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THE STRUCTURAL DEVELOPMENT OF AGRICULTURAL INTERINDUSTRY RELATIONSHIPS IN JAPAN, 1960-1985

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Table of Contents

1 INTRODUCTION

Output growth in Japanese agriculture has been ascribed to the increase and improvement of land and labor productivity. Growth in total output and output per worker in traditional small-sized family farms effected by the application of biological and chemical technologies has been referred to as the Japanese model of agricultural development. The path leading to its attainment is aptly called as the Asian path because of its relevance to agricultural development in Asian countries like Korea, Taiwan, and the Philippines.[1] The productivity and growth accounting approach has made the relationship among the intensive use of resources, techniques of production, and agricultural output growth more tractable. The existence of agriculture in an interdependent economic system, however, necessitates the consideration of the structural development of interindustry relationships that accompany output growth in agriculture.

The interindustry dimension of output growth is essentially the result of the use of intermediate inputs. The production-related interaction between agriculture and non-agriculture is sustained by interindustry flows. These in*terindustry flows hold the industries together and support interdependent rela*tionships. Moreover, these interindustry transactions are flows of communication : they provide coherence and form to the interdependent interindustry framework. To maintain coherence and viability, the constituent industries of an interdependent economic system have to organize production relationships that are adaptive and efficiently synergetic. The organization of agricultural production most suitable to existing conditions and potentially conducive to growth therefore entails changes in the structure of agricultural interindustry relationships.

The research reported in this paper aims to trace the structural development of agricultural interindustry relationships in Japan from 1960 to 1985. The structural development of agricultural interindustry relationships will correspondingly be evaluated by analyzing the economic influence and interindustry production efficiency of these changes. Input-output analysis is an indispensable tool for the attainment of these objectives and the study of the specific areas of analysis.

Section 2 elaborates on the data used and the object of the succeeding analysis.

Section 3 focuses on the qualitative structural changes that have occurred in direct agricultural input-output flows. Have the agricultural interindustry flows become more diversified or specialized through time ? How has the input-output connective structure of agriculture changed and what are its qualitative economic impact effects ?

Section 4 clarifies the changes in the transmission of economic influence to and from agriculture through structural path analysis. The pathways through which changes are communicated to and from agriculture specifically reflect the decomposition of indirect backward linkage effects.

Section 5 deals with changes in the structural complexity and interindustry production efficiency of agricultural interindustry transactions.

Section 6 outlines the major conclusions reached in this study and suggests the relevance of the results gained from the previous sections to the identification of a pattern of change in the structural development of interindustry relationships concomitant with agricultural output growth.

2 DATA AND OBJECT OF THE STUDY

The 1960, 1965, 1970, 1975, 1980, and 1985 input-output tables of Japan in competitive imports form will be used in the succeeding sections. These tables were aggregated into sixteen industries. The method of aggregation placed emphasis on the disaggregation of agriculture into three industries, namely, agricultural crops, livestock, and agricultural services. Furthermore, manufacturing was disaggregated into four industries : food manufacturing, chemicals, machinery, and manufacturing. This was done to single out the interindustry relationships agriculture has with these four manufacturing industries. The sixteen industries are the following :

INDUSTRY	SYMBOL
Agricultural Crops	AGC
Livestock	LS
Agricultural Services	AGS
Forestry	FOR
Fishery	FISH
Mining	MNG

Food Manufacturing	FMFG
Manufacturing	MFG
Chemicals	CHEM
Machinery	MACH
Construction	CONST
Electricity, Gas, and Water /	
Transportation and Communication	EGW
Commerce	COM
Finance, Insurance, Real Estate	FIRE
Government and Private Services	GPS
Others	OTHERS

The period from 1960 to 1985 generally calls attention to the remarkable structural changes that have occurred in the Japanese economy and the turbulent economic events that attended them. Undoubtedly, changes in the interindustry relationships that accompanied these changes have been varied. In this study, however, only the structural development of agricultural interindustry relationships will be dealt with. The results obtained for food manufacturing, an industry closely associated with agriculture, will also be shown.

The twenty-five year time span from 1960 to 1985 will be divided into two periods. Period 1, which covers the period from 1960 to 1970, encompasses the period of rapid growth in the Japanese economy and the pre-oil crisis years. Period 2 includes the oil and post-oil crisis years and spans from 1975 to 1985.

3 THE QUALITATIVE STRUCTURE OF INTERINDUSTRY FLOWS

Qualitative input-output analysis enables the study of the structure of interindustry flows and the processes that govern them without giving attention to the magnitude of the flows themselves. The quality of interindustry flows simply refer to their presence or absence in the input-output table. Thus the qualitative structure of direct agricultural and food manufacturing flows adverts to the distinctive presence or absence of certain interindustry flows to and from agriculture and food manufacturing.

3．1 Diversification, Indirect Relatedness and the Input-Output Connective Structure

Diversity of interindustry flows refers to the number of industries with which a particular of industry has direct input and output connections. The greater the number of direct connections, the more diverse interindustry flows become. In this sense, specialization of interindustry flows allude to the lessening of direct connections and the increase in indirect relatedness.

Direct agricultural and food manufacturing interindustry flows are those reflected in an input-output table. The direct relationships give rise to indirect connections and are thus a basal indicator of potential connectedness. These direct interindustry relationships constitute what is referred to as the input-output connective structure. One can view the connective structure from the kind of input and output dependency relationship existing between two industries, or from the speed with which a direct input and output change in an industry can affect all industries. The speed with which an industry can affect all industries is associated with the concept of qualitative economic impact effects. These economic impact effects will be studied through the analysis of input and output bases.

Methodology

Diversification and indirect relatedness can be measured by using the Yan and Ames interrelatedness function.[2] The application of the Yan and Ames interrelatedness function hinges on the construction of an order matrix, a Boolean matrix of 1's and 0's.

Let Z_{ij} : direct input-output flow

O : order matrix with elements o_{ij}

If $Z_{ij} = 0$, then o_{ij} is set to zero ; if $Z_{ij} > 0$, then o_{ij} is set to one. Apply power series multiplication to the order matrix until all the values of the order matrix becomes positive. If a zero order matrix value becomes positive in round 2, then the order matrix value becomes 2. If in 0^1, $o_{12} = 0$ and in 0^2, $o_{12} > 0$, then $o_{12} = 2$, or the first connection between industries 1 and 2 was reached in round 2. Thus the greater the number of 1 values in the order matrix, the more diverse the input-output flow structure becomes. The presence of many values greater than 1 signify that the input-output flow structure is more indirectly related or specialized.

Based on the order matrix obtained, compute the indexes of diversification and indirect relatedness using the Yan and Ames interrelatedness function.

Let R = interrelatedness function

c = number of rows and columns of a square order matrix

k = number of rounds (equal to the power series number)

N_k = number of order matrix values finishing in round k

$$R = \frac{1}{c} \sum_{k=1}^{\infty} \frac{N_k}{k} \qquad (3-1)$$

Equation 2–1 is the over-all interrelatedness function.

Isolate the first term of the series to get the following index measures :

$$R = \frac{1}{c}\left(\frac{N_1}{k} + \frac{N_2}{k} + \cdots + \frac{N_n}{k_n}\right)$$

$$= \frac{N_1}{c} + \sum_{k \neq 1} \frac{N_k}{kc} \qquad (3-2)$$

The first term of equation 3–2 is the index of diversification and second term is the index of indirect relatedness. The equation further shows that an increase in the index of diversification inevitably lowers the index of indirect relatedness.

In this study, input and output connective relationships are conditioned by the existence of input and output dependency between any two industries. Input and output dependency relationships require the existence of important input and output flows. To determine which input and output flows are important, the construction of an input and output dependency matrix is indispensable.

The quantitatively determined qualitative input and output dependency matrix is a Boolean matrix of 1's and 0's.[3] This matrix includes only quantitatively important direct input and output coefficients. The quantitatively important direct input and output coefficients are determined in the following manner :

a) Obtain the column totals of the direct input coefficient matrix and the row totals of the direct output coefficient matrix of the agricultural and food manufacturing industries. Direct input and output coefficients are computed in this manner :

$$\text{Direct input coefficient} \quad : \; Z_{ij} / X_j$$
$$\text{Direct output coefficient} \quad : \; Z_{ij} / X_i$$

where X_j and X_i are the total output of industry j and i.[4]

b) Pick out in descending order of size the agricultural and food manufacturing input and output coefficients until their total exceed ninety-five percent of the column and row totals. The selected items are considered important input and output coefficients. Construct the quantitatively determined qualitative input and output dependency matrix based on these important input and output flows.

Let a_{ij} : direct input coefficient

g_{ij} : direct output coefficient

D : input dependency matrix with elements d_{ij}

E : output dependency matrix with elements e_{ij}

If a_{ij} is important, then $d_{ij} = 1$. Otherwise, $d_{ij} = 0$.

If g_{ij} is important, then $e_{ij} = 1$. Otherwise, $e_{ij} = 0$.

c) Obtain the direct input and output connectivity matrixes using the input and output dependency matrixes.[5] The input and output connectivity matrix is defined as follows :

$$\begin{aligned} H &: h_{ij} = d_{ij} + d_{ji} + w_{ij} \\ V &: v_{ij} = e_{ij} + e_{ji} + w_{ij} \end{aligned} \qquad (3-3)$$

where H and V are the input and output connectivity matrixes. If direct input-output flows in the original input-output table exist, then $w_{ij} = 1$. Otherwise, $w_{ij} = 0$.

If h_{ij} (or v_{ij}) is equal to 3, the connective relationship between the two industries is bilateral because both industries consider each other's input (or output) as important. If h_{ij} (or v_{ij}) is equal to 2, the connective relationship between the two industries is unilateral: only one of the two industries consider the other input (or output) as important. Finally, if h_{ij} (or v_{ij}) is equal to 1, the connective relationship is weak, that is, both industries do not consider each other's input (or output) as important.

An input-output basis refers to the industry where direct input and output change is induced.[6] An input or output basis is usually the industry with the most number of input or output dependent relationships. The industry with a relatively higher row sum in the input dependency matrix is a potential input basis; the industry with a relatively higher column sum in the output dependency matrix is a potential output basis. In this study, however, only agriculture, food manufacturing, and the combination of agriculture and food manufacturing will be considered as input and output bases; only their qualitative economic effects will be studied. A combined input and output basis means that change is simultaneously induced in the industries being combined.

Using the input and output dependency matrixes obtained previously, determine the number of rounds it takes for the direct input and output effects of agriculture and food manufacturing to reach all industries.

Let D # : input basis row vector where only the input basis (either agriculture or food manufacturing, or both) element is equal to 1

E # : output basis column vector where only the output basis (either agriculture or food manufacturing, or both) element is equal to 1

D : input dependency matrix

E : output dependency matrix

Applying the Boolean multiplication rule, pre-multiply the D # vector to the D matrix and post-multiply the E # vector to the E matrix. Continue the multiplication using the power series of D and E until the vector product elements are all equal to 1, that is, all the elements are positive. The number of rounds needed to make all the elements of the vector product equal to 1 is therefore equal to the power series number. The number of rounds signify the speed with which a change in the direct input and output flows of agriculture can be induced to all industries. The number of rounds taken by agriculture as an input basis generally depends on the number of industries that consider agricultural output as an important production input : the greater the number of industries, the smaller the number of rounds. On the other hand, the number of rounds taken by agriculture as an output basis generally depends on the number of important output flows going to agriculture from other industries : the greater the number of important output flows going to agriculture, the smaller the number of rounds.

3. 2 Analysis Results and Discussion

The change in the index of diversification and indirect relatedness were computed using equation 3–2. As shown in tables 3.1 and 3.2, the diversification and indirect relatedness indexes of the direct input flows of agricultural crops and livestock have virtually remained unchanged in both periods. Agricultural crops and livestock have maintained a highly diverse qualitative input structure. Agricultural services and food manufucturing have shown a relatively similar pattern of change. Moreover, the index of diversification of agricultural services was higher in period 2 than in period 1. The input diversity of food manufacturing was higher than of agriculture in both periods.

Table 3.1 Change in the Index of Input Flow Diversification of the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	0.875	0.875	0.875	0.875	0.875	0.875
LS	0.875	0.875	0.875	0.875	0.875	0.875
AGS	0.6875	0.6875	0.8125	0.8125	0.8125	0.75
FMFG	0.9375	0.9375	1	1	0.9375	0.9375

Table 3.2 Change in the Index of Input Flow Indirect Relatedness of the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625
LS	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625
AGS	0.15625	0.15625	0.09375	0.09375	0.09375	0.125
FMFG	0.0125	0.0125	0	0	0.0125	0.0125

On the other hand, an inspection of tables 3.3 and 3.4 reveals that there was greater variation in the indexes of output flow diversification and indirect relatedness compared to that of input flow. The diversity of the direct input flow of agriculture has remained relatively more stable than its direct output flow. The index of output flow diversification of livestock, agricultural services, and food manufacturing were generally greater in period 2 than in period 1. Their direct output flows were delivered to more industries in period 2, or more industries required their output as input in production. Agricultural crops showed the reverse trend : its output flows became less diverse or more specialized. Agricultural crops have become more of a specialized input in production in period 2.

Table 3.3 Change in the Index of Output Flow Diversification of the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	0.875	0.875	0.625	0.625	0.6875	0.75
LS	0.4375	0.5	0.5625	0.625	0.625	0.625
AGS	0.1875	0.125	0.3125	0.1875	0.125	0.3125
FMFG	0.625	0.6875	0.625	0.75	0.75	0.6875

Table 3.4 Change in the Index of Output Flow Diversification of the the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	0.0625	0.0625	0.1875	0.1875	0.15625	0.125
LS	0.28125	0.25	0.21875	0.1875	0.1875	0.1875
AGS	0.40625	0.4375	0.34375	0.3854	0.40625	0.34375
FMFG	0.1875	0.15625	0.1875	0.125	0.125	0.15625

The bilateral input connective interindustry relationships of agriculture and food manufacturing were determined using equation 3–3. As shown in table 3.5, the number of strong input connective relationships of agricultural crops has decreased through time. This connotes that unilateral or weak connective input relationships dominate the structure of the direct input flows of agricultural crops. The connective relationship between agricultural crops and livestock has remained strong.

Table 3.5 Change in the Bilateral Input Connective Interindustry Relationships of Agricultural Crops,1960-1985

1960	LS	FMFG	MFG	CHEM
1965	LS	FMFG	CHEM	OTHERS
1970	LS			
1975	LS			
1980	LS			
1985	LS	AGS		

Note: Industries do not appear in any particular order.

An examination of tables 3.6 and 3.7 show that the number of bilateral input connective relationships that livestock and food manufacturing have remained relatively unchanged. The connective relationship between livestock and food manufacturing has remained bilateral. Likewise, the bilateral connective relationship between food manufacturing and fisheries has persisted. Food manufacturing also showed a bilateral input connective relationship with government and private services. Generally, the agricultural and food manufacturing industries of Japan show weak or unilateral input connective relationship with the secondary and tertiary industries. This trend was more prominent in period 2.

Table 3.6 Change in the Bilateral Input Connective Interindustry Relationships of Livestock,1960-1985

1960	AGC	FMFG	
1965	AGC	FMFG	
1970	AGC	FMFG	
1975	AGC	FMFG	
1980	AGC	FMFG	
1985	AGC	AGS	FMFG

Note: Industries do not appear in any particular order.

Table 3.7 Change in the Bilateral Input Connective Interindustry Relationships of Food Manufacturing, 1960-1985

1960	AGG	LS	FISH	CHEM	
1965	LS	FISH			
1970	LS	FISH	GPS		
1975	LS	FISH	EGW	COM	GPS
1980	LS	FISH	GPS		
1985	LS	FISH	GPS		

Note: Industries do not appear in any particular order.

The change in the bilateral output connective relationships of agriculture and food manufacturing were also determined using equation 3–3. Looking at tables 3.8 to 3.10, one can observe that the output connective relationships of the agricultural and food manufacturing industries show fewer bilateral relationships with other industries through time. Agricultural crops did not even have one single bilateral output connective relationship in 1985. Generally,

Table 3.8 Change in the Bilateral Output Connective Interindustry Relationships of Agricultural Crops, 1960-1985

1960	L S		
1965	L S	O T H E R S	C H E M
1970	L S		
1975	L S		
1980	L S		
1985			

Note: Industries do not appear in any particular order.

Table 3.9 Change in the Bilateral Output Connective Interindustry Relationships of Livestock, 1960-1985

1960	A G C	F M F G
1965	A G C	F M F G
1970	A G C	
1975	A G C	
1980	A G C	F M F G
1985	F M F G	

Note: Industries do not appear in any particular order.

Table 3.10 Change in the Bilateral Output Connective Interindustry Relationships of Food Manufacturing, 1960-1985

1960	L S	C H E M	O T H E R S
1965	L S	M F G	C H E M
1970	E G W	G P S	
1975	E G W		
1980	L S		
1985	L S	O T H E R S	

Note: Industries do not appear in any particular order.

the agricultural and food manufacturing industries show specialized or weaker output connective relationships through time.

The results obtained for the input basis analysis are enumerated in table 3.11. As can be observed in table 3.11, the number of rounds for food manufacturing and the combination of livestock and food manufacturing have shown the same pattern. Their input effect has become more immediate in period 2 than in period 1. The input effect of agricultural crops and the combination of livestock and agricultural crops fluctuated more in period 2 than in period 1. Their input effect has become relatively longer in period 2. The input effect of livestock and the combination of agricultural crops and food manufacturing in periods 1 and 2 showed the same pattern. The number of rounds taken by these two sets of input bases at the start of period 1 and at the end of period 2 were the same.

Agriculture should be combined with other industries like food manufacturing if the desired objective is the hastening of input effect. As a sole input basis, agriculture particularly agricultural crops has taken a greater number of rounds before it can affect all industries. The combination of livestock and food manufacturing looks promising because their input effect has become faster.

Table 3.11 Input Basis: Change in the Number of Rounds for the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	2	3	4	3	4	3
LS	3	4	4	3	4	3
FMFG	3	4	3	2	3	2
AGC AND LS	2	3	4	3	4	3
AGC AND FMFG	2	3	3	2	3	2
LS AND FMFG	3	4	3	2	3	2

Note: The last three rows show the results of the combined input basis.

An examination of table 3.12 shows that the number of rounds taken by agricultural crops as an output basis has remained the same in both periods. In combination with food manufacturing, livestock and agricultural crops as output bases affected all industries faster. Generally, the number of rounds in period 1 was the same as in period 2.

The output effect of agriculture seems to improve, that is the number of rounds taken by agriculture becomes shorter, if direct output change is induced in conjunction with other industries.

Table 3.12 Output Basis: Change in the Number of Rounds for the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	3	3	3	3	3	3
LS	3	3	4	4	4	3
FMFG	2	2	3	3	3	2
AGC AND LS	2	3	3	3	3	3
AGC AND FMFG	2	2	3	3	3	2
LS AND FMFG	2	2	3	3	3	2

Note: The last three rows show the results of the combined input basis.

The consideration of the qualitative structure of agriculture and food manufacturing has revealed the distinct input-output flow characteristics and connective relationships of these industries. The way this structure operates, however, has not been examined. The operation of the structure involves, among other things, the transmission of economic effects or influence. How do the effects of the changes in the output or final demand of one industry "travel" to another ? Structural path analysis in an interindustry framework offers powerful insights into the way industries interdependently affect each other.

4 THE STRUCTURAL PATHS OF ECONOMIC INFLUENCE

Lanter (1974) and Gazon (1979) have formulated the concept of economic influence and structural analysis to ascertain the paths through which influence travels within a particular structure.[7] The discovery of the pathways of influence therefore involves the tracing the effect of an exogenous variable on an endogenous variable.

The transmission of economic influence in an interindustry framework is conditioned by existing interindustry relationships which define the particular structure. Without interdependent relationships, economic influence can never be realized. Before examining the pathways of influence determined by these interdependent relationships, it is necessary to outline some of the basic concepts and methodology of structural path analysis.

4. 1　Basic Concepts and Methodology of Structural Path Analysis

Input-output flows are considered as flows of influence. The direct input from j necessary to produce output of i represents an arc which transmits the intensity of the influence of i on j.

$$i \xrightarrow{a_{ji}} j$$

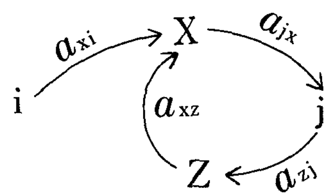
Industries i and j are considered the poles of the structure ; i is the pole of origin and j is the pole of destination.

The length of the structural path is equal to the number of arcs.

$$i \xrightarrow{a_{xi}} x \xrightarrow{a_{jx}} j$$

Thus the length of this path is 2 since there are two arcs : from i to x and from x to j. Paths involving two or more arcs are referred to as indirect paths ; paths involving one arc are called direct paths. The influence graph of a particular interdependent structure is therefore composed of the network of arcs from one industry to another.

An elementary path is one which passes a pole only once ; a circuit is a path where the first pole (pole of origin) coincides with the last one (pole of destination).



The path $i \rightarrow x \rightarrow j$ is an elementary path, while $x \rightarrow j \rightarrow z \rightarrow x$ is a circuit.

The direct influence of industry i on j is the immediate effect or change in the output of j induced by the change in the production or final demand of i. The direct input coefficient matrix A is called the matrix of direct influences. The element a_{ij} of the the direct input coefficient matrix is therefore the direct influence of j on i and the element a_{ji} is the direct influence of i on j. Direct influence can be measured in two ways :

1. direct influence along an arc

$$I^{D}_{(i \rightarrow j)} = a_{ji} \qquad (4-1)$$

2. direct influence along an elementary path[8]

$$I^{D}_{(i \rightarrow j)} = a_{xi} \cdots\cdots a_{jx} \qquad (4-2)$$

where I^D is direct influence.

Total influence is equal to the effect of the direct influence along a certain path and the indirect effects induced by the circuits of the said path. The total influence of i on j along a given path is therefore defined as follows :

$$I^{T}_{(i \rightarrow j)} = I^{D}_{(i \rightarrow j)p} Mp \qquad (4-3)$$

where I^T is total influence, M is the path multiplier, and p is the particular path associated with the influence. The first term of the equation is equal to the previously defined direct influence, and the second term is the path multiplier. Circuits amplify the effects of the direct influence along a path and thus give rise to path multipliers. The path multiplier is generally the ratio of two determinants : the determinant of the structural path and the determinant of the whole structure represented by the (I-A) matrix. The determinant of the structural path is determined after removing from the (I-A) matrix all the row and column elements of the poles involved in the path.

Global influence measures the total effects of a change in output or final demand in j on i. While direct influence involve specific paths, global influence encompasses the direct influence transmitted by all elementary paths from j to i. Moreover, it includes all induced and feedback effects brought about by the circuits in the influence graph. The Leontief inverse matrix is considered to be the matrix of global influences because each element of this matrix captures the total effect of a change in final demand in j on the output of i.

$$I^{G}_{(i \rightarrow j)} = b_{ji} \qquad (4-4)$$

where I_G is global influence and b_{ji} is the global Lentief inverse matrix element. Therefore global influence in this case is the backward linkage effect of j on i.

Lantner (1974) and Gazon (1976) have proposed that the global influence of a pole i on pole j is equal to the sum of the total influences of i on j along all elementary paths joining i to j. This is called the theorem of influence. Thus the global influence can be decomposed into a series of total influences, that is,

$$I^{G}_{(i \rightarrow j)} = \sum_{p=1}^{n} I^{T}_{(i \rightarrow j)p} = \sum_{p=n}^{n} I^{D}_{(i \rightarrow j)p} M_p \qquad (4-5)$$

where p stands for elementary paths spanning i and j.[9]

The decomposition of the global influence shown in the global Leontief inverse matrix is the object of the succeeding analysis of the structural paths of influence to and from agriculture and food manufacturing. Only the structural paths that represent the biggest backward linkage effects of agriculture on other industries and the biggest backward linkage effects of manufacturing on an agricultural industry will be analyzed. Therefore the structural path from agricultural crops to chemicals, livestock to food manufacturing, food manufacturing to agricultural crops, and from manufacturing to agricultural crops will be taken up in the analysis. Furthermore, only elementary paths with lengths equal to two will be considered.

4．2　Analysis Results and Discussion

The total influence of a particular path was determined using equation 4-3. The global Lentief inverse matrix $(I-A)^{-1}$ was used to compute the total influence of an elementary path. As shown in table 4.1, the structural path of influence that goes direct from agricultural crops to chemicals constitute most of the global influence of agricultural crops on chemicals. The share of the total influence of the elementary path from agricultural crops decreased in period 1, but increased in period 2. Generally, the share of the direct path from agricultural crops to chemicals has remained very high. This reflects the fact that the use of chemicals as input in agricultural production has generally remained at a higher level compared to other inputs. The share of the other elementary paths remained small.

Table 4.1 Structural Path Analysis: From Agricultural Crops to Chemicals, 1960-1985

PATH ORIGIN	PATH DESTINATION	GLOBAL INFLUENCE	ELEMENTARY PATHS	TOTAL INFLUENCE	A(%)
AGRI.CROPS	CHEMICALS	0. 138697	AGC-CHEM	0. 1312	94. 63
		1960	AGC-MFG-CHEM	0. 0028	1. 99
		0. 121464	AGC-CHEM	0. 1134	93. 34
		1965	AGC-MFG-CHEM	0. 0036	2. 99
		0. 104019	AGC-CHEM	0. 0947	91. 04
		1970	AGC-MFG-CHEM	0. 0043	4. 11
		0. 119359	AGC-CHEM	0. 11078	92. 81
		1975	AGC-MFG-CHEM	0. 004	3. 32
			AGC-AGS-CHEM	0. 0014	1. 17
		0. 17034	AGC-CHEM	0. 1545	90. 99
		1980	AGC-MFG-CHEM	0. 0057	3. 37
			AGC-AGS-CHEM	0. 0021	1. 26
		0. 129729	AGC-CHEM	0. 1223	94. 25
		1985	AGC-MFG-CHEM	0. 0041	3. 13
			AGC-AGS-CHEM	0. 0017	1. 3

Notes: A is the share of total influence of the elementary path in the global influence. Only those elementary paths with lengths equal to two and with a share of more than one percent are shown in the table.

Table 4.2 Structural Path Analysis: From Livestock to Food Manufacturing, 1960-1985

PATH ORIGIN	PATH DESTINATION	GLOBAL INFLUENCE	ELEMENTARY PATHS	TOTAL INFLUENCE	A(%)
LIVESTOCK	FOOD MFG.	0. 335373	LS-FMFG	0. 3317	98. 91
		1960			
		0. 490388	LS-FMFG	0. 4893	98. 78
		1965			
		0. 511337	LS-FMFG	0. 5097	99. 69
		1970			
		0. 537466	LS-FMFG	0. 536	99. 73
		1975			
		0. 536119	LS-FMFG	0. 5339	99. 59
		1980			
		0. 515171	LS-FMFG	0. 5097	98. 95
		1985			

Notes: A is the share of total influence of the elementary path in the global influence. Only those elementary paths with lengths equal to two and with a share of more than one percent 6 are shown in the table.

Looking at table 4.2, one can facilely observe that the path of influence from livestock to food manufacturing is restricted to the elementary path connecting the two industries. The total influence of the path from livestock to food manufacturing has remained relatively invariant through the years. This signifies the predictability of the pathway taken by an impulse from livestock to food manufacturing.

As can be observed in table 4.3, the direct path from food manufacturing to agricultural crops has solely dominated the global influence of food manufacturing on agricultural crops. This contributes to the certainty of the way influence travels from food manufacturing to agricultural crops.

Table 4.3 Structural Path Analysis: From Food Manufacturing to Agricultural Crops, 1960-1985

PATH ORIGIN	PATH DESTINATION	GLOBAL INFLUENCE	ELEMENTARY PATHS	TOTAL INFLUENCE	A(%)
FOOD MFG.	AGRI.CROPS	0.457064	FMFG-AGC	0.4411	96.52
		1960	FMFG-LS-AGC	0.0092	2.02
		0.409751	FM-AGC	0.3899	95.15
		1965	FMFG-LS-AGC	0.0107	2.61
		0.361282	FMFG-AGC	0.347	96.06
		1970	FMFG-LS-AGC	0.0123	3.4
		0.354246	FMFG-AGC	0.335	94.57
		1975	FMFG-LS-AGC	0.0161	4.54
		0.290597	FMFG-AGC	0.2727	93.85
		1980	FMFG-LS-AGC	0.0163	5.62
		0.240242	FMFG-AGC	0.2287	95.21
		1985	FMFG-LS-AGC	0.0101	4.22

Notes: A is the share of total influence of the elementary path in the global influence. Only those elementary paths with lengths equal to two and with a share of more than one percent are shown in the table.

A major portion of the global influence of manufacturing on agricultural crops generally comes from the direct pathway from manufacturing to agricultural crops. This can be see from table 4.4. The share of the total influence of this pathway in period 1 is on the average slightly higher than in period 2. The paths that go from manufacturing to agricultural crops have shown greater variety than the paths of influence that go from agriculture to those industries with which agriculture has strong backward linkage effects.

Generally, the predictability of the transmission of influence from agriculture to the industry where it has strong backward linkage effects is very high. The path of transmission has remained simple : the direct path has always con-

Table 4.4 Structural Path Analysis: From Food Manufacturing to Agricultural Crops, 1960-1985

PATH ORIGIN	PATH DESTINATION	GLOBAL INFLUENCE	ELEMENTARY PATHS	TOTAL INFLUENCE	A(%)
MANUFACTURING	AGRI.CROPS	0.0614644	MFG-AGC	0.0476	74.41
		1960	MFG-LS-AGC	0.0046	7.47
			MFG-CHEM-AGC	0.004	6.51
			MFG-FMFG-AGC	0.002	3.22
		0.0368224	MFG-AGC	0.0213	57.74
		1965	MFG-CHEM-AGC	0.0045	12.17
			MFG-LS-AGC	0.0022	6.04
			MFG-FMFG-AGC	0.0015	4.12
		0.0164588	MFG-AGC	0.0106	64.43
		1970	MFG-FMFG	0.0008	4.85
			MFG-LS-AGC	0.0002	1.24
		0.0136378	MFG-AGC	0.0078	57.35
		1975	MFG-LS	0.0008	5.87
			MFG-FMFG	0.0006	4.78
		0.0108	MFG-AGC	0.0073	67.15
		1980	MFG-LS-AGC	0.0007	6.38
			MFG-FMFG	0.0006	5.72
		0.0086	MFG	0.0053	62.28
		1985	MFG-FMFG-AGC	0.0004	5.28
			MFG-LS-AGC	0.0003	3.09
			MFG-CHEM-AGC	0.0002	1.85

Notes: A is the share of total influence of the elementary path in the global influence. Only those elementary paths with lengths equal to two and with a share of more than one percent are shown in the table.

tributed more than ninety percent of the global influence. On the other hand, the path of influence from manufacturing to agricultural crops has only explained around sixty to sixty-five percent of the global influence of manufacturing on agricultural crops. This implies that there are a lot of pathways for the transmission of influence from manufacturing to agriculture. The pathways, however, involve only those industries with significant backward linkage relationships with agriculture.

Since the determination of structural paths depend on the existence of input-output flows, the existence of many zero values for the agricultural and food manufacturing industries in the direct input coefficient matrix indicate that the influence of other industries on agriculture and food manufacturing involve specialized paths of influence. Likewise, the role of agriculture as a path of influence is greatly reduced by the presence of many zero output flow values. This connotes that the nonuse of agriculture as input in industrial production greatly diminishes the potential of agriculture to transmit economic influence.

Another way of looking at how the interdependent structure of agriculture and food manufacturing industries operate is to look at the complexity of its transactions with other industries and the interindustry production efficiency that results from it.

5　STRUCTURAL COMPLEXITY AND INTERINDUSTRY PRODUCTION EFFICIENCY

Interindustry flows are flows of communication. Interdependent industries operate or produce based on the "signals" received from and sent to other industries. Interindustry transactions embody these signals : they externalize the demand for inputs and outputs necessary for the attainment of production goals.

Structural complexity results from the transactions among the interdependent industries in an economy. How these transactions contribute to the achievement of production goals determine interindustry production efficiency. The Robinson and Markandya model[10] offers an empirical way of measuring structural complexity and suggests concepts related to the determination of interindustry production efficiency.

5．1　Robinson-Markandya Model

The assumptions of the Robinson-Markandya model implies that the industries in the economy produce output according to the power series expansion of the inverse.[11] Since the inverse matrix used in this section is the domestic Leontief inverse matrix $(I-UA)^{-1}$, [12] this means that the economy produces output in this manner :

$$X = (I-UA)^{-1}$$
$$= \lim_{n\to\infty} (I + UA + (UA)^2 + \cdots + (UA)^n)\, F \qquad (5-1)$$

where U is the diagonalized rate of self-sufficiency matrix, A is the direct input coefficient matrix, F is final demand which is equal to (UD + E), D is domestic final demand, and E is exports.

In the first production round, F is produced and the sectors order (UA)

F. In the second production round, (UA) F is produced and $(UA)^2$ F is ordered and so on. This series continue until each industry has reached a certain percentage of total output. In this study, the agricultural and food manufacturing industries finish production after they have achieved ninety-eight percent of total output. All the other sectors finish production after they have achieved ninety-five percent of production. The choice of the cut-off point is arbitrary. Agriculture and food manufacturing was made to produce a greater percentage of output since food is a basic necessity.[13]

The imposition of a cut-off point denotes that the power series can be written as :

$$X(i) = (I + UA^{(1)} + UA^{(2)} + \cdots + UA^{(n)}\, UA^{(n-1)}\, UA^{(1)})\, F \qquad (5-2)$$

In this equation $(UA)^{(1)}$ is equal to UA. $UA^{(2)}$ is also equal to UA, but the elements in the columns of (UA) for those sectors which finished production in the previous round is set to zero. For example, if a certain industry finishes in round 3, then that industry produces up to round 4. After round 4, its column elements are set to zero. The number of production rounds for this industry therefore is equal to 3.[14] Equation 5–2 is the Robinson-Markandya model specification.

Furthermore, Robinson and Markandya imply that the number of production rounds indicates a constant adjustment cost. Therefore the greater the number of rounds an industry takes to complete required production, the less cost efficient production becomes. In this study, interindustry production efficiency is thus equated with a fewer number of production rounds. Likewise, the greater the number of rounds an industry takes to complete production, the more complex its transactions with other industries become. Thus complexity is associated with higher adjustment cost.

Structural complexity can be examined by constructing a structure of transactions matrix from the results obtained using equation 5–2.[15]

Let T_{ij} = structure of transactions matrix

A_{ij} = direct input coefficient matrix

t_j = number of rounds for industry j to finish production

If $A_{ij} = 0$, then $T_{ij} = 0$. If $A_{ij} > 0$, then $T_{ij} = t_j$. The following summary measures of the structure of transactions matrix can be consequently computed:

$$T^{*} = \sum_{i=1}^{n} T_{ij} \qquad (5-3)$$

$$T^{**} = \sum_{j=1}^{n} T_{ij} \qquad (5-4)$$

$$T^{***} = \sum_{i}\sum_{j} T_{ij} \qquad (5-5)$$

T^{*} indicates the total number of orders placed by industry j on other industries. This measures the demand transactions that industry j have to carry out with other industries in order to acquire inputs needed for production. T^{**} shows the total number of deliveries made by industry i on all industries ; therefore, this measures the total demand transactions received by industry i from all industries so that these industries can produce needed output. T^{***} is the total number of transactions for the economy, or the amount of transactions needed by the economy to produce the requisite industrial output or to reach equilibrium. This last measure can be considered as a measure of the structural complexity of the economy.

5. 2 Analysis Results and Discussion

Equation 5–2 was used to arrive at the results listed down in table 5.1. Looking at 5.1, one can discern that the number of production rounds for both agricultural crops and livestock decreased in period 2. Agricultural production has become more interindustry production efficient, and agricultural transactions have become less complex. On the other hand, food manufacturing showed an increase in its number of production rounds in period 2 ; therefore, its transactions have become more complex and costlier.

One can also notice in table 5.1 that livestock recorded its highest number of rounds in 1960, a year that coincides with its lowest rate of self-sufficiency. Agricultural crops showed the same pattern. This suggests that the rate of self-sufficiency affects the speed with which production of outpuut and the attainment of equilibrium are achieved. This finding corroborates the empirical results obtained by Robinson and Markandya (1973).

Table 5.1 Change in the Number of Production Rounds for the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	6	5	5	9	5	5
LS	10	6	5	6	5	5
AGS	5	5	5	5	4	5
FMFG	3	3	4	3	4	4

The results shown in tables 5.2 and 5.3 were arrived at by using equations 5–3 and 5–4, respectively. In tables 5.2 and 5.3, one can note that the total demand transactions generated and received by agricultural crops and livestock decreased in period 2. This connotes that in order to produce desired output, agriculture did not need to transact with other industries for its inputs as much as before. Agriculture can produce required output with lesser transactions ; it has become more transactions efficient. Likewise, agriculture did not have to deliver or receive transactions as much as before presumably because of its declining use as input in industrial production. On the other hand, the total demand transactions generated and received by food manufacturing, however, increased in period 2. Generally, the increase in the number of production rounds is accompanied by an increase in total demand transactions generated and received, vice-versa.

Table 5.2 Change in the Total Demand Transactions Generated by the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	84	70	70	126	70	70
LS	140	84	75	84	70	65
AGS	55	70	65	60	52	60
FMFG	45	45	64	48	60	60

Note: Derived from the structure of transactions matrix(column totals).

Table 5.3 Change in the Total Demand Transactions Received by the Agricultural and Food Manufacturing Industries of Japan, 1960-1985

	1960	1965	1970	1975	1980	1985
AGC	68	63	43	43	48	50
LS	44	42	42	47	46	46
AGS	22	16	30	18	10	23
FMFG	52	43	44	53	53	49

Note: Derived from the structure of transactions matrix(row totals).

6 CONCLUSIONS

Changes in agriculture's qualitative direct input and output flow structure and connective relationships, economic influence, and interindustry production efficiency generally characterize the structural development of Japanese agricultural interindustry relationships from 1960 to 1985. Amidst these perceivable changes, one invariant aspect stands out : the direct input structure of Japanese agriculture has remained diverse in both periods. Japanese agriculture has therefore maintained a steady flow of direct inputs from other industries. The direct output flow of Japanese agriculture, however, showed varying trends. The direct output flow agricultural crops and food manufacturing has become more of a specialized input in industrial production in period 2. The flow of output from livestock has become more diversified in period 2 signifying that livestock input is being used by a greater number of industries. The agricultural and food manufacturing industries of Japan generally show weak or unilateral input and output connective relationships with the secondary and tertiary industries. This trend became more visible in period 2.

Japanese agriculture has become weaker as a basis for economic impulse in period 2. This suggests the inability of agriculture to affect more industries within a given period of time ; agriculture affects only a few industries. The combination of agriculture with other industries like food manufacturing, however, enhances the speed of its effect. Moreover, an increase in agricultural input dependency by other industries may enhance the strength of agriculture as a basis for economic impulse. This means that if the use of agricultural inputs in industrial production is widespread, agriculture stands a better chance of influencing other production activities. This entails finding ways of using the output of agriculture as input in industrial production. The efforts aimed at converting rice into fuel as a substitute for gasoline is a good example.[16]

The economic influence from agriculture to those industries with which it has strong backward linkage relationships is transmitted more intensely through the direct path. The probability that the economic influence from an agricultural industry to another agricultural industry or to food manufacturing will be transmitted directly has become higher in period 2. This means that if change is induced in livestock, most of the influence will surely travel directly to food manufacturing. As the transmission of influence becomes more certain, the path taken from one industry to another by policy induced changes also become more foreseeable. This denotes that one can judge fairly well how the effects of a change in final demand in one industry may journey to another. The paths of influence from other industries to agriculture involve specialized paths owing to the many zero input-output flows in agriculture. Likewise, the capability of agriculture as a path of influence is greatly reduced by the non-existence of many zero output flows, or the nonuse of agriculture as input in industrial production.

Although the economic influence of agriculture has weakened in period 2, its interindustry production efficiency has improved. This is presumably due to an increase in the proportion of output produced domestically or the improvement of self-sufficiency and to the change in its input structure. The ranking of agricultural input coefficients has shown that its requirements of secondary and tertiary inputs have increased. More specifically, the inputs from industries like manufacturing, commerce, finance, insurance, and real estate, electricity, gas, water and transportation and communication increased quite prominently in period 2. This change has been conducive to the interindustry agricultural production process because it provided important links with the secondary and tertiary industries.

The structural development of agricultural interindustry relationships in Japan and the economic events that have unfolded from 1960 to 1985 have to be considered concurrently in greater detail. Furthermore, the contention that countries like Korea, Taiwan, and the Philippines can follow the path traversed by Japan towards agricultural development requires an interindustry aspect to it because of the interdependent nature of agricultural production. This alludes to the possibility of recognizing an interdependent Asian path towards agricultural development. Thus the results obtained in this study may serve as a basis for the identification of a pattern of change in the structural development of agricultural interindustry relationships associated with agricultural output growth in the developing countries.

NOTES

1. For more about the Asian path see Hayami and Ruttan (1985) and Timmer (1988).
2. Blin and Murphy (1974), Hamilton and Jansen (1983), and Szyrmer (1985) have argued against the use of this index as a measure of total interrelatedness. However, Szymer (1986) has pointed out that the Yan and Ames index is a consistent measure of connectiveness, that is, the qualitative nature of direct input-output flows.
3. The construction of the dependency matrix in this study differs from that of Holub and Schnabl (1985) because only important input and output flows are considered. The important input and output flows are based on the direct input and output coefficients. See for example Simpson and Tsukui (1965), Jilek (1971), and Schintke and Staglin (1985) for a basic discussion of the concept of important coefficients. See Bon (1989) for a different kind of application of qualitative input-output analysis.
4. The direct output coefficient formula is the one used for obtaining the Augustinovics inverse which is used by some researchers to measure forward linkage effects. See Augustinovics (1970) and Miller and Blair 1985).
5. The construction of the direct input and output connectivity matrix differs from that of Holub and Schnabl (1985) because this matrix was based on a quantitatively determined input and output dependency matrix. Moreover, the term connectivity matrix also differs from the one used by Holub and Schnabl (1985). They used the term connectedness matrix. Connectivity was deemed more appropriate because the matrix shows only the relationships among direct input and output flows. The choice of the term was therefore based on the distinction between connectivity and connectedness made by Szyrmer

(1986).

6. The input basis concept of Holub and Schnabl (1985) was considered as the output basis in this study because Holub and Schnabl's input basis concept relied on the presence of distribution or output flows. Thus the input basis concept presented here is different from that of Holub and Schnabl because it relies on input flows. The interpretation of the effects of an input or an output basis, however, conforms with that of Holub and Schnabl (1985).
7. The mathematical formalization of the concepts of influence and structural analysis has made it applicable to any system of linear equations. Basic literature on this subject is written in French. See for example Lantner (1972), and Gazon (1979). See Crama, Defourny, and Gazon (1984) for an English introduction to structural path analysis. Examples of the application of the method can be seen in Defourny (1982), Defourny and Thorbecke (1984), and Kahn and Thorbecke (1989).
8. Lantner (1974) proved that the direct influence along an elementary path is the product of intensities of the arcs constituting the path.
9. The algebraic proof of the decomposition of the global influence appears in Crama, Defourny, and Gazon (1984), and Defourny and Thorbecke (1984).
10. The Robinson-Markandya model is referred to by several names. Robinson and Markandya (1973) refers to their model as a quantity adjustment model. Jackson, Hewings, and Sonis (1989) calls it the rounds-of-spending procedure. See Hewings (1982) for an example of how this model can be interpreted.
11. The assumptions of the Robinson-Markandya model can be found in their 1973 paper.
12. The domestic Leontief inverse matrix $(I-UA)^{-1}$ was used because we did not assume autarky. Moreover, the use of the $(I-UA)^{-1}$ allows for the consideration of the effect of the change in the rate of self-sufficiency on the number of production rounds.
13. Robinson and Markandya (1973) suggested the use of official data to determine the cut-off point.
14. The way the term production rounds is used in this study follows that of Robinson and Markandya (1973), that is, the length of time between making the production decision and actually producing the output. Robinson and Markandya refers to this length of time as a month.
15. Transactions between two industries include the demand and supply of input and output, or the requirement and delivery of input and output. In this sense, interindustry transactions involve certain costs which, however, cannot be clearly defined within the interindustry framework.
16. See Japan Times, 21 August 1990.

REFERENCES

Augustinovics, Maria. 1970. Methods of international and intertemporal comparison of structure. Chap. 13 in *Contributions to input-output analysis*, ed. Anne P. Carter and Andrew

Brody. Amsterdam : North Holland Publishing Co.

Blin, Jean-Marie and Frederick Murphy. 1974. On measuring economic interrelatedness. *Review of Economic Studies* 41 : 437–40.

Bon, Ranko. 1989. Qualitative input-output analysis. Chap. 16 in *Frontiers of input-output analysis*, ed. Ronald Miller, Karen Polenske, and Adam Rose. New York and Oxford : Oxford Univ. Press.

Crama, Yves, Jacques Defourny, and Jules Gazon. 1984. Structural decomposition of multipliers in input-output or social accounting matrix analysis. *Economie Appliquee* 37, no. 1 : 215–22.

Defourny, Jacques. 1982. Une approache structurale pour l'analyse input-output : Un premier bilan. *Economie Appliquee* 35, no. 1–2 : 203–30.

Defourny, Jacques and Erik Thorbecke. 1984. Structural path analysis and multiplier decomposition within a social accounting framework. *The Economic Journal* 94, no. 373 (March) : 111–36.

Gazon, Jules. 1979. Une nouvelle methodologie l'approache structurale de l'influence economique. *Economie Appliquee* 32, no. 1 : 301–07.

Government of Japan. *1960 Input-Output Table*. Tokyo, Japan.

……… . *1965 Input-Output Table*. Tokyo, Japan.

……… . *1970–1975–1980 Link Input-Output Tables*. Tokyo, Japan.

……… . *1985 Input-Output Table*. Tokyo, Japan.

Hamilton, J. R. and R. C. Jensen. 1983. Summary measures of interconnectedness for input-output models, *Environment and Planning A* 15, no. 1 (January) : 55–65.

Hayami, Yujiro and Vernon W. Ruttan. 1985. *Agricultural development : An international perspective*. Rev. and exp. ed. Baltimore and London : The Johns Hopkins Univ. Press.

Hewings, Geoffrey J. D. 1982. The empirical identification of key sectors in an economy : A regional perspective. *The Developing Economies* 20, no. 2 (June) : 173–95.

Holub, H. W. and H. Schnabl. 1985. Qualitative input-output analysis and structural information. *Economic Modelling* 2 (January) : 67–73.

Jackson, Randall W., Geoffrey J. D. Hewings, and Michael Sonis. 1989. Decomposition approaches to the identification of change in regional economies. *Economic Geography* 65, no. 3 (July) : 216–31.

Japan Times, 21 August 1990, p. 5. col. 7.

Jilek, Jaroslav, 1971. The selection of most important input coefficients. *Economic Bulletin for Europe* 23, no. 3 : 86–105.

Kahn, Haider A. and Erik Thorbecke. 1989. Macroeconomic effects of technology choice : Multiplier and structural path analysis within a SAM framework. *Journal of Policy Modeling* 11, no. 1 (Spring) : 131–56.

Lantner, Roland. 1972. Recherche sur l'interpretation du determinant d'une matrice input-output. *Revue d' Economie Politique* 82, no. 2 (March-April) : 435–42.

……… . 1974. *Theorie de la dominance economique*. Paris : Dunod.

Miller, Ronald and Peter D. Blair. 1985. *Input-output analysis : Foundations and extensions*. Englewood Cliffs, N. J. : Prentice-Hall Inc.

Robinson, Sherman and Anil Markandya. 1973. Complexity and adjustment in input-output systems. *Oxford Bulletin of Economics and Statistics* 35, 119–34.

Schintke, Joachim and Reiner Staglin. 1985. The stability of important input coefficients. *Lecture Notes in Economics and Mathematical Systems*, no. 251 : 129–39.

Simpson, David and Jinkichi Tsukui. 1965. The fundamental structure of input-output tables, an international comparison. *The Review of Economics and Statistics* 47, no. 4 (November) : 434–43. (Also Published in *Readings in input-output analysis*, ed. Ira Sohn. New York and Oxford : Oxford Univ. Press, 1986)

Szyrmer, J. M. 1985. Measuring connectedness of input-output models : 1. Survey of measures. *Environment and Planning A* 17, no. 12 (December) : 1591–1612.

………. 1986. Measuring connectedness of input-output models : 2. Total flow concept. *Environment and Planning A* 18, no. 1 (January) : 107–21.

Timmer, Peter C. 1988. The agricultural transformation. Chap. 8 in *Handbook of development economics*, vol. 1, ed. Hollis B. Chenery and T. N. Srinivasan. Amsterdam : North Holland Pubishing Co.

Yan, Chiou-Shuang and Edward Ames. 1965. Economic interrelatedness. The Review of Economic Studies 32 : 299–310. (Also Published in *Readings in input-output analysis*, ed. Ira Sohn. New York and Oxford : Oxford Univ. Press, 1986)