

The Impact of Value-added Trade and Value Chain Embeddedness on Economic Cycle Linkage in China, Japan, and South Korea

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Abstract: Northeast Asia is an important global economic engine, and its core countries (China, Japan, and South Korea) play an important role in the global value chain (GVC). Based on the decomposition of the input-output tables of China, Japan, and South Korea from the ADB-MRIOTs (Asian Development Bank Multiregional Input-Output Tables), this paper verifies the characteristics of the economic cycle linkage in China, Japan, and South Korea. It constructs a double fixed effect model and studies the impact of value-added trade and value chain embeddedness on the economic cycle linkage among China, Japan, and South Korea. The results show that both value-added trade and value chain embeddedness can positively impact this linkage. In addition, embeddedness within the same industrial value chain has a “crowding out” effect on value-added trade, which would weaken the business cycle co-movement. However, this “crowding out” effect is not evident among industries, and there is a regulating effect that strengthens the economic cycle linkages. Furthermore, the test of industrial heterogeneity shows that among the three countries, value-added trade within manufacturing industries has a stronger transmission effect on the economic cycle linkage, while value chain embeddedness has a stronger transmission effect on the economic cycle linkage between the manufacturing and service industries.

Keywords: Value-added Trade, Value Chain Embeddedness, Economic Cycle Linkage, China-Japan-South Korea

I. INTRODUCTION

The 2008 financial crisis resulted in a sluggish recovery of the world economy,

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an uneven distribution of trade benefits among countries, and an increasingly evident tendency towards “globalization fragmentation”. Regional economic integration has evolved into the main channel for nations to globalize. Since the turn of the 21st century, Europe, North America, and Asia have steadily created the “three pillars” of the global production network. In Asia, China, Japan, and South Korea occupy the central position of the regional value chain due to their large populations, strong economies, as well as high levels of scientific and technological development. At the same time, these three countries engage in frequent trade exchanges due to their geographical advantages. Among these, Japan and South Korea are upstream of the global value chain (GVC) in terms of their technological sophistication. In comparison, China has a complete range of manufacturing products and stable advantages of the whole industrial chain. Japan and South Korea can provide products for the global market because of China’s advantageous position as a global hub. For a long time, the division of labor among these three countries has been intertwined. In order to protect their interests, European and North American countries have recently imposed sanctions that have negatively impacted China-Japan-South Korea economic and trade cooperation, which specializes in manufacturing. The 2018 Asia-Pacific Economic Outlook Report points out that the trade friction between China and the United States has harmed the import and export trade of Japan and South Korea and also hindered their local sectors in the GVC.¹ For this reason, Japan and South Korea are more actively seeking cooperation with China. First, their attitude towards the Belt and Road Initiative (BRI) has changed. Now they hope to consolidate and enhance their value chain status based on the open and shared regional economic cooperation model by capitalizing on the BRI’s broad market prospects and the trade potential of regional market division. At the Eighth Trilateral Summit Meeting among the People’s Republic of China, The Republic of Korea and Japan in 2019, China expressed their willingness to strengthen industrial cooperation with Japan and South Korea. In addition, Japan and South Korea confirmed future collaborations with China in the fields of big data, artificial intelligence, and 5G. On January 1, 2021, the Regional Comprehensive Economic Partnership (RCEP) officially came into force. The

1 *Regional Economic Outlook: Asia Pacific*, <https://www.imf.org/en/Publications/REO/APAC/Issues/2018/10/05/areo1012> (Last Visited on October 27, 2022).

tariff reduction commitments among the three parties will significantly reduce the cost of intra-regional trade, which contributes to the expansion of goods trade among China, Japan, and South Korea as well as the regional member countries. Additionally, the accumulation of rules of origin will also strengthen the supply and industrial chain relationships among China, Japan, and South Korea. The constant accumulation of value chain trade between these three countries is the result of their mutual embeddedness and development of the chain. This cooperative relationship will also affect the trajectory of economic linkage among the three countries.

II. LITERATURE REVIEW

After the recovery and prosperity of the world economy following World War II, the emergence of the General Agreement on Tariffs and Trade (GATT) and the establishment of the Bretton Woods system has caused the economic variables among some developed countries to show a correlation with the time cycle, as the economic expansion and contraction among countries have formed a high degree of coordination and linkage. This phenomenon has drawn the attention of economists and subsequently has been widely studied among academics. The existence of economic cycle linkage was tested and the correlation between trade and economic cycles was also described,² which set the groundwork for future studies. An empirical model was then established to explore the effect of economic growth on the North American Free Trade Agreement (NAFTA),³ and it was found that the NAFTA promoted regional trade and investment as well as bolstered the economic cycle of regional internal linkage, which was particularly evident in the United States and Mexico. Based on the background of BRI, a study on economic cycle of regional internal linkage found that this linkage between China and Singapore was the strongest, whereas those after 2007 between China and Thailand, the Philippines, and Vietnam were weak.⁴ As trade protectionism has increased, the emergence of trade barriers

2 Ilse Botha, A Comparative Analysis of the Synchronization of Business Cycles for Developed and Developing Economies with the World Business Cycle, *South African Journal of Economics*, Vol. 78, No. 2, 2010, pp. 192-207.

3 Yan Zhihui and Song Yuhua, Empirical Study on Macroeconomic Comovement in the North American Free Trade Region, *Technical Economy*, No. 3, 2008, pp. 7-14.

4 Li Nan, Trends of Economic Cycle Synchronization between China and ASEAN, *Asia Pacific Economy*, No. 2, 2017, pp. 21-26 & 173.

severely hindered economic linkages between countries.⁵ Furthermore, the expanding global income gap and the slowdown of trade growth also had a negative impact.

The research on the influencing factors of economic cycle linkage mainly considered the perspective of the relationship between trade and economic linkage, and argued that international trade facilitates economic linkage between countries. Among them, the FR effect (Frankel-Rose effect) of bilateral trade was the first empirical study on international economic cycle linkage based on import and export trade data.⁶ The trade could improve international economic linkages.⁷ When applying economic and trade data to verify the FR effect, it was found that the influence of trade on the linkage of economic cycles could not even reach half of the original model's effect, thus disproving the "riddle of trade-economy linkage".⁸ The real problem of this riddle was based on how to determine effective statistical indicators to calculate real trade intensity.⁹ Therefore, the total trade intensity in the traditional trade systems from previous studies was replaced by value-added trade intensity.¹⁰ There are three reasons to use value-added trade intensity: First, the total trade based on traditional trade statistics contains some double calculations; Second, total trade intensity cannot reflect the value-added part of exports; And third, indirect trade originating from a third country also affects the economic cycle linkage between countries. Value-added trade can clarify the implicit value added for each country adds during the trade of intermediate products by decomposing the source of value of the final product. Therefore, value-added trade is an important factor driving the linkage of world economic cycles.¹¹ Moreover, value-added trade between axle and spoke countries has an asymmetric impact on the linkage of

5 Ma Dan and He Yaxing, Crisis Transmission, Anti-globalization and Economic Cycle Synchronization, *Statistical Research*, Vol. 36, No. 7, 2019, pp. 77-90.

6 Jeffrey A. Frankel and Andrew K. Rose, The Endogeneity of the Optimum Currency Area Criteria, *The Economic Journal*, Vol. 108, 1998, pp. 1009-1025.

7 *Ibid.*

8 M. Ayhan Kose and Kei-Mu Yi, Can the Standard International Business Cycle Model Explain the Relation between Trade and Comovement? *Journal of International Economics*, Vol. 68, No. 2, 2006, pp. 267-295.

9 Romain Duval, et al., Value-added Trade and Business Cycle Synchronization, *Journal of International Economics*, Vol. 99, 2016, pp. 251-262.

10 *Ibid.*

11 Wang Zhi, et al., Measures of Participation in Global Value Chains and Global Business Cycle, *NBER Working Paper*, No. 23222, 2017.

economic cycles.¹² The impact of value-added trade is enhanced when a country is part of a cluster of signed regional trade agreements. The significant existence of the FR effect was verified according to the decomposition framework of value-added trade, and it was found that the economic cycle linkage of bilateral trade transmission is susceptible to third-party effects.¹³ Besides, more value-added trade has a stronger impact on economic cycle linkage.¹⁴ Regardless of how the empirical model is adjusted, value-added trade can transmit economic cycle linkage and exert a positive impact. Furthermore, a simulation mechanism was implemented by creating a theory to study how the “third country effect” impacts the economic cycles of the linkage between countries.¹⁵ The control effect of the added value of trade can promote the economic cycle, and the positive influence would be greater if there was a higher level of trade facilitation among countries.¹⁶

As the GVC develops, when studying the impact of value-added trade on economic cycle linkage, scholars have focused on the relationship between the embeddedness of the GVC and economic cycle linkage. Then some scholars examined the impact of global value chain embeddedness on international business cycle co-movement by using the value-added data of bilateral exports.¹⁷ At the national level, “south-north country embeddedness” has the strongest correlation of economic cycles. At the industrial level, the embeddedness of GVC in the same industry has a limited influence on economic cycle linkage, while the cross-industrial embeddedness of GVC has a substantial impact. At the regional level, the European Union (EU), North America, and the Asia-Pacific region all have a high-level embeddedness of GVC, clearly demonstrating the presence of

12 Yang Jijun, The Effect of Value-added Trade on Global Economic Linkages, *Social Sciences in China*, No. 4, 2019, pp. 26-48 & 204-205.

13 Li Genqiang and Pan Wenqing, Value Chain Embedding and Business Cycle Co-movement: A Value-added Perspective, *Statistical Research*, Vol. 36, No. 9, 2019, pp. 18-31.

14 Liu Hui Zheng and Yang Nan, Research on the Trade Transmission of Business Cycle Synergy: Based on the Perspective of Trade Coupling and Fragmentation of Production, *Research on Economics and Management*, Vol. 41, No. 3, 2020, pp. 53-71.

15 Shao Yujia and Liu Wenge, Value-added Trade and International Business Cycle Synchronization: Theoretical Simulation and Empirical Testing, *The Journal of World Economy*, Vol. 43, No. 8, 2020, pp. 100-122.

16 *Ibid.*

17 Tang Yihong, Zhang Pengyang and Mei Dongzhou, The Global Value Chain Embeddedness and International Business Cycle Co-movement: Based on the View of Value-added Trade, *The Journal of World Economy*, Vol. 41, No. 11, 2018, pp. 49-73.

economic cycle linkage in each region. Value chain integration will reduce the domestic value-added trade obtained from China's manufacturing exports.¹⁸ This will result in asymmetric effects of the economic cycle linkage between China and its trading partners, that is, the linkage effect of economic contraction is more significant than that of economic expansion.¹⁹

Existing literature on economic cycle linkage has formed a system of scientific and systematic theoretical as well as empirical analysis. However, from a research standpoint, foreign scholars focus on the characteristics of economic linkage in the EU, North America, and throughout the world, as well as explore the impact of value-added trade on major developed countries' economic linkages. In contrast, there have been a small amount of studies on developing countries, especially in Asia. At the same time, Chinese scholars tend to emphasize the establishment of a system of theory and accounting. However, there is an insufficient amount of empirical research on the linkage characteristics of economic cycles between specific regions or countries. In this paper, 35 industries with close economic links among China, Japan, and South Korea are selected to test the transmission effect of value-added trade and value chain embeddedness on economic cycle linkage from a more detailed level of industrial data. Afterwards, the characteristics of economic cycle linkage among these three countries are analyzed to provide a useful and necessary supplement to the existing research.

III. CHARACTERISTICS OF THE CHINA, JAPAN, AND SOUTH KOREA ECONOMIC CYCLE LINKAGE

The development of GVC has increased the significance of economic cycle linkage among industries in China, Japan, and South Korea. Meanwhile, the complexity of intermediate goods trade as well as the direction and magnitude of economic fluctuations are trending in the same way within the same industry, and these aspects in different industries are gradually getting closer. This paper describes the current situation of these three countries' economic cycle

18 Wen Wu, Cheng Huifang and Zhan Miaohua, Global Value Chain Embeddedness and Asymmetric Co-movement of International Business Cycle, *Statistical Research*, Vol. 38, No. 3, 2021, pp. 71-88.

19 *Ibid.*

linkage by measuring the economic cycle linkage index of 35 industries in China, Japan, and South Korea.

In calculating international economic cycle linkage, the existing literature is mainly divided into two categories: static and dynamic correlation coefficients. Despite the presence of simultaneous economic linkage between individuals, the static index is unable to reflect dynamic economic linkage due to its simple calculation. Among the dynamic coefficients, when calculating the rolling correlation coefficients, the length of rolling windows must be selected independently, which may result in incomplete observed sample values,²⁰ while practical applications of quasi-correlation coefficients have strong autocorrelations. Therefore, the C-M synchronization index is selected in this paper.²¹ This coefficient considers the instantaneous correlation between economies and its calculation covers the time factor, which can effectively identify the economic correlation of a particular year. Therefore, it aligns more closely with research on economic cycle linkage among industries in China, Japan, and South Korea discussed in this paper. Its formula is as follows:

The industrial data is from 2008 to 2019 because the UIBE GVC Index database utilized in this study only decomposed the GDP of 35 industries from 2007 to 2019, and the index of economic cycle linkage is based on the GDP growth rate. The index of economic cycle linkage among industries in these three countries contains 44,100 samples ($35 \times 35 \times 3 \times 12$), with a large amount of data. Therefore, this paper describes the calculated results in a frequency table (see Figure 1). Each small histogram corresponds to the frequency distribution of the index of economic cycle linkage in China, Japan, and South Korea within one year. The horizontal axis of each small histogram is the data of the index of economic cycle linkage, and the vertical axis represents the frequency of occurrence of the data. The range of the abscissa (co-activity index of business cycles) is $(-\infty, 1]$. If the data is closer to 1, there is a stronger economic cycle linkage. When the index equals 1, it indicates that the economic cycle trajectories among countries are exactly the same.

20 Wang Jinming and Gao Tiemei, A Study on the Synchronization of Economic Fluctuations between China and the United States and the Driving Effect of Trade, *Statistics & Decision*, No. 12, 2014, pp. 147-149.

21 Pedro André Cerqueira and Rodrigo Martins, Measuring the Determinants of Business Cycle Synchronization Using a Panel Approach, *Economics Letters*, Vol. 102, 2009, pp. 106-108.

Figure 1 indicates that from 2008 to 2019, the frequency distribution of the economic cycle linkage index of China, Japan, and South Korea in the range of $[0, 1]$ is more than that in $[-1, 0]$, indicating that there is an economic cycle linkage between the three countries' industries. Furthermore, the economic cycle linkage index is mostly distributed in the interval of $[0.75, 1]$, indicating that the economic cycle linkage between industries in China, Japan, and

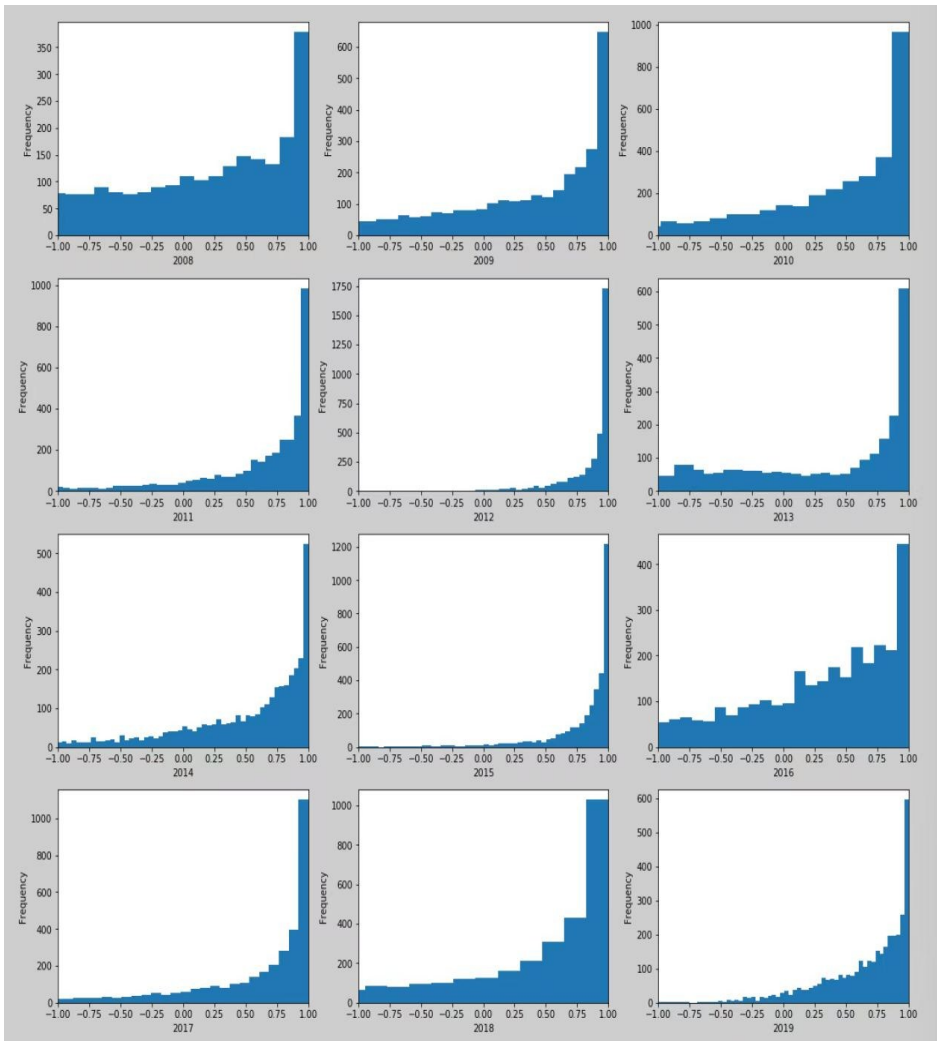


Figure 1. Frequency Distribution of Economic Cycle Linkage Index in China, Japan, and South Korea from 2008 to 2019

Source. Calculated and summarized according to the ADB-MRIOTs.

South Korea is strong. From a periodic standpoint, the exponential distribution was scattered from 2008 to 2010, and was more concentrated in the interval of $[0, 1]$ from 2011 to 2019 because the 2007-2008 financial crisis affected diverse industries in various countries in different ways. In normal circumstances, the value chain's upstream industries are significantly influenced, while there is a limited impact on the downstream industries. After 2010, the economies of several countries throughout the world recovered, and they took measures to prevent the negative impact that potentially unpredictable elements would have on their own economies. Therefore, the overall global economic environment was stable throughout this period. The economic cycle linkage index can be calculated to prove that there is an economic cycle linkage between China, Japan, and South Korea from the perspective of industrial data.

IV. EMPIRICAL ANALYSIS

In research on economic cycle linkage, scholars mostly construct empirical models from the national or industrial level to verify theoretical assumptions. It was believed that economic shocks affect upstream and downstream countries differently.²² When upstream economies are damaged, economic shocks are conveyed to downstream economies throughout the value chain. However, due to the single production mode and the highly substitutable division of labor in the value chain, when the economy of downstream countries is hit, it is poorly transmitted to upstream countries. Thus, the national economy's position in the GVC and participation of a country in the value chain can have an important impact on economic cycle linkages. The financial integration has an impact on economic cycle linkages during financial and non-financial crises: higher financial integration during crises enhances economic cycle linkages, while higher financial integration during non-crisis periods weakens economic cycle linkages.²³ An empirical study in testing the moderating role of industrial structure found a substitution relationship between industrial structure and

22 Geng Ke, The Research on the Influence of Value Chain on the Synergy of Asia-Pacific Economic Cycle, *Hainan Finance*, No. 4, 2018, pp. 17-26.

23 Yao Wen and Tang Aidi, Financial Integration and Business Cycle Synchronization, *China Journal of Economics*, Vol. 7, No. 2, 2020, pp. 61-85.

value-added trade.²⁴ A greater difference in industrial structure between China and ASEAN countries implied that there was a stronger impact of value-added trade on economic cycle linkage. Based on the model in the existing literature and the availability of industrial-level data, this paper selects the economic cycle linkage index as the explained variable, the value-added trade intensity and embeddedness of the bilateral value chain as the core explanatory variables, as well as the industrial average value chain position similarity, industrial value chain co-participation degree, industrial structure similarity, and financial integration degree as control variables to empirically study the effect of value-added trade and value chain embeddedness on the economic cycle linkage between China, Japan, and South Korea.

A. Model Setting

The empirical analysis of this paper mainly starts from three levels. First, it explores whether value-added trade and value chain embeddedness impact the economic cycle linkage between China, Japan, and South Korea. Second, it studies the impact of value-added trade and value chain embeddedness on the economic cycle linkage as well as whether it is positive. Third, it analyzes the characteristics of the value-added trade and value chain embeddedness in the same industry and across industries, as well as different industries that affect economic cycle linkage. Based on this, the following panel data model is established:

$$CORR_gdp_{ijt}^{ab} = \lambda_0 + \lambda_1 VA_trade_{ijt}^{ab} + \lambda_2 GVC_{ijt}^{ab} + \lambda_3 Control_{ijt}^{ab} + \mu + \varepsilon_{ijt}^{ab} \quad (1)$$

Specifically, $CORR_gdp_{ijt}^{ab}$ is the explained variable, and $VA_trade_{ijt}^{ab}$ is the core explanatory variable. $Control_{ijt}^{ab}$ is a series of control variables; μ is the fixed effect, including the year fixed effect μ_t and the individual fixed effect μ_{cs} ; ε_{ijt}^{ab} is the random disturbance term.

B. Indicator Description

1) Explained variable: economic cycle linkage index ($CORR_gdp$)

Based on the setting of industrial levels of China, Japan, and South Korea

24 Hu Chao, Yang Yongqin and Guo Xia, Value-added Trade, Industrial Structure Similarity and China-ASEAN Economic Linkage, *International Business Research*, Vol. 42, No. 2, 2021, pp. 51-64.

and the applicability analysis of the international economic cycle linkage index in the existing literature, this paper constructs the calculation index at the industrial level:

$$CORR_gdp_{ijt}^{ab} = 1 - \frac{1}{2} \left[\frac{(d_{it}^a - \bar{d}_i^a)}{\sqrt{\frac{1}{T} \sum_{t=1}^T (d_{it}^a - \bar{d}_i^a)^2}} - \frac{(d_{jt}^b - \bar{d}_j^b)}{\sqrt{\frac{1}{T} \sum_{t=1}^T (d_{jt}^b - \bar{d}_j^b)^2}} \right] \quad (2)$$

$CORR_gdp_{ijt}^{ab}$ represents the economic cycle linkage of industry a in country i and industry b in country j in period t ; d_{it}^a and d_{jt}^b are the GDP growth rates of industry a in country i and industry b in country j in period t ; $\bar{d}_i^a$ and $\bar{d}_j^b$ are the average GDP growth rates of industry a in country i and industry b in country j .

2) Core explanatory variables

A country's total exports can be decomposed into intermediate product exports and final product exports according to product flow, and can be decomposed into domestic value added, foreign value added, and double counting according to the source of value added. From the perspective of formula decomposition, if a model of three countries and two sectors is constructed, and it is assumed that the three countries are s , r , and t , and the two industrial sectors are 1 and 2, according to the Leontief inverse matrix and the value-added coefficient matrix, the total export can be decomposed for:

$$E^{sr} = \underbrace{A^{sr} X^t + Y^{sr}}_{①} = \underbrace{DVA + RDV + FVA + PDC}_{②} \quad (3)$$

Among them, E^{sr} is the total export of country s to country r , ① is the export of intermediate products and final products, $A^{sr} X^t$ is the export of intermediate products, Y^{sr} is the export of final products, and ② is the decomposition part of the total export under the caliber of added value. As shown below:

DVA is the domestic value added absorbed by the importing country. This is the main component of value-added trade, reflecting the part of a country's export that is classified as the added value of domestic output. FVA is foreign value added, representing the use of foreign output value in a country's exports. DVA and FVA are the two main components of total exports. PDC is the pure double counting.

3) Value-added trade intensity (VA_trade)

Value-added trade reflects the importance of domestic value-added in

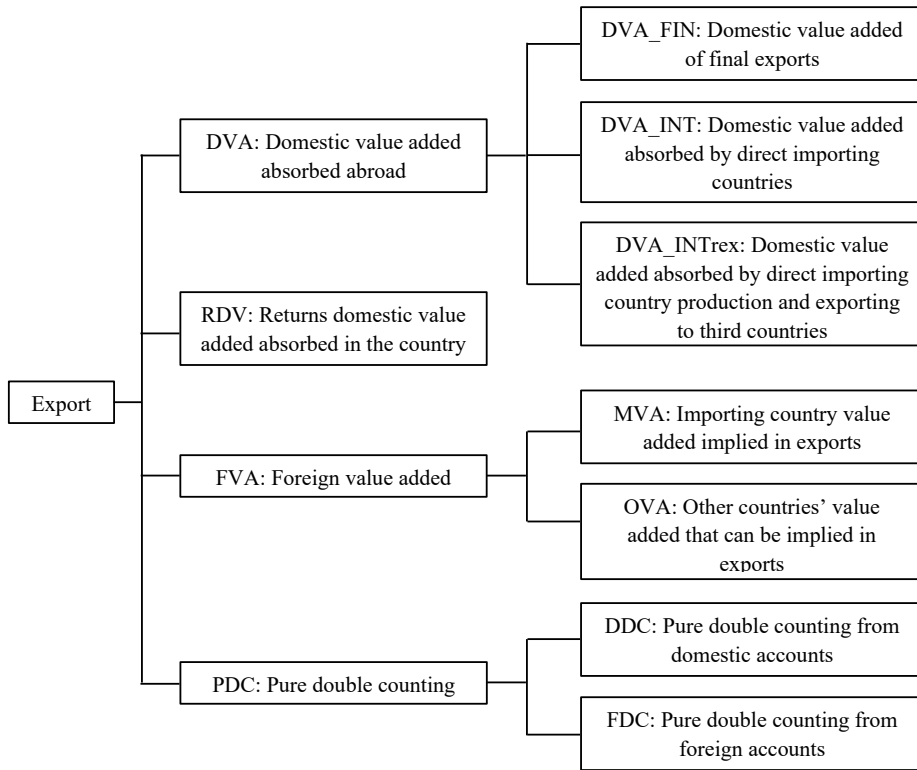


Figure 2. Breakdown Structure of Total Exports

exports. Here, we refer to the value-added trade indicator:²⁵

$$VA_trade_{ijt}^{ab} = \ln \left[\frac{DVA_{it}^a + DVA_{jt}^b}{export_{it}^a + export_{jt}^b} \right] \quad (4)$$

$VA_trade_{ijt}^{ab}$ represents the value-added trade intensity of industry a in country i and industry b in country j in period t . The DVA_{it}^a and DVA_{jt}^b in the numerator represent the implied domestic value added in the export of industry a in country i and industry b in country j in period t . The denominator is the sum of the export trade between the two countries.

4) Bilateral value chain embeddedness (GVC)

Bilateral value chain embeddedness represents the proportion of foreign production in a country's exports, and reflects the contribution of a particular country's added value to its own exports. Its calculation formula is as follows:

²⁵ *Supra* n. 9.

$$GVC_{ijt}^{ab} = \ln \left[\frac{FVA_{it}^a + FVA_{jt}^b}{export_{it}^a + export_{jt}^b} \right] \quad (5)$$

GVC_{ijt}^{ab} represents the mutual embeddedness of the value chain of industry a in country i and industry b in country j in period t , where FVA_{it}^a represents the foreign added value from industry b in country j included in the export of industry a in country i in period t . The same is true for FVA_{it}^a . The denominator is the total industrial exports of the two countries.

C. Control Variables

1) Industrial average value chain position similarity index (PSI)

Drawing on the theoretical explanation of the position of the GVC,²⁶ the relative position of a country and an industry in the global production network is used to construct the calculation index:

$$PSI_{ijt}^{ab} = -|GVC_pos_{it}^a + GVC_pos_{jt}^b| \quad (6)$$

PSI_{ijt}^{ab} represents the relative position similarity index of the average value chain of industry a in country i and industry b in country j in period t . $GVC_pos_{it}^a$ and $GVC_pos_{jt}^b$ are the GVC positions of industry a in country i and industry b in country j in period t , which are the ratios of forward and backward industrial linkages.

2) Industrial value chain participation index (PAR)

The value chain participation in constructing GVC indicators was:²⁷

$$PAR_{ijt}^{ab} = \ln(GVC_par_{it}^a + GVC_par_{jt}^b) \quad (7)$$

$GVC_par_{it}^a$ and $GVC_par_{jt}^b$ are the sum of the indirect value-added export and import of foreign intermediate products. These are compared with the total export trade to obtain the GVC participation of industry a in country i and industry b in country j in period t . It is the result of taking the logarithm of the sum of the industrial value chain participation in the two countries.

3) Industrial structure similarity index (SIS)

Countries with similar industrial structures have similar economic trends

26 Hubert Escaith and Satoshi Inomata, The Evolution of Industrial Networks in East Asia: Stylized Facts and Role of Trade Facilitation Policies, *Production Networks and Enterprises in East Asia*, Tokyo: Springer, 2016, pp. 113-138.

27 Robert Koopman, Wang Zhi and Wei Shang-Jin, How Much of Chinese Exports Is Really Made in China? Assessing Domestic Value-added When Processing Trade Is Pervasive, *NBER Working Papers*, No. 14109, 2008.

when the international environment affects their economies.²⁸

$$SIS_{ijt}^{ab} = -\ln \left[\left| IS_{it}^a + IS_{jt}^b \right| \right] \quad (8)$$

IS_{it}^a and IS_{jt}^b respectively represent the share of the output of industry a in country i and industry b in country j in the total GDP of the country in period t , and the logarithm of the absolute value of the difference between the two indicators is multiplied by -1 to convert it into a similarity index.

4) Bidirectional financial integration index (FII)

The transmission mechanism of financial integration for economic cycle linkage was analyzed in the study of economic cycle linkage.²⁹ Therefore, scholars included the degree of financial integration into the follow-up research. This paper introduces the financial development index to reflect the degree of bilateral financial integration. The index includes the financial scale, liquidity, ability to provide financial services, and efficiency between countries.³⁰

$$FII_{ijt}^{ab} = FDI_{it}^a + FDI_{jt}^b \quad (9)$$

FDI_{it}^a and FDI_{jt}^b respectively represent the financial development index of industry a in country i and industry b in country j in period t , and the sum of the two constitutes the bilateral financial integration index.

D. Data Description

Indicators selected in this paper are mostly based on the input-output table of countries in the ADB-MRIOTs, among which the UIBE GVC Index database contains the value-added trade and GVC data of 35 industries after the input-output table is decomposed. Since the growth rate indicator is included in the calculation of the economic cycle linkage index, this paper uses 2007 as the base period to calculate the indicators of 35 industries in China, Japan, and South Korea from 2008 to 2019 to construct the sample database for this paper. Since the industrial output of China c19, c35, and South Korea c35 is 0, some indicators cannot be logarithmic. Therefore, the two individuals “China

28 Eric C. Y. Ng, Production Fragmentation and Business-cycle Comovement, *Journal of International Economics*, Vol. 82, No. 1, 2010, pp. 1-14.

29 Jean Imbs, Trade, Finance, Specialization and Synchronization, *The Review of Economics and Statistics*, Vol. 86, No. 3, 2004, pp. 723-724.

30 Katsiaryna Svirydenka, Introducing a New Broad-based Index of Financial Development, *IMF Working Papers*, Vol. 15, No. 5, 2016.

c19 $\times$ South Korea c35” and “China c35 $\times$ South Korea c35” are excluded. The specific data sources and descriptive statistics of each variable are shown in Table 1.

Table 1. Data Sources and Descriptive Statistics

Variables Identify	Data Sources	Sample Size	Mean	Std. Dev.	Min	Max
<i>CORR_gdp</i>	ADB-MRIOTs	44076	0.074500	1.390523	-16.69638	1.000000
<i>VA_trade</i>	UIBE GVC Index	44076	-4.812497	1.652918	-37.80085	-1.425148
<i>GVC</i>	UIBE GVC Index	44076	-4.069432	1.619668	-23.40786	-1.384911
<i>PSI</i>	UIBE GVC Index	44076	-4.069432	1.619668	-23.40786	-1.384911
<i>PAR</i>	UIBE GVC Index	44076	-0.545824	0.571081	-4.148885	0.784758
<i>SIS</i>	ADB-MRIOTs	44076	3.888956	1.302972	1.530001	12.87069
<i>FII</i>	IMF Database	44076	1.445140	1.383300	-1.000000	4.000000

E. Basic Regression Results and Analysis

In addition to the variables chosen for the model, there are additional impractical variables affecting economic cycle linkage that are not included in the study. If the omitted variables are correlated with existing explanatory and explained variables, estimation results of the model will be inaccurate. Moreover, the variables selected in the study are all macroeconomic, which raise the possibility of endogeneity issues among variables. Therefore, this paper adopts the double fixed effect model to address biased estimates resulting from omitted variables and endogeneity issues. At the same time, the likelihood-ratio (LR) test statistics of individual and period effects were constructed. The results were much higher than the critical value, indicating that the intercept of the model varies with each individual and period. The model also passed the Hausman test, which further confirmed the applicability of the double fixed effect model. The regression results of the model are shown in Table 2, where (1) and (2) are listed as regression results of the benchmark model without control variables and with a series of introduced control variables. In order to ensure the stability of the model, this paper also includes output linkage to replace GDP linkage to measure the industrial economic cycle linkage index to form the explained variables. The results are shown in columns (3) and (4).

Table 2. Double Fixed Effect Model Regression Results

Explained Variables	Economic Cycle Linkage (GDP)		Economic Cycle Linkage (Output)	
	(1)	(2)	(3)	(4)
<i>VA_trade</i>	0.3311** (0.1453)	0.2937** (0.1323)	0.1035** (0.0382)	0.0805** (0.0319)
<i>GVC</i>	0.1995*** (0.0325)	0.1487*** (0.0297)	0.1110*** (0.0294)	0.0771*** (0.0276)
<i>PSI</i>		0.2960 (0.2514)		0.4004 (0.2878)
<i>PAR</i>		0.4647*** (0.1217)		0.5886*** (0.1276)
<i>SIS</i>		0.0449*** (0.0169)		0.0649** (0.0286)
<i>FII</i>		0.6326*** (0.0217)		0.4002*** (0.0277)
<i>_cons</i>	1.2424 (0.7544)	0.5345** (0.1776)	0.8180*** (0.2296)	0.4014* (0.2140)
μ_t	Control	Control	Control	Control
μ_{cs}	Control	Control	Control	Control
R^2	0.1900	0.2144	0.3018	0.3085
Sample Size	44076	44076	44076	44076

Note. ***, ** and * means $p < 0.01$, $p < 0.05$ and $p < 0.1$, respectively.

According to the regression results in Table 2, the following conclusions can be drawn. First of all, based on the significance results of the core explanatory variables in the model, the regression results of value-added trade intensity and bilateral value chain embeddedness are significant regardless of whether control variables are cited, confirming the first level of empirical analysis. Value-added trade and value chain embeddedness can impact economic cycle linkage in China, Japan, and South Korea. Secondly, the regression coefficient between value-added trade intensity and bilateral value chain embeddedness is positive in all models, which verifies the second level of empirical analysis. Both value-added trade and value chain embeddedness can positively impact economic cycle linkage in China, Japan, and South Korea. Finally, the study also found that except for the industrial average value chain position similarity which was not significant, other control variables including industrial value chain participation, the degree of industrial structure similarity, and financial integration were significantly positive. It also found that when the industrial

value chain embeddedness between China, Japan, and South Korea is higher, they have more similar industrial structures, closer financial ties, and stronger linkages among their economic cycles. At the same time, the robustness test results of replacing GDP linkage with output linkage as the explained variable were essentially compatible with the original model's results, which also verified the accuracy of model setting and robustness of regression results.

F. Indirect Effects of Value-added Trade and Value Chain Embeddedness

Value-added trade includes not only the import of intermediate products in the same industry, but also the processing and use of intermediate products across industries. Therefore, in the context of GVC, the value of traded products derives from the added value of each industry. Value-added trade intensity analyzes the contribution of domestic value-added to exports from the perspective of domestic output in exports, whereas value chain embeddedness examines the contribution of value-added from other countries to exports from the perspective of foreign output in exports. If a country uses more foreign value-added in an industry's output, it will "crowd out" its domestic value-added in the output of that industry, which is detrimental to the economy's cyclical linkage. However, the "crowding out" effect of bilateral value chain embedded in the same industry differs from that of value chains embedded in separate industries. In contrast, the "crowding out" effect is more likely to occur in the same industry, and the utilization of foreign value-added between different industries will increase the content of domestic value-added in exports. The rationale is that if an industry uses more foreign value added from other sectors, the demand for intermediate products of associated upstream and downstream industries will increase, which increases the proportion of value added of domestic output in exports. Next, in this paper, regression analysis is conducted by introducing the interaction term of value-added trade intensity and bilateral value chain embeddedness in order to examine the indirect effect of the embeddedness of bilateral value chains among 35 industries in China, Japan, and South Korea on the impact of value-added trade on economic cycle linkage. At the same time, the total sample is divided into two parts: the same industry and cross-industry. The regression results are shown in Table 3.

Table 3. Regression Results of Indirect Effects of Bilateral Value Chain Embeddedness

Explained Variables	Economic Cycle Linkage (GDP)	
	Same Industries	Different Industries
<i>VA_trade</i>	0.6169** (0.3032)	0.4616*** (0.0530)
<i>GVC</i>	0.0482* (0.3112)	0.3615*** (0.0598)
<i>VA*GVC</i>	-0.0114* (0.0486)	0.0387*** (0.0102)
<i>PSI</i>	2.9602** (1.2825)	0.2054 (0.2008)
<i>PAR</i>	0.6271 (0.6486)	0.4350*** (0.1060)
<i>SIS</i>	0.1977** (0.0714)	0.0416** (0.0122)
<i>FII</i>	0.7580*** (0.1153)	0.6257*** (0.0190)
_cons	2.0653 (1.7754)	1.3986*** (0.2975)
μ_t	Control	Control
μ_{cs}	Control	Control
R ²	0.2187	0.2150
Sample Size	1248	42828

From the regression results: First, the regression coefficients of value-added trade intensity are significantly positive for both the same industry and distinct industries. Moreover, value-added trade within the same industry has a stronger impact on China-Japan-Korea economic cycle linkage as compared to different industries. Secondly, the regression coefficient of bilateral value chain embeddedness is also positive and passes the significance test. It indicates that a higher value chain embeddedness implies a stronger economic cycle linkage between countries, and that the influence of bilateral value chain embeddedness between different industries on economic cycle linkage is greater than that within the same industry. The regression coefficient of the interaction term between value-added trade intensity and value chain embeddedness is negative among the same industries, indicating a “crowding out” effect, while the regression coefficient of this term is positive among different industries, indicating that this effect is not evident among different industries. Therefore, it can be concluded that when examining the 35 industries of China, Japan, and South

Korea, the positive impact of value-added trade on the economic cycle linkage within the same industry is greater than that of bilateral value chain embeddedness, which will have a “crowding out” effect on the value-added trade. A higher bilateral value chain embeddedness implies a greater role of value-added trade in promoting economic cycle linkage. However, the positive impact of value-added trade between different industries is less than that within the same industry, and there is a greater impact of bilateral value chain embeddedness. Nonetheless, the “crowding-out” effect of bilateral value chain embeddedness on value-added trade is not obvious and may have a regulatory role. A higher bilateral value chain embeddedness implies a greater role of value-added trade in promoting economic cycle linkage.

G. Industrial Heterogeneity Test

The varying positions of different industries in the GVC and the length of the production chain may lead to industrial heterogeneity in the impact of value-added trade and value chain embeddedness on economic cycle linkage. Therefore, this paper will analyze the mechanism of interaction between value-added trade and the value chain embeddedness in the context of vertical division of labor between different industries. The total sample is divided according to industrial types. As a result of the limited sample size of primary products, the proportion of China-Japan-Korea trade is extremely small, which will likely cause biased estimates. Therefore, only the manufacturing and service industries are selected for industrial heterogeneity research.

Based on the regression results in Table 4, the coefficients of value-added trade intensity and bilateral value chain embeddedness in each industry are always positive. Moreover, both of these are significant at the 5% level, indicating that the core conclusions of this paper remain robust. In addition, industrial heterogeneity will not alter the positive impact of China-Japan-Korea value-added trade and value chain embeddedness on economic cycle linkage of these three countries. In particular, value-added trade within the manufacturing industry has the greatest impact on economic cycle linkage, followed by value-added trade between the manufacturing and service industries, and value-added trade within the service industry. Since manufacturing is a major contributor to value-added trade in China, Japan, and South Korea, domestic value-added accounts

for a larger proportion of manufacturing exports. Therefore, it can be argued that the trade of added value has a stronger effect on economic cycle linkage within the industry where the export implies more domestic added value. Moreover, value chain embeddedness between the manufacturing and service industries has a greater effect on economic cycle linkage as compared to value chain embeddedness inside either the manufacturing or service industries. The reason is that the embeddedness relationship between these two industries is more stable and can form a complete value chain transmission, hence strengthening inter-industrial economic cycle linkage.

Table 4. Regression Results of Industrial Heterogeneity Test

Explained Variables	Economic Cycle Linkage (GDP)		
	Inside Manufacturing	Inside Service	Between Manufacturing and Services
<i>VA_trade</i>	0.8220*** (0.0601)	0.0957** (0.0329)	0.6358*** (0.1380)
<i>GVC</i>	0.2152*** (0.0393)	0.1606** (0.0309)	0.3423*** (0.0724)
<i>PSI</i>	0.2024 (0.2924)	0.0379 (0.3720)	-2.5878*** (0.4827)
<i>PAR</i>	0.0865 (0.1544)	0.7016*** (0.1810)	0.3787 (0.2766)
<i>SIS</i>	0.0249 (0.0172)	-0.0093 (0.0373)	0.0373 (0.0277)
<i>FII</i>	0.6215*** (0.0266)	0.8539*** (0.0373)	0.2562*** (0.0418)
<i>_cons</i>	2.9319*** (0.3317)	0.3408 (0.3407)	1.6895** (0.5638)
μ_t	Control	Control	Control
μ_{cs}	Control	Control	Control
R^2	0.2005	0.2793	0.2152
Sample Size	7056	12972	19152

V. CONCLUSION AND COUNTERMEASURES

This paper decomposes the input-output tables of 35 industries in China, Japan, and South Korea, summarizes and calculates the data, and depicts the status of economic cycle linkage of these three countries between 2018 and 2019. Then,

a panel data model is constructed to empirically test the impact of value-added trade and value chain embeddedness on economic cycle linkage between these countries, and an extended regression is conducted to research the indirect effects and industrial heterogeneity of value-added trade and value chain embeddedness. The conclusion is as follows:

Firstly, the industry's economic cycle linkage index calculation results show that the number of positive indices is greater than that of negative indices from 2008 to 2019. In addition, the index range is mostly in $[0.75, 1]$, indicating that there is not only economic cycle linkage between China, Japan, and South Korea, but it is strong.

Secondly, empirical research shows that value-added trade and value chain embeddedness have a significant positive effect on economic cycle linkages between industries in China, Japan, and South Korea, regardless of whether control variables are introduced. That is, a greater intensity of value-added trade implies a higher embeddedness of the bilateral value chain and a stronger economic cycle linkage between the industries of these three countries, which is consistent with the theoretical research conclusions.

Thirdly, value chain embeddedness and value-added trade indirectly affect the transmission of economic cycle linkage between China, Japan, and South Korea. Within the same industry, value chain embeddedness will have a "crowding out" effect on value-added trade. Nonetheless, this effect is not obvious between different industries. On the contrary, a higher embeddedness of the bilateral value chain implies that value-added trade has a greater impact on economic cycle linkage.

Lastly, regardless of whether it is the manufacturing industry, service industry, or both, value-added trade and value chain embeddedness can have a significantly positive impact on economic cycle linkage. Among these factors, value-added trade within the manufacturing industry has the strongest effect on promoting this linkage, followed by the manufacturing and service industries, and also within the service industry. In other words, industries with more added value implied in exports have value-added trade with a greater impact on economic cycle linkage. Moreover, the embeddedness of the bilateral value chain between the manufacturing and service industries has a more significant effect on promoting this linkage within the manufacturing industry or the service industry.

Based on these conclusions, this paper proposes several suggestions for future trade cooperation between China, Japan, and South Korea as well as China's response to the risk of economic cycle linkage:

Firstly, China, Japan, and South Korea should strengthen their consensus on trade cooperation between them, and also need to further expand the fields of industrial cooperation. Since export trade can achieve a virtuous circle of domestic and foreign added values as well as effectively promote economic cycle linkage between the industries of these three countries, they should increase their industrial cooperation, promote in-depth development of regional value chains, and achieve mutual benefit. At the same time, value-added trade within the manufacturing industry has a strong transmission effect on economic cycle linkage. During the fourth industrial revolution, they should work together to cooperate in high-end manufacturing fields related to machinery, automobiles, and optoelectronic equipment while continually deepening their respective niche areas of expertise. They should also innovate their industrial technology cooperation and participate in more trade exchanges involving intermediate products.

Secondly, these three countries should strengthen their service trade cooperation and promote a “two-wheel drive” between high-end manufacturing and advanced producer services. During the fourth industrial revolution, trade exchanges between them have gradually expanded to high-tech fields such as the Internet, mobile payments, and the blockchain. In addition, they maintain their technological superiority in 5G, artificial intelligence, big data services, and other fields. The interaction between manufacturing and producer services is mutually supportive. This will inevitably promote the further integration of these two factors, which will undoubtedly benefit value-added trade in these countries. The optimization of regional resource allocation will improve the stability of the regional value chain and form positive interactions between these countries' economies.

Thirdly, they should maximize the dividends of trade agreements to extend the “China-Japan-Korea + X” cooperation model. The entry into force of RCEP will further reduce the cost of trade in goods among these three countries, improve investment facilitation, establish new standards for service trade and the flow of natural persons, and reshape the value chain structure of these

countries. These countries will constitute a paradigm of increased collaboration and economic expansion. At the same time, they can iterate the BRI to participate in “fourth-party market” cooperation and create a new method of international industrial cooperation. China should conduct in-depth free trade agreement (FTA) negotiations with Japan and South Korea, sign a higher-quality and more comprehensive China-Japan-South Korea FTA as soon as possible, as well as build a China-led regional value chain and technological innovation chain based on trade agreements and regional cooperation projects.

Finally, they should prevent the risk of regional economic linkage and concentrate on promoting “dual circulation”. These three countries frequently have trade exchanges, the bilateral value chain between their respective industries is highly embedded, and their economic cycle linkage is continuously strengthened, which makes China’s domestic economy more susceptible to external shocks. Therefore, it is important to immediately implement heightened risk awareness and an early warning system. While actively utilizing the international market and regional market externally to enable production factors to flow efficiently, internally we should break down institutional barriers and enact supply-side structural changes by implementing high-level institutional reforms. When encountering domestic and international economic risks, the international and domestic cycles can complement each other to ensure the safety and stability of China’s supply chain.