A Dynamic Input-Output Price Model with Application to Iran

Thesis submitted in accordance with the requirements of
the University of Liverpool
for the degree of Doctor in Philosophy

By
Fatemeh Bazzazan

March 2002

To:

My Parents,

My Family,

&

All of the Honourable Teachers

ACKNOWLEDGEMENTS

I would like to thank all the wonderful people who helped me to write this thesis by answering to my questions, providing me with ideas by discussing issues, referring me to important references, or even just by listening to me and encouraging me to continue to put effort into it all.

I owe special debt of gratitude to the late Prof. Moss Madden, my initial supervisor for the helpful discussion to develop the theoretical framework.

I would like to express my deepest gratitude to my supervisor Prof. Peter W. Batey to whom I am highly indebted for his expert guidance and essential comments to improve the theoretical as well as empirical frameworks of this thesis and associated papers.

I would also like to record my thankfulness to Dr. Ali Asghar Banouei, my internal supervisor, who always amazed me with his thorough and fruitful comments on my scripts and understanding of the research area.

My husband Jafar was, as always a constant source of encouragement and help. I am grateful for his support and patience while I was in the UK, which he has the responsibility of managing a very demanding publishing company and being both father and mother of our children. I would have also like to thank my children, Hadjar, Hossein, and Amin for their support and patience and being mature enough.

I am thankful to the Ministry of Higher Education for its financial support.

I would like to thank a number of official staff of the Iranian Organizations who provided assistance in supplying useful information, particularly to Mrs Fatemeh Safaei in SCI, Mrs. Nahid Fattachi and Mr. Rostam Hoor in CBIRI, and Mr. Esfandiar Gahangard in PBO.

I would like to thank all the wonderful staff members at Civic Design Department and Faculty of Social and Environmental studies office.

A Dynamic Input-Output Price Model with Application to Iran

Fatemeh Bazzazan

Abstarct

One of the crucial issues of the energy market in most oil export countries is the high level of subsidies for petroleum products and the low efficiency and wasteful use of energy. These subsidies become visible when we compare the domestic prices of various petroleum products with their international prices. The present study is aimed at developing a method which can be used for a national economic impact assessment of the phasing out of energy subsidies.

This study emphasises both theoretical and empirical developments. The theoretical developments include the following innovations: first, an extended dynamic physical IO model. Secondly, an extended dynamic price IO model, and thirdly a dynamic energy IO price model. The empirical developments refer to efforts to construct an operational version of the dynamic price model. Calculation of sectoral capital stock was the first requirement and the method of excluding damaged capital stock due to eight-year war with Iraq was the fourth innovation of this research. A capital coefficients matrix was constructed with the information on the sectoral capital stocks. This matrix enables us to construct the dynamic quantity and price models. Although these both dynamic models were relatively unstable, due to structural properties of the their matrices that displayed a high balanced growth rate, there was no causal indeterminacy. Therefore we considered them as a system for short-term planning rather than a turnpike path for long-term planning.

The results revealed that the impacts of *slow* energy price increases do not generally lead to an acceleration in the rate of inflation and a proportionate loss of household welfare according to the static analysis, but for the dynamic analysis the impacts were strongly regressive. The result of the impact analysis on government income is very significant; this is due to governmental monopoly of the energy market. The results of a *sharp* increase in oil products price and *fixity* of electricity price revealed that the impacts on the inflation rate and loss of welfare were not very significant but that the government will receive a substantial income and will be able to pursue some new fiscal policies.

A sharp increase in energy prices will create a highly accelerated rate of inflation and government income. This policy should be accompanied by government compensation for poor household income groups. The mechanism for returning part of the increased government revenue to households can include a redistribution effect to the poorer income groups of society. More precise investigation is required both on the mechanism available to *identify the poor* and on the mechanism available to *transfer* such resources to the poor.

CONTENTS

LIST OF TABLES AND FIGURES

Abbreviations

CBIRI	Central Bank of Islamic Republic of Iran
GDP	gross domestic product
IO	input-output
ME	Ministry of Economy
PBO	Plan and Budget Organization
SAM	Social Accounting Matrix
SCI	Statistical Centre of Iran
Type I-S	extended static input-output type I
Type II-S	extended static input-output type II
Type IV-S	extended static input-output type IV
Type I-D	extended dynamic input-output type I
Type II-D	extended dynamic input-output type II
Type IV-D	extended dynamic input-output type IV

CHAPTER ONE: INTRODUCTION

1.1. Background

Wassily Leontief launched interindustry analysis as a new field of economics almost seventy years ago. It is a method of analysis that takes advantage of the relatively stable pattern of the flow of goods and services among the elements of the economy and brings a much more detailed statistical picture of the system into the range of manipulation by economic theory (Leontief 1985). Since then it has been attracted a number of researchers who see it as presenting a break with conventional macroeconomics and have found it an attractive alternative to the highly-aggregated macroeconomics of the Keynesian models. During this period input-output analysis has been developed and applied in many areas to help planners, public administrators and investors for a wide range of purposes.

In the last twenty years, one of the important areas of development in the field of input-output analysis has been the modelling of the linkage between industrial and household activity. The linkages between them are usually modelled in an input-output framework by treating the household sector as an ordinary industry, which produces person years of work and consumes industrial products. The most interesting of these approaches are those which concentrate on the economic and demographic status of the household. The work of Schinnar (1976), Stone (1981), Batey and Madden (1981), Madden and Batey (1980), Van Dijk and Oosterhaven (1986) in particular have used extended input-output models as a framework for studying the interrelationships between demographic and economic variables. Four types of static extended input-output quantity models were developed and in the type IV version, households are disaggregated into two groups of employed and unemployed and provided the base for a clearer picture of the economy especially useful for investigating the relationship between output growth and unemployment changes. In spite of their considerable efforts there are some questions that remain, such as: what other requirements are needed for output growth in addition to input requirements? Another question, if households are treated just like other sector, what will be their contributions to economic growth? Answers to these questions can be investigated in a dynamic extended IO model.

The price IO model as a dual of the Leontief quantity model was developed more than a decade later than the quantity model by the founding father of input-output analysis, Wassily Leontief (1947). In his price model he provided a system for describing the relationship among the prices of all the different goods, the wages of all different types of labour and the rate of return on capital for a given set of technology for each producing sector. When the price model was developed and applied for many purposes since then, it has been attracted less attention compared with the quantity models.

Why did IO price analysis drift away from the mainstream IO price model and attract less attention? In this author's opinion, a number of major causes can be identified. The main reason is that the price model is an accounting price determination and the linkage between price and quantity of goods is missing. Secondly, the possibilities of substitution between inputs or transferability of inputs from one sector to another are not permitted. The later is the basic assumption that not only IO price but also IO quantity theory have been relied on and is due to the Leontief production function. But in price IO theory it is more essential in the long-term that the combination of goods changes as a result of any change in input prices, and producers and final consumers have time to substitute the cheaper inputs for the expensive ones. Third, another of important reason is that the vast majority of the price models rely on the notion that wage is assumed to be fixed or exogenous and is a part of value added, whereas in the real world the opposite is true.

The above-mentioned causes have been investigated to some extent. For instance, there have been some attempts to overcome the dilemma regarding the lack of interdependence between prices and quantities and the simultaneous determination of both variables in IO price models (Dieckhruer 1984, Schumann 1990). The present study is a continuation of those earlier attempts in the direction of ruling out the fixity of wages. For this objective the present study focuses upon the design of a methodological approach which it could be used to estimate the changes of wages due to a change of prices. Attention is given to the design, construction and testing of the model at the national level in Iran.

1.2. The Objectives of the Study

Against this background, the particular objectives of this study are:

- To review the theoretical background of dynamic IO models.
- To develop a dynamic quantity IO model and its dual.
- To undertake the necessary data assembly for constructing the model.
- To test the stability of the models.
- To examine the empirical properties of the models.

The relationship between changes in costs of industries and the subsequent changes in prices of sales to final buyers is often estimated by econometric regression methods employing time series data. Estimates of coefficients values obtained by this method are, however, data demanding, and the values are sensitive to the sample period. Although economists have always analyzed according to the relatively simple data and their relations, in the real world things are much more complicated. When a small change in the price of one good occurs, its impact upon prices is a complex series of transactions in which actual goods and services are exchanged in economic sectors. These types of steps are less likely to be suggested by the classical econometric method. However this is the procedure employed by input-output price analysis and this method conforms much more closely to the real world and requires less data. This is because, input-output analysis is a method of systematically quantifying the mutual interrelationships among the various sectors of a complex economic system in an attempt to give a complete picture of the economy.

1.3. Overall Outline of the Thesis

In addition to this first introductory chapter, the present study is divided into nine chapters, the content of which may be summarised as follows:

Chapter 2 will conduct a literature review on the static and dynamic input-output models and their applications. It will begin with a review of theories of static and dynamic analyses. In this review the capability of the both static and dynamic input-output models will be examined in terms of theory and application, as well as their data requirements. These reviews are essential for developing and constructing an appropriate input-output model and can also provide a sufficient background for the objectives of this study.

Chapter 3 will review the static extended input-output models and their applications. A number of different approaches have been taken to the design of extended input-output models. Some of this work has been based upon the pioneering efforts of Miernyk *et al.* (1967), The most interesting of these approaches are those which concentrate on the economic and demographic status of the household. The work of Schinnar (1976), Stone (1981), Batey and Madden (1980, 1981, 1983), and Van Dijk and Oosterhaven (1986) in particular, have been important in demonstrating the value of input-output analysis as a framework for studying the interrelationships between demographic and economic variables. Some initial thoughts on a dynamic version of the extended models will be presented. Basic elements and assumptions will be examined before developing the models and considering their applications.

Chapter 4 will outline a comprehensive and systematic theoretical framework of static and dynamic input-output price theories and consider their applications. First the basic assumptions and the obstacles will be discussed and the efforts that have been made to overcome the obstacles in input-output price theories will be analysed. In this chapter we intend to design extended dynamic IO price versions of the quantity models that are introduced in chapter three.

In chapter 5, an effort will be made to review the IO tables for Iran and their applications to find out whether these tables are capable of being used to derive a dynamic IO price model for measuring energy products price rises. The survey includes traditional and modern tables as well as static, dynamic, and SAM models and their applications for national planning and academic purposes in Iran.

Chapter 6 and 7 will focus on the data requirements for constructing and operationalizing the dynamic IO price models. The dynamic model takes into account interindustry transactions not only for intermediate products but also for fixed capital items. Such items relate first to the estimation of capital stock in chapter six and then the capital coefficient matrix in chapter seven. For both the capital stock and capital coefficients matrix, different methods of estimation will be examined and the best method from a data perspective will be applied in Iran.

In chapter 8, in order to find out the workability and feasibility of the developed dynamic price models, a further examination will be made on the stability of the model. The necessary and sufficient conditions for stability of the dynamic IO model will be explored, and then the construction of extended input and capital coefficients matrices for testing the stability of the extended quantity and price models will be explained. Finally, the conditions will be tested empirically for the dynamic quantity and price models in the case of Iran.

Chapter 9 will concentrate on empirical testing of the new model. The focus will be upon comparing the various kinds of model in terms of one specific example, the impact of energy price rises. By means of this comparison we can find out the capability of the new IO price models.

The last chapter will summarise the findings of the research. Some limitations of the study will be pointed out. Recommendations of areas for the further research will be presented.

CHPTER TWO: A GENERAL PICTURE OF DYNAMIC INPUT-OUTPUT MODELS AND THEIR APPLICATIONS

2.1. Introduction

It is already more than six decades since the input-output approach originated in the pioneering work of Wassily Leontief (1936) and yet this approach, after growing so rapidly continues to attract attention in numerous areas of economic discussion today. Although by the mid-1980s, input-output analysis was no longer regarded as a part of mainstream economics and IO papers were not published in some of the journals[1], nowadays there seems to be renewed interest in IO analysis. The field of input-output analysis has indeed expanded over time and has been subdivided into so many specialized branches that it would be difficult, not to say impossible, for a single person to overview it in its entirety. For example, in dynamic input-output analysis it is not easy to find an expert who is specialized in the variety of dynamic input-output subjects such as stability, balanced growth, endogenous growth, technological change, structural changes and many other subjects which relate to dynamic IO analysis: in static analysis

[1] Such as *Econometrica, the Review of Economics and Statistics,* and *the Quarterly Journal of Economics* did not publish traditional IO analysis. Contribution on CGE-modelling and inter-industry technology flows sometimes feature in top journals with an empirical flavour (Los 2001).

the subjects are more varied. Our focus in this chapter is limited to the dynamic model framework and its applications.

In this chapter we make a very brief survey of input-output analysis covering both static and dynamic analysis, with more emphasis on dynamic analysis. The description of the static analysis provides the platform to move from static to dynamic analysis and also helps to explain the assumptions on which dynamic model is based. The difficulties which the dynamic IO model faces and its particular advantage will be investigated. The difficulties, such as singularity of the capital coefficient matrix and the possibility of negative solutions, instability, and causal indeterminacy, will be discussed extensively and the applications of the dynamic model will be explored.

The chapter is organised as follows: firstly, the static IO model will be discussed. Secondly, the dynamic model and the construction of the capital coefficient matrix will be described. Thirdly, a short review of the application of the static model will be presented. Furthermore, the application of dynamic models will be pointed out. In the final part conclusions will be drawn.

2.2. The Static Input-Output Model

The notion of input-output analysis can be traced to the early development of economic thought. In 1758 Francois Quesnay published his Tableau Economique, a device which stressed the interdependence of economic activities. The original Quesnay's tableau explained the operation of a single establishment, a farm. It showed graphically the successive rounds of wealth-producing activity, which resulted from a given increment in output. In this case it was a forerunner of modern multiplier analysis. Later Quesnay published a modified version of the Tableau, which represented the entire economy of his day in the form of circular flows, but the notion of interdependence is better expressed in his earlier version. The next link in this chain of development came more than a century later. In 1874, Leon Walras published his "Elements d'economie politique pure". He was interested in the simultaneous determination of all prices in the economy. His model considered a system of equations- one for each price to be determined. Thus he made the transition from a partial to a general equilibrium. He was not only interested in general equilibrium of exchange but also in the general equilibrium of production. In his theory of production, Walras made use of coefficients of production to measure the quantities of factors required to produce a unit of each kind of finished good. Thus in the Walrasian system all prices are determined- those of the factors of production as well as the prices of finished goods. His model shows the interdependence among the producing sectors of the economy, and the competing demands of each sector for the factors of production. His system also includes equations representing consumer's income and expenditure, and it allows consumers to substitute the products of one sector for those produced by others. Other economists- notably Vilfredo Pareto- contributed to the theory of general equilibrium. But the culmination of the work started by Quesnay came in the 1930's when Professor Wassily Leontief developed a general theory of production based on the notion of economic interdependence. An important contribution was made by Leontief when he gave empirical content to his theory and published the first input-output table for the American economy (Miernyk 1967).

Input-output analysis is a method of systematically quantifying the mutual interrelationships among the various sectors of a complex economic system. The economic system may be as large as a nation or even the entire world economy, or as small as the economy of a metropolitan area or even a single enterprise. The size of economic system does not affect the approach. Since the fundamental principle of the input-output framework is to analyse the interdependence of industries in an economy, the term inter-industry is also used for input-output analysis (Leontief 1985). An input-output model in its basic form consists of a system of linear equations, in which each equation describes the distribution of an industry's economy (Miller and Blair 1985). It is constructed from observed data for a specific economic area. The economic activity in the area must be divisible into a number of segments or producing sectors. These inter-industry or intersectoral flows are measured for a particular time period and, in monetary terms, in what is known as a transaction table. The main body of the transaction table consists of a collection of industries and sectors[1] and shows the intersectoral flows, providing many links between different sectors and industries within the economy. An input-output table is made up of rows and columns, rows representing sectoral output and the columns representing sectoral purchases. The figures entered in each column of the table describe the input structure of the corresponding sector, whereas each row shows what happens to the corresponding output sector. A table also consists of final demand and value added sections. As in an economy there are sales to purchasers who are more

[1] It might be helpful to distinguish between industry and sector concepts. According to Tiebout 1969, industries refer to aggregates of firms producing similar products and sectors refer to the kinds of markets that industries serve.

external or exogenous to the industrial sectors that constitute the producers in the economy, e.g. households, government, and foreign trade. The demand for these units and the magnitudes of their purchases from each of the industrial sectors are generally determined by considerations that are relatively unrelated to the amount being produced in each of the units. The demand from these external units, since it tends to the much more for goods to be used as such and not to be used as an input to an industrial production process, is generally referred to as final demand (Miller and Blair 1985). Final demand covers total consumption (private or public), capital formation, and exports. The row sum of intermediate demand and final demand equals the gross value of production. Similarly, the column sums of intermediate demand plus value added also equal the gross values of production of an industry.

The transaction table is the statistical basis of the input-output system, and is applied to calculate what is called unit cost structure or technical coefficients. Technical coefficients describe inputs required from each industry to produce one dollar's worth of a given industry. These coefficients are calculated by dividing each entry in an industry's column by the total gross output for that industry. If input coefficients are relatively stable or if they can be adjusted on the basis of new information, the usefulness of the table of direct coefficients is apparent. By making use of such a table, the management of a typical firm in an industry could tell in advance how much it would have to buy directly from each of its supplying industries when it adds to its own total production.

If the economy is divided into N sectors, and if we denote by X_i the total output of sector i , X_{ij} the inter-industry sales by sector i to sector j, and Y_i the total final demand of sector i's product, we can write:

$$X_i = X_{i1} + X_{i2} + \cdots + X_{in} + Y_i \qquad (2.1)$$

According to the definition of a technical coefficient, in equation 2.1, we may write;

$$X_i = a_{i1} X_1 + a_{i2} X_2 + \cdots + a_{in} X_n + Y_i$$

If we write the above equation for all N sectors the results are as follows:

$$\begin{aligned} X_1 &= a_{11} X_1 + a_{12} X_2 + \cdots + a_{1n} X_n + Y_1 \\ X_2 &= a_{21} X_1 + a_{22} X_2 + \cdots + a_{2n} X_n + Y_2 \\ &\vdots \\ X_n &= a_{n1} X_1 + a_{2n} X_2 + \cdots + a_{nn} X_n + Y_n \end{aligned}$$

These equations serve to make explicit the dependence of inter-industry flows on the total outputs of each sector. In these equations $Y_1, Y_2, \ldots, Y_n$ are given numbers, a_{ij} are known coefficients, and the $X_1, X_2, \ldots, X_n$ are unknown and to be found. Therefore, if bringing all X terms to the left and reduce them a set of linear equations with N unknowns, $X_1, X_2, \ldots, X_n$, N equations are produced as follows:

$$\begin{aligned} (I - a_{11}) X_1 - a_{12} X_2 - \cdots - a_{1n} X_n &= Y_1 \\ - a_{21} X_1 + (I - a_{22}) X_2 - \cdots - a_{2n} X_n &= Y_2 \\ &\vdots \\ - a_{n1} X_1 - a_{2n} X_2 - \cdots + (I - a_{nn}) X_n &= Y_n \end{aligned}$$

and the reduced form of the above equations and solving for X we can write;

$$X = AX + Y \qquad (2.2)$$

$$X = (I - A)^{-1} Y \qquad (2.3)$$

Equation 2.3 helps us to calculate sectoral output, the direct and indirect effects of changes in final demand on output. The direct effect shows the direct purchases of a given industry from all other industries within the processing sector for each dollar's worth of current output. But it does not show the total addition to output due to additional sales to final demand. An increase in final demand for the products of an industry within the processing sector will lead to both direct and indirect increases in the output of all industries. The amount of change in output due to a unique solution depends on fundamental condition that must be met by the matrix of $(I-A)^{-1}$ known as the "Hawkins-Simon Condition" (Hawkins and Simon 1949). The mathematical proof of this condition given by Hawkins and Simon is much too complex to be discussed here, but its meaning can be made intuitively clear. Basically the Hawkins-Simon condition states that there can be no negative entries in the matrix of direct and indirect requirements. In the mathematical terms the sufficient condition for the static input-output model to be stable is presented as $(I-A)^{-1} \geq 0$ (non negative). Once a table of direct and indirect coefficients has been obtained, the input-output model can be used for variety of analytical purposes.

The static model explains the mutual interdependence of the distinct sectors of the national (or regional) economy in terms of a given set of structural coefficients, a_{ij}. These input coefficients do not reflect, however, the stock requirements of the economy; they do not and cannot explain the magnitude of those input flows which serve directly to satisfy the capital needs of all its various sectors, either as additions to fixed investment in the form of permanent improvements, building and different kinds of equipment, or as an increase in the necessary inventories of raw material, goods in process, etc. Such explanations become possible when the stock requirements of all the individual sectors of the economy are included in the structural map of the system along with their flow requirements, i.e. in dynamic input-output model (Leontief 1953). The dynamic input-output model takes into account inter-industry transactions not only for intermediate products but also for capital items.

As an alternative to the traditional IO model, Ghosh (1958) presented a model that has become well known as the supply-driven IO model. He suggested an alternative interpretation of the basic input-output data. This approach is made operational by essentially rotating or transposing the vertical view of the model into the horizontal one. Instead of dividing each column of the transaction matrix by the sectoral gross output associated with the column, he divide each row by gross output of the sector associated with that row. The basic assumption of the supply-driven approach is that output distribution patterns are stable in an economic system. The stability means that if the output of one sector is doubled, then one might expect that the sales from that sector to each of the sectors that purchase from sector i will also be doubled, i.e. fixed output coefficients are assumed (Rose and Miernyk 1989). The output coefficients describe the fixed part of each additional unit of output in one sector that flows to other sectors; these are known as sales or allocation coefficients. The Ghosh model is known as a supply-driven IO model, since value added is an exogenously specified driving force of the model, whereas the traditional Leontief model is defined as a demand-driven model which derives the sectoral outputs from exogenously certain final demands. The supply-driven IO model, despite many criticisms (for more, see Giarratani 1980a, Oosterhaven 1981, 1988, Gruver 1989), has been discussed widely and empirically tested[1] in many economic aspects such as impact analysis (Giarrantai 1976; Davis and Salkin 1984), measuring interindustry linkages (Beyers 1976, Jones 1976, Dietzenbacher 1992, Bon 1986,1988, Dietzenbacher *et al.* 1993).

2.3. The Dynamic Input-Output Model

The static input-output model has served, and will continue to serve, a number of useful purposes. Because it is limited to the flow of current transactions, and because of its fixed technical coefficients, the applicability of the static model is limited to short-term analysis[2]. "The static model also derives the changes in the variables of a given system from the observed changes in the underlying structural relationships, but dynamic theory goes further and shows how certain changes in the variables can be explained on the basis of fixed structural characteristics of the system" (Leontief 1953, chapter 3, p 53). Dynamic IO theory extends static IO theory by the explicit representation of changes in technology and in stocks of capital. The state of the economy at a particular time is represented by the corresponding set of technical coefficients. The dynamics are governed by a law of conservation: part of a sector's output is not used up in the period in which it is produced but is conserved and adds known increments to the capital stocks of the various sectors for use in future periods (Duchin 1988). In the open static model, the

[1] First application came more than ten years after it was developed by Augustinovics (1970).
[2] Short-run does not refer to any specific time period. In the case of a slowly growing economy in which the underlying technical relationships are changing at a slow rate, the static model can be used to make projections for several years.

capital inputs, instead of being assigned to the industries, which actually absorb them, are simply considered to be a part of final demand. That means the effects of investment demand on outputs of all commodities and services are explained, while the observed magnitude of this demand itself, though 'taken in account,' is not explained. Such an explanation becomes possible as soon as the stock requirements of all the individual sectors of the economy are included in the structural map of the system along with its previously described flow requirements. If we denote the stock of a commodity produced by industry i and used by industry j at the time t, the rate change of the stock at this particular point of time can be written as ΔS_{ij}. The basic balance equation 2.2, can now be written as follows:

$$X_i - \sum_{j=1}^{n} X_{ij} - \sum_{j=1}^{n} \Delta S_{ij} = F_i \qquad (2.4)$$

The second left-hand term represents here, the sum total of those input flows of commodity i which serve the current production requirements of all the various sectors of the economy, the third term describes the inputs absorbed on capital account, i.e. that part of the final demand for commodity *i* which is being added to or subtracted from the stocks of that particular good used throughout of the economy. F_i is final demand for sector *i*. This set of equations (2.4) must now be supplemented by a corresponding set of structural stock-flow relationships:

$$b_{ij} = S_{ij} / X_j$$

The b_{ij}'s will from now on be referred to as the stock or capital coefficients of the system. The equation (2.4) is a system of *N* linear differential equations with constant coefficients and *N* unknowns. If one could measure the value of the output of sector *i*, which is held by sector j as stock, then one could estimate a capital coefficient by dividing this holding of stock by the output of sector j, over a time period. Along with this fixed investment item such as building and machinery, goods bought as inventory by sector j, to use as inputs to later production, may also be included. For current production, the machinery, building, and so on must already be in place. But if an economy is growing then anticipated production is different from current production and the amount of supporting capital may change. From this point of view dynamic input-output requires knowledge of capital-output (or capital-capacity) ratios, which are analogous to the input-output ratios used in static models of general interdependence. It should be noted that the capital coefficients are expressed in terms of capacity units, and not, as in the case of the flow coefficients, in term of output units. As an industry seldom operates at full capacity, so the calculation of the capacity is not easy.

To construct a dynamic model it is necessary to supplement the current transaction table with capital flow tables. Moreover, the capital flow table has an important function in the dynamic economic-wide model embracing sectors. It works like an engine in the model to push forward, and makes the connection between present and future. However, the existence of the capital coefficient matrix is a requirement of the dynamic model, a number of assumptions have to be made in its construction. First, economies or diseconomies of scale may cause variations in the optimum output per unit. Second, it may be necessary to allow for substitution between techniques. Third, the question of aggregation arises when we estimate capital coefficients for industries rather than for particular products[1].

Capital coefficients are defined in two ways: incremental capital coefficients and average capital coefficients. An incremental capital coefficient is the stock of capital goods of all kinds required per unit of capacity increase in each industry. Whilst an average capital coefficient is the relation between total fixed capital stock of the individual industry and its corresponding capacity for a specific period of time. For the purpose of dynamic models, incremental rather than average capital coefficients are needed (Leontief 1953, chapter 6, p.187). If engineering techniques remained constant the two methods would be the same[1] (Miernyk 1967, p. 112). As is to be expected, each method yields different results, since the accounting data refer to average (old and new) plants, while the incremental coefficients are related only to modern plant. Also it is to be expected that the incremental capital coefficients could be greater than the average capital coefficients, because there is a time gap between investment establishment and when it is effectively used in production. In the two methods of calculation of capital coefficients, the main point is the derivation of industrial capacity figures, which can be estimated in a number of ways.

In addition, the inventory coefficients and the fixed capital coefficients are of equal importance to the dynamic analysis. Inventory stocks held and considered in relation to an industry's output in order to determine the coefficients, are the stocks of raw materials

[1] For more discussion see Leontief 1953, (chapter 6, pages 185-242).

and supplies held by that industry and the stocks of finished goods of other industries which are held for sale in the industry. It is important to note that in considering the inventory figures presented, the use of stocks held for an industry is a signal departure from the usual way of describing the inventories of an industry. It should be mentioned that a few industries, for example the services sectors, may not have inventories based on the nature of their activity but, as they do not produce any physical goods, inventories in such cases have no meaning. "The primary significance of the capital and inventory coefficients lies in their importance for dynamic analysis" (Leontief 1953, chapter six, p 188). The construction of a total capital coefficient comes from both of these coefficients, i.e., fixed capital coefficients and inventory capital coefficients. Availability of data is very important. "Data and measurement problems for estimating capital coefficients are even more severe than those for technical coefficients" (Miller and Blair 1985, p 341)[2].

By constructing a capital coefficient matrix, if an economy is growing, then anticipated production (next year) is different from current production, and the amount of supporting capital may change, the amount of new production from sector i for capital stocks in sector j will be given by $b_{ij}[X_j(t+1)-X_j(t)]$. In other words, it is the amount of investment requirements, that is, additions to productive stock that would let all the industries increase their capacity output from X_t to X_{t+1} (Leontief 1970). The general form of the dynamic Leontief model is introduced (Leontief 1953, 1970) as:

---

[1] If production function of the input-output analysis, is assumed to be constant returns to scale, so incremental and average capital coefficient should be very close.

[2] The method of construction capital coefficients matrix will be fully explained in chapter seven of this study.

$$X_t = A X_t + B(X_{t+1} - X_t) + F_t \qquad (2.5)$$

where,

X_t is a column vector of output levels at time t,

F_t is a column vector of final demand (excluding investment, i.e. annual addition to the stocks of fixed capital and inventories used by productive sectors),

A is the matrix of flow coefficients that specifies direct current input requirements of all industries,

B is the capital coefficient matrix,

AX_t is current input requirements of all n industries at time t,

$B(X_{t+1} - X_t)$ is an investment requirements or excess of productive stock from the time of t to $(t+1)$.

Equation (2-5) is intended to be solved for a vector of outputs, consistent with the given time sequence of technical matrices and final demand requirements. In theoretical work the system is closed, that is, non-investment final demand is assumed to consist only of personal consumption, and the household sector is treated like any other sector with consumption as its input requirements. Model (2.5) is transformed to the closed form below:

$$X_t - A X_t - B(X_{t+1} - X_t) = 0 \qquad (2.6)$$

If there are N sectors in an economy at the period of t in which $t = 1,2,3,\dots,T$, there are $N.T$ linear equations in $N.(T+1)$ variables. Obviously the system of equations cannot be solved when the number of variables are more than the number of equations, "generally it is assumed that the initial values of output at the beginning *(t =1)* or at the terminal $(t = T)$ is fixed" (Miller and Blair 1985, page 341).

A minimal condition for an economically meaningful solution is the existence of a set of nonnegative output sectors satisfying equation (2.6). It is well known that when equation (2.6)[1] is solved for output, a set of nonnegative solutions exists if only the initial conditions lie on the so-called balanced growth path. Conditions for the existence of a balanced growth path are discussed in Szyld (1985).

If we rewrite model (2.6) for X_{t+1},

$$BX_{t+1} = X_t - A X_t + B X_t$$

$$BX_{t+1} = (I - A + B) X_t$$

$$X_{t+1} = \left[I + B^{-1}(I - A)\right] X_t,$$

then, if we assume that $\left[I + B^{-1}(I - A)\right] = M$, so

$$X_{t+1} = M X_t \qquad (2.7).$$

Here two main difficulties arise when model (2.7) is solved for output. The first difficulty refers to the eigenvalues of *M* matrix which makes the connection between output at the *t* and t_{t+1} time periods. *M* matrix has *N* eigenvalues. Suppose that δ_i is an eigenvalue of *M*. If all eigenvalues of *M* are positive, then equation (2.7) has *N* positive solutions for *N* output industries. If not, and only if one of the eigenvalues of *M* is negative, in the economic word there is no meaning for the negative output. But in general there is no guarantee that all eigenvalues of M are positive. The question that arises here is: under what conditions would the existence of a positive eigenvalue δ_i and a positive eigenvector X_i associated with it be guaranteed? The answer is in the M matrix. If M is a nonnegative indecomposable matrix, then according to the Frobenius theorem there exists a positive eigenvalue (called the Frobenius root) and a positive eigenvector associated with it. So by taking the Frobenius root as δ_i and the associated eigevector as X_i, we have a balanced growth solution for the dynamic input-output Leontief model. If the economy possesses a balanced growth path, which is relatively stable, there is no causal indeterminacy in such an economy (Takayama 1985). We know that; $A > 0$ and $(I - A) > 0$, and $B \geq 0$, but it is not concluded that $M > 0$[2].

The second difficulty that arises in solving equation (2.7) for X_{t+1} in terms of X_t is the need to invert the capital coefficients matrix B. Most of the theoretical works are carried out at a level of abstraction at which it is assumed that the B matrix is invertible. The fact is that the matrix B is invariably singular, with rows of zero elements corresponding to the sectors that do not produce storable goods (for example agriculture, or services sectors) all the elements in their corresponding row in the capital coefficients matrix are zero. So, B is a singular matrix and it is not possible to inverse. Therefore, under this condition it is unlikely that X_{t+1} can be calculated for equation (2.7) in terms of X_t. Some approaches have been verified under certain assumptions to solve the system despite the singularity of the B matrix: Luenberger and Arbel (1977) presented a method

[1] i.e., a forward in time dynamic model.
[2] Stability condition of dynamic Leontief model will be discussed widely in chapter eight of this study.

to solve the singularity problem of the B matrix by dividing all the coefficient matrices in equation (2.5) into two sub-matrices.

But if we rewrite equation (2.5) we have;

$$X_t = A X_t + B X_{t+1} - B X_t + F_t$$

$$(I - A + B) X_t = B X_{t+1} + F_t$$

$$X_t = (I - A + B)^{-1} B X_{t+1} + (I - A + B)^{-1} F_t$$

and for the closed type we have;

$$X_t = (I - A + B)^{-1} B X_{t+1}.$$

Matrix $(I-A+B)^{-1}B$ contains a type of growth concept for output X_t in period t to X_{t+1} in the next period and does not need B matrix to be inverted. Then if we assume that $U = (I-A)^{-1}B$ we have $(I - A + B)^{-1}B = (I + U)^{-1} U$ and the growth rate of the economy is a function of the Frobenius eigenvalue of U (Leontief 1970). Since $(I-A)^{-1} > 0$ and $B \geq 0$ and is irreducible , so $U>0$. Since $U>0$ it has - according to well-known theorem of Frobenius- a positive dominant simple root and only this root is associated with a positive eigenvector (Leontief 1970). For this dynamic model the balanced growth rate[1] is associated with the reciprocal of the greatest eigenvalue of the U matrix. Here it is important to note that the balanced growth condition is dependent on the U matrix. The U matrix is related to A and B matrices, and so depends on conditions of both of them. Many authors assumed different assumptions in order to get same result for U. The main

[1] Balanced growth rate means that all the sectors in an economy grow in the same rate as the slowest growth sector.

result which they are looking for is irreducibility[1] of the U matrix. In addition to the assumptions were made by Leontief (1970), Szyld assumed that if and only if the sum of $C = A + B$ is irreducible, then $U = (I - A)^{-1}B$ is irreducible. The reducibility of C is a sufficient condition of a balanced-growth solution. He believes that the values in the matrix C have no apparent economic interpretation, and that what matters is the location of the non-zero in C. He mentioned that this condition is less restrictive than the assumption of irreducibility of U (Szyld 1985). Furthermore he has proved that not only if U is irreducible but also if it is reducible, a balanced growth positive solution exists (Szyld 1985).

If we rewrite equation (2.5) for growth this time then we have;

$$X_t = A X_t + B\Delta X_t + F_t$$

in which $\Delta X_t = X_{t+1} - X_t$ and it is output growth vector, according to the growth rate g, it is $\Delta X_t = g X_t$ then we have[2]:

$$X_t = A X_t + gB X_t + F_t$$

$$X_t = (I - A - gB)^{-1} F_t \qquad (2.8)$$

Mathur called (2.8) a dynamic Leontief trajectory. As we can see in model (2.8) the size of growth rate plays an important role in the stability of the dynamic model for forecasting future outputs. In most of the cases calculated balanced growth from the associated matrices is greater than the real growth rate and for forecasting the next period

[1] In economic terms i.e. each sector of the economy requires, directly or indirectly, some current inputs from all the other sectors.

[2] This formulation is based on Mathur's modification of the Leontief Dynamic model (Mathur 1965).

outputs, the differences between the real future output and that estimated by the model become significant. This topic relates to the stability of the dynamic input-output model and will be discussed in chapter eight of this study.

One of the other issues in dynamic input-output analysis that can be addressed comes from the assumptions that the model is based on, i.e. capital items in place are assumed to be transferable in such a way that full capacity production is guaranteed. As a result gross output in the next period is not determined by demand but is determined by full utilization of what is left over from the previous period. The structure of given initial stocks need not fit full capacity requirements specified by matrix B. Therefore it is possible that negative outputs appear. In other words the fact that negative outputs will typically be generated follows from the implicit requirement in equation (2.5) that the entire physical productive capacity be utilized (i.e., full capacity utilization), which involves both perfect foresight of the future stock requirements and the reversibility[1] of the capital stock. The assumption of full capacity together with the absence of choice of technique makes the dynamic model rigid (Kurz *et al.* 1998). Without considering this assumption the system is indeterminate and requires additional technological constraints or assumptions. Leontief (1953, page 68) shows that he was aware that his multisectoral version of the acceleration principle has one particularly serious defect in neglecting the irreversibility of the accumulation. Thereafter Uzawa (1956) suggested a flexible accelerator such that demand for capital is proportional to the rate of change of outputs.

[1] The stock to be reversible if capital in place but not in use in a particular sector is freely transferable to other uses within the economy. This occurs when elements of output growth in equation (2.4) is negative (Duchin & Szyld 1985)

This process was represented by replacing the term $B(X_{t+1} - X_t)$ in equation (2.5) by $B\{\max(X_{t+1} - X_t),0\}$. Uzawa's introduction amounted to allowing for unused capacity when output is falling. Both Leontief (1953) and Uzawa (1959) were aware of a particular defect in 'a multisectoral version of the acceleration principle' which neglects the irreversibility of the accumulation process by transferring fixed capital from sectors with idle capacity to rapidly growing sectors with a scarcity of capital. For this reason Leontief and others (1953), Dorfman, Samuelson and Solow (1958) and Solow (1959) argued that there is no technological reason for assuming that at any moment of time capacity use is fully adjusted to output. This potential problem is not encountered if one abandons the requirement of full capacity utilization even when output is rising. Duchin and Szyld (1985), Jorgenson (1961), Almon (1963a, 1963b) argued that if output and capacity are not defined to be identical, then the model must provide for the determination not only of output but also of a particular, sectoral pattern of capacity utilization and introduced explicit investment hypotheses which are based on planned or desired capacities.

Capacity utilization was the main question until Duchin and Szyld (1985) developed different formulations of an investment expansion. They assumed that the effective expansion of a sector's capacity may require several time periods, in which case expansion plans must be formulated and their implementation begun this amount of time in advance. These plans are based on expected rates of growth of outputs which are a weighted average of the rates observed in the recent past. A brief description of Duchin's model is as follows.

In Szyld and Duchin's approach, the investment term i.e., $B(X_{t+1} - X_t)$ is replaced by a new expression which embodies the following considerations;

- Once capacity is in place, it need not be fully utilised and is not reversible.
- Expansion decisions made for each sector are dependent on the past rate of growth and capital goods are ordered in each period.
- Some capital goods necessary for expansion must be delivered several time periods before.

For the above purposes, three additional variables have been introduced: *C(t)*, *o(t)* and *C*(t)*, where

C(t) is output capacity during period t

o(t) is the increase in productive capacity between period of t and $t-1$, so

$$C(t) = C(t-1) + o(t)$$

C(t)* is projected capacity requirements for period t, and

increase in capacity is defined by:

$$O(t) = \max\left[o, C^*(t) - C(t-1)\right]$$

If $C(t-1) \geq C^*(t-1)$ and $C^*(t) = C(t-1)$ then $o(t) = 0$, and no new output capacity is needed, but when capacity increases, the project capacity requirement needs to be estimated.

It is reasonable that different types of capital goods may have to be delivered two or more periods earlier. If τ is the maximum lag between the period when a capital item is produced in one sector and the period which it effectively adds to the capacity of another sector (to simplify, it could be assumed that the time lags are the same for all capital-using sectors) and the investment term now becomes:

$$\sum_{\theta=1}^{\tau} B^{\theta}(t)o(t+\theta)$$

The capital coefficient matrix of B^{θ} (t) is related to the B, and also the investment term $B(X_{t+1}-X_t)$ is related to this new formulation, when each element of the B matrix describes the amount of capital produced in period *t* by sector *i* to increase the capacity of sector *j* by one unit in period $(t+\theta)$ (for periods $\theta>\tau$ this element is zero). If the maximum time lag between the period when a capital item is produced and the period in which it effectively adds to the capacity of the sector, is two i.e. $\tau=2$, then the investment term will be;

$$\sum_{\theta=1}^{2} B(t)o(t+\theta) = B(t)o(t+1) + B(t)o(t+2)$$

B(t)o(t +1) means that increase in capacity at period *t* which will be used in one period later, and *B(t)o(t +2)* means that increase in capacity at period t which will be used two periods later (next two periods).

Duchin mentioned that the future capacity $C^{*}(t+\tau)$ has been planned τ periods in advanced, and is dependant not only on the output level in the last completed period but also on recent past changes in output. In order to prevent excessive expansion plans in a time of rapid growth, likely to be followed by a long period of under utilisation, δ_i is the maximum admissible sectoral annual rate of expansion of capacity. The expression for future capacity becomes;

$$C^{*}(t+\tau)=\min\left[1+\delta_{i},\frac{X(t-1)+X(t-2)}{X(t-2)+X(t-3)}\right]^{\tau+1}X(t-1)$$

Then, the equation (3.5) has been replaced by,

$$(I-A-R)X_{t}=\sum_{\theta=1}^{\tau}B^{\theta}(t)o(t+1)+Y_{t}$$

where R is a matrix of replacement capital coefficients. Moreover, in this dynamic formulation it is not necessary to invert the B matrix, and the condition that this model produces nonnegative solutions, is met if the column sums of $(A+R)$ are less than unity, i.e. each sector's outlays for replacement capital are covered by its value added, then the Hawkins-Simon conditions which applied only to A in static form, is satisfied also by $(A+R)$. Furthermore this model has been used for empirical investigations by Leontief and Duchin (1986) in "the future impacts of automation on workers" in the USA. This model also has been developed and empirically tested on "Micro-electronics and Employment" for West Germany by Kalmbach and Kurz (1990) and on "reduction of idle capacity and modified decision function" for Germany by Edler and Ribakova (1993).

2.4. Application of Input-Output Models

There are numerous reasons why IO frameworks have been constructed. Planning officials in particular need detailed information, public administrators need to know the possible effects of their decisions before they are implemented. Investors need to know growth potential on both primary and secondary levels before making investments. When the objectives of studying or research require a complete picture at a particular point in time or for a cross section in time, this requires the levels of the many economic activities and the many existing inter-relationships to be determined.

The vast majority of applied input-output studies have relied upon the implementation of the static model because the requisite data are readily available, computational procedures are well defined and available in packaged form, and generally accepted standards exist for defining and interpreting the results of comparative static computations.

The mathematical representation of the dynamic physical and price input-output models have been developed and analyzed in the theoretical literature for several decades. See, notably, the articles of Leontief (1953), Solow (1959) and Jorgenson (1960). While computations have sometimes been made, until recently they have been mainly illustrative rather than truly empirical. This was due both to the characteristics of the mathematical model, leading to results that did not lend themselves to realistic economic interpretation (notably the balanced growth path) as well as to the absence of the requisite data.

The first set of dynamic physical results based on the simplification of a "dynamic inverse" was presented by Leontief (1970). Some more recent and more general reformulation of the dynamic physical model have been developed by Duchin and Szyld (1985), implemented by Leontief and Duchin (1986), modified by Edler (1988) and used to clarify the choice of technology in the US by Duchin and Lange (1992) and Duchin &

Lange (1995), have extended the work by of making the choice of technology endogenous.

2.4.1. *Applications of the Static Input-Output Model*

Static IO models have been applied in many subject areas. Three principal types of applications are most prominent: forecasting; impact or multiplier analysis; and sensitivity analysis. To some extent these applications overlap and are interdependent, but for the purposes of discussion we consider them separately.

2.4.1.1. Input-Output as a Forecasting Tool

Forecasting seems to have been the mainstay of past IO applications in corporate planning and it will probably remain so. There are many methods of forecasting in economic analysis, such as partial forecasting or simultaneous equations. IO forecasting seems to provide more consistent forecasting. This term has been applied to the projection of a transaction table. When an input-output table is projected, the output of each industry is consistent with demands, both final and from other industries, for its products. What the consistent forecast does is to ensure that projections for individual industries and sectors will add up to a total projection if the structural relations of the economy do not change significantly over the projection period. For short-term projections it is safe to assume that the input coefficients will not change. But for long-term projections we cannot assume that they will also remain constant. Two steps are involved in consistent forecasting:

- It is necessary to make projections of each entry in the final demand sectors of the input-output table,

- A new transaction table is projected on the basis of the assumed changes in final demand and fixed input coefficients.

Static input-output models are used to make short-term planning, and for long-term planning a dynamic input-output model is required. A dynamic input-output model is of considerable value in forecasting the balanced growth rate for industries. Meanwhile, the static input-output model is a tool to forecast an expected growth for changes in final demand. Forecasts based on an input-output framework have a major advantage over many other techniques by reason of the detail they provide.

2.4.1.2. Impact Analysis

Economists have been interested in measuring the economic impact upon one variable from a given change in other variables. The multipliers are very useful analytical tools in an IO framework, which shows the details of how multiplier effects are worked out throughout the economy. The impacts on the industries most directly affected can be measured with little difficulty. But, when one recognises the interdependence of economic activities, it is apparent that the total impacts will not be limited to those industries directly affected. Impact analysis is one of the most important uses of input-output, it is usually employed when the changes are expected to occur in the short-run. When longer term and broader changes, for example more than five years, then we are dealing with forecasting and projection. According to definition, multiplier yields on the differences between the initial effect of an exogenous (final demand) change and the total effects of that change. Total effects can be defined in two ways: direct and indirect effects (simple) and direct and indirect and induced (total) effects. Three of the most frequently used types of multiplier are those that estimate the impacts of the exogenous changes on

a) outputs of the sectors in the economy (output multiplier), b) income earned by households because of the new outputs (income multiplier), and c) employment that is expected to be generated because of the new output (employment multiplier). "An output multiplier is defined as the total value of production in all sectors of the economy that is necessary in order to satisfy a dollar's worth of final demand for sector *j*'s output" (Miller and Blair 1985, page 102). In other words, an output multiplier is the ratio of direct and indirect effects to the initial effect. If the initial effect is noted by ΔY, and changes in output by ΔX, the output multiplier is $\Delta X/\Delta Y$.

An income multiplier shows "the impacts of final demand spending changes on income received by households" (labour supply) (Miller and Blair 1985, page 105). Four types of income multiplier have been developed in many studies, the distinction here is between considering the pattern of households such as exogenous or endogenous, employed or unemployed, local residents or immigrants. A type I income multiplier is the simple multiplier, in the IO model with households exogenous it produces an underestimate of total effects. A type II multiplier estimates potential impacts in which household is exogenous. A type III income multiplier in the Boulder study (Miernyk *et al.* 1967) was estimated according to two household patterns, local residents and immigrants. A type IV income multiplier was derived by Madden and Batey (1983), with the distinction between the spending patterns of currently employed and unemployed local residents.

2.4.1.3. Sensitivity Analysis

The sensitivity analysis is, in some respects, simply a variant on the more standard forecasting work. The objective of a sensitivity analysis is to determine those elements or components of the economy which are more sensitive than others. It is geared principally to test the consequences of alternative hypotheses concerned with changes in the economic environment. Specifically, it deals with "what if" questions, that is, " what if the growth of the economy goes this way or that way". Such hypotheses may set out different final parameters of growth or component mix in the gross national product, or alternative hypotheses about changes in the market structure or technology. In making sensitivity tests, the input-output technique is often particularly useful in demonstrating the indirect effects of specific changes. Input-output analysis can be instrumental in showing up hidden but often significant indirect effects.

2.4.2. *Application of the Dynamic Input-Output Model*

Leontief's dynamic input-output model has been further refined and developed in many directions, not only for short-term planning but also it is obviously very attractive for other types of investigations such as structural change, technological change and diffusion of new technology, balanced and unbalanced growth rates, and many other uses of this model in quantity. However in the field of economics, issues of long-run economic growth and structural change have scarcely begun to be studied in a dynamic framework. After the construction and application of the well-known 'Leontief-Duchin-Szyld' model (Duchin and Szyld 1985, Leontief and Duchin 1986) in the mid-1980s, the focus of the majority of empirical input-output studies seems to be on the prediction of short-term developments and ex post accounting for growth in a comparative statics framework (e.g. structural decomposition analysis).

From the planning point of view, the dynamic input-output model has much appeal: it helps in identifying a moving equilibrium of outputs. Investment is specified at a disaggregated level in terms of specific investment goods and is treated endogenously, i.e. within the system. The planner is helped to see more clearly the implications of the rising level of investment in a particular sector, given the requirements of inter-sectoral balancing. The first suggestion that the structural change can be observed into the dynamic input-output models by considering the capital embodied technical progress was discussed Carter' (1963) paper presented at the Third International Conference on Input-Output Techniques in September 1961. According to Carter's study, technology is represented by a) average technical coefficients reflecting existing capacity observable from the past periods and b) best practice coefficients characterizing new technologies. An optimal mix of input structures, in the sense that demand for labour is minimized, subject to an overall investment ceiling given by the total amount of gross new investment available to the system, is calculated by means of a linear programming model.

More applications of the dynamic input-output models for the analysis of technical change can be found. In these studies the description of technological change is generally associated with structural change, and the structural change emphasises the formulation of investment behaviour and its changes. Under this interpretation when the capital requirements change, investment patterns will generally also change. So the difference between these applications is in the exploration of investment behaviour. Leontief and Duchin (1986) introduced an investment term with this consideration that in each time period, expansion decisions are made for each sector based on recent past growth rates and capital goods ordered. Some capital goods must be delivered several periods before the new facility of which they are part of can be effectively added to the investing sector's capacity. In Kalmbach and Kurz's (1990) study, the formulation of private behaviour investment has been improved in this respect that their model does not allow declining industries, the growth rates of output have been considered to change in different periods, the expansion of productive capacity is limited by exogenously given maximal growth rate, for the too long cycles.

Duchin and Lange (1992) went further and investigated the changes in technology in the past and prospective future changes in the various sectors. The model developed in Duchin and Lange (1992) provides a conceptual framework for examining many aspects of the relations among technology, prices, production, income, and expenditures. Edler and Ribakova (1993) modified Leontief and Duchin's (1986) model with respect to two properties: firstly, the reformulated model allows for the explicit retirement of idle capacity with a mechanism which was not included in the original model, secondly, the decision function ruling the process of the implementation of capacity expansion investment was modified using the concept of capacity reserve. Duchin and Lange (1995) extended their previous work by investigating the basis for the previous work decisions as a step towards making the choice of technology endogenous. Campisi and Nastari (1993) developed a multiregional input-output dynamic model and extensively discussed the theoretical and practical difficulties arising in the implementation of dynamic input-output models in a multiregional framework. They investigated the possibility that regional and sectoral productive processes may fail to use up all the available productive capacity, so that the output and the capacity are not forced to coincide and unused capacity is allowed in the multiregional system. Their resulting model maintained the interregional, intersectoral and intertemporal consistency between production and use of goods and services and ensures a plausible dynamic path.

Applications of dynamic input-output models for the case of differentiated rates of growth of final demand can be found in Stone and Brown (1962), Mathur (1964) and Mukerji (1964). Stone and Brown considered only a particular long-run solution for growth, and they examined the relationship between output and investment on the one hand and consumption on the other hand, when consumption is subjected to exponential growth. Murkerji (1964) generalized this approach to interconnected growth in consumption of commodities and provided a general solution, while Mathur (1964) investigated the dynamic input-output model for the case of differentiated rates of growth of final demand and also determined an upper limit to the rate of exponential growth for the consumption of any item. Mathur (1967) redeveloped the dynamic input-output Leontief model in the form most suitable for application as a planning tool especially for detailed investment planning in the industrial sector which has been tested in the Indian economy. In this study, he was able not only to calculate the maximum rate of growth for the dynamic model but also could meet the minimum socio-economic investment requirement and their minimum necessary rate of growth from the internal resources. Most of the studies, such as Takayama (1972), are concerned with the existence of balanced growth solutions for the dynamic model[1] and the effect of this growth on consumption patterns over time. Chung (1981) considered infinite-horizon consumption utilities in the two sector version of the model, and Nikaido (1961) investigated the long-term convergence characteristics of output and consumption vectors that describe the system, while Ten Raa (1986a, b) offered a general solution which also applies to unbalanced growth. Meanwhile Los (2001) introduced endogenous growth and structural change in a dynamic input-output model. He established a bridge between endogenous growth theory[1] and IO analysis by introducing a simple dynamic input-output model in which some of the most important properties of state-of-the-art endogenous growth theories are included: innovation, knowledge spillovers, constant returns to scale at the macro level and supply-side determination of the production levels. He tries to indicate how the theory of endogenous growth in mainstream economics could be improved by IO analysis.

2.5. Conclusions

This chapter started with the basic concepts in static and dynamic input-output models. It covered the chain of thought of input-output analysis since 1758 when Francis Quesney published his famous Tableau of Economique. A century later, in 1874, Leon Walras published his General Equilibrium condition, and thereafter in 1936 Wassily Leontief developed a general theory of production based on the relation of economic

[1] That is solutions in which the total outputs from each sector grow in the same constant proportion in successive time periods.

interdependence. His first great contribution came when he tested empirically this theory in the American economy. His model explains the interdependence of the national (or regional) economy in terms of a given set of structural coefficients, which shows the input flows requirement of the models but cannot explain the capital requirement of its various sectors. Another great contribution of Leontief was in developing the first version of the dynamic model in 1953, which takes into account not only intermediate products but also capital items in the inter-industry transactions. The construction of a dynamic model requires a capital coefficient matrix, in order to show the amount of investment required for output growth. His model is constructed under three main assumptions: there is no choice of technique and no technical change takes place, there is full capacity production, and fixed capital products are transferable between different lines of production at zero cost. These assumptions cause some difficulties for dynamic input-output model application. The difficulties are: the singularity of the capital coefficient matrix, instability, and causal indeterminacy. The singularity problem has been investigated in many studies. The singularity problem arises when it is required to invert the capital coefficient matrix. This requirement has been ruled out in dynamic input-output models, which have been introduced recently. So far approaches have shown that the singularity of capital problem has been solved, but instability and causal indeterminacy are still remain. The root of these two latter difficulties comes from the full capacity utilization. The assumptions of full capacity utilization together with the absence of choice of technique make the dynamic model rigid. Different authors

---

[1] A long-term growth theory of Romer's (1986) which so-called endogenous growth models, Research & Development (R&D) and its accompanying positive externalities are the driving force of long-term productivity and output growth.

proposed some suggestions to overcome this, such as: first; to consider dynamic Leontief model as a planning system rather than a model of actual behaviour of the economy. Second, to relax the full capacity assumption in the sense that capacity is not fully adjusted to output at any time period.

In this chapter we also investigated the application of static and dynamic models. The vast majority of applied input-output studies have relied upon implementation of the static model because of readily available requisite data, and computational procedures are well defined and available in package form. Most applications of the static model can be considered in forecasting, impact analysis, and sensitivity analysis.

The mathematical representation of dynamic physical has been developed but rarely applied for empirical purposes. This is because of either the characteristics of the mathematical model or the absence of the requisite data. The dynamic input-output model has been developed not only for short-term planning but also for other purposes such as structural change, technological change, balanced and unbalanced and endogenous growth. The difference between applications of the structural changes is in the exploration of investment behaviour. Adequate modelling of the investment process remains one of the main methodological problems of input-output analysis within a dynamic framework. Meeting this objective requires a further complication of the model by introducing new parameters of capacity reserves and parameters of flexible accelerator.

Although the stability of the model still remains in question, it has been used practically in empirical studies, and represents an advanced instrument for the long-term analysis of technical change.

CHAPTER THREE: DYNAMIC EXTENDED INPUT-OUTPUT MODELS - SOME PRELIMINARY THOUGHTS

3.1. Introduction

In the last twenty years, one of the most important areas of development in the field of input-output analysis has been the modelling of the linkage between industrial and household activities, especially at the regional level. The linkages between them are usually modelled in an input-output framework by treating the household sector as an ordinary industry, which produces labour and consumes industrial products and is included in the transactions matrix. Extended versions of the input-output model have been introduced by adding further rows and columns to the inter-industry flow matrix. A number of different approaches have been taken in the design of extended input-output models. Some of this work has been based upon the pioneering efforts of Miernyk *et al.* (1967), who explored the effects of a rapidly expanding local economy in Boulder, Colorado. It includes research reported by Batey, Madden and Weeks (1987), Blackwell (1977), Sadler *et al.* (1973), and Tiebout (1969). The most interesting of these approaches are those which concentrate on the economic and demographic status of the household. The work of Schinnar (1976), Stone (1981), Batey and Madden (1981, 1983), Madden and Batey (1980), Van Dijk and Oosterhaven (1986) in particular, have been important in demonstrating the value of input-output analysis as a framework for studying the interrelationships between demographic and economic variables.

The aim of the current chapter is to present some initial thoughts on a dynamic version of the extended model. The starting point is a simple static model in which household consumption is treated as a component of final demand and household income as a part of value added. This basic form of model is elaborated upon in a sequence of stages until a comprehensive version of the extended model is obtained. To a large degree the extended model conforms to the same principles as apply to a Leontief input-output system, the only differences concerning the presence of positive coefficients in some of the off-diagonal cells of the matrix of coefficients (Miller and Blair 1985). The review covers four general types of model, including the basic form, although attention is focused on two of these models, and their equation systems, as these are later re-presented in dynamic form. In the following section, the basic elements and assumptions of the dynamic model are introduced. These are then applied to two dynamic extended models, one of which takes account of different household income groups, and the other distinguishes between employed and unemployed workers.

3.2. Static Extended Models

Extensions to input-output models have a long history (see, for example, Leontief 1970). There has been increasing awareness of the need to improve the specification of the household sector in such models (for a comprehensive review, see Batey 1985). A variety of different approaches have been developed to household disaggregation and to the incorporation within an extended modelling framework of population-related variables, including household income, household consumption, income distribution, labour force participation, migration, employment and unemployment, in addition to industrial output. Going back further to the earliest work on the concept by Leontief in the simplest input-output model, final demand is exogenous and includes consumption purchases by households, as well as investment, government spending and exports. In the case of households, they earn incomes in payment for their labour input in the production process and as consumers they buy goods for final consumption. This simple model, in which households are treated exogenously, is characterised as a Type I Leontief model (Leontief 1941). It is given by:

$$X = (I - A)^{-1}.Y \qquad (3.1)$$

where

X is a column vector of gross output,

A is a technical coefficients matrix, and

Y is a column vector of final demand.

In a Type I model, the impact of household consumption of industrial output may be assessed, but the effect that a change in industrial output might have upon household income and expenditure is ignored. In other words, the consequences of direct and indirect household income change are modelled, but the induced effects of the presence of households in the economy are not captured.

The first, and most straightforward, extension involves the closure of the model with respect to households. To make the household sector endogenous, it is transferred from the final demand column to the inter-industry transactions table. The household sector is therefore assumed to behave like any other industrial sector. In this case the output is labour and the input is consumption. The household sector is assumed to behave like other industrial sectors with a linear and homogeneous consumption function.

Numerous attempts have been made to disaggregate households. Three important varieties of disaggregation can be identified, namely Types II, III and IV. The model developed by Miyazawa (1976) to disaggregate households into a number of income groups under the assumption of consumption homogeneity, may be regarded as a Type II extended input-output model. Equations and variables are as follows:

$$\begin{bmatrix} I-A & -h_c \\ -h_r & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_h \end{bmatrix} = \begin{bmatrix} d_1 \\ d_h \end{bmatrix} \qquad (3.2)$$

h_c is a column vector of household consumption,

h_r is a row vector of income from employment coefficients,

d_1 is a row vector of final demand that household consumption is extracted,

x_h is household income, and

d_h is exogenous household income, i.e. income received by residents living in the study area from sources outside the area.

and the equations are:

$$(I-A)x_1 - h_c(x_h) = d_1$$
$$-h_r(x_1) + x_h = d_h$$

Several criticisms can be made of this form of extended model.

The first criticism arises from the assumption of a linear and homogeneous consumption function. As households are confined to a single row and column in the model, i.e. one pattern of household consumption is represented, all households are assumed to have the same wage rate and consumption propensities. This is clearly an unrealistic assumption since any study area can be expected to contain a mixed assembly of households exhibiting widely differing consumption patterns (Batey and Madden 1983). Any changes in household income and consumption are regarded as being immediately related to each other, whereas in reality it is clear that decreases in wages to labour do not mean identical decreases in household consumption. As household income falls, or is removed completely by redundancy, households do not necessarily spend correspondingly less, or disappear altogether from the system, and in practice social security or unemployment benefits partly take the place of income from employment (Batey and Madden 1981).

Second, migrant flows are important elements in the economic system, introducing new consumers into regional economies, or removing existing consumers, and so the explicit treatment of migration in an extended input-output model is essential. In a Type II model this is ignored.

Third, consumption propensities are implicitly assumed to apply exclusively to employed households. The consumption of unemployed households is treated exogenously, as a part of final demand, and so is not influenced by the consumption of employed households.

Fourth, in this model it is not clear what the source is of newly employed workers - are they from the local labour force or migrants? The impact of their existence before taking up employment has been ignored (Batey 1985, Batey and Weeks 1989, Batey 1990).

It was in an effort to overcome these problems that Miernyk and his colleagues developed a new form of input-output model for their study of the impact of the space programme on Boulder, Colorado (Miernyk *et al.* 1967). To circumvent the problem of linearity of the consumption function, Miernyk and his colleagues sub-divided existing workers into a number of income groups, each with a different propensity to consume within the local economy. They furthermore assumed that changes in household income in a region could be divided into two types: extensive and intensive. Extensive growth was defined as an increase in output and employment without any increase in per capita income. Intensive growth is assumed to occur as a result of increases in productivity. Miernyk and his colleagues assumed that in-migrants receive the same wage rates as indigenous workers (extensive income), and they identified the difference between this and total income growth as intensive income, reflecting increases in productivity among the indigenous workforce (Batey and Weeks 1989). This form of extended model was labelled a Type III model by Miernyk and his colleagues. Although in its original form the model used an interative solution method, Batey, Madden and Weeks (1987) have shown that it may be represented as a system of simultaneous equations or an activity-commodity framework. Slight variant household disaggregations have been developed based on the Miernyk model, including a model for Cork, Ireland, which specifies the previous residence of workers (Blackwell 1977).

A series of extended input-output models, under the general description of Type IV, have been developed in recent years. The most important characteristics of this work, which distinguish it from other studies, are as follows:

The two main linkages in the relationship between economic and demographic variables have been specified as the economic-demographic and demographic-economic interfaces. The first of these represents the effects of economic change on population and the second the effect that demographic factors have on an economy (Madden and Batey 1980).

Identification of a particular inconsistency, which arises in the household-endogenous model Type II, concerning the calculation of the unemployment rate (Batey and Madden 1983).

The finding that there are two approaches to the solution of the problem of demographic-economic change and its consequences, one based upon an iterative technique and the other using a simultaneous method offered by activity analysis, and established that these two approaches yield identical results (Batey and Madden 1983).

Recognition of the importance of modelling the social security payments received by unemployed persons and by old age pensioners (Batey and Madden 1983). In more recent work, Madden and Trigg paid greater attention to migration and unemployment in the extended input-output model and developed a model which included only one group of migrants and unemployed (Madden and Trigg 1990). To achieve this they introduced a new column in the coefficients matrix to represent the consumption propensities of unemployed migrants (in most cases the same as those for indigenous persons) in one- and two-region formulations. Elsewhere Madden (1993) proposed a number of developments to the models of Madden and Trigg that are intended to remedy that failure, including introducing two levels of unemployment benefits - indigenous and in-migrant (Madden 1993).

More attention was paid to the design, construction, application and sensitivity testing of the model, based on the principles of extended input-output analysis, at the metropolitan area level by developing a sub-regional input-output model. For this purpose the workforce was divided into three subgroups, namely employed, short-term unemployed and long-term unemployed or economically inactive workers. This enables the income received by workers from employment, welfare payments made to the short-term unemployment and those made to the long-term unemployed or economically inactive to be separately represented (Batey, Madden and Scholefield 1993).

Madden (1993) introduced the government sector explicitly within the modelling framework as a (quasi-) economic sector with different rates of taxation on expenditure. He assumed three different categories of consumers reflecting the interrelationships of different income levels.

A simple extended Type IV input-output model, which has been formulated by Batey, Madden and Scholefield (1993) is given by:

$$\begin{bmatrix} I-A & -h_c^e & -h_c^u \\ -h^a & 1 & 0 \\ s.l & 0 & 1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_h \\ s \cdot u \end{bmatrix} = \begin{bmatrix} d_1 \\ d_h \\ sT \end{bmatrix} \qquad (3.3)$$

where;

x_1 is industrial gross output,

x_h is total income of employed workers,

h_c^e is the consumption propensity vector of employed workers,

h_c^u is the consumption propensity vector of unemployed workers,

h^a is the income coefficient vector of employer workers,

l is the vector of labour demand coefficients,

T is the total number of workers,

s is the welfare benefit payable to a single unemployed worker,

u is the number of unemployed workers.

The equations here are:

$$(I - A)x_1 - h_c^e \cdot x_h - h_c^u \cdot s \cdot u = d_1$$

$$-h^a x_1 + x_h = d_h$$

$$l \cdot x_1 + u = T$$

In a Type IV model employed and unemployed workers can be divided into subgroups with different propensities to consume, for migrants and indigenous workers, or those in receipt of welfare benefits. For simplicity they have been considered as a group. The model can be used to calculate income multipliers, production multipliers and employment multipliers representing the effects of explicitly modelled demographic-economic interaction (Madden and Batey 1983).

3.3. A Dynamic Extended Input-Output Model

This section begins by considering the dynamic extended model, which was first formulated by Madden and Batey (1983). Secondly, the assumptions that underlie such dynamic models are discussed, and finally three dynamic extended input-output models are presented.

Madden and Batey developed a (quasi-) dynamic extended input-output model in the following form:

$$(I - A - B)x_t + B\,x_{t-1} - h_c x_{ht} = d_t$$

where,

B is a matrix of capital coefficients, representing stocks of industries used per unit of output of industry,

t is a time subscript,

h_c is a vector of consumption propensities, and

x_h is the total household income.

Matrix B is introduced as part of the modelling system, but there is no discussion of it, apart from an outline of the problems in dealing with a dynamic model at the regional level such as: the lack of availability of data on capital stock measures, relationships of capacity to output, the definition of capacity, and so on. They also emphasize that changes in demographic variables will have to be obtained by estimation.

3.3.1. Assumptions of the Dynamic Extended Models

Despite the efforts to make static extended models more realistic a number of problems remain, some of which are best dealt with by dynamising the extended model.

First, in the static extended input-output model it is implicitly assumed that households consume all of their income, or it is assumed that households consume a proportion (average or marginal propensity to consume) of their income. The rest of what they earn is not modelled, in particular savings. An exception to this is the model developed by Stone and Weale (1986) who have described a model with saving and investment but these are considered as exogenous variables. In the model, which is presented next, saving is modelled as an endogenous variable.

Second, a distinguish has been made between durable and non-durable goods.

Third, in the static version of extended input-output model each industry is assumed to sell all of its products with nothing remaining. Clearly a producer needs to have raw materials and intermediate goods at least a few months before they would be used in the production process. Of course not all of an industry's production is sold immediately, so some of the finished goods, intermediate goods and raw materials remain for the next period of the production process. If the stock of industries is assumed to be included in the capital formation, should the changes in stock be treated as endogenous or exogenous? If it is exogenous it should be seen as a part of final demand, although this depends on the output level which means it could be endogenous.

Finally, in the static extended input-output model investment is exogenous, is a part of final demand and is regarded as capital formation. From an economic point of view investment is a function of the output, and so it could be introduced as an endogenous variable in the dynamic extended input-output model.

Two types of dynamic extended model will now be introduced, corresponding to two of the static type II and type IV models presented in Section 3.2. More discussion can be made on the associated assumptions about these models. We assumed that households do not spend their incomes completely and save part of it in interest-bearing savings accounts or invest in industries by purchasing shares or bonds. As a result their income includes wages or salaries from employment and income from investment, both of which have been modelled. Income from employment is represented inside the transaction matrix and their investment income could be incorporated within the intersectoral capital coefficients matrix which forms part of the dynamic input-output model. This means that the transactions matrix and the capital coefficients matrix will need to have the same dimensions. Another assumption refers to the type of goods that households buy, namely durable and non-durable goods. Non-durable goods are treated as inputs for households and so are placed inside the transaction matrix. Durable goods, on the other hand, are treated as household investments which have long service lives and are therefore located within the intersectoral capital coefficient matrix. The first of the two dynamic extended models corresponds to the Type II static model:

$$\begin{bmatrix} I-A & -h_c \\ -h_r & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_h \end{bmatrix}-\begin{bmatrix} B & h_d \\ h_s & 0 \end{bmatrix}\begin{bmatrix} \Delta x_1 \\ \Delta x_h \end{bmatrix}=\begin{bmatrix} f_1 \\ f_h \end{bmatrix} \qquad (3.4)$$

where,

B is the inter-sectoral capital coefficients matrix in the conventional dynamic input- output model,

h_d is a column vector of propensities of household investment,

h_s is a row vector of saving output ratios,

Δx_1 is a column vector of output growth,

Δx_h is a scalar of household income growth due to output growth,

f_1 is a column vector of final demands that the household consumption and capital formation are extracted,

f_h is a scalar of exogenous incomes received by workers.

The equations here are:

$$(I - A)x_1 - h_c x_h - B\Delta x_1 - h_d \Delta x_h = f_1$$
$$-h_r x_1 + x_h - h_s \Delta x_1 = f_h$$

The first of these equations is the Leontief formulation where,

$h_c x_h$ is household consumption,

$B\Delta x_1$ is industrial investment, and

$h_d \Delta x_h$ is household investment.

The second equation sets the income level,

$h_r x_1$ is income from employment, and

$h_s \Delta x_1$ is saving by workers.

More disaggregation can be provided in relation to household savings by distinguishing between indigenous household, in-migrant household and unemployment household savings.

The second dynamic extended model, corresponding to the Type IV static model with two household groups i.e. employment and unemployment groups, provides a suitable vehicle for incorporating these features:

$$\begin{bmatrix} I-A & -h_c^e & -h_c^u \\ -h^a & 1 & 0 \\ sl & 0 & 1 \end{bmatrix}\begin{bmatrix} x_1 \\ x_h \\ su \end{bmatrix} - \begin{bmatrix} B & h_d^e & h_d^u \\ h_s^e & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}\begin{bmatrix} \Delta x_1 \\ \Delta x_h \\ \Delta s.u \end{bmatrix} = \begin{bmatrix} f_1 \\ f_h \\ s.T \end{bmatrix} \qquad (3.5)$$

where

h_d^e is a column vector of savings output ratios for employed households,

h_d^u is a column vector of savings output ratios for unemployed households,

$\Delta s.u$ is the level of benefit change.

In this case the equations are:

$$(I-A)x_1 - h_c^e \cdot x_h - h_c^u \cdot s \cdot u - B\Delta x_1 - h_d^e \Delta x_h - h_d^u \Delta s.u = f_1$$

$$-h^a x_1 + x_h - h_s^e \Delta x_1 = f_h$$

$$l \cdot x_1 + u = T$$

where

$h_c^e x_h$ is employed household consumption,

$h_c^u .s.u$ is unemployed household consumption,

$B\Delta x_1$ is investment by industries,

$h_d^e \Delta x_h$ is investment by employed households,

$h_d^u \Delta s.u$ is investment by unemployed households,

$h_s^e \Delta x_h$ is saving by employed households.

As we can see in the dynamic extended models (3.4) and (3.5) the extended capital matrix has two additional rows and columns, vectors which relate to the treatment of employed and unemployed households in the same manner as other industries. These additional column vectors are due to distinction made between durable and non-durable goods for household consumption in the dynamic extended models. Non-durable goods are the goods that are used up or consumed soon after they are bought, such as food, drink and tobacco, most clothes, household cleaning materials, newspapers and magazines, and energy products. Non-durable goods are examined as current inputs for household sectors, whereas, durable goods are goods that are intended to be used over a period of time, such as dwellings, furniture and floor covering, household appliances such as cookers, refrigerators, washing machine, motor cars, pedal cycles, radios and television sets. Durable goods are considered as a type of investment for household similar to working capital for industries, because when households buy a specific durable good in one period is not necessary to buy the same good in the future until it is scrapped and it works like capital for households.

In the dynamic extended type IV model we distinguish between employed and unemployed household investment. Additional row vectors enable the distinction to be made between household income from employment i.e. wage and employment household savings. For unemployed households it is assumed that they do not have savings.

When this model is put into operation the definition of variables becomes more meaningful. Data requirements for operationalizing dynamic extended models will be discussed in the empirical part of this thesis. Once a physical (quantity model) input-output is developed, the ground is prepared to develop its dual too i.e. a price model can be developed. This will be the subject of the next chapter.

3.4. Conclusions

Static extended input-output models are notably broader in scope than conventional input-output models, and typically include the study of household income and consumption and the interactions among a number of variables: income distribution, migration, labour force participation, employment and unemployment, and industrial output. Dynamic extended input-output models are also wider in scope than conventional dynamic input-output models, since they include the study of household saving, profit and industrial investment.

Dynamic extended input-output analysis has many benefits. One of its principal advantages lies in the calculation of more realistic impact multipliers and forecasts. A wide variety of economic and demographic-economic multipliers may be derived. With regard to the dynamic extended model, it would be interesting to compare the multipliers with their equivalents derived from the static model. Some evidence of how multipliers derived from a dynamic model compare with those from a static model is provided by Gowdy and Miller (1994). Unfortunately we have not yet any experience of the dynamic extended model, but in theory we know that when a new endogenous variable is incorporated in the model, the changes in multipliers are broadly predictable, but the precise magnitude of the changes will depend on the nature of the variable. In the dynamic extended type II and IV models, industrial investment has positive effects on the size of the multipliers but household saving represents the opposite of consumption and has negative effects. We can speculate about the relative size of multipliers, drawing upon earlier empirical work, which compared static extended models. Batey and Weeks (1989), using an extended model of the Greater Cork region, observed the relationship between the size of employment obtained from Type I, Type II and Type IV models. We can expand the comparison to include the dynamic versions of the extended model, taking into account the nature of the changes that have been made. The multipliers of the dynamic model for Types I, II and IV are larger than corresponding static models. It is predictable that although the differences between multipliers of dynamic extended Type I and Type II will be greater, those between Types II and IV will not be significant, because unemployed households generally not only spend all of their income, so their saving are most likely to be zero, but also, a small proportion of their income is used for durable goods.

One the most useful applications of the input-output model is in forecasting and planning. The new models enable us to estimate the industrial investment and household saving resulting from the adoption of different economic policies in the short term and alternative economic development plans in the long term. These models also have potential applications at the national and regional levels of the economy, although data availability at regional level regarding the different types of goods (durable and non-durable) on industrial or sectoral household consumption may limit the scope for model-building.

CHAPTER FOUR: INPUT-OUTPUT PRICE THEORY

4.1. Introduction

Over a period of more than sixty years economists have tried to establish price IO theory and its applications in static and dynamic analyses. The first version of Leontief's physical model was not associated with an explicit theory of price (Leontief 1937). Two empirical studies of the interdependencies of prices within an interindustry framework were conducted by Leontief (1937 and 1947). His fruitful approach provided a foundation and prompted further development of versions of the price model in a number of studies for example: Samuelson (1951), Koopmans (1951), Arrow (1951), Solow (1959), Morishima (1958), Sekerka, *et al.* (1970), Johansen (1978), Seton (1981), Duchin (1986, 1988 and 1992), Kurz and Salvadori (1994), and Raa (1995).

The main discussion of the IO Price model is based on a series of assumptions. These assumptions are more restrictive than in the quantity model, because they include not only all the assumptions of the quantity model but also further assumptions such as; uniformity of profit rate (or interest rate), wage rates, inelastic demand function, perfect elasticity of supply and perfect competition. One area of discussion related to these assumptions is about the non-substitution theorem and has featured in many studies:

Samuelson (1951), Koopmans (1951), Arrow (1951), Solow (1959), and Morishima (1958). The most general proof of this theorem was provided by Kurz and Salvadori (1994).

The price formation model was discussed in the literature on centrally planned economies, in which Marx with the theory of labour values is the first. His model has been developed and called two- and three- channel price models where channel refers to the number of accounts for income components (Sekerka *et al.* 1970).

The aim of this chapter is to outline a systematic theoretical framework for the static and dynamic IO price theories and their applications. The basic assumptions of the IO price framework and their consequences will be discussed. Moreover, the main aim of this chapter is to present some preliminary thoughts on the dual of the extended dynamic quantity models that were introduced and discussed in chapter three. For this purpose the starting point will be extended quantity models in which households are treated as a sector. For their dual a vector of prices will be obtained in which both the output (production) price and wage will be taken account. For the other model a distinction is made between employed and unemployed household production prices.

For above purposes the chapter is organized as follows: first, the structure of Leontief's traditional demand-driven price model and its alternative, Ghosh's supply-driven model, will be discussed. Secondly, the dynamic price model as a dual of conventional dynamic IO quantity model will be illustrated. Thirdly, the applications of the static and dynamic price models will be explored. Moreover, the extended dynamic models will be introduced and their application will be elaborated upon. Finally, conclusions will be drawn.

4.2. Static Input-Output Price Theory

4.2.1. Demand-Driven Price Theory

Attempting to establish an input-output price theory is a difficult task. So far the IO price model, as the dual version of the quantity IO model, has received less attention in the literature. The first version of the Leontief IO physical model was not associated with an explicit theory of prices. The first empirical study of the determinants and interdependences of prices within an interindustry framework was made by Leontief (1937). In this study he was interested in the interdependence of prices within an interindustry framework and therefore he used a 10-sector IO table of the US economy for 1919 to estimate the sectoral price changes due to an increase in sectoral productivity. The second Leontief study in this chain is an empirical study and may be traced back to his work in 1947 (Leontief 1947, reprinted in 1986), in which he estimated the price impact of a ten percent wage rise and of a ten percent rise in business where changes in taxes were ruled out; he labelled this model the "Cost-Price Structure" formulation (Leontief 1986, page 56). Afterwards this model was called the Leontief price model. This model is defined as a set of simultaneous linear equations in which the price each productive sector of the economy receives per unit of its output must be equal to the total costs incurred in the course of its production. These costs comprise not only payments for inputs purchased from the same and from the other industries but also the value added, which essentially represents payments made to the exogenous sectors. For each sector, each equation describes the balance between the price received and payment made by each endogenous sector per unit of its product. These usually comprise wages, interest on capital and entrepreneurial revenues credited to households, taxes paid to the government, and other final demand sectors (Leontief 1985). The simple Leontief price model is expressed as follows:

$$P = A'P + V \qquad (4.1)$$

where:

P is the column vector of commodity prices,

V is the column vector of value added per unit,

A' is the transpose of the technical input coefficients A.

In the classical IO analysis, the price model is introduced as the dual of the quantity system. In the quantities system, the structure of final demand is exogenous. In the price system, value added (in monetary terms) by physical units of output is given. Assuming that each producer retains a profit margin as well as the replacement cost of capital goods in the production process, so value added can be broken down into wages, profit, and replacement cost. Such a price model is based not only on the same severe, standard assumptions of the quantity version, but also on some heavy additional assumptions that are specific to the price version. The IO model draws its assumptions from both the microeconomic level (production and demand functions) and from the macroeconomic level (exogeneity of demand and aggregate equilibrium), which can be summarized as follows:

- The price version, just like the quantity version, assumes fixed input coefficients. Substitution among inputs is ruled out in the short term. It is only in the long term that technical changes and variations in relative prices cause the structure of the coefficients to alter.
- In the open IO quantity model it is assumed that final demand is exogenous, value added is the corresponding final demand; in the price model it is also assumed to be exogenous.
- If the price of each good is defined by the average cost; as the weighted average of the prices for the intermediate and primary inputs regardless of the profit hence, perfect competition will be assumed implicitly. The equilibrium prices, in a competitive economy, are determined by a system of simultaneous equations expressing the fact that the prices of goods are equal to their unit costs. The unit cost for each good is independent of the scale of production if the production functions are homogenous of degree one, and all the production coefficients remain constant in this condition, all industries produce until their marginal profits become zero (Samuelson 1951, Arrow 1951, Georgescu-Roegen 1951, Koopmans 1951). So far, this is the main concept in an IO price theory.
- The uniformity of the cost of inputs such as wage rates, interest rates, profit rates, is assumed. For example, Mathur (1970) assumed that a uniform interest rate for all sectors, an identical wage rate, and zero residual profit rate.

- The essence of the IO price model lies in the additional assumptions regarding the causal relationships between the input prices. The primary input prices are assumed to be exogenous, whereas the single, homogenous outputs are determined by the solution of the model (Oosterhaven 1996).
- All demand functions for goods are inelastic with respect to prices, and the supply functions of primary factors are perfectly elastic even in the short-term (Moses 1974).

Leontief developed another IO price model and called it: "a refined version of the basic input-output price model" (Leontief 1986, page 392) to analyze the new wave of technological change in the US economy. In this model he specifies the requisite amounts of current inputs such as intermediate and capital goods that are required. The relationship between value added (wage rates), the rate of return on capital, and the price of different goods and services takes on the following form (Leontief 1947, reprinted in 1986):

$$P = A'P + rB'P + lw \qquad (4.2)$$

where;

A is the technical coefficient matrix, each element describing the amount of input required to produce one unit of output sector,

B is a matrix of capital coefficients, each element describing the stock of goods sector that has to be employed per unit of output sector,

l is a vector of labour coefficients, each element describing the amount of labour services that have to be employed to produce one unit of the output sector,

P is a vector of output sector prices,

r is the scalar of long-run rate of return on capital,

w is a matrix of wage rates by labour type employed by sector.

This is a system of n equations showing the relationship between the prices of different goods. The variables in these equations can be shown in a compact matrix notation as below:

$$A=\begin{bmatrix} a_{11} & \cdot & \cdot & a_{1n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ a_{n1} & \cdot & \cdot & a_{nn} \end{bmatrix} \quad B=\begin{bmatrix} b_{11} & \cdot & \cdot & b_{1n} \\ \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot \\ b_{n1} & \cdot & \cdot & b_{nn} \end{bmatrix} \quad r=\begin{bmatrix} r & \cdot & \cdot & \cdot \\ \cdot & r & \cdot & \cdot \\ \cdot & \cdot & r & \cdot \\ \cdot & \cdot & \cdot & r \end{bmatrix} \quad P=\begin{bmatrix} p_1 \\ \cdot \\ \cdot \\ p_n \end{bmatrix} \quad \overline{W}=\begin{bmatrix} W_1 \\ W_j \\ \cdot \\ W_n \end{bmatrix}$$

where $W_1=\sum_{i=1}^{m} l_{ij}w_{ij}$, $i,j=1,2,\ldots,n$

m = the number of worker types.

Solving equation (4.2) for the price vector, then price vector P dependent on the price of inputs, the rate of return on capital and the money wage paid for various types of labour in different industries. This can be shown as follows:

$$P=(I-A'-rB')^{-1}lw$$

or

$$P=(I-A'-rB')^{-1}\overline{W} \qquad (4.3).$$

The economic interpretation of the price model (4.3) is simple. An increase in any type of wage rate must lead to an increase in some, and more likely all prices if all elements of the inverse matrix are positive. Moreover, if r is kept constant and all wage rates are multiplied by the same positive factor, then all prices will change proportionally, and as a result the real wage and total real return on investment will remain constant. With the given money wage rates and fixed technology, the price depends on the rate of return on capital, and any increase in the rate of return on capital must be accompanied by an increase in prices (Leontief 1985). The size of the direct effect of wage rate change on endogenous price (P) is determined first by the fixed primary output coefficients. Next, the price of intermediate input rises as the firm compensates for the unit cost increases in output prices. The subsequent endogenous increases in intermediate input prices again cause output prices to rise, and the cumulative effect of this cost-push process is described by the Leontief-inverse in (4.3).

When the output price rises then the demand for the good will reduce, the extent of the reduction depends on its own-price elasticity which will govern the amount of reduction in its demand, and also relates to the cross-price elasticity which describes the impact of the price change of this good on the demand for other goods. These concepts have been widely discussed in the substitution theorem since 1951 by many authors on IO price theory. The substitution theorem was originally proved by Samuelson (1951), and Arrow (1951), Koopman (1951), and Georgescu-Roegen (1951). It demonstrates that, in a pure competitive economy, a set of equilibrium prices is uniquely determined by a system of simultaneous equations that describes the prices of goods are equal to their unit costs. This unit of cost is independent of the scale of production under the assumption of constant returns to scale of production function. Consequently, no variation in the composition of output takes place as a result of the price change, so that under pure competition the input coefficients, and hence the relative prices, will stay fixed. This means that interdependency between the quantity of demand and the price changes is ruled out. The non-substitution theorem using differentiable production functions was proved by Solow (1951) and Morishima (1958), meanwhile Koopman (1951), Arrow (1951), and Georgescu-Rogen (1951) repeated Samuelson's assumptions and results but within the more general framework of activity analysis. Morishima (1958, page 358) believes that "the substitution theorem assumes that competition between industries eliminates profits, but the original Leontief theory does not adopt such a long-run static view", and he (Morishima) arrived at the non-substitution theory. In pure competition when the price of goods are equal to their unit costs, the profits are eliminated or considered to be zero for all sectors. Morishima (1958, page 360) distinguishes between interest rate and profit rate, and "weak and strong competition". He posited that when "weak competition" prevails, entrepreneurs switch from one line of production to another and establish a uniform rate of profit. Under weak competition, the price IO model includes three distributive variables (the rate of interest, the profit rate and wages), given that two of these three variables are known, then a set of prices and the third variable can be determined without being affected by demand. On the other hand, when strong competition prevails, the positive profit rate lets other firms enter the market which allows the input prices to rise and the output price to decrease until reaching zero profits. This is called the long-run equilibrium price. In both classifications, the non-substitution theorem is satisfied. Furthermore Raa (1995) proved the substitution theorem for the case that some activities do not require a labour input. The most general proof of the non-substitution theorem with respect to the labour inputs was introduced by Kurz and Salvadori (1994).

Price determination appeared initially in the literature of the central planned economies with the labour value theory of Marx as its starting point, and was later developed as comprehensive multi-channel prices by Sekerka *et al* (1970). They identified a price vector which guarantees the non-dependence on the quantity produced of certain fundamental relationships between the magnitudes of the system, and three income components: the first is the intermediate goods to income ratios, the second is the capital income ratio, and the third is the wages to income ratio. Different types of price model were derived from Sekerka et al's price model by assuming one or two of the three ratios is equal to zero. In the next section we discuss another version of input-output price model, i.e. supply driven model.

4.2.2. Supply-Driven Input-Output Price Model

The price version of the supply-driven IO model is based on the accounting identity for total input rather than that for total output. It is formulated by Oosterhaven (1996) as follows:

$$P_s = A_s P_s + V_s P_f$$

where

P_s is the vector of prices for total sectoral input,

A_s is the matrix of fixed intermediate output coefficients,

V_s is the matrix of fixed final output coefficients,

P_f is the vector of prices for final output per category.

P here relates to the price for each sector's single homogenous *input*, in contrast to the Leontief price theory which refers to the price for a sector's single homogenous *output*. This model gives unit revenues per sector, and under perfect competition equals the price of each sector's single input. The sum of the output weights per industry is equal to one. The direction of causality runs opposite to that of the Leontief price model. The single price for each column with final output is assumed to be exogenous, whereas the prices for primary inputs are now endogenous. The endogenous price of total (intermediate and primary) input per sector can be calculated by:

$$P_s = (I - A_S)^{-1} V_s P_y$$

The economic interpretation of the supply-driven model is described as the cumulative effects of changes in final output prices on the prices of primary inputs such as labour and the use of capital. In this interpretation, the direct effect of an exogenous change in the price of a final output on unit revenues per sector is given by the importance of that category of final output for that sector, as value added in the demand-driven model. Under perfect competition, any change in unit revenues is entirely passed on to the price for the single homogenous input. Hence, when the price of total input per sector increases, the prices of all intermediate inputs must also increase, not row-wise as in the demand-driven model but column-wise. Although Oosterhaven initiated the supply-driven price model, he has finally established that: in principle, the causality and the assumptions involved in the supply-driven price model are as implausible as those of the quantity version and all sectors set their input prices independently, passing any increase in revenue from rising output prices on to their suppliers, who do not react either. As a result, the demand-driven price model may not be entirely plausible, but the supply-driven model is much less plausible and the contrast between them, however, is not as large as that between two quantity models because of the independence of the quantity and the price models (Oosterhaven 1996). Dietzenbacher (1997), in a vindication of the supply-driven price model, has shown that the supply-driven IO model yields the same result as the Leontief price model. He also mentioned that it has small advantages (in terms of required information and the number of computational steps) over the Leontief IO price model. The potential use of the supply-driven price model lies in the simulation of demand-driven inflationary processes as opposed to the demand-driven price Leontief model.

4.3. Dynamic Price Model

The first version of the dynamic price model, in which the sales of each industry must just cover its current costs plus the *full* cost of required new capital goods was formulated by Hawkins in 1948. Leontief himself ignored the dynamic price theory in the first published version of his dynamic quantity theory (Leontief 1953). According to the first definition of the dynamic price theory as spelled out by Georgescu-Roegen (1951): the price of each commodity must cover its current costs plus interest on the value of the capital equipment required per unit of output, Solow (1959) referred to it as Roegen's doctrine and felt it was more reasonable than Hawkin's model. The result was a system of price and quantity variables for both the open and the closed economy under the assumption of fixed technical coefficients and full utilization and transferability of capital goods from one sector to another sector. Briefly, in the history of literature on dynamic IO price model, three main ideas exist:

First, it is assumed that entrepreneurs always expect prices to remain constant. The model is made to answer this question: what set of constant prices can be made to endure? It is associated with no change in price or technology, and based on the unit costs, so it is called long-run competitive equilibrium price; this price model is the dual of the Leontief dynamic quantity open model (Solow 1959, Mathur 1977[1], and Leontief 1985).

$$P = A'P + rB'P + w.l$$

This model is the same as model 4.2, in terms of the formulation and definition of the variables. We call it the dynamic price model type I-D.

$$P = (I - A' - rB')^{-1} w.l \qquad \text{(type I-D)}$$

Thus, in the type I-D the price equals the unit costs of production given by values of current inputs and by the interest rate on the value of fixed capital, and it is assumed only value added contains wages. The closed model of type I-D is;

$$P = A'P + rB'P$$

Type I-D model raised several objections, such as; without the implicit assumption of foresight and static price expectations by entrepreneurs, the stationary equilibrium of this

[1] Mathur distinguished between working capital and fixed capital and their returns. Returns on working capital are governed by the prevailing interest rate, while returns on the fixed capitals are the profit rates.

system would almost certainly be unstable if the initial prices and interest rate were not the equilibrium ones (Filippini 1983). Further work was carried out by Solow (1959) and Morishima (1964) to let prices change or be expected to change.

Secondly, if one starts with this presumption that prices might have been changing over time, (no technological change has taken place yet), the price model should be different, by assuming perfect foresight and logical consistency of price movements by the entrepreneur maximizing the sum of profits and capital gains or minimizing losses, one may derive the new set of price equations (Morishima 1958, Solow 1959, Duchin 1988);

$$P_{t+1} = A' P_{t+1} + rB' P_t + B'(P_t - P_{t+1})$$

If solved for P_{t+1},

$$(I - A + B)' P_{t+1} = (I + r)B' P_t$$

They have shown that prices are equal to production costs plus capital losses or gains due to any changes in price by introducing the $B'(P_t - P_{t+1})$ term in the model.

Note that if we put $P_{t+1} = P_t$, this system of difference equations reduces to the first price linear equation type I-D.

Thirdly, in the third type, factor prices and technological changes are permitted and represent three cost components corresponding to inputs including current inputs, labour and capital. According to this model, prices depend on the technical coefficients, factor prices and rates of return on capital. Capital cost is represented by two components; first, the cost of replacement capacity by the concept of depreciation and second, profit rate defined as a rate of return or cost of borrowing money to the value of the capital stock. The third model allows the possibility of representing a third component of actual capital earnings: value changes of the physical assets in place due to changes in relative prices and in technology (Johansen 1978, Duchin 1986,1988, 1992, 1995). The Johansen model is a price model based on the cost-benefit analysis with different construction periods and finite lifetime of capital equipment. He implied that the present value of future revenue achieved by establishing a piece of production capacity in a sector should be unbalanced. He pointed out that if we consider a piece of production capacity through its history, it will begin to increase the value from the first investment, then it will reach the maximum value when it is ready to be used and from then on decline in value towards the expiration of its life-time (Johansen 1978), so that to establish a capacity of one unit in each sector we must invent an amount $B(t-1)'P(t-1)$ one period earlier, an amount $B(t-2)'P(t-1)$ two periods in advance, etc. The value of this stream of investment outlays calculated at the time when the capacity is completed, will be;

$$\sum_{\theta=1}^{\tau} B(t-\theta)'P(t-\theta)(1+r)^{\theta}.$$

He determined that the value of r (interest rate), is the same as the growth rate in the dynamic IO quantity model. He pointed out that this equality represents the fact that the rate of interest is equal to the rate at which capital is able to grow if all outputs are ploughed back as productive inputs. Duchin developed Johansen's price model that is associated with her dynamic physical model. Duchin's model includes sectoral prices as the sums of the costs corresponding inputs, labour and capital i.e. input prices, wages and rates of return on capital (Duchin 1992). The rates of return formed two parts: rates of depreciation and return of the value of the capital stock. She assumed that if the initial conditions exist; *P(t-1), P(t-2), P(t-3),* then the price model for one unit of output is:

$$P_t = A' P_t + R_t' P_t + w'l + (I + r_t)\sum_{\theta=1}^{\tau} B^{\theta}(t-\theta)'P(t-\theta) - \sum_{\theta=1}^{\tau} B^{\theta}(t+1-\theta)'P(t+1-\theta)$$

where,

τ = number of periods lag between delivery of a capital good and its use in production,

$R_t' P_t$ = cost of capital replacement, often approximated by the concept of depreciation,

$r(t) \sum_{\theta=1}^{\tau} B^{\theta} (t-\theta)'P(t-\theta)$ = return on capital (cost of borrowing money), which defined as

profit,

$\sum_{\theta=1}^{\tau} \left[B^{\theta}(t-\theta)'P(t-\theta) - B^{\theta}(t+1-\theta)'P(t+1-\theta)\right]$ = revaluation of the capital stock.

The revaluation of the capital shows the actual capital earning, i.e. the changing value of the physical assets in place, due to changes in relative prices and in technology. When the value of stock is rising, due to one or both reasons, then this term represents an income for the owner of capital that will be reflected in a compensating increase in the price of borrowed money. The sign of this term turns out to be negative because of the appreciation of the capital stock. She believes that by introducing the last variable this dynamic price model is able to represent the component of actual earnings.

In Duchin and Lange's price model, government income (received tax) has been neglected. As we know, a part of the price is tax. Indirect tax is not paid by the taxpayer direct to the government, but is collected by suppliers, shopkeepers, stores, etc., and transferred to the final users who have to pay it as a part of the prices of commodities. So by considering the indirect tax rate, the price model third type can be rewritten as follows:

$$P_t = A' P_t + R_t' P_t + S' P_t + W' \cdot L + (I + r_t)\sum_{\theta=1}^{\tau} B^{\theta}(t-\theta)' P(t-\theta) - \sum_{\theta=1}^{\tau} B^{\theta}(t+1-\theta)' P(t+1-\theta)$$

where S is the vector of per unit net indirect taxes. As in the price model, the price of each good is one dollar's worth, so S is the indirect tax rate.

4.4. The Extended Input-Output Price Models

The dual price model for extended input-output quantity models, which were discussed more fully in chapter three, can be introduced by considering an endogenous price of households product as well as industry production prices. Price vector development for the extended dynamic price type II (type II-D) model, $\overline{P}$, includes production prices and the price of household products that is expressed by person years of work for employed household and is defined by the wage payment for person years of work and is shown by W. The price vector that can be associated with type II-D model is a $(n+1)$-element column vector in which n elements, are the prices of sector goods (output prices) and $(n+1)$th element is the price of household production, i.e. wage. So, $\overline{P}$ can be written;

$$\overline{P} = \begin{bmatrix} P \\ W \end{bmatrix}$$

and the price model which is associated with the extended dynamic quantity type II model, should be written as:

$$\begin{bmatrix} P \\ W \end{bmatrix} = \begin{bmatrix} A & h_c \\ h_r & 0 \end{bmatrix}' \begin{bmatrix} P \\ W \end{bmatrix} + \begin{bmatrix} r & 0 \\ 0 & r_h \end{bmatrix} \begin{bmatrix} B & h_d \\ h_s & 0 \end{bmatrix}' \begin{bmatrix} P \\ W \end{bmatrix} + \begin{bmatrix} (OVA) \\ (OPH) \end{bmatrix}$$

where,

r is the rate of return on capital,

r_h is the profit rate on household investment,

W is the price of household sector,

(OVA) is other value added such as; non-distributed profit, tax and depreciation paid by industries,

(OPH) is other sources of payment by households such as rent, insurance and income tax.

The reduced form of the extended dynamic price (type II-D) model, is introduced by an equation such as:

$$\overline{P} = \overline{A}'\overline{P} + \overline{r}\overline{B}'\overline{P} + OVA$$

in which,

$$\overline{A} = \begin{bmatrix} A & h_c \\ h_r & 0 \end{bmatrix}, \ \overline{B} = \begin{bmatrix} B & h_d \\ h_s & 0 \end{bmatrix} \text{ and } \ \overline{r} = \begin{bmatrix} r & 0 \\ 0 & r_h \end{bmatrix}$$

Now we turn to a simple example of an economy with two industries and write input, capital and rate of return on capital matrices. For this aim we keep our discussion at a general level and ignore the type of goods they produce: input, durable, non-durable or capital goods. For an economy with two sectors, the input and capital coefficients matrices A and B , the rate of return on capital matrix, r and the price vector, P can be written as follows:

$$A=\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, \quad B=\begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix}, \quad r=\begin{bmatrix} r & 0 \\ 0 & r \end{bmatrix}, \quad P=\begin{bmatrix} P_1 \\ P_2 \end{bmatrix}.$$

Their corresponding extended input, capital and return on capital matrices for type II-D model are;

$$\overline{A}=\begin{bmatrix} a_{11} & a_{12} & h_c^1 \\ a_{21} & a_{22} & h_c^2 \\ h_1^a & h_2^a & 0 \end{bmatrix}, \quad \overline{B}=\begin{bmatrix} b_{11} & b_{12} & h_d^1 \\ b_{21} & b_{22} & h_d^2 \\ h_s^1 & h_s^2 & 0 \end{bmatrix}, \quad \overline{r}=\begin{bmatrix} r & 0 & 0 \\ 0 & r & 0 \\ 0 & 0 & h_h \end{bmatrix}, \quad \overline{P}=\begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix}.$$

If we write the type II-D price model in expanded matrix form, we would have:

$$\begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix}=\begin{bmatrix} a_{11} & a_{12} & h_c^1 \\ a_{21} & a_{22} & h_c^2 \\ h_1^a & h_2^a & 0 \end{bmatrix}'\begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix}+\begin{bmatrix} r & 0 & 0 \\ 0 & r & 0 \\ 0 & 0 & r_h \end{bmatrix}\begin{bmatrix} b_{11} & b_{12} & h_d^1 \\ b_{21} & b_{22} & h_d^2 \\ h_s^1 & h_s^2 & 0 \end{bmatrix}'\begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix}+\begin{bmatrix} (OVA)_1 \\ (OVA)_2 \\ (OPH)_h \end{bmatrix}$$

taking account of the transpose, then we have:

$$\begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix}=\begin{bmatrix} a_{11} & a_{21} & h_1^a \\ a_{12} & a_{22} & h_2^a \\ h_c^1 & h_c^2 & 0 \end{bmatrix}\begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix}+\begin{bmatrix} r & 0 & 0 \\ 0 & r & 0 \\ 0 & 0 & r_h \end{bmatrix}\begin{bmatrix} b_{11} & b_{21} & h_s^1 \\ b_{12} & b_{22} & h_s^2 \\ h_d^1 & h_d^2 & 0 \end{bmatrix}\begin{bmatrix} P_1 \\ P_2 \\ W \end{bmatrix}+\begin{bmatrix} (OVA)_1 \\ (OVA)_2 \\ (OPH)_h \end{bmatrix}$$

then the prices for two production (output) sectors and the household sector are determined as follows:

$$P_1 = a_{11}P_1 + a_{21}P_2 + h_1^a W + r b_{11} P_1 + r b_{21} P_2 + r h_s^1 W + (OVA)_1$$
$$P_2 = a_{12}P_1 + a_{22}P_2 + h_2^a W + r b_{12} P_1 + r b_{22} P_2 + r h_s^2 W + (OVA)_2$$

$$W = h_c^1 P_1 + h_c^2 P_2 + r_h h_d^1 P_1 + r_h h_d^2 P_2 + (OPH)_h$$

In the first equation the price of the good produced by sector one includes the following costs:

p_1, the price of output of industry one,

$a_{11} P_1$, the cost that the first industry should pay from its output to produce a unit of output,

$a_{21} P_2$, the cost that the first industry should pay to buy the second industry's output for producing a unit of output,

$h_1^a W$, the share of labour cost in producing a unit of output for the first industry,

$r b_{11} P_1$, the capital cost for industry one to buy capital goods of industry one,

$r b_{21} P_2$, the capital cost for industry two to buy capital goods of industry two,

$r h_s^1 W$, the cost of borrowing money from households to be used by industry one.

We also can define,

$h_s^1 W$ as the total household saving that household invested,

$a_{11} P_1 + a_{21} P_2 + h_1^a W$ as the total input costs of industry one for each unit of output,

$b_{11} P_1 + r b_{21} P_2 + r h_s^1 W$ as the total capital and investment costs of industry one for each unit of output,

$(OVA)_1$ as the other value added of industry one such as: rent and tax.

The second equation also has the same cost concepts as the first one for industry two. The third equation appears to be different and explains the price of the household sector,

W is the price of household production,

$h_c^1 P_1$ is the input cost of household for consuming the industry one good (non-durable),

$h_c^2 P_2$ is the input cost of household for consuming the industry two good (non-durable),

$r\, h_d^1 P_1$ is the capital cost of household for consuming the industry one goods (durable),

$r\, h_d^2 P_2$ is the capital cost of household for consuming the industry two goods (durable).

We can also summarize:

$h_c^1 P_1 + h_c^2 P_2$ is the total input cost of the household sector,

$r_h h_d^1 P_1 + r_h h_d^2 P_2$ is the total capital costs of the households.

$(OPH)_h$ is other payments such as tax and rent by the households.

In the type II-D model, if any elements of value added change, for example: a tax rate, rent, or distributed profit change, then not only industry prices will change but also the wage rate will be affected as a result of this change. This model can be used for impact analysis and it is to be expected that much more sensitive than type I-D, and the difference will probably be pronounced, because price change depends on wages and the cost of wages accounts for a high share of the price of goods.

$\overline{P}$ is the vector price which includes production prices and household wage and can be derived from the model while, other components such as social security payable to unemployed households, taxes to the government, subsidies, rents, and profits which are parts of production prices are determined to be exogenous and placed in the value added.

When households are taken into account in the price system, with the vector of household consumption as inputs, then the consequent changes in output price may lead to changes in labour demand and in the level of employment which are the most important input elements of production. So, there is a dependency between the share of social security payments and wages in the price determination. When the share of social security payment decrease as a result of decreasing the number of unemployed households, in contrast the share of wage payment increases (and vice versa). So there is an interrelationship between employed and unemployed households in price determination. By this is meant that if we consider employed households in the model, we may have to consider unemployed households in the same way. Otherwise, we will ignore the changes in the combination of elements that are important in price determination. In addition, the consistency of integrating demographic-economic modelling with an activity-commodity framework in an input-output analysis has been discussed widely by Madden and Batey (1980), Batey and Madden (1981).

Basically, in input-output price theory, the price vector is the vector of output prices. Industries produce and sell their physical production and employed households produce person years of work. In the case of unemployed households they do not take part in the production process and therefore their production has a zero element in the price vector. By introducing unemployed households endogenously, their impacts on the demand side and on the supply side are taken into account. The impression on the demand side by introducing their consumption on the transaction matrix. While on the supply side they do not play any significant role because of no production. Moreover, it is more reasonable that unemployed households who receive social security benefits should have negative sign in the value added. So even the price vector has one zero element, input and capital coefficients matrices includes inputs and capital goods consumption of unemployed households.

The price vector in the extended dynamic type IV model is $\widetilde{P}$ with a $(n+2)$-element vector, in which $(n+2)$-th element is zero and other elements have the same definition as the $\overline{P}$ price vector in the extended dynamic price type II model. This price model can be written as follows;

$$\begin{bmatrix} P \\ W \\ 0 \end{bmatrix} = \begin{bmatrix} A & h_c^e & h_c^u \\ h^a & 0 & 0 \\ -sl & 0 & 0 \end{bmatrix}' \begin{bmatrix} P \\ W \\ 0 \end{bmatrix} + \begin{bmatrix} r & 0 & 0 \\ 0 & r_h & 0 \\ 0 & 0 & r_h \end{bmatrix} \begin{bmatrix} B & h_d^e & h_d^u \\ h_s^e & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}' \begin{bmatrix} P \\ W \\ 0 \end{bmatrix} + \begin{bmatrix} (OVA) \\ (OPH)_e \\ -s \end{bmatrix}$$

The reduced form for extended dynamic price type IV (type IV-D) model is:

$$\widetilde{P} = \widetilde{A}'\widetilde{P} + \widetilde{r}\widetilde{B}'\widetilde{P} + (OVA)$$

in which matrices are as follows:

$$\widetilde{A} = \begin{bmatrix} A & h_c^e & h_c^u \\ h^a & 0 & 0 \\ -sl & 0 & 0 \end{bmatrix}, \quad \widetilde{B} = \begin{bmatrix} B & h_d^e & h_d^u \\ h_s^e & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \quad \widetilde{r} = \begin{bmatrix} r & 0 & 0 \\ 0 & r_h & 0 \\ 0 & 0 & r_h \end{bmatrix}, \quad \widetilde{P} = \begin{bmatrix} P \\ W \\ 0 \end{bmatrix}$$

In the same manner if we write the input, capital, return on capital, price and other value added in the very small economy of two industries and insert in the type IV-D model, and considering the transpose we obtain:

$$\begin{bmatrix} P_1 \\ P_2 \\ W \\ 0 \end{bmatrix} = \begin{bmatrix} a_{11} & a_{21} & h_1^a & -sl_1 \\ a_{12} & a_{22} & h_2^a & -sl_2 \\ h_c^{e1} & h_c^{e2} & 0 & 0 \\ h_c^{u1} & h_c^{u2} & 0 & 0 \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ W \\ 0 \end{bmatrix} + \begin{bmatrix} r & 0 & 0 & 0 \\ 0 & r & 0 & 0 \\ 0 & 0 & r_h & 0 \\ 0 & 0 & 0 & r_h \end{bmatrix} \begin{bmatrix} b_{11} & b_{21} & h_s^1 & 0 \\ b_{12} & b_{22} & h_s^2 & 0 \\ h_d^{e1} & h_d^{e2} & 0 & 0 \\ h_d^{u1} & h_d^{u1} & 0 & 0 \end{bmatrix} \begin{bmatrix} P_1 \\ P_2 \\ W \\ 0 \end{bmatrix} + \begin{bmatrix} (OVA)_1 \\ (OVA)_2 \\ (OPH)_e \\ -s \end{bmatrix}.$$

The equation prices for two industries and employed and unemployed households are as follows:

$$P_1 = a_{11}P_1 + a_{21}P_2 + h_1^a W + r b_{11} P_1 + r b_{21} P_2 + r h_s^1 W + (OVA)_1$$
$$P_2 = a_{12}P_1 + a_{22}P_2 + h_2^a W + r b_{12} P_1 + r b_{22} P_2 + r h_s^2 W + (OVA)_2$$
$$W = h_c^{e1} P_1 + h_c^{e2} P_2 + r_h h_d^{e1} P_1 + r_h h_d^{e2} P_2 + (OPH)_e$$
$$s = h_c^{u1} P_1 + h_c^{u2} P_2 + r_h h_d^{u1} P_1 + r_h h_d^{u2} P_2$$

The first three equations were explained earlier, and fourth equation includes new variables that are defined as follows,

$h_c^{u1} P_1$ is the input cost of unemployed household for consuming the first industry (non-durable) good,

$h_c^{u2} P_2$ is the input cost of unemployed household for consuming the second industry (non-durable) good,

$r_h h_d^{u1} P_1$ is the capital cost of unemployed household for consuming the first industry (durable) good,

$r_h h_d^{u2} P_2$ is the capital cost of unemployed household for consuming the second industry (durable) good,

s is the real level of social security payable to one unemployed household.

According to this equation, the real level of social security payment will be affected by any changes in output prices, the outputs that are consumed by unemployed households.

In other words this equation enables the changes in real level of social security payment to unemployed households due to change in production prices to be calculated.

We can also write;

$h_c^{u1} P_1 + h_c^{u2} P_2$ is the total input cost of an unemployed household,

$r_h h_d^{u1} P_1 + r_h h_d^{u2} P_2$ is the total cost of capital consumption for an unemployed household.

The type IV-D model is the dual version of the dynamic extended quantity model type IV-D (3.5) model, which was developed in chapter three. This price model can be a tool for investigating the impact of price change not only on the production prices but also on wages as well as real level of social security payments to unemployed households.

When we introduce the unemployed households in the model the price impacts will be affected by the both sides, the unemployed households consumption and their incomes. On the consumption side, unemployed households consumption propensities are more likely to be greater than those when they were employed. On the income side, as unemployed households receive less income than they did when they were employed, so the labour coefficients decrease. Final price impacts depend on the strength of each element and it is likely that the impact of decrease in income will be more than the increase in their consumption propensity and as a result the total impacts will decrease. In chapter nine we will test empirically the impacts by using two type II-D and type IV-D models and comparisons will be made.

4.5. Application of the Price Theory

The IO price model has been applied for a number of purposes, and a review of these applications is helpful to find out the potential uses of the model. The application includes open, closed, static and dynamic versions. The main applications examined are price impacts analyses of the following areas: on production prices (Leontief 1947, 1951), on protected industries (Aukrust 1970), energy price changes (Polenske 1978), price movement and structural change (Mathur 1977), distinction between commodity and input markets (Tsoulfidis 1990), on tax reform (Folloni and Miglierina 1994) , and on the technological changes (Duchin and Lange 1992). In what follows part we explain these applications very briefly.

The first application of the price model was by Leontief in 1951 to simulate cost-push inflationary processes. He started with primary input price increases (e.g. wages, capital cost, indirect taxes/subsidies or imports) via unit cost and intermediate input price increases, and he arrived at the output price increases (Leontief 1951). Leontief also used the static IO price model to show the national impacts on industrial prices of changes in wages and profit (Leontief 1947, 1985). Later on, Rasmussen (1956) developed a methodological extension of price analysis to the terms of trade among sectors of a national economy. Then, Sekerka *et al.* (1970) introduced different price systems, depending on three rates of return: on material cost, on fixed capital and wages, and they called it a three-channel price model. They computed these various price systems for a range of rates of return to the factors for the Czechoslovak economy for 1966 and showed how certain macro-economic variables vary with these price changes.

Another price model was applied by Aukrust (1970). Aukrust presented a model of price and income distribution mechanism of an open economy for Norway and his model introduced a distinction between the sheltered and exposed industries as a key feature. In his study the sheltered industries were defined as sectors that sell their outputs in the domestic market and are able to set their prices such that profits have a fixed ratio to costs. Exposed industries were subject to strong price competition and defined as industries that sell their products either abroad or in the domestic market under strong foreign competition. He pointed out that a general rise in wages and salaries would increase prices of all sheltered industries and reduce profits in exposed industries.

Years later Mathur (1977) presented another price model. He discussed the characteristics of the fix-price versus flex-price commodities, which came from Hicks' observation (Hicks 1965). Hicks observed that in modern (capitalist) economies there are, at least, two sorts of market, one where prices are set by producers; for those markets the fix-price assumption can be considered. But there are other markets, flex price or speculative markets, in which prices are still determined by supply and demand (Hicks 1965, page 23). Mathur pointed out that his study vindicated Hicks' insight. He developed a demand-based price of flex-price commodities with the determination of the IO based price structure for fixed-price commodities. He applied this price input-output model to analyse the observed price movements and structural changes in the British economy during the period 1963-1973 (Mathur 1977). Other research in this direction was presented by McGregor *et al.* (1995). They also introduced scarcity into a conventional demand-driven IO system and produced a flex-price Leontief model. In the latter model, the relative prices are allowed to change to reflect variations in the real wage.

Polenske (1978) applied the price model to energy analyses and the determination of multiregional prices. She put forward a theoretical general equilibrium framework which she used to trace both the regional and industrial results of changes in wages and prices, or demands in the energy industry as traced through changes in the cost of living for consumers.

Tsoulfidis (1990) used an IO price model to investigate the price effects of indirect and corporate income taxes on the U.S. economy. His efforts revealed the impacts of tax reform proposal on prices, workers' purchasing power, and international trade patterns. A strict deflation method on the hypothesis of two different markets (the industrial market of intermediate and investment goods; and the commercial market of final consumption goods), with two different mechanisms of price formation has been developed by Folloni and Miglierina. The theories of price formation and the method of deflation that is suggested by the two market hypothesis have been empirically tested in the case of Italy for the 1985-table (Folloni and Miglierina 1994).

Aulin-Ahmavaara (1991) proposed that the valuation of human capital and of human time as well as the valuation of the rest of the products could be based on the production prices as the balanced growth price vector of the closed dynamic IO model. Human capital, in this model is defined as every person who has finished his basic education, has formed a unit of simple human capital, human time being defined as any time use of human beings who have passed their basic education and have not retired. He augmented the proposed model with an additional production process for different types of human capital. Gestation periods, production periods as well as periods of retirement of variable length are taken into account. The main advantage of this model is that it lets the composite labour as well as determining the prices of commodities and human capital. Duchin and Lange (1992) developed a dynamic IO price model to examine the influence of technological change and changing factor prices in the US economy on prices and incomes between 1967 and 2000. Their results revealed that over the historical period, despite increasing capital intensity, the labour share of national income has been maintained. Duchin and Lange (1995) used a static optimization framework which was developed by Carter (1970) and revised by Leontief (1986) and Duchin (1988) for the US economy in two time periods with choice of cost minimizing techniques. McGregor *et al.* (1995) examined the impact of labour scarcity in the form of a less than infinitely elastic labour supply curve into an open conventional IO system and assumed the conditions generated a consumption-and investment-endogenous IO system. They investigated the consequence of the changes in wages on the income distribution by treating consumption and investment as endogenous variables. They provided a theoretical and simulation computational general equilibrium (CGE) analysis of systems. Their systems are necessarily characterized by sensitivity of prices to excess demands, and they are labelled flex-price Leontief models.

4.6. Some Comments on Input-Output Price Theory:

The mutual dependence of primary-factor and final-product prices is a fact. That the natural framework within which this dependence is arbitrated in the network of goods and service flows between providers of primary inputs, final users, and intermediate sectors of the economy is described in the standard input-output table due to Leontief input-output price theory. This theory can provide a framework to trace through economywide repercussions of changes in prices of exogenous inputs. Moreover, another fact can be said about the potential power of input-output price model, that can provide differential total impacts on various industries due to prices of exogenous inputs changes, because of the second, third and higher-round effects, which the final impacts cannot be easily determined without the use of an input-output analysis (Polenske1978). Furthermore, the input-output price model is a proper method for investigating the impact analysis in the cases which the time series data on the production prices or wages are not available. This can be useful tool when the analyst is faced with a shortage of time series data. Finally, the price vector in which the production prices are normalized, makes international comparison possible.

In spite of the above advantages of the input-output price model these comments have been made by some scholars:

- There is a simple duality relation between quantities and prices in the Leontief inverse system (apart from final demand in quantity and value added in price models both of which are assumed to be exogenous): by transposing the A matrix of the quantity form so that the price form is obtained, similarly by transposing the A matrix of the price form so that the quantity form is obtained.

- The price of each commodity equals the unit cost of production. It is the flexibility of the price structure (neoclassical theory) that ensures the equality of supply and demand of each commodity. There, in the short-run, the supply of commodities is given, and then the price is determined in the market so as to clear it. Only in the long-term, that is in a stationary state, may the price structure be determined by the cost of production. So the price introduced in an IO model is a long-run price and only gives us the supply price[1]. Demand will not play a significant role even if the economy is in a stationary state (Mathur 1970).
- In the price model there is no relation between quantity and price. Consequently, in each market prices and quantities move independently. Supply is perfectly price elastic and demand is perfectly price inelastic. Such a model can be used to stimulate cost-push inflationary processes. Starting from primary input price increases, for example in wages, capital costs, indirect taxes or subsidies via unit cost and intermediate input price increases, the inflationary process ends with final output price increases and totally passes them on to pure price-taking purchases whose demand does not react at all (Oosterhaven 1996).
- In practical as well as in theoretical terms in input-output analysis, the prices are uniform and relative. It is well known that IO analysis discusses only relative prices (Miller and Blair 1985, Davar 1993). These are more convenient than absolute prices for utilization and for solving mathematical problems. At the same time, the prices of commodities and primary factors are uniform in IO analysis (Stone 1961). This

means that the wage of a certain occupation is the same for all the branches and the price of a certain commodity is also the same for all final user categories. However, it is well known that in reality, this is not exactly true (Thurow 1983).

- In addition, in the general price and quantity IO model, it is assumed that the input coefficients and the prices of the primary factor are constant. Therefore, there is no link between prices of goods in reality (Robinson 1965).
- In a real system like Leontief's, under perfectly competitive static conditions, the equilibrium price for each producible good must be exactly equal to unit cost. The unit cost consists of the costs per unit of each and every needed intermediate good, plus direct-labour cost. Now it is obvious that the absolute level of prices plays no role in the Leontief price model. And we cannot hope to solve for determinate prices of all variables (Dorfman 1958).

An attempt has been made to overcome the dilemma particularly regarding the lack of interdependence between prices and quantities, and simultaneous determination of both variables in the IO price model. A number of approaches have been tried to restore the dependence of quantities on prices;

- ☐ The first suggestion is to let final demand depend not only on income, but also on prices or price relations (for more, see Dieckheuer *et al.* 1984).
- ☐ Secondly, if neoclassical production functions are allowed, it is necessary to assume that sectors minimize their cost, and at given input prices the combinations of inputs are determined.

---

[1] Davar (1989) used the label "supply price model", and Oosterhaven (1996) "cost-push price model".

- Thirdly, a neoclassical approach has been suggested which assumed a non-competitive sectoral price-setting output market i.e. assumed that sectors as monopolistic price makers in the markets for their output, rather than as price takers (Schumann 1990). Folloni and Miglierina (1994) believe that Schumann's approach is inadequate because of the limitations of a neoclassical production function.

4.7. Conclusions

This chapter has reviewed static and dynamic input-output price models and their applications. The assumptions of price IO theory have been discussed and attention has been drawn to the fact that price models make more restrictive assumptions than the quantity model. The assumptions can be addressed, such as uniformity of wage rates, interest rates, profit rates, as well as inelastic demand function, perfect elasticity of supply function, and perfect competition.

The review has also revealed the problems that IO price theory is faced with and has shown that although many economists have tried to overcome these difficulties, problems such as no connection between price and quantity models still remain and it is not possible to analyze the impact of price changes on actual variables such as output, investment, consumption, saving and employment. This is a subject for further research.

Application of different versions of price models were investigated. The investigation showed that although the static version of IO price model has been applied in impact analysis by many researchers, the dynamic version of IO price model has been empirically tested in less studies and the latest version of the dynamic IO price model has identified the effects of technological and factor price changes on prices and incomes by Duchin (1992, 1995).

The particular attention of this chapter has been the presentation of the dual price versions of the extended dynamic quantity models that were developed in chapter three. These models have three characteristics: first, they are price models so they include a vector of prices of all types of goods and services in the economy. Second, since they are dynamic the price of capital goods as well as current inputs has been considered. Third, they are extended models, i.e. they comprise not only all the industries but also groups of households. Consequently, two extended dynamic price type II and IV models were introduced. In the type II model employed households were considered while for the type IV model, employed and unemployed households were modeled. As a result, wages were regarded as employed household products prices and a zero price element for unemployed households were assumed in the price vector. It has also considered that unemployment do not produce any goods, so they do not have a particular price but, as a group who consume different goods, their impacts on the demand side were considered.

Attention was also drawn to the fact that the extended price models have the same applications as other price models i.e. impact analysis, but the main distinction is that they can provide changes in production prices as well as the wages of employed households and social security benefit payments to unemployed households. In other words the extended dynamic price models go further than the conventional model (type I) since the latter provides only the impacts on production prices. Furthermore, it has also been pointed out that the extended dynamic type II price model is more likely to estimate the *greatest* impacts as a result of considering household product price, wage, and its changes in the model while the extended dynamic type IV price model estimate less impact but still more than the type I price model. These extended models will be empirically tested in chapter nine of this study.

CHAPTER FIVE: A SURVEY OF INPUT-OUTPUT, RELATED TABLES, THEIR APPLICATIONS IN IRAN

5.1. Introduction

An input-output table presents a picture of the structure of an economy, introducing the relations and connections between economic sectors, and is considered as one of the strongest tools in economic planning. Providing an IO table helps the planner to design more accurate plans. Some countries provide or update IO tables regularly. In this chapter we shall examine the history of the compiling or providing of IO tables and the organizations responsible for them. We present a survey of IO tables in Iran. The chapter covers the compilation of IO flows, imports and exports, regional, and sectoral tables as well as static, dynamic and SAM models and their application in planning and academic exercises at national and regional levels in Iran. Definitions of, and differences between, the tables will be discussed. For these purposes this chapter is organized as follows: the historical background compilation of the tables will be covered in a section that includes; IO flows, imports and exports, regional, sectoral tables, and the social accounting matrix. The second part deals with application of the IO tables and includes static and dynamic exercises. In the last part conclusions will be drawn.

5.2. Historical Background[1]

Iran has the experience of modeling estimation of national accounts and the compiling of IO tables over the last four decades. The compilation of IO tables in Iran can be divided into two periods with regard to methodology and specifications. The first period refers to the years 1965-1986 and the second period covers 1987- to the present. All of the survey and non-survey tables provided in the first period can be called traditional types and those in the second period, modern types (Banouei 1996). Traditional IO tables can be defined as tables with these specifications:

- They have been provided sector-by-sector on the assumption that each sector produces only a single good or a homogenous good which includes secondary goods.
- Imports are assumed to be competitive. Under such an assumption all non-competitive imports are considered as competitive imports, which may not to be a realistic assumption because of the high dependence of the economy on imports with different types of tariff rates.
- Many tables have been constructed in Iran by different organizations, but they are not comparable because of the use of different classifications and the fact that they are valued in purchaser's or producer's price. Purchase price is the price paid by the consumer whereas producer's price is the price paid by the wholesaler to the producer. The difference between two prices is due to value added tax (VAT) for purchase prices.

[1]Most of the ideas in this part extracted from Banouei 1997.

5.2.1. Traditional Input-Output Flow Tables (1965-1975)

The first attempt to compile IO tables for Iran dates back to 1954 when the Center for Middle Eastern Studies at Harvard University initiated a project to compile one. Because of a lack of requisite data this project did not materialize until 1958 when the Harvard Advisory Group, in collaboration with Iranian experts, attempted to estimate a number of macroeconomic variables. Soon thereafter the Iranian officials conducted a number of studies and surveys not only at the national level but also for industrial sectors, including agriculture, manufacturing, and household expenditure surveys during the early 1960's[1]. This information enabled the newly established Bureau of Statistics in the Ministry of Economic Affairs and Finance to construct the first IO table for 1962, and later on the Bureau of Statistics tried to complete a table for 1965[2]. This table is known as the first comprehensive IO table for Iran, and provides with two sets of classification, valued at purchaser's prices. One is aggregated to 10 sectors and the other covers 29 sectors. In both classifications, aggregated agriculture and oil sectors were used and for the manufacturing and services sectors as many as possible disaggregated subsectors were introduced. In both classifications, the import component is considered to be competitive imports but is introduced in different places in the IO table. For example, in the 10-sector classification model, imported goods are represented as a separate row for intermediate sectors and final demand components; whereas in the 29-sector classification, the imported goods are distributed to the appropriate 29 intermediate industries as imported

[1] An attempt was made in the later years of the Second Seven-Year Plan (1957-1963). The main aims were to establish some macroeconomic variables, especially national income and predicting growth rate for the Second Five-Year Plan under assumptions of Harrod-Domar model.

[2] This table was provided in consultation with Leontief and Mahalanobis from Harvard University and "Central Statistical Organization and Indian Planning Commission" respectively (Banouei 1993).

inputs and to final demand components as final consumption goods. The imported goods and imported inputs and imports for final consumption are shown separately for their respective matrix cells corresponding to their domestic activities (Shaheen, no date).

The Bureau of Statistics, Ministry of Economics, made another attempt to update and project the integrated 1965 flow table and 1962-70 tables for imports and exports for 1972 and 1977 at purchaser's prices. This work corresponded closely to the period of the Fifth Five-Year Plan (1973-77). A non-survey IO table for 1972 at current prices and another non-survey table for 1977 at 1972 constant prices were the results of this attempt. Other specifications, such as sectoral classifications and separate imported goods, were the same as for the 1965 table (Eckestein and Badkhshan 1972).

The Department of Economic Accounts of the Central Bank of Iran (CBI)[1] made an independent attempt to construct an IO table for the year 1969 at producer's prices. This was the first experimental work of the CBI and was completed in 1976. Like the 1965 IO table, this table used two sets of sectoral classifications: one with 10 aggregated sectors, like the aggregated version of the 1965 IO table, and the other with 25 aggregated sectors. The difference between the 1965 and 1969 IO tables appears in the manufacturing sector classification. For example, the 1965 table provides 16 manufacturing subsectors, whereas the 1969 table gives only 13. Imports for the 1969 table were valued as competitive imports and placed as a separate vector in the final demand components (CBIRI 1981).

---

[1] This is renamed Central Bank of Islamic Republic of Iran since 1979 (CBIRI).

The Department of Financial Statistics and National Accounting, a unit of the Statistical Center of Iran (SCI) of Plan and Budget Organization (PBO) compiled an independent IO table for 1973 valued at purchaser's prices in 1977 in collaboration with Yekom Consultant, under Polenske's supervision and with Leontief acting in an advisory capacity. They provided two sets of sectoral classifications: one an aggregate version covering 13 sectors and the other a more detailed version with 60 sectors. This table, for the first time, introduced many new features in the IO field pertaining to the Iranian economy (PBO 1977). These features are identified as follows (PBO 1977):

- More independent sectors, namely trade, hotels and restaurants, real estate and rental, and also separate row and column vectors for unallocated inputs, were introduced; these were absent in the previous IO tables.
- In addition, this table includes row and column vectors for small-scale industries as an independent sector with blank cells in the transaction matrix due to a lack of suitable data. This table also disaggregates the agriculture sector into five separate subsectors, namely grain, industrial crops, other crops, livestock, and a separate sector for hunting, fishing and forestry.
- Similarly, crude oil and oil products have been broken down into three distinct sectors, namely crude petroleum and natural gas, petroleum refineries, and other petroleum products and coal.
- Imports in this table have been valued as competitive imports and allocated to an independent vector in the final demand component with a negative sign.

The Department of National Accounts, a unit of the CBI, made another independent attempt to construct an IO table for 1974 at purchaser's prices on the eve of the 1979 Iranian Revolution (CBI, no date). This table was published in three sets of sectoral classifications -13, 25, and 101 sectors and presented as two leaflets without a date. In the first leaflet a 101-sector classification and in the second leaflet 13 and 25-sector classifications were provided (Toufigh 1992). Although this table gives five separate agricultural subsectors, like the 1973 IO table, the composite sectoral classifications appear to be different. They are farming, livestock, hunting, forestry and logging, and a separate sector for fishing. With regard to the oil and oil-related products, this table is similar to the 1973 table. In the manufacturing sector the 1973 IO table covers 27 subsectors whereas the 1974 table covers 60. Also, the 1974 table includes a separate row and column for unallocated inputs in order to balance between total input and total output. Similarly, imports have been treated as competitive imports and shown as a separate column in the final demand component with a negative sign (Banouei 1996).

In 1989, the PBO compiled an IO table at purchaser's and producer's prices for the year 1984. This table covers 92 sectors and seems in many respects to be similar to the 1974 IO table because it is a non-survey table and provides information from the 1974 IO table and updated with the RAS method; trade and transport margins of the 1974 table are taken to be true for 1984. So, if it is deflated, sectoral comparability between the two tables is possible. The only viable data which have been used for compiling the 1984 table are from the 1984 industrial survey covering large industrial establishments.

However, the information pertaining to the 1984 table does not provide other relevant data with respect to non-industrial sectors and the balancing of non-industrial sectors has been carried out by using the RAS method with the help of information from the 1974 table. The 1974 table furnished two types of table: one is at purchaser's prices and the other at producer's prices. The 1974 table in purchaser's prices provided not only domestic goods and services separately but also trade and transport margins (PBO 1989). The PBO also provided a 21-sector classification for the year 1985. This table was up-dated by using the RAS method and includes three separate tables: two national IO tables, one at purchaser's prices and the other at producer's prices, and the third is an imports IO table (Toufigh 1992).

5.2.2. Imports and Exports Tables

In the history of IO tables in Iran, several IO tables for imports and exports have been compiled or provided but unfortunately literature about the methodology of compiling the tables and the nature of the data is not available (Banouei 1996). Technically, the procedures for the construction of an import matrix within the IO framework of a single country are well known. As far as we know, Iran could be the only country in the world that has attempted to compile complete export matrices at different points in time (Banouei 1993). The first matrix for exports was constructed by the Bureau of Statistics, Ministry of Economy (ME), for 1962. This table covers 20 sectors inclusive of petroleum as a separate sector and the agriculture sector divided into two subsectors, agriculture and livestock. The Bureau of Statistics made another independent attempt to compile exports and imports matrices separately in 1968. These tables have the same specifications as the first table, i.e. 20 sectors and an independent petroleum sector and two agriculture sub-sectors. The difference lies in the combination of manufacturing sub-sectors. Another attempt has been made by the Bureau of Statistics to update and project the imports flow matrix through the adjustment of input coefficients of 1962-70 import tables: one for 1972 at current prices and the other for 1977 at 1972 prices. The classification of both tables is similar to that used for the 1962 and 1968 tables. The SCI, a Unit of the PBO, made an independent attempt to compile imports and exports matrices in 1982. The peculiarity of these tables lies in the nature of the sectoral classifications. This table comprised only 11 sectors. In addition, in the 1982 tables the agriculture sector is considered as a separate sector, and the petroleum sector has been excluded (Banouei 1993).

Table 5.1- Import and Export Tables

Compiler	Base Year	Dimension
Burea of Statistics, ME	1962	20-sector
Burea of Statistics, ME	1968	20-sector
Burea of Statistics, ME	1972	20-sector
Burea of Statistics, ME	1977	20-sector
Statistics Centre of Iran	1982	11-sector

Source: author's research

5.2.3. Social Accounting Matrix (SAM)

In the middle of 1971, the Iranian Government requested the International Labor Office (ILO) to organize an appropriate comprehensive employment strategy mission in Iran. The main aims were as follows: 1) designing a long-term plan for achieving a high level of productive employment in Iran, taking 1985 as the time horizon; and 2) advising the

Iranian authority on policies and plans consistent with this strategy which could be incorporated in the Fifth Five Year Plan under the monarchy, 1974-78 (ILO 1973). As a part of this programme, the mission developed several policy recommendations with regard to employment, unemployment, income distribution. One of them which requires special mention is the construction of a SAM for macroeconomic projection under the leadership of Pyatt (Pyatt *et al.* 1972). Pyatt's team compiled a SAM model for 1970 which includes 12 sectors: two agricultural sub-sectors, eight industrial sub-sectors, one construction sector and one sector for owners of dwellings. They applied this SAM model as a planning tool in order to quantify social objectives of the Fifth Plan such as a fairer distribution of income and a higher level of employment. They developed a macro-economic model for Iran, with an integrated set of consistencies in a matrix framework, i.e. commodity transactions, domestic income, rest of the world, government income, direct and indirect taxes, and a combined capital account of saving by sources at 1970 prices for those 12 sectors. Recently, other efforts have been made by Banuoei *et al.* (2000) in order to investigate the relationship between the structure of output and employment in economic sectors by using a semi-social accounting matrix for the 1991 IO table updated to 1996 using an adjusted RAS method and detailed survey data of population and dwelling stock. This study revealed that the employment impacts (multipliers) of the semi-social accounting model are higher than those from conventional open IO models, in the construction sector this difference is significant, and agriculture and construction have high employment potential. Because, in this study, new endogenous variables, i.e. household consumption is introduced to the open IO model, so the induced employment impacts are higher.

An Iranian researchers group[1] has been compiling a comprehensive SAM matrix at national level for 1996 table, that has not been published yet.

5.2.4. Regional Input-Output Tables

The Battelle Institute made a contract in 1972 with the PBO to prepare a regional plan within the Fifth Five-Year Plan before the Islamic Revolution. First, they provided an 18-sector national IO table and then they used this table as a base in order to estimate the regional inputs coefficient. So they provided eleven regional[2] tables for 1972, and used these for planning by taking 1978 as the time horizon, by using the adjusted RAS method and benefiting from the help of Iranian expert opinion for the input coefficients. This method is debatable especially in the case of Iran. Although the experts opinions are useful, in a high aggregated IO table in which each sector is composed of many various products, it was not easy to find an expert who is proficient in all the activities in one sector. For example in agriculture it was not possible to find a person who was an expert in farming, livestock, fishing, and forestry. On the other hand, the use of many experts for each sector would have incurred a huge cost. These tables are well known as the first regional IO tables in Iran. These tables were rarely used[3] and it was not until 1984 that the PBO compiled provincial tables[4] for some provinces of Iran and the SCI has provided

---

[1] CBIRI, SCI and Centre of Economic Research in Iran have been collaborating this project under leadership of Dr. Ali Asgar Banouei since 1999.
[2] In the Battelle Project Iran had been divided into 11 regions.
[3] The period of preparation concurred with the onset of the Islamic Revolution.
[4] Iran has been divided into 28 provinces, which for the purposes of the division will be used to describe for region.

regional accounts for six provinces (SCI 2000)[1]. The Kerman Province table is the first table at a regional level that has been compiled in an academic context by using survey and non-survey data (Dashtban 1994). It should be mentioned that the IO table for the largest province in Iran i.e. Khorasan is the subject of an MA dissertation being prepared at the University of Allameh Tabatabei.

5.2.5. Modern Input-Output Tables

The Economic Accounts Department in SCI and Economic Accounts Department in CBIRI compiled three input-output tables for the period 1986-1991. These three tables are famous for modern IO tables and are commodity-by-industry frameworks as described in a United Nation report on System of National Accounts 1968 (United Nations 1968). The main specifications of the modern tables provide not only sector by commodity (make matrix) but also commodity by sector tables (absorption matrix) and as a result the sector by sector and commodity by commodity tables are computable, which is sometimes not possible in the traditional table.

The 1960's IO tables were not able to respond to specialized activities and their relationships at macro and international levels, and so a modern IO table describing the economic relationships between lower commodity groups, and more detailed data, was required. Modern tables show a more realistic picture of the economy with sector-

[1] These provinces are Charmahal Bakhtiari in 1984,Esfahan, Fars, Hamadan,and Kerman, Kordestan in 1986.

commodity (make matrix) and commodity-sector (absorbing matrix)[1]. In the mid-1980's an effort was made to compile a modern table for Iran. The Economic Accounting Department in SCI compiled the first modern table for 1986[2]. This table was presented as two leaflets: first, the general picture in 1994 (SCI 1994) and then in detail in 1995 (SCI 1995). This table was published in three sets of classifications -9, 78, and 172 sectors and a 240-commodity tables. In the 78-sector table the agriculture sector is disaggregated into ten sub-sectors and manufacturing sector into 33 sub-sectors for the first time. This is the first table that takes account of the main and secondary activities. Moreover, the 172-sector table contains 21-agriculture sectors and 80-manufacturing sectors (SCI 1995).

Thereafter the Economic Accounts Department in CBIRI made another effort to compile two modern IO tables for 1988; a 108 activities by 258 commodity make matrix and a 258 commodity by 108 activities absorption matrix; and, secondly, a make and absorption matrix with 95 activities, both in producer and purchaser's prices (CBIRI 1996).

In 1997 the SCI provided a third modern table, for 1991, by using an adjusted RAS method with the help of information from the 1986 table. Because of the lack of detailed information, this table was provided as a 78-sector classification.

---

[1] Two matrices were introduced in Cambridge Model Project under leadership of Stone in the mid-1960's.
[2] Compilation of this table required 60 census projects and started in 1987. It was finished in 1995 (SCI 1995).

Finally, in 2001, the CBIRI is providing a fourth modern table for 1996, by using an adjusted RAS method with the help of detailed information from the 1988 table, which has not been generally published yet. A summary of the national IO tables are presented in table 2.3.

5.2.6. Sectoral Input-Output Tables

Sectoral input-output table in the Iranian input-output context is defined as a national table in which a specific sector is disaggregated as much as data are available. Since 1991 several attempts have been made to compile IO tables at sectoral level for specific purposes such as structural reform or to identify the potential of sectoral employment. The first sectoral IO table was provided by the Ministry of Jahad-e-Sazandagi (1999) with livestock and poultry as the agriculture subsectors. In Winter 2000, a group of researchers in the Ministry of Agriculture provided a 59-subsector IO table for 28 agriculture products. It is notable that the agriculture sector in Iran is one of the sectors with a high share of Gross National Product (GNP) and high capability of employment capacity. This table is consistent with the information prepared in other important statistical organizations such as the SCI and the CBIRI in concepts and methodology of construction. This table can be applied for estimating: the demand for agriculture goods, production, employment, income distribution, and exports, etc (Banouei *et al.* 2000).

The second sectoral IO table is a 43-sector energy IO table for 1994 for six oil products: gasoline, kerosene, diesel oil, natural gas, fuel oil, and electricity and their inter-sectoral relations with other sectors prepared by Ministry of Power (1998). This table is used empirically in chapter nine to investigate the impact of increases in energy product prices.

The third sectoral table is a 33-sector IO table for two communications products provided as a collaborative research project by the Economic Research Centre of Iran and the Ministry of Posts and Telecommunications for 1994 (forthcoming). In this table the communication sector is disaggregated into post and communications subsectors. A summary of sectoral IO tables are presented in table 3.2.

Table 5.2 – Sectoral Input-Output Tables

Compiler/Provider	**Sector**	**Base Year**	**Number of Subsectors**
Ministry of Jahad – Sazandegi	Agriculture	1991	2
Ministry of Agriculture	Agriculture	1996	28
Ministry of Power	Energy	1994	8
Ministry of Posts and Telecommunications	Communication	1994	2

Source: author's research

5.3. Input-Output Applications

There are a lot of reasons why the official organization should spend a lot of money on compiling an IO table. The main reason that can be ascribed to the application of IO table is planning. The IO table provides detailed data and a complete picture with respect to the interrelationships in the economy, and this is what the planning officials are interested in. Although nine national IO tables have been compiled or provided in Iran since the 1960s, they have been used rarely in national planning officially and some of the uses are in sectoral planning especially in the manufacturing sector[1]. Different types of IO tables such as national, regional, sectoral, and imports and exports have been used in empirical studies and these will be discussed next.

Table 5.3- National Input-Output Tables in Iran: A Summary

	Compiler / Provider	Base year	Dimension	Year of Publication	Type
1	ME	1965	29 by 29	1968	traditional
2	CBI	1969	25 by 25	1972	traditional
3	SCI & ME	1973	59 by 59	1977	traditional
4	CBIRI	1974	101 by 101	1982	traditional
5	PBO	1985	92 by 92	1989	traditional
6	SCI & ME	1986	78-sector, 172-commodity	1994	modern
7	CBIRI	1988	108-sector, 258-commodity	1996	modern
8	SCI	1991	78-sector	1998	modern
9	CBIRI	1996	In progress	-	modern

Source: author's research

5.3.1. Static Input-Output Applications

Applications of static IO models in Iran have two main purposes: in planning and as academic exercises. In the history of planning in Iran, there are eight national macro plans. Five plans were prepared under the monarchy, and three Five-Year Plans under the present government (1989-2004), and the plan holiday (1979-88). Technical planning in Iran shows that the first and second plans under the monarchy could not use the planning technique either at a macro level (national) or at sector level, due to the lack of enough information, and was therefore restricted to a few projects. In the third plan under the monarchy, the national output growth rate was estimated by using the Harod-Domar

[1] According to an interview with Mardookhi B. president consultant in PBO.

model. The Fourth Five-Year Plan (1973-1977) under the monarchy ensured not only the consistency of the macroeconomic model with sectoral plans but also used IO techniques for the purpose of import substitution by using the 1965 IO and import tables which were the main tools of this plan (Razavi and Vakil 1974). By using the IO technique the Fourth Five-Year Plan was prepared for the provision of a comprehensive plan. This plan also benefited from the use of the SAM technique to estimate level of employment and income distribution analysis (Pyatt *et al.* 1972). In addition this plan also used a regional IO technique. For this purpose, the Battelle Institute made an attempt to provide 24 IO tables for the first and final years i.e. 1973 and 1977. Twenty-two regional IO tables were prepared for eleven regions in addition to two national tables for the first and final years of the plan. These 24 IO tables were used for this plan.

In the Third Five-Year Plan (2000-2004), the present government intended to perform some structural reforms in the monetary and financial parts of the economy. In the financial part the main reform refers to eliminating subsidies gradually on some principal goods which are used by households, such as energy, foods, and medicine[1]. In relation to reducing the subsidies on energy prices, the IO technique has been employed by the World Bank (1999, unpublished report)[2] to analyse the impact of increasing the price of energy on price indices, government budget, and household income group expenditures by using the IO table for the energy sector in 1994.

[1] Subsidy payments to energy are the major part of governmental subsidies, about 80%.
[2] It has been only provided for Islamic Consultant Assembly (Majles).

The application of IO techniques has been extended not only into the planning arena but also covers some academic exercises. The literature covering applications of the IO technique in Iran shows that international organizations and independent researchers have investigated IO techniques in their research and projects in a number of different ways. In 1970, a first attempt was made by the United Nations to analyse the impact of three scenarios on the growth rate of gross domestic product (GDP) on sectoral outputs and employment with the help of the 1965 IO table (United Nation 1970). In 1976, another attempt was made by the International Labor Organization (ILO) to explore the extent of change in income distribution, employment and the structure of the economy with the help of the 1965 IO table (Skolka and Gruzet 1976). The 1973 IO table and its update for 1982 were used by Bulmer-Thomas and Zamani (1989) to analyze industrialization, employment and income distribution pre- and post- Islamic Revolution with the help of an adjusted Skolka and Gruzet model (1976) and simulation techniques for three household income groups: one rural and two urban income groups. Bulmer- Thomas and Zamani's achievement was in making the connection between the distribution of income and output, productivity, employment, saving, tax, and imports. Thereafter, Ardeshiri (1995) developed the Bulmer-Thomas-Zamani Model (1989), and applied it to investigate the impacts of income distribution change on macroeconomic variables with the help of the 1984 IO table. In 1986, Zanour made another attempt to examine the consistency between the required resources and the projected investment incorporated in the aborted First Five-Year Socio-Economic and Cultural Development, SECD Plan (1983-87) by using the 1973 IO table (Zanour 1987). The 1973 table was also applied by Razavi and Vakil, to develop long term multi-sectoral optimal planning for Iran. Their model is based on a combined Leontief IO model and Chow's dynamic programming technique (Razavi & Vakil 1984). They tried to establish the relationship between oil extraction, the welfare of the nation and the portfolio of national wealth at the end of the aborted long-term plan (1983-92).

5.3.2. Dynamic Input-Output Applications

The idea of developing a dynamic IO model and constructing an intersectoral capital coefficients matrix for Iran was discussed by Skolka and Garzuet (1976) and Naseem (1972), but was not made operational until the work of Banouei (1989), when a 10-sector intersectoral capital coefficients was constructed for the 1974 table for the first time. For this purpose he relied heavily on various sources of data but as the data on net capital stocks were not provided, a gross intersectoral capital coefficients matrix was estimated. He also calculated the von Neumann growth path for the Iranian economy by using the calculated capital coefficient matrix (Banouei 1989, 1992a). A group of three researchers[1] from the University of Bombay, Planning and Development Department investigated different aspects of the dynamic IO in Iran and India. The first approach of this group's work for Iran concerned the effect of the climate on agricultural outputs and the direct and indirect effects on other sectors in Iran and India (Prasad *et al.* 1994). For this purpose, they used the dynamic IO system and optimization techniques together. This group also used dynamic IO systems and a semi-IO framework in developing trade and development strategies for the years 1974 and 1984 at 1974 prices by using the 1974 IO table (Prasad *et al.* 1992).

[1] This group contains Prasad K.N & Banouei A.A, and Swaminathan A.M.

5.4. Conclusions

In this chapter we have provided a short review of the history of compiling and providing IO tables and discussed different aspects of the IO applications that have been carried out in Iran since the 1960s. The history of IO frameworks revealed that the idea of compiling an IO table for Iran is one of the reasons to survey and manage data and information and finally calculate the national income since the first table was prepared. This history also shows that Iran is one of the countries with a relatively large body of experience in compiling IO tables. The first experience dates back to 1958 when help was obtained from American experts. This help continued in the compilation of the 1973 national IO table and in preparing regional tables. Thereafter tables were prepared at approximately five-year intervals by Iranian experts without any international help. Preparation of IO tables has been a statutory function of the Bureau of Statistics, in the ME. However, the CBIRI and the SCI have also prepared separate IO tables. The results of their efforts over almost five decades are nine national, six regional, five exports and imports, four sectoral and two SAM tables which have been compiled, provided or estimated by different official organizations. Iran is one of the first countries that has also attempted the compilation of complete five imports and exports matrices at different points of time.

The main purpose of preparing an IO table is to use it for planning at different levels: at nation, region, sector, and even firm levels. The Iranian economy is currently undergoing structural reforms, and IO techniques are a useful tool for such a transitional phase. Most IO applications in Iran refer to static models in the time since the first IO table was compiled in 1968, because of greater data availability. Meanwhile, the dynamic model has not been used until the first capital coefficient matrix was constructed in 1991. This is despite the fact that Iran is one of the countries with a central governmental plan and an IO technique can be considered as one of the strong techniques to capture a long-term and short-term economic plan. The review of the application of the IO technique in Iran shows that it was not used often for planning either under the monarchy until 1979 or after the Islamic Revolution since 1979. This gap has been filled by some economists interested in working in this area especially a group of economists at the Center of Economic Research in Iran[1] who started studying and carrying out some research and projects not only on compiling IO tables but also using IO techniques for economic analysis. The number of theses and dissertations on IO analysis has increased sharply since then. The first IO congress on "Compiling and Preparing IO Tables and Its Application in Economic Planning" was held in 1998 which is one of their efforts[1]. The thought of compiling IO table was one of the main elements in collecting and organizing data, and the application of IO techniques for planning and other purposes revealed not only the scarcity of information but also prepared the ground for collaboration and the improvement of data by the different official organizations.

During our investigation of IO applications in Iran, we found that there is close cooperation between those calculating the national accounts (CBIRI & SCI), IO table compilers and model builders and users. Although this close involvement is one of the advantages in Iran, some basic problems have been revealed which should be carefully looked into and improved upon:

[1] At Allameh Tabatabei University under the leadership of Dr. Banouei

- We have seen in the review of the historical background that there is no single organization legally responsible for assembling the data and compiling the IO table. As we can see, when the Bureau of Statistics compiled an IO table, later on other governmental organizations also constructed IO tables and sometimes with different concepts, definitions and dimensions, so making comparative analysis difficult. Therefore, it is essential that the Iranian government should assign this job to a particular organization, which can compile regularly IO tables for a specific time interval, for example five years, if they want to apply it for planning and other purposes.
- This study also showed that although IO studies in Iran have a very long history (about five decades), most of the effort has been placed on compiling IO tables at a national level and rarely at a regional level. The importance of preparing regional IO table relies on two basic elements in the regional economy, firstly data in a national IO table are some kind of average data, and the structure of data may differ notably from that recorded in the regional data. Secondly, it is true that a regional economy depends to a greater degree on imports and exports than a national economy. Iran, with 28 regions, each with various climate, economic and natural resource possibilities, and differing degrees of industrialization, the preparation of regional IO tables can help the planner design a more accurate regional plan. Data collection and assembly of data in necessary frameworks are the preliminary task in compiling regional IO tables. For compiling the regional IO tables two related approaches can

---

[1] This congress was held at Allameh Tabatabei University and organized by SCI and Faculty of Economics, Allaneh Tabatabaei University, and this group is going to prepare the second conference next year.

be considered. The first consists of extracting regional tables from the national tables. This was pioneered by Isard and Kuenne (1953). The second consists of arranging the regional IO tables exactly in the same way as the national tables. The main point is the shortage of regional data which means that the regional tables can be estimated in the short-term by using the first approach, and that comprehensive regional tables will be constructed by using the second approach when the comprehensive regional data is collected.

- A few sectoral IO tables have been provided, such as IO tables for energy, agriculture and communication sectors and this represents a good start. The provision of sectoral IO tables should be continued not only for the sectors for which the IO tables have been prepared but also for the rest of the sectors which are suffering economically such as the oil, manufacturing and services sectors.
- Most of the input-output tables in Iran are out of date, and to prepare a table by survey takes too long and every table is several years old. As a result, using it in an economic analysis for the short term (up to 5 years) is of limited use and for the long term is based on the strong assumption of no changes in technology. This of course is not peculiar to Iran and refers to the nature of the construction of the IO table.
- There are a lack of some particular IO tables in IO analysis such as environmental accounting and environmental models, the basic idea of such a model being to supplement IO tables or Social Accounting Matrix (SAMs) by additional accounts showing the physical flows from the environmental system to the economic system and vice versa. The construction of this table is subject to the availability of additional accounts on a set of ecological commodity inputs of resources; such as

water, land and air as well as a set of ecological commodity outputs such as sectoral sulphur dioxide air pollution. The availability of this information enables a table of economic-ecologic commodity flows, and the ecological commodity input-output coefficients in the same way to be produced. This may be a subject for future research on environmental IO analysis.

CHAPTER SIX: ESTIMATION OF CAPITAL STOCK

6.1. Introduction

One of the main requirements of the dynamic input-output model is a capital coefficients matrix. The construction of this matrix relies on information on the capital stock for industries. According to our investigation such data has not as yet been prepared in Iran, particularly for disaggregated industries. This chapter provides thorough documentation about estimating the sectoral capital stock of the development net and gross capital stock, for the most disaggregated data that is available. Sources and methodology used to develop the input data, and actual capital stock measures for 9 sectors and 9 manufacturing sub-sectors in Iran in 1991 will be investigated. The perpetual inventory method (PIM), in which capital stock is estimated as a weighted sum of past investment flows, a bell-shaped retirement pattern and a beta-decay depreciation function will be employed. the investigation cover three types of capital stock: construction, machinery and vehicle equipment. The technique of excluding war damaged capital stock from net capital stock is an innovation of this study. For the above purposes the chapter is organised as follows: first the methodology of capital stock estimation is presented. An exposition of the data requirements for the calculation of capital stock follows. Finally, data adjustments and the results of the calculation are presented and compared with other studies.

6.2. General Considerations

There is no precise and up-to-date estimation of net capital stock for industries in Iran. Some effort has been made in this regard by using different methodologies[1] such as : Shahshhani (1978); Zolnoor (1986); Arab Mazar and Kalantary (1992); Gharoon (1994); Amini (1996); Statistical Centre of Iran (SCI) (unpublished); and the Central Bank of Isalmic Republic of Iran (CBIRI) (two approaches first 1982, and second, unpublished research in progress). The main differences between the above studies relate to the assumptions about service lives[2] and depreciation function[3] and the level of sectoral disaggregation[4]. In contructing the capital coefficients matrix it is important to disaggregate the manufacturing sector into as many subsectors as possible, but all previous studies introduced aggregated manufacturing as a sector. The main aim of those studies was to calculate total sectoral capital stock, changes and growth, rather than subsectoral disaggregated capital stock for the purpose of input-output analysis (discussed further in chapter 3). The present investigation is the first attempt to

---

[1] Such as: capital-output ratio, exponential process, and production function methods that are not common methods and most applications of them refer to the calculation of total capital stock in the whole economy. Whereas we need total capital stock in as disaggregated form as possible into the different types for constructing the capital coefficients matrix.

[2] Only PIM method requires service lives of assets. The assumption on service life of capital stock in different studies are as follows: CBIRI assumed different sectoral service life, which I follow in this study, and in Gahroon and SCI a 20-year life for machinery and a 40-year life for construction.

[3] Previous studies assumed a straight-line pattern for the depreciation function with the exception of SCI which employs a declining balanced pattern.

[4] Most of the previous studies provided capital stock for four sectors with the exception of CBIRI (unpublished) which used 10 sectors, and Amini 8 sectors, and SCI which distinguished between two types of ownership groups (public and private).

calculate gross and net capital stocks at the level of nine sectors and nine industries disaggregation which together cover the whole Iranian economy.

6.3. Methodology

There are basically two methods, each with its variations for estimating capital stock:

- Direct measurement of the stock for a benchmark year, through different types of surveys such as physical assets, insured values, company book values, and direct estimation on the basis of stock exchange values. Direct measurement provides more accurate estimation with more cost and time required for data collection on company accounts and macroeconomic accounts (for more details see Mayes and Young 1994).
- Accumulating historical series on past investment and deducing assets that are scrapped, worn out or destroyed by war by the perpetual inventory method (PIM). This is the method is discussed in this chapter.

In this study, fixed capital stock estimates are presented for the year 1991, i.e. the year of the latest input-output table, using the perpetual inventory method (pioneered by Goldsmith 1951). The preference for this method is based upon the fact that it uses a methodology which facilitates international comparisons and because it produces figures with clearer meaning since all the hypotheses and calculations are transparent and consistent. It is now generally used in official estimates in most countries.

The perpetual inventory method estimates capital stock as a weighted sum of past investments made in previous periods. This involves estimation of an initial capital stock consisting of the sum of past investment during the assumed service lives of different asset categories. This initial stock can easily be updated on a yearly basis by adding investment during the year and subtracting assets that are scrapped. The related net capital stock estimate can be obtained by deducing derived accumulated capital consumption (depreciated) estimates from the gross capital stock series.

The requirements of the PIM method are as follows:

First, since the objective of this study is to estimate capital stock for the year 1991, historical time series of gross fixed investment were needed over a long period of time, basically since 1951 (especially for construction, with a 40-year service life). This requirement was difficult to meet for Iran where most of the official series do not go back further than 1959. The major problem in this kind of research is the assumption of the length of life of capital assets[1]. In the case of Iran not much empirical information about service lives of capital stock is available. For the empirical calculations, the assumption about service lives that are defined by average service lives is the first step. Average service lives are shown in Table 6.1. In developing countries the assumption about the length of service lives may be critical, as they often relate to technological and economic considerations such as absence of regular repairs and maintenance capital stocks have shorter service lives than those in developed countries. On the other hand

[1] It should be mentioned that any changes in the service lives assumptions affect the size of the capital stock.

most of the cases they use capital stocks in the production process and this is something we shall explore carefully.

Secondly, there is the issue of defining the type of retirement (discard or mortality) pattern and depreciation function of the capital stock. In this study a bell-shaped discard pattern[1] with the average service life of a group of similar capital goods, the cut-off points of a distribution around the average service life, and the standard deviation of the distribution. The latter two variables are assumed to be 50 and 25 percent, respectively, of the mean life in this study and it is the same assumption as in LBS (1979). The depreciation function should be defined in order to calculate the amount of depreciation to be deducted from gross capital stock to derive net capital stock. In theory a close relationship between retirement pattern, service life and depreciation function can be seen (Jorgenson 1974).

In fact there is no general agreement on the type of depreciation function to be employed but it can be generally characterised by one of three classes. The first class comprises the straight-line pattern of depreciation in which efficiency declines linearly over the life-time of the capital good. The second class of depreciation function assumes that most of the depreciation occurs in the later years of service rather than earlier. The third class of depreciation function assumes that most of the efficiency decline occurs early in the service life of the asset[1]. We assume the second class of depreciation function for this study is in line with the practice in other countries such as

---

[1] This kind of pattern was also used by Hamilton (1986) in South Korea and by BLS (1979) in US.

the United States (Bureau of Labour Statistics 1979, 1983, 1995, Ball *et al.* 1993); and OECD countries (Jacob *et al.* 1997). We assume that the efficiency (or survival rate) of an asset is approximated by a rectangular hyperbole with a curvature parameter of $\delta = 0.75$ for machinery equipment and $\delta = 0.9$ for construction[2]. In most of the developing countries such as Latin America (Hofman 2000), Pakistan (Khan and MacEwan 1967) and South Korea (Hamilton 1986), a straight-line depreciation function (i.e. implicitly assumed that $\delta = 1$) was assumed over the working life of different types of asset. By assuming a value of δ which is not very small (0.9), not only is our assumption close to that of developing countries, but also we have improved the method of estimation. We do not pay much attention to the point in time when the assets start depreciating. However, this assumption is important as the resulting net capital stocks can have different levels[1]. It has also been assumed that scrap value at the end of the economic life of the capital good is zero, which is not very important but this treatment of obsolescence simplifies the calculation procedure and this procedure is used in most countries.

The calculation of capital stock by the PIM method in Iran covers an investment time series of more than thirty years that includes an eight-year war period with its destruction. In the PIM method, there is no mechanism for taking into account sudden and unexpected events such as a war, and no technique takes account of war conditions. In this method which accumulates past investment time series, much attention has been

---

[1] The specification of the depreciation function is relevant for tax deduction purposes.
[2] We follow the US experiment, because most of our technologies came from there and also the larger value of δ the faster loss in efficiency, whereas curvature parameters in OECD studies are 0.50 for equipment and 0.75 for structure (Jacob *et.al.* 1979).

paid to the starting time for investment and not to what happens to the capital once it is put into effect. So if capital is destroyed suddenly for any reason before the end of its service life, this method cannot suggest any direction. In this method, without taking account of the size of the damage, we calculate the depreciation of all the assets include the damaged asset, so our figures should not show the real size of the capital stock, and we have to find a technique to estimate the amount of depreciation which we deduced wrongly. The main variables in the depreciation function, which have been discussed earlier, are the service life of an asset and the real age of that asset. There is no lack of information about the service lives but unfortunately no information on the real age of damaged or destroyed asset types is available. It should be mentioned that without any assumption about the age of destroyed assets during the war period, it is not possible to achieve that aim. As war is not a common situation, it is not easy to find comparable experience from other countries. In the case of Iran we are faced with conditions in which much capital stock has been destroyed by war, and the calculation is likely to produce overestimates if we do not pay attention to this matter. Several scenarios can be suggested for this purpose. These scenarios can be developed by making the assumptions about the real age of assets in order to calculate the amount of returned depreciation which has to be deducted during and after the war. If we do not take account of the war damage in the calculation, this means that we assume implicitly all destroyed assets were at the end of their service lives. This is the first scenario. Two other scenarios can be considered about the real age of destroyed capital stock that: a) it was new; and b) it was in the middle of its service life. If we assumed a full service life for damaged capital stocks (case a) then the replacement costs of damaged stocks

[1] We have not found idea bout the time lag between instalation and exploitation.

would be more than the real damage of capital stocks. This fails to reflect the reality especially with respect to the war area and the quality of the capital stock that has been destroyed. Most of the war area is near to the borders where the stock is always less modern rather than in the central area of the country. So it would be more logical to assume a 'middle age' of service lives for the damaged asset, and this is what we have assumed in this study (we return to this in section 6.5).

6.4. Database

In this study, like any other, the selection of the sectors and sub-sectors is dictated by the availability of time series data on investment. The major sectors included in this study are: agriculture; oil and gas; manufacturing; mining; water and electricity; construction and housing; transport; communications; real estate; and other services. The major sub-sectors considered are: food; beverage and tobacco industries; textiles; wood products and furniture; paper and printing publishing; chemical products; non-metallic mineral products; basic metal products; and fabricated metal industry. Yearly data from 1959 to 1991 for the major sectors divided into two capital stock types were extracted from Bank Markazi Iran (CBIRI) and the National Accounts of Iran (Vol. I and II). The data for the manufacturing industries on capital stock types were extracted from different organisations and are described briefly in the Table 6.2. We deflated investment series to 1991 prices by using data on the capital stock time series in fixed prices from the official data in CBIRI (1982 and 1994) on price indices; the result of this price index calculation is shown in Table 6.3. In order to estimate net sectoral and subsectoral capital stock, data adjustment is required.

6.5. Data Adjustment

Investment time series have been compiled by a number of different official organizations. In order to use them in estimating capital stocks, four steps of adjustment are required:

- Sectoral disaggregation,
- Investment time series on machinery and transport equipment disaggregation for sectors and manufacuring industries,
- Investment time series on construction estimation, and
- Wartime data adjustment.

6.5.1. Sectoral Data Adjustment

As the main aim of the capital stock estimation is the construction of an intersectoral capital coefficient matrix, it was envisaged that the capital coefficients matrix should include as many sectors as possible. So, adjustments are required to two data groups of sectoral and sub-sectoral investment time series. In view of this, the classification of CBIRI data was adopted with the following adjustment. Investment time series data on construction data are aggregated for the manufacturing and mining sectors for the period 1959-1990 and are disaggregated for the period 1991-1997. To disaggregate these data into two sectoral groups, we had to introduce an index of the average proportion of investment in construction for mining compared to that for mining and manufacturing combined during the period of 1991-1997, and generate it for the period

1959-1990. This index has also been checked with output ratio of mining to manufacutring and are very close (with less than 5 percent error).

6.5.1.1. Sectoral Investment on Machinery and Equipment Data Adjustment

Most of the investment time series data are available for two types of capital stock, i.e. machinery and transport equipment and construction[1]. Although investment time series data for manufacturing subsectors have been provided in more detail since 1979 (which is very helpful given the importance of the manufacturing subsectors in constructing the capital coefficients matrix), the lack of detailed data for other sectors remained a problem. The minimum number of capital stock types which are experienced in other approaches has let us to introduce three types of asset[2] i.e., machinery equipment; transport equipment; and construction, which is also appropriate in the case of data availability in Iran. Three types of capital stock are a limited number, but as mentioned earlier source sectoral and subsectoral data are not available and data adjustment is required.

6.5.1.2. Sectoral Investment on Machinery and Equipment in Disaggregated Form

Sectoral CBIRI data on investment time series have been provided for two types of capital stock. In order to disaggregate this into three types, we need to introduce a method which relates to data availability in each sector. The standard approach adopted is: first, in each sector for which data is available, even if just for a short period of time,

[1] Land is excluded, because it is a depletable asset.
[2] We followed Indian experience (Mathur 1967).

the average share of capital stock type is calculated for that period and it is assumed that this ratio also holds for the years before that period for which the aggregated data is observed, (such as agriculture; mining and quarrying sectors). Secondly, if there is no data whatsoever on three types of capital stock since 1959, another investment time series index on asset types, i.e. "sectoral operational of surplus[1] to sectoral value added ratio in 1991" is introduced (such as: oil and gas; water and electricity; transport; communication; construction; and other services sectors)[2]. The comparisons have been made between indices of existing data for the year 1991-7 and the estimated data for 1959-91, and the error is not significant i.e. the maximum level is 5%. The results are shown in Table 6.4 and Table 6.6.

6.5.2. Machinery and Equipment Disaggregation for Manufacturing Industries

Although investment time series on six capital stock types in the manufacturing subsectors are available for the period since 1979, as mentioned in Table 6.2, the time series data for investment is not long enough[3] and in most of the manufacturing subsectors it would be preferable to go further back and use data before 1979. In preparing investment time series data for three types of asset for the period before 1979 we should first aggregate the investment time series by six types of asset during the 1979-1991 period to three types of the selected capital stock and then calculate the ratio

[1] It is a sector's production value after subtracting capital consumption and indirect tax and employee's compensation

[2] The investment time series in the real state sector is based only on construction asset, so it is not necessary to disaggregate it.

[3] We introduced a certain amount of service life for each asset types. So each investment time series requirement is different and depends on an asset's retirement pattern.

of investment in transport equipment to the combined amount of investment in transport and machinery equipment. Third, by assuming that this share held for the years before 1979 we can calculate time series on investment for three types of capital stock in subsectoral manufacturing.

It should be mentioned that in manufacturing sub-sectors, a four-year data gap is observed, i.e. 1975-1978 on the investment time series of capital stock types. Total investment in manufacturing sub-sectors is the only data available for two years (1975 and 1976) of this gap, and data is lacking for the other two years. To fill this data gap, for the first two years the above index was used to disaggregate and for the second two years we used the "Gross Capital Stock Changes Index" (CBIRI 1978-81) to calculate total investment and followed the above method for the disaggregation of capital stock types. The results are shown in Table 6.7 and Table 6.9.

6.5.3. Data adjustment of Investment Time Series on Construction

We are seeking to estimate sectoral and manufacturing sub-sectoral capital stocks in construction in 1991. In order to do this we need a benchmark figure for the stock in the year just prior to the year when our series begins, but we do not have that data. We assume a 40-year service life for construction and a bell-shaped retirement function, so a 60-year time series data is required and we do not have that data. This problem is expected in practice and our case is not the only one where a compromise solution is needed. For example, Hofman (1992) constructed manufacturing capital stock estimates for several Latin American economies and Ball *et al.* (1993) also faced the problem when of estimating agricultural capital stocks for several OECD countries, and Jacob *et al.* (1997) faced this problem in estimating capital stock for major sectors in selected OECD countries. We follow their approach and artificially construct values for investment on construction under the assumption that capital stock on construction was zero in the year 1931 and that gross investments grew linearly from that date to its observed level data in 1959[1]. Actual data and estimation figures on construction investment are shown in Table 6.5 (sectoral) and Table 6.8 (manufacturing sub-sectors)[2].

Investment time series on machinery, transport equipment and construction have been prepared for capital stock estimation on three types. This was the first step of the PIM method. Providing sectoral and manufacturing sub-sectors discard patterns and depreciation functions for service lives of capital stocks is the next step[3]. Thus, by following the above discussion and methodology, we obtained the estimates of capital stock measured in constant rial. These net capital stocks include 8-year war damage. To determine the real total of net capital, war damage should be excluded. So the final adjustments take account of the war damage. The technique of excluding war damage is described in the next section.

[1] It should be mentioned that the amount of investment on construction estimation for those 8 years is not remarkable.
[2] Highlighted and bold figures are estimated.
[3] Excel and Access softwares have been used to calculate discards patterns and depreciation functions.

6.5.4. Wartime Data Adjustment

As we mentioned earlier, in wartime some of the capital stocks were completely destroyed before the end of their service lives and there is no standard procedure to take account of war damage in the PIM method. Without taking account of the size of war damage it is not possible to estimate actual net capital stock. Also, we discussed earlier the assumption about damaged assets which had been in the middle of their service lives when they were destroyed, rather than new or not scrapped completely. The technique for taking account of war damage is as follows.

An annual sectoral war damage has been provided by Budget and Plan Organisation (BPO 1990) on construction and machinery for the period 1980-1988 (war period). What we need is sectoral and manufacturing subsectoral war damage for three types of capital stock and also the amount of depreciation, which we had deducted since 1980. To reach this aim: first, annual sectoral war damage on three asset types is provided by share of sectoral of asset types index. Second, for the manufacturing subsectoral war damage on three types were estimated by a subsectoral manufacturing output index. Third, sectors and manufacturing subsectors depreciation returned were calculated in this way: the sum of the annual sectoral and manufacturing subsectoral damaged asset types multiplied by the corresponding cumulative depreciation rates the results for which are shown in Tables 6.10-15.

Regarding the sectoral and subsectoral time series on investment for three types of capital stock and the amount of the replacement cost which has been calculated on the basis of retirement pattern and depreciation function introduced earlier, the information is prepared to derive real net fixed capital stock: the sum of the investment time series multiplied by the corresponding survival factor from which is deducted the corresponding war damage. The results are presented in Table 6.16.

It would be helpful if the results of this study could be compared with those of other scholars, such as CBIRI (unpublished Data); Gharoon (1994); and Amini (1995).

The only study which can be compared with this study is CBIRI results which uses the same method of calculation. i.e. PIM method, with less disaggregation; unfortunately these results have not been officially published yet and include war damage (see Table 6.17). This comparison shows that the effect of war damage, especially in the oil and gas sector, which was the main target of the enemy in war, is significant.

Another comparison can be made between the results of this study with Amini (1995), and Gharoon (1994). Here a siginificant difference is observed. The significiant differences is due to using different method of estimation, or assuming very different service lives of assets. Gharoon used the PIM method with a 40-year service life for construction and a 20-year service life for all machinery types in all sectors. This is a simple technique but may not reflect the reality. Although Amini practiced other method i.e. the production function method that has the advantage of not needing the assumption on service life of capital goods, he borrowed some coefficients and made some extra assumptions on the sectoral production functions that can have had an effect on the calculation results. We can see that Amini's results are much smaller than those from this research and the CBIRI study. Generally the difference between PIM and production function method is fundamental because in the PIM method we estimate the existing capital stock in the economy (may or may not be used in the production process), while in the production function method estimates the capital stocks measurment that have taken part in the production process to produce goods or services. We know that for most of the time, capital stocks do not work under full capacity utilization i.e. we are faced with an idle capacity problem. Therefore the difference between Amini's results and those from this study are meaningful and can show the idle capacity.

6.6. Conclusions

This chapter has provided the basis for deriving a series of capital stocks estimations for Iran. The PIM method in which capital stock is estimated as a weighted sum of past investment flows was employed. The main requirements of the PIM method are a specific retirement pattern and a proper depreciation function. For these purposes an initiated assumption was made about the service lives of assets and then a bell-shaped retirement pattern and a beta-decay depreciation function were employed to derive replacement function. With the information on the past investment time series on asset types and corresponding replacement functions, the net capital stocks for each sector and manufacturing industries were calculated. Moreover, we introduced a technique to exclude eight-year war damage in the estimation. Finally the capital stocks for eight sectors and nine manufacturing industries, for three types of asset i.e., machinery, construction and vehicle equipment were estimated. This study was able to provide a disaggregated capital stock estimation for manufacturing industries, and a method of excluding war damage for the first time. The results of the calculations were compared with those from other approaches, and the differences were particularly great when compared with studies that have not applied the PIM method.

The main limitation of this study was the shortage of detailed time series data on asset types. For this reason we have had to do a considerable amount of adjustment and manipulation of the existing data. From these calculations we shall be able to construct the intersectoral capital coefficient matrix for the most recent input-output table, and this will be the subject of next chapter.

Table 6.1- Average Service Lives of Machinery in Different Sectors

industry code	sector/industry	Average Service Life (year)
1	Agriculture, Forestry and Fisheries	13
2	Mining and Quarrying	10
3	Oil	18
4	Food products, Beverages and Tobacco	9
5.1	Paper products	18
5.2	Woods	15
6	Non-Metallic Mineral products	17
7	Textile and Leather	17
8	Chemical	18
13	Basic Metal products	20
14	Machinery and Equipment	22
15	Motor vehicles and trilers and sem-itrailers	18
16	Construction	9
17	Electricity	18
19.1	Communication	22
19.2	Transport	10

Sources: Agricultural Machinery, PBO, Agriculture Department (1999).
Mining, Construction, and other services' lives, CBIRI, unpublished data.
Transport equipment, Indirect Taxes Law (1988).
Rest of asset types from Austrian and American experiences (Kachooian 1994)

Table 6-2 -Data Collection by: Organisation, Types of Asset, and Time Period

Investment Time Series	Types of Asset	Time Period
Investment time series by sector:		
CBIRI (1)	Two	1959-1998
Investment time series by manufacturing sub-sectors:		
Ministry of Interior (2)	Two	1963
Ministry of Economy (3)	Three	1965-1973
Ministry of Manufacturing (4)	Three	1974-1978
SCI (5)	Three	1973-1980
SCI (6)	Six	1979-1998

(1) a)machinery and transport equipments, b)construction
(2) a)machinery and transport equipments, b)construction and land
(3) a)machinery and transport equipments, b)construction, c)land
(4) a)machinery and transport equipments, b)construction, c)land
(5) a)machinery and transport equipments, b)construction, c)land
(6) a)machinery equipment, b) transport equipment, c) office equipment, d)durable capital goods, e)construction, f)land.

Table 6.3- Annual Production Price Indices by Type of Assets, base year =1991, index set at 100

Sector	Machinery Price Index	Construction 1	2	3	Total manufa-ctruing	17	19.1	19.2	19.3
1959	4.02	3.00	2.91	2.83	2.83	2.95	2.79	2.67	2.93
1960	4.11	3.05	2.94	2.89	2.89	2.92	0.59	2.67	2.94
1961	4.23	2.67	2.57	2.50	2.50	2.59	0.66	2.67	2.57
1962	4.28	2.55	2.50	2.42	2.42	2.51	0.93	2.26	2.50
1963	4.41	2.45	2.38	2.38	2.38	2.39	1.05	2.39	2.40
1964	4.50	2.66	2.57	2.56	2.56	2.61	0.96	2.41	2.57
1965	4.53	2.66	2.60	2.56	2.56	2.57	0.83	2.48	2.61
1966	4.60	2.65	2.62	2.66	2.66	2.62	0.73	2.53	2.60
1967	4.64	2.78	2.74	2.74	2.74	2.73	0.69	2.74	2.74
1968	4.63	2.87	2.81	2.77	2.77	2.82	0.85	2.74	2.82
1969	4.73	3.30	3.25	3.20	3.20	3.22	1.04	3.19	3.26
1970	4.85	3.36	3.29	3.25	3.25	3.29	0.98	3.22	3.29
1971	5.05	3.34	3.27	3.23	3.23	3.28	1.12	3.21	3.27
1972	5.61	3.63	3.56	3.49	3.49	3.58	1.29	3.50	3.56
1973	5.89	4.40	4.33	4.27	4.27	4.34	2.44	4.26	4.32
1974	6.23	5.67	5.56	5.47	5.47	5.58	5.32	5.46	5.56
1975	7.06	6.53	6.32	6.22	6.22	6.32	6.26	6.34	6.32
1976	7.84	8.02	7.63	7.55	7.55	7.62	7.65	7.60	7.63
1977	8.76	10.43	9.76	9.70	9.70	9.75	9.85	9.72	9.76
1978	9.55	11.41	10.45	10.43	10.43	10.44	10.80	10.43	10.44
1979	10.60	12.14	11.39	11.33	11.33	11.39	11.77	11.22	11.39
1980	12.57	14.97	13.73	13.68	13.68	13.71	14.27	13.74	13.73
1981	13.72	17.36	15.60	15.58	15.58	15.60	16.41	15.60	15.59
1982	15.35	20.12	17.39	17.36	17.36	17.38	18.73	17.36	17.39
1983	15.93	23.37	19.84	19.86	19.86	19.84	21.88	19.81	19.85
1984	15.97	26.03	21.91	21.95	21.95	21.91	24.38	21.92	21.93
1985	16.50	27.40	23.20	23.27	23.27	23.18	25.81	23.15	23.19
1986	19.07	31.74	26.93	26.99	26.99	26.87	29.93	26.92	26.93
1987	29.06	39.42	33.88	33.91	33.91	33.80	37.14	34.09	33.91
1988	39.61	51.63	45.01	44.99	44.99	45.01	48.47	44.77	45.03
1989	45.39	62.13	53.47	53.42	53.42	53.52	36.56	53.38	53.48
1990	58.70	79.00	78.90	78.56	78.56	78.80	77.16	78.32	78.84
1991	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The codes are associated with bellow sectors:

1.agriculture,
2. mining,
3. oil,
17. electricity,
19.1 communication,
19.2 transport,
19.3real state.

Table 6.4- Sectoral Investment in Machinery in Current Prices, in billion rial: 1959-1991

Sector	1	2	3	16	17	19.1	19.2
1959	1.0	1.3		1.4			4.9
1960	1.5	1.4		1.6			5.4
1961	1.6	1.2		1.3			3.9
1962	1.4	0.8		1.1			4.8
1963	1.2	0.6		0.9			4.2
1964	2.2	0.8		1.4	0.0		7.2
1965	1.7	1.2	2.4	1.8	0.4	0.1	8.8
1966	1.9	1.5	2.4	2.1	0.6	0.3	9.8
1967	2.0	1.8	6.5	2.8	1.2	0.1	13.8
1968	2.2	1.8	6.5	2.9	1.3	0.4	14.7
1969	2.6	2.1	5.7	3.3	1.5	0.7	16.5
1970	2.8	2.3	4.9	3.5	1.7	1.1	16.6
1971	3.6	3.3	7.3	4.4	2.1	2.9	18.1
1972	7.2	3.9	6.6	5.4	3.2	5.0	23.1
1973	6.7	5.7	4.9	7.2	3.4	6.8	28.9
1974	8.4	8.4	8.2	8.0	3.9	9.2	43.4
1975	16.5	29.6	12.1	22.2	8.5	12.7	76.6
1976	16.8	20.1	13.5	15.2	11.6	15.0	84.6
1977	17.8	17.4	23.1	8.7	19.7	23.9	99.1
1978	12.2	8.6	7.3	5.1	12.8	23.6	63.3
1979	11.1	5.5	26.1	3.4	7.0	6.6	46.9
1980	13.8	2.4	8.1	6.4	6.7	11.2	69.6
1981	22.6	6.9	17.9	13.4	13.8	9.4	80.3
1982	19.0	11.5	39.8	25.1	16.7	12.3	97.7
1983	26.3	15.5	63.2	28.1	20.6	17.7	160.5
1984	28.8	23.7	74.7	29.1	19.8	25.2	209.6
1985	38.6	11.4	22.7	24.8	15.1	24.4	182.9
1986	27.7	8.0	5.7	9.3	10.8	13.7	82.2
1987	23.8	5.7	4.9	8.1	13.3	21.9	117.3
1988	29.8	13.7	5.4	10.7	23.0	7.3	149.3
1989	41.0	19.0	9.7	16.2	36.7	7.2	282.8
1990	63.3	35.4	31.8	37.8	62.3	18.2	328.1
1991	145.4	166.3	105.0	205.9	182.7	49.0	773.0

The codes are associated with the following sectors:

1. agriculture,
2. mining,
3. oil,
16. construction
17. electricity,
19.1 communication,
19.2 transport,

Table 6.5- Sectoral Investment in Construction in Current Prices, in billion rial: 1952-1991

Sector	1	2	3	17	19.1	19.2	19.3
1952	**0.3**	**0.1**	**2.5**	**0.5**	**0.1**	**1.0**	**2.6**
1953	**0.3**	**0.1**	**2.9**	**0.6**	**0.1**	**1.1**	**3.3**
1954	**0.4**	**0.1**	**3.3**	**0.7**	**0.1**	**1.3**	**4.1**
1955	**0.5**	**0.1**	**3.7**	**0.9**	**0.1**	**1.5**	**5.2**
1956	**0.6**	**0.1**	**4.3**	**1.0**	**0.1**	**1.8**	**6.6**
1957	**0.7**	**0.2**	**4.9**	**1.3**	**0.1**	**2.1**	**8.3**
1958	**0.8**	**0.2**	**5.5**	**1.5**	**0.2**	**2.4**	**10.5**
1959	**1.0**	**0.2**	**6.3**	**1.8**	**0.2**	**2.8**	**13.2**
1960	1.7	0.3	7.3	2.0	0.2	3.5	3.3
1961	2.1	0.3	7.7	2.1	0.2	3.1	4.1
1962	2.0	0.2	5.5	1.4	0.3	4.1	5.5
1963	2.4	0.2	5.7	1.5	0.4	4.7	7.1
1964	3.3	0.2	5.5	1.5	0.5	6.2	7.1
1965	2.7	0.4	9.0	2.5	0.6	8.0	8.6
1966	1.9	0.3	6.8	3.1	0.7	7.5	8.0
1967	4.5	0.5	10.5	5.0	0.6	10.5	8.1
1968	4.9	1.5	12.6	4.8	0.9	10.5	10.1
1969	5.7	2.2	13.8	4.8	3.4	10.5	12.9
1970	6.7	2.7	10.0	3.9	6.5	10.7	15.5
1971	10.2	2.1	15.1	9.3	9.7	13.0	17.8
1972	12.4	2.0	24.5	9.3	9.3	16.9	25.7
1973	18.3	3.4	31.5	8.8	8.8	12.9	53.0
1974	41.0	3.4	40.7	19.6	8.3	26.6	134.5
1975	49.2	7.6	63.4	35.9	13.0	39.8	223.6
1976	56.5	7.7	260.0	90.6	24.7	57.6	390.6
1977	62.8	11.5	202.0	166.9	29.0	67.7	471.5
1978	52.1	11.2	169.8	118.5	33.4	114.9	464.7
1979	55.2	8.7	65.7	39.0	5.3	73.1	478.1
1980	72.4	10.2	67.6	59.5	9.1	81.0	622.8
1981	80.4	7.8	84.6	58.9	14.2	89.5	594.4
1982	82.3	10.1	126.7	96.2	21.5	106.8	681.1
1983	133.6	13.0	143.2	100.9	19.4	143.7	1284.5
1984	88.1	14.5	82.3	175.9	33.2	151.6	1383.3
1985	82.4	12.6	102.6	133.4	6.8	124.0	1365.6
1986	99.4	14.4	131.5	136.7	29.0	123.9	1269.4
1987	136.0	20.4	83.6	134.8	16.3	128.1	1317.8
1988	172.7	21.0	116.5	90.4	19.6	181.8	1314.9
1989	182.2	23.1	166.4	112.4	49.5	135.0	1571.8
1990	336.9	31.3	178.8	191.8	39.7	261.6	2030.2
1991	439.4	95.0	526.3	407.4	141.7	493.4	3050.8

Sources: bold figures are manipulated, and others are calculated from CBIRI (1994 &1982).

The codes are associated with bellow sectors:

1. agriculture, 2. mining, 3. oil, 17. electricity,
19.1 communication, 19.2 transport, 19.3 real state.

Table 6.6-Sectoral Investment in Vehicle in Current Prices, in billion rials, 1956-1991

Sector	1	2	3	16	17	19.1	19.2
1959	0.4	0.2		0.9			1.8
1960	0.6	0.2		0.9			2.0
1961	0.6	0.2		0.7			1.5
1962	0.5	0.1		0.6			1.8
1963	0.5	0.1		0.5			1.5
1964	0.9	0.1		0.8	0.1		2.7
1965	0.7	0.2	0.1	1.1	0.5	0.1	3.3
1966	0.7	0.2	0.1	1.3	1.0	0.1	3.7
1967	0.9	0.3	0.2	1.7	1.9	0.1	5.1
1968	0.9	0.3	0.2	1.8	2.0	0.2	5.5
1969	1.1	0.3	0.2	2.0	2.2	0.3	6.1
1970	1.1	0.4	0.2	2.1	2.5	0.5	6.2
1971	1.5	0.6	0.3	2.6	3.2	1.4	6.8
1972	2.9	0.7	0.2	3.2	4.8	2.4	8.6
1973	2.5	0.9	0.2	4.3	5.3	3.3	10.8
1974	3.4	1.4	0.3	4.7	6.0	4.4	16.1
1975	6.5	5.0	0.4	13.2	12.9	6.1	28.5
1976	6.7	3.4	0.5	9.0	17.8	7.1	31.5
1977	7.1	2.9	0.8	5.2	30.1	11.4	36.9
1978	4.9	1.4	0.3	3.0	19.6	11.3	23.6
1979	4.4	0.9	0.9	2.1	10.7	3.1	17.5
1980	5.5	0.4	0.3	3.9	10.3	5.3	25.9
1981	8.9	1.2	0.6	8.0	21.0	4.5	29.9
1982	7.6	1.9	1.4	15.0	25.6	5.8	36.3
1983	10.5	2.6	2.2	16.7	31.4	8.5	59.7
1984	11.4	4.0	2.6	17.3	30.2	12.0	78.0
1985	15.3	1.9	0.8	14.8	23.1	11.7	68.1
1986	10.9	1.3	0.2	5.6	16.6	6.5	30.6
1987	9.4	0.9	0.2	4.8	20.3	10.4	43.7
1988	11.8	2.3	0.2	6.4	35.1	3.5	55.5
1989	16.3	3.2	0.3	9.6	56.0	3.5	105.2
1990	25.1	5.9	1.1	22.5	95.0	8.7	122.1
1991	58.4	27.9	3.7	122.9	279.0	23.3	287.6

Sources: author research calculation.

1. agriculture, 2. mining,
3. oil, 16. Construction
17. electricity, 19.1 communication,
19.2 transport,

Table 6.7- Manufacturing Industries Investment in Machinery in current prices, in billion rials, 1963-1991

Year	4	5.1	5.2	6	7	8	13	14	15
1963	**0.045**	**0.003**	**0.006**	**0.009**	**0.098**	**0.010**	**0.023**	**0.026**	**0.000**
1964	**0.077**	**0.017**	**0.036**	**0.010**	**0.159**	**0.012**	**0.003**	**0.078**	**0.000**
1965	**0.078**	**0.009**	**0.007**	**0.039**	**0.164**	**0.029**	**0.005**	**0.122**	**0.001**
1966	**1.810**	**0.206**	**0.055**	**0.299**	**1.114**	**0.168**	**0.196**	**3.442**	**0.015**
1967	**1.891**	**0.235**	**0.047**	**0.323**	**1.166**	**0.166**	**0.019**	**0.354**	**0.015**
1968	**1.912**	**0.292**	**0.244**	**1.103**	**2.883**	**0.833**	**1.445**	**1.136**	**0.085**
1969	**2.002**	**0.125**	**0.233**	**0.472**	**1.645**	**4.968**	**1.154**	**1.093**	**0.033**
1970	**1.974**	**1.014**	**0.057**	**1.750**	**2.599**	**4.776**	**1.023**	**1.160**	**0.025**
1971	**2.398**	**0.251**	**0.129**	**1.485**	**3.278**	**0.663**	**1.124**	**1.229**	**0.014**
1972	**2.433**	**0.334**	**0.074**	**2.570**	**5.199**	**1.680**	**0.141**	**0.530**	**0.012**
1973	**1.704**	**0.499**	**0.096**	**1.013**	**4.298**	**1.691**	**1.608**	**8.019**	**0.072**
1974	**3.070**	**2.104**	**0.234**	**5.312**	**7.795**	**16.875**	**2.573**	**12.700**	**0.028**
1975	**3.224**	**0.928**	**0.188**	**9.414**	**1.344**	**10.218**	**2.117**	**2.777**	**0.039**
1976	**3.996**	**0.705**	**0.242**	**11.781**	**1.613**	**12.788**	**1.118**	**4.256**	**0.071**
1977	**2.365**	**1.651**	**0.626**	**8.865**	**10.339**	**9.622**	**19.824**	**5.102**	**0.086**
1978	**3.884**	**1.493**	**0.424**	**5.194**	**10.451**	**5.638**	**20.191**	**2.467**	**0.105**
1979	3.553	1.139	0.553	11.826	5.483	3.348	10.521	3.716	0.016
1980	5.033	1.929	0.240	5.788	4.467	2.933	0.494	9.965	0.009
1981	6.658	2.106	0.792	0.841	6.658	4.039	1.432	13.003	0.063
1982	5.934	0.873	0.868	6.721	9.721	6.070	16.014	7.654	0.103
1983	10.013	1.847	1.330	11.515	12.338	7.388	2.821	11.036	0.120
1984	7.843	1.998	0.646	11.115	7.496	8.420	2.890	13.830	0.179
1985	8.953	1.225	1.160	10.747	7.810	7.665	2.654	10.815	0.325
1986	9.803	0.901	0.475	13.987	9.853	7.392	2.333	9.205	0.292
1987	24.439	5.407	5.093	18.823	18.330	11.237	4.203	29.497	0.663
1988	22.017	3.485	4.808	28.974	18.736	15.300	12.841	37.183	1.538
1989	25.361	9.094	7.027	35.736	29.012	30.649	6.105	50.608	2.025
1990	32.365	8.306	5.961	34.355	41.960	21.287	13.846	46.389	3.657
1991	34.152	8.444	3.425	38.714	65.857	37.417	30.159	62.399	0.797

Sources: bold figures are drawn from calculations, and others are derived from SCI (1963-1991).

The codes are associated with the following sectors:

4. food industry
5.1 paper industry
5.2. wood industry
6. Non-metalic industry
7. Textile industry
8. chemical industry
13. Basic metal industry
14. Machinery industry
15. Motor vehicle industry

Table 6.8- Manufacturing Industries Investment in Construction in Current Prices, in billion, 1952-1991

Sector	4	5.1	5.2	6	7	8	13	14	15
1952	**0.003**	**0.000**	**0.000**	**0.000**	**0.002**	**0.000**	**0.000**	**0.001**	**0.000**
1953	**0.003**	**0.000**	**0.000**	**0.000**	**0.003**	**0.000**	**0.000**	**0.002**	**0.000**
1954	**0.004**	**0.000**	**0.001**	**0.000**	**0.004**	**0.000**	**0.000**	**0.002**	**0.000**
1955	**0.005**	**0.000**	**0.001**	**0.000**	**0.004**	**0.001**	**0.000**	**0.003**	**0.000**
1956	**0.006**	**0.001**	**0.001**	**0.001**	**0.005**	**0.001**	**0.000**	**0.003**	**0.000**
1957	**0.007**	**0.001**	**0.001**	**0.001**	**0.007**	**0.001**	**0.000**	**0.004**	**0.000**
1958	**0.009**	**0.001**	**0.001**	**0.001**	**0.008**	**0.001**	**0.000**	**0.005**	**0.000**
1959	**0.011**	**0.001**	**0.002**	**0.001**	**0.010**	**0.001**	**0.000**	**0.006**	**0.000**
1960	**0.014**	**0.001**	**0.002**	**0.001**	**0.012**	**0.002**	**0.000**	**0.007**	**0.000**
1961	**0.017**	**0.002**	**0.003**	**0.002**	**0.015**	**0.002**	**0.000**	**0.009**	**0.000**
1962	**0.020**	**0.002**	**0.004**	**0.002**	**0.019**	**0.003**	**0.001**	**0.012**	**0.000**
1963	0.025	0.003	0.005	0.003	0.023	0.004	0.001	0.014	0.000
1964	0.034	0.003	0.001	0.005	0.025	0.009	0.019	0.060	0.000
1965	0.047	0.001	0.004	0.003	0.070	0.014	0.001	0.074	0.000
1966	0.764	0.010	0.032	0.078	0.465	0.049	0.004	0.738	0.002
1967	0.790	0.013	0.033	0.083	0.504	0.046	0.000	0.077	0.003
1968	0.675	0.030	0.051	0.585	0.507	0.281	0.226	0.321	0.032
1969	0.695	0.011	0.144	0.441	1.121	0.697	1.200	0.481	0.004
1970	0.662	0.685	0.038	0.596	0.472	0.951	1.083	0.673	0.010
1971	1.010	0.042	0.010	0.718	0.106	0.126	0.177	0.445	0.010
1972	1.108	0.062	0.012	1.150	0.658	0.306	0.031	0.205	0.000
1973	0.056	0.103	0.006	0.062	0.219	0.172	0.180	0.337	0.019
1974	0.110	0.436	0.013	0.420	0.378	1.672	0.288	0.444	0.024
1975	**2.137**	**0.531**	**0.119**	**5.987**	**0.757**	**5.987**	**2.286**	**1.990**	**0.026**
1976	**3.542**	**0.286**	**0.109**	**5.317**	**0.645**	**5.317**	**1.207**	**2.164**	**0.031**
1977	**3.305**	**0.952**	**0.399**	**5.681**	**5.870**	**5.681**	**21.409**	**3.683**	**0.038**
1978	**6.271**	**1.190**	**0.373**	**4.600**	**8.199**	**4.600**	**21.805**	**2.461**	**0.046**
1979	2.187	0.909	0.166	5.485	0.912	0.906	0.128	2.961	0.004
1980	2.879	0.277	0.393	3.577	1.289	0.933	0.129	4.804	0.004
1981	2.745	0.594	0.182	2.863	2.745	2.422	0.190	7.173	0.013
1982	2.251	0.199	0.392	3.433	4.147	1.734	2.477	2.088	0.005
1983	3.582	0.648	0.584	5.380	6.042	2.707	0.337	4.602	0.052
1984	4.303	1.134	0.373	6.126	5.947	3.754	0.847	3.484	0.065
1985	5.388	1.357	0.401	6.958	5.939	4.410	1.889	4.914	0.045
1986	6.533	0.806	0.859	8.764	6.401	4.377	1.967	7.557	0.041
1987	17.982	2.393	4.522	8.015	14.343	6.212	2.947	20.831	0.234
1988	13.068	1.502	3.212	6.820	19.742	8.522	10.521	11.508	0.095
1989	13.094	2.137	2.696	14.976	11.458	13.728	2.551	17.918	0.481
1990	28959	2.423	4.525	15.421	17.184	14.757	7.159	19.795	0.973
1991	15.794	7.618	4.156	11.985	22.312	15.834	78.449	35.825	0.412

Sources: bold figures are drawn from calculations and others are derived from SCI (1963-1991).

The codes are associated with the following sectors:

4. food industry 5.1 paper industry 5.2. wood industry 6. Non-metalic industry
7. Textile industry 8. chemical industry 13. Basic metal industry 14. Machinery industry
15. Motor vehicle industry

Table 6.9-Manufacturing Industries Investment in Vehicles in Current Prices, in billion rials, 1963-1991

Year	4	5.1	5.2	6	7	8	13	14	15
1963	**0.009**	**0.000**	**0.002**	**0.002**	**0.010**	**0.001**	**0.002**	**0.001**	**0.000**
1964	**0.014**	**0.002**	**0.009**	**0.002**	**0.016**	**0.002**	**0.000**	**0.003**	**0.000**
1965	**0.015**	**0.001**	**0.002**	**0.009**	**0.017**	**0.004**	**0.000**	**0.005**	**0.000**
1966	**0.343**	**0.024**	**0.013**	**0.073**	**0.112**	**0.024**	**0.016**	**0.138**	**0.002**
1967	**0.358**	**0.028**	**0.011**	**0.078**	**0.118**	**0.024**	**0.002**	**0.014**	**0.002**
1968	**0.363**	**0.034**	**0.057**	**0.268**	**0.291**	**0.121**	**0.116**	**0.046**	**0.009**
1969	**0.380**	**0.015**	**0.055**	**0.115**	**0.166**	**0.719**	**0.092**	**0.044**	**0.004**
1970	**0.374**	**0.120**	**0.013**	**0.425**	**0.262**	**0.691**	**0.082**	**0.047**	**0.003**
1971	**0.455**	**0.030**	**0.030**	**0.360**	**0.330**	**0.096**	**0.090**	**0.049**	**0.002**
1972	**0.461**	**0.039**	**0.018**	**0.624**	**0.524**	**0.243**	**0.011**	**0.021**	**0.001**
1973	**0.323**	**0.059**	**0.023**	**0.246**	**0.433**	**0.245**	**0.129**	**0.321**	**0.008**
1974	**0.582**	**0.248**	**0.055**	**1.289**	**0.786**	**2.443**	**0.206**	**0.509**	**0.003**
1975	**0.514**	**0.109**	**0.044**	**2.284**	**0.136**	**1.479**	**0.169**	**0.111**	**0.004**
1976	**0.637**	**0.083**	**0.057**	**2.858**	**0.163**	**1.852**	**0.089**	**0.171**	**0.008**
1977	**0.377**	**0.194**	**0.147**	**2.151**	**1.042**	**1.393**	**1.585**	**0.205**	**0.010**
1978	**0.619**	**0.176**	**0.100**	**1.260**	**1.054**	**0.816**	**1.614**	**0.099**	**0.012**
1979	0.319	0.028	0.024	0.329	0.053	0.033	0.100	0.149	0.003
1980	0.465	0.041	0.028	0.867	0.125	0.147	0.088	0.487	0.005
1981	0.718	0.108	0.033	1.188	0.718	0.517	0.031	1.084	0.005
1982	1.541	0.146	0.268	1.338	0.790	0.898	0.332	1.012	0.012
1983	3.894	0.424	0.354	3.388	1.214	1.280	0.364	2.258	0.017
1984	3.845	0.451	0.429	3.776	2.243	1.523	0.585	2.239	0.019
1985	2.815	0.354	0.430	3.418	1.221	1.473	0.707	2.174	0.026
1986	1.066	0.109	0.194	2.691	0.816	0.675	0.346	0.990	0.026
1987	1.965	0.207	0.186	2.043	1.169	1.377	4.281	2.593	0.089
1988	1.940	0.313	1.314	2.327	2.857	2.877	1.814	4.676	0.260
1989	3.032	0.428	0.856	4.386	2.764	2.657	0.546	3.720	0.023
1990	5.897	0.579	1.120	7.187	2.246	6.000	1.848	6.858	0.485
1991	10.710	2.124	2.017	15.902	8.949	11.272	9.321	17.632	0.298

Sources: bold figures are drawn from calculations and others are derived from SCI (1963-1991).

The codes are associated with the following sectors:

4. food industry
5.1 paper industry
5.2. wood industry
6. Non-metalic industry
7. Textile industry
8. chemical industry
13. Basic metal industry
14. Machinery industry
15. Motor vehicle industry

Table 6.10- Sectoral War Damage in the Machinery Assets, in billion

Year	1	2	3	16	17	19.1	19.2	Total
1980	9.87	0.21	6.00	0.03	2.62	0.34	18.08	151.57
1981	18.72	0.41	11.38	0.06	4.97	0.65	34.29	287.45
1982	4.07	0.09	2.48	0.01	1.08	0.14	7.46	62.53
1983	50.20	1.09	30.53	0.17	13.33	1.74	91.94	770.74
1984	47.17	1.02	28.68	0.16	12.52	1.64	86.39	724.17
1985	44.07	0.95	26.80	0.15	11.70	1.53	80.71	676.59
1986	40.05	0.87	24.35	0.13	10.63	1.39	73.34	614.84
1987	55.49	1.20	33.74	0.19	14.73	1.93	101.63	851.96
1988	128.73	2.79	78.28	0.43	34.17	4.47	235.76	1976.39

Source: author's calculation

Table 6.11- Sectoral War Damage in the Construction Assets, in billion

Year	1	3	2	17	19.1	19.2	19.3	Total
1980	19.28	203.51	0.57	3.44	0.35	2.05	0.06	277.16
1981	22.32	235.54	0.67	3.98	0.41	2.38	0.07	356.16
1982	3.29	34.76	0.10	0.59	0.06	0.35	0.01	58.92
1983	66.29	699.56	1.98	11.83	1.22	7.06	0.22	1031.61
1984	15.49	163.43	0.46	2.76	0.28	1.65	0.05	412.88
1985	36.23	382.38	1.08	6.47	0.66	3.86	0.12	644.52
1986	433.11	4570.73	12.91	77.28	7.94	46.14	1.44	5343.77
1987	40.36	425.92	1.20	7.20	0.74	4.30	0.13	748.97
1988	8.17	86.22	0.24	1.46	0.15	0.87	0.03	721.44

Source: author's calculation

Table 6.12 – Sectoral War Damage in the Vehicles Assets, in billion

Year	1	2	3	16	17	19.1	19.2	Total
1980	1.67	0.04	0.21	0.02	1.72	0.16	6.73	47.15
1981	3.17	0.07	0.40	0.04	3.26	0.31	12.76	89.42
1982	0.69	0.01	0.09	0.01	0.71	0.07	2.78	19.45
1983	8.49	0.18	1.08	0.10	8.73	0.83	34.21	239.76
1984	7.98	0.17	1.01	0.09	8.20	0.78	32.14	225.27
1985	7.46	0.16	0.95	0.09	7.66	0.73	30.03	210.47
1986	6.78	0.15	0.86	0.08	6.96	0.66	27.29	191.26
1987	9.39	0.20	1.19	0.11	9.65	0.92	37.81	265.02
1988	21.78	0.47	2.76	0.26	22.38	2.13	87.72	614.80

Source: author's calculation.

The codes are associated with the following sectors:

1. agriculture, 2.mining,
3. oil, 16. Construction
17. electricity, 19.1 communication,
19.2 transport, 19.3. real state

Table 6.13-Machinery War Damage in Manufacturing Industries, in billion

Year	4	5.1	5.2	6	7	8	13	14	15	Total
1980	7.02	1.16	0.43	1.76	6.37	4.67	2.14	7.53	0.03	31.13
1981	12.11	1.60	0.39	2.67	10.73	9.77	4.35	17.63	0.01	59.25
1982	2.26	0.43	0.17	0.93	2.43	1.42	1.27	3.94	0.01	12.87
1983	27.88	5.29	2.08	11.50	30.00	17.56	15.60	48.60	0.18	158.69
1984	22.28	4.53	2.15	11.49	28.81	16.97	18.18	44.56	0.21	149.18
1985	21.27	4.26	1.91	9.98	24.85	14.04	16.49	46.48	0.17	139.44
1986	26.88	3.96	2.16	9.85	25.54	15.09	15.66	26.84	0.17	126.15
1987	40.80	4.40	6.02	18.97	39.84	16.75	9.08	36.98	1.28	174.12
1988	82.63	10.99	18.00	37.53	104.01	35.86	23.70	88.85	3.61	405.18

Source: author's calculation.

Table 6.14-Construction War Damage in Manufacturing Industries, in billion

Year	4	5.1	5.2	6	7	8	13	14	15	Total
1980	1.08	0.17	0.07	0.28	0.91	0.69	0.32	1.10	0.00	4.62
1981	1.14	0.14	0.04	0.26	0.93	0.88	0.39	1.56	0.00	5.35
1982	0.14	0.03	0.01	0.06	0.14	0.09	0.08	0.24	0.00	0.79
1983	2.90	0.52	0.22	1.25	2.89	1.76	1.56	4.78	0.02	15.90
1984	0.58	0.11	0.06	0.31	0.69	0.42	0.45	1.09	0.00	3.71
1985	1.38	0.26	0.13	0.68	1.49	0.88	1.03	2.85	0.01	8.69
1986	22.91	3.17	1.91	8.78	20.15	12.38	12.83	21.61	0.13	103.88
1987	2.34	0.24	0.36	1.14	2.11	0.92	0.50	2.00	0.07	9.68
1988	0.41	0.05	0.09	0.20	0.48	0.17	0.11	0.42	0.02	1.96

Source: author's calculation.

Table 6.15- Vehicle War Damage in Manufacturing Industries, in billion

Year	4	5.1	5.2	6	7	8	13	14	15	Total
1980	1.33	0.14	0.10	0.43	0.64	0.68	0.31	0.93	0.00	4.56
1981	2.29	0.19	0.09	0.65	1.08	1.41	0.62	2.17	0.00	8.52
1982	0.43	0.05	0.04	0.23	0.25	0.21	0.18	0.49	0.00	1.87
1983	5.29	0.62	0.49	2.79	3.02	2.54	2.24	6.00	0.02	23.01
1984	4.22	0.53	0.51	2.79	2.90	2.46	2.61	5.50	0.02	21.54
1985	4.03	0.50	0.45	2.42	2.51	2.03	2.37	5.73	0.02	20.06
1986	5.10	0.47	0.51	2.39	2.57	2.19	2.25	3.31	0.02	18.80
1987	7.74	0.52	1.42	4.60	4.02	2.43	1.30	4.56	0.14	26.72
1988	15.67	1.30	4.24	9.11	10.49	5.19	3.40	10.96	0.40	60.75

Source: author's calculation.

The codes are associated with the following sectors:

4. food industry
5.1 paper industry
5.2. wood industry
6. Non-metalic industry
7. Textile industry
8. chemical industry
13. Basic metal industry
14. Machinery industry
15. Motor vehicle industry

Table 6.16 - Net Fixed Capital Stock Type by Sector in 1991 Price

Sector/Industry	Machinery Equipment	Construction	Transport Equipment	Total Capital Stock
Agriculture sector	1018.13	9183.90	455.04	10657.07
Mining sector	579.67	129.34	77.91	786.92
Oil sector	3127.28	5192.84	38.06	8358.18
Food industry	447.60	651.83	40.88	1140.31
Paper industry	135.53	109.09	7.70	252.33
Woods industry	72.79	66.94	1.15	140.88
Non-metallic industry	812.73	660.92	94.79	1568.44
Textile industry	586.59	531.28	24.67	1142.53
Chemical industry	776.17	519.85	44.77	1340.79
Basic metal industry	657.15	706.32	47.42	1410.89
Machinery industry	1150.42	105.80	605.11	1861.33
Motor vehicle industry	290.04	227.36	49.43	566.83
Construction sector	787.58	-	611.41	1398.99
Electricity sector	1164.89	11735.44	1383.48	14283.81
Communication sector	2009.21	3426.80	374.07	5810.09
Transport sector	12394.09	13621.11	2278.24	28293.44
Real state sector	-	86448.54	-	86448.54

Source: author's calculation.

Table 6.17 - Different Approaches of Calculating Total Capital Stock in Iran in 1991 price

Sector/Industry code	CBIRI (1)	Gharoon(2)	Amini (3)	This Study
Agriculture sector	10365.85	5736.93	5152.34	10657.07
Mining sector	895.63	-	-	786.92
Oil sector	14233.78	7269.46	6509.76	8358.18
Manufacturing and mining	12012.79	59578.35	9155.14	9669.02
Food industry	-	-	-	1730.18
Paper industry	-	-	-	333.30
Wood industry	-	-	-	189.60
Non-metallic industry	-	-	-	1801.05
Textile industry	-	-	-	1684.37
Chemical industry	-	-	-	1524.72
Basic metal industry	-	-	-	1410.89
Machinery industry	-	-	-	1861.33
Motor vehicle industry	-	-	-	566.83
Total manufacturing	11117.16	-	-	8882.40
Construction sector	679.68	-	966.96	1398.99
Electricity sector	11488.44	-	9184.35	14283.81
Communication sect.	3217.38	-	3810.01	5810.09
Transport sector	19848.37	-	19035.93	28293.44
Real state sector	63134.81	-	-	86448.54
Total service sector	123435.66	28658.16	64253.14	171280.38

Sources:
(1) - CBIRI, unpublished research,
(2) - Gharoon 1994,
(3) - Amini 1997
This study: author's research

CHAPTER SEVEN: AN INTER-INDUSTRIAL CAPITAL COEFFICIENTS MATRIX

7.1. Introduction

Analyses of dynamic models such as those discussed in chapters 3, 4 and 5 require knowledge of capital-output (or capital-capacity) ratios. These ratios are analogous to the input-output current ratios used in the static model. Current ratios only include relations between current flows and current outputs and therefore exclude stock-flow relationships. Efforts to construct a capital coefficient matrix for development of the dynamic model in Iran do not have a very long history. This is not because of any lack of recognition of the importance of this matrix and dynamic analysis, but because of a lack of the required data. Therefore an experimental attempt in this direction was made by Banouei (1989) in 1974. As he pointed out in relation to his ten by ten capital coefficient matrix, what it needed is more reliable and more disaggregated information. This study aims to use more reliable and accurate data to estimate fixed and working capital stock and corresponding capital-output ratios in order to construct a capital coefficient matrix using the same method as that used in Banouei's initial attempt.

The main significance of the capital coefficients matrix lies in its importance for dynamic analysis. When input-output information is restricted to the current flows, only a static analysis is possible, but what happens to the economic system if the capacity of a certain industry is expanding? Here, the capital coefficient tells us that for each additional unit of capacity a certain amount of additional capital will be needed, similarly the inventory coefficients indicate the necessary increase in working capital. For long-run planning and dynamic analytical purposes, it is necessary to supplement the current flow table with a separate capital coefficients matrix. This is so because it is propounded to be the heart and engine of dynamic input-output analysis. So, the availability of a capital coefficients matrix enables us to perform a wide range of long-term planning operations by using dynamic input-output methods.

The concept of a capital coefficient is defined as the quantity of capital required per unit of capacity in an industry, including stocks of various types of equipment, buildings, and inventories. So, capital coefficients would be the ratios of the number of units of a given type of capital to the maximum output mentioned above, and in the short-term the proportion of the different types of capital would be fixed by the technique employed. Once this concept of fixed capital coefficients is accepted, the next problem is that of obtaining an empirical estimation of the capital coefficients. It should be mentioned that for the purpose of deriving capital coefficients two items can be defined- incremental and average capital coefficients. The actual ratio of capital to output (or capacity) differs considerably from the ratio of increments of capital to increments of output (or capacity). The scale of this difference depends on the rate of change of technique in the industry in question. For the purpose of dynamic analysis, such as those models discussed in chapter 2, incremental rather than average capital coefficients are needed (Grosse 1953). The incremental capital coefficients can be derived either from data on the construction of new plants or directly from engineering sources. Because of data limitations, capital coefficients in this study represent average rather than incremental coefficients.

The flow coefficients are expressed in terms of output units, whilst as in the case of capital coefficients they are usually described in terms of capacity units. An industry rarely operates at maximum short-run capacity, due to marketing conditions, differences in shifts, the requirement for repairs, and the maintenance of a normal spare capacity. So, capital equipment is usually maintained on the basis of capacity rather than actual output, and capital coefficients computed in this study are capital-capacity ratios rather than capital-output ratios.

In this chapter fixed and working capital coefficients of Iranian industries for the year 1991 are presented according to a 15-industry classification. This chapter also reviews experience in other countries, describing and explaining the sources of data and the method of calculation, and provides some interpretation of the results compared with the first (Banouei) estimation in Iran.

7.2. The Theoretical Structure of the Capital Coefficients Matrix

In fact the capital coefficients matrix in a dynamic input-output model is a disaggregated version of the simple Harrod-Domar model of capital-output ratios (Mathur 1967). The difference between the dynamic and static input-output model is as follows: sectoral capital formation in the static version of input-output model is a component of final demand with the same exogenous character as any other component of final demand (consumer purchases, government purchases, and exports), which justifies the use of the model for short-term periods under the assumption of constant technology. By contrast, in the dynamic model capital formation is treated as endogenous and placed on the left hand side of the model, where the current transaction of goods and services and corresponding capital transactions are not only distinguishable but also operating simultaneously within the economy. Such a distinction makes the dynamic input-output model so flexible that not only can excess capacity be created, but also the growth path of the economy over the time horizon can be achieved (Mathur and Bharradwaj 1967). Thus, the main difference between static and dynamic versions is the position and treatment of capital coefficients. In this respect analysis of dynamic models requires knowledge of sectoral capital-output ratios, (which are analogous to the input-output ratios used in the static model), and require reliable data about the interdependence of stock flows, known as a capital flow coefficients matrix.

The general concept of a sectoral capital-output ratio is the quantity of capital required per unit of capacity in an industry. Leontief's matrix of capital coefficients describes the capital stock requirements of each industry represented by the column, for the purpose of producing its output. The capital-output ratio is defined in two ways: i) by the average capital-output ratio (ACR) and ii) increment capital-output ratio (ICR). As Leontief's input-output system enjoys constant returns to scale so that ACR equals ICR, the main aspect of the two definitions in theory are very close (Grosse 1953). ACR is derived from estimates of the total fixed capital stock of the individual industries and their corresponding capacities for a given year. Otherwise, the incremental capital-output means that new plants or additions to existing facilities lead to corresponding changes in capacity. Estimating ACR is easier and faster than ICR. ICR requires data on newly constructed plants or direct engineering information for the specific year that should have been provided previously. In most of the countries no surveys have been made of new plants and additions to the corresponding new capacity. Even if one can find the new plants, it is not easy to estimate their excess capacity. Whether ACR or ICR is considered has an effect on the size of the capital-output ratios. Empirical evidence shows that countries rarely provide capital-output ratios at the level of capacity utilization due to the unavailability of data. Although empirically the two items provide different figures, theoretically there should be no difference because of the assumption of a linear production function in the input-output system, as mentioned earlier.

Leontief's matrix of capital coefficients describes the capital stock requirements of each industry represented by the column, for the purpose of producing its output. Different scholars have presented different definitions of capital coefficients. It should be noted that the definition of the capital-output ratio has affected the method of constructing the capital coefficients matrix. For example; if each element of the capital coefficients matrix is defined as "capital stock in the i^{th} the sector that is necessary for one unit of production in the j^{th} the sector"[1], the concept and the value of each element in that matrix should differ when it is defined as: "the stock of the particular kinds of goods-machine tools, industrial buildings, working inventories of primary or intermediate material produced by industry i that industry j has to employ per unit of its output (Leontief 1985)"[2]. We kept the last definition through constructing the capital coefficient matrix. Therefore, we could calculate the value of the output of sector i that is held by sector j as stock, then estimate a "capital coefficients" by dividing this holding of stock by the capacity of sector j over the same period. Along with fixed capital items such as buildings and machinery, those goods bought as inventory (finished goods, raw material, and semi-finished goods) by sector j, for use as inputs in later production, are also included in the coefficients. So the capital coefficient is interpreted as the amount of sector i's product (in rials) held as capital stock and inventory for production of one rial's worth of output by sector j.

The structural characteristics of the economy in the dynamic model are described by the square matrix of technical flow coefficients that specifies the direct current input requirements of all industries, and the corresponding square matrix of capital coefficients. According to Leontief (1970), the capital coefficients matrix (B) is a square matrix with the same dimensions as the corresponding technical flow coefficients matrix.

---

[1] This is consistent with the definition of ACR.

[2] The methodology of construction will be described in Indian experience.

Moreover, there is general agreement in this respect and most empirical works in countries such as America (Groose 1953), India (Mathur and Bharadwaj 1976) and Japan (Tsukui and Murakami 1979) suggest that it is more appropriate and realistic to use a square B matrix. According to their method, there is no row with all zero elements in the square capital coefficients matrix, so that they do not encounter the singularity problem when it is required to invert the B matrix. Taken into account of this technical problem, we followed their experience and in the next section, the methodology of construction is described in detail.

7.3. The Methodology of Constructing a Capital Coefficient Matrix

As well as reviewing the early empirical work of Banouei (1989) in constructing a capital coefficients matrix for Iran for the year 1974, it would be also useful to review other countries' experience. An investigation of this kind could be helpful to identify the best technique. So, for this reason this section will cover the methodologies and estimates of the capital coefficients that have been undertaken in other developed and developing countries, countries including: the United States, the United Kingdom, and India.

7.3.1. American Experiences

7.3.1.1. Ex post Method

There is no comprehensive information regarding the methodological estimation of the capital coefficients matrix for the United States. Discussion in this context is limited to the work of Grosse (1953) and Ritz *et al.* (1973), which has not provided a method for estimating the capital coefficients matrix, but rather it presents a general picture of the capital output ratio for the American economy in 1939. The first attempt (Grosse 1953) provided capital-output ratios of the American industries for the year 1939. For this purpose, of those industries for which information was available, ICRs or ACRs of net and gross value of capital stock were estimated. And the working capital coefficients (inventory stock coefficients) are based on stock figures which combine for each kind of commodity the stocks of finished goods held *for* that industry and the stocks of supplies, raw materials and goods in process held *by* the industry at the end of the reference year. He noted that for the purpose of input-output analysis, finished goods inventories are associated with the industry for which they are being held, i.e. the consuming industry, rather than the producing industry. So the inventory for raw materials and goods in process was assumed to be proportional to the inputs of the corresponding industries, whereas for finished goods the output proportions of the corresponding industries were sidered (Grosse 1953). On the other hand, Ritz *et al.* (1973), in the estimation of the inventory coefficients through the 1963 American input-output table, defined the inventory data as the stocks held by industries during the beginning and end of year not at the closing of the year as estimated by Grosse. As a result of such variations in the nature of available data, different methods were considered. Grosse also has adopted a number of methods for estimating maximum capacity. Maximum capacities were estimated in a number of ways: a) the use of independent estimates; b) the selection of a year or month of peak output reasonably close to the corresponding year; and c) the determination of a capacity output by finding a year of maximum utilization of capital.

Another attempt has been made to construct the capital coefficients matrix. This matrix has been estimated for the 'region' of West Virginia and incorporates two matrices, one for expansion capital and the other for replacement capital expenditures (Miernyk *et al.* 1970).

7.3.1.2. Ex ante Method

Battelle-Columbus developed an alternative (ex ante) method not only for constructing the transactions tables but also for estimating capital coefficients and calculating the flow coefficients directly. Battelle-Columbus researchers developed an 82-sector I/O table and capital coefficients during 1966-67 and predicted them for the United States in 1975 by using ex ante method. Their method of constructing the transaction matrix and capital coefficients appears to be completely different, and the differences are fundamental. Battelle's researchers not only consider flow and capital coefficients beyond the current technology, but also forecast the kind of technology a given sector would be using in a given year. Their technique can be described as a series of steps (Fisher and Chilton 1975):

- The first step in generating either an input-output table or a capital coefficients matrix is to define the sectors into which the economy will be divided; it is similar to the ex post method.
- The second step is to express current and projected technology in coefficient terms. For current technology there may be access to statistics which exist on these proportions, whereas for projecting a future technology attention should usually turn

to the knowledge and judgment of industry experts. This is the crucial part of the Battelle-Columbus method. A great deal of preparatory time must be considered with various interviews to assure that a valid and meaningful set of expert judgments is obtained and converted into coefficients in order to generate for each sector a set of direct capital coefficients.

- The third step is field interviews and includes: selecting the experts, conduct of interviews, and interview follow-up.
- Fourthly, it is assumed that the entire input column has been expressed as total capital coefficients.
- Finally, before the capital coefficients matrix can be completed, every capital coefficient must be established to the satisfaction of the experts involved.

The ex ante method is up-to-date, less expensive and less difficult than the ex post (traditional) method, but the latter is more realistic. As the ex ante method involves the undertaking of a very big project, it needs more time to prepare and more cost to implement, and gaining access to experts is very hard (sometimes impossible). Hence, this method is beyond the scope of the present research.

7.3.2. British Experience

The single most important source of information regarding the methodological estimation of the investment matrix for the United Kingdom can be found in Green (1975). Most of the argument in this subsection is drawn from his work. The main part of his work is to split down gross domestic fixed capital formation (investment) into its components in the

United Kingdom for the 1963 input-output table, although his work on the structure of the investment matrix does not provide a comprehensive method of constructing an investment coefficient matrix. His matrix describes a picture of the commodity composition of investments, by individual industries under the technique which can be summarized as follows:

- He assumes two groups of industry, the first as consumer (in column) and the other as producer of capital stock (in row) in the whole economy.
- The plant and machinery investment in the UK is composed of four types of commodity. The first is the output of the engineering industries and the second is public utilities such as gas, electricity, water and communications industries. The third is commodity construction, which covers some of the installation expenditure for large items of capital equipment. The final type is metal and wooden furniture, etc. In order to split down the plant and machinery investment, some assumptions about the allocation of the supplies of agriculture machinery, textile machinery, and agriculture tractors are considered. In the cases of agriculture and textile industries, it is assumed that they sell their production only to their related sectors, and tractors are only sold to the agriculture sector.
- To examine the reports of certain nationalized industries. These reports make it possible to construct an analysis of investment by the gas, electricity and communications industries broken down into broad commodity groups. From this fixed columns of investment analyzed by commodity can be prepared.
- To examine the reports on the production and imports of capital goods. The amount of the capital goods produced and imported, and the supply allocated to feasible

purchasing industries was studied in some detail to establish the amount of capital goods purchased by each industry.

- To introduce special 'indicators' for some of the rows in order to allocate the individual cell entries, for example for some cells the number of people employed were used (machine tools). For other commodities, capital formation entries were allocated according to employment indicators (office machinery, scientific instruments, industrial trucks, etc).

7.3.3. Indian Experience

The first capital coefficient matrix in India was constructed under the leadership of Mathur, for the year 1960. His team provided a 29 by 29 square matrix which is composed of two matrices: a rectangular matrix of fixed capital and a square matrix of working capital (inventory). The data was gathered from an Annual Survey of Industry. In this survey the capital within each industry has been classified under the following sub-heads: a) buildings and improvements; b) transport equipment; c) machinery and other assets; d) stocks of materials and stores; e) stocks of semi-finished goods; and f) stock of finished goods. These six sectors out of 29 sectors were introduced as suppliers of stocks; fixed and working capital. The most important part of the Indian study, which is distinct from the experience of other countries referred to earlier, is to introduce a methodology for constructing a working capital matrix. They combined the stocks of materials and semi-finished goods and distributed these along the columns of the capital table in proportion to the input coefficients of the corresponding industries. In distributing the rows of the input-output table it has been assumed that the outputs of these industries can be stored and form a part of a stock matrix whereas the stock of finished goods has been apportioned diagonally (Mathur and Bharadwaj 1967). Subsequently Somayajulu (1971) introduced an independent working capital matrix for Maharashtra. The only difference between this working capital and Mathur's refers to the data, which for the first time furnished working capital held by industry at the end year and for the latter both at the beginning and at the end of the year. Besides these two studies, there are a number of other studies by different scholars (Mathur and Hashim 1963, Dutta Mazumdar 1968, and Koti 1967), which employed the same methodology.

7.3.4. Iranian Experience

A first approximation of the capital coefficient matrix has been constructed for Iran by Banouei. He constructed a ten-by-ten capital coefficient matrix for the year 1974 (Banouei 1989). He followed the Mathur and Grosse method, i.e. two types of intersectoral capital matrix have been compiled. The first refers to the inventory coefficients matrix and the second shows the intersectoral fixed capital coefficients matrix. The combination of these two matrices provided him with a general picture of the intersectoral capital coefficients for Iran. In his study two main achievements are apparent:

First: He found that the availability of reliable data with respect to manufacturing subsectors' inventories in Iran were almost the same as the other countries. Therefore, given such available data, the estimation for intersectoral-interindustrial inventories can be made with more confidence.

Second: Data on net fixed capitals industries in Iran were poor which in turn reduces the accuracy of the interindustrial fixed capital matrix. He, therefore, used sectoral gross fixed capital for the construction of that matrix.

7.3.5. A Comparative View of the Experiences

In the review of other countries' experience on constructing a capital matrix two main items are remarkable; the first relates to the fixed capital coefficients matrix and the second relates to the working capital matrix. Most of the experience in other countries shows that the fixed capital coefficient matrix is a rectangular matrix, due to differences in the number of producers (row) and consumers (column) of the capital goods. If fixed capital coefficients are introduced as a total capital coefficients matrix, it is possible to have a square matrix with some rows with all zero elements. Moreover, if working capital is introduced into the construction of the matrix it enables us to have a square matrix without all zero elements in any row or column. From this point of view, the experience of different countries can be entirely classified into three groups:

- First, countries such as India and the United States have considered fixed capital and working capital together so they constructed a square capital matrix. For the reason that a fixed capital matrix is rectangular and working capital matrix[1] is a square matrix, and so the capital matrix composed of two matrices should be square too.

[1] If all sectors have an inventory, for example service sectors do not produce any commodity to stock it.

- Second, the British experience seems different in nature, an investment matrix rather than a capital coefficients matrix is provided and appears to be a rectangular matrix[1].
- Third, in some cases that have not been mentioned, e.g. in Pakistan (Khan and Macewan 1967)[2] and South Korea (Hamilton 1986)[3] the studies considered only fixed capital so they obtained a rectangular matrix.

In respect of the method of working capital (inventory) estimation, it has been observed that some of the countries have used different value of stocks held in industries, some during the closing year (Mathur 1967, Grosse 1953) and some others have used the average total value of stock held by industry during the beginning and end of the year (Ritz *et.el* 1973, Somayajulu 1971).

Based on the review of other countries' experience with respect to the compilation of the capital coefficient matrix, and also on the operational experience with respect to the first compilation of the capital coefficient matrix by Banouei in Iran, we can establish what methodology is more appropriate to satisfy the Leontief's dynamic input-output model. In applications of the dynamic IO model, sometimes we need to invert the B matrix[4], and in the case of rectangularity or some rows with all zero elements (singularity of B), this is impossible. So, we should look for a technique which guarantees this, i.e. the method used in India and the United States. For this study we follow their experience and a

[1] An investment 21 by 26 matrix in plant and machinery.
[2] A multi-sectoral capital coefficients 5 by 35 matrix in the manufacturing sector for Pakistan for the year 1962/63.
[3] A fixed capital coefficients 3 by 26 matrix in the mining and manufacturing sectors for Republic of Korea.
[4] In forward lag dynamic IO model.

tentative capital coefficient matrix is constructed for Iran for the reference year 1991. All the data that have been used for this purpose are Iranian, which is elaborated below.

7.4. Construction of an Intersectoral Capital Coefficients Matrix for Iran (1991)

As in this study we follow the method of constructing the capital coefficients matrix which has been used in the United States and India and provided the basis for the first approach in Iran, so we should provide two matrices; working capital and fixed capital coefficients matrices. In the next section we discuss the sources of data and the method of estimating a working capital coefficients matrix first and then a net fixed capital coefficients matrix.

7.4.1. Estimation of a Working Capital Matrix

The Iranian Manufacturing Census and Surveys provide manufacturing sub-sectors inventory time series of the industrial establishments referring to the values of inventory such as: raw material, finished, semi-finished goods and sales the commodity without any changes held by industries during the beginning and end of the year since 1979. This data for the year 1991 is shown in Table 7.1. In the manufacturing sub-sectors no data problem on working capital exists, but data for other sectors are poor. In order to provide data on the inventory for other sectors, data adjustment are as follows:

- In the agriculture sector, there is not enough sectoral and subsectoral detailed inventory data, the only data has been provided in the "Annual Report and Balance Sheet" (CBIRI 1991) for the year 1991 and the Iran Statistical Yearbook 1998 (SCI 1999). The available data do not cover the whole of agriculture sub-sectors and reflects only farming, livestock, and poultry as agricultural subsectors. For the livestock subsector a breeder chickens inventory was prepared at the beginning and the end of the year (SCI 1999), and average inventory in physical terms for farming particularly wheat, sugar and red meat (CBIRI 1991). They have been converted into value terms with respect to their prevailing prices[1]. Given the nature of these agricultural inventories (meat, sugar, and chicken), they are assumed as agricultural outputs and can be considered as finished goods.
- Data for the oil and gas sector were not available. So it was assumed that there is no inventory in this sector.
- SCI survey provides inventory data for the mining sector at the beginning and end of the year 1991 and including mining of coal, iron, cooper, zinc, lead (SCI 1992).
- As for all service subsectors such as construction, water and electricity, real estate, communication, and transportation inventories, data are not available; and the single data for the transportation sector is for the beginning and end of the year 1993 (not for 1991). An inventory in the service sector is important because if we do not consider it, due to lack of data, we will have a row with all zero elements corresponding to this sector in the B matrix. To avoid this problem we assume that the inventory in the year 1991 is the same as that in the year 1993 in this sector.

[1] The price of wheat, sugar, red meat in CBIRI 1991, page 47 and price of breeder chicken in SCI 1999,

After data collection on the sectoral working capital, the methodology of constructing the working capital matrix by using this data can be summarized as follows:

First, the values of the stocks of finished goods held by sectors and manufacturing sub-sectors have been distributed according to the diagonal input proportions of the corresponding industries.

Second, all given sectors and manufacturing sub-sectors for which the stocks of semi-finished goods and raw materials are available, have been combined and distributed along the column of the capital table in proportion to the input coefficients of the corresponding activities. For this purpose first, the original 43 by 43 commodity by commodity input-output table has been aggregated into 19 by 19 sectors to be adjusted by the amount of sectoral working capital, and flow coefficients matrix (A) calculated for this table and then the inventory was distributed along the column of the matrix A.

Based on the above two steps, a 19 by 19 intersector inventory flow or working capital matrix was provided at current prices.

7.4.2. Estimation of Fixed Capital Coefficients Matrix

The estimation has relied on the net fixed capital stocks for both sectors and manufacturing sub-sectors. For this purpose, net capital stocks were estimated for three

---

page162.

types of asset: construction, machinery equipment and transport equipment in chapter six were employed. A fixed capital coefficients matrix has been obtained by taking the following steps:

First, The output of three industries, i.e. machinery, transport equipment, and construction, provides capital goods, which have been considered as producers of capital goods and placed in the three rows of the fixed capital matrix. Otherwise (rest of the industries) it is assumed to be consumers of the capital goods and placed in the columns.

Second, since the sectoral breakdown of the fixed capital estimate in chapter six is not compatible with 19 industries in the working capital matrix, eight given sectors have been aggregated into six sectors as follows: agriculture, oil and gas, mining, construction, electricity and total services (it is an aggregation of: transportation, real estate, communication and other services). For manufacturing industries adjustments have been made in three industries i.e. chemical, paper and wood industries. Kerosene, fuel oil, diesel oil, gasoline and natural gas which are produced by the chemical industry are extracted and disaggregated according to the average of their outputs for ten years, 1985-94. Another adjustment is the aggregation of wood and paper industries into one group (wood and paper industries).

Through the above data adjustment we arrived at a 3 by 19 matrix of net fixed capital stock for the year 1994 in current prices which are similar to the sectoral classification made for the 1994 energy input-output table. The combination of these two fixed and working capital matrices would then represent the general picture of the intersectoral capital flow matrix. In order to calculate the capital coefficients matrix, since the capital output ratio is defined as the ratio of capital to maximum capacity, so maximum industries' capacity is required. Because of lack of information regarding the sectoral or subsectoral capacity, a ten years trend-line sectoral outputs is introduced as a capacity index.

The fixed and flow capital coefficients matrices have been estimated by dividing the value of each cell of those matrices by a trend-line projection of the gross outputs for the corresponding industries. The results are shown in Tables 7.1 and 7.2. The total capital coefficients matrix is calculated by combining two fixed and working capital coefficients matrices, and is displayed in Table 7.3. This table of capital ratios shows that, in addition to the flow of inputs, raw materials in oil industry -when operating to full capacity- it required 1750 rials of fixed investment for each 1000 rials worth of output. This would include 1289 rials worth of machinery tools, 173 rials worth of construction and 288 rials worth of vehicle tools. This means that in order to expand its capacity so as to be able to increase its output by one thousand rials worth of finished products annually, the machinery industry would have to install 1289 rials worth of machinery tools and spend corresponding amounts on all other types of new fixed installations. This investment demand constitutes additional input requirements for the product of the corresponding capital goods industries that are taken into account in the solution of an appropriate system of dynamic input-output equations.

The capital-output ratios in this study are different from those derived by Banouei. Although the two approaches employed the same methodology for constructing the capital coefficient matrix as far as constructing the working capital matrix is concerned, the main distinction refers to the fixed coefficients matrix. Reviewing the results of the two approaches in Table 7.4 several points emerge:

- This study was able to provide a 19 by 19 whereas the first study a 10 by 10 capital coefficients matrix was constructed. The bigger dimension refers to more data availability. Sectors in the first study are: agriculture, crude petroleum and gas, mining, industries, machinery equipment, transport equipment, petroleum refineries, miscellaneous petroleum products and coal, construction, and services. In this study an attempt has been made to introduce as many sectors and sub-sectors as possible. Finally, 19 sectors and subsectors have been introduced, include six main sectors and eight manufacturing subsectors.
- Government organizations have made much more effort to collect data for three five-year "Socio-Economic Development Plans" after the Islamic Revolution, some improvement has been made in this regard which enables us to estimate net capital stock. As has been discussed in chapter six, to estimate net capital stock large amounts of data are required, such as: sectoral and sub-sectoral data investment for long time periods, sometimes more than fifty years (particularly in construction), the service life of many types, depreciation and deterioration of fixed capital and so on, which for Banouei's attempt was not possible. So he was compelled to base his data on the gross fixed capital for constructing capital coefficients matrix rather than net

capital stock. In this study, on the other hand, we used net capital stock in constructing the capital coefficients matrix and this is a major advantage of this study.

- An attempt has been made to estimate capital coefficients in terms of maximum capacity. Due to lack of accurate data about capacity, the 1991 outputs, which was the maximum output during 1981-1991 period, were assumed as the maximum capacity[1].
- As we observed, the value of capital-output ratios in the first approach are much smaller than those from this approach and the differences are very significant particularly in; agriculture, mining, oil and gas, and services sectors and so this obliges us to probe further. These differences particularly refer to the amount of fixed capital rather than working capital. Bigger ratios were expected due to the fact that net fixed capital stock was used in the first study. So more investigation is required. The investigation covers a comparison of these results with the experience of other countries such as developing countries or any other information which can be helpful to make a judgement. The comparison includes subsectoral capital-output ratio in some countries such as Australia, the United States, South Korea, Brazil, and Pakistan as shown in the table. Being aware of the international comparison of capital-output ratios would not be a complete indication of relative capital intensities because of the: different systems of sectoral classification, different compositions of output of the various products in each sector, and some uses allowance for excess capacity while not, but basically it can be helpful to give confidence in the results of this approach. Although the capital-output ratio in Table 7.5 is in the manufacturing subsectors particularly, this is due to more data availability in manufacturing subsectors in other

countries. It should be mentioned that the total capital-output ratio at the international level is possible but is highly aggregated and cannot help us effectively. The figures in Table 7.5 show that this study provides more consistent values of capital-output ratios compared with the experience of other countries especially in the paper, wood, chemical and textile industries.

It should be mentioned that the construction of the extended capital coefficients for type II and type IV models will be discussed in the next chapter in order to avoid repetition because the construction of capital coefficients matrix and input coefficients are closely connected contents.

7.5. Conclusions

This chapter has initially described not only the theoretical aspects of the importance of the capital coefficient matrix but has also been taken an experimental step in dynamic input-output models. In the theoretical aspects, the discussion concludes that the main distinction between static and dynamic input-output analysis lies in the treatment and position of capital formation. In the empirical aspects, by taking examples from the other countries' experience, an intersectoral capital coefficients matrix has been constructed by using merely Iranian data information. In order to construct that matrix, two types of capital matrices have been compiled, one refers to fixed capital and the other shows the working (inventory) matrix. By combining these two matrices and dividing the column-

---

[1] This assumption is due to lack of data, and is a technique that has been tested by Grosse (1953) in

wise elements of each industry to the capacity utilization of the corresponding industry, an intersectoral capital matrix has been provided. Although we were dealing with the problem of data availability regarding sectoral working capital, relying on scattered data gathering from different sources just as Banouei's approach did, our experiment revealed different aspects of data availability on fixed capital by industries, the preparation of which was described in chapter six. A more accurate capital coefficients matrix for Iran, with less adjustments on capital stock and working capital and also a more disaggregate nature, can be constructed. This is an essential requirement for long term economic planning particularly for Iran with an oil-based economy whose long term development strategy is based on the transformation of the economy from a mono-economy to a poly-economy and reconstruction phase.

American studies.

Table 7.1- Fixed Capital Coefficients Matrix

code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0.067	0.740	1.289	0.058	0.260	0.665	0.125	0.451	0.451	0.451	0.451	0.451	0.334	0.400	0.235	0.104	0.000	0.000	0.758
15	0.030	0.009	0.173	0.005	0.011	0.078	0.005	0.026	0.026	0.026	0.026	0.026	0.023	0.039	0.040	0.081	0.000	0.000	0.183
16	0.607	1.229	0.288	0.085	0.220	0.541	0.113	0.302	0.302	0.302	0.302	0.302	0.351	0.208	0.179	0.000	0.000	0.000	4.213
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1. Agriculture sector
2. Oil sector
3. Mining sector
4. Food industry
5. Paper and Wood industries
6. Non-metal industry
7. Textile industry
8. Chemical industry
9. Kerosene
10. Fuel oil
11. Gasoline
12. Gas oil
13. Metal industry
14. Machinery industry
15. Motor vehicle industry
16. Construction sector
17. Electricity
18. Natural gas
19. Services sector

Table 7.2- Working Capital Coefficients

code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0.021	0.000	0.000	0.010	0.047	0.000	0.007	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.001	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.133	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.107	0.001	0.012	0.003	0.005	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.106	0.006	0.001	0.006	0.000	0.000	0.000	0.000	0.000	0.003	0.011	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.002	0.077	0.000	0.003	0.000	0.000	0.000	0.000	0.001	0.002	0.001	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.003	0.000	0.137	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.011	0.008	0.007	0.117	0.000	0.000	0.000	0.000	0.002	0.012	0.013	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.001	0.007	0.000	0.002	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.195	0.040	0.059	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.219	0.002	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.002	0.020	0.003	0.004	0.000	0.000	0.000	0.000	0.008	0.035	0.143	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.009	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.001	0.009	0.001	0.001	0.000	0.000	0.000	0.000	0.002	0.001	0.003	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.001	0.052	0.030	0.021	0.038	0.000	0.000	0.000	0.000	0.034	0.073	0.051	0.000	0.000	0.000	0.000

1. Agriculture sector
2. Oil sector
3. Mining sector
4. Food industry
5. Paper and Wood industries
6. Non-metal industry
7. Textile industry
8. Chemical industry
9. Kerosene
10. Fuel oil
11. Gasoline
12. Gas oil
13. Metal industry
14. Machinery industry
15. Motor vehicle industry
16. Construction sector
17. Electricity
18. Natural gas
19. Services sector

Table 7.3- Total Capital Coefficients Matrix

code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0.021	0.000	0.000	0.010	0.047	0.000	0.007	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.001	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.133	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.107	0.001	0.012	0.003	0.005	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.106	0.006	0.001	0.006	0.000	0.000	0.000	0.000	0.000	0.003	0.011	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.002	0.077	0.000	0.003	0.000	0.000	0.000	0.000	0.001	0.002	0.001	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.003	0.000	0.137	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.011	0.008	0.007	0.117	0.000	0.000	0.000	0.000	0.002	0.012	0.013	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.001	0.007	0.000	0.002	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.195	0.040	0.059	0.000	0.000	0.000	0.000
14	0.067	0.740	1.289	0.058	0.261	0.666	0.125	0.451	0.451	0.451	0.451	0.451	0.334	0.620	0.237	0.104	0.486	0.000	0.758
15	0.030	0.009	0.173	0.006	0.013	0.097	0.008	0.030	0.026	0.026	0.026	0.026	0.031	0.074	0.183	0.081	4.898	0.000	0.183
16	0.607	1.229	0.288	0.085	0.229	0.542	0.114	0.303	0.302	0.302	0.302	0.302	0.352	0.210	0.183	0.000	0.577	0.000	4.213
17	0.000	0.000	0.000	0.000	0.001	0.009	0.001	0.001	0.000	0.000	0.000	0.000	0.002	0.001	0.003	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.001	0.052	0.030	0.021	0.038	0.000	0.000	0.000	0.000	0.034	0.073	0.051	0.000	0.000	0.000	0.000

1. Agriculture sector
2. Oil sector
3. Mining sector
4. Food industry
5. Paper and Wood industries
6. Non-metal industry
7. Textile industry
8. Chemical industry
9. Kerosene
10. Fuel oil
11. Gasoline
12. Gas oil
13. Metal industry
14. Machinery industry
15. Motor vehicle industry
16. Construction sector
17. Electricity
18. Natural gas
19. Services sector

Table 7.4. Sectoral Capital-Output Ratios

Sector/Subsector	First Study 1974	This Study 1991
Agriculture sector	0.2205	0.9598
Crude oil and gas sector	0.0451	2.2659
Mining sector	0.9956	1.8831
Food industry	-	0.2676
Paper industry	-	0.8038
Wood industry	-	0.4627
Non metal industry	-	1.4798
Textile industry	-	0.3526
Chemical industry	-	0.9643
Basic metal industry	-	0.9522
Machinery industry	0.5885	0.9496
Transport industry	0.1337	0.7447
Total Manufacturing industries	0.1499	-
Petroleum refineries	0.0094	-
Petroleum products and coal	0.0070	-
Construction sector	0.5165	0.1855
Services sector	0.1929	5.1551

Sources: first study Banouei (1992), this study author research

Table 7.5. Capital-Output Ratios for Mining and Manufacturing Subsectors in Other Countries

Subsector	Iran 1991	Australia 1971/72	Brazil 1959	South Korea 1978	Pakistan 1962/63	U.S.A. 1958
Coal and mining	1.883	1.193	0.720	0.889	-	0.345
Food industry	0.268	0.296	0.610	0.306	-	0.213
Paper industry	0.804	0.239	0.767	0.642	-	0.179
Wood industry	0.463	0.207	0.400	0.526	0.228	0.205
Non metal industry	1.480	0.357	0.918	0.428	0.447	0.454
Textile industry	0.353	0.583	0.403	0.983	1.974	0.346
Chemical industry	0.964	0.547	-	0.811	1.810	0.844
Basic metal industry	0.952	0.497	0.228	0.826	0.251	0.466
Machinery industry	0.947	0.279	0.785	0.444	0.419	0.137
Transport industry	0.745	0.295	1.010	0.475	1.861	0.233
Other industry	0.017	-	-	0.367	-	-

Sources: Iran: author research, Australia: Hourigan (1980), Brazil: Taylor and Cardoso (1980), South korea: Hamilton (1986), Pakistan: Khan and Mac Ewan (1967), U.S.A: Carter (1970).

CHAPTER EIGHT: BALANCED GROWTH AND STABILITY OF THE EXTENDED DYNAMIC MODELS

8.1. Introduction

The dynamic input-output Leontief model (1953, 1970) takes into account inter-industry transactions not only for intermediate products but also for fixed capital items. This model is based on three restrictive assumptions of: no choice of technique, full capacity utilisation, and transferability between different lines of production at zero cost (Kurz *et al.* 1998). Within these assumptions and framework three items seem particularly relevant. The first of these concerns the singularity of the capital coefficient matrix, as analysed and solved in Kendrick (1972), Livesey (1973, 1976), Luenberger and Arbel (1977), Meyer (1982), and Raa (1986a). The second is a well known observation that, for certain initial values of output, the output of some sectors may become negative in later periods; this possibility of negative sectoral outputs is labelled as causal indeterminacy. Many authors have faced this problem and tried to solve it by utilising the concept of relative stability of the balanced growth solution (Nikaido 1968, 1972, Takayama 1985, Tsukui 1961,1968). The third is the existence of a balanced growth solution of the dynamic system that has been discussed many scholars and provides necessary and sufficient conditions for the existence of balanced growth solution (Campisi and La Bella 1988, Leontief 1970, Meyer 1982, Szyld 1985, Szyld *et al.* 1988, Takayama 1985).

In this chapter three issues are brought together, the second issue will be discussed extensively, and the necessary and sufficient conditions for the stability and relative stability and the size of the balanced growth rate in the dynamic model will be investigated. In addition, the theory will be empirically tested on a small-scale (fourteen sectors) dynamic model in the case of Iran.

We will emphasize that although the stability is very important in the dynamic model, it does not mean that the unstable model is has no value. On the contrary the unstable dynamic model can provide the path way of the output in the short-term future. Moreover it can help economic planners to estimate the period of time that they can use the model without facing with the difficulty of negative output.

For this purpose this chapter is organised as follows. Firstly, the possibility of the existence and relative stability of the balanced-growth path in relation to the structural matrices A, B; and $(I-A)^{-1}B$ for backward-lag and forward-lag dynamic Leontief models will be discussed. Secondly, we will provide some empirical results arising from the experience of the Iranian economy and analyse these results. In the last section of the chapter conclusions will be drawn.

8.2. Stability and Relative Stability of The Balanced-Growth Path

8.2.1. *Stability of the Dynamic Leontief Model*

The discussion of stability (instability) of the Leontief dynamic model has a long history. During the last five decades, the dynamic Leontief model has been criticised by several authors for its lack of stability (Wurtele 1959, Sargen 1961, Steenge 1978, Tsukui and Murakami 1979, Heesterman 1990, Campisi *et al.* 1992). The initial idea of stability was raised by Harrod (1948). Conceptually, instability means that the Leontief dynamic model is not adopted for explaining the actual movement of the economic system and it would be better to regard the Leontief system as strictly a planning system (Sargen 1958). Because the application of the dynamic model in a long-term plan depends on its stability, so the stability conditions and technique of testing this model are the focus of attention here. In pursuing these aims, in this section we discuss the stability conditions for different well-known specifications of the forward-lag and backward-lag dynamic models. The discussion includes the physical model and its dual, the price model. First we examine the conditions for stability of the physical model.

We have two specific dynamic IO models: the forward-lag model (8.1), and the backward-lag model (8.2),

$$X_t = A X_t + B(X_{t+1} - X_t) + Y_t \qquad (8.1)$$

$$X_t = A X_t + B(X_t - X_{t-1}) + Y_t \qquad (8.2)$$

In both models A is an $n \times n$ non-negative matrix of current input-output coefficients, B also is a $n \times n$ non-negative matrix of capital coefficients, X_t and X_{t+1} are the vectors corresponding to the industry's output at the end of the periods t and $t+1$, and Y_t is an exogenous vector of final demand. All assumptions of Leontief input-output model are satisfied, i.e., an economic system subdivided into n productive sectors and each sector produces only one good by means of only one production process lasting only one period, and the current and capital input coefficients are all constant over time. Moreover, the productive process exhibits constant returns to scale, and there is a one-period lag between the acquisition of capital goods and their utilisation for all sectors and for every capital good. In the closed version of these models, A is the matrix of intermediate input coefficients which includes replacements and endogenous household consumption and Y_t is zero.

When we discuss the stability of the dynamic model, we mean in effect the stability of the growth rate that can be derived from the dynamic model; under stable conditions this is called the balanced growth solution of the dynamic model. The stability of the balanced growth solution in the dynamic Leontief model has been investigated by many scholars (Nikaido 1968, 1972, Takayama 1985, Tsukui, 1961,1968, 1979, Campisi *et al.* 1985, Steenge 1978). Their main findings are that the different types of Leontief dynamic models (forward-lag, backward-lag) require a particular condition to be stable and the stability properties of backward-lag and forward-lag are antipode (Steenge 1978).

Brody (1970) has shown that the growth rate associated with the maximal eigenvalue is the maximal one in the long-term, on the von Neumann path (Hamilton 1986)[1]. If all sectors are growing at the same rate which we shall call g. Then we have;

$$\left[(I-A)^{-1}B\right]X = (1/g)X$$

The existence of the balanced growth solution relates to the eigenvalues of the matrix $(I-A)^{-1}B$ (Leontief 1970, Takayama 1974, Meyer 1982). If λ_m is the maximum eigenvalue of matrix $(I-A)^{-1}B$, the balanced growth rate g is $1/\lambda_m$. This immediately throws up a fundamental question, viz with given technology, defined broadly as the elements of the augmented A and B matrices, under which conditions the balanced growth path for the dynamic Leontief model exists and is stable?

The existence and stability of the growth rate of the dynamic model have been discussed by many scholars such as Tsukui (1968), Tsukui and Murakami (1979), and Takayama (1985). They discussed that the stability conditions for forward and backward dynamic model are different. The forward-lag model (8.1) is stable if and only if:

$$1+1/\lambda_m > \left|1+1/\lambda_i\right| \qquad i=2,\dots\dots,n$$

where λ_i are the eigenvalues and λ_m is the Frobenius eigenvalue i.e. the greatest eigenvalue of $(I-A)^{-1}B$ matrix. If this condition is satisfied, the vector of output X_t is growing at the rate of $1/\lambda_m$ per year. This has been labelled a Leontief trajectory

[1]To take an analogy from geometry, if we have a rectangle of variable side but with a fixed perimeter the area enclosed will be at maximum when the sides are equal in a square.

(Mathur 1967). The literature has shown that all implemented forward-lag versions appear to be not only unstable but, in most of cases, completely unstable (Tsukui 1968, Steenge 1990), because it appears that;

$$1 + 1/\lambda_m < |1 + 1/\lambda_i| \qquad i = 2,\ldots\ldots,n$$

The other version, the backward-lag model (model 8.2), appears to have stability properties often radically different from the forward-lag variant. The backward model (8.2) is stable if:

$$(1-\lambda_m)^{-1} > \left|(1-1/\lambda_i)^{-1}\right| \qquad i = 2,\ldots\ldots,n$$

Although it has been proved that is impossible to provide any convincing explanation for the difference in economic terms $(X_t - X_{t-1})$ in the backward lag model (8.2), there is more hope of stability.

The condition of stability of two types of dynamic model as discussed above imposes certain conditions on the current and capital coefficients matrices. It is well-known that, if the Hawkins-Simon condition (1949) holds, the irreducibility[1] of matrix $(I-A)^{-1}B$ is a sufficient condition for the existence of a balanced-growth solution for the dynamic Leontief model as given by Model (8.1). On the irreducibility of $(I-A)^{-1}B$, many authors have assumed restrictions on A and B matrices. For example, Leontief (1970) assumed the irreducibility of both A and B, whereas Meyer (1982) retained the irreducibility of A but assumed the singularity and reducibility of B.

[1] Reducibility of matrix $(I-A)^{-1}B$ means that if the system is divided into two or more groups of sectors which the sectors of some groups do not need, either directly or indirectly any current or capital inputs from some other groups of sectors.

Szyld *et al.* (1988) relaxed the hypothesis on the matrices A and B, by taking into account the singularity of the capital coefficients matrix and proving that, if each column of B has at least one nonzero entry, then $(I-A)^{-1}B$ is irreducible if and only if the sum of A and B, i.e. $M = A+B$ is irreducible. Campisi *et al.* (1992) emphasised that the sufficient condition for stability of the dynamic model is satisfied if each sector uses at least one capital good in its productive process even though, the B matrix is singular. Their finding has been successfully tested for the Italian economy (Campisi *et al.* 1992).

8.2.2. *Relative Stability in the Dynamic Leontief Model*

The Von Neumann growth path, in which all sectoral outputs grow at the same rate, is relatively stable if for each sector the ratio between the actual output and the output of the Von Neumann growth path converges to a positive constant, as time extends without limitation regardless of the initial value of output. The ratio is identical for all sectors, but the amount of value depends on the initial value of output. Such convergence is formulated (Tsukui and Murakami 1979) as;

$$\lim_{t\to\infty}\frac{\|X(t)-X^*(t)\|}{X(t)}=0 \quad \text{for any } X(0)\geq 0$$

where $X^*(t)$ is the Leontief trajectory or turnpike path. The forward-lag dynamic model (model 8.2) is relatively stable if and only if all λ_i^{-1}'s other than λ_m^{-1} lie inside a circle with radius $1+\lambda_m^{-1}$ centred at $(-1,0)$ on the complex plane of λ^{-1} (Tsukui and Murakami 1979, Steenge 1978). If this condition of relative stability of the balanced growth path (λ_m) is satisfied, then all sectoral outputs are non-negative and growing at the same rate during and after a certain future period (Jorgenson 1976). It seems quite likely that the forward-lag model is relatively unstable (Tsukui and Murakami 1979). For the backward model the situation is reversed, i.e. the backward model is relatively stable if and only if all characteristic roots of the $B^{-1}(I-A)$ matrix other than λ_m^{-1} lie outside a circle with the radius $(1-\lambda_m^{-1})$ centred at $(1,0)$ on the complex plane of λ^{-1} (Tsukui and Murakami 1979). Model (8.2) presents a striking contrast to the original model (8.1). That is when the model is changed from forward-lag to backward-lag type the relative stability zone is turned inside out. So the backward-lag model seems likely to be relatively stable, even when the forward-lag model is unstable. The balanced growth rate in model (8.2) is greater than the balanced growth rate in model (8.1). However, in the case of the backward-lag model, the interpretation of this model is debatable. The interpretation of $B(X_t - X_{t-1})$ means that you should invest before you have usable capacity and within the assumption of dynamic Leontief model generally, model (8.2) is not a correct dynamic specification while model (8.1) is (Heersterman 1990) and in other words, model (8.2) is accelerated beyond the possible growth of supply capacity (Tsukui and Murakami 1979).

There is relatively little work on the stability of the closed dynamic input-output model; the only piece of research that can be mentioned is the paper of Heersterman (1990) in which he proved that the closed version of the dynamic Leontief model is unstable whereas in most cases the open backward lag model can be stable.

The dynamic Leontief model has a balanced growth solution with a growth rate $g = 1/\lambda_m$. This model always predicts a high growth rate g. The size of this growth rate is compatible with the growth rate in sectoral outputs. If the general form of the actual output growth is $X(t) = (1+\alpha)^t X(0)$ where α is a positive actual output growth rate, i.e. $\alpha \in R^+$, and g is the calculated growth rate of the dynamic model. The relation between these two rates is; $\alpha < g$, i.e. the dynamic model always derives greater growth rate (Schoonbeek 1990).

Schoonbeek (1990) proved two theorems that the principal minors with the order 1 of $(I - A - \alpha B)$ matrix in the forward dynamic model are positive. This means that if, in the case of balanced growth path with a growth rate of α and where $\alpha < g$, in industry i there is a positive output of one unit of good i, then the current direct input requirement (a_{ij}) plus the direct investment requirement (αb_{ij}) of good i in industry i is smaller than unity, and then industry i can meet a positive final demand. Otherwise, i.e. $\alpha > g$ or $\alpha = g$ the industry of i can meet negative or zero final demand which is an undesirable situation. He also mentioned that a similar solution can be obtained with respect to a variant of the dynamic backward-lag model; this model has a balanced growth solution with a growth rate $\delta = g/(1-g) > 0$, whereas above $g = 1/\lambda_m$, it can be proved easily that $\delta > g > \alpha$ (Schoonbeek 1990)[1].

There is not much discussion about the stability of the dual of the dynamic physical model, (see the discussion, in chapter three). Discussion has been confined to the remark that the stability condition for the dynamic price model requires the

[1] If and only if $[I - A - (\alpha/(1+\alpha)B)]$ is a P-matrix, i.e. if all principal minors are positive (Schoonbeek 1990).

invertibility of the matrix $(I-A+B)$ in addition to the conditions in the physical model (Heesterman 1990).

Finally, to conclude this literature review of the stability and relative stability conditions and the comparison of the size of growth rate, it would be helpful to know the time required for industries to adjust their capital stocks to their output growth rates. Wurtele (1959) proved that for an aggregated one-sector model this period of time means that the solution is stable if this time period is greater than $2b/(1-a)$ in which a and b are input and capital coefficients respectively. This time period is also computable with respect to the eigenvalues of the matrix $(I-A)^{-1}B$ which is two times of the greatest eigenvlaue of $(I-A)^{-1}B$ (Wurtele 1959).

8.3. Application of the Stability Conditions

There has been a remarkable increase in the collection of statistical data for the computation of intersectoral tables in Iran since the 1950s. However, these data mainly refer to the current input coefficients i.e., A matrix. The information on the capital coefficients, meanwhile, was only provided for the first time in 1989 (Banouei 1989). This is due to the ambiguities about the concept and measurement of the capital stock, and especially to the technical difficulties and data availability regarding the empirical estimation of sectoral capital stock. The methodology and estimation of capital stock, and the methodology of the construction of the capital coefficient matrix have been discussed in chapter six and seven. A capital coefficient matrix has been constructed.

The latest intersectoral flows table for Iran refers to 1994, and was prepared as a 43-industry classification by the Ministry of Power in 1998. For testing the stability condition, the national economy is aggregated into nineteen industries, the number of sectors used the corresponding classification of the Ministry of Power in 1994 and aggregated codes are reported in Table 8.1[1]. The only limitation on the number of sectors refers to the size of the capital coefficients matrix that was prepared in chapter seven. The input coefficients of the 19 by 19 matrix, A, is shown in Table 8.3, and corresponding $(I-A)$ and $(I-A)^{-1}$ matrices were prepared. Moreover the corresponding 19 by 19 capital coefficients matrix is presented in Table 8.4. Capital coefficients B and $(I-A)^{-1}$ matrices are required for testing the stability condition of the conventional dynamic model. Extended dynamic models require more information to construct, and their construction will be described in the following sections.

8.3.1. *Construction of Extended Input Coefficients Matrices*

The extended input matrix in the extended dynamic models includes one additional row and column vector for the type II model and two additional row and column vectors for the type IV model. The first additional column vector is the propensity to consume (non-durable goods) for employed households, and the second is the propensity to consume (non-durable goods) for unemployed households. The first additional row is the income coefficient vector of employed households and the second row is the vector of social security payments coefficients for unemployed

[1] The sectors and their corresponding code number are the same as in the classification of chapter six.

households. For constructing these additional rows and columns vectors the following techniques are employed.

First of all we have noticed there is an inconsistency between data on sectoral household consumption and incomes during data investigation. This inconsistency can be attributed to the fact that average household income is smaller than average household consumption in the survey of household expenditure and income as well as IO table. In the input-output table, the remainder of household income was examined at the bottom of the IO table, referred to as property-type income or operation surplus. The property-type income includes not only the rest of household income but also replacement income, revaluation of capital and return on capital. Extracting the rest of household income from the property-type income is a complicated task that can only be carried out by an official organization, SCI, which administered the household expenditure survey. As a result the first column for employed households is obtained from national information. At the national level, the average ratios of consumption to total income for the last ten years, 1988-1998, is regarded as the propensity to consume for households. We consider the average propensity to consume during last ten years, because we noticed that when the international price of oil was relatively low the propensity to consume increased in the period 1988-93 and when it was high, it decreased for the remaining years. This is the first step in constructing extended input coefficients matrices.

Secondly, a vector of the shares of total household expenditure on different goods, durable and non durable, for employed household is calculated as categorized in the input-output tables. An equivalent vector, for unemployed households is estimated using the vector of shares of total household expenditure on different goods for the lowest household income group. The shares are taken as in the year of the household survey 1994 and may have changed somewhat since then but it is unlikely that there will have been very large shifts in the proportions since the survey was undertaken.

Thirdly, for the extended dynamic type I model, additional row and column vectors in the extended input coefficients matrix are calculated as follows: using the information on national propensity to consume and the share of goods types (non-durable)[1] for the households, the column vector of the propensity consumption for employed households by sector is computed. The additional row vector is computed first by using household consumption and propensity to consume to calculate total employed household income[2] and secondly employed household income is disaggregated according to labour coefficients in value added in the input-output table.

Finally, in the extended type IV models two additional column and row vectors in the extended input coefficients matrix are required. Two column vectors refer to propensities to consume for employed and unemployed households. The propensity to consume for employed households is the same as that in the extended type II, but for unemployed households it is assumed that a) they consume all of their income, b) the

[1] Durable and non-durable goods are defined in chapter three.
[2] Total employed income is derived from dismantled unemployment allowance to total household income.

shares of goods consumption are the same as the first quintile i.e. level income group. There are two additional rows, the first row referring to employed income coefficients and assumed to be the same as that in the extended type II model. The second additional row refers to social security welfare payments to unemployed households, and is obtained from the information on the short-term unemployed households income support (social welfare payments) (SCI 1998, Table 14-15, page 566) and is disaggregated according to labour demand coefficients.

Moreover, employed and unemployed household consumption by sector are divided by the corresponding income figures, to establish two additional input coefficients column vectors for the extended type IV model. All the elements in the employed and unemployed household income vectors are each divided by their corresponding output sector to derive the two additional input coefficients row vectors for the extended type IV model. Using these two additional rows and columns, together with the conventional input coefficients, two extended input coefficients matrices are computed.

8.3.2. *Construction of Extended Capital Coefficients Matrices*

The capital coefficients matrix in the extended dynamic models includes one additional row and column vectors for the type II model and two additional row and column vectors for the type IV model. First, the additional column vector is consumption of capital goods (durable goods) for employed households while the second one is consumption of capital goods (durable goods) for unemployed household. The first row vector is the investment coefficients by employed households and the second is the investment coefficient by unemployed households.

To calculate these additional rows and columns vectors the following technique is employed. The first additional column vector, employed household capital consumption, is calculated with the information on the national propensity to consume and the share of goods types (durable) for households obtained from the 1994 household expenditure survey. The second additional column vector i.e. unemployed household capital consumption is computed from information on the shares of durable goods consumption for the first quintile income group. The first additional row vector is calculated from information on total employed household saving derived when the total employed consumption was subtracted from total household income. For unemployed households, it is assumed that they spend all of their income so all of the elements in the second additional row vector are zero. For the capital coefficients matrix two additional column vectors are divided by their corresponding incomes and two additional row vectors are divided by their corresponding outputs. With these additional two column and two row vectors, together with and the conventional capital coefficients matrix that was prepared in chapter seven, two additional extended capital coefficients matrices are obtained.

Finally we arrive at four additional coefficients matrices for the extended models: two input coefficients, $\overline{A}$ and $\tilde{A}$, and other two capital coefficients, $\overline{B}$ and $\tilde{B}$, matrices.

Input coefficients $\overline{A}$ and capital coefficients $\overline{B}$ for constructing the extended type II model, while $\tilde{A}$ and $\tilde{B}$ coefficients matrices for setting up the extended type IV model. Moreover, with the information on input and capital coefficients A and B matrices for the conventional dynamic model, we now have three pairs of input and capital coefficients matrices for the three dynamic models.

8.4. Stability Test Results

From the numerical computation of input and capital matrices, and the balanced growth solution, the condition of stability and relative stability can be verified. The capital coefficients matrices in the case of this study, with the special methodology[1], are non-singular. Even if they were singular this would not present a serious problem, since the only condition on the B matrix relating to the stability of model, is the need to satisfy the requirement that irreducible matrix $(A+B)$ (Campisi *et el.* 1992). Moreover, the $(I-A)^{-1}B$ matrices are irreducible, according to the Leontief's stability condition for the matrix of $(I-A)^{-1}B$. So, the necessarily condition for stability of the dynamic model of this study is satisfied and the matrix $(I-A-gB)$, in which g is the reciprocal greatest eigenvalue of the matrix $(I-A)^{-1}B$, is absolutely non-negative. This means that, although the developed dynamic models of this study are relatively unstable, there is no causal indeterminacy, and the only problem faced in these models are that as time passes the balanced growth path diverges from the actual output.

---

[1] As discussed in chapter six.

The balanced growth factors g for the three dynamic models are equal to 0.348, 0.221 and 0.220 for the conventional and extended type II and type IV models respectively. The computed growth rates lie outside the circle with radius $1+\lambda_m^{-1}$, so the sufficient stability condition is not satisfied and the three dynamic models are relatively unstable. This means that for these dynamic models when time pass, the ratio between the balanced-growth output of each sector and that of non-balanced growth trajectory diverges to a positive constant regardless of the sectoral output levels in 1994.

Moreover, the above balanced growth paths do not provide an indication of the long-term trajectory of the economy and therefore these models can be used as a tool for short-term planning. So, if the output vector for 1994 lies in the direction of this balanced growth path, then the economy would evolve in accordance with the rule $X_{1994+t} = 1.348^t X_{1994}$ for the conventional model, $\overline{X}_{1994+t} = 1.221^t \overline{X}_{1994}$ and $\tilde{X}_{1994+t} = 1.220^t \tilde{X}_{1994}$ for the extended type II and type IV models respectively. This rule will work under the assumption of no change in both of their input and capital coefficients matrices in the short-term. After any change in those two matrices, this condition will not be set. Another important result is that the balanced growth rates for two extended type II and IV models are smaller than in the conventional type. The smaller balanced growth rate is an indication for the model that it is closer to the real economy.

As we expected and discussed in the theoretical part (8.2) of this chapter, the calculated growth rate is always more than the actual growth rate in an economy. The actual growth rates of gross national product (GNP) in Iran in the last six years (i.e. after 1991)[1] are as follows (SCI 1998): 8.02% (1992-1993), -1.55% (1994), 4.16% (1995), 6.73% (1996), and 3.36%(1997). The actual growth rate is less than the balanced growth calculated in the developed dynamic models. As results show, the dynamic quantity models are relatively unstable and their dual i.e. the price dynamic models are also relatively unstable. It should be added that the stability of the dynamic price model requires the invertibility of the matrix of $(I-A+B)$ in addition to the conditions in the physical dynamic model. In the case of this study the matrix $(I-A+B)$ is non-singular and irreducible for three extended dynamic models. Based on the stability testing for the dynamic price model, we will be able to apply this model to answer the question of the impacts of the energy price increase in the short-term i.e. the Third Five-Year Plan period.

8.5. Conclusions

In this chapter, the dynamic behaviour of the Leontief model has been investigated through the structural properties of the matrices representing the linkage between the different sectors of the economy. The necessary and sufficient conditions for stability and relative stability of the balanced-growth solution for forward and backward dynamic models have been discussed. The balanced growth conditions were discussed: firstly on the type of A, B matrices and as a result on the $(I-A)^{-1}B$ matrices. The review of literature showed that the irreducibility of the A, B, or $(A+B)$ matrices

[1] The period around the time that input-output table was constructed.

(Leontief 1970, Tsukui and Murakami 1979, Meyer 1982, Szyld 1988) is the necessary condition for the dynamic model to be stable. Other attempts emphasised that if each sector uses at least one capital good in its productive process, this is the sufficient condition for the dynamic model to be stable (Campisi *et al.* 1992). Secondly on the area of the relatively stable zone, and in describing different relative stability conditions for forward-lag and backward-lag (Tokoyama and Murakami 1972, Steenge 1978, Tsukui and Murakami 1979), the forward-lag model is also quite likely to be relatively unstable (Tsukui 1979, Steenge 1978).

The literature also shows that, if it has a balanced-growth path which is relatively unstable, the economy -especially output production- tends to diverge from the balanced growth path and can reach a situation that does not make any economic sense. This result can be used as a tool to show what may be hidden in the current economic variables in the long-term behaviour of the dynamic system in terms of a progressive convergence or divergence from the balanced-growth trajectory.

In this chapter approaches have been applied in the case of Iran by means of an operational model based on input-output data for 1994. The structural properties of the matrices gave rise to high balanced growth solutions, and the three forward-lag dynamic models are relatively unstable but there is no causal indeterminacy in them. So, the calculated balanced-growth path cannot be considered as a real output trend or a turnpike path. To investigate the reason for this we should refer to the fact that the dynamic analysis requires the availability of requisite and comprehensive data preliminaries for constructing coefficient matrices, particularly the capital coefficient matrix. If these data have not already been prepared, there would be less prospect of a good result in the stability test of the dynamic model. The calculation and disaggregation of the data on capital stock in this study relied on some data adjustments that affected the results. We should mention that even though the requisite data has been obtained, there is no guarantee that the dynamic model on the basis of those data will be stable, because other countries' experiences, such as Japan (Tsukui and Murakami 1979), show an unstable dynamic model. As the dynamic physical model and its dual, price model are relatively unstable, they will be more suitable for short-term planning.

Table 8.1- Aggregated Branches of the National Economy and Codes

Code	Branch	Sector No.
1	Agriculture, Forestry, and Fishing	1-3
2	Oil and Natural fuel	5
3	Mining	4
4	Manufacture of Food products	6-7
5	Manufacture of Paper and wood	8
6	Manufacture of Non-metal and Mineral products	9-13
7	Manufacture of Textile	14-16
8	Manufacture of Chemical Products	17-18, 23-24
9	Kerosene	19
10	Fuel Oil	20
11	Gasoline	21
12	Gas oil	22
13	Manufacture Metal Products	25-27
14	Manufacture of Machinery and Equipment	28-29-31
15	Manufacture of Motor vehicle	30
16	Construction	35
17	Electricity	32
18	Natural Gas	34
19	Services	31,33,36-43

Table 8.2- Eigenvalues of Matrix $(I-A)^{-1}B$

	United States		Japan		Germany		Iran Extended Type IV		Iran Extended Type II		Iran Conventional	
Sec. Cod.	Real part	Impaginary part	Real part	Impaginary part	Real part	Impaginary part	Real part	Impaginary part	Real part	Impaginary part	Real part	Impaginary part
1	8.333		7.788		15.87		4.52		4.538		2.866	
2	0.679		0.198		0.489		0.052	0.183	0.051	0.182	0.021	0.208
3	0.278		-0.064	0.082	0.3		0.052	-0.183	0.051	-0.182	0.021	-0.208
4	0.19		-0.064	-0.082	-0.116		0.271	-	0.272	-	0.222	0.025
5	0.149		0.074	0.027	0.081		0.219	-	0.218	-	0.222	-0.025
6	0.105	0.024	0.074	-0.027	0.069	0.025	0.206	-	0.206	-	0.203	-
7	0,105	-0.024	0.045	-	0.069	-0.025	0.144	0.033	0.143	0.033	0.145	0.018
8	0.076		-0.033	-	0.069	-	0.144	-0.033	0.143	-0.033	0.145	-0.018
9	0.034		0.028	-	0.013	0.062	0.127	0.005	0.127	0.005	0.125	0.007
10	-0.005		0.018	-	0.013	-0.062	0.127	-0.005	0.127	-0.005	0.125	-0.007
11	-		0.003	0.003	0.052		0.051		0.051		0.063	
12	-		0.003	-0.003	-0.024		0.043		0.043		0.031	
13	-		-		-		-0.003		-0.003		-0.003	
14	-		-		-		1E-11		8E-04		0.001	
15	-		-		-		0.001		0.001		0.001	
16	-		-		-		8E-04		0.001		0.001	
17	-		-		-		0.001		0.001		0.001	
18	-		-		-		0.001		0.001		0.001	
19	-		-		-		0.001		0.001		0.001	
20	-		-		-		0.001		0.001		-	
21	-		-		-		0.001		-		-	

Source: Germany, Japan, and the United States in Steenge (1990), and Iran Author's research.

Table 8.3- Extended Input Coefficients

code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.294	0.000	0.000	0.530	0.163	0.000	0.045	0.011	0.001	0.000	0.001	0.001	0.000	0.000	0.001	0.011	0.000	0.000	0.007	0.062	0.105
2	0.001	0.004	0.000	0.002	0.000	0.063	0.000	0.003	0.003	0.001	0.003	0.003	0.057	0.000	0.000	0.026	0.000	0.000	0.001	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.327	0.094	0.336	0.339	0.000	0.000	0.000	0.000	0.000	0.116	0.000	0.000	0.000
4	0.067	0.001	0.011	0.111	0.005	0.034	0.021	0.024	0.004	0.001	0.004	0.004	0.033	0.001	0.001	0.008	0.000	0.010	0.046	0.144	0.363
5	0.001	0.001	0.000	0.013	0.224	0.017	0.008	0.029	0.003	0.001	0.003	0.003	0.001	0.006	0.035	0.029	0.000	0.001	0.004	0.008	0.014
6	0.001	0.001	0.000	0.004	0.008	0.069	0.003	0.012	0.009	0.003	0.009	0.009	0.004	0.003	0.003	0.111	0.001	0.003	0.011	0.001	0.002
7	0.004	0.000	0.010	0.000	0.009	0.000	0.307	0.003	0.000	0.000	0.000	0.000	0.001	0.000	0.001	0.012	0.006	0.016	0.012	0.081	0.046
8	0.021	0.002	0.026	0.010	0.038	0.022	0.046	0.315	0.038	0.011	0.039	0.039	0.013	0.023	0.041	0.003	0.001	0.010	0.023	0.022	0.053
9	0.000	0.000	0.004	0.001	0.002	0.009	0.000	0.000	0.005	0.001	0.005	0.005	0.006	0.000	0.002	0.001	0.000	0.001	0.001	0.004	0.007
10	0.000	0.000	0.003	0.001	0.000	0.003	0.000	0.010	0.004	0.001	0.004	0.004	0.012	0.000	0.001	0.000	0.020	0.003	0.001	0.000	0.000
11	0.003	0.000	0.004	0.000	0.001	0.004	0.000	0.001	0.001	0.000	0.002	0.002	0.023	0.000	0.002	0.019	0.001	0.012	0.009	0.002	0.002
12	0.001	0.001	0.004	0.002	0.001	0.011	0.001	0.003	0.005	0.002	0.005	0.005	0.041	0.001	0.006	0.006	0.007	0.003	0.011	0.000	0.000
13	0.000	0.001	0.008	0.002	0.015	0.000	0.000	0.003	0.006	0.002	0.006	0.006	0.327	0.075	0.191	0.136	0.000	0.014	0.004	0.001	0.000
14	0.000	0.002	0.051	0.001	0.003	0.003	0.001	0.002	0.002	0.001	0.002	0.002	0.003	0.293	0.007	0.005	0.002	0.006	0.005	0.007	0.002
15	0.005	0.001	0.025	0.016	0.008	0.057	0.019	0.019	0.008	0.002	0.008	0.008	0.046	0.065	0.096	0.047	0.006	0.015	0.023	0.017	0.000
16	0.001	0.000	0.099	0.006	0.031	0.005	0.006	0.004	0.001	0.000	0.001	0.001	0.005	0.004	0.014	0.000	0.001	0.001	0.018	0.003	0.001
17	0.001	0.001	0.065	0.004	0.004	0.027	0.005	0.005	0.003	0.001	0.003	0.003	0.013	0.002	0.011	0.000	0.062	0.014	0.006	0.008	0.012
18	0.000	0.000	0.000	0.000	0.001	0.005	0.001	0.003	0.003	0.001	0.003	0.003	0.004	0.001	0.000	0.000	0.049	0.000	0.000	0.002	0.004
19	0.037	0.012	0.329	0.080	0.180	0.088	0.138	0.172	0.110	0.032	0.113	0.114	0.187	0.136	0.166	0.119	0.048	0.243	0.108	0.541	0.388
20	0.222	0.229	0.034	0.045	0.133	0.165	0.136	0.119	0.054	0.519	0.177	0.173	0.097	0.130	0.104	0.146	0.104	0.171	0.177	0.000	0.000
21	0.000	-0.010	0.000	0.000	-0.003	-0.002	0.000	-0.001	-0.008	-0.028	-0.009	-0.012	-0.001	-0.002	-0.001	0.000	-0.003	-0.018	0.000	0.000	0.000

1. Agriculture sector
2. Oil sector
3. Mining sector
4. Food industry
5. Paper and Wood industries
6. Non-metal industry
7. Textile industry
8. Chemical industry
9. Kerosene
10. Fuel oil
11. Gasoline
12. Gas oil
13. Metal industry
14. Machinery industry
15. Motor vehicle industry
16. Construction sector
17. Electricity
18. Natural gas
19. Services sector
20. Employed households
21. Unemployed households

Table 8.4- Extended Capital Coefficients

code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	0.021	0.000	0.000	0.010	0.047	0.000	0.007	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.021	0.000	0.001	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.133	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.107	0.001	0.012	0.003	0.005	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.106	0.006	0.001	0.006	0.000	0.000	0.000	0.000	0.000	0.003	0.011	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.002	0.077	0.000	0.003	0.000	0.000	0.000	0.000	0.001	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.003	0.000	0.137	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.011	0.008	0.007	0.117	0.000	0.000	0.000	0.000	0.002	0.012	0.013	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.004	0.000	0.001	0.000	0.000	0.000	0.001	0.007	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.004	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.195	0.040	0.059	0.000	0.000	0.000	0.000	0.000	0.000
14	0.067	0.740	1.289	0.058	0.261	0.666	0.125	0.451	0.451	0.451	0.451	0.451	0.334	0.620	0.237	0.104	0.486	0.000	0.758	0.007	0.002
15	0.030	0.009	0.173	0.006	0.013	0.097	0.008	0.030	0.026	0.026	0.026	0.026	0.031	0.074	0.183	0.081	4.898	0.000	0.183	0.016	0.000
16	0.607	1.229	0.288	0.085	0.229	0.542	0.114	0.303	0.302	0.302	0.302	0.302	0.352	0.210	0.183	0.000	0.577	0.000	4.213	0.003	0.002
17	0.000	0.000	0.000	0.000	0.001	0.009	0.001	0.001	0.000	0.000	0.000	0.000	0.002	0.001	0.003	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.001	0.052	0.030	0.021	0.038	0.000	0.000	0.000	0.000	0.034	0.073	0.051	0.000	0.000	0.000	0.000	0.000	0.000
20	0.055	0.057	0.008	0.011	0.033	0.041	0.034	0.030	0.000	0.000	0.000	0.000	0.001	0.042	0.006	0.002	0.000	0.000	0.002	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

1. Agriculture sector
2. Oil sector
3. Mining sector
4. Food industry
5. Paper and Wood industries
6. Non-metal industry
7. Textile industry
8. Chemical industry
9. Kerosene
10. Fuel oil
11. Gasoline
12. Gas oil
13. Metal industry
14. Machinery industry
15. Motor vehicle industry
16. Construction sector
17. Electricity
18. Natural gas
19. Services sector
20. Employed households
21. Unemployed households

CHAPTER NINE: EMPIRICAL TESTING OF EXTENDED DYNAMIC INPUT-OUTPUT PRICE MODELS

9.1. Introduction

Static extended input-output quantity models have been discussed and applied in many studies in the last two decades. The main applications of these models have been in impact analysis, mostly on a series of production, income and employment multipliers and the comparison of the size of impacts measured by each of four types of input-output model. Dynamic extended quantity and price models of types II and IV are discussed in theoretical terms in chapters three and four. In addition they have been tested empirically for their stability in the case of Iran in chapter eight of this study. Although both conventional and extended dynamic price models are unstable, through the use of stability tests we can make sure about the time period that they can be applied without negative and high diversity problems.

Dynamic extended quantity models have the same potential applications as the static extended types of the models, but inevitably there are differences in the size of impacts.

Dynamic extended input-output price models, as the dual of dynamic extended quantity models, are developed and their applications discussed in chapter four. These price models can provide a basis for examining the impact of any change in the value added on production prices, e.g. changes in government tax policy. Furthermore, they can also explore the impacts of a change in input price not only on the production prices but also on the wages of employed households and on the social security payments to unemployed households.

One of the matters to be considered here is a comparison between the size of the impacts measured by the extended static and dynamic price models. This will be the main purpose of this chapter. In this chapter we will conduct empirical testing of the extended price models designed in chapter four, constructed and tested for stability in chapter eight, to study national price impacts that result from energy products price changes. The experiment includes six models: three static and three dynamic models. Impact results will be analysed by comparing static with dynamic, and extended with conventional type models.

In the next section we describe further development of the models for assessing the impact of energy policy in Iran. We characterize these models as extended input-output energy price models, incorporating a number of price variables. The third section deals with the problems associated with data collection for an exercise of this sort. Much of the data required is not readily available, so that data estimation techniques have to be used in relation to data from published sources. These data have then to be prepared for constructing the model and setting up the impact measurement. We then discuss the size of price impacts with particular reference to the comparison measurement of static and dynamic models as well as that for conventional and extended type models. In the final section we present conclusions based upon the empirical aspects of the exercise.

9.2. The Design of Extended Input-Output Price Models for Measuring the Impacts of Energy Price Rises

In developing extended price models to measure the impacts of energy price rises, some specific requirements must be addressed. Of primary importance is the need to examine the energy market in Iran and the mechanism of its price determination under which condition the price rise will occur. The model should also be capable of establishing impacts on production prices, as well as on the wages of employed households and the social benefits payable to unemployed households. Finally, it will be desirable that the models should provide a basis for outlining the impacts of energy price rises on the household cost of living and the inflation rate.

The main point here in the context of the energy market in Iran is that the energy prices are increased up to a certain amount each year, and are fixed at that level. In other words, the energy prices will not respond further to the indirect price impacts caused by their own price changes. To elaborate, when the price of gasoline is increased, the cost of transportation and also that of other goods in which gasoline is an input during the production process will rise. Increased costs of transportation and other goods will increase the gasoline price further in the standard formulation, but in the case of this study the latter effect has been ruled out. So, the price of energy types are assumed to be fixed after a sudden change, consistent with the condition that the energy sector is run by a state enterprise. If the final energy product prices are exogenous, we must detach the energy prices from non-energy prices i.e., dividing the price vector into two parts; energy prices and non-energy prices. As a result the technical coefficients must be divided according to the price vector for a static input-output type I price (type I-S) model as follows[1]:

$$\begin{bmatrix} p_e \\ p_n \end{bmatrix} = \begin{bmatrix} A_{ee'} & A_{en'} \\ A_{ne'} & A_{nn'} \end{bmatrix} . \begin{bmatrix} p_e \\ p_n \end{bmatrix} + \begin{bmatrix} V_e \\ V_n \end{bmatrix} \qquad \text{(Type I-S)}$$

where;

p_e is the vector of prices of energy sectors,

p_n is the vector of prices of non-energy sectors,

V_e is the vector of value added per unit of energy sectors

V_n is the vector of value added per unit of non-energy sectors,

$A_{ee'}$ is transpose of a square matrix of inputs of energy sector to energy outputs,

$A_{en'}$ is the transpose of a matrix of inputs of non-energy sector to energy output,

$A_{ne'}$ is the transpose of a matrix of inputs of energy sector to non-energy outputs,

$A_{nn'}$ is the transpose of a square matrix of inputs of non-energy sector to non-energy outputs.

[1] This equation was developed and applied by the World Bank (1999).

As the final energy product prices are fixed, we can solve the above equation for the prices of non-energy outputs as follows;

$$p_n = [I - A_{nn'}]^{-1} A_{ne'} \cdot p_e + [I - A_{nn'}]^{-1} V_n \qquad (9.1)$$

In equation (9.1) the prices of non-energy sectors depend not only on the price of energy sectors but also on the value added in the non-energy sector modified by the relevant portions of the input-output matrix, and the equation for the non-energy price change according to the type I-S model is:

$$\Delta p_n = [I - A_{nn'}]^{-1} A_{ne'} . \Delta p_e \qquad (9.2)$$

Corresponding equations can be derived for the dynamic input-output price type I (type I-D) model. The type I-D model, in which the price vector is divided into two parts: energy and non-energy product prices, can be extended as follows:

$$\begin{bmatrix} p_e \\ p_n \end{bmatrix} = \begin{bmatrix} A_{ee'} & A_{en'} \\ A_{ne'} & A_{nn'} \end{bmatrix} . \begin{bmatrix} p_e \\ p_n \end{bmatrix} + r \begin{bmatrix} B_{ee'} & B_{en'} \\ B_{ne'} & B_{nn'} \end{bmatrix} . \begin{bmatrix} p_e \\ p_n \end{bmatrix} + \begin{bmatrix} V_e \\ V_n \end{bmatrix} \quad \text{(type I-D)}$$

where;

$B_{ee'}$ is a square matrix of capital stock of energy sector to energy output

$B_{en'}$ is a matrix of capital stock of non-energy sector to energy output

$B_{ne'}$ is a matrix of capital stock of energy sector to non-energy outputs,

$B_{nn'}$ is a square matrix of capital stock of non-energy sector to non-energy outputs.

It should be mentioned that energy sectors do not produce any capital goods, rather working capital goods, so $B_{en'}$ and $B_{ee'}$ can be assumed to be zero. If the model is solved for p_n,

$$P_n = A_{ne'} \cdot p_e + A_{nn'} \cdot p_n + r\,B_{ne'}\,p_e + rB_{nn'} \cdot p_n + V_n \quad (9.3)$$

and the vector of non-energy price increment is:

$$\Delta p_n = [I - A_{nn'} - r\,B_{nn'}]^{-1}(A_{ne'} + r\,B_{ne'})\Delta p_e \quad (9.4)$$

Equation (9.4) shows that the change in non-energy sector prices depends not only on the change in energy prices, but also on the degree to which energy inputs or working capital are used by non-energy outputs, and the extent to which non-energy sector inputs and capital stocks are also used by the non-energy sectors.

Corresponding equations can be derived for the extended static type II price (type II-S) model, the input coefficients of which include one additional row and column compared to the type I-S model.

$$\Delta \overline{p}_m = [I - \overline{A}_{mm'}]^{-1}\,\overline{A}_{me'} \cdot \Delta p_e \qquad (9.5)$$

in which the vector of price and input coefficients matrix are as follows:

$$\overline{P}_m = \begin{bmatrix} P_n \\ W \end{bmatrix} \;,\; \overline{A}_{mm} = \begin{bmatrix} A_{nn} & h_c \\ h_n^a & 0 \end{bmatrix} \text{ and } \overline{A}_{me} = \begin{bmatrix} A_{ne} \\ h^a \end{bmatrix}$$

The corresponding equations (9.5) for the extended static type IV price (type IV-S) model, in which the input coefficients matrix includes two more rows and columns compared with the type I-S model, can be determined using the following equation;

$$\Delta \tilde{p}_k = [I - \tilde{A}_{kk'}]^{-1}\,\tilde{A}_{ke'} \cdot \Delta p_e \qquad (9.6)$$

in which both the vector of price and the input coefficients are defined as follows:

$$\tilde{P}_k = \begin{bmatrix} P_n \\ W \\ 0 \end{bmatrix} \;,\; \tilde{A}_{kk} = \begin{bmatrix} A_{nn} & h_c^e & h_c^u \\ h_n^a & 0 & 0 \\ sl_n & 0 & 0 \end{bmatrix} \text{ and } \tilde{A}_{ke} = \begin{bmatrix} A_{ne} \\ h_e^a \\ sl_e \end{bmatrix}$$

Parallel equations for the type II -D and type IV-D models are as follows:

for the type II-D model: $$\Delta \bar{p}_m = [I - \bar{A}_{mm'} - \bar{r}_m \bar{B}_{mm'}]^{-1} (\bar{A}_{me'} + \bar{r}_m \bar{B}_{me'}) \Delta p_e \qquad (9.7)$$

for the type IV-D model: $$\Delta \tilde{p}_k = [I - \tilde{A}_{kk'} - \tilde{r}_k \tilde{B}_{kk'}]^{-1} (\tilde{A}_{ke'} + \tilde{r}_k \tilde{B}_{ke'}) \Delta p_e \qquad (9.8)$$

The returns on capital rates matrix is:

$$\bar{r}_m = \begin{bmatrix} r & 0 \\ 0 & r_h \end{bmatrix}, \quad \tilde{r}_k = \begin{bmatrix} r & 0 & 0 \\ 0 & r_h & 0 \\ 0 & 0 & r_h \end{bmatrix}$$

and the extended capital coefficients matrices for extended dynamic price type II (type II-D) and extended dynamic price type IV (type IV-D) models are:

$$\bar{B}_{mm} = \begin{bmatrix} B_{nn} & h_d \\ h_{ns} & 0 \end{bmatrix} \text{ and } \tilde{B}_{kk} = \begin{bmatrix} B_{nn} & h_d^e & h_d^u \\ h_{ns} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

The variables in the above matrices for extended types are defined in chapters three and four.

The six equations, 9.2-9.7, are straightforward in expressing changes in the level of output price by sector in percentage terms. On the other hand these changes explain direct and indirect impacts of any changes in input price. Direct impacts for type I-S and type I-D models (9.2) and (9.4) can be written as:

direct effects (type I-S) = $A_{ne'} \Delta p_e$

direct effects (type I-D) = $A_{ne'} \Delta p_e + r B_{ne'} \Delta p_e$

The indirect effects can be obtained by subtracting the above direct effects from the total impacts of the corresponding equations (9.2) and (9.4).

It can be seen that there are, in all, n equations in the type I-S and type I-D models, $(n+1)$ equations in the type II-S and type II-D models, and $(n+2)$ equations in the type IV-S and type IV-D models with an equivalent number of unknowns. Each system of equations produces a single determinate solution, which may be obtained in the model. By using these equations we will be able to calculate other impacts such as the household cost of living changes and the inflation rate rise. For estimation purposes, the output price change can be combined with household expenditure shares to establish household cost of living changes. These can be given by[1]:

$$\Delta p_h = \sum_{i}^{N} p_i h_i \qquad (9.9)$$

where,

Δp_h is percentage households living cost changes,

h_i is share of household expenditure of good i,

N is number of sectors.

The initial household cost of living is also unity, since it is a weighted average of sector prices in the base year, all of which are unity. Hence, equation (9.9) is the percentage change in the aggregate household cost of living index. In the next section we deal with some of the requirements for constructing the models.

[1] For estimating inflation rate change the formulation is the similar to this equation, the only difference is that instead of household expenditure shares, sectoral production shares are defined.

9.3. Model Construction and Sources of Data

In this section, we describe briefly the process of constructing the models specified earlier in section 9.2. These models are constructed at the national level for the most recent input-output table for Iran, available for 1994. This table refers to the national level and describes the economy in terms of 43 sectors. In this table six industries are energy products: gasoline, kerosene, diesel oil, fuel oil, electricity, and natural gas. Other sectors are: agriculture (3)[1], mining (2), manufacturing (26) (including four energy products; gasoline, kerosene, diesel oil, and fuel oil), and services (12) (includes electricity and natural gas) sectors. As a capital coefficients matrix was constructed in chapter seven. A capital coefficients matrix was constructed for the year of 1991, we assumed this to hold for 1994, on account of its dimension as well as to achieve more consistency between dynamic and static models we had to aggregate the original 43-sector table into a 19 industries table. Data requirements and the procedure for data adjustment for calculating extended input and extended capital coefficients matrices were discussed in chapter eight. They were necessary for testing the stability of the dynamic extended models; the additional rows and columns of input and capital coefficients matrices are shown in Table 9.2. This table includes average consumption propensities for employed (h_c^e) and unemployed households (h_c^u) (including durable and non-durable goods) and labour demand coefficients (e) (or income coefficients). Any figure in the first column (h_c^e) shows the percentage of income that employed households spend on the specific sector's good, for example, employed households spend 14% of their income on

[1] The figure in the bracket shows the number of industries in each sector.

buying food industry products, whereas, the second column (h_c^u) shows this ratio is 36.343% for unemployed households. Each element of the third column (e) in this table presents the percentage of wage cost (or the share of labour) for each unit cost by sector. For example; in agriculture sector 22.169% of average production cost may be attributed to the wage cost. This table also presents a comparison between the consumption propensities for short-term unemployed households and employed households. As we might have expected, although average consumption propensities for unemployed households are greater for necessary goods, such as agriculture and food industry products, for durable goods, (with high income elasticities) such as machinery, transport, and construction, the propensities are smaller.

Moreover, looking at income coefficients for employed households, shown in Table 9.2, when we compare employment coefficients in manufacturing subsectors with other sectors, we can see that the share of labour in production in agriculture, mining, construction and services is greater. On the other hand for the manufacturing industries, i.e., food, non-metal, textile, chemical, basic metal, machinery and transport industries the coefficients are smaller. Since manufacturing industries are less labour intensive and use relatively modern methods of production, other industries are more likely to depend on the traditional production method. The greater size of income coefficients might produce greater price impacts for the corresponding sectors.

Besides, in order to construct models (9.2) to (9.8), it is necessary to produce two matrices: one a square matrix of non energy inputs sector to non energy outputs i.e. A_{nn}, and the other a rectangular matrix of non energy sector inputs to energy sectors, $A_{ne'}$. For this purpose the A matrix is divided into four sub-matrices, two square and two rectangular sub-matrices are provided, $A_{nn'}$, $A_{ne'}$, $A_{ee'}$, and $A_{en'}$. Two of these sub-matrices, i.e. $A_{ne'}$ and $A_{nn'}$ are used in the type I-S and type I-D models. Similarly, the dimensions of the capital coefficients matrices are disaggregated and two corresponding sub-matrices $B_{nn'}$ and $B_{ne'}$ are provided. In like manner two extended input and two extended capital coefficients matrices are provided for use in equations (9.3), (9.4), (9.5), and (9.5).

Further, in the absence of data on the rate of return of capital for production sectors, a vector of rates of return on capital by sector is estimated, while for the household sector the short-term interest rate on saving account, i.e. 8% is considered[1]. The rate of return on capital was estimated by considering the average ratio of capital formation (investment) to changes in outputs at a macro level during 1991-1996 (most recent data in SCI 1998), i.e. 3.65%.

Furthermore, the vector of energy price changes is calculated under the assumption of a 10% annual increase for five years, which means a total rise of 61.051% for every energy product.

Finally, with information on six reduced input coefficients matrices, three reduced capital coefficients matrices, and three reduced rate of return on capital matrices, three static and

[1] Interest rates on saving account for employed and unemployed households are assumed to be the same.

three dynamic models are constructed. In other words, two models are conventional, type I-S and type I-D, and two other models are type II-S and type II-D, and the last two models are type IV-S and type IV-D. In the next section we put these models into operation to measure the impacts of energy price rises at the national level in Iran and make comparisons.

9.4. Measuring the Impacts

In this section we assess the impacts of an annual 10% increase in the price of energy products in the period 2000-2004[1]. By considering this scenario we attempt to project future changes of production prices, the household cost of living, and the inflation rate for this period. An estimate has been made by combining the information of the extended input and capital coefficients matrices, the vector of energy price rises and the rate of return on capital matrices, and using equations (9.2), (9.5) and (9.6) for static versions and (9.4), (9.7), and (9.8) for dynamic versions of the models. This gives us six column vectors of output price rises, one column vector for each model.

The results of the calculation of output price rises for the six models are shown in Table 9.3. This table shows production price rises due to the current governmental energy pricing policy. Each element of this table shows the impact of an annual increase of 10% in six energy products for five years on output price by sector in each specific model. For instance; if the energy products prices increase by 61.05% (during five years) then the price of agriculture products will rise by almost 0.85%, 6.90%, 6.88%, 1.01%, 9.72%, and 9.64% according to the type I-S, type II-S, type IV-S, type I-D, type II-D, and type IV-D, models respectively.

Several points may be observed from these preliminary calculations the results of which are shown in Table 9.3. The first and most important one, changes in the price of energy products such as kerosene, fuel oil, gasoline, diesel oil, natural gas, and electricity will have differential impacts on various industries. Because of not only the first round, but also the second and third round effects, the final impact cannot be easily determined without the use of an input-output model.

Secondly, the effects that are shown in Table 9.3 represent only the impacts on the prices of output industries in the short-term. Apart from price rises for energy products, for those industries which consume more energy proportionally, the prices of their production increase more than those in the other industries. For example, the non-metal industry, which produces cement, brick, gypsum and consumes greater energy products, shows the highest impacts. The construction sector, in which the inputs are non-metal industry products, has the second highest impact. The other high impacts are in the chemical, basic metal and transport sectors, in which transport and chemical sectors consume more energy products. The rank of impacts in production sectors is strikingly similar for all six models. With the exception of the food industry and the agriculture sector, the impacts derived by means of the four extended (type II-S, type IV-S, type II-D, type IV-D) models are much higher than those obtained using the two type I-S and type I-D models. This difference is due to the nature of the extended models in which

[1] The reason for 10% increase in the price of energy relates to the current government policy.

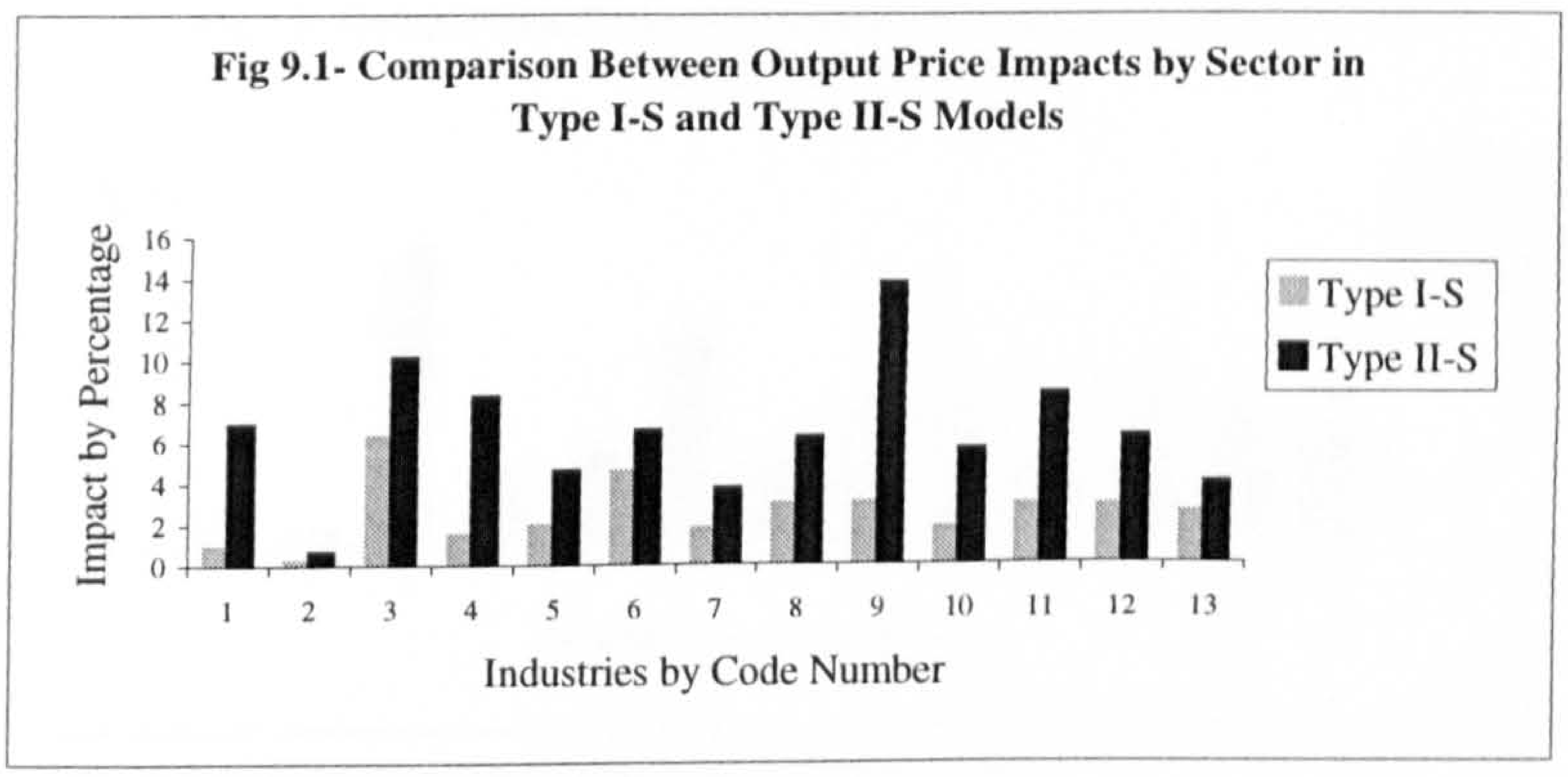
households are treated endogenously in the same way as other industries. Treating households endogenously means that the impacts of their inputs, i.e. final goods that mostly include food and agriculture products and their outputs i.e. person years of work input to the first, second and third rounds effects, therefore the price rise will be sharper.

Moreover, the type II-S and type II-D models provide information about the impacts on wages as well as on output prices. The size of the income wage that should cover the energy price rise, in the type II-S model is 5.05% and for type II-D it is 7.01%. This is one of the main characteristics of the type II-S and type II-D models, which is the ability to estimate wage rises. The wage rise shows that if households consume as much as they did before the energy price rise, then they must receive much larger wages to compensate for the output price rise, according to the input-output price model in which the changes in price do not affect the quantity of production. If substitution between inputs were possible, the impacts on the output prices would have been more likely to be smaller.

Furthermore, the type IV-S and type IV-D models provide not only the impacts on the production prices and wage rises but also the extent that social benefit payments should increase to compensate the price rise for unemployed households. The third element of the price vector in type IV-S and type IV-D models is zero and can be interpreted as the unemployed households output prices. This increases, for type IV-S and type IV-D models, 4.7% and 6.5% respectively. These figures show that the cost of living for unemployed households will increase, if these households do not decrease their quantity of consumption. Even if they decrease their consumption, these price models cannot measure it. These figures also show that if unemployed households continued to buy the same amount of goods as they did previously, then the government would have to increase the social security payment per household at exactly the same rate as prices rises according to the input-output price models. But we know that if the price of some goods increases and unemployed households income also increases, then, according to the price and income elasticities, the quantity of consumption of related (substitution and complementary) goods will change too.

Other comparisons can be made between the conventional and extended types of model by comparing the impacts measured using two type I-S and type II-S models, shown in Fig. 9.1. As these figures show, in general the impacts obtained by using the type II-S model are much greater than those from the type I-S model. The greater impacts are associated with industries, the production of which accounts for a higher share of household expenditure, such as agriculture, food industry, and transport. For example, in the agriculture sector the impact obtained from the type II-D model is almost eight times, and, for the food industry six times, the impacts obtained by using the type I-S model. These are the results we anticipated.

Although we have noticed that the impacts in both the type II-S and type II-D models compared with those from the type I-S and type I-D models are very significant, when a similar comparison is made between the type IV-S and type IV-D models, and the type II-S and type II-D models, only very slight differences are observed. These very slight differences might refer to the limited data availability for the extended type IV models on social welfare payments to unemployed households on the one hand, and on the other hand to the assumption about their consumption propensities. In this experiment, because the lack of regular social benefit payments by the government to long-term unemployed households, we had to use the only data item that contains social security payments to short-term unemployed households. If a regular social benefit payments system was established by the government, the differences in impacts might have been much more substantial. We will investigate these two matters in the sensitivity testing in section 9.5.

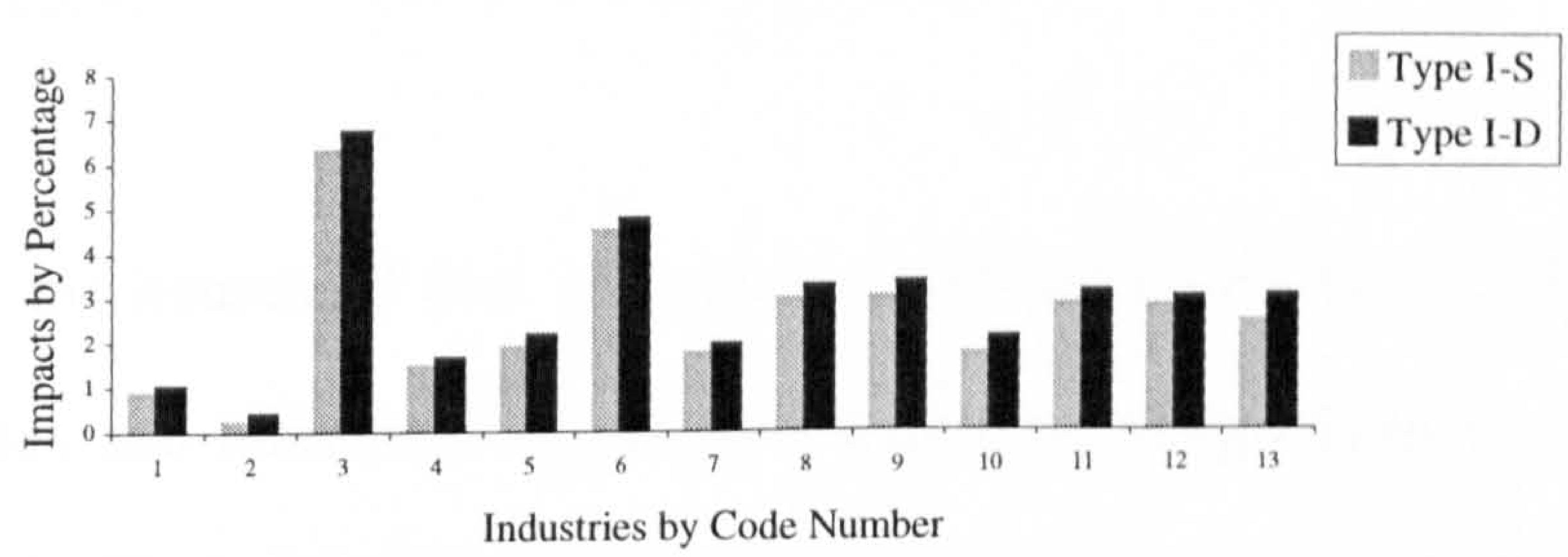


The code numbers are associated with the following sectors:

1.Agriculture sector 2. Mining sector 3. Oil sector 4. Food industry 5. Paper and wood industry 6. Non.metal industry 7. Textile industry 8. Chemical industry 9. Basic metal industry 10. Machinery industry 11. Motor vehicle industry 12. Construction 13. Services

More comparisons can be made between the impacts measured by the static and dynamic models. In general dynamic impacts are greater than static impacts in the three types of model. The greater impacts are as a result of taking into account not only the impacts of energy price rises on the inputs for industries but also on the price of fixed capital and working capital goods. The difference is not constant, but varies from sector to sector and from conventional to extended model. For a sector with a high rate of energy consumption this ratio is relatively greater, in the metal and transport industries, and the construction sector, as shown in Table 9.4. Figures in this table show how close the output price impacts measured are by using static or dynamic models in different sectors. For example, for the agriculture sector the output impacts measured by using type I models 83.61% are closer than those measured by the static and dynamic type II models with the ratio of 70.98% for type IV models, 71.32%. The greatest difference between static and corresponding dynamic output price impacts in the agriculture sector is that for type II models and that same result is obtained for all sectors. This comparison is shown for the example of the type I-S and type I-D models in Fig. 9.2.

Fig 9.2- Comparison Between Output Price Impacts by Sector in Type I-S and Type I-D Models



The code numbers are associated with the following sectors:

1.Agriculture sector 2. Mining sector 3. Oil sector 4. Food industry 5. Paper and wood industry 6. Non.metal industry 7. Textile industry 8. Chemical industry 9. Basic metal industry 10. Machinery industry 11. Motor vehicle industry 12. Construction 13. services

Further comparisons can be derived by investigating the impacts on the household cost of living, which is an important variable for policy makers. In interpreting the estimated increases in the household cost of living, several qualifications must be borne in mind:

- The calculations assume that in the conventional models there is no increase in any other money variable such as wages as a result of the energy products price rise, while in the extended model such an assumption can be ignored.

- The calculations are made also under the assumption of no financial help from government for poor household income groups.
- The calculation also assumes that household expenditure shares are the same as they were at the time of the household expenditure and income survey in 1994 (Ministry of Power 1998);
- The calculation itself is only approximate since it has had to be based on a 1994 input-output table, and ignores changes in technology and in relative factor use due to price rises in the ten year period between the base year of 1994 and the final year of estimation, 2004.

The impact on the household cost of living is calculated with the information about output price rises and household expenditure shares by using equation (9.9), and the result is shown in Table 9.5. This table shows impacts on the total household cost of living measured using the static and dynamic models at the foot of the table. For example, 3.12%, 5.93%, 5.92%, 3.57%, 8.20%, and 8.16% household cost of living increases are obtained according to the type I-S, type II-S, type IV-S, type I-D, type II-D, and type IV-D models respectively. In addition in each column shows the share of sectoral output price increase in the basket of household consumption. These results show the total impacts on household cost of living increase when we move from the static to the dynamic model as well as from the conventional model to the extended type II model. In contrast the total impacts decrease when we move from the extended type II models to the extended type IV models. These results are similar to those for output prices. The size of these impacts might be greater in reality than they are derived here, because the

1994 input-output energy table was compiled according to producers' prices, while the household cost of living is expressed according to consumers' prices which are usually found to be greater.

Finally, the impacts on the inflation rate are calculated with the information about output price rise and total shares of sectoral production, and the results are shown in Table 9.6. Looking at this table can see that the total impact on the inflation rate measured using the static and dynamic models are at the foot of the table. For example, 3.95%, 7.39%, 7.38%, 4.33%, 9.60%, and 9.55% price rises impacts are observed according to the type I-S, type II-S, type IV-S, type I-D, type II-D, and type IV-D models respectively. The greatest inflation impact is obtained from type II-D model. In addition, each column shows the share of sectoral output price increase in the national consumption. We should mention that although these dynamic models are relatively unstable but they have not provided a great range of inflation rates.

9.5. Sensitivity Testing

In empirical analysis such as we have discussed in this study, there are a number of assumptions that emphasise the input data used in the constructed models. In particular, assumptions were made in order to construct the extended type IV models. In this part we discuss a series of tests aimed at establishing the sensitivity of these models i.e. type IV-S and type IV-D models, in the forecasting of impacts.

First, we focus on the assumption we have made to split the consumption propensity for unemployed households into the elements of the vector of unemployed household consumption. As we have already mentioned, the unemployed household consumption propensity was disaggregated according to the shares of goods consumption for the first decile i.e. the lowest household income group. A distinction is made between this initial assumption and an alternative assumption. The alternative assumption is to split unemployed household consumption propensity according to the fifth decile income group. This assumption may be more reasonable for short-term unemployed households in that in the short-term, changes in the consumption pattern are less likely to occur. In other words the consumption pattern for short-term unemployment is closer to the one that was applicable when they had a job. This test will show us how sensitive the model is to a change in this parameter.

Secondly, because of a lack of regular social security payments to long-term unemployed households we used only the available data for short-term unemployed households. An additional assumption was made on the size of social security payments to analyse the impacts of an unemployment benefits increase.

Table 9.1- Parameter and Input Assumptions Used for Sensitivity Testing

Parameter	Initial value	Alternative value
h_c^u	First decile income group	Fifth decile income group
S	S	2S
h_c^u	1	0.95

h_c^u is consumption propensity for unemployed households,
S is social benefit payment to unemployed household

Thirdly, we have made another assumption on the size of the consumption propensity for unemployed households. The initial value of h_c^u is 100% means that they consume all of their income. An additional assumption is made by considering the alternative condition in which h_c^u is 95%. It means that they save 5% of their income. The summary of parameters and input assumptions used for sensitivity testing are shown in the Table 9.1.

9.5.1. Sensitivity Test Results

The results of sensitivity testing are summarized in Tables 9.7-9.9, which include some particular cases. The first consists of the condition in which the unemployed household consumption pattern is the same as the fifth decile income group. Table 9.7 shows that the model results are almost completely insensitive to this variation. That sensitivity relates to the social benefit payments to unemployed households, shown at the foot of the table.

The second test consists of the condition in which the social security payment to unemployed households is increased by 100%. Table 9.8 shows that static and dynamic models are completely insensitive to this change too and that the social security payment is a little more sensitive to change in social benefit payments in that the figure drops from 6.41% to 5.41%.

Finally, we pointed out earlier that the initial assumption about the unemployed households consumption propensity is that it is 100%, the effect of decreasing this item to

95% is shown in the Table 9.9. Very slight increases are obtained by using the type IV-S and type IV-D models for all the sectors and the social welfare payments were slightly greater than those for the other models.

9.6. Conclusions

In this chapter we have focussed upon empirical and methodological issues encountered in the demographic and economic forecasting models that were discussed in chapters 3 and 4. We adopted a modelling framework based on the extended input-output price models in which emphasis is placed on the energy market in Iran. We discussed how these kinds of models can be constructed by using a national input-output table and adjusted national data. We have identified an important role for the model as a tool for impact analysis of price changes not only in relation to output prices but also to wages for employed households and social security payments to unemployed households.

In the empirical studies we have concentrated on six models, the most elaborate of which included two types of household: employed and unemployed. The empirical study was based on the national case that allowed several conclusions to be drawn about the effects of household disaggregation in the input-output price model. First, we have noticed that a series of output prices, the household cost of living and inflation rate impacts can be derived. These impacts measures provided considerable advantages over those that are currently available from conventional models. Secondly, according to comparisons that were made for all industries, the differences between price impacts measured by conventional and extended models were very high. Our comparison between extended static type II and IV models indicated that the introduction of unemployed household consumption and income had a small effect on impact values. Thirdly, another comparison was made between the size of impacts by using dynamic forms of the model. We have noticed that the dynamic models generally yield greater impacts. The greatest impact among the six models, was found in the type II-D model whereas the smallest impact was found in the case of the type I-S model. The type IV-D model, on the other hand, yielded smaller impacts than the type II-D model, but not to any great extent.

It should be mentioned that, because of a lack of information on household incomes disaggregated into the categories of employed, short-term unemployed, long term unemployed, retired, and old age people, it was only possible to extract one small section of households under the short-term unemployed household category that received social security payments in the short-term. The consumption propensity for long-term unemployed households might be different from that for short-term unemployed households.

In addition we have established systematic sensitivity tests for those models that were constructed under certain assumptions about key parameters. The aim of the sensitivity tests was to check if some of the relatively arbitrary assumptions made to construct the model have any significant effect on the measurement of the impacts. We found the models are generally not at all sensitive to changes in parameters.

Table 9.2-Average Consumption Propensities and Wage Coefficients-in Percentages

sector	h_c^e	h_c^u	e
Agriculture	6.199	10.533	22.169
Mining	0.005	0.000	22.900
Oil	0.000	0.000	3.404
Food industry	14.009	36.343	4.548
Paper and wood	0.806	1.410	13.310
Non metal	0.137	0.223	16.493
Textile	7.883	4.557	13.579
Chemical	2.148	5.269	11.908
Kerosene	0.371	0.718	5.386
Fuel oil	0.000	0.012	51.918
Gasoline	0.213	0.167	17.720
Gas oil	0.042	0.019	17.344
Basic metal	0.118	0.007	9.733
Machinery	0.684	0.216	12.970
Motor vehicle	1.646	0.014	10.400
Construction	0.268	0.114	14.569
Electricity	0.785	1.178	10.374
Natural gas	0.148	0.383	17.081
Total services	52.666	38.837	17.684

h_c^e is employed households propensity to consume,

h_c^u is unemployed households propensity to consume,

e is the labour demand coefficients.

Table 9.3- National Level Impacts of an Annual 10% Energy Price Rise in the Period 2000-2004, on Output Prices – in Percentages

	Static			Dynamic		
Sectors	Type I	Type II	Type IV	Type I	Type II	Type IV
Agriculture	0.8450	6.8954	6.8754	1.0107	9.7153	9.6406
Mining	0.1822	0.6141	0.6079	0.3722	1.3448	1.3304
Oil	6.2794	10.0874	10.0765	6.6843	12.6751	12.6281
Food industry	1.4369	8.1512	8.1313	1.6351	11.3253	11.2458
Paper and wood	1.8670	4.5989	4.5861	2.1490	6.3797	6.3398
Non metal	4.4749	6.4864	6.4768	4.7278	7.9641	7.9333
Textile	1.6834	3.6708	3.6600	1.9070	5.0487	5.0166
Chemical	2.9001	6.0977	6.0852	3.2240	8.2286	8.1841
Kerosene	61.0510	61.0510	61.0510	61.0510	61.0510	61.0510
Fuel oil	61.0510	61.0510	61.0510	61.0510	61.0510	61.0510
Gasoline	61.0510	61.0510	61.0510	61.0510	61.0510	61.0510
Gas oil	61.0510	61.0510	61.0510	61.0510	61.0510	61.0510
Basic metal	2.9479	13.5956	13.5827	3.3106	16.0250	15.9770
Machinery	1.6945	5.4725	5.4598	2.0652	7.7988	7.7539
Motor vehicle	2.7858	8.2332	8.2199	3.0850	10.6300	10.5787
Construction	2.7519	6.1322	6.1217	2.9540	7.5202	7.4880
Electricity	61.0510	61.0510	61.0510	61.0510	61.0510	61.0510
Natural gas	61.0510	61.0510	61.0510	61.0510	61.0510	61.0510
Total services	2.3992	3.8599	3.8516	3.0076	6.0440	6.0150
Employed household	-	5.0630	5.0534	-	7.0150	6.9801
Unemployed household	-		4.7840			6.5058

Table 9.4 - Static to Dynamic Output Price Impact Ratios- in Percentages

Sector	Type I-S/ Type I-D	Type II-S/ Type IID	Type IV-S/ Type IV-D
Agriculture	83.61	70.98	71.32
Mining	48.95	45.67	45.69
Oil	93.94	79.58	79.79
Food industry	87.88	71.97	72.31
Paper and wood	86.87	72.09	72.34
Non metal	94.65	81.44	81.64
Textile	88.28	72.71	72.96
Chemical	89.95	74.10	74.35
Kerosene	100.00	100.00	100.00
Fuel oil	100.00	100.00	100.00
Gasoline	100.00	100.00	100.00
Gas oil	100.00	100.00	100.00
Basic metal	89.05	84.84	85.01
Machinery	82.05	70.17	70.41
Motor vehicle	90.30	77.45	77.70
Construction	93.16	81.54	81.75
Electricity	100.00	100.00	100.00
Natural gas	100.00	100.00	100.00
Total services	79.77	63.86	64.03
Employed household	-	72.17	72.40
Unemployed household	-	-	73.53

Table 9.5 - Impacts of an Annual 10% Energy Price Rise in the Period 2000-2004, on Household Cost of Living- in Percentages

	Static			Dynamic		
Sectors	Type I	Type II	Type IV	Type I	Type II	Type IV
Agriculture	0.06	0.48	0.48	0.07	0.68	0.68
Mining	0.00	0.00	0.00	0.00	0.00	0.00
Oil	0.00	0.00	0.00	0.00	0.00	0.00
Food industry	0.23	1.30	1.29	0.26	1.80	1.79
Paper and wood	0.02	0.04	0.04	0.02	0.06	0.06
Non metal	0.01	0.01	0.01	0.01	0.01	0.01
Textile	0.15	0.33	0.33	0.17	0.45	0.45
Chemical	0.07	0.15	0.15	0.08	0.20	0.20
Kerosene	0.26	0.26	0.26	0.26	0.26	0.26
Fuel oil	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline	0.15	0.15	0.15	0.15	0.15	0.15
Gas oil	0.03	0.03	0.03	0.03	0.03	0.03
Basic metal	0.00	0.02	0.02	0.00	0.02	0.02
Machinery	0.01	0.04	0.04	0.02	0.06	0.06
Motor vehicle	0.05	0.15	0.15	0.06	0.20	0.20
Construction	0.01	0.02	0.02	0.01	0.02	0.02
Electricity	0.54	0.54	0.54	0.54	0.54	0.54
Natural gas	0.10	0.10	0.10	0.10	0.10	0.10
Total services	1.43	2.31	2.30	1.80	3.61	3.59
Total	3.12	5.93	5.92	3.57	8.20	8.16

Table 9.6 - Impacts of an Annual 10% Energy Price Rise in the Period 2000-2004, on Inflation Rate- in Percentages

	Static			Dynamic		
Sectors	Type I	Type II	Type IV	Type I	Type II	Type IV
Agriculture	0.11	0.88	0.87	0.13	1.23	1.22
Mining	0.00	0.00	0.00	0.00	0.01	0.01
Oil	0.64	1.03	1.03	0.68	1.29	1.28
Food industry	0.12	0.70	0.70	0.14	0.98	0.97
Paper and wood	0.02	0.05	0.05	0.02	0.07	0.07
Non metal	0.08	0.11	0.11	0.08	0.14	0.14
Textile	0.12	0.27	0.27	0.14	0.37	0.37
Chemical	0.08	0.18	0.18	0.09	0.24	0.24
Kerosene	0.09	0.09	0.09	0.09	0.09	0.09
Fuel oil	0.27	0.27	0.27	0.27	0.27	0.27
Gasoline	0.28	0.28	0.28	0.28	0.28	0.28
Gas oil	0.21	0.21	0.21	0.21	0.21	0.21
Basic metal	0.10	0.46	0.46	0.11	0.54	0.54
Machinery	0.02	0.08	0.07	0.03	0.11	0.11
Motor vehicle	0.09	0.26	0.26	0.10	0.34	0.34
Construction	0.23	0.51	0.51	0.24	0.62	0.62
Electricity	0.48	0.48	0.48	0.48	0.48	0.48
Natural gas	0.14	0.14	0.14	0.14	0.14	0.14
Total services	0.87	1.39	1.39	1.08	2.18	2.17
Total	3.95	7.39	7.38	4.33	9.60	9.55

Table 9.7- The Impacts of Changing Unemployed Household Consumption Propensity on Output Prices - in Percentages

Model	Type IV-S		Type IV-D	
Income Groups	First decile	Fifth decile	First decile	Fifth decile
Agriculture	6.86	6.88	9.64	9.64
Mining	0.60	0.61	1.33	1.33
Oil	10.07	10.08	12.63	12.63
Food	8.12	8.13	11.25	11.24
Paper and wood	4.58	4.59	6.34	6.34
Non- metal	6.47	6.48	7.93	7.93
Textile	3.65	3.66	5.02	5.02
Chemical	6.08	6.09	8.18	8.18
Kerosene	61.05	61.05	61.05	61.05
Fuel oil	61.05	61.05	61.05	61.05
Gasoline	61.05	61.05	61.05	61.05
Gas oil	61.05	61.05	61.05	61.05
Basic metal	13.58	13.58	15.98	15.98
Machinery	5.45	5.46	7.75	7.75
Motor vehicle	8.21	8.22	10.58	10.58
Construction	6.12	6.12	7.49	7.49
Electricity	61.05	61.05	61.05	61.05
Natural gas	61.05	61.05	61.05	61.05
Total services	3.85	3.85	6.02	6.01
Employed household	5.05	5.05	6.98	6.98
Unemployed household	3.80	4.17	6.51	6.78

Table 9.8- The Impacts of Changing Social Benefit Payments on Output Prices - in Percentages

Model	Type IV-S		Type IV-D	
Social benefit Payments	S	2S	S	2S
Agriculture	6.88	6.86	9.64	9.62
Mining	0.61	0.60	1.33	1.32
Oil	10.08	10.07	12.63	12.61
Food	8.13	8.11	11.25	11.22
Paper and wood	4.59	4.58	6.34	6.33
Non-metal	6.48	6.47	7.93	7.92
Textile	3.66	3.65	5.02	5.00
Chemical	6.09	6.07	8.18	8.17
Kerosene	61.05	61.05	61.05	61.05
Fuel oil	61.05	61.05	61.05	61.05
Gasoline	61.05	61.05	61.05	61.05
Gas oil	61.05	61.05	61.05	61.05
Basic metal	13.58	13.57	15.98	15.96
Machinery	5.46	5.45	7.75	7.74
Motor vehicle	8.22	8.21	10.58	10.56
Construction	6.12	6.11	7.49	7.48
Electricity	61.05	61.05	61.05	61.05
Natural gas	61.05	61.05	61.05	61.05
Total services	3.85	3.84	6.02	6.00
Employed household	5.05	5.05	6.98	6.97
Unemployed household	4.78	4.45	6.41	5.41

Table 9.9- The Impacts of Changing Consumption Propensity for Unemployed Households on Output Prices - in Percentages

Model	Type IV-S		Type IV-D	
Consumption Propensity	**100%**	**95%**	**100%**	**95%**
Agriculture	6.86	6.88	9.64	9.65
Mining	0.60	0.61	1.33	1.33
Oil	10.07	10.08	12.63	12.63
Food industry	8.12	8.14	11.25	11.25
Paper and wood	4.58	4.59	6.34	6.34
Non-metal	6.47	6.48	7.93	7.94
Textile	3.65	3.66	5.02	5.02
Chemical	6.08	6.09	8.18	8.19
Kerosene	61.05	61.05	61.05	61.05
Fuel oil	61.05	61.05	61.05	61.05
Gasoline	61.05	61.05	61.05	61.05
Gas oil	61.05	61.05	61.05	61.05
Basic metal	13.58	13.59	15.98	15.98
Machinery	5.45	5.46	7.75	7.76
Motor vehicle	8.21	8.22	10.58	10.58
Construction	6.12	6.12	7.49	7.49
Electricity	61.05	61.05	61.05	61.05
Natural gas	61.05	61.05	61.05	61.05
Total services	3.85	3.85	6.02	6.02
Employed household	5.05	5.06	6.98	6.98
Unemployed household	3.80	3.52	6.51	6.82

CHAPTER TEN: CONCLUSIONS

10.1. Introduction

This thesis began with a brief review of static and dynamic IO models and their applications. In earlier chapters a dynamic IO model that preserves the characteristic elements of extended IO analysis was presented and was shown to yield plausible results in sensitivity testing. The main message of the model is that price impacts increase when one moves from a conventional dynamic to an extended dynamic IO model. It must be emphasised that the model itself has something to offer policymakers who are faced with decision making problems with regard to change price of particular industry production in terms of other industries production prices or wages and social security payments. It must be admitted, however, that the model does not offer any insight about changes in the quantity of goods due to a price change.

In this concluding chapter there is an opportunity to demonstrate how this study contributes to meeting the objectives that were stated in chapter 1. In the next section we will report the findings of this research in relation to these objectives. Section 10.3 will explore the wider implications of the research and what this research implies for any future research.

10.2. Summary of Key Findings

In this section the key findings are explained briefly in relation to the research objectives. For this reason it might be helpful to restate the particular research objectives here:

- To review the theoretical background of dynamic IO models.
- To develop a dynamic quantity IO model and its dual.
- To undertake the necessary data assembly in order to construct the model.
- To test the stability of the models.
- To explore the empirical properties of the models.

In the following part we explain separately how we meet each of these objectives.

10.2.1. Reviewing the Theoretical Background of Dynamic IO models

A very brief survey of IO analysis was presented in chapters 2, 3 and 4. This review covers static and dynamic extended quantity models as well as price models and their applications with greater emphasis on the dynamic extended aspects. The description of the static analysis provided the platform to move from static to dynamic analysis and helped to explain the assumptions on which the dynamic model is based. The key findings in these chapters may be summarised as follows:

We found that the main difference between dynamic and static IO analysis lies in taking into account not only intermediate products but also capital items in the interindustry transactions in the dynamic model by introducing the capital coefficients matrix. The role, formation and nature of the capital matrix in the dynamic IO analysis were the key findings in this review. For this reason we discussed the role and formation of capital stock in more detail in the literature review (chapter 2). The nature of the capital coefficients matrix was also explored. Some difficulties such as: singularity or the possibility of negative outputs, symptoms of instability arising from the nature of the capital coefficients matrix were examined. Apart from these difficulties, this review revealed that the dynamic IO model has been developed not only for short term planning but also for long term purposes such as structural change, technological change and balanced, unbalanced and endogenous growth.

We found out that the vast majority of applied IO studies have relied upon implementation of the static model because of the ready availability of the requisite data and the fact that computational procedures are well defined and available in package form. The mathematical representation of dynamic models has been developed but rarely applied for empirical purposes. This is either because of the attributes of the mathematical model or as a result of the absence of the requisite data. So, the dynamic model is not only a complicated model but also has demanding data requirements in order to be put into operation. Generally, the dynamic IO model is more complicated and more interesting than static models.

A systematic theoretical framework for the static and dynamic IO price models and their applications was reviewed. This review revealed that every price model has its own dual i.e. quantity model. We concluded that in developing a dynamic price model we first had to introduce the quantity model.

This review also revealed the problems of IO price theory and showed that although many economists have tried to overcome some of the difficulties it presents, the important problem of no connection between price and quantity of goods still remains. So, this review provided a warning about the applicability of the price IO model. That is, we should not expect that this model provides any changes in quantity of goods as a result of price changes.

10.2.2. Developing Dynamic Quantity and Price IO Models

The development of dynamic quantity and price models was discussed in chapters 3 and 4. According to the conclusion in the review of IO quantity and price models, first of all two dynamic extended quantity models were developed, one of which takes into account the different household income groups endogenously, and the other of which distinguishes between employed and unemployed households. The distinctive feature of the extended dynamic quantity models is that they present the household contribution to output growth. This is because household saving and investment are modelled.

Then dual versions of the extended quantity models were developed. The main purpose of the extended price models is to provide more information about impacts on price as well as on the size of wage and social security payments compared with conventional types of model.

10.2.3. Undertaking the Necessary Data Assembly in Order to Construct the Model

The preparation of the necessary information for constructing the extended dynamic price models was discussed in chapters 5, 6, 7, and 8. These data include the most recent input-output table to calculate input coefficients and capital stock (by industries) to construct the capital coefficients matrix. By reviewing the input-output tables in Iran in chapter 5 we found that the most recent input-output table is a 43-energy IO table that was compiled by the Ministry of Power in 1994. But, because of a lack of data on capital stock at disaggregated levels especially for manufacturing industries, we estimated capital stocks for 16 industries for three types of asset (capital) for 1991 which was discussed in chapter 6. The PIM method with a bell-shaped retirement pattern and a beta-decay depreciation function were employed to calculate a replacement function. The calculation of this replacement function was found to be a very complicated and tedious task. For example we calculated: 48 bell-shaped retirement functions and for each bell-shaped retirement function cut-off points of distribution around the average service live, and 48 beta decay functions. Then 48 replacement functions were obtained by combining each retirement function with a corresponding depreciation function. Finally, to calculate capital stock, the replacement functions were multiplied by an investment time series. This operation was repeated 48 times to calculate sectoral capital stocks and 48 times in order to exclude war damages.

We also found that the PIM is a highly demanding data method and requires a lengthy investment time series for industry assets. This method becomes harder when it is practised in Iran with that country's transformation from peace to a long period of war (1980-1988) and from monarchy to republic in 1979 (Islamic Revolution). The first item, war, brought a huge amount of damage to assets, which have had to be excluded. The second item caused an interruption to data surveys for two years, 1977-8, which meant that data series had to be manipulated or adjusted. We adjusted and manipulated a considerable amount of data not only to exclude war damage but also to provide sectoral investment time series for three types of asset. For example, the official data on war damage are 18 figures that is for nine main sectors and for each sector on two types of asset. These 18 figures were disaggregated into the 432 figures in which 16 industries, for each industry 3 types of asset and a series of 9 years. After the considerable amount of data adjustment and manipulation, when the capital-output ratios were compared with other countries experiences, consistency was observed. In addition we gained confidence when the results of this study on capital-output ratios were compared with the first study (Banouei 1991). We will gain more confidence when the capital stock time series are prepared and compared with output growth or other relevant indices.

The capital stocks estimation was a basic requirement for the construction of a capital coefficients matrix. Two types of capital matrices were compiled, one referring to net fixed assets by using the capital stocks, and another showing the working (inventory) capital. Dividing each element of the total capital stock matrix by the corresponding industry output, an intersectoral capital coefficients matrix was constructed and this is presented in chapter 7. We found that constructing a capital coefficient matrix required less effort and the main point is data availability of the capital stocks and working capital by industry. Preparing data for working capital for the cases in which the amount of working capital was given in terms of weight was found to be confusing because to transform into value, three types of prices (sheltered, consumer or imported prices in the case of agriculture sector) were supplied and the average price is unknown.

Moreover, we found that there is an inconsistency between household consumption and income in the household expenditures and income surveys that are prepared by SCI annually. These two variables are necessary to calculate the propensity to consume for households to construct extended models. We have also found that there is no regular payment to the unemployed household recorded in the household income survey by SCI, nor in any other data. This led us to conclude that we have to concentrate on implementing the developed model to test it empirically instead of focussing on the policy impacts of an energy price rise. Such an application of the model requires both more reliable data amore rigorous testing.

10.2.4. Testing the Stability of the Models

In the review of dynamic IO analysis model stability is a major issue. The importance of stability for the dynamic IO model was discussed and tested in chapter 8. It was mentioned that the instability means the dynamic IO model is not adopted for explaining the actual movement of the economic system and that it would be better to regard it strictly as a planning system. There are two types of stability; complete and relative stability, each type requiring particular conditions to be satisfied. Besides, the stability condition for the price model is stricter than that for the quantity model. In the review of stability of the dynamic model, we found that it is the most complicated part of the dynamic IO literature, a limited number of articles or book have been published and those that have require a greater deal of effort to understand. Three main difficulties emerged in relation to stability: first understanding the concept of stability and the differences between stability and relative stability in the real world. The second, finding out the relationship between the balanced growth rate and the stability of the dynamic model, which is the most complicated part. This specific relationship has been proved through a large number of theorems. Thirdly, finding out the relationship between the nature and type of input and capital coefficients matrices and the stability of the dynamic model.

Moreover we found that there is little expectation of obtaining a stable dynamic price model, particularly when we noticed instability and relatively instability results for most of the countries' experiences. The results of testing confirmed our finding and showed high balanced growth rates, and relative instability for the constructed dynamic models. According to this result, we reached the conclusion that our model is only appropriate for short-term planning.

The interesting result was that the balanced growth rates for extended models, i.e. type II 22.1% and for type IV 22%, were considerably less than those for the conventional model, i.e. 34.8%. So, it means that the extended dynamic model can yield an economic growth rate that is close to that in the real world.

10.2.5. Exploring the Empirical Properties of the Models.

The empirical properties of the models were explored in chapter 9. By testing the extended IO dynamic price models, a number of results have been observed. First, we noticed that the price impacts calculated by these models provided considerable advantages over those that are currently obtained from conventional models, because these models provide not only impacts on the output price but also on the wage and social security. Secondly, extended type II impacts in both static and dynamic forms have estimated greater impacts than the conventional and extended type IV models. Thirdly, we have also noticed that the dynamic models generally yield greater impacts.

Although the empirical testing provided us with assurance about the capability of the models, there was some doubt about the sensitivity of the models. For this reason we established a series of sensitivity tests. The aim of the sensitivity tests was to check if some of the relatively arbitrary assumptions made to construct the model have any significant effect on the measurement of the impacts. We have found the models are generally not at all sensitive to changes in all the parameters. Therefore the models are worthy enough to be considered as a tool for estimating any price impacts caused by changing input prices or value added changes.

10.3. Wider Implications of the Study

The state of the economy at a particular point in time is represented by the corresponding set of technical coefficients in IO analysis. For current production, the machinery, premises, and so on must already be in place. But if an economy is growing then anticipated production is different from current production and the amount of supporting capital may change. From this point of view dynamic IO requires knowledge of capital-output (or capital-capacity) ratios, which are analogous to the IO ratios used in static models of general interdependence. To construct a dynamic model it is necessary to supplement the current transaction table with capital flow tables. Moreover, the capital flow table is the main requirement of the dynamic economy-wide model embracing sectors. It works like an engine in the model to push forward, and makes the connection between present and future. The construction of a total capital coefficient comes from both kinds of coefficients: fixed capital coefficients and inventory capital coefficients.

In the last twenty years, one of the most important areas of development in the field of static IO analysis has been the modelling of the linkage between industrial and household activities especially at the regional level. The linkages between them are usually modelled in a static IO framework by treating the household sector as an ordinary industry, which produces labour and consumes industrial products and is included in the transactions matrix. Extended versions of the IO model have been introduced by adding further rows and columns to the inter-industry flow matrix. A number of different approaches have been taken to the design of extended IO models. Static extended IO models are notably broader in scope than conventional IO models, and typically include the study of household income and consumption and the interactions among a number of variables: income distribution, migration, labour force participation, employment and unemployment, and industrial output.

From the theoretical review of extended static and dynamic IO models we found that the capital coefficient matrix plays a significant role in the construction of the dynamic model. Therefore the starting point for developing dynamic extended models was to present an extended capital coefficient matrix which has the same dimension as the extended input coefficients matrix. Some basic assumptions were made about household consumption (inputs) and income (output). We made a distinction between the durable and non-durable goods that households consume and the durable goods were considered as a type of capital for them. Non-durable goods consumption is placed in the input coefficients matrix while consumption of durable goods appears in the capital coefficients matrix. By introducing durable goods for the household sector in a column of the capital matrix, we considered households in the same way as other sectors which have their capitals located in the capital coefficients matrix. Another assumption was made about household income. We assumed that they do not spend all of their income but rather they save a part of their income and the latter part is placed in the row of the capital coefficients matrix. Again, by this assumption on saving, we consider household investment on production. These assumptions were then applied to two dynamic extended models, one of which takes account of different household income groups, and the other distinguishes between employed and unemployed workers. The main purpose of this dynamic model is to examine the size of household investment in output growth.

Another lesson from the review of IO analysis was that, to develop a dynamic price model, it is necessary to introduce the quantity model in advance. Therefore after the dynamic quantity model was developed, the next step was to develop an extended dynamic price model. We found that the IO price model is supply price determined in which the price of each good is defined as the costs that each productive sector of the economy receives per unit of its output. These costs comprise not only payments for inputs purchased from the same and from the other industries but also the value added. Value added usually includes: wages, interest on capital and entrepreneurial revenues credited to households, tax paid to the government, and other final demand and assumed to be given. For developing the extended price model, the price vector must include the price of household production, i.e. persons years of work, as well as industries production. We introduced wages as the price of employed household production while for unemployed households who do not produce output, their production prices were considered to be zero.

In the extended price model, when employed households are modelled, then the impact of any changes in input prices on the production prices are due not only to the direct and indirect price impacts but also on wages, and wages on the output prices in the second, third and higher-round effects. Therefore extended price models will provide larger impacts compared with conventional ones.

Empirical testing of dynamic price models was explored in the context of energy product prices changes in Iran. Six price models were examined in testing the current government policy. They were divided into two main groups; static and dynamic. Each group includes conventional type I, extended type II and type IV models. The results of the tests showed that the extended price models in which households are taken into account provided higher impacts. These results also indicated that the impacts measured by dynamic models were greater than those of static models. These results were the ones that we anticipated before operating the models. Nevertheless, this model does not offer any insight about changes in the quantity of goods as consequences of price changes.

The successful empirical testing of the extended dynamic model, provides an addition to the dynamic IO literature. This model is capable of being applied by those governmental organizations that deal with economic planning at the national or regional levels, in particular by governments that aspire to be a member of any international trade organizations. As we know, the first condition for membership is to remove tariffs and subsidies. This model can serve as a proper tool for investigating the impacts of such changes in some detail. This model provides the output price changes as well as wage and social security changes due to any removal of subsidies or tariffs.

This model is also capable of being developed even further for different household income groups such as: rural and urban, ten quintile income groups, retired and disabled groups. Such further development can provide the impacts of any price reform on the income of different groups and enable government to present more detailed financial help to low income groups who will lose their welfare due to the carrying out of this reform. The main difficulty for such practice is most likely to be data availability on the consumption for the different above groups. This can be a subject for further research.

This model is capable of being applied at both the national and regional levels. For the regional level the main limitation is in constructing the regional extended capital coefficients matrix which relies heavily on the information on regional capital stocks by industries. The another limitation is in providing the household propensity to consume, which in most cases was found difficult to establish. Our view is that the application of this model at regional level in Iran is same distance away until a regional IO table is prepared. For other countries that have already prepared a capital coefficients matrix and data on the household propensity to consume it would not be a difficult task. In these countries the most difficult task is to provide data on the propensity to consume for households.

As one of the main difficulties of this study was data collection, it would be helpful to make some recommendations to organizations that carry out surveys e.g. Central Bank of Islamic Republic of Iran (CBIRI) and the Statistical Centre of Iran (SCI) and academic researchers. Because providing the necessary data is one of the main steps of the research if the required data had been prepared already, it would not only have speeded up the research but it would also have helped to achieve acceptable and reliable results. Both a strong and comprehensive model and reliable data can lead to faithful results. On the contrary, a strong model with unreliable data can provide misleading research outcomes.

We make a friendly recommendation to our colleagues at the universities or at other institutions in terms of research priorities. Although there are significant numbers of expert economists in Iran, only a few undertake research projects. One of the main reasons here is the difficulty of inadequate data. If the researchers do not ask for necessary data from the organizations the main function of which is to carry out surveys, then these data are less likely to be collected. If we define exactly the necessary data (and may the method of calculation) and convince the official organizations about our research aims and define the variables precisely, then they are more likely to collect them in future. This is especially true for the data for which are already collected in other countries. The experience of this author in convincing the CBIRI about the importance of estimating sectoral capital stocks provides an illustrating of what needs to be done.

We make the second suggestions to official organizations in more detail, particularly CBIRI and SCI. When we reviewed the historical background of the IO table in Iran we noticed that there is no simple organization legally responsible for assembling the data and compiling the IO table. When one organization compiled an IO table, later on other governmental organizations also constructed an IO table, sometimes with different concepts, definitions and dimensions, so making comparative analysis hard. Therefore it is essential that the Iranian government should assign this job to a particular organization, which can compile IO tables on a regular basis, for a specific time interval, for example five years. Such an attempt increases the possibility of comparisons.

We also noticed that although IO studies in Iran have a very long history (about five decades), most of the effort has been placed on compiling IO tables at a national level and rarely at a regional level. The importance of preparing regional IO table relies on two basic elements in the regional economy, first the structure of data in a national IO table may differ markedly from that recorded in the regional data. Secondly, it is true that a regional economy depends to a greater degree of imports and exports than a national economy. Iran, with 28 regions, each with various climate, economic and natural resource possibilities, and differing degrees of industrialization, the preparation of regional IO tables can help the planner design a more accurate regional plan. Data collection and assembly of data in necessary frameworks are the preliminary task in compiling regional IO tables. For compiling the regional IO tables two related approaches can be considered. The first consists of extracting regional tables from the national tables. This was pioneered by Isard & Kuenne (1953). The second consists of arranging the regional IO tables exactly in the same way as the national tables. The main point is the shortage of regional data which means that the regional tables can be estimated in the short-term by using the first approach method, and that comprehensive regional tables will be constructed by using the second approach when the comprehensive regional data is collected.

Moreover, we have also noticed that there is an essential inconsistency between the consumption and income households survey. This inconsistency can be attributed to the fact that total household consumption is greater than total household income. Both these variables are the basic variables in the economic analysis in terms of policy making for household income groups. In the input-output table information is slightly improved because the IO compiler (SCI) believes that the remainder of household income is in the surplus operation, at the bottom of the IO table. The property-type income includes not only the rest of household income but also replacement income, revaluation of capital and return on capital. Although extracting the rest of household income from the property-type income is a difficult task, it is possible. When such data are prepared, then operating static and dynamic extended models could be accomplished much more smoothly.

REFERENCES[1]:

Almon C. (1963a), "Consistent Forecasting in a Dynamic Multi-sector Model", *Review of Economics and Statistics* 45, 148-61.

Almon C. (1963b), "Numerical Solution of a Modified Leontief Dynamic System for Consistent Forecasting or Indicative Planning", *Econometrica* 31(4), 665-78.

Amini A., " Estimation Capital Stock Time Series", 1997, *Plan and Budget Organization*, Working Paper (in Persian).

Arab Mazar A. and Kalantary B. 1993, "Estimation of capital stock of Iran in 1960-1989", *Eghtesad* 1(1), (in Persian).

Ardeshiri M. 1995, *"Impact Analysis of Changes of Income Distribution on Macroeconomic Variables by Using Input-output Techniques*", Unpublished MA Dissertation, University of Allameh Tabatabaei, Tehran, Iran, (in Persian).

Arrow K. J. 1951, "Alternative Proof of The Substitution Theorem for Leontief Models in the General Case" in Koopmans T.C. (ed.), *Activity Analysis of Production and Allocation*, New Haven and London: Yale University Press, 147-54.

Augustinovics M 1970, "Methods of International and Inter-temporal Comparison of Structure", in Carter and Brody *(eds.) Contributions to Input-Output Analysis*, Amsterdam: North-Holland, 249-69.

Aukrust O. 1970, "Prime IO Model of the Price and Income Distribution Mechanism of an Open Economy", *Income and Wealth*, 16(1), 51-78.

Baghozian A. 1993, "Estimation of Capital Stock on Main Subsector of the Iranian Economy in 1960-1978", Unpublished MA Dissertation, Shahid Beheshti University, Tehran, Iran (in Persian).

Ball V.E., Bureau, J.C., Buault, J.P., and Witzke H. P. 1993, "The Stock of Capital in European Community Agriculture", *European Review of Agricultural Economics* 20, 437-50.

Banouei A.A. 1989, *"Planning Model for Iran in Input-Output Framework: an Empirical Analysis*", Unpublished Ph.D. thesis, University of Bombay, India, chapter eight, 264-307.

---

[1] It should be mentioned that, the references those are specified in Persian, are reckoned from the Hegira, A.H., For transferring the Christian calendar, A.D., to A.H. from 21st March up to 31st December should subtract 621 years, meanwhile from 1st January up to 20th March should subtract 622 years A.D. originated date.

Banouei A.A. 1992, "Relevance of Inter-sectoral Capital Coefficient Matrix for Planning In Dynamic Input-Output Framework, *Proceeding of the First Conference on Planning and Development*, Institute for Research and Development, Tehran, Iran, 1-31 (in Persian).

Banouei A.A. 1992a, "Planning and Development Under Monarchy and the Islamic Government of Iran: a Critical Assessment", *International Studies* 29, 41-54.

Banouei A.A. 1992b, "Application of a Dynamic System for Planning in Iran", *Economic Systems Research* 4(1), 77-85.

Banouei A.A. 1993, "Input-Output Tables in Iran: Compilation, Use, Prospects, and Problems", *Economic Systems Research* 4(3), 335-341.

Banouei A.A. 1996, "Review of the State of Input-Output and Different Aspects of Its Application in Iran", *Economic Research* 1(3), Part II, Centre for Economic Research, University of Allameh Tabatabaei, 58-86 (in Persian).

Banouei A.A. & Aryafar A. 1992, "Economic Planning in Iran: Roots, Processes and Prospects", *Asian & African Studies* 25, 26-36.

Banouei A.A. & Asgari M., and Mahmoudi M. 2000, "Studying of the Relationship Between Structure of the Production and Employment in Economic Sectors: by Using a Semi-Social Accounting Matrix", paper presented at the "*Second Economic Congress*" held at the University of Tarbiat Modaress, Tehran, Iran (in Persian).

Batey P. W. J. and Madden M., 1981, " Demographic-Economic Forecasting within an Activity-Commodity Framework: Some Theoretical Considerations and Empirical Results", *Environment and Planning A* 13 (9), 1067-1083.

Batey P. W. J. and Madden M. 1983, " The Modelling of Demographic-Economic Change Within the Context of Regional Decline: Analytical Procedures and Empirical Results", *Socio-Economic Planning Sciences* 17 (5), 315-328.

Batey P. W. J. 1985, "Input-Output Models for Regional Demographic-Economic Analysis: Some Structural Comparisons", *Environment and Planning A* 17, 73-99.

Batey P. W. J., Madden M., and Weeks M. 1987, " Household Income and Expenditure in Extended Input-Output Models: A Comparative Theoretical and Empirical Analysis", *Journal of Regional Science* 27 (3), 341-356.

Batey P. W. J. and Weeks M, 1989, " The Effect of Household Disaggregation in Extended Input-Output Models, in R.E. Miller, K.R., Polenske and A.Z. Rose (eds.) *Frontiers of Input-Output Analysis*, New York, Oxford University Press, 119-62.

Batey P. W. J. and Rose A. Z., 1990, "Extended Input-Output Models: Progress and Potential", *International Regional Science Review* 13 (1&2), 27-49.

Batey P. W. J 1990, "Demographic-Economic Impact Multipliers for Greater Manchester and Merseyside", Department of Civic Design, University of Liverpool, URPERRL, *Working Paper 8.*

Batey P. W. J., Madden M. and Scholefield G. 1993, " Socio-economic Impact Assessment of Large-Scale Projects Using Input-Output Analysis: A Case Study of An Airport", *Regional Studies* 27 (3), 179-191.

Beyers W. B. 1976, "Empirical Identification of Key Sectors: Some Further Evidence", *Environment and Planning* 8 (2), 231-6.

Birol F., Aleagha A.V., and Ferroukhi R. 1995, "The Economic Impact of Subsidy Phase Out in Oil Exporting Developing Countries: a Case Study of Algeria, Iran and Nigeria", *Energy Policy* 23(3), 209-215.

Blackwell J. 1977, " Disaggregation of the Household Sector in Regional Input-Output Analysis: Some Models Specifying Previous Residence of Worker", *Regional Studies* 12, 367-377.

Bon R. 1986, "Comparative Stability Analysis of Demand-Side and Supply-Side Input-Output Models", *International Journal of Forecasting* 2 (2), 231-35.

Bon R. 1988, "Supply-Side Multiregional Input-Output Models", *Journal of Regional Science* 28 (1), 41-50.

Brody A. 1970, *Proportions, Prices and Planning. A Mathematical Restatement of the Labour Theory of the Value*, North-Holland, Amsterdam.

Brody A. 1995, "Truncation and Spectrum of the Dynamic Inverse", *Economic Systems Research,* Vol.7, No.3, 235-47.

Bulmer-Thomas V. 1982, *Input-Output Analysis for the Developing Countries,* NewYork, John Wiley.

Bulmer-Thomas V. & Zamani H. 1989, *"Industrialization and Income Distribution in Iran, since 1960: an Input-Output Approach"*, paper presented to the 9th International Conference on Input-Output Techniques, Kezsthely, Hungry.

Bureau of Labour Statistics 1983, U.S. Department of Labour, "*Trends in Multifactor Productivity*", 1948-81, Bulletin 2178, U.S. Government Printing Office, Washington D.C.

Bureau of Labour Statistics (BLS) 1995, U.S. Department of Labour, "*Trends in Multifactor Productivity Measures for Selected Industries and Government Services*", Bulletin 2461, U.S. Government Printing Office, Washington D.C.

Campisi D. & La Bella A. 1988, "Transportation Supply and Economic Growth in Multiregional System", *Environment and Planning* A 20, 925-36.

Campisi D., Nastasi A., and Bella A. 1992, "Balanced Growth and Stability of the Leontief Dynamic Model: and Analysis of the Italian Economy", *Environment and Planning A* 24, 591-600.

Campisi D. & Nastasi A. 1993, "Capital Usage and Output Growth in Multiregional Multisectoral Models: An Application to the Italian Case", *Regional Studies,* 27 (1), 13-27.

Carcernes L.R. 1977, "Economic Integration and Export Instability in Central America: A Portfolio Model in: S. Shaila & T. John (eds.), *Trade and Poor Economies*", London, Francess and Company Ltd, United Nations, Industrial Countries, New York, II, Part one.

Carter A.P. 1963, "Incremental Flow Coefficients for a Dynamic Input-Output Model with Changing Technology", in Barna *et al.* (eds.), *Structural Interdependence and Economic Development Proceedings of an International Conference on Input-Output Techniques, Geneva, September 1961,* New York: Macmillan and Co. Ltd, 277-302.

Carter A.P. 1970, "A Linear Programming System Analysing Embodied Technological Change", in Carter A.P. and Brody A. (eds.), *Contributions to Input-Output Analysis,* Amsterdam and London: North-Holland Publishing Company, 77-98.

Central Bank of Islamic Republic of Iran (CBIRI) (n.d.), "*The 1353 Input-Output Table For the Iranian Economy*", Tehran, Iran (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1981, "*The 1358 Input-Output Table for the Iranian Economy*", Tehran, Iran (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1981, "Studying Statistical Result of Large-Scale Establishments in 1356-1360" *Economic Statistics Department, Manufacturing Statistics Center* (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1982, "*National Accounts of Iran in 1338-1356*", Economic Accounts Department", CBIRI (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1991, "*Annual Economic Report and Balance Sheet 1991*", CBIRI, 46 (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1994, "*National Accounts of Iran in1353-1369*", Economic Accounts Department", CBIRI (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1994, *"National Accounts of Iran in 1370",* Economic Accounts Department", CBIRI (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1995, Economic Accounts Department, "*National Accounts of Iran 1372*", (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1996, Economic Accounts Department, "*National Accounts of Iran 1373*" (in Persian).

Central Bank of Islamic Republic of Iran (CBIRI) 1996, *"The 1367 Input-Output table for the Iranian Economy",* Tehran, Iran (in Persian).

Chung J.W. 1981, "The price of gasoline, the oil crisis, and the choice of transportation mode", *Quarterly Review of Economics and Business* 21(3), 77-86.

Dashtban M 1994, *"Regional Planning by Using Input-Output Technique for Kerman Province",* Unpublished MA Dissertation, Allameh Tabatabaei University, Tehran, Iran (in Persian).

Davar E. 1989, "Input-Output and General Equilibrium", *Economic Systems Research,* 1 (3), 331-44.

Davar D. 1993, "Price Discrimination in Input-Output", *Economic Systems Research,* 5 (1), 3-10.

Davis H. C. & Salkin E. L. 1984, "Alternative Approaches to the Estimation on Economic Impacts Resulting from Supply Constraints", *Annuals of Regional Science* 18 (1), 25-34.

Debreu G and Herstein 1953, "Non-negative Square Matrices", *Econometrica* 21 (4), 597-607.

Dieckheuer G., Meyer U., & Schumann J. 1984, "Simultaneous Determination of Quantities and Prices in A Dynamic Input-Output Model. Demonstrated for the Federal Republic of Germany, *Proceedings of the Seventh International Conference on Input-Output Techniques* (New York, UNIDO).

Dietzenbacher E. 1992, "The Measurement of Interindustry Linkages: Key Sectors in the Netherlands, *Economic Modelling* 9, 419-37.

Dietzenbacher E. 1997, "In Vindication of The Ghosh Model: A Reinterpretation as a Price Model", *Journal of Regional Science* 37 (4), 629-651.

Dietzenbacher E., Linden J. A. V., & Steenge A.E. 1993, "The Regional Extraction Method: EC Input-Output Comparisons", *Economic Systems Research* 5 (2), 185-206.

Dorfman R, Samuelson P., & Solow R. (1958), *"Linear Programming and Economic Analysis"*, New York, Mc Graw-Hill.

Duchin F. & Szyld D.B. 1985 "A Dynamic Input-Output Model with Assured Positive Output", *Metroeconomica* 37(3), 269-282.

Duchin F.1988 "Analyzing Structural Change in the Economy", in Ciaschini M.(ed.), *Input-Output Analysis: Current Developments,* London: Chapman and Hall, 113-128.

Duchin F & Lange G. 1992, "Technological choices and prices and their implications for the US economy, 1963-2000" , *Economic Systems Research* 4 (1), 53-76.

Duchin F. & Lange G. 1995, "The Choice of Technology and Associated Changes in Prices in the U.S. Economy", *Structural Change and Economic Dynamics* 6, 335-357.

Duchin F. 1988, "Analysing Structural Change in the Economy", in *Input-Output Analysis: Current Developments,* Ciashini M., Chapman and Hall, 113-28.

Dutta Mazumdar D.K. 1968, "Capital Coefficient Matrix for Indian Economy1963", in *Application of Input-Output Techniques to Growth and Trade*, 272-284.

Eckestein G. and Badakhshan G 1972, *"Projections of Input-Output Tables For Iranian Economy",* Ministry of Economy (ME), Tehran, Iran, (in Persian).

Economic Research Centre & Ministry of Post and Telecommunications 2000, *"Post and Communication Input-Output Table"*, Tehran, Iran (in Persian).

Edler D. 1988, "Impacts of Selected Technologies on Employment and Its Occupational Composition: an Input-Output Approach. Paper presented at the *International Conference on New Technology: Its Impact on Labour Markets and the Employment System,* Berlin, December 6.

Edler D.& Ribakova T. (1993), "The Leontief-Duchin-Szyld Dynamic Input-Output Model with Reduction of Idle Capacity and Modified Decision Function", *Structural Change and Economic Dynamics*, 4 (2), 279-97.

Fetini H. & Bacon R. 1999, *"Economic Aspects of Increasing Energy Prices to Border Price levels in the Islamic Republic of Iran"*, the World Bank, Middle East Department.

Filippini L. 1983, "Price and Quantity Adjustment in A Dynamic Closed Model: The Dual Stability Theorem", *Journal of Macroeconomics* 5, 185-196.

Fisher W.H. & Chilton C.H. 1975, "Developing Ex Ante Input-Output Flow and Capital Coefficients" Chapter 1, in *Capital Coefficients and Dynamic Input-Output Models,* Cater A. & Gossling W.F. (eds.), Input-Output Publication Co., London.

Folloni G. & Miglierina 1994, "Hypothesis of Price Formation in Input-Output Tables", *Economic Systems Research* 6 (3), 249-64.

Georgescu-Roegen N. 1951, "Some Properties of a Generalized Leontief Model", *Activity Analysis of Production and Allocation*, Koopman T.C. (ed.), New York, Chapter X, 167-73.

Georgescu-Roegen N. 1951, "Relaxation Phenomena in Linear Dynamic Models", *Activity Analysis of Production and Allocation*, Koopman T.C. (ed.), New York: Wiley, 116.

Gharoon M. 1994 " Sectional Capital Stock Estimation in Iranian Economy 1974-1992", *Ravand* 4(14,15), Tehran, Iran (in Persian).

Ghosh A. 1958, "Input-output Approach in an Allocation System", *Econometrica*, February, 58-64.

Giarrantani F. 1974, "The Effect on Relative Prices of Air Pollution Abatement: A Regional Input-output Simulation", *Modelling and Simulation* 5, 165-70.

Giarratani F. 1980a," The Scientific Basis for Explanation in Regional Analysis", *Paper of the Regional Association* 45, 185-196.

Goldsmith R.W. 1951, "A Perpetual Inventory of National Wealth", *Studies in Income and Wealth* 14, 1-72, New York, NBER.

Gowdy, J.M. and Miller, J.L., 1994, "Impact of Capital Formation on Input-Output Multipliers", *Socio-Economic Planning Sciences* 28(4), 211-217.

Green M.J. 1971, "Investment Matrices for Plant and Machinery: 1963 and 1968" *Economic Trends,* H.M.S.O., London.

Green M.J., 1975, "Investment Matrix for United Kingdom; Their Structure and Use in Forecasting", in Carter A. and Gossling W.F. (eds.), *Capital Coefficients and Dynamic Input-Output Models,* 14-35.

Grosse N.R. 1953, "The Structure of Capital" in Leontief W. and Others, *Studies in the Structure of the American Economy, Theoretical and Empirical Explorations in Input-Output Analysis*, New York, Oxford University Press, 185-242.

Gruver G.W. 1989, "On the Plausibility of the Supply- Driven Input-Output Model: A Theoretical Basis for Input-Output Coefficient Change", *Journal of Regional Science*, 26, 441-50.

Hamilton C. 1986, "A Technique for Calculating Capital Coefficients in Newly Industrializing Countries, With Application to the Republic of Korea", *The Developing Economies* 24 (1), 56-70.

Hamilton C. 1989, " A Technique for Calculating Capital Coefficients in Newly Industrializing Countries, With Application to the Republic of Korea", *The Developing Economies* XXIV-1 (1), 56-70.

Harrod, R.E. 1948: *Towards a Dynamic Economics*, Macmillan, London.

Hassan Khonsari Z. 1983, "Estimation of Capital Stock in Iranian Economy in 1338-1360 and Sectional Estimation Separately for 1343-1360", Report for *Plan and Budget Organization,* Tehran, Iran (in Persian).

Hawkins D. & Simon H.A. 1949, "Some Conditions of Macro-Economic Stability", *Econometrica* 17 (July-October), 245-8.

Heerterman A.R.G. 1990, "The Instability of the Dynamic Input-Output Model", *Economic Systems Research* 2 (4), 351-5.

Hicks J.R. 1965, "Capital and Growth", Clarendon Press, Oxford , Chapter VII.

Hofman A.A. 1992, "Capital Accumulation in Latin America - a Six Country Comparison for 1950-89", *Review of Income and Wealth* 38(4), 365.

Hofman A.A. 2000, "Standardised Capital Stock Estimates in Latin America: a 1950-94 Update", *Cambridge Journal of Economics* 24(1),45-86

Hooker O.T. 1970, "Some Engineering Data for 1964", SUP43. *Department of Applied Economics*, Cambridge. Mimeographed.

Hulten C. R. 1981, *"Depreciation, Inflation, and the Taxation of Income from Capital"*, Washington DC, Urban Institute Press.

International Labor Office (ILO) 1973, *"Employment and Income Policies in Iran"*, Geneva.

Isard W. 1953, "The Impact of Steel Upon the Greater New York-Philadelphia Industrial Region", *Review of Economics and Statistics* XXXV, 289-301.

Jacob Jacob V., Sharma S.C. & Grabowski R. 1997, "Capital Stock Estimates for Major Sectors and Disaggregated Manufacturing in Selected OECD Countries", *Applied Economics* 29 (5), 563-79.

Johansen L. 1978, "On the Theory of Dynamic Input-Output Models with Different Time Profiles of Capital Construction and Finite Life-Time Capital Equipment", *Journal of Economic Theory* 19(2), 513-533.

Jorgenson D. W. 1960, "A Dual Stability Theorem", *Econometrica* 28, 892-9.

Jorgenson D. W. 1961, "Stability of a Dynamic Input-Output System", *Review of Economic Studies* 28, 105-16.

Kachooian M. 1990, "Fixed Capital Consumption in National Accounts", Ravand, 2(1), 47-56.

Kalmbach P. & Kurz H.D. 1990, "Micro-electronics and Employment: a Dynamic Input-Output Study of West German Economy", *Structural Change and Economic Dynamics* 1 (2), 371-86.

Kendrick D. 1972, "On the Leontief Dynamic Inverse", *Quarterly Journal of Economics* 86, 963-6.

Koopmans T. C. 1951, "Alternative Proof of the Substitution Theorem for Leontief Models in the Case of Three Industries", in Koopmans T.C. (ed.), *Activity Analysis of Production and Allocation*, New Haven and London: Yale University Press, 147-54.

Khan A.R. & MacEwan A. 1967, "A Multisectoral Analysis of Capital Requirements For Development Planning in Pakistan", *Pakistan Development Review* 7 (4), 445-9.

Koti R.K. 1967, "Capital Coefficient Matrix Based on Company Data 1960", in Mathur P.N. and Bharadwaj R. 1967, *Economic Analysis in Input-Output Framework*, With Indian Empirical Explorations, Poona, India, 65-87.

Kurz H.D. and Salvadori N. 1994, "The Non-substitution Theorem: Making Good a Lacuna", *Journal of Economics* 59, 97-103.

Kurz H.D., Dietzenbacher E., and Lager C. 1998, "Introduction to Part II: Dynamic Input-output Analysis" in Kurz H.D., Dietzenbacher E., and Lager C. (eds.), *Input-Output Analysis*", Vol. I, Edward Elgar Publishing, UK.

Kurz H.D., Dietzenbacher E., and Lager C. 1998, "Introduction to Part II: Price Models" in Kurz H.D., Dietzenbacher E., and Lager C. (eds.), *Input-Output Analysis*", Vol. III, Edward Elgar Publishing, UK.

Lager C. 1997, "On the Treatment of Fixed Capital in the Sraffian Framework and in the Theory of Dynamic Input-Output Analysis", *Economic Systems Research* 9, 357-73.

Leontief W. 1936, "Quantitative Input and Output Relations in the Economic System of the United States", *The Review of Economics and Statistics* 18, 105-125.

Leontief W. 1937, "Interrelation of Prices, Output, Savings, and Investment", *Review of Economic [s and] Statistics* 19, 109-32.

Leontief W. 1941, *The Structure of the American Economy: 1919-1929*, Oxford University Press, New York.

Leontief W. 1947, *Input-Output Economics*, New York: Oxford University Press.

Leontief W. 1953, "Dynamic Analysis", *Studies in the Structure of the American Economy*, New York: Oxford University Press.

Leontief W. 1953, "Dynamic Analysis", in: *Studies in the Structure of the American Economy*, New York: Oxford University Press.

Leontief W. 1961a, "Lags and the Stability of Dynamic Systems", *Econometrica* 29 (4), 659-69.

Leontief W. 1961b, Lags and Stability of Dynamic Systems: a Rejoinder", *Econometrica* 29 (4), 674-75.

Leontief W. 1970, " The Dynamic Inverse" in Carter P. & Brody A. (eds.), *Contribution to Input-Output Analysis*, volume 1, North Holland, Amsterdam, 17-46.

Leontief W. 1985, *Input-Output Analysis*, New York, Oxford University Press.

Leontief W. & Duchin F. 1986, *The Future Impact of Automation on Workers*, New York and Oxford: Oxford University Press.

Livesey D. A. 1973, "A Minimal Realization of the Leontief Dynamic Input-Output Model", in K.R. Polenske and J.V. Skolka (eds.), *Advances in Input-Output Analysis*, Cambridge: Ballinger, 527-41.

Livesey D.A. 1976, "The Singularity Problem in the Dynamic Input-Output Model", *International Journal of System Science* 4, 437-40.

Los B. 2001, "Endogenous Growth and Structural Change in a Dynamic Input-Output Model", *Economic System Research* 13 (1), 3-34.

Lumberger D. G. & Arbel A. 1977, "Singular Dynamic Leontief Systems", *Econometrica* 45 (4), 991-5.

Madden M. 1993, "Welfare Payments and Migration in a Non-linear, Extended Input-Output Model with an Application to Scotland", *Papers in Regional Science* 72 (2), 177-179.

Madden, M. and Batey, P.W.J., 1980, " Achieving Consistency in Demographic Economic Forecasting", *Papers of the Regional Science Association* 44, 91-106.

Madden, M. and Batey, P.W.J., 1983, "Linked Population and Economic Models: Some Methodological Issues in Forecasting, Analysis and Policy Optimisation", *Journal of Regional Science* 23 (I), 141-164.

Madden M. and Trigg A.B., 1990, "Interregional Migration in an Extended Input-Output Model", *International Regional Science Review* 13 (1&2), 65-85.

Mashayekh Ahangarani R. 1999, "An Almost Ideal System for Iran", IRDP, *working paper.*

Mathur P.N. and Hashim S.R. 1963 "A Capital Coefficient Matrix 65 by 65 for India" Mimeographed.

Mathur P.N. 1964, "Output and Investment for Exponential Growth in Consumption", *Review of Economic Studies* 31 (1), 73-76.

Mathur P.N. 1967, "An Application of Dynamic Input Output Model for Planning", in Mathur P.N. and Bharadway R.(eds), *Economic Analysis in Input Output Framework, with Indian Empirical Exploration*, 109-30.

Mathur P.N. & Bharradwaj J. 1967, "An Interindustrial Capital Coefficient Table for India, First Approximation 1960" in Mathur P.N. and Bharadwaj J *Economic Analysis in Input-Output Framework,* With Indian Empirical Explorations, Poona, India, PP. 60-64.

Mathur P.N. & Bharradwaj J. 1967, "Application of Dynamic Model for Planning", in Mathur P.N. and Bharadwaj J *Economic Analysis in Input-Output Framework,* With Indian Empirical Explorations, Poona, India, PP. 111.

Mathur P.N. 1970, "Introduction", in: Carter A.P. & Brody A. (eds.), *Contributions to Input-Output Analysis* 1, (Amsterdam, North-Holland).

Mathur P.N. 1977, "A Study of Sectoral Prices and their Movements in the British Economy in an Input-Output Framework", in Leontief W. (eds.), *Structure, System and Economic Policy,* Proceeding of Section F of the British Association for the Advancement of Science held at the University of Lancaster 1-8 Sep., Cambridge University Press.

Mayes D. and Young G. 1994, " Improving The Estimates of the UK Capital Stock", *National Institute Economic Review,* February 1994, 84-96.

McGreggor, P. G., Swales J.K.& Ping Yin Ya 1995, " Input-Output Analysis, Labour Scarcity and Relative Price Endogenity: Aggregate Demand Disturbances in a 'Flex-Price' Leontief System", *Economic Systems Research* 7 (2), 189-205.

Meyer U. & Schumnn J 1977, "Das Dynamische Input-Output Modell als Modell Gleichgewichtigen Wachstums", *Zeitschrift fur die Gesamte Staatswissenschaft* 133, 1-37.

Meyer U 1982, "Why Singularity of Dynamic Leontief System Doesn't Matter", in *Proceedings of the Third Hungarian Conference on Input-Output Techniques,* 3-5 November 1981, Budapest (Statistical Publishing House, Budapest), 181-189.

Miyazawa K. 1976, *Input-Output Analysis and the Structure of Income Distribution,* Berlin Springer-Verlag.

Miernyk W. H. 1967, *The Elements of Input-Output Analysis,* New York, Random House.

Miernyk W. H., Bonner E.R., Chapman J.H., and Shelhammer K., 1967, *Impact of the Space Program on a Local Economy: An Input-Output Analysis,* Morgantown: West Virginia University Library.

Miernyk W. H., Shelhammer K. L., Brown D. M., Coccari R. L., Gallagher C. J., and Wienman W. H. 1970, "*Simulating Regional Economic Development*", Lexington, Massachusetts, USA.

Miller R.E. and Blair P.D. 1985, *Input-Output Analysis: Foundations and Extensions,* Prentice-Hall, New Jersey, USA.

Ministry of Power 1998, "*Energy Input-Output Table*", Ministry of Power, Tehran, Iran (in Persian).

Ministry of Jahad-e-Sazandegi 1999, "*Agriculture Input-Output Table*", Ministry of Agriculture, Tehran, Iran.

Ministry of Post and Communications forthcoming, "*Communication Input-Output Table*", Ministry of Communications & Centre for Economics Research at Allameh Tabatabei University, Tehran, Iran.

Morishima M. 1958, "Prices, Interest and Profits in a Dynamic Leontief System", *Econometrica* 26, 358-80.

Morishima M. 1964, *Equilibrium, Stability, and Growth,* London, Oxford University Press.

Moses L. N. 1974, "Outputs and Prices in Inter-industry Models", *Paper of the Regional Science Association,* 32, 7-18.

Mukerji V. (1964), "Output and Investment for Exponential Growth in Consumption the General Solution and Some Comments", *Review of Economic Studies* 31(1), 77-82.

Naseem S.M. 1972, "Regional Plan Harmonization for Regional Cooperation Development Countries: a Programming Approach, *UN Economic Bulletin for Asia and Far East* 23 (4), 77-83.

Neumann J. V. 1945, "A Model of General Economic Equilibrium", *Review of Economic Studies* 13, 1-9.

Nikaido H.1961, "Persistence of Continual Growth Near the Von Neumann Ray: a Strong Version of the Radner Turnpike Theorem", *Econometrica* 32(1-2), 151-162.

Nikaido H. 1968, *Convex Structures and Economic Theory*, Academic Press, New York.

Nikaido H. 1972, "Introduction to Sets and Mapping in Modern Economics", North-Holland, Amsterdam.

Oosterhaven J. and Van Dijk J. 1986, "Regional Impacts of Migrants' Expenditures: An Input-Output Vacancy Chain Approach", in Batey, P.W.J. and Madden M. (eds.) *Integrated Analysis of Regional Systems*, London Papers in Regional Science 15, London : Pion, 122-147.

Oosterhaven J. 1988, "On the Plausibility of the Supply-Driven Model", *Journal of Regional Science* 28, 203-17.

Oosterhaven J. 1989, "The Supply-Driven Input-Output Models: A New Interpretation But Still Implausible", *Journal of Regional Science* 29, 459-65.

Oosterhaven J. 1996, "Leontief Versus Ghoshian Price and Quantity Models", *Southern Economic Journal* 62(3), 750-759.

Plan and Budget Organization (PBO) 1977, *"Iran's Input-Output Table for 1352, Methodology and Tentative Estimate"*, Tehran, Iran.

Plan and Budget Organization (PBO) 1989, *"The 1364 Input-Output Table for The Iranian Economy"*, Tehran, Iran (in Persian).

Plan and Budget Organization (PBO) 1991, *"Final Report on Estimation Economic War Damaged"*, Macroeconomic Department, 16, 29 (in Persian).

Plan and Budget Organization (PBO) 1999, *"Statistical Yearbook 1997"*, Statistical Centre of Iran (in Persian).

Plan and Budget Organization (PBO) 2000, Plan Document, *"Third Socio-Economic, and Cultural Development Plan of the Islamic Republic of Iran (2000-2004)"*, Appendix no.2, II, 203.

Polenske K.R. 1979, "Energy Analyses and the Determination of Multiregional Prices", *Paper of the Regional Science Association* 43, 83-95.

Prasad K.N., Banouei A.A. & Swaminathan A.M. 1992, "Development and Trade Strategies for an Exhaustible Resource Endowed Economy of Iran: an Empirical Analysis in the Framework of Dynamic Input-Output and Semi-input-Output Techniques", *Proceeding of the First Conference on Planning & Development, Institute for Research and Development*, Tehran, Iran.

Prasad K.N., Banouei A.A., Achuttan C.V., and Parker R.G. 1994, "Weather and Structural Reforms Induced Instability in Agriculture and Buffer Stocks in India" *International Journal of Production Economics*, 35.

Pyatt, G., Bharier J., Lindley R. M, Mabro R. and Saolo Y. 1972, "Methodology for Macroeconomic Projections", *Working Paper No. 12*, International Labour Office (ILO), Geneva (Micro-Film).

Raa T ten 1986a, "Dynamic Input-Output Analysis with Distributed Activities", *Review of Economics and Statistics*, LXVIII (2), 300-310.

Raa T. ten 1986b, "Applied Dynamic Input-Output Analysis with Distributed Activities", *European Economic Review* 30, 805-31.

Raa T. ten 1995, "The Substitution Theorem", *Journal of Economic Theory* 66, 632-6.

Rasmussen P.N. 1956, *Studies in Intersectoral Relations*, Amsterdam: North-Holland.

Razavi H. and Vakil F. 1974, "Planning Techniques in Iran, *United Nations, Economic Bulletin for Asia and the Pacific* XXV (2,3).

Razavi H. & Vakil F. 1984, *"The Political Environment of Economic Planning in Iran: 1971-83, From Monarchy to Islamic Republic"*, Boulder, Colorado, Westview Press.

Ritz,P.M. and Others 1973, "Industry Inventory Requirements: An Input-Output Analysis", *Survey of Current Business* 11 (53), 15-19.

Robinson J. 1965, *Collected Economic Papers*, 3, Oxford Basil Blackwell.

Romer P.M. 1986, "Increasing Returns and Long-run Growth", *Journal of Political Economy* 94, 1002-1037.

Rose A & Miernyk W. 1989, "Input-Output Analysis: the First Fifty Years", *Economic Systems Research* 1(3), 229-271.

Sadler P., Archer B. and Owen C. 1973, "Regional Income Multipliers: the Anglesey Study", *Bangor Occasional Papers in Economics* 1, University of Wales Press.

Samuelson P.A. 1951, "Abstract of a Theorem Concerning Substitutability in Open Leontief Models", in Koopmans T.C., (ed.), *Activity Analysis of Production and Allocation,* Chapter VII, 142-46.

Samuelson_PA 1953-4, "Prices of Factors and Goods in General Equilibrium", *Review of Economic Studies* 54, 1-20.

Sargen J.D. 1958, The Estimation of Economic Relationships Using Instrumental Variables, *Econometrica,* 26, North-Holland Publishing Co. Amsterdam, 381-392.

Sargen J. D. 1961, "Lags and the Stability of Dynamic Systems: a Reply", *Econometrica* 29, 670-73.

Schinnar A.P. 1976, "A Multi-Dimensional Accounting Model for Demographic and Economic Planning Interaction", *Environment and Planning A* 8, 455-475.

Schoonbeek L. 1990, "The Size of the Balanced Growth Rate in the Dynamic Leontief Model", *Economic Systems Research* 2 (4), 345-349.

Schumann J. 1990, "On Some Basic Issues of Input-Output Economics: Technological Structure, Prices, Imputations, Structural Decomposition, Applied General Equilibrium", *Economic Systems Research* 2(3), 229-39.

Sedighi K. and Kordbache M. 1981, " Production Function and Estimation of Capital stock for non-oil Iranian Economic Sectors, in 1345-58", *Plan and Budget Organization, Department of Macroeconomics and Plan Assessment* (in Persian).

Sekerka B., Kyn O., & Hejl L 1970, "Price Systems Computable from Input-Output Coefficients", in: Carter A.P. & Brody A. (eds.), *Contributions to Input-Output Analysis* 1, Amsterdam, Holland.

Seton F. 1981, "A Quasi-Competitive Price Basis for Intersystem Comparisons of Economic Structure and Performance", *Journal of Comparative Economics* 5(4), 367-91.

Seton F. 1993, "Price Models Based on Input-Output Analysis: East and West", *Economic Systems Research* 5 (2), 101-111.

Shaheen A.S. (n.d.), "*The 1965 Input-Output Table for the Iranian Economy*", Ministry of Economy, Tehran, Iran.

Shahshahani A., *"Iranian Econometric Models and Their Applications"*, 1979, Tehran University Press (in Persian).

Skolka J. & Garzuet M. 1976, *"Changes in Income Distribution and the Structure of the Iranian Economy"*, Geneva, International Labour Organization (ILO).

Solow R. M. 1959, "Competitive Valuation in a Dynamic Leontief Model", *Economic Letters* 1, 105-9.

Solow R. M. 1959, "Competitive Valuation in a Dynamic Input-Output System", *Econometrica* 27, 30-53.

Somayajulu V.V.N. 1971, "A Working Capital Coefficients Matrix from Annual Survey of Industries, Capital Data, Maharashtra, 1959- A Disaggregative study" *Margin*, 37-51.

Statistical Centre of Iran (SCI) 1991, "Survey on Manufacturing Establishments", Value of Inventory in Manufacturing Establishments by Type of Industry, *Department of Manufacturing Statistics*, 27-29 (in Persian).

Statistical Centre of Iran (SCI) 1963-91, *"Survey on Manufacturing Establishments"*, Investment in Manufacturing Establishments by Type of Industry and type of Assets, Department of Manufacturing Statistics (in Persian).

Statistical Centre of Iran (SCI) 1992, " *Survey on Operating Mines*", Value of Inventory in Operating Mines, 10 (in Persian).

Statistical Centre of Iran (SCI) 1994, *"The 1365 Input-Output Table for the Iranian Economy, General Report"*, Tehran, Iran (in Persian).

Statistical Centre of Iran (SCI) 1995, "The 1365 Input-Output Table for the Iranian Economy, Detailed Report", Tehran, Iran (in Persian).

Statistical Centre of Iran 1998, *"Iran Statistical Yearbook"*, Spring, Tehran, Iran.

Steenge A.E. 1978, "On Two Types of Stability in the Dynamic Leontief Model", *Economic Letters* 21, 105-109.

Steenge A.E. 1990, "On the Complete Instability of Empirically Implemented Dynamic Leontief Models", *Economic Systems Research* 2 (1), 3-16.

Steenge A.E. 1990, "Instability Problems in the Dynamic Leontief Model: an Economic Explanation", *Economic Systems Research* 2(4), 357-361.

Stone R. 1961, *Input-Output and National Accounts*, Paris, OECD.

Stone R. & Brown J.A. 1962, "Output and Investment for Exponential Growth in Consumption", *Review of Economic Studies* 29 (June), 241-5.

Stone R., 1981, " The Relationships of Demographic Accounts to National Income and Product Accounts. In Juster, F.T. and K.C. (eds.) *Land Social Accounting Systems: Essay on the State of the Art*, New York: Academic Press, 307-376.

Stone J. R. N. and Weale M.R. 1986, " Two Populations and Their Economies", in Batey, P.W.J. and M. Madden (eds.) *Integrated Analysis of Regional Systems*, London Papers in Regional Science 15, London: Pion, 74-89.

Szyld D. 1985,"Conditions for the Existence of a Balanced Growth Solution for The Leontief Dynamic Input-Output Model", *Econometrica* 53, 1411-19.

Szyld.D., Moledo L., Sauber B., 1988, "Positive Solutions for the Leontief Dynamic Input-Output Model", *Input-Output Analysis,* ed. M. Ciaschini, Chapman and Hall, Andorer, Hants, 91-97.

Takayama K. & Murakami Y. 1972, "Relative Stability in Two Types of Dynamic Leontief Models", *International Economic Review* 13 (2), 408-15.

Takayama A. 1985, *Mathematical Economics 2nd edition,* New York: Cambridge University Press, Chapter 6.

Tiebout C. M. (posthumously) 1969, "An Empirical Regional Input-Output Projection Model: The State of Washington 1980", *Review of Economics and Statistics* 51(3), 334-40.

Thurow L. S.1983, *Dangerous Currents*, New York: Random House.

Toufigh F. 1992, *"Input-Output Analysis in Iran: Its Application in Measurement, Forecasting and Planning"*, Publication and Teaching of Islamic Revolution Press, Tehran, Iran, (in Persian).

Tsoulfidis L. 1990, "Price Effects of Indirect and Corporate Income Taxes: An Input-Output Analysis", *Metroeconomica* 41(2), 111-135.

Tsukui J 1961, "On a Theorem of Relative Stability", *International Economic Review* 2(2), 229-230.

Tsukui, J. 1968, " Application of a Tutnpike Theorem to Planing for Efficient Accumulation: An Example for Japan," *Econometrica* 36(1), 172-186.

Tsukui J. and Murakami Y. 1979, *"Turnpike Optimality in Input-Output Systems, Theory and Application for Planning"*, North-Holland Publishing Company, Amsterdam, Chapter 3, 49-66.

United Nations (1968), *"A System of National Accounts: Studies in Methods*", Series No. 2.

United Nations 1970, "Sectoral Output and Employment Projections for the Second Development Decade", *Second Development Series* 8, Bangkok, ECAFE.

United Nations 1999, "*Human Development Report 1999*", New York, Oxford University Press.

U.S. Department of Labor Bureau of Labor Statistics " *Capital Stock Estimates for Input-Output Industries: Methods and Data Bulletin 2034*, 1979, Washington D.C.

Uzawa M. (1956), "Note on Leontief's Dynamic Input-Output System", *Proceedings of the Japan Academy* 32, 79-82.

Walras L. 1954, *Theory of Pure Economics*, London, Allen & Unwin.

World Bank Middle East Department 1999, "*Economic Aspects of Increasing Energy Prices to Border price Levels in the Islamic Republic of Iran*", the Document of World Bank.

Wurtele Z. S. 1959, "A Note on Some Stability Properties of Leontief's Dynamic Models", *Econometrica* 27(4), 672-675.

Zanour H.S. (1987), "The Analysis of the Investment Consistencies in the Islamic Republic of Iran's First Five-Year Plan: An Input-Output Model", *Plan and Development* 4, 77-85 (in Persian).