SAM-based Multiplier Analysis for China's Economy

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Abstract

The Social Accounting Matrix (SAM) sketches out a general figure of a nation or a region by listing the national economy accounting data within a square table. While providing data basis for the construction of economy model, SAM itself is a powerful tool of studying industry structure and the interdependence of economy accounts. Multiplier Decomposition and Structural Path Analysis is two main methods within a SAM framework. The basic idea of the methods is to partition the SAM accounts into endogenous and exogenous accounts and then to see what related effects happen as a result of the external injection on certain endogenous account. Multiplier Decomposition reveals the magnitude of global effect and shows the quantity distribution of the global effect within and among endogenous accounts. On the basis of this, Structural Path Analysis further illustrates the operation path and mechanism of external injection, i.e., along what path and to what extent does an external injection act on other accounts in an economy. Such analysis results will provide greater reference for policy makers and decision makers. This article takes the static value-type model as a background, gives a brief introduction of the basic theory of SAM and Multiplier Decomposition, then introduces the Structural Path Analysis method with an illustration of its principle and the relationship between the two methods. Then, on the basis of the SAM of China in 1997, this article sets several policy simulation scenarios and does some positive research on characteristics of Chinese industry structure and income distribution using Structural Path Analysis method. Finally, this article summarizes the strengths and limitations of the Structural Path Analysis method and indicates the direction for further research.

Keywords：**Social Accounting Matrix; Accounting Multiplier Matrix; Path Multiplier; Structural Path Analysis**

SAM is an important form to exhibit the quantity relationship among national accounts. The System of National Accounting (SNA) that issued by Statistics Office of United Nation in 1993 gives a definition of SAM as follows: It is SNA account in the form of a matrix which depicts the relationship among supplying table, using table and institution accounts, thus reflects all kinds of social-economic relations of a certain period. In contrast with input-output model, SAM not only reflects the relationship among production sectors and the primary distribution of income, but reflects the secondary distribution of income as well. In recent years, SAM is used as database and provides data for constructing economic model more and more frequently. However, SAM itself is a powerful tool for studying industry structure and the interdependence of economy accounts. Multiplier Decomposition and Structural Path Analysis is two most important methods within a SAM framework.

1. An Introduction of SAM

According to the theory of double-entry accounting, SAM takes the form of n×n matrix to reflect the income and expenditure of each account. Every element in the SAM has double meaning, that is, it reflects the income of an account from the perspective of row and the expenditure of another account from the perspective of column. The total of certain row and that of the corresponding column must be equal, which means that total income is equal to total expenditure of each account.

By integrating all kinds of economic flows, SAM reveals the circular links among various economic accounts. The following figure shows the relationships reflected by SAM. The figure is in point not only for a nation but for a region as well[1]. In the figure, each arrowhead represents an element in SAM. Income flows from production to the distribution of factor income, then to final consumption and investment, and then back to production form a simple production cycle. The supplying, consumption and investment of commodity construct the supply-demand relationship of the commodity market. The demand on factor for production and the supply of labor and capital

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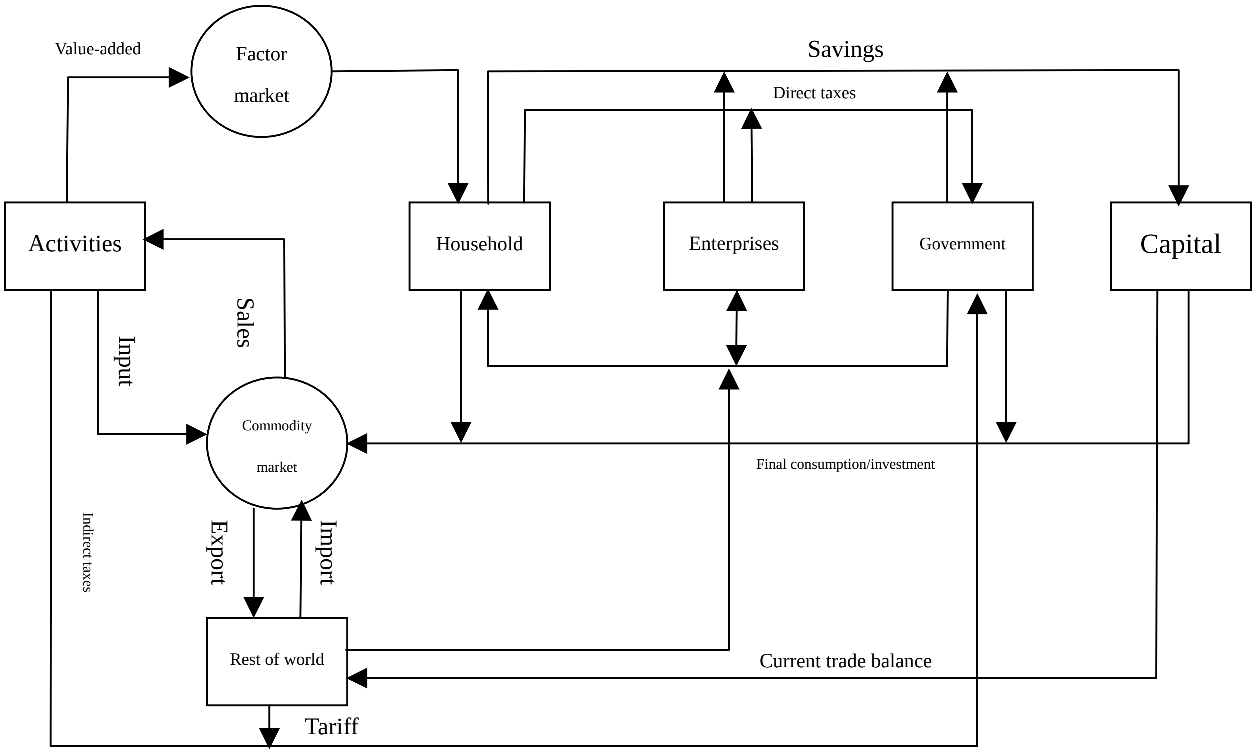
[1] If the SAM is about a region within a country, then perhaps it is necessary to distinguish the trade partners between "rest of world" and "rest of the nation".

construct the supply-demand relationship of the factor market. With external trade and internal trade and the secondary distribution of income, all above construct the whole social-economic system.

Figure1 Economic relationships reflected by SAM



Note: The arrow head represents income and the arrow tail represents expenditure.
Source：Adapted from Jeffery Round (2002)

There are two kinds of SAM, that is, macro-SAM and micro-SAM. On the basis of macro-SAM, according to the requirement of the subject under study and meanwhile taking the availability of data into consideration, micro-SAM partitions certain accounts into more detailed classifications. For the sake of demonstration, on the basis of micro-SAM, table 1 builds up the accounts into several big sets and exhibits the SAM in a simplified form. Thus, we can demonstrate the interaction among accounts through the operation of block matrices.

Table 1 Sketch map of a simplified SAM[1]

Expenditure Income		Endogenous accounts			Exogenous accounts	Total
		1．Activities	2．Factors	3．Institutions		
Endogenous accounts	1．Activities	T_{11}		T_{13}	X_1	Y_1
	2．Factors	T_{21}			X_2	Y_2
	3．Institutions		T_{32}	T_{33}	X_3	Y_3
Exogenous accounts		L_1	L_2	L_3	LX	Y_4
Total		Y_1	Y_2	Y_3	Y_4	

It is necessary to partition accounts of SAM into endogenous accounts and exogenous accounts before any quantitative analysis. In the simplified SAM shown by table 1, endogenous accounts include three big sets——activities, factors and institutions (here means households and enterprises specifically). The activities account is the integration of all kinds of production activities. The factors account includes such production factors as labor, land and capital. The institutions account mainly includes enterprises and households, and the households can further be partitioned into several groups according to their residence (i.e. urban or rural) and income level. Such accounts as government, capital and rest of the country[2] are taken as exogenous[3]. In the area of the 3×3 endogenous accounts represented by block matrices, block matrix T_{11} captures the demand on intermediate inputs among production activities, which is virtually the intermediate flow of the input-output table; Block matrix T_{13} captures the expenditure mode on products of various institutions (usually all kinds of households and enterprises); Block matrix T_{21} captures

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[1] Generally, the “institutions” in SAM include households, enterprises and government, etc. In this sketch map, the “institutions” in the endogenous accounts specially means households and enterprises, and government is classified into exogenous accounts.

[2] It is an account set by an open SAM when taking trade into consideration.

[3] Taking capital endogenous means more flexibility in internal resources flow and collocation. Taking the account —— “rest of the country” ——endogenous means that the trade between regions is relatively free.

the distribution of value-added created by production activities among factors; Block matrix T_{32} captures the distribution mode of factor income among different households and enterprises; Block matrix T_{33} captures the income transfer within institutions, i.e., among enterprises and various groups of households.

2. A Brief Discussion on Multiplier Decomposition within a SAM Framework

Under such assumptions such as fixed prices, demand orientation (i.e., there exist excess production capacities and resources) and linear relationship among economic accounts, SAM can be used as the basis for simple modeling. Similar to the matrix of direct input coefficients of IO model, a matrix of average expenditure propensities matrix is defined within the SAM framework. To get the numerical value of each element in the matrix, just divide the corresponding element of SAM by the total of the column which contains the element. Using A_n to denote the matrix of average expenditure propensities and then block A_n according to the pattern of 3×3 endogenous accounts matrix in the simplified SAM, we get

$$A_n = \begin{pmatrix} A_{11} & 0 & A_{13} \\ A_{21} & 0 & 0 \\ 0 & A_{32} & A_{33} \end{pmatrix} \tag{2.1}$$

Since the total of column and that of the corresponding row are equal in SAM, the total income of endogenous accounts can be written as following:

$$y_n = A_n y_n + x \tag{2.2}$$

Transform the equation (2.2) and we can get the following equation which captures the relationship between the endogenous incomes y_n and the exogenous injections x.

$$y_n = (I - A_n)^{-1} x = M_a x \tag{2.3}$$

The matrix M_a is called accounting multiplier matrix. This matrix reflects the basic interaction among data flows of SAM. Just as the Leontief inverse matrix in the IO model, accounting multiplier matrix is the core of the method within a SAM framework. The element m_{aji} of the matrix M_a reflects the global effects of the exogenous injection x_i on endogenous account y_j.

Through decomposing the matrix M_a, we can understand the effects caused by exogenous injections more clearly. The decomposition results can be shown by two forms——multiplicative form and additive form as follows[1]:

$$M_a = M_{a3}M_{a2}M_{a1} \qquad (2.4)$$

$$M_a = I + (M_{a1} - I) + (M_{a2} - I)M_{a1} + (M_{a3} - I)M_{a2}M_{a1} = I + T + O + C \qquad (2.5)$$

In the equation (2.4) which is shown in multiplicative form, matrix M_{a3} is a block diagonal matrix which captures the circular transferred relationship of the income flows among endogenous accounts, thus it is referred to as closed-loop or circular multiplier matrix. Matrix M_{a1} is also block diagonal. It reflects the effects of certain group of accounts on itself through direct transfers and is independent of the closed-loop nature of the system. It is referred to as the transfers' multiplier matrix. Matrix M_{a2} is not diagonal and its diagonal blocks are all identity matrices. It captures all effects between partitions of the accounts. Therefore the matrix is called as the cross-effects matrix or open-loop multiplier matrix. Figure 2 visually exhibits the three effects of multiplier decomposition. Transfers' multiplier effects are reflected within the activities accounts and the institutions accounts. Open-loop multiplier effects are reflected between any two different groups of endogenous accounts. Close-loop multiplier effects can start from any account and finally go back to the origin after a series of interactions.

Figure2 Three effects reflected by multiplier decomposition

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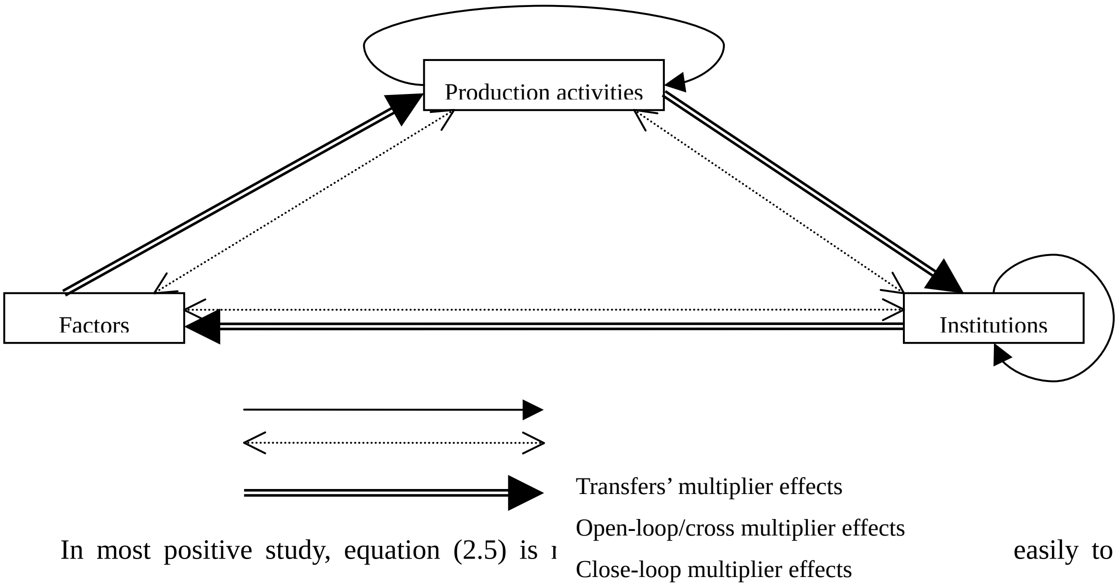
[1] Since the subject of this article is structural path analysis and the article length is limited, this article only gives the results of multiplier decomposition. To obtain more information about the deduction process of multiplier matrix decomposition, please see reference 6.



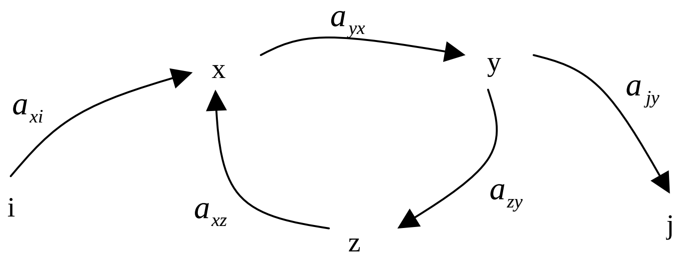
In most positive study, equation (2.5) is ı easily to express and understand than equation (2.4). Moreover, through separating the initial injection matrix I from the global effects, we can get three kinds of net effects, that is, Matrix T represents the net contribution of transfers' multiplier effects; Matrix O represents the net contribution of open-loop multiplier effects; Matrix C represents the net contribution of close-loop multiplier effects.

3. Theory of the Structural Path Analysis Method

Accounting multiplier matrix reveals the extent of effects on other endogenous accounts caused by the change of external demand on certain endogenous account. Through multiplier decomposition we can get the distribution of global effects on the three aspects, thus understand the dependence of global effects caused by external injection on different influence transmission patterns. However, the results of multiplier analysis only provide us with some quantitative reference and the mechanism of interactions remains a "black box", since the decision makers cannot find out that, along what paths do the influences among accounts transmit and which paths are better than the others in transmitting influences. All these are usually necessary for decision-making. Based on multiplier decomposition, structural path analysis further reveals the transmission mechanism of the interactions among accounts, thus opens the "black box".

The following will briefly describe the theory of structural path analysis by the aid of topology language. Take every endogenous account in SAM as pole and the link between any two poles is represented by arc (i, j). Then we can define the element a_{ji} in the average expenditure propensity matrix A_n as the intensity of arc (i, j) which reflects the magnitude of influence transmitted from pole i to pole j. A sequence of consecutive arcs (i, k), (k, l), $\cdots$, (m, j) form a path and the number of arcs composing it is referred to as length of path. A path which does not pass more than one time through the same pole is called an elementary path. A path whose pole of origin coincides with its pole of destination is referred to as circuit. In Figure 3, $i \to x \to y \to j$ is an elementary path and $x \to y \to z \to x$ is a circuit.

Figure 3 Elementary Paths and Circuits



Suppose account i is disturbed by external injection and finally acts on account j by way of path s, then we can use $(i \to j)_s$ to denote the influence of i on j. There are three kinds of influences between accounts: direct influence, total influence and global influence.

3.1 Direct Influence

The direct influence of i on j transmitted through an elementary path is the change in income of j induced by a unitary change in i, the income of all other poles except those along the selected elementary path remaining constant. In terms of numerical value, the direct influence of i on j is the intensity of arc (i, j), i.e., the element a_{ji} of the average expenditure propensity matrix A_n [1].

$$I^{D}_{(i \to j)} = a_{ji} \tag{3.1}$$

Therefore, from the perspective of path analysis method, average expenditure propensity matrix is

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[1] According to the definition of average expenditure propensity and the balance condition, we know that there exists the following relationship between the flows in SAM—— $y_j = a_{ji} y_i$. Thus, when there is a production change of one unit in account i ($\Delta y_i = 1$), the production change of account j is $\Delta y_j = a_{ji}$.

also called direct influence matrix.

While an elementary path whose two ends are i and j passes more than two poles, the direct influence transmitted from pole i to pole j along the path is equal to the product of the intensities of the arcs constituting the path. Thus,

$$I^{D}_{(i\cdots j)} = a_{jn} \cdots a_{mi} \qquad (3.2)$$

In figure 3, the direct influence caused by the elementary path $i \to x \to y \to j$ is $I^{D}_{(i \to j)} = a_{xi} a_{yx} a_{jy}$.

3.2 Total Influence

In a complicated economic system, it is impossible that there exist only several elementary paths between two poles. On the contrary, there are a lot of circuits because of the existence of feedback effects. The total influence is the influence transmitted from origin to destination along the elementary path including all indirect effects within the structure imputable to that path. That is, the total influence cumulates the direct influence transmitted along the elementary path and the indirect effects induced by the circuits adjacent to that same path.

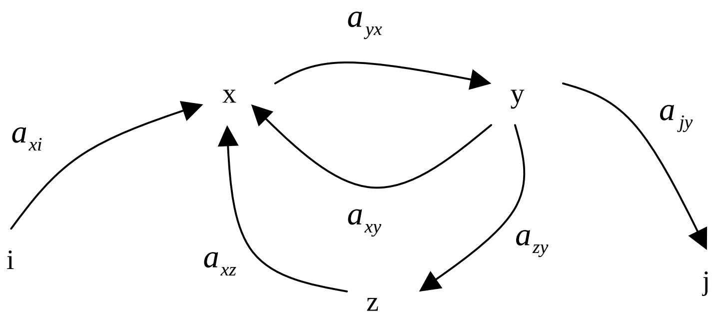
On the basis of figure 3, figure 4 adds a circuit $x \to y \to x$. Now we can explain the calculation process of the total influence according to figure 4. The direct influence between pole i and pole j is $a_{xi} a_{yx}$. This influence transmits back to pole x through the following two circuits: $x \to y \to x$ and $x \to y \to z \to x$. The indirect influence is $a_{xi} a_{yx} (a_{xy} + a_{zy} a_{xz})$ and this influence circulates continuously between pole x and pole y, thus we finally get

$$a_{xi} a_{yx} \left\{ 1 + a_{yx} (a_{xy} + a_{zy} a_{xz}) + \left[a_{yx} (a_{xy} + a_{zy} a_{xz}) \right]^{2} + \cdots \right\} = a_{xi} a_{yx} \left[1 - a_{yx} (a_{xy} + a_{zy} a_{xz}) \right]^{-1} \qquad (3.3)$$

Then the influence above transmits to destination j through arc (y, j). Now we get the expression of the total influence resulted from this elementary path as follows:

$$I^{T}_{(i \to j) p} = a_{xi} a_{yx} a_{jy} \left[1 - a_{yx} (a_{xy} + a_{zy} a_{xz}) \right]^{-1} \qquad (3.4)$$

Figure 4 Sketch Map for Calculation of the Total Influence



It can readily be seen that the first term on the right-hand side of the formula (3.4) just represents the direct influence defined previously, i.e., $I^D_{(i\to j)} = a_{xi}a_{yx}a_{jy}$. The second term is defined as path multiplier M_p which captures the extent to which the direct influence along the elementary path is amplified through adjacent feedback circuits. Thus, the total influence between two poles can be written in the form of the product of direct influence and path multiplier, that is,

$$I^T_{(i\to j)p} = I^D_{(i\to j)p} M_p \tag{3.5}$$

Generally, M_p is equal to the ratio of two determinants $\Delta p / \Delta$, where Δ is the determinant of $| I - A_n |$ and Δp is the determinant of the structure excluding the poles constituting the elementary path[1]. The size of path multiplier is usually determined by the path length and feedback intensity. The more poles passed through by elementary path, the bigger the probability that the path contains feedback circuits and the greater the path multiplier. On the other hand, the bigger the feedback intensity of the circuits contained by elementary path, the greater the path multiplier. Transform the formula (3.5) and we get

$$1/M_p = I^D_{(i\to j)p} / I^T_{(i\to j)p} \tag{3.6}$$

The inverse of path multiplier just reflects the proportion of the total influence transmitted along an elementary path which is accounted for by the immediate effects, namely the direct influence. It is a very useful index for policy makers, because it implies the transmission time of external injection to a certain degree. The greater the numerical value of $1/M_p$, the bigger the proportion of direct influence and the more rapidly the transmission of external injection. On the contrary, the

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[1] The measure of M_p is developed more formally and detailedly in the Appendix through the algebra operation of determinant.

greater the path multiplier, to a greater extent the direct influence is extended. But the transmission speed of the influence may be low[1]. So there exists a trade-off between the magnitude and the spread time of the influence caused by external injection.

3.3 Global Influence

Global influence is not a topological concept, but an abstraction of the results caused by all paths. Global influence can be expressed by the element in the matrix M_a which is developed by the formula (2.3), so the accounting multiplier matrix can also be called global influence matrix from the perspective of path analysis. The global influence of external injection x_i on endogenous variable y_j is the element of the matrix M_a that is in the j^th row and the i^th column. That is,

$$I^G_{(i \to j)} = m_{aji} \tag{3.7}$$

Global influence reflects the sum of all the total influence caused by various elementary paths between origin and destination. Therefore, suppose there are p elementary paths between the origin i and the destination j, then the relationship between the three kinds of influence can be expressed by the following[2]:

$$I^G_{(i \to j)} = m_{aji} = \sum_{p=1}^{n} I^T_{(i \to j)p} = \sum_{p=1}^{n} I^D_{(i \to j)p} M_p \tag{3.8}$$

Relative to direct influence, global influence integrates the effects of all the paths between origin and destination (including elementary paths and circuits). It does not study the influence caused by certain path separately.

In a complicated economic system, there are countless elementary paths. It is very helpful to understand the economic structure characteristics of certain region if we can find those paths with relative big global influence and further study it structure. Furthermore, it can help us understand more deeply the action mechanism of external injection, which can assist the policy makers to

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[1] Strictly speaking, it is not correct to use this index to weigh the influence transmission time within a path analysis framework, because the whole analysis process is under the static time framework. However, the following assumption is reasonable logically: the number and length of the circuits contained by the elementary path are different, which leads to different influence transmission time; the more poles passed through by elementary path and its adjacent circuits, the longer time is needed for influence caused by external injection to transmit to destination. Thus, relatively great path multiplier usually means relatively long influence transmission time.

[2] This formula is also formally developed in the appendix by way of the algebraic operation of determinant.

identify the possible bottlenecks in the transmission process of the influences caused by policies.

4. A Case of Structural Path Analysis Based on Chinese SAM in 1997

On the basis of the conclusions of structural path analysis, we can apply the method by way of illustration to a SAM which is built for China. Within the framework we can analyze the effects resulted from external injection and acquaint ourselves with the magnitude of the effects and the transmission mechanism of the interactions. The following study is on the basis of Chinese SAM in 1997. We set different scenarios in allusion to the three endogenous accounts to see about the characteristics of the industry structure in China, and conduct some policy simulation analysis at the same time.

4.1 The Structure of Chinese SAM in 1997[1]

The analysis foundation of this part is Chinese SAM in 1997[2]. The micro-SAM contains 57 sectors, 5 production factors, 7 groups of households according to their income level, 1 enterprise account and other macro accounts such as government subsidies, production taxes, import, export and capital, etc. In order to simplify the analysis process and meanwhile make the key problem outstand, this article merges the 57 sectors into 29 big sectors and takes the accounts relating to government, taxes, import, export and capital as a whole exogenous account. Thus, we now have a 50×50 SAM with three groups of endogenous accounts——production activities (including 29 sectors), factors (including 5 production factors), institutions (including 14 groups of households and 1 enterprise). The accounts in detail are shown in the following table.

Table 2 the Schedule of Detailed Endogenous Accounts of Chinese SAM (after merger)

Production Activities	1．Agriculture	Production Activities		25．Banking & Insurance
	2．Mining			26．Real Estate
	3．Foodstuff			27．Social Service
	4．Textile			28．Education & Health
	5．Apparel, Leather and Furs Products			29．Administration & Others
	6. Sawmills and Manufacture of Furniture	Institutions	Urban	Lowest
	7．Manufacture of Paper & Cultural			Low
	8．Petroleum Refineries and Coking			Medium-Low

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[1] The Chinese SAM in 1997 used by this article comes from the Department of Development Strategy and Regional Economy of DRC. The SAM is once used as an important data reference in the research on the influences of China's entering into WTO. It is also the data basis for CGE model construction.

[2] To get more information about Chinese SAM in 1997, just see the following website of DRC: http://www.drc.gov.cn/hsjz/index1.html.

	9．Chemical Industries			Medium
	10．Building Materials			Medium-high
	11．Primary Metal Manufacturing			High
	12．Metal Products			Highest
	13．Machinery		Rural	Lowest Income
	14．Transport Equipment			Low
	15．Electric Machinery and Instrument			Medium-Low
	16．Computers			Medium
	17．Instruments and Meters			Medium-high
	18．Other Manufacturing			High
	19．Electric Power, Steam and Water			Highest
	20．Construction		Enterprise	
	21．Transport	Factors	Agriculture Labor	
	22．Communication		Production Worker	
	23．Commerce		Professionals	
	24．Restaurants		Land	
			Capital	

4.2 Case Study by Structural Path Analysis Method

On the foundation of the SAM, divide the account flow by the total of the column it occurs and we get the average expenditure propensity matrix, that is, direct influence matrix A_n. Then we can acquire the accounting multiplier matrix, i.e., global influence matrix M_a. Limit to the article length, we only exhibit a simplified global influence matrix with randomly selected rows and the corresponding columns in the attached table[1].

The element in the matrix M_a reveals the global influence on other accounts in an economic system produced by an external injection on certain endogenous account. The point-to-point global influence is the sum of all the total influence along lots of different paths. By calculating the direct influence and the path multiplier M_p, we can get the total influence of different paths and based on this we can compare the transmission effects of external injections through different paths.

Through setting different scenarios, table 3 studies the different paths and their characteristics. Furthermore, to evaluate the transmission capacity of a path, we use the ratio of total influence to global influence as an important indicator.

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[1] The integrated direct influence matrix, global influence matrix and the three kinds of effect multiplier matrix are available upon request from the authors.

Case Ⅰ and case Ⅱ take the influence of restaurants on agriculture and the influence of construction on mining as an example respectively to see the influence between different sectors within the production activities account. This kind of analysis can answer the problems as follows: If the exogenous demand on certain sector rises, what influences will be caused by this on other sectors and are there any differences between the different paths in transmitting the influences? The results show that the influence of restaurants on agriculture mainly depends on the path “restaurants→agriculture”, which is the shortest and most direct path. 47% of the global influence is transmitted through this path. The path “restaurants→foodstuff→agriculture” which is via the foodstuff as a medium transmits 30% of the global influence. The above two paths are the most important ways through which restaurants industry affects agriculture. The remaining less than one-fourth of the global influences are partaken in by other paths such as “restaurant→commerce →foodstuff→agriculture” and “restaurant→textile→agriculture”, etc. However, the proportion of the global influence transmitted by each of the other paths is very small; the influences transmitted by the paths which pass the factor accounts and household accounts are much smaller. The influence of construction on mining presents different characteristics, that is, the path which transmits the biggest proportion of the global influence is the path “construction→building materials→mining” which takes building materials as a medium. This path transmits 22% of the global influence, whose transmission proportion is 6% higher than that of the direct path “construction→mining”. Among the other numerous paths, the path “construction→metal products→primary metal manufacturing→mining” which passes two other sectors as mediums transmits 2.3% of the global influence, showing a relatively strong transmission capability. It is obvious that the best transmitter is not always the most direct one and a longer path does not necessarily mean the weakening of the transmission capability. The transmission capability of a path reveals that to what extent the different accounts connected by the path interdependent.

Case Ⅲ to case Ⅴ see about the relationship between production accounts and factor accounts. Case Ⅲ mainly analyzes the influence of the production increase of certain industry on the labor factor and this analysis can answer the question that in which industry sectors additional jobs will be created for production workers as a result of the increase in export demand on the products of apparel manufacturing. From the calculation results of 4 different elementary paths in the table, we can see that for the production workers, it is mainly the apparel manufacturing industry itself that benefits from the injection, since approximately half (48%) of the global influences are transmitted through the direct path “apparel manufacturing→production workers”. The production workers of textile also get some related benefits in that 15% of the global influences are transmitted through the path “apparel manufacturing→textile→production workers”. The benefit obtained by the production workers of other sectors is much limited. Case Ⅳ sees about the influence of commerce on capital demand. After contrasting the different paths we can see that the influence of external injection on commerce is transmitted mainly by the point-to-point (commerce→capital) path. The transmission capability of other paths that take other sectors as mediums such as “commerce→communication→capital” and “commerce→social service→capital” is relatively weak. Case Ⅴ takes the production workers of mining as research object to see in which industry sectors the external demand increase will bring more jobs to the production workers of mining by setting different origins of the path. The results show that, the production workers of mining benefit most from the output increase of mining itself. The path “mining→production workers” transmits 64% of the global influence. In addition, the increase of output of certain industry sector that closely relates to mining can also make the production workers of mining benefit. For example, petroleum refineries and coking (41%), electric power, steam and water(15%), primary metal manufacturing (13%), and building materials (8%), etc. It is obvious to see that there exist many fairly good indirect paths to improve the employment of the production workers in mining. This provides the policy makers with more choice.

Both case Ⅵ and case Ⅶ are to see about the linkage between production accounts and household accounts. Households gain their incomes through factors, so in SAM, there exist no flows between households in row and production activities in column, thus the production activities has no direct influence on the households. Case Ⅵ and case Ⅶ contrastively study the influences of foodstuff industry and transport industry on urban and rural households with different income level via the factor of production workers. The influence tendency of these two sectors on urban and rural households is consistent. In terms of global influence, if the output of the industry increases 1 unit, then the urban households with medium income benefit most and those with highest income in the next place; while for the rural households, the benefit increases as the income level rises. However, the foodstuff industry makes rural households benefit more while the transport industry makes urban households benefit more. From the perspective of the characteristics of the transmission paths of the global influence, the lower the income level of the urban households, the higher the proportion of the global influence transmitted by direct path (path which does not pass through other accounts as medium). The case of rural households is just on the contrary. The lower the income level, the lower the proportion of the global influence transmitted by direct path. Moreover, when rural households accept the influences from production activities via the factor of production workers, the dependence on direct path is far less than urban households. Finally, comparing with the different industries we can see that, the dependence of foodstuff industry on the direct path is far less than transport industry. So we know that the paths through which the foodstuff industry affects households' income via the factor of production workers are more dispersive and the transmission capability of different paths does not differ greatly.

Case Ⅷ and Case Ⅸ mainly see about the influence of households accounts on production activities accounts. Suppose the households will receive some transfer payments from government, then what influences will be caused on agriculture production when government offers the subsidies to urban households with lowest income and the rural counterpart respectively? The results exhibit that, the global influence is higher if the rural households obtain the subsidies. Moreover, the influence of the income increase of the rural households on agriculture production mainly depends on the direct path "rural households with lowest income→agriculture" to transmit. The direct path transmits 70% of the global influence. In the respect of urban households, only 50% of the global influences are transmitted along direct path, so the influence of income increase of urban households on agriculture disperses into other paths to a great extent.

If we pay more attention to the path multipliers in table 3, we can find some tradeoff problems about the substitution of effect and efficiency. Just as we have pointed out in the third section of this article, the inverse of path multiplier $1/M_p$ is equal to the ratio of the direct influence to the total influence, which reflects the transmission time of external injection to a certain degree. The bigger the value of $1/M_p$, the more rapidly the external injection transmits; on the contrary, the bigger the value of path multiplier, the slower the influence spreads. However, since the path multiplier reflects the amplifying action of powerful circuits, bigger path multiplier often means bigger total influences. Thus, there exists a tradeoff between the effect resulted from external injection and the time needed for influence spreading. The following is another example. Case Ⅱ sees about the influence on mining of 1 unit increase of the external demand on construction. The path multiplier of the direct path “construction→mining” is 1.18, and the total influence produced by this path is 0.03; while the path multiplier of the path “construction→building materials→mining” which passed through the building materials is 1.4 and the total influence is 0.042. Although the latter has a relatively low efficiency, its effect is more remarkable. In addition, case Ⅴ sees about the influence on the employment of the production workers in mining along different paths. The path “construction→mining→production workers” has a path multiplier of 1.62, while the path “primary metal manufacturing→mining→production workers” has a path multiplier of 1.91. Although the former has a higher efficiency, the latter creates more total influence (0.045 vs. 0.031).

Table 3 Case Study of Structural Path Analysis within a SAM Framework

Case	Path origin （1）	Path destination （2）	Global influence （3）	Elementary path （4）	Direct influence （5） ×	Path multiplier （6） =	Total influence （7）	Proportion (%) （8） ＝ （7） / （3）
Ⅰ	Restaurant（Res）	Agriculture（Agr）	0.9131	Res->Agr	0.2208	1.9462	0.4298	47.07
				Res->Foodstuffs->Agr	0.1177	2.3118	0.2722	29.81
				Res->Commerce-> Foodstuffs ->Agr	0.0005	2.6774	0.0014	0.15
Ⅱ	Construction（Con）	Mining（Min）	0.1942	Con->Min	0.0261	1.1828	0.0309	15.92
				Con->Building Materials->Min	0.0302	1.4086	0.0425	21.88
				Con->Metal Products-> Primary Metal Manufacturing ->Min	0.0024	1.8280	0.0044	2.28
Ⅲ	Apparel, Leather and Furs Products (Appr)	Production Workers（Pw）	0.3902	Appr ->Pw	0.1354	1.3763	0.1863	47.75
				Appr ->Textile->Pw	0.0263	2.1613	0.0569	14.58
				Appr -> Machinery ->Pw	0.0002	1.6882	0.0004	0.09
				Appr ->Textile-> Machinery ->Pw	0.0003	2.6559	0.0008	0.20
Ⅳ	Commerce（Com）	Capital（Cap）	0.4354	Com->Cap	0.1247	1.3118	0.1636	37.58
				Com->Communication->Cap	0.0032	1.3333	0.0042	0.97
				Com->Social Service->Cap	0.0054	1.4516	0.0078	1.79
Ⅴ	Mining（Min）	Production Workers（Pw）	0.3728	Min->Pw	0.1737	1.3763	0.2391	64.13
	Petroleum Refineries & Coking（Ptr）		0.2879	Ptr->Min->Pw	0.0826	1.4409	0.1190	41.35
	Building Materials（Bdm）		0.3956	Bdm->Min->Pw	0.0194	1.6237	0.0315	7.97
	Primary Metal Manufacturing（Met）		0.3412	Met->Min->Pw	0.0237	1.9140	0.0454	13.32

	Electric Power, Steam and Water（Ews）		0.3181	Ews->Min->Pw	0.0322	1.4946	0.0481	15.13
Ⅵ	Foodstuffs（Fpr）	Urban-lowest（U-Lst）	0.0204	Fpr->Pw->U-Lst	0.0028	1.6344	0.0046	22.50
		Urban-medium（U-Med）	0.0727	Fpr-> Pw ->U-Med	0.0082	1.6452	0.0135	18.65
		Urban-highest（U-Hst）	0.0637	Fpr->Pw->U-Hst	0.0048	1.6452	0.0079	12.42
		Rural-lowest（R-Lst）	0.0354	Fpr->Pw->R-Lst	0.0004	1.6667	0.0006	1.80
		Rural-medium（R-Med）	0.1051	Fpr->Pw->R-Med	0.0021	1.7097	0.0035	3.35
		Rural-highest（R-Hst）	0.1442	Fpr->Pw->R-Hst	0.0042	1.6882	0.0071	4.89
Ⅶ	Transport（Trs）	Urban-lowest（U-Lst）	0.0306	Trs->Pw->U-Lst	0.0112	1.3118	0.0147	48.20
		Urban-medium（U-Med）	0.1043	Trs->Pw->U-Med	0.0329	1.3226	0.0436	41.77
		Urban-highest（U-Hst）	0.0862	Trs->Pw->U-Hst	0.0192	1.3226	0.0254	29.47
		Rural-lowest（R-Lst）	0.0166	Trs->Pw->R-Lst	0.0015	1.3441	0.0021	12.39
		Rural-medium（R-Med）	0.0586	Trs->Pw->R-Med	0.0082	1.3978	0.0115	19.65
		Rural-highest（R-Hst）	0.0930	Trs->Pw->R-Hst	0.0167	1.3763	0.0230	24.75
Ⅷ	Urban-lowest（U-Lst）	Agriculture（Agr）	0.9239	U-Lst->Agr	0.2408	1.9355	0.4661	50.45
				U-Lst->Fpr->Agr	0.1044	2.3011	0.2402	26.00
				U-Lst->Appr->Agr	0.0023	2.2366	0.0051	0.55
Ⅸ	Rural-lowest（R-Lst）	Agriculture（Agr）	1.2532	R-Lst->Agr	0.4595	1.9140	0.8795	70.18
				R-Lst->Fpr->Agr	0.0926	2.2903	0.2121	16.92
				R-Lst->Appr->Agr	0.0013	2.2151	0.0029	0.23

5. Conclusions and Further Research Suggestions

It can readily be seen from the basis structure of SAM, multiplier decomposition and the developing process of the structural path analysis method, that SAM is the extension of Input-output table. The accounts in SAM include all the sectors in the economic system and it also contains the income re-distribution accounting, so it integrally captures the relationships in an economy. The structural path analysis method detailed the influence of external injection into every path. Relative to the quantitative calculation results of the transfers' multiplier effects, open-loop multiplier effects and close-loop multiplier effects in the multiplier decomposition method, the results of structural path analysis show the interactions among accounts and the action mechanism more clearly. This is very important for nicely judging the interdependence between accounts. One of the most important uses of structural path analysis method is to do some anticipated research on policy impact, which can help decision makers see the probable development tendency and contrast the possible effects of different policies and measures.

Although relative to IO table, SAM more comprehensively exhibits the social-economic accounting, and the structural path analysis method within the SAM framework brings some improvement to a certain degree, there is still some limitation in this analysis because of the relatively strong presuppositions. First of all, the assumption of linear structure and average expenditure propensity does not accord with the reality. Secondly, it is necessary to prepare enough basic data to compile a SAM and path analysis method also needs high-quality data. Since it always takes a lot of time to obtain comprehensive and high-quality data, the time-efficiency of the analysis results is often not very good.

For further research, on the one hand, we should strengthen the application researches on the path analysis method within the SAM framework such as analyzing the industry interdependence by the aid of regional SAM or comparing the characteristics of economic links between different regions, etc; On the other hand, we can do some further research on theoretic analysis by amending various assumptions such as substituting marginal expenditure propensity for average expenditure propensity and substituting non-linear structure for linear structure, etc.

Appendix

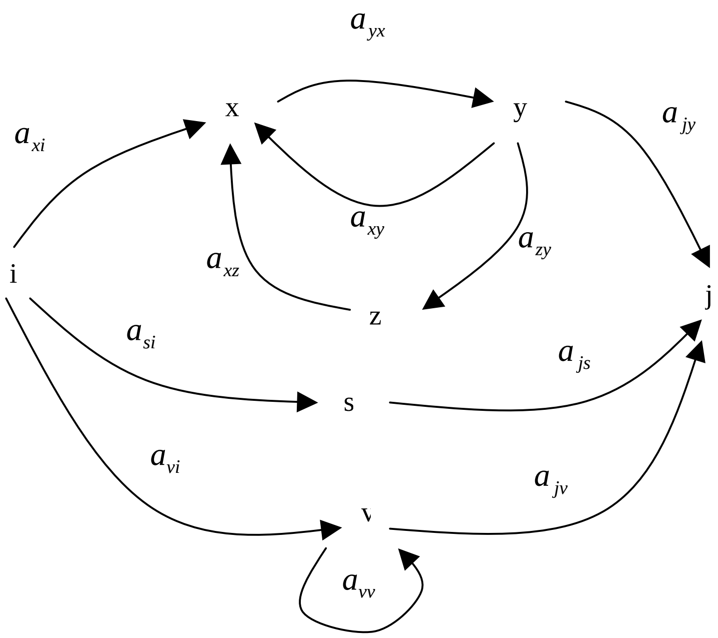
Decomposition of Global Influence

In the structural path analysis method, the relationship among direct influence, total influence and global influence is as follows:

$$I^{G}_{(i\to j)} = m_{aji} = \sum_{p=1}^{n} I^{T}_{(i\to j)p} = \sum_{p=1}^{n} I^{D}_{(i\to j)p} M_{p} \qquad ①= (3.8)$$

The formula above can be developed through induction or deductive method. Here we use algebraic operation of determinant to develop the formula (3.8) by the aid of a representative topological path graph.

Picture 5 Sketch Map for Developing the Relationship between Global Influence and Total Influence



Picture 5 adds two more elementary paths on the basis of picture 4, that is, $i \to s \to j$ and $i \to v \to j$. Moreover, the latter contains a circuit. Therefore, there are 3 elementary paths between pole i and pole j. For the sake of simplicity, we use 1, 2 and 3 to denote the following three paths: $i \to x \to y \to j$, $i \to s \to j$ and $i \to v \to j$. Now we start from the algebraic expression of the global influence m_{aji} to prove that it is just equal to the sum of the total influences of the above three paths.

According to the topological paths in the picture 5, we get the matrix $(I - A_n)$ in the following form.

$$I - A_n = \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \end{array}\begin{array}{ccccccc} i & x & y & z & s & v & j \\ \end{array}$$

$$\begin{array}{r} \\ I - A_n = \end{array}\left[\begin{array}{ccccccc} 1 & & & & & & \\ -a_{xi} & 1 & -a_{xy} & -a_{xz} & & & \\ & -a_{yx} & 1 & & & & \\ & & -a_{zy} & 1 & & & \\ -a_{si} & & & & 1 & & \\ -a_{vi} & & & & & 1-a_{vv} & \\ & & -a_{jy} & & -a_{js} & -a_{jv} & 1 \end{array}\right]\begin{array}{c} i \\ x \\ y \\ z \\ s \\ v \\ j \end{array} \tag{②}$$

From the expression of matrix M_a developed by formula (2.3) we know that

$$I^G_{(i \to j)} = m_{aji} = \frac{\Delta_{ij}}{\Delta} \tag{③}$$

Here Δ is the determinant of $|I - A_n|$ and Δ_{ij} is the ij$^{\text{th}}$ cofactor of Δ. Expanding Δ_{ij} by minors according to elements of its first column, we obtain:

$$\begin{aligned} \Delta_{ij} = (-a_{xi})\begin{vmatrix} -a_{yx} & 1 & & & \\ & -a_{zy} & 1 & & \\ & & & 1 & \\ & & & & 1-a_{vv} \\ & -a_{jy} & & -a_{js} & -a_{jv} \end{vmatrix} - (-a_{si})\begin{vmatrix} 1 & -a_{xy} & -a_{xz} & & \\ -a_{yx} & 1 & & & \\ & -a_{zy} & 1 & & \\ & & & & 1-a_{vv} \\ & -a_{jy} & & -a_{js} & -a_{jv} \end{vmatrix} \\ + (-a_{vi})\begin{vmatrix} 1 & -a_{xy} & -a_{xz} & & \\ -a_{yx} & 1 & & & \\ & -a_{zy} & 1 & & \\ & & & 1 & \\ & -a_{jy} & & -a_{js} & -a_{jv} \end{vmatrix} \end{aligned} \tag{④}$$

The three minors above can be further expanded by suppressing column 1, column 4 and column 5 respectively. Here we get:

$$\begin{aligned} \Delta_{ij} = (-a_{xi})(-a_{yx})\begin{vmatrix} -a_{zy} & 1 & & \\ & & 1 & \\ & & & 1-a_{vv} \\ -a_{jy} & & -a_{js} & -a_{jv} \end{vmatrix} + (-a_{si})(-a_{js})\begin{vmatrix} 1 & -a_{xy} & -a_{xz} & \\ -a_{yx} & 1 & & \\ & -a_{zy} & 1 & \\ & & & 1-a_{vv} \end{vmatrix} \\ + (-a_{vi})(-a_{jv})\begin{vmatrix} 1 & -a_{xy} & -a_{xz} & \\ -a_{yx} & 1 & & \\ & -a_{zy} & 1 & \\ & & & 1 \end{vmatrix} \end{aligned} \tag{⑤}$$

Continue to expand the first term on the right-hand side of formula ⑤ by minors according to elements of its first column, we get:

$$(-a_{xi})(-a_{yx})(-a_{zy})\begin{vmatrix} 0 & 1 & 0 \\ 0 & 0 & 1-a_{vv} \\ 0 & -a_{js} & -a_{jv} \end{vmatrix} + (-a_{xi})(-a_{yx})(+a_{jy})\begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1-a_{vv} \end{vmatrix} = (-a_{xi})(-a_{yx})(+a_{jy})\begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1-a_{vv} \end{vmatrix}$$

Take the above result back to formula ⑤ and we obtain:

$$\Delta_{ij} = (-a_{xi})(-a_{yx})(+a_{jy})\begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1-a_{vv} \end{vmatrix} + (-a_{si})(-a_{js})\begin{vmatrix} 1 & -a_{xy} & -a_{xz} & \\ -a_{yx} & 1 & & \\ & -a_{zy} & 1 & \\ & & & 1-a_{vv} \end{vmatrix} + (-a_{vi})(-a_{jv})\begin{vmatrix} 1 & -a_{xy} & -a_{xz} & \\ -a_{yx} & 1 & & \\ & -a_{zy} & 1 & \\ & & & 1 \end{vmatrix}$$

$$= a_{xi}a_{yx}a_{jy}\Delta_1 + a_{si}a_{js}\Delta_2 + a_{vi}a_{jv}\Delta_3$$

⑥

The determinants Δ_1, Δ_2 and Δ_3 in formula ⑥ are the determinants of the sub-structures of $|I - A_n|$ excluding, respectively, the poles composing the three elementary paths —— $i \to x \to y \to j$, $i \to s \to j$ and $i \to v \to j$.

On the basis of formula ⑥, divide both sides by Δ, which is the value of the determinant $|I - A_n|$ and we get:

$$\frac{\Delta_{ij}}{\Delta} = a_{xi}a_{yx}a_{jy}\frac{\Delta_1}{\Delta} + a_{si}a_{js}\frac{\Delta_2}{\Delta} + a_{vi}a_{jv}\frac{\Delta_3}{\Delta} = I^D_{(i\to j)1}M_{p1} + I^D_{(i\to j)2}M_{p2} + I^D_{(i\to j)3}M_{p3} \quad ⑦$$

Thus we have successfully developed the formula ①. In the formula ⑦, M_{p1}, M_{p2} and M_{p3} are path multipliers of the three paths respectively, and still

$$M_{p1} = \frac{\Delta_1}{\Delta} = [1 - a_{yx}(a_{xy} + a_{zy}a_{xz})]^{-1} \quad ⑧$$

$$M_{p2} = \frac{\Delta_2}{\Delta} = 1 \quad ⑨$$

$$M_{p3} = \frac{\Delta_3}{\Delta} = (1 - a_{vv})^{-1} \quad ⑩$$

Compare the formula ⑧ with the formula (3.4) in the text and we can see the two calculation results of path multiplier are just the same.

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Attached table: The Global Influence Matrix Based on Chinese SAM in 1997 (intercepted)

		1	5	6	7	15	16	20	24	27						Urban	Urban	Urban	Rural	Rural	Rural	
		Agriculture	Apparel, Leather and Furs Products	Sawmills and Manufacture of Furniture	Manufacture of Paper & Cultural	Electric Machinery and Instrument	Computers	Construction	Restaurants	Social Service	Agri. L	Pw	Prof	Land	Capital	Lowest	Medium	Highest	Lowest	Medium	Highest	Enterprise
1	Agriculture	1.9133	0.5329	0.4754	0.4590	0.3188	0.2257	0.4003	0.9131	0.4101	0.9135	0.6396	0.5166	0.8156	0.2340	0.9239	0.5608	0.3707	1.2532	1.0040	0.6059	0.1810
5	Apparel, Leather	0.0731	1.1754	0.0909	0.0695	0.0523	0.0363	0.0661	0.0663	0.0651	0.0883	0.1003	0.1017	0.0824	0.0330	0.1354	0.1098	0.0819	0.1090	0.0939	0.0677	0.0242
6	Sawmills and Manufa	0.0253	0.0188	1.3076	0.0304	0.0253	0.0149	0.0506	0.0292	0.0401	0.0270	0.0271	0.0264	0.0265	0.0093	0.0359	0.0267	0.0237	0.0303	0.0272	0.0259	0.0069
7	Manufacture of Paper &	0.0755	0.0686	0.0824	1.3034	0.0841	0.0576	0.0860	0.0756	0.1143	0.0784	0.0733	0.0679	0.0737	0.0251	0.1100	0.0724	0.0529	0.0942	0.0830	0.0632	0.0188
15	Electric Machinery and	0.0610	0.0486	0.0530	0.0529	1.1700	0.1212	0.1105	0.0526	0.0776	0.0688	0.0617	0.0590	0.0675	0.0221	0.0702	0.0581	0.0607	0.0766	0.0685	0.0650	0.0165
16	Computers	0.0497	0.0403	0.0435	0.0513	0.0913	1.4418	0.0537	0.0454	0.1336	0.0564	0.0553	0.0555	0.0552	0.0195	0.0608	0.0534	0.0587	0.0630	0.0565	0.0525	0.0144
20	Construction	0.0155	0.0112	0.0120	0.0115	0.0117	0.0074	1.0139	0.0129	0.0335	0.0139	0.0123	0.0112	0.0131	0.0043	0.0173	0.0117	0.0091	0.0166	0.0146	0.0114	0.0032
24	Restaurants	0.0420	0.0350	0.0369	0.0371	0.0380	0.0226	0.0397	1.0355	0.0453	0.0502	0.0451	0.0422	0.0468	0.0158	0.0590	0.0440	0.0365	0.0585	0.0548	0.0380	0.0118
27	Social Service	0.0783	0.0687	0.0751	0.0649	0.0752	0.0481	0.0904	0.0873	1.1249	0.0829	0.0773	0.0735	0.0779	0.0268	0.1015	0.0757	0.0644	0.0974	0.0887	0.0657	0.0200
	Agri L	0.8616	0.2400	0.2141	0.2067	0.1436	0.1016	0.1803	0.4112	0.1847	1.4114	0.2880	0.2326	0.3673	0.1054	0.4160	0.2525	0.1669	0.5643	0.4521	0.2729	0.0815
	Prod W	0.2271	0.3902	0.3680	0.3608	0.3208	0.2259	0.4671	0.3647	0.4156	0.2238	1.1988	0.1826	0.2109	0.0694	0.2749	0.1918	0.1512	0.2698	0.2359	0.1818	0.0522

	Prof	0.1076	0.1208	0.1292	0.1245	0.1214	0.0921	0.1468	0.1234	0.1362	0.1004	0.0917	1.0846	0.0948	0.0317	0.1324	0.0891	0.0681	0.1202	0.1057	0.0822	0.0238
	Land	0.1170	0.0326	0.0291	0.0281	0.0195	0.0138	0.0245	0.0558	0.0251	0.0559	0.0391	0.0316	1.0499	0.0143	0.0565	0.0343	0.0227	0.0766	0.0614	0.0371	0.0111
	Capital	0.4067	0.4333	0.4447	0.4324	0.4103	0.3226	0.4539	0.4626	0.4504	0.3536	0.2992	0.2684	0.3314	1.1056	0.4169	0.2825	0.2195	0.4333	0.3741	0.2822	0.0799
Urban	Lowest	0.0185	0.0275	0.0267	0.0261	0.0237	0.0172	0.0323	0.0265	0.0294	0.0176	0.0667	0.0437	0.0166	0.0146	1.0218	0.0150	0.0117	0.0213	0.0186	0.0143	0.0113
Urban	Medium	0.0669	0.0946	0.0932	0.0909	0.0836	0.0612	0.1116	0.0922	0.1018	0.0634	0.2060	0.2371	0.0597	0.0515	0.0790	1.0543	0.0423	0.0765	0.0668	0.0515	0.0366
Urban	Highest	0.0598	0.0779	0.0781	0.0760	0.0709	0.0528	0.0907	0.0775	0.0840	0.0556	0.1366	0.2461	0.0524	0.0622	0.0694	0.0474	1.0368	0.0672	0.0587	0.0451	0.0360
Rural	Lowest	0.0611	0.0206	0.0188	0.0182	0.0136	0.0097	0.0172	0.0320	0.0172	0.0958	0.0289	0.0180	0.0413	0.0122	0.0316	0.0195	0.0132	1.0415	0.0335	0.0207	0.0098
Rural	Medium	0.1734	0.0676	0.0623	0.0605	0.0471	0.0340	0.0601	0.0983	0.0589	0.2545	0.1036	0.0549	0.2073	0.0461	0.0948	0.0591	0.0407	0.1218	1.0989	0.0624	0.0376
Rural	Highest	0.2278	0.1015	0.0945	0.0918	0.0736	0.0533	0.0948	0.1393	0.0917	0.3056	0.1682	0.0773	0.4323	0.0746	0.1317	0.0830	0.0581	0.1653	0.1351	1.0868	0.0604
Enterprise		0.1575	0.3250	0.3462	0.3553	0.3455	0.3278	0.2578	0.3627	0.3696	0.3599	0.2826	0.2391	0.2145	0.2648	0.8834	0.3331	0.2257	0.1753	0.3462	0.2989	0.2254