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# External Backward Linkage and External Forward Linkage in Asian International Input-Output Table

**Toshiaki Hasegawa**
**Faculty of Economics**
**Chuo University**
**Tokyo, JAPAN**
**E-mail: vinomac@tamacc.chuo-u.ac.jp**

# External Backward Linkage and External Forward Linkage in Asian International Input-Output Table*

**Toshiaki Hasegawa****
Professor of International Economics,
Chuo University
Tokyo, JAPAN

**Abstract:**

The regional market framework to reduce the trade costs affects the international trade flow and the foreign direct investment, especially more in Asian region. Under the globalised economy, each economy's industry is heavily interdependent across borders. The use of Asian International Input-Output Tables[1] brings the cross-border industrial fragmentation into focus. The paper focuses on the Asia-Pacific 10 economies during 1995–2005 in the framework of the international (or regional) interindustry analysis to clarify the empirical method in analyzing not only the domestic industrial structure, but also the cross-border selling/sourcing trade, referred to as the offshoring, by B2B transaction specifically.

Growing interest in the framework of the market involving in regional trade agreements in Asia, it has become important increasingly to recognize how the interdependence of industries in Asian economies has developed. The international input-output analysis is a technique that can be analyzed, not only in its own regional industrial structure, but in trade of supplies for sales and sourcing by industry with other

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** Toshiaki Hasegawa is Professor of International Economics, Faculty of Economics, Chuo University, Higashinakano 742-1, Hachioji, Tokyo, Japan 192-0393. E-mail: vinomac@tamacc.chuo-u.ac.jp

[1] JETRO-I.D.E. (2001 & 2006) provides the updated Asian International Input-Output Table in 1995 and 2000.

regions.

Taking advantage of Asian International Input-Output Table (AIIO), we introduce the definition of the External Backward Linkage (EBL) and the External Forward Linkage (EFL) in this paper to show the strength of the interdependence across the borders in Asian economies. EBL and EFL for Asian industries, especially for Japanese, Chinese and Korean industries in terms of the same industrial classification are depicted in the same figure. In consequence, in spite of the growing scale of Chinese economy, Chinese industries have not been ranked necessarily in the top group. In Asia-Pacific regions, Korea had many industries in the top group to indicate those strengths in the External Backward Linkage of interdependence. Japan had kept those positions in many industries at the higher rank in the External Forward Linkage.

**Definition of External Linkage**

Business companies in the globalized industrial activities, to source supplies between the domestic industries, and also to supply intermediate inputs, do not accomplish its production, but accomplishes across the border in their production network. International Input-Output Table, as well as the regional input-output table, as defined in part by industry trade not only to sell (or source) in its own region, to sell to (or source from) other regions.

Asian International Input-Output (AIIO) Table published by the Institute of Developing Economies (JETRO-I.D.E.) has been provided in the industrial classification by 7, 24, and 76 sectors in 10 countries (or economies). Classification used in this paper is 24 sectors. Using AIIO Table in 1995 and 2000, we analyze the changing interdependence of the Asian region between the year 1995 and 2000. The advantage of analysis in terms of the International Input-Output Table is in the same industry segment where we can

compare between different regional economies each other.

Among 10 economies in Asia-Pacific region, Japan, Korea and China, except for the United States, have the economies of scale and large impact influence. We examine the magnitude of the interdependence occurred as economic activities in terms of the External Backward Linkage and the External Forward Linkage to analyze the height of the presence of the three countries in the Asian region.

In this paper, we pay attention to intermediate demand $A_{ij}^{RS}$ in describing the interdependence across borders. Final demands in "Asian Input-Output Table" are divided into four categories in matrix. $A_{ij}^{RS}$ shows the input coefficient to be purchased by the *j-th* industrial sector in the country (or economy) S in the intermediate input produced in the *i-th* industrial sector in the country (or economy) R.

$$\mathbf{A^{RS}} = \left[A_{ij}^{RS}\right], \text{ where } R, S = I, M, P, S, T, C, N, K, J, U. \text{ and } i, j = 1, 2, \cdots\cdots, 24. \qquad (1)$$

This matrix consists of elements of 24 × 24[2], and the matrix in case of R = S is the domestic intermediate demand. And, the matrix in the case of R ≠ S is to show the trade coefficient matrix from the economy R to the economy S. In the above notations, I, M, P, S, T, C, N, K, J and U representing the country (economy), refer to Indonesia, Malaysia, Philippines, Singapore, Thailand, China, Taiwan, Korea, Japan, and the United States, respectively.

[2] For classification of industry, we adopted the same 24 sector classification as "Asian International Input-Output Table". In order to facilitate the description, we integrated into 7 sectors. For more information, please refer to the appendix of endnotes.

**Interdependence in the Asian region**

In size of the economy, Japan, China, and Korea are very large in the presence in Asia-Pacific region. Asian International Input-Output Table provides the basic data showing the interdependence among these 10 countries (or economies). In this section, we analyse the purchasing and supplying the intermediate inputs in production activities, and examine how each industry in the entire Asian region involve mutually, and how large the magnitude of its involvement is. In the description of the industrial structure due to noise skyline of the previous sections is to bird's-eye the size of the economic activity of the country was able to, have not to explain that depend on each other how it across the border individual industries. We try to explain the interdependence of individual industry across borders.

Therefore, in order to analyze the external interdependence, in the following analysis, we focus on the part of the trade matrix in AIIO Asian International Input-Output Table. However, because there is 24 industry sectors in each 10 countries, n=240. Input coefficient matrix $[A_{ij}^{RS}]$ makes up the $240 \times 240$ (domestic intermediate input coefficient + trade coefficient) square matrix in the entire Asian International Input-Output Table. And, Leontief inverse obtained from this matrix is shown in $[L_{ij}^{RS}]$. We calculate the External Backward Linkage and the External Forward Linkage involving the inverse of trade coefficient in AIIO. Whereas we calculated using $24 \times 24$ Leontief inverse matrix in the part of domestic intermediate demand to get the indicators of backward linkage and forward linkage conventionally[3], we calculate the newly defined indicators; the External

[3] Conventionally, the Backward Linkage $\mathbf{R_i}$ and the Forward Linkage $\mathbf{S_j}$ defined in the self-region ( $\mathbf{R} = \mathbf{S}$ ) are obtained in the calculation of the following $24 \times 24$ Leontief Inverse. $\mathbf{R_i} = \frac{\sum_j L_{ij}^{RS}}{\frac{1}{n}\sum_i \sum_j L_{ij}^{RS}}$ , および $\mathbf{S_j} = \frac{\sum_i L_{ij}^{RS}}{\frac{1}{n}\sum_i \sum_j L_{ij}^{RS}}$. With respect to the concept of Backward Linkage and Forward Linkage and its application, refer to Miller–Blair (2009) and Hasegawa (2011).

Backward Linkage, EBL and the External Forward Linkage, EFL. We calculate EBL and EFL as for the inverse of trade coefficient part with the other 9 regions ($R \neq S$), excluding the Leontief inverse matrix in the self economic region (R=S), to identify the *j-th* sector in destination S and the *i-th* industry in the shipping region R, i.e., excluding the diagonal block-matrix of self region's transaction part, within the block-matrix consisting of 10 regions[4]. In the globalized economy, companies behave cross-regionally across the border in the production process of goods and services. These activities can be described in terms of trade matrix that has been expanded to conduct fragmentation in sourcing.

In contrast with the conventional definition of Backward Linkage and Forward Linkage, we call this new definition to use the part of trade coefficient as the External Backward Linkage, EBL and the External Forward Linkage, EFL.

As for the coefficient of sensitivity coefficients and influence using one country table as a normal, the sourcing supplies has been ignored completely as export and import of intermediate goods. Explicitly, EFL and EBL defined here, focus on the strength of interdependence across border measured on the basis of the Leontief inverse derived from industrial activities in the self region economic activity at the beginning.

In other words, when one unit of final demand for goods and services in the *j-th* sector in region S has increased, the External Backward Linkage $\mathbf{EBL_{Sj}}$ can be defined to see how much the column sum as the increasing influence of industrial production diverge from an average increase, which make an impact on 216 sectors (= 240-24) in case of R ≠ S, to across the border, excluding the part of the self region.

$$\mathbf{EBL_{Sj}} = \frac{\sum_R \sum_i L_{ij}^{RS}}{\frac{1}{n-24} \sum_R \sum_S \sum_i \sum_j L_{ij}^{RS}}, \text{ where } R \neq S \quad i, j = 1,2,\cdots\cdots,24. \qquad (2)$$

[4] The indicators EBL and EFL in terms of this definition were originally analyzed in Toshiaki et al. (2012).

On the other hand, the External Forward Linkage $\mathbf{EFL_{Ri}}$ for the *i-th* sector of region R can be defined as the ratio of the increase of one unit of demand for all industry of each industrial sector 216 (= 240-24) of the row sum of R ≠ S line, to be purchased across the border, excluding the portion of the region to increase its own region, as a percentage of average value.

$$\mathbf{EFL_{Ri}} = \frac{\sum_S \sum_j L_{ij}^{RS}}{\frac{1}{n-24} \sum_R \sum_S \sum_i \sum_j L_{ij}^{RS}}, \text{ where } R \neq S \quad i, j = 1,2,\cdots\cdots,24. \tag{3}$$

Calculated the EBL and EFL defined in this manner for the inverse 216×216, it was compared to the indicators of the entire 10 economies in the upper part of Table 3. The lower part expresses about the top 10 of each indicator by a factor of attention to the three economies, China, Japan, and Korea.

Listed to be noted mostly in the upper part of table, in both years of 1995 and 2000, it was Machinery industry (code 17) which maintained the high External Backward Linkage, in Malaysia, Philippines, Thailand, Singapore, and Taiwan in a whole Asia Pacific region. Additionally, the sector 16 (Metal products) in the Malaysia, 14 (Rubber products) in the Philippines, and sector 9 (Textile, leather, and the products thereof) and 18 (Transport equipment) in Malaysia, and sector 18 (Transport equipment) in Thailand are raised to the rank in the top 10 in this region. From the top 10 sectors in 2000, 9 (Textile leather, and the products thereof) and 18 (Transport equipment) in the Philippines, and 14 (Rubber products), 9 (Textile, leather, and the products thereof), and 18 (Transport equipment) in Singapore disappeared. Judging from the indicator EBL, it is clear that changes have occurred in the strength of the interdependence between economies in the Asian region. On the other hand, observed EFL in 10 economies, as for economies and industries ranked

in top 10 by comparing the 1995 and 2000, appearance are exactly same, but only slightly swapped in ranking. Namely, Japan and the United States have an overwhelming alone in sectors 17 (Machinery), 12 (Chemical products), 22 (Trade and transport), 23 (Services) and Japan added 16 (Metal products) and 18 (Transport equipment) to occupy the top 10.

Looking at the top 10 of EBL and EFL in the lower part of Table 3, which were extracted only for three economies, Japan, China, and Korea, the indicator EBL in sectors 17, 14, 9, 12, 18, 10, 16, 19, 11 in Korea, except for sector 17 in China, shows a high value. C11 has appeared in 2000, replaced with K11. Also if you look at the top 10 in three countries for the indicator EFL, both in 1995 and 2000, Japan occupied in the industries of sector 17, 16, 12, 22, 23, 18, and 19. In addition, Korea for sector 12 and 16, and China entered in top 10 in code 12.

As far as the indicators of EBL and EFL in 1995 and 2000 extracted only for the three countries, major changes in the interdependence of the top 10 industries cannot be observed in terms of new entry and exit. The indicator of EBL and the indicator of EFL were depicted all at once for both years in 1995 and 2000 in Figure 1 and Figure 2, respectively. Among them, what are arranged to extract the top 10 has been shown in the lower part of Table 1.

**Table 1 External Backward Linkage and External Forward Linkage**

| Top 10 of External Backward Linkage and External Forward Linkage in 10 economies | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ranking | 1995 | | | | 2000 | | | |
| | code | EBL | code | EFL | code | EBL | code | EFL |
| 1 | S17 | 4.9315 | J17 | 14.3329 | M17 | 4.7202 | J17 | 12.9615 |
| 2 | P18 | 4.5564 | J16 | 12.7329 | P17 | 4.1883 | J16 | 10.4174 |
| 3 | T17 | 4.0802 | J12 | 11.6180 | T17 | 4.0049 | J12 | 10.4074 |
| 4 | P17 | 3.4806 | J22 | 9.3669 | S17 | 3.9389 | J22 | 8.2670 |
| 5 | M17 | 3.1916 | J18 | 9.1766 | M16 | 3.3130 | J23 | 8.1685 |
| 6 | S14 | 3.0868 | U12 | 8.3540 | P14 | 3.3060 | U17 | 6.8549 |
| 7 | N17 | 3.0350 | J23 | 8.2994 | N17 | 3.1786 | U23 | 6.7251 |
| 8 | P09 | 3.0350 | U22 | 7.3533 | M09 | 3.1088 | U12 | 6.6802 |
| 9 | S09 | 3.0349 | U17 | 6.5637 | M18 | 2.9539 | U22 | 6.4299 |
| 10 | S18 | 2.8583 | U23 | 6.4401 | T18 | 2.9030 | J18 | 4.0554 |
| **Top 10 of External Backward Linkage and External Forward Linkage in Japan, China and Korea** | | | | | | | | |
| ranking | 1995 | | | | 2000 | | | |
| | code | EBL | code | EFL | code | EBL | code | EFL |
| 1 | K17 | 1.9163 | J17 | 14.3329 | K17 | 2.2140 | J17 | 12.9615 |
| 2 | K14 | 1.7492 | J16 | 12.7329 | K12 | 1.4887 | J16 | 10.4174 |
| 3 | K9 | 1.5311 | J12 | 11.6180 | K9 | 1.3822 | J12 | 10.4074 |
| 4 | K12 | 1.4910 | J22 | 9.3669 | K14 | 1.3475 | J22 | 8.2670 |
| 5 | K18 | 1.4077 | J18 | 9.1766 | K18 | 1.3235 | J23 | 8.1685 |
| 6 | K10 | 1.3257 | J23 | 8.2994 | K19 | 1.3010 | J18 | 4.0554 |
| 7 | K16 | 1.2423 | J19 | 3.1774 | C17 | 1.2290 | K12 | 3.9614 |
| 8 | K19 | 1.2320 | K16 | 3.0667 | K16 | 1.2247 | J19 | 3.6359 |
| 9 | C17 | 1.0572 | K12 | 3.0279 | K10 | 1.1411 | C12 | 2.8210 |
| 10 | K11 | 1.0094 | C16 | 2.9359 | C11 | 1.0300 | K16 | 2.7961 |

Remarks: The initial letter used for the code denotes for the name of economy,
and the subsequent numbers indicate the number of industrial classification.

**Figure 1 External Backward Linkage and External Forward Linkage of Japan, China and Korea in Asian Economies (1995)**

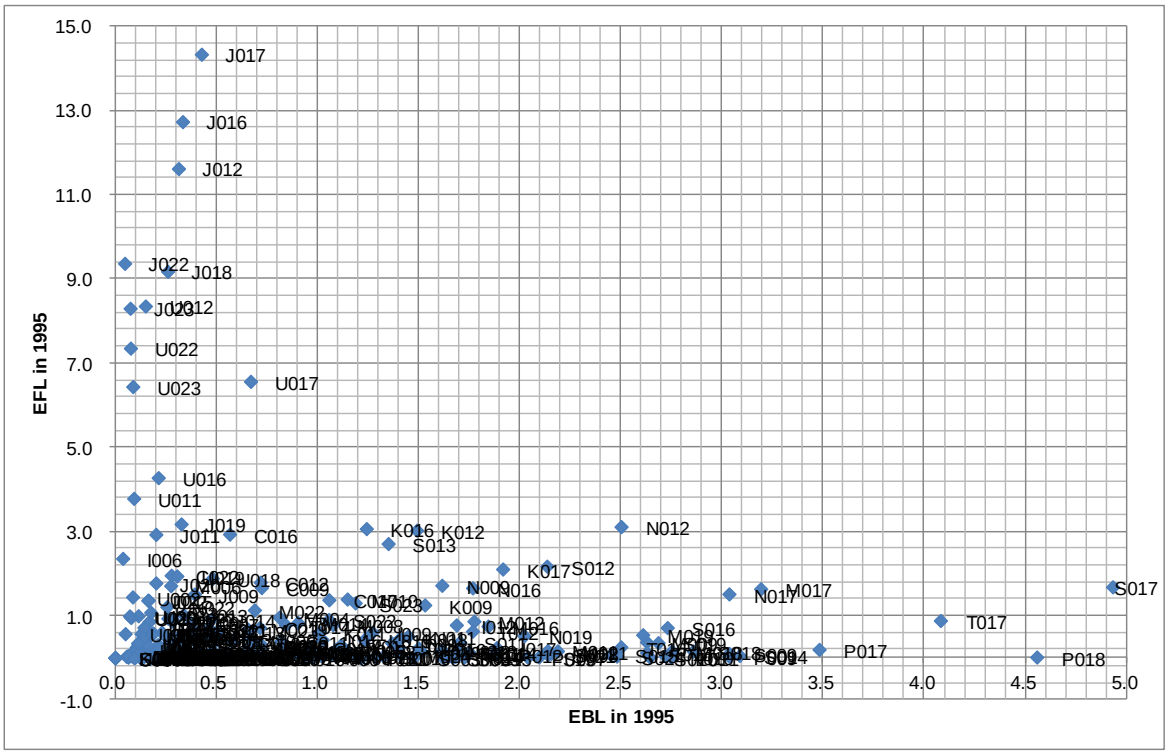
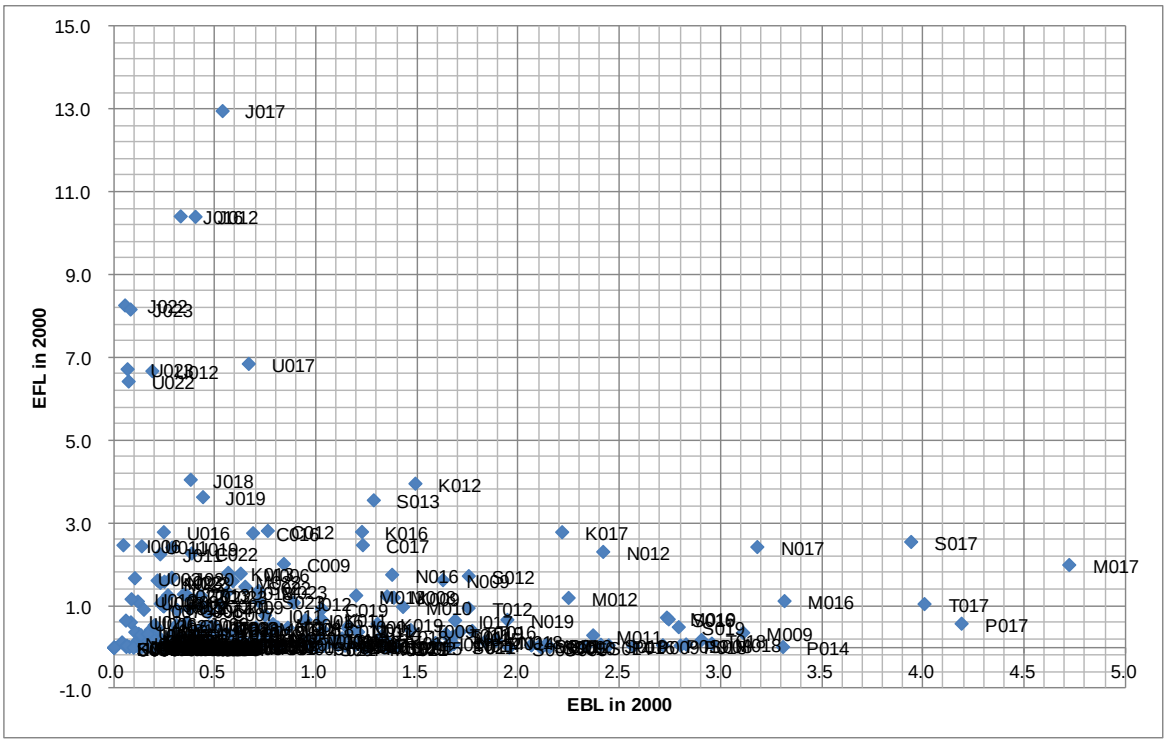



**Figure 2 External Backward Linkage and External Forward Linkage of Japan, China and Korea in Asian Economies (2000)**



**Concluding Remarks**

In the analysis using Asian International Input-Output Table, this paper could successfully depicted the strength of interdependence in Asia-Pacific region interconnected in supplying and sourcing by industry across border, especially expanded by Japan, China, and Korea.

Despite the compared time span in five years, from the analysis of the External Backward Linkage and the External Forward Linkage shows the interdependence of industrial activity in the Asia-Pacific region, compared to the economy in a whole 10 Asia-Pacific region, the change occurred among economies on the strength of interdependence in Asia-Pacific region could be observed. In consequence, in spite of the growing scale of Chinese economy, Chinese industries have not been ranked necessarily in the top group. In Asia-Pacific region, Korea had many industries in the top group to indicate those strengths in the External Backward Linkage of interdependence. Japan has shown the overwhelming strength, keeping those positions in many industries at the higher rank in the External Forward Linkage.

It is expected that the formation of regional trade agreement settled by Asian big three economies to reduce trade costs might enhance the intra-regional trade as European Union has experienced.

| Appendix: Sector Classification in Asian Input-Output Table | | | |
|---|---|---|---|
| 1 | Agriculture, livestock, forestry and fishery | 001 | Paddy |
| | | 002 | Other agricultural products |
| | | 003 | Livestock |
| | | 004 | Forestory |
| | | 005 | Fishery |
| 2 | Mining and quarrying | 006 | Crude petroleum and natural gas |
| | | 007 | Other mining |
| 3 | Manufacturing | 008 | Food, beverage and tobacco |
| | | 009 | Textile, leather, and the products thereof |
| | | 010 | Timber and wooden products |
| | | 011 | Pulp, paper and printing |
| | | 012 | Chemical products |
| | | 013 | Petroleum and petro products |
| | | 014 | Rubber products |
| | | 015 | Non-metallic mineral products |
| | | 016 | Metal products |
| | | 017 | Machinery |
| | | 018 | Transport equipment |
| | | 019 | Other manufacturing products |
| 4 | Electricity, gas, and water supply | 020 | Electricity, gas, and water supply |
| 5 | Construction | 021 | Construction |
| 6 | Trade and transport | 022 | Trade and transport |
| 7 | Services | 023 | Services |
| | | 024 | Public administration |

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