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WORKING PAPER

Shifting Global Order

China's Role as a Trade Bridge for Expanding Regional and World Trade

Min Gong
Wenpu Li

Working Paper No. 41
October 2008

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Abstract

To understand China's trade relations with the US, Japan, and South Korea, we estimate a vector autoregressive model (VAR) model to investigate the trade interactions among these four countries using data from the period of the first quarter of 1993 to the fourth quarter of 2005. We find substantial Foreign Direct Investment (FDI)-induced indirect trade from Japan and Korea to the US through China, and between Japan and Korea through China. These indirect trade flows lead to increases in China's trade deficit with Japan and Korea as well as China's trade surplus with the US. The indirect trade flows through China also indicate the importance of China's role as a trade bridge. From the viewpoint of world trade growth, as a trade bridge, China contributes to the stable growth of the regional and world economies. However, China's role as a trade bridge may negatively affect its long-run economic growth.

1. Introduction

Since China launched its economic reform and opening-up policy 20 years ago, the Chinese economy has been rapidly integrating into world markets. Continued growth in exports and imports has increased China's dependence on foreign trade to more than 70 percent in 2005. External trade contributed strongly to economic growth, while domestic demand has slowed down in the recent years. In the current period, the United States, Japan, and South Korea are China's biggest trading partners. However, China's trade balances with these three countries reveal that the trade flows between China and the three trade partners are highly asymmetric: while China's trade surplus with the US (and the EU) continues to surge, its trade deficit with Japan and South Korea is growing rapidly. The total value of imports and exports was US$1422.12 billion in 2005, and the trade surplus reached US$101.88 billion. Exports to the US accounted for 21.38 percent of China's total exports, while the share of imports from the US in China's total imports was 7.38 percent in 2005. China's trade surplus with the US increased to US$114.17 billion, larger than the total surplus. On the other hand, the share of exports to Japan and Korea amounted to 15.63 percent, and 26.85 percent of China's total imports were from these two countries. China's trade deficit with Japan and Korea was estimated at US$58.17 billion, an amount equivalent to about half of China's trade surplus with the US.[1]

Obviously, the above-mentioned asymmetric trade flows are closely related to China's geographical location, factor endow-

[1] The authors' calculations are based on data released by the Ministry of Commerce of the People's Republic of China. Available at: http://zhs.mofcom.gov.cn/aarticle/Nocategory/200602/20060201484766.html.

ments, and stage of economic development. China has become the second-largest FDI recipient in the world as a result of its export-promotion growth strategy. Most FDI in China has come from Asian sources such as Hong Kong (SA), Taiwan (province), Japan and Korea. Zhang (2005) argues that China's export-promotion strategy encourages export-oriented FDI. In the Asian region, a huge pool of cheap labour attracts export-oriented multinational firms. Since China currently needs to import the necessary equipment and key production parts from multinational firms, the boom of export-oriented FDI is associated with the increasing imports. Foreign-funded enterprises accounted for 58.3 percent of China's imports and 58.7 percent of exports in 2005.[2] As a result, the export and import shares of China in the world market increased by about 100 percent from 1999 to 2005. Meanwhile, China's trade surplus with the US continues to grow, while China's trade deficit with Japan and Korea is expanding. What explains the asymmetry of China's trade balances with its main trading partners? Does China function as a bridge to increase regional trade? What is the impact of the asymmetry of trade balances on China's sustainable growth?

After the 1997-1998 Asian financial crisis, China, Japan, and Korea began to show increasing interest in forming regional trade arrangements in Northeast Asia. During the Manila Summit in November 1999, the leaders of these three countries reached an understanding on establishing a closer economic partnership and stronger economic cooperation. A trilateral free trade agreement (FTA) between China, Japan, and Korea (hereinafter CJK FTA) has been suggested against a background of

[2] Data source is the same as in note 1.

the growing trend of regionalism worldwide (Hu, 2001).[3] It is believed that the establishment of a CJK FTA will give Japan and Korea an incentive to export FDI to China and promote China's exports outside the region at a higher growth rate (Gong and Li, 2006). Since China has an increasing trade deficit with Japan and Korea, tax cuts arising from the establishment of a CJK FTA will contribute to a further rise in China's trade deficit. More attention should be paid to trade frictions between China and its main trading partners in Asia, such as Japan and Korea.

In this paper, we analyze the features of the trade relations among China, the United States, Japan, and Korea in order to understand the role of China in enhancing regional and world trade. The question is: Does the increase in China's trade deficit with Japan and Korea and in its trade surplus with the US imply that Japan and Korea are expanding their exports via China and increasing their shares in the regional and world markets? If the answer is positive, then China's opening-up and stable growth is not a threat to the regional and world economy. Instead, China's rapid growth is not only an engine of growth in the regional economy but also an important factor contributing to rapid growth in the world economy. In addition, we also analyze the possible negative impact of the asymmetry of trade balances on China's long-term growth.

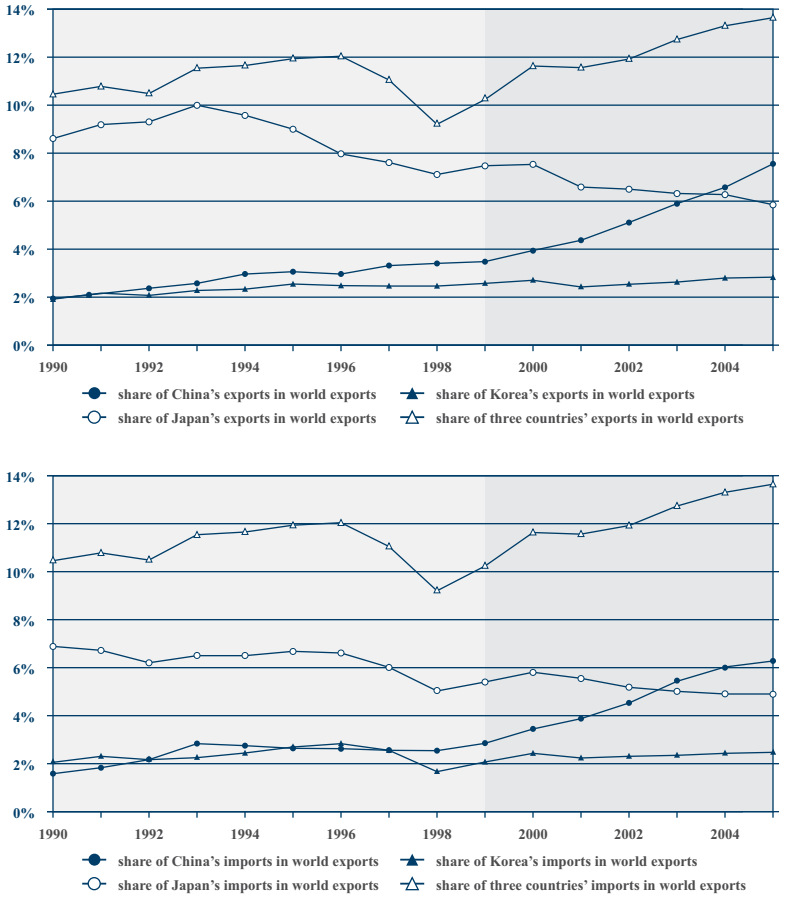
[3] The union research group, consisting of the Development Research Centre of the State Council of China, the National Institute of Research Advancement of Japan, and the Korea Institute for International Economic Policy, carried out a survey to investigate the effect of a CJK FTA on the three countries' economies. Three reports were published between 2002 and 2004. They are "Enhance the Trade and Investment between China, Japan and Korea"; "The Economic Welfare Effect of FTA between China, Japan and Korea"; and "Analysis on Industrial Effect of FTA between China, Japan and Korea."

The rest of the paper is organized as follows. In the next section, we give a brief overview of the current situation of trade development in these four countries, sum up some features of trade relations, then make a short survey of the study of the trade relations between these countries. The third section estimates a vector autoregressive model (VAR) to figure out the dynamic interrelations of trade among the four countries. We use the Granger causality test to identify the trade interdependence among Japan, Korea, and the US, and apply the pulse response function and variance decomposition to illustrate the degree and time path of the impact of one country's trade shock on the other countries. Finally, we offer our conclusions and policy implications.

2. Overview of the Current Situation of Trade Development between China and its Main Trading Partners

Firstly, compared with Japan and Korea, China's growth rate of foreign trade is the fastest in recent years. Figure 1 shows the shares of China's imports and exports in the world trade from 1990 to 2005, as well as those of Japan and Korea. Since 1999, China's imports and exports have been growing at a fast pace. In 2005, the export and import shares of China in the world market increased to 7.52 percent and 6.27 percent respectively. They are respectively 4.1 and 3.4 percentage points higher than in 1999. Meanwhile, Japan's shares of imports and exports have clearly declined, and Korea's shares remain stable with an upward trend. With China's rapid growth in foreign trade, the combined share of these three Northeast Asian countries in the world market has increased significantly. In 1999, these three countries' exports and imports accounted for 13.42 percent and 10.28 percent of the world's totals. In 2005, these numbers have increased to 16.19 percent and 13.65 percent respectively.

Figure 1: The Shares of Imports and Exports in World Trade
for China, Japan, and Korea



Source: International Financial Statistics (IFS) online database

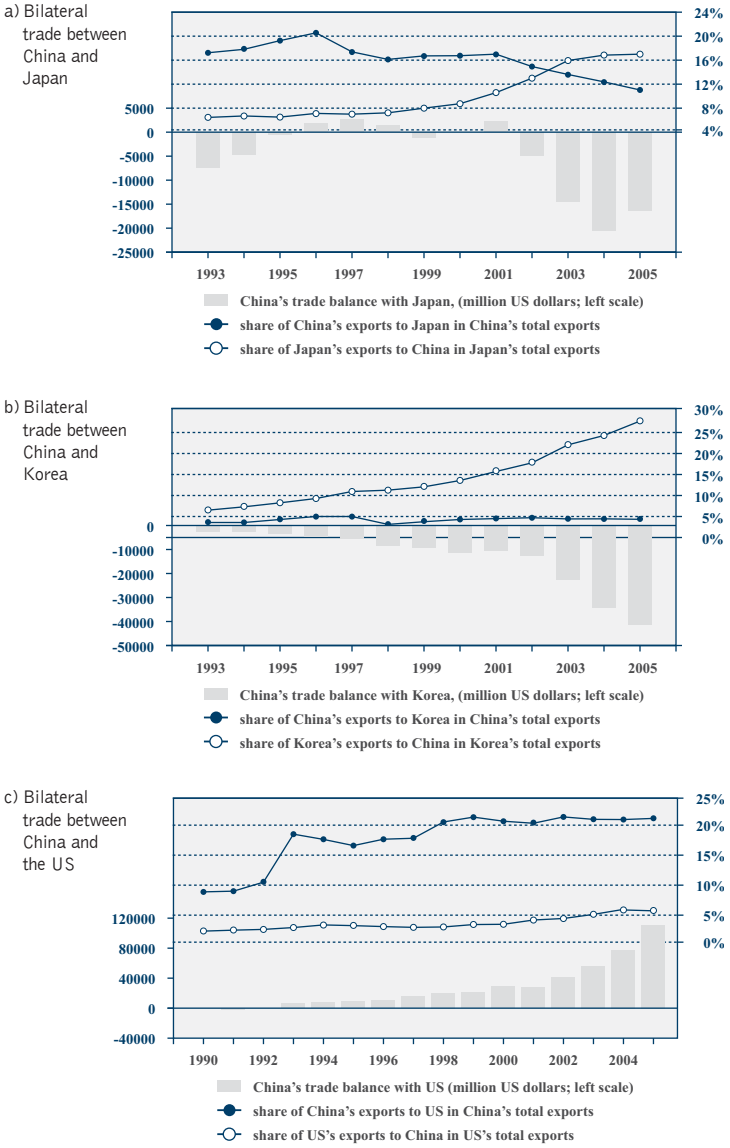
Second, we review the trade between China and Japan. In 2002, China's trade balance turned into a deficit, and that trade deficit has since increased substantially. The share of China's

exports to Japan in China's total exports is constantly falling, while the share of Japan's exports to China in Japan's total exports is significantly rising (see Figure 1). Of China's total exports, the share of China's exports to Japan was 16.72 percent in 2000 but declined to 11.02 percent in 2005. On the other hand, exports from Japan to China accounted for 8.66 percent of Japan's total exports in 2000 but jumped to 16.89 percent in 2005. This evidence shows that China is becoming an important market for Japanese final products, or that Japan is exporting its products to other markets (such as the US or EU) via China. The latter implies that Japan uses China as a trade bridge to expand its exports to the US or the EU.

Third, we turn to the bilateral trade between China and Korea. China has maintained a trade deficit with Korea (see Figure2b), and the trade deficit has increased rapidly in recent years. The share of China's exports to Korea in China's total exports remains stable with a weak downward trend, while the share of Korea's exports to China in Korea's total exports is rising rapidly. Of Korea's total exports, the share of exports to China increased from 13.47 percent in 2000 to 27.01 percent in 2005.

Finally, with regard to Sino-US trade, China's trade surplus has been increasing rapidly and continuously (see Figure2c). Compared to a stable upward trend in the share of China's exports to the US in China's total exports, the share of US exports to China in its total exports is obviously rising. In 2000, US exports to China accounted for 2.86 percent of its total exports. This number increased to 5.37 percent in 2005.

Figure 2: Bilateral trade between China and its Main Trading Partners



Source: COMTRADE database online. We use data of SITC Rev.1, based on China's reports. Data for 2005 available at: http://gcs.mofcom.gov.cn/tongji.shtml

To sum up, the data presented above show that the shares of Japanese and Korean exports to China in their countries' totals are rapidly rising; the share of China's exports to Japan and Korea is constantly falling; and the share of China's exports to the US tends to be on an uptrend. As a result, China's trade deficit with Japan and Korea becomes closely related to China's trade surplus with the US. Based on this fact we predict that, given the current trade situation among China, the US, Japan, and Korea, two indirect trade relations exist: one is from Japan to China, then to Korea, or from Korea to China, then to Japan; the other is from Japan (or Korea) to China, then to the US (or EU). The former shows that China functions as a bridge to increase the bilateral trade between Japan and Korea within the northeast region, while the latter shows that Japan and Korea expand their exports to such countries as the US or EU via China. As a result, both the world and regional economies benefit from economic growth in China. Therefore, China's opening-up and sustainable growth will never be a threat.

To analyze the role of China's rapid trade growth in enhancing regional and world trade, we have not considered the several trade-related indices such as intensity of export competition, trade specialization index (TSI), export similarity index (ESI), export market intensity index (EMI), and intra-industry trade index (ITI) (Li, 2005; Zhang and Zhang, 2005; Xu, 2004; Wong, 2004; Ushijima, 2001). Instead, we use a vector autoregressive model (VAR) to investigate the features of the trade relations among China, the US, Japan, and Korea. Since all these indices are static ratios, they cannot be used to find the dynamic movements of trade flows among countries. So we use a VAR model to find out quantitatively how China and its main trading partners depend on each other through foreign trade.

3. Empirical Analysis of the Trade Interdependency between China and its Main Trading Partners

We estimate a VAR model,[4] consisting of trade flows among China, the US, Japan, and Korea, to reveal the trade interaction relationships and find out the trade characteristics behind the trade data. EXPCUS, EXPCJ, and EXPCK refer to the exports from China to the US, to Japan, and to Korea respectively. EXPUSC, EXPJC, and EXPKC represent the exports from the US to China, the exports from Japan to China, and the exports from Korea to China, respectively.

The import-export data before the fourth quarter in 1997 are taken from the International Monetary Fund Direction of Trade Statistics (IMF DOTS). Because COMTRADE only provides annual trade data, in order to obtain quarterly data on the trade flow among these four countries for the period 1998-2005, we insert quarterly data between one year and the consequent year by using Cubic Hermite Spline.[5] Data on the bilateral trade flows among China, Japan, and Korea are recorded from 1998 to 2004 in the United Nations Commodity Trade Statistics (COMTRADE) online database. We selected the data reported by China. The quarterly data for the total exports of China, Japan, and Korea for this period are available from IMF International Financial Statistics (IMF IFS). We use the quarterly data of the total exports of these three countries as the introductory series to insert the quarterly data on the exports among them. The Chinese Business

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[4] Vector autoregression, or the VAR model, is a dynamic system that models a column vector of k different variables in terms of past values of the vector. We use a vector autoregression model to discuss quantitatively how much these three countries depend on each other through foreign trade. See text box for further explanation of the methodology used.

[5] For explanation of terms and methodology, please see discussion in the Appendix.

Board reports the data for 2005.[6] The sample period is from the first quarter of 1993 to the fourth quarter of 2005. All of these variables are nominal variables in logs (unit: million US dollars; import price: CIF). We include nominal effective exchange rate (NEER) of RMB as an exogenous variable into the model estimation to remove the impact of the change in the exchange rate on trade volume. The NEER data come from the IFS online database.

The results from the unit root test for these bilateral trade variables show that all of the variables involved in the model estimation are I(1) (see Table 1).

Table 1: Unit Root Test

	Test equation	ADF test statistic	Test equation	ADF test statistic
Exports from China to Japan (EXPCJ)	(C,T,4)	-2.875	(C,0,3)	-2.661**
Exports from Japan to China (EXPJC)	(C,T,4)	-3.205	(C,0,3)	-2.691**
Exports from China to Korea (EXPCK)	(C,T,4)	-2.330	(C,T,3)	-3.988
Exports from Korea to China (EXPKC)	(C,T,9)	-2.686	(C,0,7)	-2.691**
Exports from China to US (EXPCUS)	(C,T,4)	-2.851	(C,T,5)	-4.303
Exports from US to China (EXPUSC)	(C,T,3)	-0.59669	(C,T,2)	-8.774

**denotes rejection of the hypothesis at 0.10 level

Cointegration Test

We conducted a cointegration test[7] before we estimated the VAR model by using the Johansen test. We assume deterministic linearity, and set the lag period as 2, and give the variables the

[6] The data on the bilateral trade between China and the US is available from the US Census Bureau: http://www.census.gov/foreign-trade/www.

[7] The presence of nonstationary variables in VAR raises the possibility of cointegrating relations. Suppose that two nonstationary time series, x_t and y_t are each integrated, i.e., have unit roots. If there is some linear combination, say $y_t - ax_t$, that is stationary, x_t and y_t are said to be cointegrated. The cointegration test shows if there are stable equilibrium relationships between them.

following order: EXPCUS, EXPJC, EXPCJ, EXPKC, EXPCK, and EXPUSC. The test results (see Table 2) indicate that there exists only one cointegration relation among the six trade variables, which suggests that there is a stable equilibrium trade relation among China, Japan, and Korea in the long run. Moreover, we can estimate a VAR model consisting of these six trade variables.

Table 2: Cointegration Test

	No. of CE(s)	Eigenvalue	Statistic	0.05 critical value	Probability
Trace test	0*	0.668	137.410	117.708	0.002
Maximum Eigenvalue Test	0*	0.668	57.377	44.497	0.001

*denotes rejection of the hypothesis at 0.05 level

The cointegration equation is given as follows:

$$lEXPCUS_t = \underset{(-7.426)}{3.19}\, lEXPJC_t - \underset{(2.023)}{1.48}\, lEXPCJ_t - \underset{(0.066)}{0.03}\, lEXPKC_t + \underset{(-2.813)}{1.33}\, lEXPCK_t - \underset{(6.615)}{3.43}\, lEXPUSC + \underset{(-2.602)}{0.03}\, TREND + 6.31C + \varepsilon_t$$

where ε_t is white noise, TREND and C are time trend and constant, respectively. t-statistics are given in parentheses.

In this cointegration equation, the coefficient of the exports from Japan to China (EXPJC) is positive, indicating that an increase in Japan's exports to China is closely linked to a rise in China's exports to the US. This result is closely related to FDI from Japan to China. As a recipient of FDI, China needs to import equipment and key production parts from Japan. Export-oriented FDI inflow from Japan to China leads to an increase in China's imports from Japan (i.e., Japan's exports to China). After processing, foreign-funded enterprises would have more final products to export to the US.

Granger Causality Test

We use the Granger causality[8] test to find out the causal relationships between China and its three main partners. The aim is to test whether a change in exports from Japan (or Korea) to China plays an important role in the determination of exports from China to the US. As Table 3 shows, we find that: (i) a positive shock from China's exports to the US can statistically lead to a change in exports to China from Japan, Korea, as well as from the US. This result implies that the stable and sustainable growth of trade between China and the US has important implications for the regional trade (among the northeastern region), and for world trade as well; (ii) Based on the Granger causality test of bilateral trade, we find that the exports from Japan to China do not Granger cause the exports from China to Japan; no opposite direction is found. There exist two-way causal trade relations between China and Korea (and the US). In other words, the purpose of Japan's FDI in China is different from Korean and US FDI. Korea and the US export equipment and key production parts to China; after processing, they import the final products from China. Compared with Korea and the US, the purpose of Japan's FDI in China is to expand the Japan's export to such countries as the US; (iii) The change in the exports from Japan to China is positively related to the change in the exports from China to the US and Korea. The change in the exports from Korea to China is also positively linked to the change in the exports from China to the US and Japan. In other words, there are indirect trade relations of Japan→China→US (or Korea)

[8] In the general VAR formulation, the lagged values of every variable appear in every equation of the VAR. One needs to do the Granger Causality test when testing whether a specific variable or group of variables play any role in the determination of other variables in the VAR. Using the test of Granger causality can examine the causality of trade with each other between China and its main trade partners.

and Korea→China→US (or Japan), which indicates that China is playing an important role in the determination of trade relationships among Japan, Korea, and the US. Japan and Korea are not only continually expanding their exports to the US via China but also the exports between each other via China. This result confirms China's role as a trade bridge among the four countries.

Table 3: Causality Tests for the Relationships between China and Its Main Trading Partners

Items	Null Hypothesis	Probability	Results
The importance of Sino-US trade	China's exports to the US do not Granger-cause Japan's exports to China	0.000	rejection
	China's exports to the US do not Granger-cause Korea's exports to China	0.000	rejection
	China's exports to the US do not Granger-cause US's exports to China	0.001	rejection
The relationships of Bilateral trade between China and its main partners	Japan's exports to China do not Granger-cause China's exports to Japan	0.199	acceptance
	China's exports to Japan do not Granger-cause Japan's exports to China	0.592	acceptance
	China's exports to Korea do not Granger-cause Korea's exports to China	0.036	rejection
	Korea's exports to China do not Granger-cause China's exports to Korea	0.000	rejection
	China's exports to the US does not Granger-cause the US's exports to China	0.001	rejection
	the US's exports to China do not Granger-cause China's exports to the US	0.001	rejection
The indirect trade relations between China and its main partners	Japan's exports to China do not Granger-cause China's exports to Korea	0.011	rejection
	Japan's exports to China does not Granger-cause China's exports to the US	0.048	rejection
	Korea's exports to China do not Granger-cause China's exports to Japan	0.000	rejection
	Korea's exports to China do not Granger-cause China's exports to the US	0.001	rejection

Estimation

Although we can figure out the direction of trade flow among these four countries based on the Granger causality tests, in order to trace how a shock from one country's trade affects

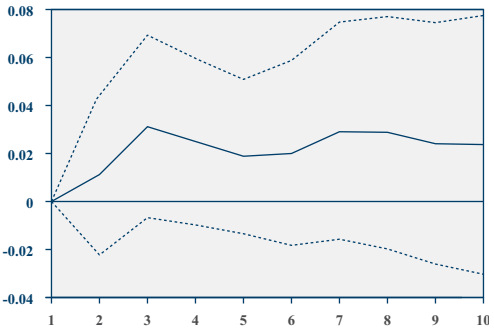
the other countries' trade over time, we need to estimate a VAR model, consisting of trade flows between China and its main trade partners. We denote the export from country *i* to country *j* as EXP*ij,* where *i,j*=C(China), J(Japan), K(Korea), and US(United States). We rank the endogenous variables of VAR as *EXPCUS*、*EXPJC*、*EXPCJ*、*EXPKC*、*EXPCK*、*EXPUSC.* To remove the effects of nominal prices on the trade flows, we include the RMB's REER (real effective exchange rate) in our VAR model as an exogenous variable. By using impulse response functions and variance decomposition,[9] we are able to estimate the dynamic linkage of trade relationships between China and its main trade partners.

Taking the above empirical results above into consideration, we focus on the effects of a positive shock from Japan's (as well as Korea's) exports to China on China's exports to the US. A chain reaction over time by a shock from Japan's exports to China is shown in Figure 3a. Figure 3b gives the response of China's exports to the US to a shock of Korea's exports to China. In addition to the two responses, we also calculate the effects of a positive shock of exports from Japan/Korea to China on China's exports to Korea/Japan. We found similar results; that is, there is a positive linkage between Japan's (or Korea's) exports to China and China's exports to Korea (or Japan). Therefore, we find evidence that Japan and Korea are expanding their exports to the US via China. This result shows that China functions as a trade bridge to increase the trade between Japan/Korea and the US.

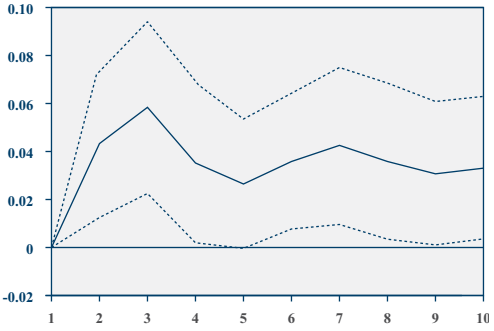
[9] The impulse responses and variance decomposition generated by the estimated VAR can be used to find out qualitatively how a shock from one country's trade triggers a chain reaction over time.

Figure 3: Impulse Responses

a) Response of China's exports to the US to a shock of Japan's exports to China



b) Response of China's exports to the US to a shock of Korea's exports to China



Source for data in graphs: Authors' calculations

Moreover, an examination of variance decompositions (VD) enables us to obtain important evidence in a different way. We find that shocks of China's exports to the US can explain about 33.45 percent of the variation in Japan's exports to China after eight quarters, and 26.28 percent of the variation in Japan's exports to China can be affected by the change in China's exports to Korea. Of variation in Korea's exports to China, 38.16 percent can be accrued to the shocks of China's exports to the US, and 12.65 percent to the change in China's exports to Japan.

In short, the above empirical results show the following: given the current trade situations in China and its main trading partners, on the one hand, China's exports to the US are a crucial determinant of the exports from Japan and Korea to China. On the other hand, Japan's (or Korea's) exports to China are greatly influenced by China's exports to Korea (or Japan). This result demonstrates how Japan and Korea could increase their exports to the US and to each other via China. Meanwhile, this result means that the purpose of Japan's and Korea's FDI in China is, to some extent, not to obtain market share of their products in China but to raise the share of their products in a third market such as the US and EU. In fact, in addition to Japan and Korea, Taiwan province and Hong Kong SAR in the Asian region also use Mainland China as a bridge to increase their exports to the US or other countries.

4. Conclusions and Policy Implications

Our empirical results show that there are two indirect trade flows among China and its main trading partners. One is from Japan/Korea to the US through China. The other is from Japan to Korea or from Korea to Japan through China. These indirect trade relationships imply that China plays the role of trade bridge to increase Asia's trade with the US (as well as the EU), and to increase the trade between Japan and Korea in Northeast Asia. Therefore, from the viewpoint of trade and economic growth in the world economy, China's opening-up and rapid growth are not only favourable to of the intra-regional trade within Northeast Asia, but also beneficial to the inter-regional trade between Asia and the US. In this sense, China would be an engine of stable growth in the regional and world economies.

However, China's role as a trade bridge may have a negative impact on its economic growth in the long run. We offer three main reasons for this: First, with a huge pool of cheap labour in China, the boom of export-oriented FDI leads to the rapid growth of outward processing trade. As a result, China's exports depend heavily on the processing trade, which is characterized as labour-intensive and low value-added trade. Second, the uneven trade balances could become barriers to the increase in China's trade surplus in the future. If trade protectionism prevents the US from increasing imports from China, or the RMB's appreciation causes a slowdown in China's exports, China's trade surplus will fall rapidly. This is because it is difficult for China to substantially cut its trade deficits with Japan and Korea given the current development stage and the factor endowments. Third, and more importantly, given the fact that Japan and Korea are expanding their exports to the US via China, trade frictions between Japan (and Korea) and the US may contribute to trade tension between China and the US (or EU).

In the final analysis, the trade relationships among China and its main trade partners can be considered as an outcome of intra-regional industrial division. The analysis of the trade relations provides another source from which we can investigate the situation of intra-regional industrial division and adjustment of intra-regional industrial structure. In terms of the stage of economic development, China, Japan, and Korea are very different. Japan is a developed country with an abundance of capital and technology. Japan is also an exporter of capital and technology. South Korea is a New Industrialized Country, starting to become a main exporter of capital in the northeastern region. Compared with these two countries, China is a transitional country at a catch-up stage, and is an important recipient of capital, technology, and industry transfer in the region.

As a result, a vertical division of industry is coming into existence among China, Japan, and Korea, with a ranking of Japan, Korea, and China from top to bottom. This vertical division of industry causes Japan and Korea to continue to increase the exports of equipment and intermediate products, after processing, back to Japan or Korea, or to such markets as the US or EU via China. In other words, Japan and Korea partially extend part of their production processes to China. Japan, Korea, and China are forming a relatively independent production chain through FDI to expand their exports to the USA (CCER, 2006).

However, since Japan's and Korea's FDI in China is closely related to the adjustment of the industrial structure in each country, one important purpose of exports from Japan and Korea to China is to take advantage of the low production costs in China to strengthen their international competitiveness. One possible outcome of this export-oriented FDI is that China's export products rely heavily on the adjustment of the industrial structure in Japan and Korea. Meanwhile, as mentioned above, export-oriented FDI leads to the rapid growth of outward processing trade. Worse still, there is a trend for China's industrial structure to be locked at a low stage (producing low-end products). Under current circumstances, China needs to absorb this export-oriented FDI. But, with economic growth and changes in the price ratios of production factors, some it will be necessary for measures to be adopted measures that give firms incentives to innovate are adopted so as to prevent China's industrial structure from being locked at this low stage.

Therefore, from a long-term perspective, our findings suggest that China needs to develop new technologies and hi-tech standards, adjust its export structure, and strengthen and upgrade its industrial structure.

Appendix

Explanation of Methodology

Azim Essaji*

Cubic Hermite Spline

Trade data is only available yearly. In the analysis, however, we use quarterly data. We interpolate the quarterly data using a Cubic Hermite Spline.

Suppose we denote years by $y_1 ... y_n$. Assume, as well, that each year y is an interval between zero and one, and is made up of sub-intervals $t \in [0,1]$. Suppose, moreover, that trade values z can be represented as a function of y, that is, $z_i = f(y_i)$ for any year i between one and n. The Cubic Hermite Spline then fits a function between any two consecutive time-trade value, (y,z), combinations. Specifically, between year one and two it fits a function such that at any point t between year one and two:

$$z(t) = (2t^3 - 3t^2 + 1)z_1 + (t^3 - 2t^2 + t)z'(y^1) + (-2t^3 + 3t^2)z_2 + (t^3 - t^2)z'(y_2)$$

To determine the quarterly data, we input the appropriate annual values of $z1$, $z2$, $z'(y1)$ and $z'(y2)$, set t=0.25, 0.5, and 0.75, and interpolate trade values for those junctures. We repeat this for each interval in the data.

Unit Root Test

Time series data, such as the export data used in this paper, are often highly persistent; that is, past values significantly influence the present values of the variable. Econometric inference when data is highly persistent is problematic, as conventional ordinary least squares methods will provide erroneous results.

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Of particular concern are time series that follow a random walk; that is, series that wander around and do not return to their starting values with any regularity (Wooldridge 2003). Statisticians refer to these series as non-stationary, or containing a unit root. More concretely, these series take the following form:

$$z_t = z_{t-1} + \varepsilon_t$$

To test for a unit root, we use an augmented Dickey-Fuller (ADF) test. This involves running the following ordinary least squares regression and testing whether θ is equal to zero:

$$z_t - z_{t-1} = \theta z_{t-1} + \lambda(zt\text{-}1 - zt\text{-}2) + u_t$$

If θ is equal to zero, the series has a unit root. Unsurprisingly, all the data series in this paper are highly persistent, so they all contain a unit root. The critical values for the Dickey-Fuller test are contained in many econometric textbooks.

Cointegration

The central problem in analyzing the relationships between two series that have unit roots is that it can lead to spurious regressions. Granger and Newbold (1974) showed that even if the two non-stationary series were independent, an ordinary least squares regression of one series on the other would lead one to find a statistically significant relationship: put another way, even though the two series are unrelated, ordinary least squares would suggest a relationship.

Engle and Granger (1987) argue, however, that the regression of one non-stationary series on another will yield non-spurious results if the series have a long-run relationship. If the series have a long-run relationship, they are termed cointegrated. The test for cointegration is fairly straightforward. Consider two non-stationary series, x_t and y_t. Begin by running an ordinary least squares regression of y_t on x_t (or vice versa). More formally, run the following regression.

$$y_t = \beta x_t + \varepsilon_t$$

This regression yields β, and a residual ε_t. To test if the series are cointegrated, we simply check that the residuals are stationary; that is, they do not have a unit root. If the residuals do not, it means that the two series move together in the long-run, and as such share a stable relationship.

Having shown that our individual series have unit roots, it was necessary to demonstrate that the series had a long-run, stable relationship before continuing with any regression analysis. To this end, we show that the residuals from a regression of exports from China to the United States on all other export series are stationary. We can thus proceed to regression analysis.

Vector Autoregressive (VAR) Models

In this paper we are concerned with multiple trade relationships, not just China's relationship with a single trading partner. Moreover, the various export series that we analyze in this paper are closely interrelated. It is likely, for example, that the present value of exports from Japan to China not only depends on past values of exports between Japan and China, but also on past values of trade between China and its other trading partners. A VAR model allows the estimation of multiple interrelated series simultaneously and allows us to predict how all the variables will respond to a shock to one of the variables.

A typical VAR model takes the following form. Consider two time series y_t and z_t; each is determined by its own past values and past values of the other variable. The VAR model in this case would consist of two equations,

$$y_t = \alpha_1 y_{t-1} + \ldots + \beta_1 z_{t-1} + \ldots + \varepsilon_t$$

$$z_t = \delta_1 z_{t-1} + \ldots + \eta_1 z_{t-1} + \ldots + \upsilon_t$$

These equations would be estimated jointly in a VAR model. In our study, we have six equations, one for each trade flow between China and its major trading partners. We thus use a six equation VAR model to obtain our results.

Granger Causality Tests

In constructing a VAR model, it is often difficult to determine which lagged values of other variables should be included in each equation. For example, it is not clear that China's exports to the USA should matter for Japan's exports to China; should one, therefore, include past values of Japanese exports to China in the equation for China's exports to the USA?

Granger causality tests provide a way of determining which past values need to enter each equation. Consider again, two series y_t and z_t. Granger causality tests help determine whether once we control for past values of *y,* past values of *z* also help to forecast *y,* and vice versa. To see this more concretely, consider the following regression:

$$y_t = \alpha_1 y_{t-1} + ... + \beta_1 z_{t-1} + ... + \varepsilon_t$$

A Granger causality test would test whether the lagged z terms improved the fit of the regression. If they did, we would say that *z* "Granger causes" *y.* In that case, the lagged values of *z* should thus be included in the *y* equation of the VAR.

It is important to note that a finding that *z* "Granger causes" *y,* does not imply anything about the relationship between *y* and *z* at time *t.* It also tells us nothing definitive about whether *z* is determined independently of *y* at time *t,* or vice versa. Our finding, therefore, that Japan's exports to China "Granger cause" Chinese exports to the United States does not imply that the former determine the latter in any given quarter. It also does not rule out the possibility that Chinese exports to the USA might determine Japan's exports to China.

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