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Decomposing Intra-industry and Net One-way Trade of East Asian Food Market

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Previous studies use numerous measures to examine regional trade structures and describe comparative advantages or interdependence between regions. Recently, however, studies adopting social network analysis to trade have become a growing concern. This study analyzes structural changes in intra-regional trade of food market in East Asia by decomposing trade networks and creating consistency between reciprocity as measured by Squartini et al. (2013) and the Grubel–Lloyd index of intra-industry trade. We confirm East Asia’s intra-industry trade in foods has deepened, however, its position in overall trade remains small in a comparison with each country’s centrality in reciprocated and non-reciprocated networks.

Key words: reciprocity of network, intra-industry trade, food trade in East Asia

1. Introduction

Clarifying trade structures is a central issue in discussions regarding interdependence among economies. Intra-industry trade underlies product differentiation, increasing returns to scale, diversified preferences, and internationalized production, and studies have proposed various intra-industrial measures of global or regional trade.

Social network analysis—a prominent approach in recent scholarship—examines world trade flows as a structure of networks. Squartini et al. (2013) introduced weighted reciprocity of a weighted network (SPRG reciprocity) as aggregations of reciprocity between vertices, which refers to the overlap between the in- and out-strengths of a vertex. Applying this method, they examined changing reciprocity in the world trade web.

However, both intra-industry trade and reciprocity measures evaluate overlapping trade, and assuring consistency between their respective measures is essential. We demonstrate that SPRG reciprocity for an entire market can be decomposed into the sum of trade-weighted bilateral Grubel–Lloyd intra-industry trade measures (GL-IIT). Since non-reciprocated measures also can be understood as net one-way trade networks, our approach can decompose an entire trade network into reciprocated (intra-industry) and non-reciprocated (net one-way) networks.

Relying solely on intra-industry trade measures does not capture features of an entire trade structure, however. Our decomposition reveals how reciprocated (intra-industry) and non-reciprocated (net one-way) trade contribute to overall trade flows. Further, social network analysis employs a centrality measurement that describes structures of entire networks. Applying a degree centrality measure to reciprocated and non-reciprocated trade networks clarifies which countries dominate each trade network.

Section 3 applies this approach to inter-regional trade in food & beverages in East Asia. Earlier regional studies, including those of Northeast and Southeast Asia, examine changes in comparative advantage or intra-industry trade phenomena. Our approach aids in understanding the region’s markets from the perspective of one-way and two-way trade.

2. Decomposition of Trade Networks

1) Reciprocated network (intra-industry trade)

X_{ij}^k signifies the flow of commodity k from country i to country j . The total trade volume of commodity k (X^k) is denoted as

$$X^k = \sum_i \sum_j X_{ij}^k. \quad (1)$$

Therefore, the bilateral trade share of this commodity (x_{ij}^k) is described as

$$x_{ij}^k = \frac{X_{ij}^k}{X^k}. \quad (2)$$

With trade flow thus defined, X_{ij}^k shows the export of

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commodity k from country i to country j , and X_{ji}^k is the import by country i from country j .

Squartini et al. (2013) defines reciprocated weight at the weighted network ($X_{ij}^{\leftrightarrow,k}$) as

$$X_{ij}^{\leftrightarrow,k} \equiv \min[X_{ij}^k, X_{ji}^k]. \quad (3)$$

They introduce a reciprocal network-wide measure (r_{ij}^k)—SPRG reciprocity—as

$$r_{ij}^k \equiv \frac{\sum_i \sum_j X_{ij}^{\leftrightarrow,k}}{X^k}. \quad (4)$$

The GL-IIT measure of trade in commodity k between country i and j (IIT_{ij}^k) is defined as

$$IIT_{ij}^k \equiv 1 - \frac{|X_{ij}^k - X_{ji}^k|}{X_{ij}^k + X_{ji}^k} = 2 \times \frac{X_{ij}^{\leftrightarrow,k}}{X_{ij}^k + X_{ji}^k}. \quad (5)$$

The right-hand side is derived from the definition of the reciprocated weight in equation (3).

By introducing the trade weight as $w_{ij}^k = \frac{X_{ij}^k + X_{ji}^k}{\sum_i \sum_j (X_{ij}^k + X_{ji}^k)}$, we decompose SPRG reciprocity into a weighted sum of the GL-IIT index as

$$r_{ij}^k = \sum_i \sum_j w_{ij}^k \times IIT_{ij}^k \quad (6)$$

2) Non-reciprocated network (net one-way trade)

Suppose the comprehensive measure of a non-reciprocated market (nr_{ij}^k) is defined as

$$nr_{ij}^k \equiv 1 - r_{ij}^k = \frac{X^k - X^{\leftrightarrow,k}}{X^k} = \frac{\sum_i \sum_j (X_{ij}^k - X_{ij}^{\leftrightarrow,k})}{X^k}. \quad (7)$$

Then the entire market is decomposed into a reciprocated intra-industry network (r_{ij}^k) and a non-reciprocated net one-way trade network (nr_{ij}^k) as

$$x_{ij}^k = \underbrace{w_{ij}^k \times IIT_{ij}^k}_{r_{ij}^k} + \underbrace{\frac{X_{ij}^k - X_{ij}^{\leftrightarrow,k}}{X^k}}_{nr_{ij}^k}. \quad (8)$$

3) Centrality of (non-) reciprocated trade network

Barrat et al. (2004) and Opsahl et al. (2010) employ the centrality measurement of social network analysis to describe weighted network structures. Here, centrality measures for a reciprocated intra-industry trade network and for a non-reciprocated one-way trade network describe which countries dominate each trade network.

The degree centrality measure of (symmetric)

reciprocated intra-industry trade network ($d_{r_i}^k$) is given by

$$d_{r_i}^k = \sum_j r_{ij}^k = \sum_j r_{ji}^k. \quad (9)$$

Inward degree centrality ($d_{nr_i}^{in,k}$) and outward degree centrality ($d_{nr_i}^{out,k}$) for a non-reciprocated (net one-way) trade network are defined as

$$d_{nr_i}^{in,k} = \sum_j nr_{ij}^k \text{ and } d_{nr_i}^{out,k} = \sum_j nr_{ji}^k. \quad (10)$$

3. Application to East Asian Trade Networks

1) Literature review

This section decomposes the structure of East Asian trade in food & beverages. East Asian economies have grown through regional economic partnerships or agreements, and numerous studies examine their inter-dependence and/or intra-industry trade. Kiminami and Kiminami (2000), and Kiminami and Kiminami (2002) indicated that East Asian intra-industry trade in processed foods and intermediate products has been rather extensive and that averages for bilateral GL-IIT indexes among regions have risen. Kanada (2013) estimated intra-industry trade in food-related commodities in East Asia using Harmonized System and Broad Economic Category (BEC) classifications. It shows a growing concern regarding the deepening of intra-industry trade in East Asia.

2) Data

We use the United Nations Comtrade Database to estimate trade structures from 1998 to 2012. Following Kanada (2013), we adopted the three-digit BEC classification to distinguish between primary and processed foods and between industry and household consumption. Specifically, we examined BEC classifications 111 (primary food & beverages mainly for industry), 112 (primary food & beverages mainly for household consumption), 121 (processed food & beverages mainly for industry), and 122 (processed food & beverages mainly for household consumption). We investigated Cambodia, China (mainland), Macau, Hong Kong, Indonesia, Japan, Republic of Korea, Malaysia, Singapore, Thailand, Other Asia, nes²⁾, Philippines, Timor-Leste, Mongolia and Viet Nam³⁾. We estimate trade flows using nominal values for imports without deducting re-imports.

2) These regions' data includes Taiwan's trade in practice. Refer <http://unstats.un.org/unsd/tradekb/Knowledgebase/Taiwan-Province-of-China-Trade-data>.

3) Because of data availability, Democratic People's Republic of Korea, Lao People's Democratic Republic, Negara Brunei Darussalam, and Myanmar are not included in this study.

3) Analysis

Figure 1 demonstrates changes in SPRG reciprocity among the four product classifications during 1998–2012. Kanada(2013) shows the sum of weighted bilateral GL-IIT measures for 12 economies in East Asia for 2008–2010. This measure is consistent with SPRG reciprocity. Kanada(2013) examined deepening intra-industry trade using a different measure to compare 1998–2001 and 2008–2010.

Our estimations for the 2000s generally mirror his results, albeit with a few divergences. For instance, Figure 1 indicates that reciprocity of trade in processed food & beverages for household consumption (BEC 122) increased drastically.

Moreover, Kanada (2013) noted a decline in intra-industry trade in primary food & beverages for industry (BEC 111) between 1998–2001 and 2008–2010. By contrast, we find that measures of reciprocated trade declined drastically from the late 1990s to mid-2000s but revived in the early 2010s (Figure 1). After 2000, in East Asia, reciprocity increased for food & beverages and declined for processed food consumed industrially (BEC 121).

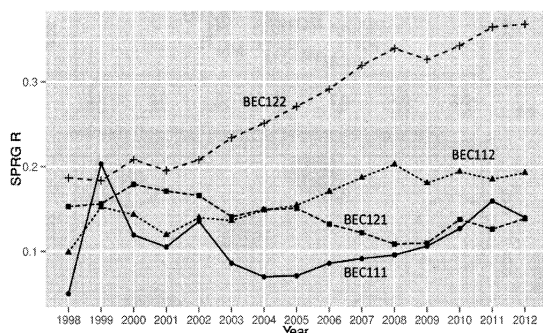


Figure 1. The SPRG reciprocity of food related commodities in East Asia trade network

Decomposing a trade network into reciprocated and non-reciprocated subnetworks aids in showing countries' relative positions in both subnetworks. We examine changes in relative positions by plotting the degree centrality in reciprocated and non-reciprocated trade. Figure 2-5 indicates changes in reciprocity and reveals structures for 1998–2002, 2003–2007, and 2008–2012. Finding above justifies to examine systematically changes in structures for 1998–2002, 2003–2007 and 2008–2012.

The top, middle, and bottom portions of Figure 2-5 for each BEC classification show each economy's centrality in the reciprocated and non-reciprocated network. The label of plot stands for ISO 3166-1-alpha-2 code⁴⁾. The vertical axis in Figure 2-5 indicates the degree centrality in the reciprocated network (Eq. (9)), revealing each economy's relative significance in intra-industry trade. The positive (negative) areas of the horizontal axis indicate the out-degree (in-degree) centrality in the net one-way trade network (Eq. (10)). This indicates an economy's relative importance as an exporter (importer) in non-reciprocated (net one-way) trade. To avoid overlap of economy labels, we insert a gap between the positive and negative panel for degrees centrality in non-reciprocated networks. The area of the white (gray) circle coincides with annual average export (import) volume during the three periods. This diagram compares market size and growth between commodities.

These figures present several noteworthy considerations. Figure 2 indicates that Indonesia and China are significant in the network of reciprocated trade in primary food & beverages for industry (BEC 111). It also indicates that centrality changed over time. Decline in reciprocity during mid of 2000s shown in Figure 1 is consistent with a significant decline in centrality of Indonesia in reciprocated network during 2003–2007.

In non-reciprocated trade networks, China and Indonesia are large exporters. Japan, Hong Kong, Singapore, Malaysia and Korea are the main importers. During 1998–2002, Japan and Hong Kong were dominant importers, although Malaysia subsequently became the largest importer. Korea and Singapore raised imports to levels approaching Japan and Hong Kong.

Figure 3 shows that China occupies the center of reciprocated trade in primary food & beverages for household consumption (BEC 112) for all investigated periods. Its centrality intensified throughout the three periods. Japan is a persistently important presence in reciprocated trade. From 2003–2007 onward, the centrality of Korea and Thailand increased. In non-reciprocated trade, China is the largest exporter and Japan is the largest importer. Japan's import values held steady throughout the three periods.

4) We can refer the page "United Nations Code for Trade and Transport Locations (UN/LOCODE)" by UNECE (<http://www.unece.org/cefact/locode/service/location>). And 'TW' represents Other Asia, nes. (See footnote 1)

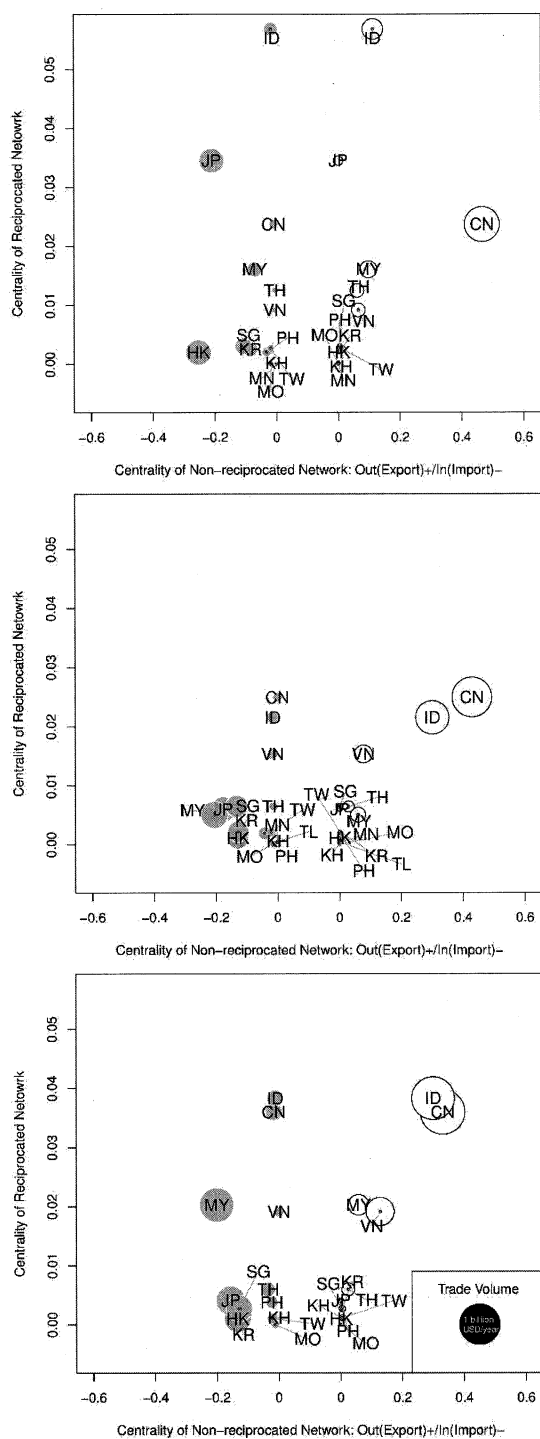


Figure 2. Centrality in Reciprocated and Non-Reciprocated Trade for Classification BEC 111 (Top: 1998-2002, Middle: 2003-2007, Bottom: 2008-2012)

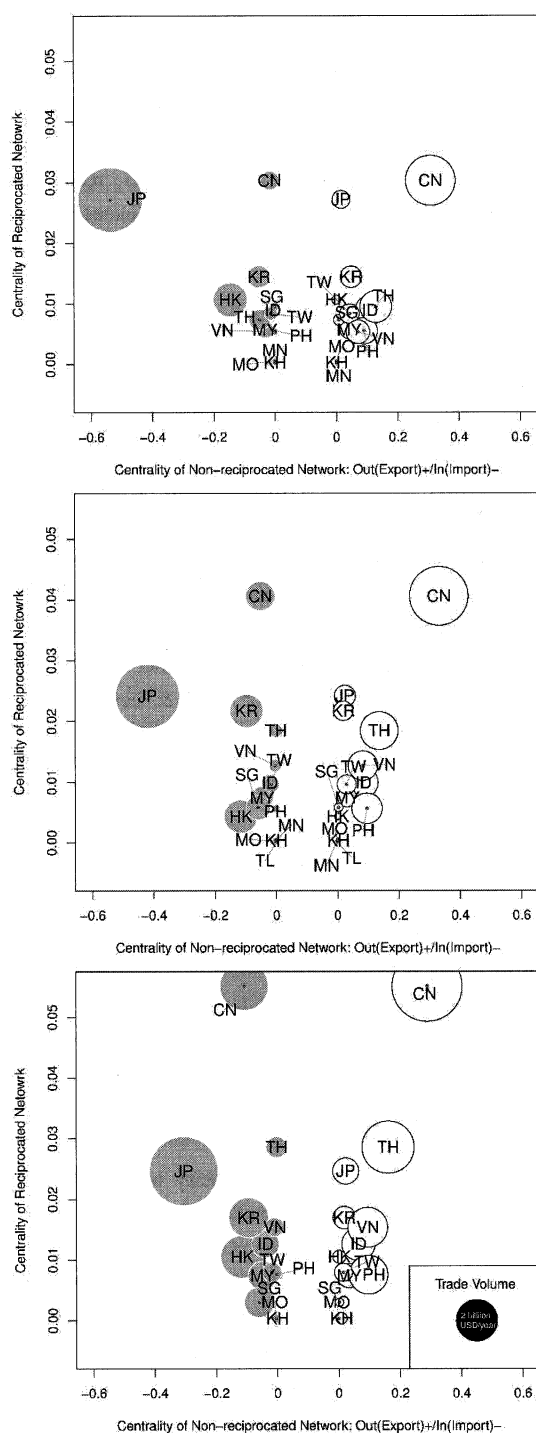


Figure 3. Centrality in Reciprocated and Non-Reciprocated Trade for Classification BEC 112 (Top: 1998-2002, Middle: 2003-2007, Bottom: 2008-2012)

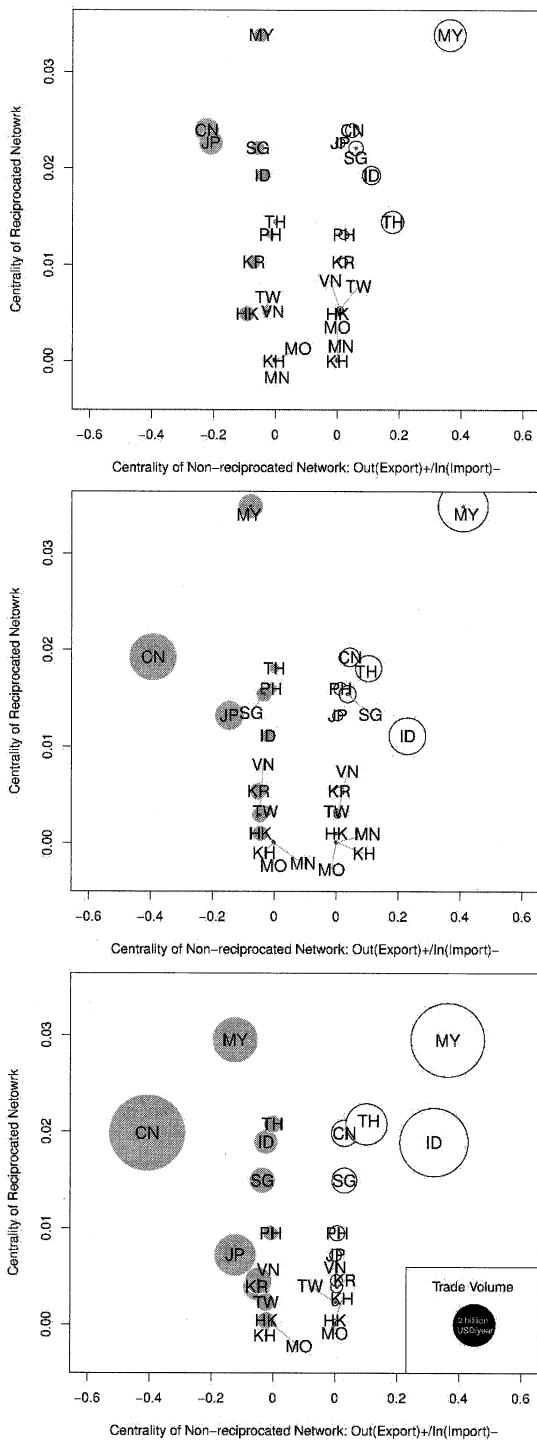


Figure 4. Centrality in Reciprocated and Non-Reciprocated Trade for Classification BEC 121 (Top: 1998–2002, Middle: 2003–2007, Bottom: 2008–2012)

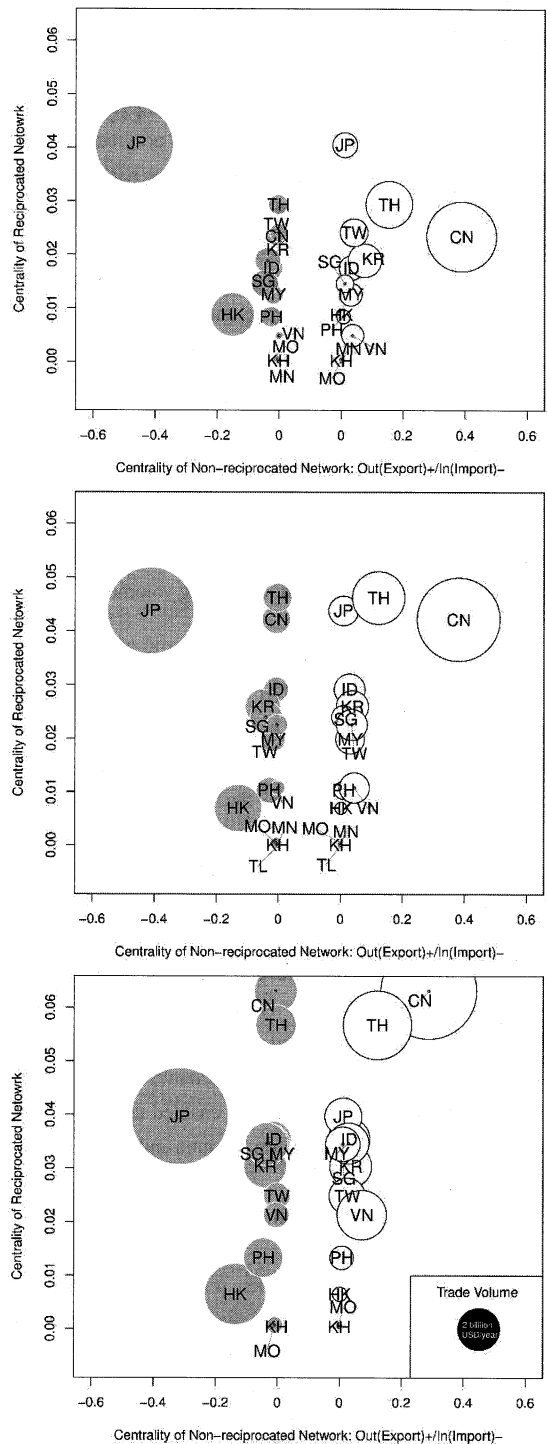


Figure 5. Centrality in Reciprocated and Non-Reciprocated Trade for Classification BEC 122 (Top: 1998–2002, Middle: 2003–2007, Bottom: 2008–2012)

Figure 4 concerns trade in processed food & beverages for industry (BEC 121). Malaysia is the prominent and persistently central trader in the reciprocated network with a small reduction in the centrality during 2008-2012. Furthermore, it is the largest exporter in non-reciprocated trade. The value of its imports and exports rises. Distinct from what we observe for other commodities, China has become a main importer, and its imports and centrality in non-reciprocated trade rise dramatically. Japan's centrality in reciprocated trade declined across the three periods. These findings are revealed in the decline of reciprocity in 2000s.

Figure 5 indicates trade in processed food & beverages for household consumption (BEC 122). China, Japan, and Thailand dominate the reciprocated network; however, their relative positions changed across the three periods. The centralities of China and Thailand rose relative to Japan. In non-reciprocated trade, China is the dominant exporter and Japan the largest importer with increasing volumes.

4. Conclusion

This study has decomposed the structure of trade in primary and processed food & beverages in East Asia for 1998–2012 by combining traditional GL-IIT measures and network reciprocity. It adopted the measures of centrality from social network analysis to document countries' relative positions in reciprocated intra-industry trade and non-reciprocated net one-way trade in overall trade flows. We believe our approach is the first in the international trade literature to analyze bilateral and unilateral trade in one framework, especially East Asian trade in food-related commodities. We established a straightforward way to document the relative significance of countries (regions) for both aspects of trade. Our approach enabled us to explicitly discuss each country's position in intra-industry and net one-way trade networks.

The following results from our decomposition of trade networks are noteworthy.

First, SPRG reciprocity, which reflects the extent of a region's intra-industry trade, indicates that trade in products classified BEC 121 slightly descends toward the end of the period. However, intra-industry trade in products classified BEC122 deepened.

Our findings are generally parallel with those in previous studies of intra-industry trade of food in East Asia, notably Kanada (2013), who discussed changes between the beginning and end of the 2000s. However, our analysis of

annual changes in reciprocity captured important features that were overlooked in earlier studies. In particular, we found that reciprocity for BEC111 products sharply declined from the late 1990s to the mid-2000s but revived early in 2010.

Second, our decomposition established China, Japan, Indonesia, Malaysia, and Thailand as the dominant parties in reciprocated trade. However, their relative importance changed as China's centrality increased. Japan's position remained relatively stable during the period studied. The remaining countries dominate reciprocated trade in selected commodities.

Third, Japan is the main importer in non-reciprocated trade networks, and its import values are highest for all product classifications except BEC 121. East Asia's intra-industry trade in foods has deepened; however, its position in overall trade remains small in a comparison with each country's centrality in reciprocated and non-reciprocated networks.

Our result shows the reciprocated trade in primary goods (BEC 111 and 112) has deepened since the mid of 2000s. It is coincident with the enforcement of trade agreements in this regions and significant change in food prices. Further studies are required in order to examine the effects of these events on trade structure revealed by this study.

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