sum_{t=0}^{p} b_{ti} y_{it-t}^f + e_{it} \tag{5}$$

where t is an lag subscript. Note that a_i is:

$$a_i = \sum_{t=0}^{p} b_{ti} \Bigg/ \left(1 - \sum_{t=1}^{p} f_{ti}\right)$$

The entire system of equation (5) for all countries can be expressed as a structural VAR. The general VAR(p) form for the entire system is:

$$(B_0 * W_t)y_t = l + (B_1 * W_{t-1})y_{t-1} + \ldots + (B_p * W_{t-p})y_{t-p} + e_t \tag{6}$$

where y_t, l and e_t are $(n\times 1)$ vectors, B and W are $(n\times n)$ parameter matrices and export-share matrices, and $*$ indicates the element-wise product of two matrices. For $n = 3$ and $p = 1$ the parameter matrices are:

$$B_0 = \begin{bmatrix} 1 & -b_{01} & -b_{01} \\ -b_{02} & 1 & -b_{02} \\ -b_{03} & -b_{03} & 1 \end{bmatrix}, \quad B_1 = \begin{bmatrix} f_{11} & b_{11} & b_{11} \\ b_{12} & f_{12} & b_{12} \\ b_{13} & b_{13} & f_{13} \end{bmatrix}$$

$$W_t = \begin{bmatrix} 1 & w_{12,t} & w_{13,t} \\ w_{21,t} & 1 & w_{23,t} \\ w_{31,t} & w_{32,t} & 1 \end{bmatrix}$$

where $w_{ij,t} = X_{ij,t} / X_{i,t}$, i.e. the export share from country i to country j over the total exports of country i. The export shares sum up to unity. Note that they are allowed to change over time.

As discussed above, the baseline model uses an export-share matrix as an economically meaningful restriction on the VAR model to avoid arbitrariness. This model is an over-identified model whose structural restrictions are: (1) the elements of W are known, and (2) all elements in each row of B are set to be the same except for its diagonal one. The most important feature is that the effective parameter matrices $(B_p * W_{t-p})$ change over time along with changes in the export-weight matrix. This feature enables the model to capture trade-induced transmission effects in international business cycles reasonably well.

2-2. The Model Extension

This paper presents modifications with respect to the following two features to make the model more "realistic" than the baseline model. One modification is the introduction of trade openness, relaxing the assumption of $a_i = h_i(X_i / Y_i)$ being time invariant. Constant a_i is the important assumption for simplicity in the baseline model but may look too strong (less realistic), since the actual export-GDP ratio X_i / Y_i has increased in many countries. Such an increase in X_i / Y_i captures the strengthened interdependency of the global economy under the progress of so-called "globalization." More and more goods that had been non-tradable in earlier times have become tradable in recent years[4], and both global integration of markets and local specialization of products have progressed rapidly in the area of production processes of tradable goods. Eased trade restrictions and developments in information technology (IT) have made it easier for multinational enterprises to move factories of labor-intensive goods from

[4] An example is a call-center operation for customer service.

countries where wages are relatively high to those with lower wages. To capture such structural changes, it may be a straightforward extension to assume that X_i/Y_i is time variant. This paper, instead, incorporates the ratio of export and import volume over output that is commonly used as an indicator of trade openness. Here, we assume that a_i is proportional to the trade openness indicator:

$$h_i(X_i/Y_i) = m_i op_i \tag{7}$$

where op_i is country i's trade openness indicator. op_i possesses an upward trend in many countries and represents structural change. op_i is assumed to be exogenous and time variant while m_i is constant. Then, Equation (4) is transformed into:

$$y_{it} = m_i op_{it} y_{it}^f + u_{it} \tag{4'}$$

Equation (4') involves the property that the higher the trade openness of country i, i.e. the closer its linkage to rest of world, the more synchronized the business cycle of country i to those of its trading partners. The expected sign of coefficient m is positive.

The other modification is to incorporate country specific input-good price indices in the export function. A country specific shock on raw materials may influence input-good prices. A rise in input-good prices lowers the price-competitiveness of tradable goods produced in country i. Thus, it works as a negative shock on exports from country i and, consequently, country i's growth. As such, any fluctuations in input-good prices may betray the assumption of a_i in equation (4) as being time invariant. We transform equation (2) into the following form:

$$X_{ij} = X_{ij}(Y_j, RP_{ij}) \tag{2'}$$

where RP_{ij} is the relative input-good price of country i to country j. Equation (4) in the baseline model can be transformed into the following:

$$y_{it} = a_i y_{it}^f + r_i \Delta RP_i + u_{it} \tag{4''}$$

where ΔRP_i is the differential between country i's input-good price and the export-share weighted average of input-good prices of trading partners. It is clear from the above discussion that the expected sign of r is negative.

The evolution of country specific input-good price is considered exogenous to every country. Abeysinghe [2001a] and [2001b] presents the general form to introduce exogenous variables to equation (6) as follows:

$$\left(B_0 * W_t\right)y_t = l + \sum_{t=1}^{p}\left(B_t * W_{t-t}\right)y_{t-t} + \sum_{t=0}^{p}\Gamma_t z_{t-t} + e_t \tag{8}$$

where z_t and Γ_t are exogenous variables and diagonal parameter matrices for the lag t , respectively. We adopt the above formulation in our estimation to introduce RP_i .

It is important to recognize the limitations of this model as well as its advantages. First, this model is based only on trade-induced macroeconomic linkages, while there are a variety of international linkages, through channels such as foreign direct investments, portfolio investments, and movements in labor. Second, although disaggregated data should produce better estimates, we only use aggregate data for estimation due to constraints on data availability. Finally, since this model is not a theory-oriented structural model but a VAR, its estimates are subject to problems inherent to any VAR models.

3. Data

The data set consists of quarterly data of real GDP growth rates, bilateral export shares, trade openness indicators, and country specific input-good prices. As AF mention, it is difficult to construct the necessary data set. We basically follow AF with respect to construction of the data set. The appendix provides a detailed explanation of the data. We use 12-quarter moving averages of export-share and trade-openness matrices to allow the data to vary smoothly over time, i.e. to reduce noise in data. Country specific input-good prices are basically raw material prices or their equivalent in national producer price indices (PPI). Countries and regions covered by this paper are the North Americas (hereafter "N.A."), EU, Japan, China, NIEs and ASEAN. We divide Asia into three large regions instead of using individual country data or aggregating all country data into one "Asia," since the countries within each region have similar industrial and trade structures. The data for the N.A (the U.S., Canada and Mexico), NIEs (Hong Kong, Korea, Singapore and Taiwan) and ASEAN (Indonesia, Malaysia, the Philippines and Thailand) are calculated as weighted-averages of individual countries' data using the purchasing power parity (PPP) weight of real GDP presented by the IMF. All data series start in 1980Q1 and end in 2003Q2.

4. Estimation

This section describes the estimation results and the process to investigate model specifications for further analyses. Following AF, I set $p = 4$ and estimate the models without interceptions to avoid the same collinearity problems that AF faced. I add a dummy variable corresponding to the Asian crisis period (from 1997Q1 to 1998Q4) in order to absorb excess volatility in the crisis period. The main estimation method is two-stage least squares (2SLS) using four lags of each variable as instruments. If one were to estimate each single equation in the model separately, ordinary least squares (OLS), in addition to 2SLS, would be suitable, since it is possible to consider y_{it}^{f} as an exogenous variable in each equation. 2SLS is, however, an appropriate method for the system estimation, since y_{it}^{f} is an endogenous variable in the VAR structure.

Table 1 shows the comparisons between estimates of (1) the baseline model, (2) the model incorporating relative input-good prices, (3) the model incorporating trade-openness indicators, and (4) the model incorporating both elements. The determinant residual covariances in the first row are information criteria. Those of baseline models with or without relative input-good prices are smaller than those of openness incorporated models. This result supports the baseline model's superiority to the openness-incorporated model in terms of information criteria. The smallest among them is that of the model incorporating relative input-good prices.

a_i or m_i in Table 1 are the coefficients for the export-share weighted averages of trading partners' growth rates. Using these estimates, a_i (or m_i) are calculated by:

$$a_i = \sum_{t=0}^{4} b_{ti} \Big/ \left(1 - \sum_{t=1}^{4} f_{ti}\right)$$

The estimates of a_i and m_i for each country are similar in various specifications and estimation methods except those for EU. Their stability is examined later by recursive estimations.

r_i in the column "relative input-good prices" of Table 1 represents estimates of coefficients for the export-weighted average of changes in relative input-good prices. In the 2SLS columns, the estimates of r_i in the model with relative input-good prices are all negative as expected, while those in the model incorporating two elements are negative except that of ASEAN. This result reinforces the appropriateness to incorporate relative input-good prices in export functions.

In order to assess the parameter stability, this paper executes recursive estimations. It begins the estimation at the sub-sample whose end period is 1995Q1 and extend sample periods one by one to repeat estimation. The estimation method is 2SLS. Chart 1 shows the recursive estimates of a_i in the baseline model and m_i in the openness-incorporated model. It is clear that a_i in the baseline model is surprisingly stable, confirming the appropriateness of its assumption as time invariant. On the other hand, m_i in the model incorporating trade openness are less stable than a_i. Why are there such counter-intuitive results? The difference in measurement may be one reason. Since the numerator (sum of export and import volumes) is a gross variable whereas the denominator (output), is a value added variable, the trade-openness indicator may contain a measurement error. Another reason may come from the assumption that the trade-openness indicator is a proper proxy for the extent of international linkage. In recent years, correlations between exports and imports have increased in many countries, that is, exports and imports now move in a more parallel fashion. This is because of the growing local specialization of tradable products and the strengthened international dispersion of product chains. Under such circumstances, trade openness may overstate the influence of world growth on domestic growth. For example, the volume of value added in export goods produced domestically has been unrelated to the increase in the trade–openness indicator. Thus, in conclusion, I leave the application of this extension incorporating the trade-openness indicator to empirical study for future work.

Chart 2 compares the recursive estimates of a_i in the baseline model to those in the model incorporating relative input-good prices. Although the difference between them is not large, a_i in the model incorporating relative input-good prices appears more stable than in the baseline model in the N.A. and NIEs. As shown above, the model incorporating relative input-good prices possesses the desirable properties: (1) the smallest information criteria among the models examined here, (2) the expected signs on estimates of r_i, and (3) the stability of parameter a_i being equal to or greater than the baseline model's. Therefore, this is an appropriate model for further empirical studies (hereafter, we simply call it "the extended model").

5. Impulse Response Analyses

5-1. Output Multipliers

The impulse responses of the baseline and extended models are obtained by transforming equation (7) and (8) into a moving average representation. The impulse response to a shock changes over time in these models since the export-share matrix W changes over time. Following AF, we choose the sample-end matrix W to calculate impulse responses. An output multiplier is defined as a cumulative impulse response matrix after four quarters of external shocks. A normalized output multiplier is a matrix whose diagonal elements are set to unity and other elements in each column are divided by its diagonal element. In other words, a normalized output multiplier matrix represents multiplier effects of a 1% positive output shock to external growth (e.g. Japan) on the growth of country in question (e.g. NIEs), given the trade patterns in the sample end (e.g. 2003Q2). This matrix enables us to compare the relative importance of trading partners as a "source" of external shock between sample countries. To save space, this paper presents the normalized output multipliers instead of showing all impulse responses in the chart. Tables 2 and 3 summarize the normalized output multipliers of the baseline model estimated by OLS and those of the extended model estimated by 2SLS. Each row in Tables 2 and 3 shows the impact on GDP growth of a one-unit positive shock originating in the countries whose names appear in the top row. Numbers in parentheses are standard errors of the normalized output multipliers derived by 999 times bootstrapping. The shadows in the matrices indicate that the multiplier estimates exceed two standard errors. Since the extended model estimated by 2SLS is preferred to the baseline model by OLS in the previous discussion[5], the remaining analyses focus on the results of the extended model estimated by 2SLS.

Tables 3 reveals a number of interesting features. Shocks to larger countries generally produce larger and more significant multiplier effects. The N.A. generate the largest impact on the output growth of other countries. Since the PPP weight of U.S. in the N.A. exceed 80%, this result implies that the U.S. has the largest influence on other countries' business cycles among sampled countries. Japan's influence on NIEs and ASEAN are larger than the EU's, indicating their close economic linkages. The transmission channel from Japan to the EU is relatively weak and vice versa, whereas both of them are sensitive to a shock in the

[5] In addition, the differences between the two matrices are not so large.

N.A. China has a larger effect on both NIEs and ASEAN than in the opposite direction. The average responses of NIEs and ASEAN are larger than other countries, especially those of ASEAN. This may be because their trading sectors have been the "main engines" of their economic growth. The responses of China follow them. A shock to NIEs affects the output of ASEAN most strongly in sample countries and vice versa, representing their high degree of interdependency. Table 4 reports the bilateral export shares as of 2003Q2. It is clear, when comparing Tables 3 and 4, that the estimated multiplier effects show a different "picture" of international transmission of shocks from that drawn only by a bilateral trade matrix, as AF points out. For example, China responds to shocks in Japan, NIEs and the EU in roughly the same manner, although the export share of NIEs is almost twice as large as Japan and the EU. The responses of the N.A. and the EU to a shock in Japan are larger than (or the same as) that in NIEs, although NIEs has larger weights than Japan in terms of bilateral export shares of the U.S. and E.U. A shock in the N.A and Japan affects the ASEAN economy to a larger extent than that in NIEs, while their trade shares are smaller than that of NIEs.

5-2. Evolutions of Output-Multiplier Effects

Next, this paper analyzes the evolution of output-multiplier effects. We compare normalized output multipliers estimated in the full sample from 1980Q1 to 2003Q2 to those in the sub-sample which covers the periods before the Asian crisis of 1997-1998, namely from 1980Q1 to 1996Q4. Tables 5 and 6 are the matrices of the normalized output multipliers in sub-sample (1980Q1-1996Q4) and the "evolution ratios," the ratios of the output multipliers in the full sample (1980Q1-2003Q2) over those in the sub-sample, respectively.

Table 6 highlights the evolution over time. A shadowed evolution ratio in Table 6 indicates that it exceeds one, i.e. the normalized output multiplier in that cell increases over time. Most multipliers increase between the pre-1997 and the post-1997 periods, indicating the strengthened international business cycle synchronization. The most notable feature is that the multiplier effects of a shock originating in China increase to the rest of the world. Among the responses of N.A., Japan and EU, those to China increase the most. These results coincide with the perception that China has recently developed as an economy driven by internal demand and has grown in presence in the global trade market, especially as a large absorber of industrialized countries' products. Second, those multiplier effects emanating from the N.A. on other countries also grow with the exception of that vis-à-vis Japan. This result appears plausible, because the U.S. in the N.A. has gained more importance in its role as the "leader" of global business cycles during the latest global economy recovery. Third, the responses of NIEs in the full sample increase more than 3 times as much as those before the Asian crisis, while the multiplier effects originating in NIEs decrease except for that to ASEAN. The estimated multipliers of Japan and the EU on NIEs become significant when including post-crisis data. These results may reflect a rapidly grown dominance of NIEs manufacturers in the world semiconductor market as well as an increasing dependency of NIEs' economy on world growth. Fourth, the ratio of NIEs to ASEAN has become larger and vice versa, representing their increasing interdependency. Finally, Japan's responses to shocks, except to a NIEs shock, decrease (although to a small extent), indicating a more autonomous Japanese business cycle after the late 1990s. Most of these results seem to indicate an increasing interdependency of the world economy. Another interpretation is that the recent configuration of monetary and fiscal policies has strengthened the synchronization of international business cycles.

6. Conclusions

This paper attempts to illustrate the international transmission of shocks via trade linkages. I constructed an extended model of a structural VAR model introduced by AF in order to empirically measure how a shock in one country's growth affects other countries' output growths. This paper first tries to incorporate two important determinants of growth dynamics in the AF (baseline) model: the trade-openness indicators and relative input-good prices. The incorporated model is inferior to the baseline model in terms of trade-openness. Thus, this paper concludes this type of extension needs further improvements for empirical application. The model incorporating the relative input-good prices, however, proves its appropriateness by the smallest information criteria, the correct sign condition and the stability of estimated parameters. Therefore, I applied this model (the "extended model") for this paper's empirical analyses.

An output multiplier is defined as a cumulative impulse response after four quarters. Those of the extended model are estimated by 2SLS. Its most obvious feature is that the N.A. (i.e. the U.S.) has the largest influence on other countries' business cycles. A comparison between the output multipliers and the bilateral export shares shows that the direct effect through bilateral trade as well as the indirect effects via third countries' output fluctuations are important as international transmission channels of business cycles.

The output multipliers have evolved over time. Most multipliers have increased, especially those of shocks originating in China and the N.A., representing the growing presences of China and the U.S. in world trade and the spillover effects of their relatively strong domestic demand growth in recent years. Since the Asian economic crisis, the NIEs economies have become more sensitive to external shocks. This result implies that NIEs tend to face volatile output fluctuations in response to shocks emanating from other countries. Such evolutions of output multipliers reflect the growing and changing interdependency of the global economy.

This set of results contributes to a better understanding of how external shocks affect an economy and also illustrates the possible quantitative impact of one country's output shock on other countries' outputs. It also has some implications for policy discussions about the adjustment of current global imbalances. One of the implications involves the role of structural reforms and trade liberalization for the imbalance adjustment. Both structural reform and trade liberalization in a country not only improve its productivity and, therefore, its long-run growth trend, but also benefit its direct and indirect trading partners. It is particularly true of China, whose autonomous growth has a significant positive impact on other countries. Another implication is that it would be misleading to envision the "right" policy for global imbalances only on the basis of bilateral trade relationships. In order to expand on this thought, one must construct a theory-based structural model such as a multi-country dynamic general equilibrium model.

However, our model can be of further use when modified in the following ways. One possible modification would be a straightforward extension to analyze the influences of globalization on international trade flows by applying this model to the data set consisting of disaggregate multilateral trade flows and industrial level data of comparative advantages. In addition, it would also be fruitful to successfully incorporate trade openness, as mentioned before. This paper leaves these for future research.

[Appendix]

The data set consists of quarterly data of real GDP growth rates, bilateral export shares, trade-openness indicators, and country specific input-good prices.

Most of the real GDP growth rate data come from CEIC databases, while data for the U.S., Japan and China are obtained from their national statistics and EU data come from OECD Economic Indicators. Some earlier data that are unavailable in CEIC and national statistics are supplemented by Abeysinghe's homepage at the National University of Singapore: http://courses.nus.edu.sg/course/ecstabey/Tilak.html. Some series that are released only in their original bases (not seasonally adjusted) are seasonally adjusted by a Census X-11 procedure. PPP weights to aggregate the country data of the N.A., NIEs and ASEAN are obtained from the IMF WEO database (April 2003) on an annual basis. We interpolate annual data into quarterly data using a HP filter.

The bilateral export shares are, for the most part, calculated by using data from the Directions of Trade (IMF, December 2003). The exceptions are data from China and exports from Singapore to Indonesia. Following AF, we use trading partners' imports from China as China's exports. We assume that exports from Singapore to Indonesia equal 61 % of total Indonesian imports. The trade-openness indicators are calculated as the sum of real export and import volumes over real GDP for each country. Most trade data we use come from GDP databases contained in CEIC or national statistics. Some data that are unavailable in CEIC or national statistics are estimated by other databases like IMF DOTs or WEFA. The input-good prices are basically raw material prices or their equivalent in national producer price indices (PPI). Because of data unavailability, we consider the purchasing power parity (PPP) weighted average of raw material prices in Korea and Taiwan and Thailand's raw material prices as proxies of NIEs and ASEAN, respectively. Some earlier data (e.g. the EU and China) are supplemented by author's estimate.

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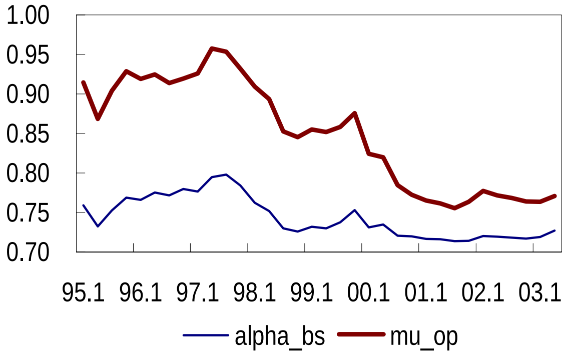
Table 1: Information Criteria and Parameter estimates

		Baseline Model				Openness Incorporated			
				& Prices				& Prices	
		OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
D.R.Covariance		706709	873303	467269	524865	809826	1082602	513151	588711
alpha	N. America	0.76	0.73	0.78	0.79	0.78	0.77	0.81	0.85
or mu	Japan	0.69	0.58	0.59	0.53	0.71	0.58	0.58	0.51
	China	1.87	1.82	2.08	2.08	1.78	2.00	2.02	2.10
	NIEs	1.45	1.42	1.44	1.35	1.36	1.41	0.84	0.99
	ASEAN	1.42	1.44	1.44	1.44	1.56	1.67	1.24	1.22
	EU	0.53	0.53	0.56	0.57	0.54	0.55	0.21	0.13
rho	N. America			-0.29	-0.28			-0.29	-0.32
	Japan			-0.24	-0.26			-0.30	-0.30
	China			-0.63	-0.56			-0.59	-0.52
	NIEs			0.06	-0.13			0.04	-0.19
	ASEAN			-0.18	-0.16			0.05	0.09
	EU			-0.10	-0.09			-0.12	-0.11

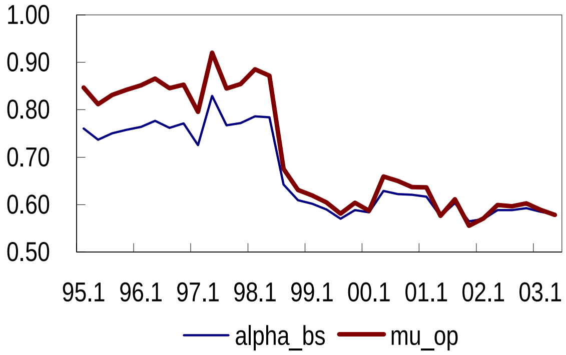
Note: Sample period is 1980Q1-2003Q2.
D.R.Covariance: Determinant residual covariance.
Prices: Relative input-good prices.

Chart 1: Recursive estimates (baseline <alpha> vs. openness incorporated <mu>)

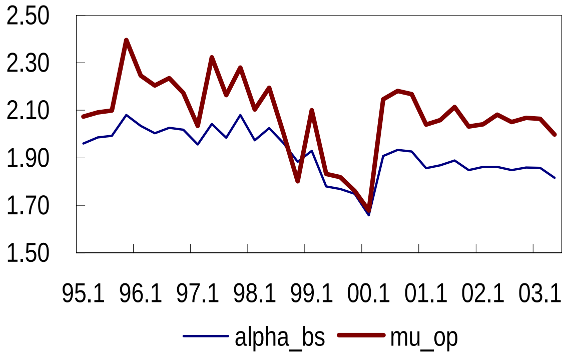
(1) North America



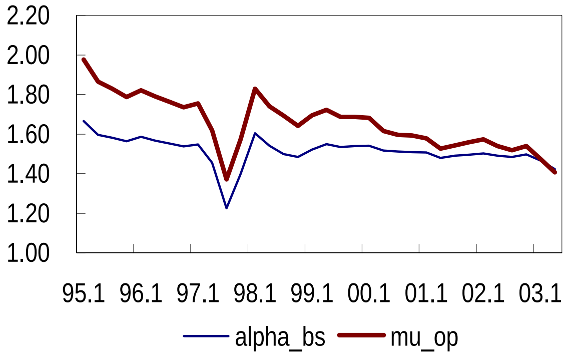
(2) Japan



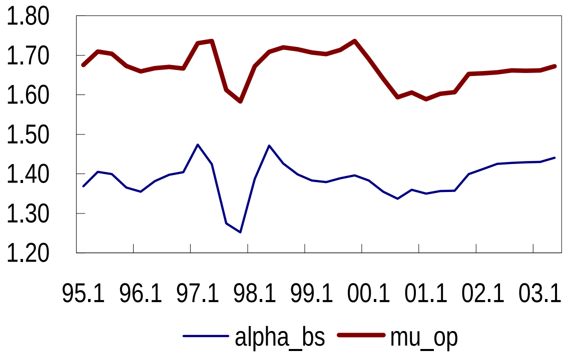
(3) China



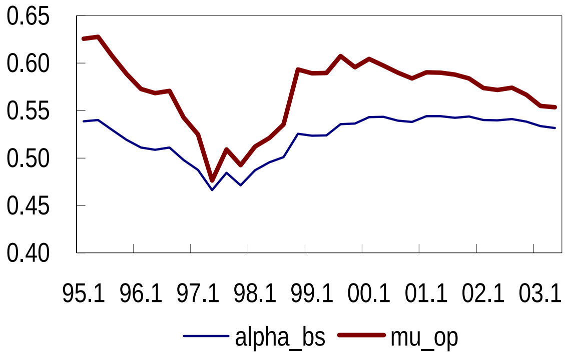
(4) NIEs



(5) ASEAN



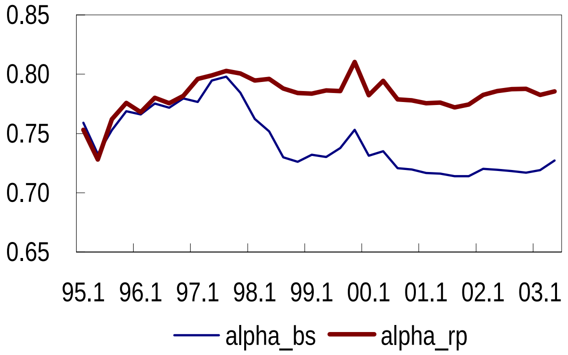
(6) EU



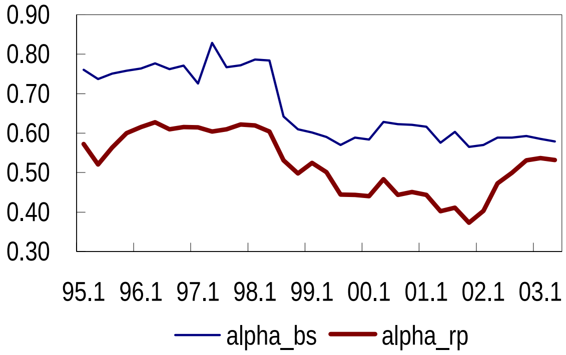
Note: Estimation method: 2SLS.
alpha_bs: estimate of alpha in the baseline model.
mu_op: estimate of mu in the model incorporating trade openness indicators.

Chart 2: Recursive estimates of "alpha" (baseline vs. relative input-good price incorporated)

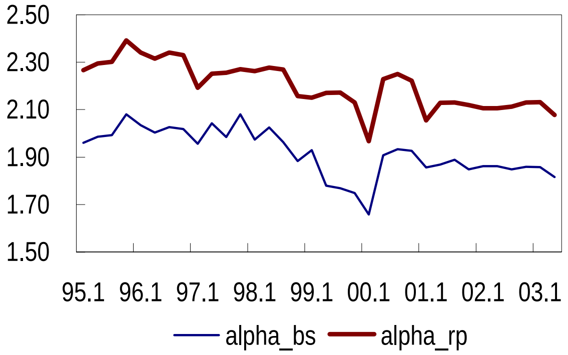
(1) North America



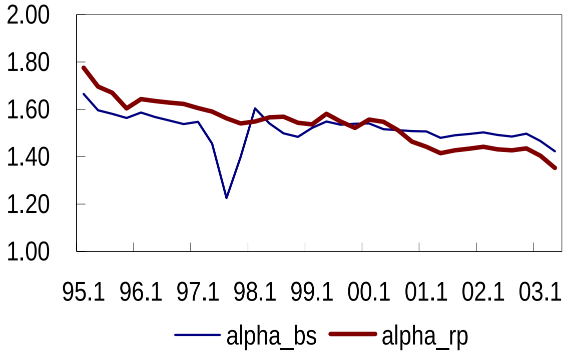
(2) Japan



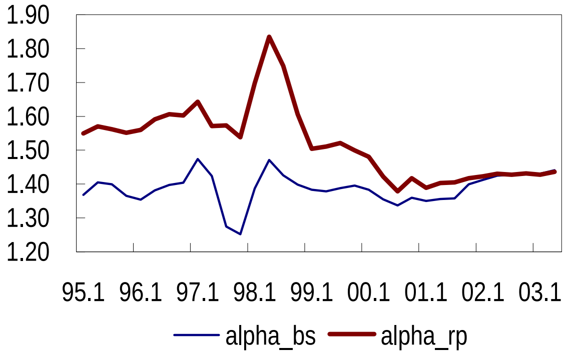
(3) China



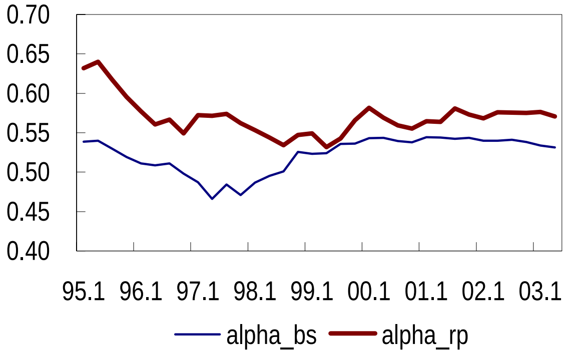
(4) NIEs



(5) ASEAN



(6) EU



Note: Estimation method: 2SLS.
alpha_bs: estimate of alpha in the baseline model.
alpha_rp: estimate of alpha in the model incorporating relative input-good prices.

Table 2: Normalized Output Multiplier of Baseline Model (OLS)

(Cumulative Impulse Responses after Four Quarters devided by its "own" effects)

Sample period: 1980Q1-2003Q2, Estimation method: OLS

		Shocks to					
		N.A.	Japan	China	NIEs	ASEAN	EU
Responses of	N.A.	**1.00**	**0.30**	**0.15**	**0.26**	**0.12**	**0.46**
		(0.07)	(0.13)	(0.18)	(0.14)	(0.24)	(0.09)
	Japan	**0.27**	**1.00**	**0.10**	**0.18**	**0.08**	**0.20**
		(0.03)	(0.06)	(0.08)	(0.08)	(0.15)	(0.02)
	China	**0.37**	**0.25**	**1.00**	**0.27**	**0.11**	**0.29**
		(0.02)	(0.03)	(0.07)	(0.06)	(0.06)	(0.01)
	NIEs	**0.61**	**0.56**	**0.40**	**1.00**	**0.22**	**0.51**
		(0.05)	(0.10)	(0.16)	(0.08)	(0.22)	(0.04)
	ASEAN	**0.68**	**0.62**	**0.28**	**0.51**	**1.00**	**0.58**
		(0.02)	(0.03)	(0.03)	(0.03)	(0.10)	(0.01)
	EU	**0.32**	**0.16**	**0.09**	**0.15**	**0.07**	**1.00**
		(0.07)	(0.08)	(0.12)	(0.09)	(0.17)	(0.08)

Note: Numbers in parentheses are standard errors derived by Bootstrapping.
Shadows indicate that multipliers are larger than two standard errors.

Table 3: Normalized Output Multiplier of Extended Model (2SLS)

(Cumulative Impulse Responses after Four Quarters devided by its "own" effects)

Sample period: 1980Q1-2003Q2, Estimation method: 2SLS

		Shocks to					
		N.A.	Japan	China	NIEs	ASEAN	EU
Responses of	N.A.	**1.00**	**0.27**	**0.12**	**0.23**	**0.10**	**0.41**
		(0.11)	(0.22)	(0.29)	(0.24)	(0.34)	(0.13)
	Japan	**0.14**	**1.00**	**0.04**	**0.10**	**0.03**	**0.08**
		(0.06)	(0.10)	(0.15)	(0.15)	(0.23)	(0.04)
	China	**0.34**	**0.24**	**1.00**	**0.26**	**0.09**	**0.25**
		(0.03)	(0.05)	(0.09)	(0.10)	(0.09)	(0.02)
	NIEs	**0.50**	**0.50**	**0.34**	**1.00**	**0.18**	**0.38**
		(0.08)	(0.18)	(0.24)	(0.14)	(0.31)	(0.06)
	ASEAN	**0.60**	**0.60**	**0.23**	**0.49**	**1.00**	**0.49**
		(0.02)	(0.05)	(0.06)	(0.06)	(0.13)	(0.02)
	EU	**0.35**	**0.17**	**0.09**	**0.15**	**0.07**	**1.00**
		(0.10)	(0.15)	(0.20)	(0.16)	(0.25)	(0.09)

Note: Numbers in parentheses are standard errors derived by Bootstrapping.
Shadows indicate that multipliers are larger than two standard errors.

Table 4: Export Shares at 2003Q2

(12-Quarter Moving Average)

		Share of					
		N.A.	Japan	China	NIEs	ASEAN	EU
Export from	N.A.		0.17	0.07	0.21	0.08	0.47
	Japan	0.36		0.10	0.26	0.11	0.18
	China	0.34	0.15		0.30	0.04	0.17
	NIEs	0.26	0.23	0.25		0.09	0.16
	ASEAN	0.25	0.23	0.06	0.28		0.18
	EU	0.63	0.10	0.07	0.15	0.05	

Note: Export shares are adjusted to have sum of shares equal unity.

Table 5: Normalized Output Multiplier of Extended Model before the Asian Crisis

(Cumulative Impulse Responses after Four Quarters devided by its "own" effects)

Sample period: 1980Q1-1996Q4, Estimation method: 2SLS

		Shocks to					
		N.A.	Japan	China	NIEs	ASEAN	EU
Responses of	N.A.	**1.00**	**0.30**	**0.07**	**0.29**	**0.10**	**0.39**
		(0.12)	(0.22)	(0.27)	(0.16)	(0.20)	(0.11)
	Japan	**0.16**	**1.00**	**0.02**	**0.13**	**0.04**	**0.08**
		(0.06)	(0.11)	(0.15)	(0.10)	(0.14)	(0.04)
	China	**0.29**	**0.19**	**1.00**	**0.36**	**0.08**	**0.22**
		(0.02)	(0.05)	(0.11)	(0.08)	(0.05)	(0.02)
	NIEs	**0.12**	**0.14**	**0.11**	**1.00**	**0.06**	**0.10**
		(0.08)	(0.16)	(0.29)	(0.12)	(0.16)	(0.06)
	ASEAN	**0.29**	**0.38**	**0.07**	**0.31**	**1.00**	**0.25**
		(0.02)	(0.05)	(0.05)	(0.03)	(0.13)	(0.02)
	EU	**0.28**	**0.16**	**0.06**	**0.19**	**0.08**	**1.00**
		(0.10)	(0.13)	(0.18)	(0.10)	(0.14)	(0.10)

Note: Numbers in parentheses are standard errors derived by Bootstrapping.
Shadows indicate that multipliers are larger than two standard errors.

Table 6: Evolution of Multipliers

(Evolution ratio = normalized output multiplies of full sample over those of sub sample)

Model: Extended model, Estimation method: 2SLS

		Shocks to					
		N.A.	Japan	China	NIEs	ASEAN	EU
Responses	N.A.		**0.90**	**1.67**	**0.81**	**1.08**	**1.07**
of	Japan	**0.92**		**1.60**	**0.78**	**0.95**	**0.95**
	China	**1.19**	**1.27**		**0.73**	**1.13**	**1.12**
	NIEs	**4.01**	**3.45**	**3.10**		**3.01**	**3.90**
	ASEAN	**2.04**	**1.58**	**3.26**	**1.55**		**1.95**
	EU	**1.25**	**1.06**	**1.62**	**0.81**	**0.94**	

Note: Shadows indicate that the ratio exceeds one, i.e. the normalized output multiplier increases over time.