

The 20th NFORUM World Conference
Firenze, Italy, September 2-9, 2012

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



Toshiaki Hasegawa
Faculty of Economics
Chuo University
Tokyo, JAPAN

Deepening Global Production Network, especially in Asia

- Is the market in intraregional trade in Asia seamless, and have the markets been integrated enough?
- Under the globalized economy, each economy's industry is heavily interdependent across borders.
- The international input-output analysis is a technique that can be analyzed, not just in its own regional industrial structure, but in trade of supplies for sales and sourcing by industry with other regions.

- Under the globalized economy, each economy's industry is heavily interdependent across borders. Then, the use of Asian International Input-Output Tables brings the cross-border industrial fragmentation into focus. This paper focuses on the Asia-Pacific 10 economies during 1995–2000 in the framework of **the international (or regional) interindustry (Input-Output) 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.

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 networks.
- 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, but also to sell to (or source from) other regions.

Useful AIIO table and the method in explaining global production network

- Taking advantage of **Asian International Input-Output (AIIO) Table**, we introduce the definition of the **External Backward Linkage (*EBL*)** and the **External Forward Linkage (*EFL*)** 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. **(To be shown later)**

Asian International Input-Output (AIO) Table: useful statistics to explain for fragmentation of across borders

- Asian International Input-Output (AIO) 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 AIO Table in 1995 and 2000 (currently unavailable for 2005 table yet), we can 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.

Globally Expanded Input-Output Approach

- Among 10 economies in APEC 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 Asia-Pacific region.
- In this paper, we pay attention to the intermediate demand in describing the interdependence across borders. Final demands in "Asian International Input-Output Table" are divided into four categories in matrix. A^{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 .
 - $A^{RS} = [A^{RS}_{ij}]$ eq. (1)
 - where $R, S = I, M, P, S, T, C, N, K, J, U$ and $i, j = 1, 2, \dots, 24$.

- The matrix consists of elements 24×24 , and the matrix in case of $R = S$ is the domestic intermediate demand. And, the matrix in the case of $R \neq S$ 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.
- 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.

Appendix Sector Classification in Asian Input-Output Table

1	Agriculture, livestock, forestry and fishery	001	Paddy
		002	Other agricultural products
		003	Livestock
		004	Forestry
		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

Interdependence 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 Asia-Pacific region involve mutually, and how large the magnitude of its involvement is. We try to explain the interdependence of individual industry across borders.

- Therefore, in order to analyze the external interdependence, 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 economies, $n=240$. Input coefficient matrix $A^{RS} = [A^{RS}_{ij}]$ makes up the 240×240 (domestic intermediate input coefficient + trade coefficient) square matrix in the entire AIIO Table. And, Leontief inverse obtained from this matrix is shown in $[L^{RS}_{ij}]$. We calculate the External Backward Linkage and the External Forward Linkage involving the inverse of trade coefficient in AIIO.

- Whereas we calculated using Leontief inverse matrix in the part of domestic intermediate demand to get the indicators of backward linkage and forward linkage conventionally, we calculate the newly defined indicators; the External 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. 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 the Backward Linkage and the 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, ***EBL*** and ***EFL*** defined here, describe 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.

Definition of EBL and EFL

- 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** 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 (= 240-24) sectors in case of ($R \neq S$), to across the border, excluding the part of the self region.

- $$EBL_{Sj} = \frac{\sum_R \sum_i L^{RS}_{ij}}{\frac{1}{n-24} \sum_R \sum_S \sum_i \sum_j L^{RS}_{ij}} \quad (2)$$

- where $R \neq S$, and $i, j = 1, 2, 3, \dots, 24$

- On the other hand, the **External Forward Linkage** 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 $R \neq S$ line, to be purchased across the border, excluding the portion of the region to increase its own region, as a percentage of average value.

- $$EFL_{Ri} = \frac{\sum_S \sum_j L^{RS}_{ij}}{\frac{1}{n-24} \sum_R \sum_S \sum_i \sum_j L^{RS}_{ij}}$$

- where $R \neq S$, and $i, j = 1, 2, 3, \dots, 24$ (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 1**. The lower part expresses about the top 10 of each indicator by a factor of attention to the three economies, China, Japan, and Korea.

- *EBL* (External Backward Linkage) shows the relations with the upstream industries across border.
- *EFL* (External Forward Linkage) shows the relations with the downstream industries across border.
- During 1995 until 2000, *EFL* changed much bigger than *EBL* in the Asia-Pacific region.
(refer to the following **Figure 1**)

Figure 1 Different Influences in Downstream and Upstream Industries across border

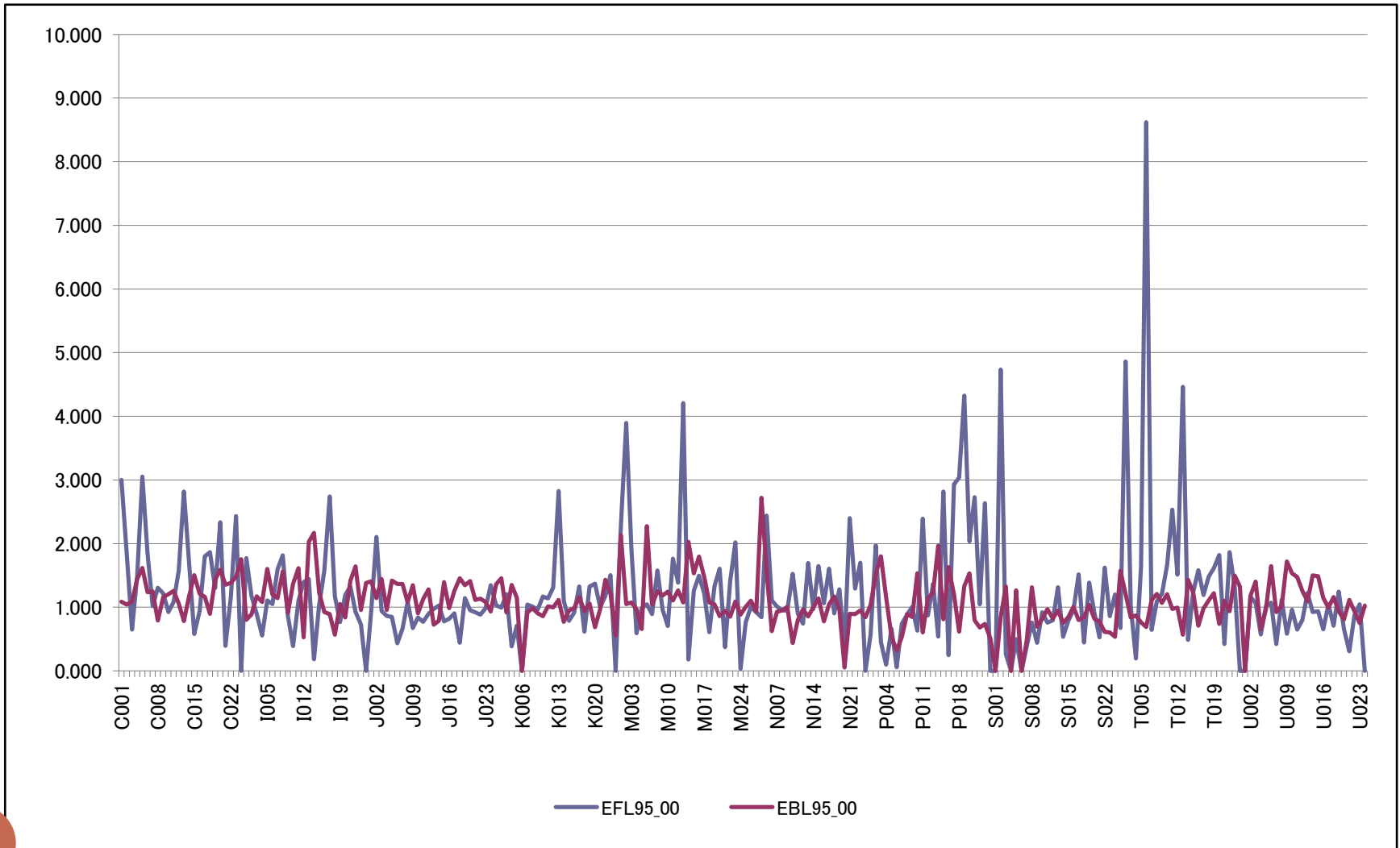


Table 1 External Backward Linkage and External Forward Linkage

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

- 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 1**, 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 can not be observed. To extract only three countries, Japan, Korea and China, the indicator of *EBL* and the indicator of *EFL* are depicted all at once for both 1995 and 2000 in **Figure 2 and Figure 3**, respectively. Among them, what are arranged to extract the top 10 has been shown in the lower part of **Table 1**.

Figure 2 External Backward Linkage and External Forward Linkage of Japan, China and Korea in Asian Economies (1995)

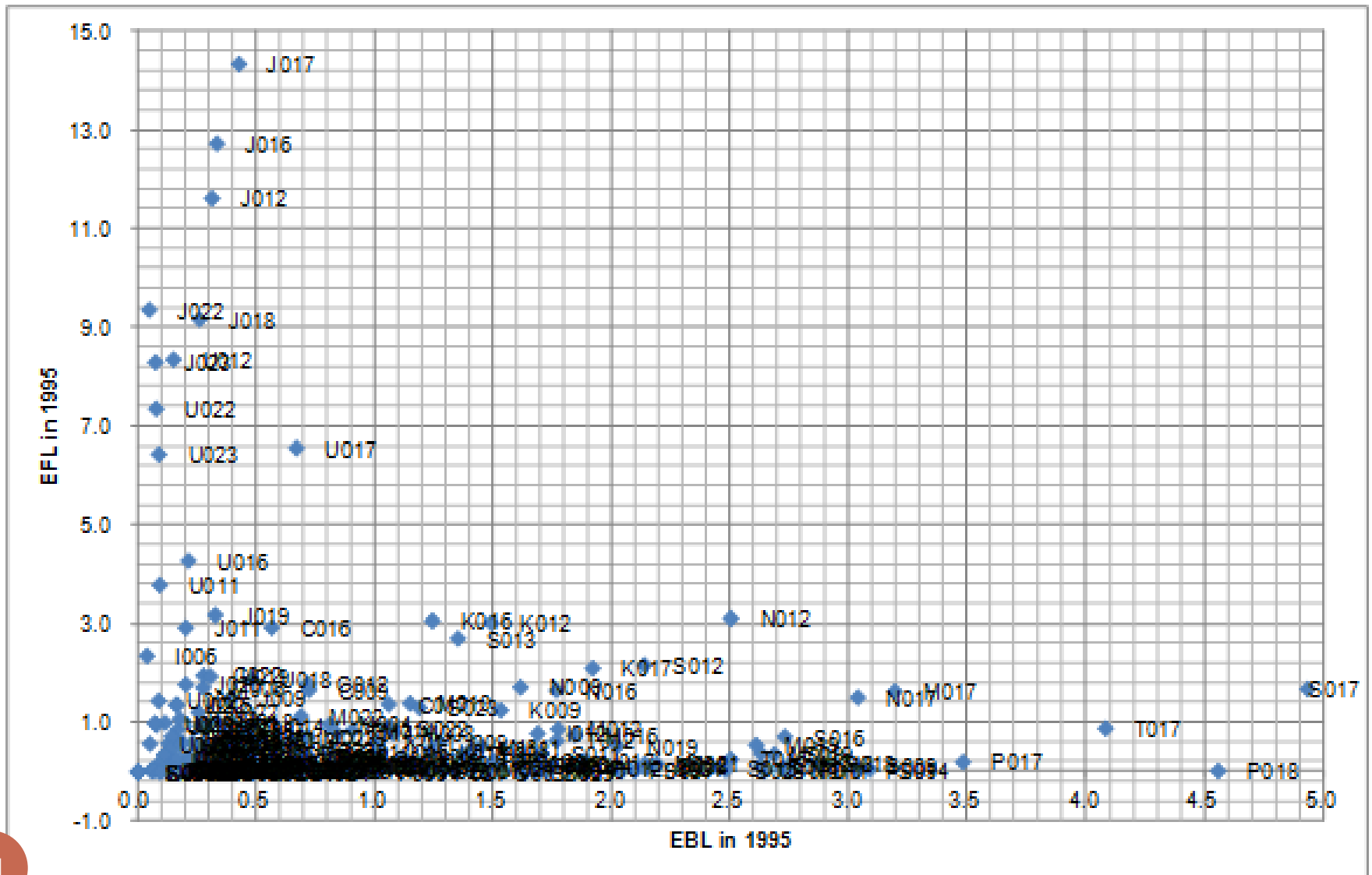
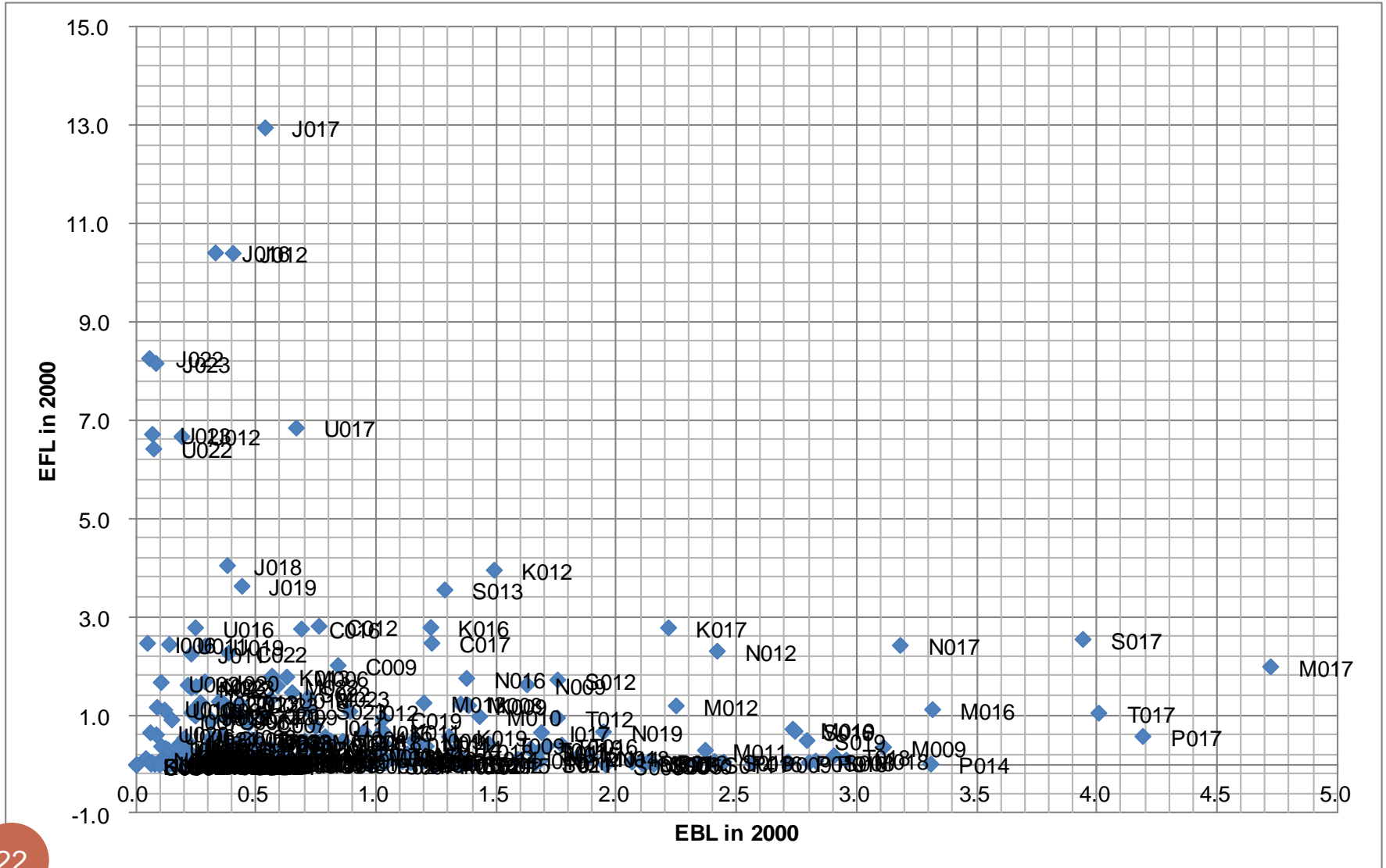


Figure 3 External Backward Linkage and External Forward Linkage of Japan, China and Korea in Asian Economies (2000)



Concluding Remarks

- In the analysis using Asian International Input-Output Table, this paper could successfully depicted the strength of interdependence in APEC region interconnected in supplying and sourcing by industry across border, especially expanded by Japan, China, and Korea.
- Despite the compared time span of 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 APEC region, the change occurred among economies on the strength of interdependence in APEC 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 APEC 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.

Thank you for your listening