STRUCTURAL CHANGE IN CHINA 1987-2007

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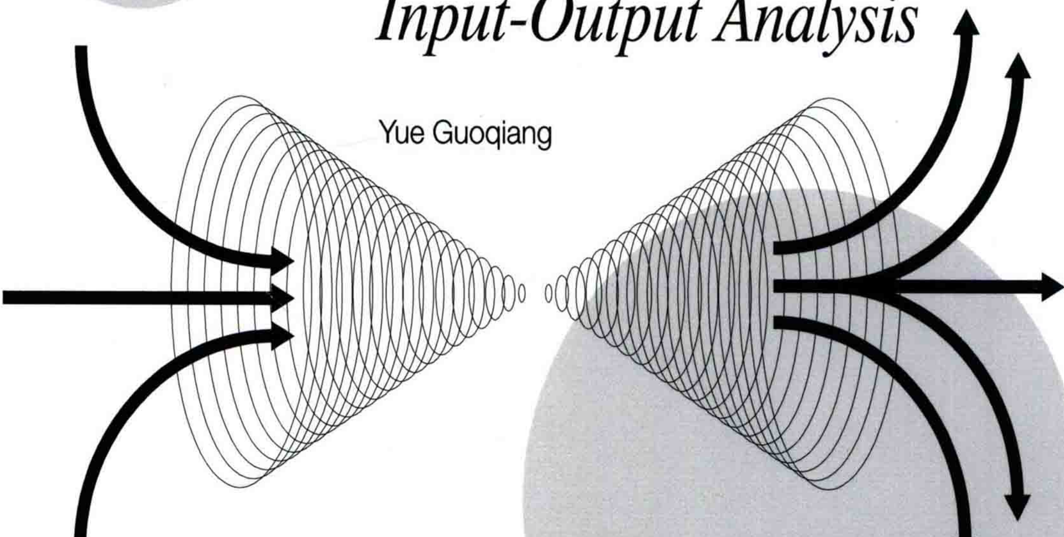
-An Application of Input-Output Analysis

Yue Guoqiang



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Contents

Chapter 1
Introduction

1.1 The Purpose and Outline of the Study

This study is an application of input-output analysis to the case of structural change in China. The purpose of the study is to examine thoroughly the changes in the structure of the Chinese economy accompanying rapid growth in the past decades. This book is therefore aimed at making a substantial contribution to the understanding of the changes in the Chinese productive fabric, and of economic growth, since the beginning of the economic reforms pertaining to the industrial sector in China.

In 1978, China implemented progressive economic reforms aimed at the gradual transition from a planned economy to a market economy. The reforms had huge effects on the economic development of China. During the past three decades, China sustained high economic growth rates: while the annual average growth rate of GDP reaching 9.8 percent, the annual average growth rate of GDP per capita reached 8.7 percent over the period from 1978 to 2012. ① With the rapid growth of the economy, the changes in the economic structure have taken place in many aspects obviously. Consequently, the share of the primary sector in GDP decreased from 28.1 percent in 1978 to 10.1 percent in 2012. Conversely, the share of the tertiary industries increased from 23.9 percent in 1978 to 44.6 percent in 2012. ② In the meantime, the pattern of consumption has also changed with the increasing income. For example,

①② China Statistical Yearbook, 2013.

the ratio of urban per capita annual expenditure on food and clothing to total consumption decreased from 67.6 percent in 1990 to 47.2 percent in 2012.① These changes indicate that the Chinese economy is undergoing a massive structural transformation.

A systematic and quantitative examination on the changes in the structure of the economy is therefore required to obtain a better understanding of structural change in China. There are two factors making it possible: one is the publication of a series of input-output tables of China; another is the development of the input-output model tools on structural change analysis.

This study will therefore exploit well established techniques of input-output structural change analysis, such as structural decomposition technique, linkage analysis, and biproportional filter method, it will provide some extensions and modifications to these techniques, and it will analyse the tendency of structural change in China. The study begins with a clarification of the concept of economic structure and with a basic description of the methodology in the next two sections of this chapter. Section 4 of this chapter introduces the input-output data of China. A literature review will be presented in the last section.

The organisation of the material by chapters is as follows. Following this introduction, Chapter 2 deals with the measurement of structural change. An index will be adopted to measure the extent of structural change. The sizes of the growth rates of various sectors of an economy over a certain period reflect the direction of structural change in the economy. A brief description of the general structural change will be given in the chapter using the input-output data.

Chapter 3 examines the sources of output change of China by using the structural decomposition analysis. The method involves breaking down the economic structure into various determinants. The various decomposition methods are illustrated and summarized. A comparison of the results derived from various decomposition forms will be carried out. The step-average decomposition method will be applied to the case of China in this chapter.

Chapter 4 deals with the biproportional filter method, which implies examining structural change in intersectoral interactions by decomposing the changes in interme-

① China Statistical Yearbook, 2013.

diate flow matrices at the different points in time. Methodology and recent improvements will be reviewed in detail in the chapter. The one–stage and two–stage methods of the biproportional filter will be illustrated and applied to the case of China.

Chapter 5 discusses the well–established concepts of backward and forward linkages which are important measures of intersectoral interdependence in terms of structural change. Having a special significance in all measures of input–output analysis, these methods have been thought to be the most useful tools in economic policy decisions and in development strategy studies. Four established ways of measuring backward and forward linkages are introduced in detail and some modifications on the linkage measures are made in this chapter. The differences between the results of the various linkage measures will be discussed. 'Key sectors' for China will be highlighted using various measures.

Finally, Chapter 6 contains the conclusions of the study. These are of two kinds: the first is on the methodology. An examination is made of the extent to which some of the measures that have been considered are superior to others. The second set of conclusions derives from the empirical results of the preceding chapters. It is an attempt to summarize the trend and degree of the changes in the Chinese economic structure during the period considered.

1.2 Economic Structure

In the very beginning of the study, it is necessary to clarify the concepts of economic structure and structural change used throughout the study. The analysis of structural change has a long tradition in economic studies, especially, in development economics. Since Kuznets' work (1951) on modern economic growth, structural change and economic growth have been the main issues studied in the area of development economics. The concepts of structure and of structural change were proposed under different aspects in the field of development economics. The most common usage of the word 'structure' refers to the relative importance of productive sectors in an economy in terms of development. Kuznets (1959) defined structure as "... a relatively coherent framework of interrelated parts, each with a distinctive role but harnessed to a set of common goals".

Quantitatively, structure refers to some ratios of economic variables considered, which are derived from technological relations. Input-output coefficients, *e.g.* the share of overall output, input coefficients, etc, are examples of it. These ratios of various variables reflect the sectoral composition of economic activities, which depict the structural characteristics of the economy studied. The changes in those ratios indicate the extent and trend of structural change during the process of economic development of the developing and developed countries.

The principal changes in the economic structure are the shifts in the sectoral composition of economic activities focusing on the use of production factors, and the changes in the location of economic activity. The former is about how industrialisation performs, in other words, industrialisation is one part of the central process of structural change in an economy. The latter reflects the process of urbanisation.

The scope of this study is restricted to the change in the sectoral composition of economic activities, *i.e.* the shifts in the sectoral composition of demand, production, and trade, which are described as the economic core of the transformation (Chenery and Syrquin, 1986). The changes in sector proportions are reflected by a variety of models. Such a change in the relative importance of sectors is defined as 'structural change'. Structural change is at the centre of modern economic growth. The interrelated processes of structural change that accompany economic development are jointly referred to as the structural transformation of an economy.

1.3 Methodology

Input-output analysis is a versatile tool with a broad range of applications to various issues. Over the years and since the inception of input-output analysis, this tool has been widely applied to examine the structural change in an economy, and to disclose particular characteristics of the economy represented by various input-output tables. In the past half-century, input-output techniques have been developed in many ways. Particularly in the study of structural change, many methods have been proposed. These methods strongly support the empirical studies on structural change. As implied by the title of this study, the purpose of the study is to examine the changes in the economic structure of China with the help of input-output techniques. Therefore, some common methods of input-output analysis will be used in this study. These methods are based on basic, open, and static input-output models. In order to understand better the various methods used and to define the concept of structural change within the framework of input-output analysis, it is necessary to recapitulate its simple theoretical outlines in concise quantitative terms. Following is the description of the demand-driven and supply-driven input-output models adopted in the study, as well as of the corresponding typology that will be frequently quoted in the following chapters.

The starting point for input-output techniques is to view any national economy as a system of mutually interrelated sectors. These sectors purchase various inputs that are used in their production process, and sell their outputs to various purchasers. Therefore, there are many streams of goods and services in the economic system, which directly or indirectly link all the sectors of the economy one to another. These flows can be observed and described in quantitative terms (Leontief, 1953).

Let: w_{ij} be the amount of products of sector i purchased by sector j;

x_i be total domestic annual output of sector i;

y_i be total final demand for sector i's products, which consists of consumption, fixed capital formation, inventory, and net exports;

v_j be the value-added resulting from the production process in sector j.

Certain derived measures used in the subsequent analysis are described as follows:

a_{ij} is the input of sector i's product per unit of output of sector j, or

$$a_{ij} = \frac{w_{ij}}{x_j} \tag{1.1}$$

b_{ij} is the output of per unit sector i's product going to sector j, or

$$b_{ij} = \frac{w_{ij}}{x_i} \tag{1.2}$$

The relations between different categories of variables separately identified in input-output tables can be described as follows:

$$\sum_{j=1}^{n} w_{ij} + y_i = x_i \quad \text{or} \quad \sum_{j=1}^{n} a_{ij}x_j + y_i = x_i \text{ for } i=1,2,\cdots,n \tag{1.3}$$

and

$$\sum_{i=1}^{n} w_{ij} + v_j = x_j \quad \text{or} \quad \sum_{i=1}^{n} b_{ij}x_i + v_j = x_j \text{ for } j=1,2,\cdots,n \tag{1.4}$$

These two relation equations allow one to present the above various variables in an input-output table as follows:

$$\begin{bmatrix} w_{11} & \cdots & w_{1j} & \cdots & w_{1n} & y_1 & x_1 \\ \vdots & & \vdots & & \vdots & \vdots & \vdots \\ w_{i1} & \cdots & w_{ij} & \cdots & w_{in} & y_i & x_i \\ \vdots & & \vdots & & \vdots & \vdots & \vdots \\ w_{n1} & \cdots & w_{nj} & \cdots & w_{nn} & y_n & x_n \\ v_1 & \cdots & v_j & \cdots & v_n & & \\ x_1 & \cdots & x_j & \cdots & x_n & & \end{bmatrix} \tag{1.5}$$

This basic input-output table includes three quadrants: Quadrant I is the left-top square matrix $\{w_{ij}\}$, also called intermediate flow matrix, which reflects the intersectoral transactions in the production processes. Quadrant II is at the right-top of the table and corresponds to the vector $\{y_i\}$, which is a final demand vector including consumption, fixed capital formation, etc. Quadrant III is represented by the left-bottom row vector $\{v_j\}$, which shows the primary inputs (value-added) of each sectors, including tax, wage, and profits, etc.

The row sum of an input-output table is always equal to the column sum for any industry k, reflecting the equality between the value of output and the overall inputs of production. Thus,

$$\sum_{j=1}^{n} w_{kj} + y_k = \sum_{i=1}^{n} w_{ik} + v_k \text{ for } k=1,2,\cdots,n \tag{1.6}$$

The separate terms of distributed output and the input are not equal for any given industry k:

$$y_k \neq v_k \quad \text{and} \quad \sum_{j=1}^{n} w_{kj} \neq \sum_{i=1}^{n} w_{ik} \tag{1.7}$$

However, there is equality between the sum of gross outputs and the sum of gross inputs, *i.e.*,

$$\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij} + \sum_{i=1}^{n} y_i = \sum_{j=1}^{n}\sum_{i=1}^{n} w_{ij} + \sum_{j=1}^{n} v_j \tag{1.8}$$

So, the sum of final demand and the sum of value-added of all sectors are equal:

$$\sum_{i=1}^{n} y_i = \sum_{j=1}^{n} v_j \tag{1.9}$$

The above description of relations between various input–output variables can be facilitated by using matrix algebra. Thus, the set of equation (1.3) and equation (1.4) can be rewritten in terms of matrix notation as:

$$A\,x + y = x \tag{1.10}$$

and

$$x'\,B + v = x' \tag{1.11}$$

Where, x is a column vector of gross output; x' is a transpose vector of x; y is a column vector of final demand; v is a row vector of value–added (primary inputs); A is a square matrix of input coefficients; B is a square matrix of output coefficients. The equation (1.10) is called as demand–driven input–output model, also referred to as the Leontief model, with fixed input coefficients. The relationship between output and demand is a linear one, in which total output of each sector is composed of intermediate demand and final demand. The variables are the output x and the final demand y, which are related by the matrix of input coefficients A. If the actual values of the input coefficient matrix A are known, then the structure of this input–output model is known, given by the equation (1.10). Accordingly, this model reflects not only the input structure of the economy, but also the relationships between the structures of output, final demand, and production.

Equation (1.11) is called as supply–driven input–output model with fixed output (or allocation) coefficients, which was primarily proposed by Ghosh (1958). The total output of each sector of the supply–driven model is indicated as the sum of intermediate inputs and value–added. Thus, this model reflects the allocation structure of the economy and the relationship between the structures of output and value–added in terms of product supply.

If we consider y as an independent variable, x as a dependent variable in the input–output system, then from equation (1.10), output x can be expressed in terms of y.

$$x = (I-A)^{-1}\,y \quad \text{or} \quad x = G\,y \tag{1.12}$$

Where the matrix $G = (I-A)^{-1}$, known as the Leontief inverse, plays a key role in input-output analysis. The matrix consists of coefficients g_{ij}, which can be defined as measuring both the direct and the indirect requirements of sector i per unit value of final demand y_j. Thus, an economy's total requirements in the output of sector i depend on both the structure of final demand and the technology prevalent in the economy.

Similarly, if we consider the value-added vector v as an independent variable, then x can be solved from equation (1.11). We have,

$$x' = v(I-B)^{-1} \quad or \quad x' = vZ \qquad (1.13)$$

The matrix, $Z = (I-B)^{-1}$, can be called as output inverse, which is also an important coefficient matrix. This relation indicates that the total production of an economy relies on the structure of the product allocation in the economy.

It is noteworthy that there still exists some debate on the application of the supply-driven model and the stability of the coefficient matrices (Oosterhaven, 1988, 1989; Gruver, 1989; Rose and Allison, 1989; Dietzenbacher, 1992). Oosterhaven (1988) argued that "only under conditions of very uneven sectoral growth can one except a significant difference in stability between the two sets. Formally, if one set of coefficients is stable and the other set is not". The writer suggested that if the empirical results were carefully interpreted, *i.e.* if they were not formulated in any casual way, the use of equation (1.13) and its derivatives might shed some light on differences in economic structure between regions and nations, and on differences in forward linkages between sectors. Dietzenbacher (1992) used the supply-driven model to measure forward linkages. In his works, the production denoted by the supply-driven model was interpreted as satisfying final demand, either directly in the first round or indirectly in any of the following rounds, through viewing the row sum of output coefficient matrix B as the share of output that remains within the production process.

In this study, the economic structure of China will be examined on the basis of the input-output framework described above. The reasons for doing so are that it has three advantages that make them particularly well suited to analysing structural change. First, the data are unusually comprehensive and consistent. The tables cover every industry in the economy, including the services sectors which are frequently poorly represented. The tables are linked with many of the traditional indicators of economic performance such as production and GDP. So input–output table frequently plays a fundamental role in the construction of the national accounts. Second, the nature of input–output analysis makes it possible to analyse the economy as an interconnected system of industries that directly and indirectly affect one another, and to trace back structural changes through industrial interconnections. Third, the design of input–output table allows a decomposition of structural change which identifies the sources of the change as well as the direction and magnitude of the change (OECD, 1992).

1.4 China's Input–Output Tables

The earliest attempt to construct national input–output tables in China can be traced back to the 1970s. The first national input–output table of China was for the year 1973. It was based upon the Material Balance System (MPS) and it was expressed in physical units. In the 1973 table, there are 61 sectors in the first quadrant, of which six sectors are in agriculture, 53 sectors are in the manufacturing area, one each in transportation and construction. There are two tables for 1979: one is updated from the 1973 table by means of the RAS method①; another is a roughly estimated input–output table, which includes 21 sectors in the first quadrant, and where all the information is given in producers' prices. There are also two input–output tables for 1981, which are based on the MPS. One is in value terms and includes 26 sectors in the first quadrant, while the other is in physical units and includes 146 key products. On the basis of the 1981 tables, the 1983 input–output table compiled by the State Statistical Bureau (SSB) of China in 1984 includes 22 sectors②.

It is worthy to mention that the 1987 input–output table is different from the previous tables. The 1987 table is the first one based not only on the System of National Account (SNA), but also on the data of the input–output surveys. It includes 118 sectors in quadrant I, and it is in current producers' prices. Since the 1987 table, China's government decided to compile a national input–output table every five

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① All details on the RAS method will be given in Chapter 4.

② For details, see Chen (1991).

years, which is based on the data of surveys and on the SNA. The government also decided to construct an expanded table between the two tables based on the surveys. So far, there are five national input–output tables based on surveys for 1987, 1992, 1997, 2002 and 2007. These tables, based on the same accounting system, *i.e.* the SNA, have a very similar classification of sectors. Thus, they are comparable. These five tables will therefore be chosen to form the database in this study in order to examine structural change in the Chinese economy. Next we describe briefly the basic structure of these chosen tables and the main classifications of the sectors used in this study.

Table1.1 the contents of input–output table of China

<table>
<tr><td></td><td>Sector 1 Sector 2 …
Sector n</td><td>Rural personal consumption</td><td>Urban personal consumption</td><td>Government consumption</td><td>Fixed capital formation</td><td>Inventory</td><td>Net exports</td><td>Others</td><td>Total output</td></tr>
<tr><td>Sector 1
Sector 2
⋮
Sector n</td><td>Quadrant I:
Intermediate flows</td><td colspan="7">Quadrant II:
Final demand</td><td>Output</td></tr>
<tr><td>Primary inputs
(or value–added)</td><td>Quadrant III:
Primary inputs</td><td colspan="8"></td></tr>
<tr><td>Total input</td><td>Input</td><td colspan="8"></td></tr>
</table>

As in the case of the basic, open input–output tables, the central part of the Chinese input–output table in value terms is a three–quadrant table of transactions or flows, which describes the interrelations among various segments of the economy. Quadrant I is the intermediate flow matrix (or inter–industry transaction matrix), which includes n sectors. Quadrant II is the final demand quadrant, which includes five sectors, Consumption, Fixed capital formation, Inventory, Net–exports, and Others, and Quadrant III is the primary inputs (or value–added) quadrant, which shows depreciation and factor payments (labour income, profits, taxes) originating in each of the producing sectors. Table 1.1 shows the contents of a modern and typical input-output table for China.

It is necessary to state the classification of sectors used in this study, because the different industrial classification would more or less affect the results calculated in practice. If the classification was rather broad, this would result in some important characteristics of structural change in the economy being undiscovered. Conversely, a very detailed classification would increase the amount of computing work. According to the situation of the input-output tables of China, the classification into 37-sectors is comparably suitable for this study. Thus the 37-sector tables for those years considered will be chosen in the following applications. In addition, in order to disclose the characteristics of structural change by main sectors, the 37 sectors are grouped into six main categories, *i.e.* Agriculture, Mining, Manufacturing, Power, Construction, and Services. Mining refers to four mining industries. The manufacturing sector refers to an aggregation of 16 industries whose outputs are broadly grouped as manufacturing and processing. The power sector refers to an aggregation of Electricity, Gas, and Water. The services sector refers to an aggregation of 12 industries whose outputs are primarily used as consumption. The contents of a sector's labels and the corresponding classifications are shown in Appendix A. These classifications and labels will be used throughout the study.

1.5 Literature Review

Methodology

Since Leontief's work on input-output analysis, several measures derived from input-output tables have been common tools for analysing structural change in various countries. The availability of input-output tables in many countries, or at different points in time within a country, makes it possible to analyse the change in the structure of an economy by comparing the change in input-output coefficients.

In the early days, attention was paid primarily to the comparison of different countries on the basis of summary measures of input-output tables or coefficient matrices. Comparing a situation at two points in time, Leontief (1951) developed the index of relative change which is defined as the difference between two input coeffi-