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Interdependence, Linkages and Multipliers in Asia: An International Input-Output Analysis

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Abstract

This paper uses a set of international input-output tables constructed for selected Asian countries (and the USA) for the years of 1975 and 1985 to compare sectoral and intercountry changes over this decade. The analysis makes use of a framework developed by Guilhoto, Hewings, and Sonis (1996) where two literatures that have explored the structure of economics are combined, namely, approaches to key sector identification presented by Guilhoto *et al.* (1994) to reveal what may be referred to a *pure linkage* approach and the concerns of Miyazawa and his identification of internal and external multiplier effects. While Miyazawa was interested mainly in identifying the sources of change in an economy, his approach shares considerable commonality with the new ideas in key sector identification in which a sector or set of sectors are separated from the rest of the economy. The results reveal the importance of employing alternative measures of structure and structural change but the overall pattern of greater regional integration is readily apparent, paralleling findings for the European Union.

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1. Introduction

Several important themes focusing on an understanding of the economic structure of economies as represented by input-output systems have appeared recently. First, there has been the recognition that only a small set of transactions or sectors in an economy may be considered to be analytically important, in the sense that changes in their values create significant changes elsewhere in the economy (Sonis and Hewings, 1992, 1995). Secondly, the complexity of transactions in an economy, especially in very detailed interindustry matrices, precludes understanding of the structure of the economy without some translation or decomposition of these transactions to a set of hierarchical flows. As a result, many alternative decompositions have been proposed to assist the analyst in obtaining a better appreciation of the economic structure.

In this paper, the analysis begins with the traditional method for identifying key sectors initially identified with the work of Hirschman (1958) and Rasmussen (1956). Then an alternative, based in the work of Guilhoto, Hewings, and Sonis (hereafter, GHS) (1996) is offered, i.e., a procedure to separate out the impacts of either a specific sector from the rest of the economy or a single region from the rest of the economy or even a country from the trading bloc in which it is nested. The above methodology is applied to a set of Asian interregional input-output tables constructed for the years 1975 and 1985.

In the next section the theoretical background will be presented. In the third section the theory will be applied to the Asian interregional tables, while in the last section some conclusions will be offered.

2. Theoretical Background

There is a lengthy literature devoted to the concept of key sector analysis; Rasmussen and Hirschman's notions have received widespread application and significant critical commentary (see, for example, McGilvray, 1977, Hewings, 1982). These debates will not be revisited in this paper; rather, the focus will begin with a brief presentation of the Rasmussen and Hirschman approach followed by a more detailed presentation of the work proposed by GHS (1996).

2.1. The Rasmussen/Hirschman Approach

The work of Rasmussen (1956) and Hirschman (1958) led to the development of indices of linkage that have now become part of the generally accepted procedures for identifying key sectors in the economy. Define b_{ij} as a typical element of the Leontief inverse matrix, B; B^* as the average value of all elements of B, and if B_{*j} and B_{i*} are the associated typical column and row sums, then the indices may be developed as follows:

Backward linkage index (power of dispersion):

$$U_j = B_{*j} / n \ / B^* \tag{1}$$

Forward linkage index (sensitivity of dispersion):

$$U_i = B_{i*} / n \ / B^* \tag{2}$$

One of the criticisms of the above indices is that they do not take into consideration the different *levels* of production in each sector of the economy.

2.2. The GHS Approach[4]

Consider a two-region input-output system represented by the following block matrix, A, of direct inputs:

$$A = \left[\begin{array}{c|c} A_{jj} & A_{jr} \\ \hline A_{rj} & A_{rr} \end{array}\right] \tag{3}$$

where A_{jj} and A_{rr} are the quadrate matrices of direct inputs within the first and second region and A_{jr} and A_{rj} are the rectangular matrices showing the direct inputs purchased by the second region and vice versa.

From (3), one can generate the following expression:

$$B = (I - A)^{-1} = \begin{bmatrix} B_{jj} & B_{jr} \\ B_{rj} & B_{rr} \end{bmatrix} = \begin{bmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{bmatrix} \begin{bmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{bmatrix} \begin{bmatrix} I & A_{jr}\Delta_r \\ A_{rj}\Delta_j & I \end{bmatrix} \tag{4}$$

where:

$$\Delta_j = \left[I - A_{jj} \right]^{-1} \tag{5}$$

$$\Delta_r = \left[I - A_{rr} \right]^{-1} \tag{6}$$

$$\Delta_{jj} = \left[I - \Delta_j A_{jr} \Delta_r A_{rj} \right]^{-1} \tag{7}$$

$$\Delta_{rr} = \left[I - \Delta_r A_{rj} \Delta_j A_{jr} \right]^{-1} \tag{8}$$

By utilizing this decomposition (equation 4), it is possible to reveal the process of production in an economy as well as derive a set of multipliers/linkages.

The matrix

$$\begin{bmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{bmatrix} \tag{9}$$

can be interpreted as the Miyazawa (1976) external multipliers for region j and the rest of the economy, r.

And, the matrix

$$\begin{bmatrix} \Delta_j & 0 \\ 0 & \Delta_r \end{bmatrix} \tag{10}$$

can be interpreted as the Miyazawa (1976) internal multipliers for region j and the rest of the economy, r.

In the matrix

$$\begin{bmatrix} I & A_{jr}\Delta_r \\ A_{rj}\Delta_j & I \end{bmatrix} \tag{11}$$

[4] For a complete description of the GHS approach, including the derivation of the set of equations presented here see Guilhoto, Hewings, and Sonis (1996).

the first row separates the final demand by its origin, i.e., distinguishes between the final demand that comes from inside the region (I) from the one that comes from outside the region ($A_{jr}\Delta_r$). The same idea applies to the second row.

From the Leontief formulation:

$$X = (I - A)^{-1} Y \tag{12}$$

and using the information contained in equations (4) through (11), one can derive a set of indexes that can be used: a) to rank the regions in terms of its importance in the economy; b) to see how the production process occurs in the economy.

From equations (4) and (12) one obtains:

$$\begin{bmatrix} X_j \\ X_r \end{bmatrix} = \begin{bmatrix} \Delta_j & 0 \\ 0 & \Delta_{rr} \end{bmatrix} \begin{bmatrix} I & A_{jr}\Delta_r \\ \Delta_r A_{rj} \Delta_j & I \end{bmatrix} \begin{bmatrix} Y_j \\ Y_r \end{bmatrix} \tag{13}$$

which leads to:

$$\begin{bmatrix} X_j \\ X_r \end{bmatrix} = \begin{bmatrix} \Delta_j & 0 \\ 0 & \Delta_{rr} \end{bmatrix} \begin{bmatrix} Y_j + A_{jr}\Delta_r Y_r \\ \Delta_r A_{rj} \Delta_j Y_j + Y_r \end{bmatrix} \tag{14}$$

where

$$A_{jr}\Delta_r Y_r \tag{15}$$

is the direct impact of the rest of the economy final demand on region j, i.e., it provides the level of exports in region j that are needed to satisfy the production necessities of rest of the economy for a level of final demand given by Y_r; and

$$A_{rj}\Delta_j Y_j \tag{16}$$

is the direct impact of region j final demand on the rest of the economy, i.e., it generates the level of exports in rest of the economy that are needed to satisfy the production necessities of region j for a level of final demand given by Y_j.

Continuing from equation (14):

$$\begin{bmatrix} X_j \\ X_r \end{bmatrix} = \begin{bmatrix} \Delta_{jj} & 0 \\ 0 & \Delta_{rr} \end{bmatrix} \begin{bmatrix} \Delta_j Y_j + \Delta_j A_{jr} \Delta_r Y_r \\ \Delta_r A_{rj} \Delta_j Y_j + \Delta_r Y_r \end{bmatrix} \tag{17}$$

One has the definitions for the Pure Backward Linkage (PBL) and for the Pure Forward Linkage (PFL), i.e.,

$$\begin{aligned} PBL &= \Delta_r A_{rj} \Delta_j Y_j \\ PFL &= \Delta_j A_{jr} \Delta_r Y_r \end{aligned} \tag{18}$$

where the PBL will give the pure impact on the rest of the economy of the value of the total production in region *j*, $\Delta_j Y_j$: i.e., the impact that is free from a) the demand inputs that region *j* makes from region *j* , and b) the feedbacks from the rest of the economy to region *j* and vice-versa. The PFL will give the pure impact on region *j* of the total production in the rest of the economy $\Delta_r Y_r$.

Continuing from equation (17):

$$\begin{bmatrix} X_j \\ X_r \end{bmatrix} = \begin{bmatrix} \Delta_{jj} \Delta_j Y_j + \Delta_{jj} \Delta_j A_{jr} \Delta_r Y_r \\ \Delta_{rr} \Delta_r A_{rj} \Delta_j Y_j + \Delta_{rr} \Delta_r Y_r \end{bmatrix} = \begin{bmatrix} X_j^j + X_j^r \\ X_r^j + X_r^r \end{bmatrix} \tag{19}$$

hence, the level of total production in region *j* can be broken down into two components:

$$\begin{aligned} X_j^j &= \Delta_{jj} \Delta_j Y_j \\ X_j^r &= \Delta_{jj} \Delta_j A_{jr} \Delta_r Y_r \end{aligned} \tag{20}$$

where the first component, X_j^j, indicates the level of total production in region *j* that is due to the level of final demand in region *j*, and the second component, X_j^r, will yield the level of total production in region *j* that is due to the level of final demand in the rest of the economy.

In the same way, the level of total production in rest of the economy can also be broken down into two components:

$$\begin{aligned} X_r^j &= \Delta_{rr} \Delta_r A_{rj} \Delta_j Y_j \\ X_r^r &= \Delta_{rr} \Delta_r Y_r \end{aligned} \tag{21}$$

where the first component, X_r^j, is the level of total production in rest of the economy that is due to the level of final demand in region *j*, and the second component, X_r^r, will give the level of total production in the rest of the economy that is due to the level of final demand in the rest of the economy.

In the next section, this methodology will be applied to the interregional tables for Asia to explore the differing nature of internal and external linkages that characterize these economies as well as the nature, direction and strength of changes over the period 1975-1985.

3. An Application to Asia

The methodology presented in the above section was applied to the interregional input-output tables constructed for Asia, including the USA, for the years of 1975 (see Institute of Developing Economies, 1982) and 1985 (see Institute of Developing Economies, 1992). The original 24 sectors presented in the tables were aggregated to 18 sectors, as shown in Table 1. For 1975, the tables were constructed for 8 countries (Indonesia, Malaysia, Philippines, Singapore, Thailand, Korea, Japan, and USA, while for 1985, China and Taiwan were added.

Tables 1 to 10 and Figures 1 to 8 show the results for the Hirschman/Rasmussen and for the Pure linkages when all the sectors in the Asian system are taken into consideration, and its relative importance to the other sectors is taken into consideration, independently from the country to which it belongs.

From Table 1 and Figure 1, one can see that the highest Hirschman/Rasmussen backward linkages for the year of 1975 are found in Singapore, Korea, Japan, and USA; while, from Table 2 and Figure 2, the highest forward linkages are found mainly in Japan and USA revealing the importance of these countries in the productive process for the region as a whole. An examination of Tables 3 to 5 and Figures 3 and 4, that show the results for the pure linkages and thus take into consideration the level of production in each sector, one can clearly see the dominance of Japan and the USA. Closer inspection reveals a second level of importance for Indonesia and Korea in comparison to the remaining countries (i.e., excluding Japan and USA).

For 1985 with the inclusion of China and Taiwan into the system, some changes were revealed in the importance of individual countries as can be seen in Tables 6 to 10 and Figures 5 to 10. In the Hirschman/Rasmussen backward linkages, the most important countries are now China, Taiwan, Korea and Japan; while in the case of Hirschman/Rasmussen forward linkages the most important are China, Japan, and USA. In the case of the pure linkages, again, the importance of Japan and the USA dominates the others; again, at a second level importance (see Figure 10), China reveals its dominating position in the region, followed by Korea, Taiwan, and Indonesia.

If instead of taking into consideration each sector isolated from the others, one takes into consideration one country interacting with the others, as can be seen in the results presented into Tables 11 to 14 and Figures 9 and 10, it is possible to examine the strength of the relations among the countries and to uncover evidence of change through time. In essence, all domestic interactions are collapsed into one sector and interactions between countries takes place at this one-sector level of detail. The results reveled patterns that were not dissimilar from those already described earlier.

The next set of analyses focuses on the nature and strength of interaction with other countries. Tables 13 and 14 present the results of equations (20) and (21), i.e., they show how the total production in one country is affected by its own production and by the production of the remaining countries in the system. For example, for 1975, the value of the production of all sectors of Indonesia is US$ 51.876 billion, of which US$ 45.323 billion (87.37 %) is due to the production needed to supply the final demand of this country (including exports), and US$ 6.552 billion (12.63%) is generated by the production needs of the other countries in the region. Thus, the larger the entries in columns (5) and (9) in Tables 13 and 14, the more the system is open, i.e., the more integrated in the world economy is the system. Note that a comparison of 1975 and 1985 shows for these Asian countries, an increase in the "internationalization" of the productive process, namely a greater dependence of any country on the rest of the system for generating demand for its goods and services. For some countries, the increased dependence on the rest of the system has resulted in dramatic changes (see the growth factors in columns 5 and 9 of table 14). Even though the percentage of total activity in the rest of the region that is due to any one individual country is still small (most are less than 1%), the growth rates between

1975-1985 have been very large. Two phenomena are occurring here: (1) the regional economy as a whole is growing and (2) there is a change in the domestic versus non-domestic dependency. Hence, the small percentages of output in the rest of the region due to any single economy belies the absolute volume increases. For example, Indonesia's influence on the region grew from $3.9 billion in 1975 (column 6, table 13) to $8.4 billion in 1985 (column 6, table 14) - more than double in volume terms even though the share of rest of the economy production due to Indonesia decreased from 0.10 to 0.07%. Malaysia's growth in this category is even more impressive. Note also the increasing involvement of both Japan and the USA in this regional system.

It should be noted that similar findings were derived from comparison of structural changes within the expanded European Union (EU) by Sonis *et al*. (1993). Over time, individual economies were exchanging domestic dependence for greater reliance on imports and exports - in other words, expanding their dependence on the EU as a whole. By and large, the Asian countries considered in this analysis are much more open to begin with than their counterparts in Europe but the process of greater regional integration can be seen to have commenced over twenty years ago.

4. Conclusions

The main contribution of this paper was to show, using different matrixes decompositions, a formal link between two different approaches: one directed to the identification of key sectors; the other directed to identifying the sources of change in an economy. In this way, with the new development it is possible to break-down the impact of a sector/region in the economy on its various components. The applications to the Asian region provides further insights into the emerging integration of the region's individual economies and the increasing involvement of both Japan and the USA in this regional system. As the time series of input-output tables is extended, the internal/external changes can be monitored to reveal the degree to which changes are region-wide or sector-specific and, eventually, to chart the nature of competition and complementarity that may exist among these economies.

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