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A COMPUTABLE GENERAL EQUILIBRIUM MODEL FOR THE CHINESE ECONOMY

By

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at

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Abstract

In this study we constructed a CGE model for the Chinese economy which is used to study the impacts of the economic reforms on the Chinese economy.

The model consists of five sectors, namely, agriculture, industry, construction, transportation and commerce. For the supply side of the market, the individual labourer's supply of output is a result of applying his/her optimal effort level to the production process. The demand side of the economy consists of four components, namely, consumption, investment, intermediate demand and net export. The determination of private demand for consumption goods is specified as a two stage optimization model. The sectoral supply and private consumption functions are estimated by using the two-stage least squares estimator. The estimation of the supply function for the agricultural sector is achieved by using a recursive formula for least squares estimation with forgetting factors. Given the estimated supply and demand functions, the CGE model is reduced to a set of excess demand equations along with a price normalization rule. The solution to the CGE model is reduced to a problem of finding a vector of equilibrium relative prices such that excess demand is equal to zero in each sector.

The estimated structure of the CGE model of the Chinese economy is used to conduct a simulation experiment. The experiment consists in computing a set of relative equilibrium prices and equilibrium outputs assuming the bonus ratio to be unity in the non-agricultural sectors and comparing these equilibrium prices and ouputs with the actual relative prices and outputs when the bonus ratio is equal to a fraction of profits. The results of the experiment show that the efficiency gain of allowing the bonus ratio to be unity is small. This is because no reallocation of resources is allowed in the experiment. If reallocation of resources is allowed, the efficiency gain is expected to be much bigger.

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CHAPTER 1

Description of the Chinese Economy

1.1 Introduction

During the last two decades there has been an increased application of computable general equilibrium (CGE) models to analyze the structures of the economies of both developed and developing countries. Until recently, modelling of centrally planned economies is undertaken either within the framework of linear programming or in terms of input-output analysis. However, during the past fifteen years or so, economists have applied the CGE models to describe planned economies and used them to simulate the impacts of alternative economic policies. As a case in point see, Kis, Robinson and Tyson's CGE model for socialist economies (1985), Robinson and Tyson's CGE model for the Yugoslavia economy (1987).

The theoretical framework of CGE models is the well-known modern version of Walras' model of the competitive economy. Accordingly, in most CGE models reported in the literature, producers are described as profit-maximizers facing non-increasing returns to scale, consumers are utility-maximizers and inputs are paid according to their marginal revenue productivity and that only the relative prices of outputs are determined in the market. The solution of the model yields the set of relative prices which are consistent with feasible individual optimization wherein all markets are cleared simultaneously.

The purpose of this study is to construct a CGE model to describe the Chinese economy in the post-reform period which will allow us to simulate the impacts of the economic reforms which are underway in China.

1.2 China in the pre-reform and post-reform periods

In the pre-reform period China, the Planning Commission controlled all the sectors in the economy by imposing production targets, allocating investment funds and intermediate inputs, and even allocating labour directly in physical terms without regard to any sort of market incentives. The essential elements which distinguish the Chinese planned economy from that of a market oriented economy may be enumerated as follows:

(1) The state dominates all forms of economic activity. Most land and raw materials are owned by the state, and the state is the major employer of labour in the industrial, construction, transportation and commercial sectors. In the agricultural sector, although household is the basic unit of production, peasants are just members of the communes. Peasants work on assigned tasks in exchange for work points, which represent a share of the commune's net income at the end of the year. A tax is levied on the commune for using the state owned land. In addition, the commune is expected to meet a pre-specified quota of output to be delivered to the state at some specified prices. These prices are well below the free market prices.

(2) The allocation of resources and operation of enterprises is largely carried out according to centrally determined plans. These plans include framing of the budget, formulating credit plans, determining input allocations, fixing output quotas, controlling trade (domestic and foreign), transportation, and employment. These plans are often based on information or decisions made at lower levels of the economic bureaucracy, or even at the level of the individual firms. No matter how the plans are formulated, they reflect essentially the priorities determined by the planners.

(3) Since most of the resources are state owned and allocated according to centrally determined plans, prices do not play an allocative role in the Chinese economy. The planned targets are determined as non-substitutable quantities among various firms, while

prices play the role of an accounting function in the planned sector of the economy. In other words, when a gap appears between the supply and demand of an important commodity in the planned sector, the planner reacts by changing the planned targets, but not by changing prices.

Given the above description of the pre-reform period Chinese economy, the traditional input-output and linear programming models are suitable for achieving the desired objectives of the planner by taking into account the various physical and technological constraints.

In the post-reform period, China is working within the environment of a mixed economy in which a great deal of the economic activity is subject to free market forces. Since 1978, attempts have been made in China to incorporate aspects of free market mechanism without radically changing the central planning system. Partial reforms such as these, which represent an attempt to find a "third way", intermediate between a centrally planned economy and a free market economy, gave rise to significant changes in Chinese economic system. Before we embark on a detailed analysis of these economic reforms, it is useful to describe them.

Since 1978, the leadership in China has implemented a number of reforms in the economic system. Two particular features of the program of economic reforms that have already taken place have changed the Chinese economic system in a fundamental way. These are the contract responsibility system in the agricultural sector and the self-responsibility for profits or losses in the industrial, construction, transportation and commercial sectors.

Undeniably the most radical institutional change in the economy has occurred in the agricultural sector: the adoption of a contract responsibility system and the permitting of some households to specialize in side-line or completely commercial farming, with no limit placed on household income. The contract responsibility system restores, in effect, household-tenant farming, with leases longer than fifteen years. The tenant's contract with the state includes that the peasant should produce the planned target of output included in the state plan. In addition, they have to meet their tax obligations, contribute to the welfare fund, and meet other obligations to the local government. The important difference between the pre-reform and the post-reform period is that the household is free to organize the resources at its disposal to produce the output required to meet its state contract quotas, and that it is given private ownership rights in the disposal of any surplus produced. Peasant households now enjoy the freedom to trade and to hire farm labourers as well. The contract responsibility system for agricultural production is being experimented with beginning in 1978, and has been expanded to include nearly all production communes in agriculture. In general, these policy reforms have resulted in higher prices in the rural areas where the agricultural surplus is traded. These higher agricultural prices provided an incentive to the peasants to increase their productivity which led to an increase in their income and aggregate agricultural output.

Impressed with the results of the contract responsibility system in agriculture, reforms with a similar purpose have been introduced in the industrial, construction, transportation and commercial sectors. A new profit retention system has been implemented under which the business enterprises are contracted to hand over a certain percentage of profits to the state, and the remaining profits could be used to supplement wages in the form of bonuses to workers and other welfare funds. The profit retention program was designed to provide incentives to enterprises thereby allowing enterprises to augment their income by virtue of their superior performance. Enterprises which prove unprofitable might find themselves threatened with closure by the state.

In addition, firms are allowed to sell any surplus output at free market prices. This led to an expansion of the market activities significantly. Free markets for raw materials, foreign exchange, technology, research services, project design and construction in which buyers and sellers could negotiate mutually satisfactory agreements and sign contracts that are enforced through the newly established economic courts have come into being. Thus a dual price system has emerged wherein free market prices coexisted with the state controlled prices which are often lower.

The CGE model formulated in this study attempts to determine the effects of these economic reforms on the allocation of resources, and on production and consumption in the Chinese economy. The impacts of these reforms can be estimated by incorporating the free market mechanism into a macroeconomic CGE model of the Chinese economy. Such a model will be specified in Chapter 2.

1.3 Institutional changes due to economic reforms

Changes in the management and incentive systems

Before the beginning of economic reforms in 1978, Chinese enterprises turned over all their profits to central or local authorities. Firms have little or no incentive to improve performance or economize on production outlays, for they had no direct interest in the profitability of their operation. The increased managerial autonomy that characterized the recent economic policies in China has brought about changes in the management and incentive mechanism. With the introduction of the profit retention system, profit became the primary index of performance of enterprises. The level of profits is of considerable importance as the workers' bonuses and welfare depended on it. The Chinese enterprises unanimously endorsed the notion of material incentives which motivated the worker to become more productive.

The next question that comes up is how profits in these enterprises are determined. This is no easy task in view of the dual nature of the price system - one where prices of products are determined in the free market and the other where the state fixes the prices for the same products. The revenue R from the sale of the output of a typical firm to the state is the sum of two components $P_g X_g$ and $P_f X_f$, where X_g is the output sold at the official price, P_g, and X_f is the output sold at the free market price, P_f. The firms lobby for higher prices with the government for their product and also for a higher ratio of profits to be retained by the firm so that they could offer larger bonuses for their workers.

Allocation of labour

Allocation of labour to various firms by the state is different from that in other communist countries of Eastern Europe and the U.S.S.R. In particular, the local labour bureau has control over job assignments within an overall quota set by the Ministry of Labour. Neither workers nor enterprises have much say in job assignments. Swapping of jobs to allow families to be together or for other personal reasons is sometimes allowed. This problem becomes more acute because residence permits and grain ration coupons preclude migration of workers to seek employment. As a result, most workers expect to spend all their working lives with the enterprises to which they are assigned.

However, due to the recent economic reforms, this system has been loosened up slightly. A new labour market is developing gradually in which labourers choose their assignments through mutual agreement with interested enterprises. Enterprises also have some flexibility in hiring rural labourers. However, the number of people enjoying freedom of choice of job in regard to jobs is still limited.

Laying off workers from their jobs is not easy for the employers. As employers provide their workers with housing, pensions, and many medical and educational benefits, loss of employment is more serious for workers in China than in other countries. Workers almost feel as if they have a property right to the job they have been assigned.

Dismissal can occur only for flagrant misbehaviour and that too after elaborate and exhaustive administrative procedures.

Although the state has relaxed its control on the allocation of labour to enterprises, yet the reforms did not go far enough to allow the emergence of a free market mechanism in the allocation of labour. In other words, wages are not determined freely in the market.

Allocation of capital

Allocation of capital in China has always been subject to a formidable array of administrative controls involving numerous government organizations. These controls include annual fixed investment plans, multi-year investment plans, project approval processes, fund allocation processes, and administrative controls over the allocation of investment goods. As a result, investment decision making is both bureaucratic and political.

Since the economic reforms have been put in place, the state has allowed the enterprises to use their retained profit to finance their own investment projects. Enterprise profitability thus became very important in investment decision making since more profits meant more internal sources of investment, as it has made it easier for the enterprise to obtain bank loans and government grants for further investment. Nevertheless, given the limited degree of enterprise autonomy, the investment funds accumulated by the enterprises are usually not sufficient enough to undertake the medium and large investment projects as they require extra funds from the government and banks to cover the shortfall. Since major investment funds could be obtained from the government as a "natural gift", many enterprises prefer to spend their retained profits on items such as bonuses and welfare funds, rather than on investment projects. There still exist formal investment controls and project approval procedures. All these elements suggest that reforms have not yet progressed far enough to increase flexibility in regard to capital allocation. In short, there does not yet exist a free capital market in spite of serious attempts to foster one.

1.4 Characteristics of the CGE model

The post-reform Chinese economy is characterized by dual markets and dual prices. Peasants receive their income by selling their contracted output to the state at official prices and by selling the remaining output on the free market. Industrial workers also benefit when their products are sold on the free market after the enterprise have sold the stipulated quotas to the state at the fixed official prices. In particular, higher market prices contribute to increases in retained profit, which is the main source of workers' bonuses. Allocation of factors of production is still subject to tight control by the government. A macroeconomic model of the Chinese economy should be formulated within the framework of these institutional features. The appealing features of a CGE model make it an attractive tool to capture the institutional uniqueness of the Chinese economy.

Firstly, a CGE model is able to incorporate the market mechanism. It extends the economic model to include the feedbacks through the price mechanism that achieve equilibrium between the independently pursued optimizing behaviour of suppliers and demanders of products. It is customary to deal with a CGE model by separating the supply and demand sides of the economy and then to solve the resultant system of excess demand functions. Market interaction takes place between production and consumption. A CGE model, by incorporating the market mechanism, appears to be broader and more realistic than the linear programming models or input-output models.

Secondly, a CGE model allows for flexibility regarding the institutional specification of how the various economic agents behave and how the markets function. A

CGE model may not always conform to the pure Walrasian model. Researchers specify various forms of general equilibrium models with rationing and rigidity in some important markets in order to approximate economic reality. However, the neoclassical resource allocation theory remains the fundamental framework for these models.

Thirdly, a CGE model is a sectoral interdependent model. The Chinese economy has undergone a systematic transformation in its structure of production, demand, employment and investment. It is, however, possible to formulate a CGE model which takes into account the various broad sectors into which the economy is divided without ignoring the fundamental differences in the underlying structures.

Fourthly, in a CGE model equilibrium prices can be solved for endogenously. A comparison of the equilibrium prices with the actual prices allows us to identify those which have come close to being market determined and those which are distorted. Knowledge of these equilibrium prices which the model yields are important for the policy makers in choosing more effective reform measures.

1.5 Outline of the study

The objective of this study is to construct a computable general equilibrium model of the Chinese economy that will allow us:

(1) to simulate the impacts of the economic reforms on the Chinese economy, particularly, the potential responses of the economy to alternative reform measures and policy designs; and

(2) to compute equilibrium prices which could be compared with the officially fixed prices so that misallocation of resources could be identified.

Chapter 2 is devoted to the specification of the model. In that chapter, the demand and supply sides of the markets are formulated taking into account the dual prices in the Chinese economy.

Chapter 3 deals with estimation and calibration of the model. In particular, an algorithm based on the recursion formula for least squares estimation with forgetting factors for overcoming the data shortage in estimating structural changes is also presented.

The simulation results of the model are reported in Chapter 4. The conclusions and the policy implications that have emerged from the study are summed up in the final chapter.

CHAPTER 2

The Specification of the CGE Model

2.1. Introduction

Beginning in 1978, the Chinese economic system has undergone sweeping reforms aimed at decentralizing the decision-making processes, increasing the decision power of the individual economic agents (individual peasants and manufacturing firms). In particular, the reforms have enabled these agents to sell the excess of outputs produced over and above their stipulated quotas on the free market and have introduced a system of incentives that reward effort while linking those rewards to enterprise performance.

This chapter is devoted to the specification of a CGE model which is designed to simulate the reform process and examine its impact on certain key macroeconomic variables of the Chinese economy. For purposes of specifying such a CGE model the Chinese economy is divided into five sectors, namely, agriculture, industry, construction, transportation and commerce. First, the institutional framework of the study is described using accounting flows and the payment structures related to the five sectors mentioned above. Since the accounting flow and the payment structure of the agricultural sector differ markedly from the other four sectors, we shall examine them separately. In addition, the individual labourer's supply function of output is derived by maximizing the net utility expressed as a function of income and effort. Then the aggregate supply function in each sector is constructed as the sum of individual labourer's supply functions engaged in that sector. The demand side of the market is expressed in terms of a linear expenditure system taking into account the dual pricing system that has come into being after the reforms.

Finally, excess demand functions for sectoral outputs are computed from the demand and supply functions. A brief description of the Powell algorithm which is used to solve the system of excess demand functions is presented in the last section.

2.2 An accounting framework for the CGE model

The economy is divided into five sectors. The subscript i taking the values 1 through 5, represents the sectors of agriculture, industry, construction, transportation and commerce respectively. We shall present first the accounting flow of a typical Chinese firm engaged in any one of the four sectors, namely, the industry, construction, transportation and commerce, as they are identical and differ from the one engaged in the agricultural sector. This will be followed by a description of the accounting flow of a typical Chinese firm (peasants) operating in the agricultural sector.

Before the economic reforms, a typical Chinese firm in the industrial, construction, transportation or commercial sector would produce the quantity of output stipulated in the annual plans by using labor and capital assigned by the government and sell the output to government at fixed official prices. The value-added in production after deducting wage payments was transfered to the government by way of taxes and remitted profits. See Figure 2.1. The income received by a typical household for its involvement in the production process consists of the government-determined wage payments for the sector. Thus, before the economic reforms, a typical household's income is given by

$$y_{ip} = w_i \qquad i = 2,\dots,5 \qquad (2.1)$$

where y_{ip} is private income received by a typical household which works in the ith sector, and w_i is the average wage in the ith sector.

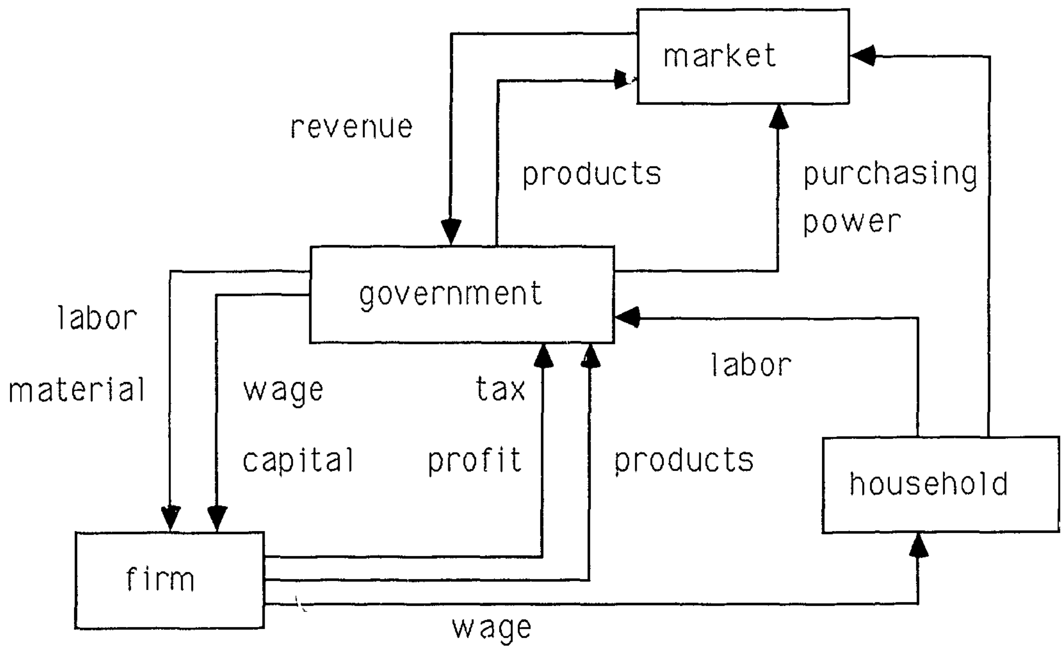

Figure 2.1 An accounting flow diagram of a typical firm in the industrial sector in the pre-reform Chinese economy

All value-added generated in the production process would be submitted to the government as taxes t_i per head, and profits π_i per head. In such a scenario, it is clear that effort is not rewarded.

After the economic reforms, the firm is allowed to retain a certain percentage of profits as determined by the government to pay for bonuses and improve workers' welfare. Accordingly, the profits π_i per head is divided into two parts: retained profits and remitted profits to the government. Major investment funds are still supplied by the government, but no longer without a cost. In return for the loaning of investable funds from the government, the firm is obliged to pay interest at an officially fixed rate. The firm is allowed to sell its product on the free market after delivering the stipulated quota to the government. It should be noted that the concept of profit used in this context must be distinguished from the conventional one. It refers to the short-run profit which is equal to the difference between the revenue and short-run variable cost which includes payments for intermediate inputs and operation cost. Since capital investment is supplied by the government, it is external to the firm, and hence is excluded from cost calculation. The post-reform scenario described above is illustrated in Figure 2.2.

After the economic reforms, the private income of a typical household who is employed by a firm in the ith sector consists of an average fixed wage w_i plus a government-determined fraction β_i of the firm's short-run profit per head. Formally,

$$y_{ip} = \beta_i(P_{ig}x_{ig} + P_{if}x_{if} - sc_i - t_i) + w_i$$

$$= \beta_i(P_i x_i - sc_i - t_i) + w_i \qquad i = 2,\ldots,5 \qquad (2.\ 2)$$

where x_{ig} represents that part of the individual worker's output which is sold to the government at the fixed price P_{ig};

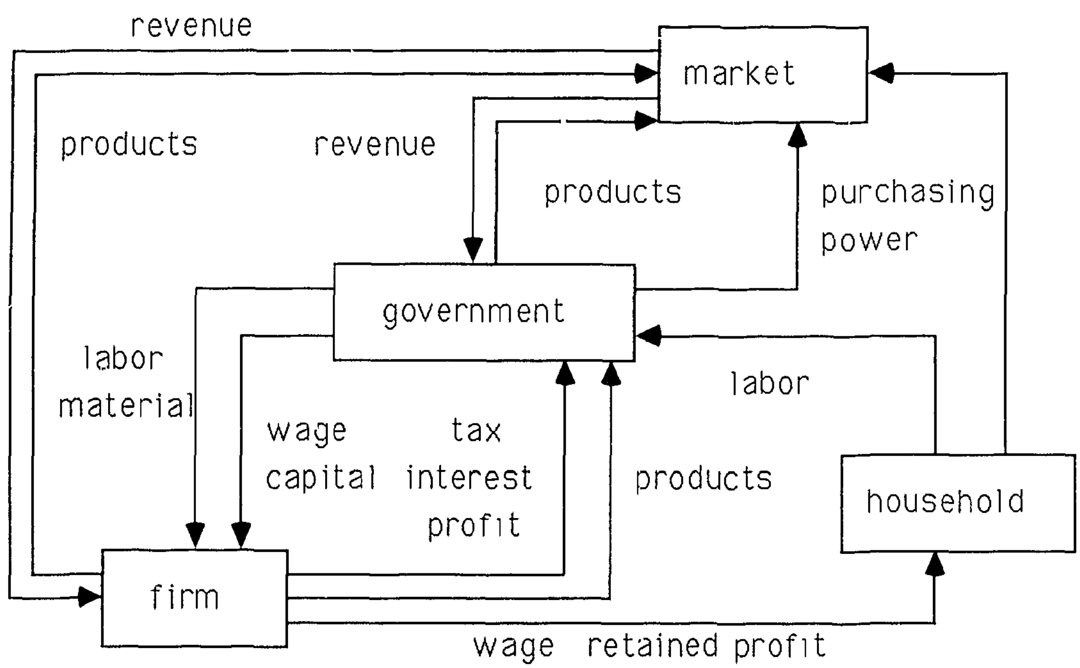

Figure 2.2 An accounting flow diagram of a typical firm in the industrial sector in the post-reform Chinese economy

x_{if} represents that part of the individual worker's output which is sold on the free market at the price P_{if};

sc_i represents the short-run production cost per head; and

t_i denotes the per head taxes.

Note that the individual worker's total output in the ith sector is $x_i = x_{ig} + x_{if}$ and P_i is a weighted average of the prices P_{ig} and P_{if}.

It should be noted that while the firm is allowed to retain the fraction β_i of short-run operation profit to provide for bonuses and welfare, it is also responsible to remit to government the remaining fraction $(1-\beta_i)$. In interpreting (2. 2) we might assume that $\beta_i = 0$ prior to the economic reforms, while after the economic reforms, β_i lies between zero and one.

Thus, it is clear that under this scheme incentives are provided for hard work. However, although bonuses and welfare expenditures are linked to enterprise performance, conventional cost minimization or profit maximization behaviour in the typical capitalist sense is not observable. Conditional factor demand under the profit-maximization or cost-minimization assumption cannot be derived, since labour and investment funds are determined by the government and are external to the firm. Moreover, it is possible that within this scheme, the firm can increase its retained profits by different means: e.g., rather than by improving its economic performance, the firm could negotiate with central authorities for a higher retained profit ratio β_i, a lower quota delivery to the government, or even a lower tax rate. All these different variants represent what Kornai called the "soft budget constraint problem," which means that state-owned enterprises face only weak financial disciplines because of their access to friendly bureaucracy and helping-out intervention which do not allow unprofitable firms go bankrupt as a result of poor performance (Kornai, 1986). If the short-run operation profit of a firm becomes zero or even negative, the firm is still certain to receive a positive payment from the government to bail it out of the crisis.

By aggregating over all households employed by the firm, and then over all the firms operating in the ith sector, the private income, Y_{ip} generated in the ith sector can expressed as

$$Y_{ip} = \beta_i(P_i X_i - SC_i - T_i) + W_i \qquad i = 2,...,5 \qquad (2.\ 3)$$

where X_i is the total product produced in the ith sector; SC_i is the total short-run production cost in the ith sector; T_i is the total taxes collected from the ith sector, and W_i is the total wage bill paid to the workers employed in the ith sector.

If a factor cost approach is adopted, sectoral national income Y_i is the sum of all incomes paid to households, Y_{ip} (wages, bonuses and other welfare payments) and the government Y_{ig} (taxes, remitted profits and interest payments). Thus, we have the following identity:

$$Y_i = Y_{ip} + Y_{ig} \qquad i = 2,...,5 \qquad (2.\ 4)$$

In the agricultural sector, before the economic reforms were formally introduced in 1978, peasants must always deliver a fixed quota to the government first. If the output is larger than the fixed quota, then the peasants are allowed to keep a certain amount of output for personal consumption and for maintaining their agricultural operations and if there is still some output remaining, then they should sell it to the government at the fixed prices. If the output is smaller than the fixed quota, the peasants receive subsidies in order to continue operating in the agricultural sector. Therefore, the accounting flow of a typical firm (peasants) in the agricultural sector prior to the economic reforms is very much the same as that of the other sectors after the economic reforms. Thus, the peasant's income may be represented by the following equation:

$$y_{ip} = \beta_i P_{ig} x_{ig} + w_i \qquad i = 1 \qquad (2.5)$$

where y_{ip}, is the private income received by the peasant; P_{ig} is the price fixed by the government for agricultural products; x_{ig} is the agricultural output per peasant; and w_i is the subsidy. The parameter β_i is the fraction of the value of output that the peasant is allowed to keep.

The differences in the payment structures between the agricultural and the other sectors lie in the interpretation of w_i and retained income. Peasants are allowed to retain a certain proportion of output for personal consumption and operational maintenance. w_i represents subsidies in kind given by the government. Note that no wages are paid to the peasant as is the practice in the other four non-agricultural sectors.

In the post-reform period, peasants are allowed and encouraged to sell their outputs on the free markets after delivering the stipulated quotas to the government. Peasants are thus rewarded for their effort. The accounting flow diagram for a typical firm (peasants) in the agricultural sector in the post-reform period is depicted in Figure 2.3.

It is possible to present the private income of a typical peasant in the post-reform period by an expression which is formally similar to (2.5):

$$y_{ip} = P_i x_i - w_i \qquad i = 1 \qquad (2.6)$$

Since the economic reforms of 1978 abolished the compulsory remission of agricultural output to government, the coefficient β_i in (2.5) is now equal to unity. Another difference

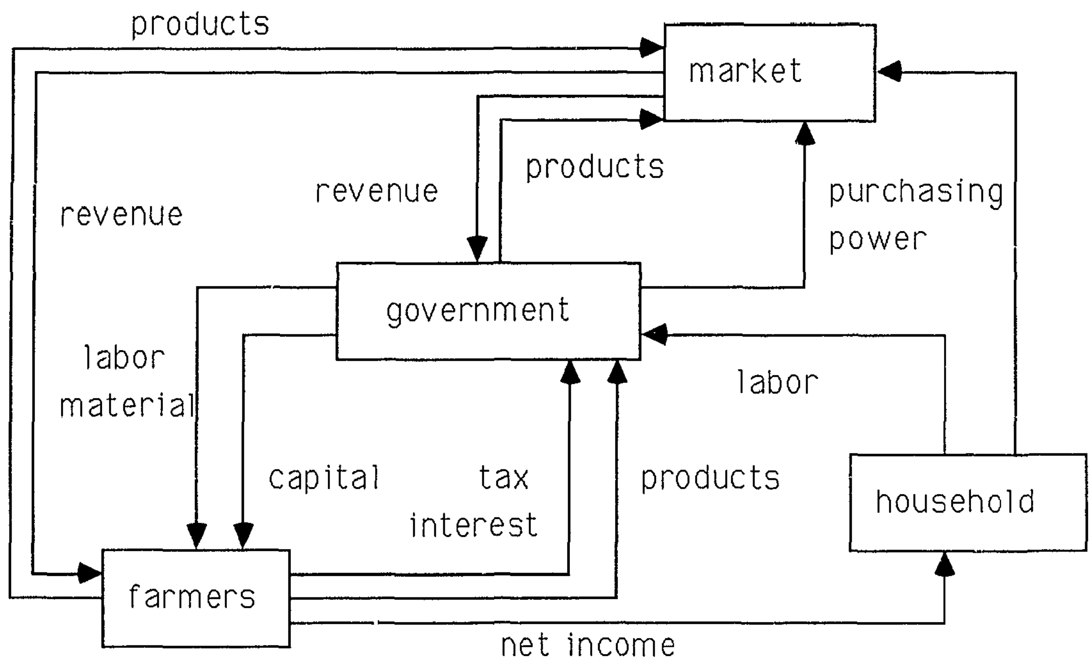

Figure 2.3 An accounting flow diagram for a typical firm (peasants) in the agricultural sector in the post-reform Chinese economy

between (2. 5) and (2. 6) concerns the variable w_i: whereas prior to the reforms, w_i is the per peasant government subsidy, after the reforms, w_i is the stipulated value of output per head delivered to government and is thus a negative component.

2. 3. The supply side of the economy

The production side of the economy is divided into five sectors, namely, agriculture, industry, construction, transportation and commerce. Let X_i represent the output in the ith sector. In the post-reform period, the output X_i is assumed to be divided into two parts, namely, a fixed contractual quota X_{ig} that the sector must deliver to the state at a government-fixed price P_{ig}, and the remainder X_{if} which the sector is allowed to sell at a market-determined price P_{if}. Thus,

$$X_i = X_{ig} + X_{if} \qquad i = 1,\ldots,5 \qquad (2.7)$$

It is reasonable to assume that $P_{if} \geq P_{ig}$ for each sector, that is, there is an incentive for economic agents to participate in the free market. Furthermore, it is assumed that the stock of labour L_i and capital K_i in each sector are exogenously determined.

Microeconomic foundation

The supply side of the model formulated in this study is an extension, to the five sectors of the Chinese economy, of a framework developed by McMillan, Whalley and Zhu (1989) who investigated the impacts of reforms on the productivity growth of Chinese agriculture, and whose work was, in turn, inspired by Stiglitz's work (1976) on "the efficiency wage hypothesis".

The standard assumption that firms maximize profits -- a natural assumption for a general equilibrium model of a capitalist economy -- is replaced in this study by the assumption of utility-maximization by individual agents. More precisely, a typical agent in the ith sector maximizes a utility function which depends on income and effort.

A firm is a conglomerate of individual labourers and a sector is a conglomerate of individual firms. Each labourer determines, by utility maximization, his/her optimal income and effort levels, given the prices. The sum of incomes over all labourers working in the firm equals the income of the firm. The optimal income in any sector is the sum of optimal incomes of all firms operating in that sector. As mentioned earlier, the notion "income of the firm" contains only the short-run profit representing the difference between the revenue and short-run variable cost which includes intermediate inputs and other operation costs. Capital investment is done by government and hence is external to the firm. Therefore, it is excluded from short-run cost calculation. As a result, "income of the firm" is different from and more restricted than the usual concept of "profit of the firm". "Income maximizing" is different from "profit maximizing" and it is correct to state that the firm chooses a production plan which maximizes its income, but that does not necessarily imply that the chosen production plan is also the profit maximizing one in the conventional microeconomic-theoretic sense. Under this scheme, it is clear that supply of each sector cannot be derived in the same manner as under the assumptions of profit-maximization or cost-minimization. Supply is determined by applying an optimal effort level to the production process. Labourer's effort will be increased only if the marginal income of effort is positive.

Starting with the agricultural sector and keeping in mind the accounting framework presented in the last section, the income of a peasant is given by (2. 5)

$$y_{ip} = \beta_i P_{ig} x_{ig} + w_i \qquad i = 1 \qquad \text{(2.5 repeated)}$$

The production capacity of an individual peasant in the agricultural sector is represented by the individual peasant's production function

$$x_i = \alpha_{oi}\varepsilon_i^{\alpha i}k_i^{1-\alpha i} \qquad i = 1 \qquad (2.8)$$

where x_i denotes output per head, k_i is capital per head, and ε_i is individual effort.

The individual's preferences for income and effort are, in turn, described by the utility function

$$u_i(y_{ip},\varepsilon_i) = y_{ip} - \frac{\varepsilon_i^{\lambda}}{\lambda\delta}, \quad \frac{\partial u_i}{\partial y_{ip}} > 0, \quad \frac{\partial u_i}{\partial \varepsilon_i} < 0 \qquad i = 1 \qquad (2.9)$$

where λ and δ are positive and denote taste parameters. Note that the utility increases with income and decreases with effort.

Substituting the production function (2.8) into the income function (2.5), the individual peasant's income becomes effort-related:

$$y_{ip} = \beta_i P_i \alpha_{oi}\varepsilon_i^{\alpha i}k_i^{1-\alpha i} + w_i \qquad i = 1 \qquad (2.10)$$

Substituting y_{ip} given in (2.10) into the utility function (2.9), we obtain

$$u_i(y_{ip},\varepsilon_i) = \beta_i P_i \alpha_{oi}\varepsilon_i^{\alpha i}k_i^{1-\alpha i} + w_i - \frac{\varepsilon_i^{\lambda}}{\lambda\delta} \qquad i = 1 \qquad (2.11)$$

Maximizing the utility function (2.11) with respect to effort, we obtain the following equation for the optimal effort

$$\varepsilon_i^* = (\delta\alpha_{oi}\alpha_i\beta_i k_i^{1-\alpha i})^{1/(\lambda-\alpha i)} P_i^{1/(\lambda-\alpha i)} \qquad i = 1 \qquad (2.12)$$

The individual supply function representing the efficient usage of production capacity is obtained by substituting the optimal effort ε_i^* given in (2.12) into (2.8). Thus, we have:

$$x_i^s = \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\alpha i/(\lambda-\alpha i)} k_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} \qquad i = 1 \qquad (2.13)$$

The sectoral supply function is obtained by multiplying both sides of (2.13) by L_i, the aggragate labor force employed:

$$X_i^s = x_i^s L_i = \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\alpha i/(\lambda-\alpha i)} k_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} L_i$$

$$= \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\alpha i/(\lambda-\alpha i)} \left(\frac{K_i}{L_i}\right)^{\lambda(1-\alpha i)/(\lambda-\alpha i)} L_i$$

$$= \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\alpha i/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$i = 1 \qquad (2.14)$$

In a more compact way, the sectoral supply function can be written as

$$X_i^s = A_i P_i^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} \qquad i = 1 \qquad (2.15)$$

after writing $A_i = \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)}$, $\gamma_1 = \alpha_i/(\lambda-\alpha_i)$, $\gamma_2 = (\lambda-1)\alpha_i/(\lambda-\alpha_i)$ and $\gamma_3 = \lambda(1-\alpha_i)/(\lambda-\alpha_i)$.

The supply functions for the other sectors, namely, industry, construction, transportation and commerce are constructed in the same manner as in the agriculture sector. The individual's income function in any one of these sectors is

$$y_{ip} = \beta_i(P_i x_i - sc_i - t_i) + w_i \qquad i = 2,\ldots,5 \qquad \text{(2.2 repeated)}$$

The individual's production function is specified as

$$x_i = \alpha_{oi}\varepsilon_i^{\alpha i}k_i^{1-\alpha i} \qquad i = 2,\ldots,5 \qquad (2.16)$$

and the short-run variable cost is represented by Leontief technology,

$$sc_i = \sum_j P_j a_{ij} x_i = \sum_j P_j a_{ij} \alpha_{oi}\varepsilon_i^{\alpha i}k_i^{1-\alpha i} \qquad i = 2,\ldots,5 \qquad (2.17)$$

Substituting x_i given in (2.16) and sc_i given in (2.17) into y_{ip} given in (2.2) yields the following effort-related income function for the non-agricultural sectors:

$$y_{ip} = \beta_i(P_i \alpha_{oi}\varepsilon_i^{\alpha i}k_i^{1-\alpha i} - \sum_j P_j a_{ij}\alpha_{oi}\varepsilon_i^{\alpha i}k_i^{1-\alpha i} - t_i) + w_i$$

$$i = 2,\ldots,5 \qquad (2.18)$$

Substituting (2.18) into the utility function of the non-agricultural sector,

$$u_i(y_{ip},\varepsilon_i) = y_{ip} - \frac{\varepsilon_i^{\lambda}}{\lambda\delta}, \quad \frac{\partial u_i}{\partial y_{ip}} > 0, \quad \frac{\partial u_i}{\partial \varepsilon_i} < 0 \qquad i = 2,\ldots,5 \qquad (2.19)$$

and maximizing $u_i(y_{ip},\varepsilon_i)$ given in (2.19) with respect to effort, we arrive at the equation for the optimal effort

$$\varepsilon_i^* = (\delta \alpha_{oi} \alpha_i \beta_i k_i^{1-\alpha i})^{1/(\lambda-\alpha i)} (P_i - \sum_j P_j a_{ij})^{1/(\lambda-\alpha i)} \quad i = 2,\ldots,5 \qquad (2.20)$$

Substituting (2.20) into the production function (2.16), we arrive at the individual supply function for these sectors:

$$x_i^s = \alpha_{oi} (\delta \alpha_{oi} \alpha_i \beta_i)^{\alpha i/(\lambda-\alpha i)} (P_i - \sum_j P_j a_{ij})^{\alpha i/(\lambda-\alpha i)} k_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$i = 2,\ldots,5 \qquad (2.21)$$

The sectoral supply function is obtained by aggregating over all households employed in a firm, and then by aggregating over all firms in a sector. This is given by

$$X_i^s = \alpha_{oi} (\delta \alpha_{oi} \alpha_i \beta_i)^{\alpha i/(\lambda-\alpha i)} (P_i - \sum_j P_j a_{ij})^{\alpha i/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$i = 2,\ldots,5 \qquad (2.22)$$

which can be written in a more compact way as

$$X_i^s = A_i (P_i - \sum_j P_j a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} \qquad i = 2,\ldots,5 \qquad (2.23)$$

after writing $A_i = \alpha_{oi}(\delta \alpha_{oi} \alpha_i \beta_i)^{\alpha i/(\lambda-\alpha i)}$, $\gamma_1 = \alpha_i/(\lambda-\alpha_i)$, $\gamma_2 = (\lambda-1)\alpha_i/(\lambda-\alpha_i)$ and $\gamma_3 = \lambda(1-\alpha_i)/(\lambda-\alpha_i)$.

2.4 The demand side of the economy

The specification of the demand side of the economy in this study follows the World Bank's input-output framework of the Chinese economy (World Bank, 1982).

Sectoral demand X_i^D is expressed as the sum of consumption C_i, investment I_i, intermediate demand IN_i and net export NEX_i. Thus, we have

$$X_i^D = C_i + I_i + IN_i + NEX_i \qquad i=1,...,5 \qquad (2.24)$$

Investment, I_i, is assumed to be determined by the government. Since the major investment decisions in China are made by a relatively small number of people in the central planning committee, there can be abrupt changes in behaviour if members change their minds or are replaced by others with different views. Such abrupt changes are less likely to happen in the households and firms because of the large number of decision makers in each unit (Fair, 1982).

The demand for intermediate commodities by the ith sector from the jth sector, IN_{ij}, is obtained by the Leontief's input-output coefficients:

$$IN_{ij} = a_{ij} X_j \qquad i,j = 1,...5 \qquad (2.25)$$

where a_{ij} denotes the requirements of intermediate goods per unit of output from sector i to sector j; and X_j represents the output in sector j. Total intermediate demand by sector of origin is given by

$$IN_i = \sum_j IN_{ij} = \sum_j a_{ij} X_j \qquad i=1,...5 \qquad (2.26)$$

Finally, due to the relatively small importance of exports and imports in China, and given that international trade is controlled by government policies, net export is also treated as exogenously determined. Under these assumptions, the endogenous determination of aggregate demand is equivalent to the endogenous determination of consumption.

A two stage optimization model of consumer's demand

To explain the determination of the demand for consumption goods, this study adopts a two stage optimization model. In the first stage, given the optimal effort, the typical household determines the optimal level of output he/she is willing to supply, which, in turn, determines his/her optimal level of income. In the second stage, the typical household optimally allocates a given income among the products of the five sectors.

The determination of income

Consider a dual-market economy wherein both the government operated markets, and free markets coexist. Consumers are assumed to acquire goods in the amount X^C_{ig} from the government operated stores at the government fixed prices P_{ig}. Consumption demand X^C_{if}, in excess of X^C_{ig}, is satisfied by purchases on the free market at the free market price P_{if}. Total consumption $X^C_i = X^C_{if} + X^C_{ig}$. Again, it is assumed that $P_{if} > P_{ig}$, so that, each firm in each sector has sufficient incentives to participate in the free market.

First, we consider the agricultural sector. As shown in the previous section, the effort-related income of a typical peasant can be represented by:

$$y_{ip} = \beta_i P_i \alpha_{oi} \varepsilon_i^{\alpha i} k_i^{1-\alpha i} + w_i \qquad i = 1 \qquad \text{(2.10 repeated)}$$

In the first stage, given the above effort-related income function, a typical peasant will maximize his/her utility function with respect to effort and determines the optimal effort ε_i^* :

$$\varepsilon_i^* = (\delta \alpha_{oi} \alpha_i \beta_i k_i^{1-\alpha i})^{1/(\lambda-\alpha i)} P_i^{1/(\lambda-\alpha i)} \qquad i = 1 \qquad \text{(2.12 repeated)}$$

Substituting ε_i^* given by (2.12) into y_{ip} given by (2.10), the optimal income y_{ip}^* becomes

$$y_{ip}^* = \beta_i P_i \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\lambda/(\lambda-\alpha i)} k_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} + w_i \quad i = 1 \quad (2.27)$$

Clearly, y_{ip}^* depends on the variable P_i through ε_i^*, and on the parameters β_i, α_{oi} and k_i. The equation also implies that higher P_{if} and a higher proportion of x_{if} in x_i will significantly increase the level of personal income since $P_{if} > P_{ig}$.

Multiplying (2.27) by the sectoral stock of labor L_i, and writing A_i = $\alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)}$, $\gamma_1 = \alpha_i/(\lambda-\alpha_i)$, $\gamma_2 = (\lambda-1)\alpha_i/(\lambda-\alpha_i)$ and $\gamma_3 = \lambda(1-\alpha_i)/(\lambda-\alpha_i)$, we obtain the optimal private aggregate agricultural income

$$\begin{aligned} Y_{ip}^* &= \beta_i P_i \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\sigma i)} \\ &\quad + W_i \\ &= \beta_i A_i P_i^{1+\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} + W_i \qquad i = 1 \qquad (2.28) \end{aligned}$$

The optimal income in the other sectors, namely, industry, construction, transportation and commerce are derived in a similar manner. A typical household's effort-related income in these sectors, after the economic reforms, can be formulated as,

$$y_{ip} = \beta_i(P_i \alpha_{oi}\varepsilon_i^{\alpha i} k_i^{1-\alpha i} - \sum_j P_j a_{ij}\alpha_{oi}\varepsilon_i^{\alpha i} k_i^{1-\alpha i} - t_i) + w_i$$

$$i = 2,\ldots,5 \qquad (2.18 \text{ repeated})$$

The optimal income after the economic reforms is derived by substituting ε_i^* given by (2.20) into the effort-related income which yields

$$y_{ip}^* = \beta_i \Big\{ P_i\, \alpha_{oi}(\delta \alpha_{oi} \alpha_i\, \beta_i)^{\alpha i/(\lambda - \alpha i)} (P_i - \sum_j P_j\, a_{ij})^{\lambda/(\lambda - \alpha i)} k_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$- \sum_j P_j\, a_{ij} \alpha_{oi}(\delta \alpha_{oi} \alpha_i\, \beta_i)^{\alpha i/(\lambda - \alpha i)} (P_i - \sum_j P_j\, a_{ij})^{\lambda/(\lambda - \alpha i)} k^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$- t_i \Big\} + w_i \qquad i = 2,\ldots,5 \qquad (2.29)$$

Again, y_{ip}^* depends on P_i through ε_i^*, and on the parameters β_i , α_{oi} and k_i. This income function serves as a potential soft budget constraint in view of the fact that one may increase his/her income by bargaining with the government for a higher β_i or a higher P_{ig} or a higher proportion of x_{if} in x_i .

Aggregating over all households employed in the ith sector, the non-agricultural sectoral private income is given by

$$Y_{ip}^* = \beta_i \{ P_i\, \alpha_{oi}(\delta \alpha_{oi} \alpha_i\, \beta_i)^{\alpha i/(\lambda - \alpha i)}$$

$$(P_i - \sum_j P_j\, a_{ij})^{\lambda/(\lambda - \alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$- \sum_j P_j\, a_{ij} \alpha_{oi}(\delta \alpha_{oi} \alpha_i\, \beta_i)^{\alpha i/(\lambda - \alpha i)}$$

$$(P_i - \sum_j P_j a_{ij})^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} - T_i) + W_i$$

$$= \beta_i \{P_i A_i (P_i - \sum_j P_j a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} - \sum_j P_j a_{ij} A_i (P_i - \sum_j P_j a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3}$$

$$- T_i) + W_i \qquad i = 2,\ldots,5 \qquad (2.30)$$

The total optimal private income is the sum of the sectoral incomes and is given by

$$Y_p^* = \sum_i Y_{ip}^* \qquad (2.31)$$

The private expenditures are defined by

$$E_p = Y_p^* - S \qquad (2.32)$$

where private saving S is treated as a predetermined variable since the Chinese banking is centrally controlled and the interest rate is officially determined. The total expenditures E are divided into two components, namely, the private expenditures E_p and the government expenditures E_g. Accordingly, we have:

$$E = E_p + E_g \qquad (2.33)$$

Allocation of expenditures

Once total private expenditures are determined, consumers then arrive at the second stage of maximization, namely, optimal allocation of the expenditures E_p over consumption goods produced by the firms in different sectors.

Consider a situation in which the individual may buy a maximum of X_{ig}^C of goods from state-operated stores at the official prices P_{ig}. However, if he/she wants to consume this goods in excess of X^C_{ig}, the additional quantity must be purchased on the free market at higher prices P_{if}. Then, a consumer's utility maximization problem may be formulated as:

$$\text{Max } U(X^C_i)$$
$$\text{s.t. } \sum_i^5 P_{ig}X^C_{ig} + \sum_i^5 P_{if}X^C_{if} = E_p \tag{2.34}$$

It is assumed that no one will buy any goods on the free market until X^C_{ig} is exhausted. The opportunity set of the consumer is depicted in Figure 2.4.

Suppose there are only two goods - agricultural goods X^C_1 and industrial goods X^C_2. In the shaded area, the consumer pays the price P_{ig} and the slope of the budget line in this range of X^C_{ig} is $-(P_{1g}/P_{2g})$. To purchase goods in excess of X^C_{ig}, the open market price P_{if} applies. The consumer maximizes his/her utility at D on the budget constraint AB. When $X^C_i > X^C_{ig}$, then the consumer moves into the free market to purchase the additional quantity on the free market. This implies that the budget line which has a slope $-(P_{1f}/P_{2f})$ is the relevant one. The equilibrium point D indicates that the consumer buys X^{C*}_1 units of goods 1 of which X^C_{1g} is purchased from the state-operated stores, and the remaining amount $X^{C*}_1 - X^C_{1g}$ is purchased on the open market.

If a linear expenditure system is adopted, a consumer is expected to maximize his utility of X^C_i in excess of X^C_{ig}, subject to the budget constraint at the price P_i, assuming $0 < \beta_i < 1$ and $\sum_i^5 \beta_i = 1$. The utility maximization problem may now be formulated as follows:

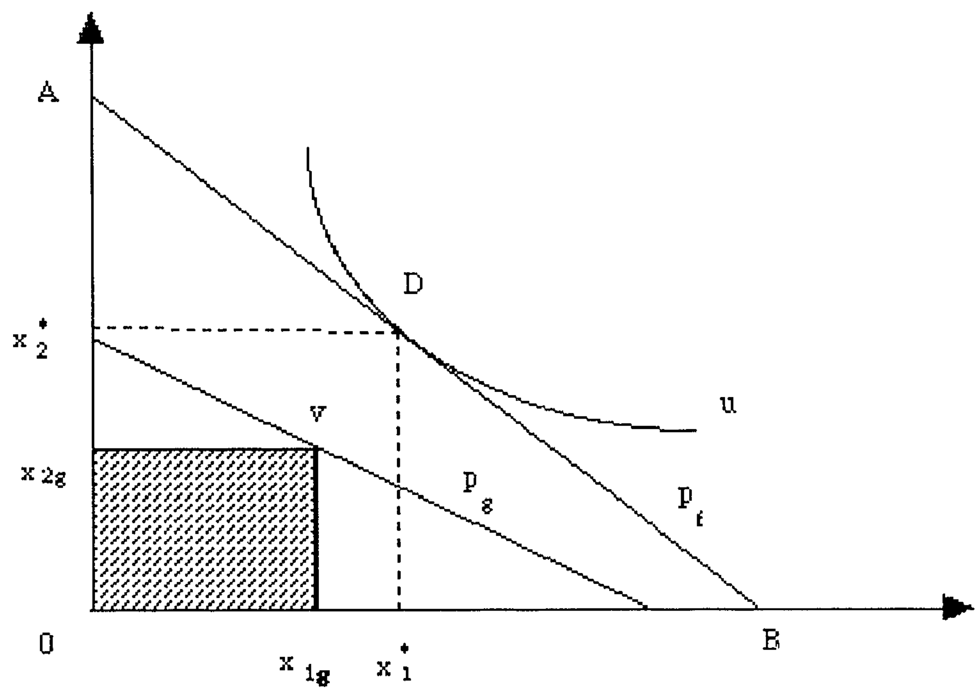

Figure 2.4 A consumer's opportunity set

$$\text{Max } U(X) = \sum_{i}^{5} \beta_i \ln(X_i^C - X_{ig}^C)$$

$$\text{s.t.} \sum_{i}^{5} P_{ig} X_{ig}^C + \sum_{i}^{5} P_{if}(X_i^C - X_{ig}^C) = \sum_{i}^{5} P_i X_i^C = E_p \tag{2.35}$$

Taking the partial derivatives of (2.35) with respect to X_i^C and the Lagrangean multiplier λ and setting them equal to zero, we obtain the following system of equations:

$$\frac{\partial U(X)}{\partial X_i} = \frac{\beta_i}{X_i^C - X_{ig}^C} - \lambda P_i = 0 \tag{2.36}$$

$$\sum_{i}^{5} P_i X_i^C = E_p \tag{2.37}$$

The set of equations in (2.36) can be rearranged as,

$$\beta_i = (X_i^C - X_{ig}^C)\lambda P_i \tag{2.38}$$

since $\sum_{i}^{5} \beta_i = 1$, (2.38) becomes

$$\sum_{i}^{5} \beta_i = \sum_{i}^{5} (X_i^C - X_{ig}^C)\lambda P_i = 1 \tag{2.39}$$

which when solved for λ yields

$$\lambda = (E_p - \sum_{i}^{5} P_i X_{ig}^C)^{-1} \tag{2.40}$$

since $\sum_{i}^{5} P_i X_i^C = E_p$. Substituting λ into β_i in (2.38), we obtain

$$\beta_i (E_p - \sum_{i}^{5} P_i X_{ig}^C) = (X_i^C - X_{ig}^C) P_i \tag{2.41}$$

The demand for the goods of the ith sector is

$$X_i^C = X_{ig}^C + \frac{\beta_i}{P_i} (E_p - \sum_{i}^{5} P_i X_{ig}^C) \tag{2.42}$$

It should be noted that X_{ig}^C represents the maximum quantity of goods one can purchase from the state-operated stores at fixed prices. Consumers attain their maximum satisfaction levels by purchasing goods on the free market to the extent that goods bought from the state-operated stores do not satisfy their demand.

Alternatively, demand for consumption goods in each sector might be written as a function of real expenditures E_p and relative prices P_i as follows:

$$X_i^C = \alpha_0 + \sum_{i}^{5} \alpha_i P_i + \alpha_2 E_p \tag{2.43}$$

Alternatively, the consumption demand function may be written in the log-linear form as,

$$\log X_i^C = \alpha_o + \sum_{i}^{5} \alpha_i \log P_i + \alpha_2 \log E_p \tag{2.44}$$

The total consumption C_i is sum of the private consumption X_i^C and government consumption X_{ig}^C, $C_i = X_i^C + X_{ig}^C$.

2.5 The model

The model we have developed has five sectors indexed by i = 1, 2, 3, 4, 5 representing the agriculture, industry, construction, transportation and commerce. The model consists of 45 endogenous variables of which 10 are explained by stochastic equations and the remaining 35 are defined by identities. The number of predetermined variables is 44. The data used in estimation cover the period from 1952 to 1987. Thus, we have 35 observations. The various equations we have derived describing the Chinese economy in the post-reform period are assembled below.

The supply side of the economy

The supply function for the agricultural sector:

$$X_i^s = \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)} P^{\alpha i/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} \qquad i = 1 \qquad (1)$$

The supply function for any of the four non-agricultural sectors:

$$X_i^s = \alpha_{oi}(\delta\alpha_{oi}\alpha_i\beta_i)^{\alpha i/(\lambda-\alpha i)}(P_i - \sum_j P_j a_{ij})^{\alpha i/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} \qquad i = 2,\ldots,5 \qquad (2)$$

Income and expenditures

The private income function for the agricultural sector:

$$Y_{ip}^{*} = \beta_i P_i \alpha_{oi}(\delta \alpha_{oi} \alpha_i \beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$+ W_i \qquad i=1 \qquad (3)$$

The private income function for the non-agricultural sectors:

$$Y_{ip}^{*} = \beta_i \{ P_i \alpha_{oi}(\delta \alpha_{oi} \alpha_i \beta_i)^{\alpha i/(\lambda-\alpha i)}$$

$$(P_i - \sum_j P_j a_{ij})^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$- \sum_j P_j a_{ij} \alpha_{oi}(\delta \alpha_{oi} \alpha_i \beta_i)^{\alpha i/(\lambda-\alpha i)}$$

$$(P_i - \sum_j P_j a_{ij})^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-ai)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} - T_i) + W_i$$

$$i = 2,\ldots,5 \qquad (4)$$

Total private income:

$$Y_p^{*} = \sum_i Y_{ip}^{*} \qquad i = 1,\ldots,5 \qquad (5)$$

Total income:

$$Y = Y_p^{*} + Y_g \qquad (6)$$

Total private expenditures:

$$E_p = Y_p^{*} - S \qquad (7)$$

Total expenditures:

$$E = E_p + E_g \qquad (8)$$

The demand side of economy

Sectoral private consumption function:

$$X_{ip}^{C} = \exp\{\alpha_0 + \sum_{i} \alpha_i \log p_i + \alpha_2 \log E_p\}. \qquad i = 1,...,5 \qquad (9)$$

Total sectoral consumption:

$$C_i = X_i^{C} + X_{ig}^{C} \qquad i = 1,...,5 \qquad (10)$$

Intermediate demand:

$$IN_i = \sum_{j} IN_{ij} = \sum_{j} a_{ij} X_j \qquad i = 1,...,5 \qquad (11)$$

Sectoral demand equation:

$$X_i^{D} = C_i + I_i + IN_i + NEX_i \qquad i = 1,...,5 \qquad (12)$$

Excess Demand

$$EX_i = X_i^{D} - X_i^{s} \qquad i = 1,...,5 \qquad (13)$$

Prices

Relative prices

$$P_i = \mathbf{P}_i / \sum_i \mathbf{P}_i \qquad i = 1,\ldots,5 \tag{14}$$

which satisfy the normalization rule

$$\sum_i P_i = 1 \tag{15}$$

Endogenous variables

X_i^D	demand for goods produced in the ith sector
X_i^s	supply of goods produced in the ith sector
X_{ip}^C	consumption of goods produced in ith sector
Y_{ip}^*	private income received by ith sector
Y_p^*	total private income
Y	total income
E_p	private expenditures
E	total expenditures
IN_{ij}	intermediate input demand by sector i from sector j
IN_i	intermediate input demand by sector i
C_i	total consumption of goods produced in the ith sector
EX_i	excess demand in the ith sector
P_i	relative price of the ith sector goods

Exogenous variables

NEX_i	net export of the goods produced in the ith sector
I_i	investment in the ith sector
K_i	capital stock used in the ith sector

L_i	the number of labour employed in the ith sector
S	private saving
Y_g	government income
SC_i	short-run production cost in ith sector
T_i	taxes in ith sector
W_i	total wage bill in ith sector
E_g	government expenditures
X^C_{ig}	government consumption of goods produced in the ith sector
P_i	price index of the goods produced in the ith sector

2.6 The Price Adjustment Process

The basic solution strategy consists of several stages. First the sectoral demand and supply functions are estimated and the CGE model is reduced to a set of excess demand functions. A solution is found such that the excess demand is zero.

Given the values of all exogenous variables including the stock of capital and labour employed in each sector, and the initial set of relative prices which satisfied the normalization rule, we can derive the sectoral supply and sectoral income. The demand side of the market has four components: investment and net export which are exogenously determined; intermediate demand in each sector which is specified by the Leontief technology with its the input-output coefficients a_{ij} taken from the World Bank's input-output table for the year 1981 (World Bank, 1986); and the private consumption which is computed given the private income and the set of relative prices.

Finally, the excess demand functions, EX_i, for the five sectors are calculated. The solution to the CGE model is reduced to the problem of finding a vector of equilibrium relative prices (P_1, ..., P_5) such that the excess demand is equal to zero in each sector. Thus, we have

$$EX_i = X_i^D - X_i^s = 0 \qquad i = 1,...,5 \qquad (2.45)$$

It should be pointed out that the above system of equations contains only four independent equations. In order to solve the system of excess demand equations given in (2.45), we impose the following normalization rule which the relative prices should satisfy:

$$\sum_i P_i = 1 \qquad (2.46)$$

Thus the system of equations to be solved consists of any four of the five excess demand equations in (2.45) plus the normalization equation in (2.46). The solution for the prices which clear any four of the five markets, along with the normalization rule determines the price in the fifth market. This is the Walras' law.

In this study, the Powell algorithm is used to solve the system of non-linear excess demand functions. Consider a set of nonlinear excess demand functions, $f_i(P_1, ..., P_5)$. In matrix terms, we have:

$$f(P) = 0 \qquad (2.47)$$

where P is the vector of the relative prices in the excess demand functions, f is the vector of non-linear excess demand functions. The objective is to find a solution vector of relative prices which renders the excess demands equal to zero. The price vector in the (k+1)th iteration can be written as

$$P^{(k+1)} = P^{(k)} + \alpha^{(k)} d^{(k)} \tag{2.48}$$

where $d^{(k)}$ is a direction vector and $\alpha^{(k)}$ is a scalar giving the size of the step to be taken in the direction $d^{(k)}$. If we take the linear Taylor series expansion for f(P), the system of excess demand functions can be rewritten as follows:

$$f(P) \approx f(P^{(k)}) + J(P^{(k)})(P - P^{(k)}) \tag{2.49}$$

where J is the Jacobian matrix defined by

$$J_{ij} = \frac{\partial f_i}{\partial P_j} \tag{2.50}$$

Setting f(P) = 0, and solving for $P = P^{(k+1)}$ yields

$$P^{(k+1)} = P^{(k)} - J^{-1} f(P^{(k)}) \tag{2.51}$$

where the direction vector d is given by $-J^{-1} f^{(k)}$ and the step size α is equal to one. $f^{(k)}$ is the value of the excess demand function in the kth iteration.

Powell's approach, which is used in this study, is to set up the solution problem as a minimization problem of a special kind. Let

$$F(P) = [f(P)]' f(P) \tag{2.52}$$

F(P) is a scalar function that has a minimum when f(P) = 0. Thus, minimizing the function F(P) will yield a solution to f(P) = 0. The Powell algorithm estimates the initial Jacobian by numerical approximation and then updates the approximation using a technique that does not involve additional function evaluations. For a detailed description of the algorithm, see Powell (1970).

The interpretation of the price adjustment algorithm is illustrated in Figure 2.5. When demand exceeds supply, the value of excess demand function f(P) and the value of F(P) are on the left hand side of the equilibrium price P*. The relative price for the next iteration will increase according to the following rule:

$$\text{If } EX_i^{(1)} > 0,\ P^{(2)} > P^{(1)} \tag{2.53}$$

The values of the excess demand function in the next iterations will decrease to zero along the southeast direction. When the value of the excess demand function approaches zero, the slope of F(P) gets flatter and eventually becomes zero. On the contrary, when the system has excess supply, that is, $f(P) < 0$, the values of f(P) and F(P) are located on the right hand side of the equilibrium price P*. The relative price for the next iteration will decrease according to the following rule:

$$\text{If } EX_i^{(1)} < 0,\ P^{(2)} < P^{(1)} \tag{2.54}$$

The values of the excess demand functions in the next iterations will increase to zero along the southeast direction. The absolute values of the slope of F(P) decline along the southeast direction. The iteration will stop when equilibrium is reached, that is, a set of relative prices is found such that all excess demands are sufficiently close to zero. Figure 2.6 illustrates the construction and solution for the excess demand functions using the basic equations of the CGE model.

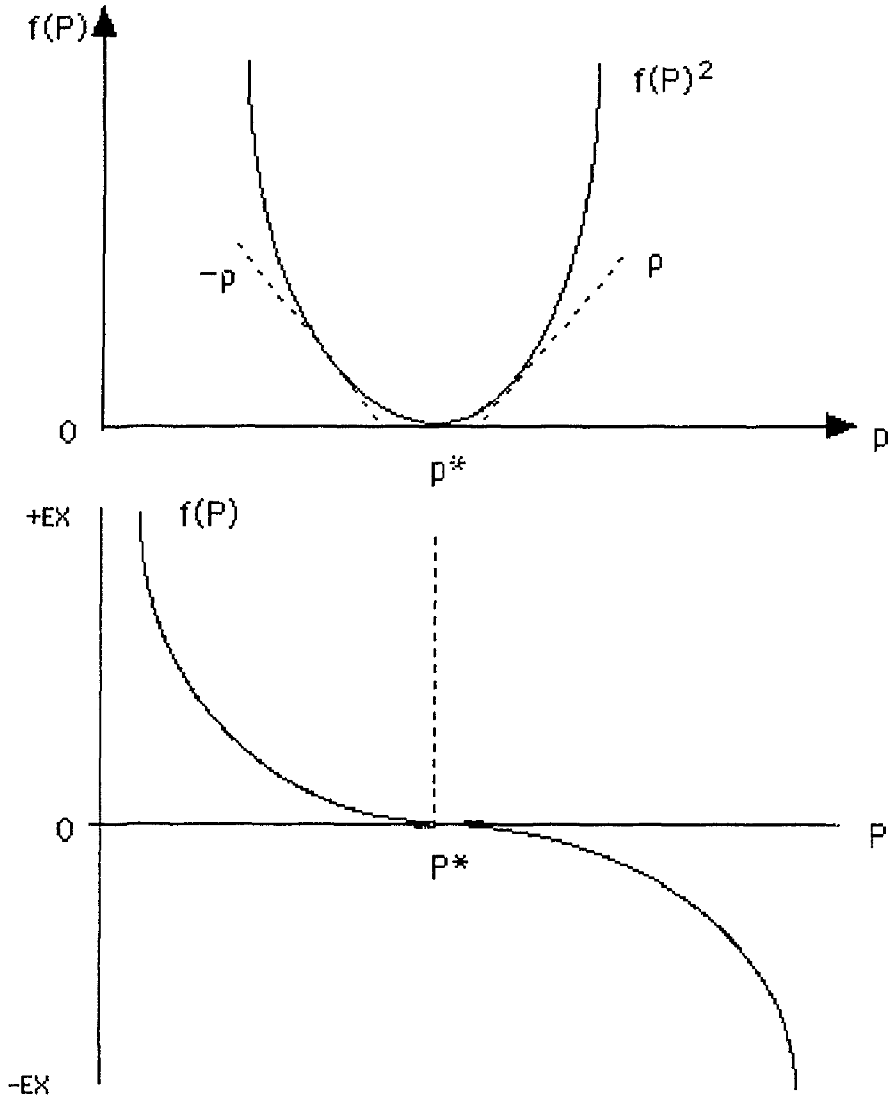

Figure 2.5 Price adjustment

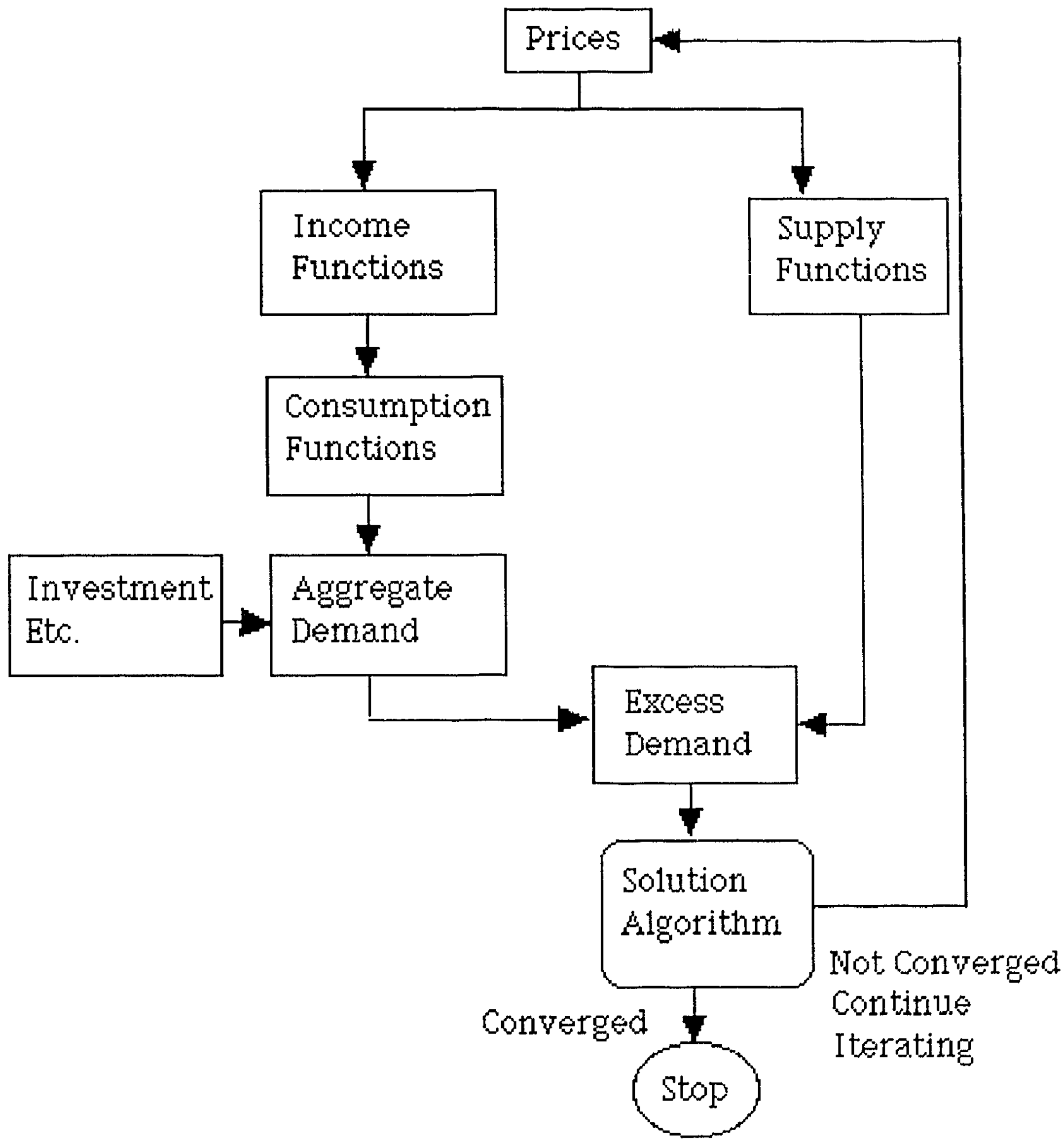

Figure 2.6 A Solution Strategy

CHAPTER 3

Estimation

3.1. Introduction

This chapter is devoted to the estimation of the CGE model. In section 2 the data and sources from which they are obtained are described. In section 3, the estimated sectoral supply functions are reported and discussed. In estimating the agricultural supply function, the recursive formula for the least squares estimator with forgetting factors is adapted to capture the structural changes when limited data are available. Section 4 deals with calibration of income functions. The estimated demand functions are reported and discussed in the fifth section. Since the objective of this study is to simulate the impacts of the economic reforms on the Chinese economy, the data related to the period of the economic reforms are given a greater weight in estimating the CGE model.

3. 2. Data

The data on the various variables in the equations of the model cover the period from 1952 to 1987. These data are collected and compiled from various published sources. These sources along with their limitations are described below. The subscript i = 1 is used to denote the agricultural sector and the subscripts i = 2, 3, 4 and 5 denote the other four sectors.

(1) X_i^s, output supplied by the ith sector, is the total value of products produced in that sector measured in constant prices of the base year 1952. This is computed by multiplying the index of total value of product for each sector, measured in 1952 prices, by the

sectoral output in 1952. These data are obtained from the Chinese Statistical Year-book, 1988, pp. 27-28.

(2) K_i , capital stock is compiled by summing the fixed capital and circulating capital. These data are obtained from the Chinese Statistical Year-book, 1988, pp. 23-24.

(3) L_i , labour input, is measured by the number of workers (peasants) engaged in the ith sector. These data are from the Statistical Year-book, 1988, p.142; 1983, p.122, p.224.

(4) P_i , denotes the sectoral relative price. The agricultural prices are computed by using the general index of purchasing prices of farm and sideline products; the industrial prices are calculated by using the general index of ex-factory prices of industrial products; the price index for the commercial sector is the index of retail prices, which is a weighted average of the prices fixed by the state and the free market prices. These price indices are available in the Statistical Year-book, 1988, p. 691. However, price indices for the construction and transportation sectors are not directly available. They are calculated as sectoral price deflators in the following way: the total value of product at current prices divided by the total value of product in 1952 price. The total value of product at current prices and the total value of product in 1952 prices are obtained from the Chinese Statistical Year-book, 1988, pp. 27-28.

(5) W_i , i =1, income in the agricultural sector, is the annual net income of the farmers; W_i , i = 2,...5, incomes in the non-agricultural sectors are the corresponding wages which include the standard wages, bonuses and subsidies. E_p, total private expenditures are computed by subtracting total saving from total income. Private saving is defined as the sum of rural and urban saving deposits. These data are obtained from the Chinese Statistical Year-book, 1989, p. 98 and p. 645.

(6) C_{ip} private consumption and C_{ig} government consumption are calculated following the approach used by the World Bank in editing the Chinese economic model (World Bank, 1985, p. 11). For each sector these are computed using the share parameters obtained

from the Chinese input-output table. For details regarding the construction of these data, see World Bank B, 1985, p. 30.

3.3 Estimation of supply functions

Most works related to the supply function emphasize the principle of profit-maximization or cost-minimization of the firm. The supply functions are derived from input demand functions which are obtained either directly from the production function using cost minimization or indirectly from cost function using Shephard's lemma. For a discussion of Shepard's lemma, see Varian (1987).

In this study, the production inputs, capital and labour are assumed to be exogenously determined by the government, and hence, the possibility of mobility of inputs across sectors is excluded. However, as the output supplied in each sector depends upon changes in optimal effort which, in turn, is related to changes in relative prices, it is reasonable to treat the sectoral supply functions as interdependent. Moreover, it is consistent with the behaviour of a single competitive price-taking firm that in the estimation of its supply curves we can safely ignore the demand side of the market. However, at the sectoral aggregate level, we can not afford to neglect the demand side as the prices are determined by the interaction of the supply and demand functions. In other words, it is inappropriate to estimate the sectoral supply functions without recognizing the simultaneous nature of the demand and supply functions in determining the sectoral prices. Accordingly, the sectoral supply functions are estimated by using a simultaneous structural estimator like the two-stage least squares estimator (2SLS).

The supply function of the agricultural sector derived earlier in Chapter 2 is given by

$$X_i^s = \alpha_{oi}(\delta\alpha_{oi}\alpha_i\ \beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\alpha i/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

i = 1 (2.6 repeated)

The supply functions of the non-agricultural sectors are given by

$$X_i^s = \alpha_{oi}(\delta\alpha_{oi}\alpha_i\ \beta_i)^{\alpha i/(\lambda-\alpha i)} (P_i - \sum_j a_{ij}P_j)^{\alpha i/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

i =2,...,5 (2.22 repeated)

These can be written in a more compact way as

$$X_i^s = A_i P_i^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} \qquad i = 1 \qquad \text{(2.7 repeated)}$$

and

$$X_i^s = A_i (P_i - \sum_j a_{ij}P_j)^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} \qquad i = 2,\ldots,5 \qquad \text{(2.23 repeated)}$$

Introducing a multiplicative log-normally distributed disturbance term e^{u_i} into the supply function of the ith sector and expressing it in log-linear form, we have:

$$\ln X_i^s = \gamma_0 + \gamma_1 \ln P_i + \gamma_2 \ln L_i + \gamma_3 \ln K_i + u_i \qquad i = 1 \qquad (3.1)$$

$$\ln X_i^s = \gamma_0 + \gamma_1 \ln(P_i - \sum_j a_{ij}P_j) + \gamma_2 \ln L_i + \gamma_3 \ln K_i + u_i$$

i =2,...,5 (3.2)

The variable $(P_i - \sum_j a_{ij}P_j)$ represents the value-added in the sector i =2,...,5. Note that if e^{u_i} follows a log-normal probability law, then u_i is normally distributed.

These supply functions are estimated in their log-linear form as given above using the 2SLS estimator. In the first stage, the ordinary least squares (OLS) regressions of the price variables (endogenous variables) are computed using the exogenous variables L_i and K_i as regressors. In other words, the instrumental variables used in the first stage are the labour L_i and capital K_i, which are determined by the government and hence are exogenous for each sector. In the second stage, we replace P_i by its OLS estimates $\hat{P}_i$, and estimate the supply function by OLS estimator. In other words, we compute the OLS regression of X_i^s using $\hat{P}_i$ and the other exogenous variables L_i and K_i.

Another problem that one is likely to face in estimating models using time series data is the presence of autocorrelation in the disturbances. In this study, the presence of autocorrelation in the disturbances is tested using an approximation of the Durbin-Watson test (1951). This test is based on the DW statistic, computed from the 2SLS residuals, the distribution of which is approximated by a beta-distribution. It should be pointed out that the Durbin-Watson bounds test based on the 2SLS residuals may be subject to wider bounds and its usefulness is likely to be limited. For more details regarding this test, see Savin and White (1977). If autocorrelation of disturbances is detected, the supply equation is reestimated by 2SLS after correcting it.

Supply function of the agricultural sector

Since the objective of this study is to simulate the impacts of the economic reforms on the Chinese economy, reliable estimation of the supply function of the agricultural sector is important. In particular, the important changes which have occured during the reforms period should be recognized in estimating the agricultural supply function.

The economic reforms in the rural areas have brought a new incentive system which boosted agricultural production. Since 1978, the Chinese agriculture has been experiencing substantial growth. To study the impact of economic reforms on the Chinese agriculture, we might compare the agriculture performance before and after 1978. Between 1965 and 1977, the overall agricultural growth is around 2.1 percent, just a little above the population growth rate of 1.9 percent, in spite of a substantial increase in modern inputs like machinery, irrigation power equipment and chemical fertilizers that became available during the same period. According to Tang's (1980) research on Chinese agriculture, between 1952 and 1977, increases in agricultural output failed to keep pace with material input increases. In the post-reform period, Chinese agriculture has grown at an unprecedented rate. The annual growth rate of grain output reached 4.9 percent, more than twice the previous rate of 2.1 percent achieved between 1957 and 1978. Soybeans, cotton and edible vegetable oils, all have posted substantial annual growth rates since 1978. Output of cotton, almost tripled between 1978 and 1984. These comparisons suggest that actual output before 1978 was far below the potential output of the agricultural sector. See Table 3.1.

Since these pronounced changes have occurred after the economic reforms were put in place, estimates of the supply functions using the data covering the period from 1952 to 1987 may prove less reliable unless recognition is accorded to possible structural shifts. To detect structural shifts in the sectoral supply functions we have tested for the equality of sets of coefficients in the two regressions, one based on the pre-reform period data and the other based on the post-reform period data using the Chow test. In particular, the null hypothesis tested is: there is a stable relationship over the entire period in question. Rejection of the null hypothesis implies that the data covering the entire period, i.e. 1952-87 which covers the pre and post-reform period should not be pooled to estimate the supply function and that separate regressions are needed in the case of agriculture, one for the pre-reform period and the other for the post-reform period. Moreover, rejection also implies that economic reforms have had a significant impact on the Chinese agriculture. This is particularly interesting in this study as it provides information about

Table 3.1

Average Annual Growth Rates for Selected Agricultural Products between 1957-78 and 1978-84*

	Grain	Meat	Soybeans	Cotton
1957-78	2.1	3.7	-1.1	1.3
1978-84	4.9	10.1	4.2	18.7

* These growth rate were computed from data given in Chinese Statistics Yearbook, 1988, p.212, p.224.

the extent to which the reform measures affected favorably the agricultural production.

The Chow test proceeds on the usual assumptions that the disturbances in the equation are independently and normally distributed with zero mean and constant variance. However, if the disturbances in the model are serially correlated, it is no longer true that the quadratic form of the disturbances are distributed as a Chi-square, and hence, the Chow test is not valid. In such a case, the Chow test is frequently biased toward rejecting the hypothesis of stability in the regression coefficients. See Corsi, Pollock and Prakken, (1982). In this study, the Chow test is conducted based on the 2SLS residuals of the estimated model after correcting for autocorrelation.

If the null hypothesis of stability of the regression coefficients is rejected, there are two possible approaches to explore the relationship further. In the first approach, we split the sample into sub-samples corresponding to the two sub-periods and estimate separate equations one for each sub-period. The second approach is to specify explicitly a more general model embodying parameter variability over time. In the present study, we are precluded from taking the first approach as the available number of observations in each sub-sample is small enough to make the parameter estimates less reliable. This is particularly true for the post-reform period. Accordingly, in this study, a time-varying parameter estimation approach is adopted. This is achieved by using a recursive formula for least squares estimation with forgetting factors, corrected, if necessary, for the first order autocorrelation. This is one of the ways in which data shortage could be overcome. This method traces the structural changes in the sector by using the forgetting factors to gradually phase out the influence of old data, and put more weight on the more recent data. Detailed description of this procedure is presented in the appendix at the end of this chapter.

Empirical results

The supply function of the agricultural sector is estimated in log-linear form given in (3.1) by 2SLS estimator using the data covering the entire period from 1952 to 1987. This is reported below.

$$\ln X_1^s = -0.5919 + 0.2465\ln L_1 + 0.1309\ln K_1 + 0.2491\ln P_1$$

se	(1.7751)	(0.0942)	(0.0854)	(0.2612)	$R^2 = 0.8529$
t	(-0.3334)	(2.6170)	(1.5331)	(0.9537)	DW = 3.1242 (3.3)

The Durbin-Watson approximation test statistic is 5.536, which is greater than the critical value of 2.08 of F(7,20) at 5 percent level of significance. This indicates that the disturbances are serially correlated. The Chow test is performed to test for stability of the structure as the Chinese economy passes through the pre-reform period of 1952-77 into the post-reform period of 1978-87. The F-statistic for the Chow test is equal to 3.8150 which is greater than the critical value of 2.69 of F(4,28) at 5 percent level of significance. This suggests that the relationship is not stable and that a structural change had occurred in the Chinese agriculture around that time in which the economic reforms were formally introduced. This is also corroborated by the negative and insignificant intercept at 5 percent level. In order to capture such a structural change in the agricultural sector, first, a correction is made for the presence of first order autocorrelation. Then, the supply function of the agricultural sector over the post-reform sample period from 1978 to 1987 is estimated by applying the OLS recursive formula with the forgetting factors in the second stage to obtain the 2SLS estimates. In other words, the supply function (3.1) is estimated by the 2SLS method using the data from 1952-73. The estimates for the following period, i.e., 1974-87 are calculated by using the updated formula, namely, previous estimates plus the gain factor multiplied by the prediction error. See the appendix at the end of this chapter for a description of the recursive OLS and how the gain factor is computed. Forgetting factors are imposed so that the influence of the past data is gradually phased out and more weight is put on the recent data. To this end, we first estimated the parameters based on the data from 1952-74 using the recursive least squares (RLS) estimator. We placed 50 percent weight on the data before and including 1973, and estimated the parameters covering this period. When the data set is updated for the next year, i.e., 1975, we placed 81.6 percent weight on the data which covered the period from 1952-74 and estimated the parameters for the period 1952-1975. Clearly, in the second updating, the forgetting factor is reduced to 40.8 percent (0.50×0.81.6) for the data from 1952-1973. In subsequent updating, we placed 93.2 percent weight on the data from 1952-75 in estimation covering the period from 1952-76, and 97.5 percent weight on the data from 1952-76 in estimation covering the period from 1952-77, and 99 percent weight on the data from 1952-77 in estimation for the period 1952-78. Finally, the unity weight is placed on the data after 1978. In this way, the estimates after 1978, mainly reflect the economic conditions in the post-reform period. The values of the above forgetting factors are calculated based on the formula of the first order response. These forgetting factors that were imposed on the past data in estimating the parameters of the supply function of agriculture tended to reflect the importance of the pre-reform data relative to the post-reform data. Detailed description of the forgetting factors is given in the Appendix to this chapter. The estimates are displayed in Table 3.2.

During the 1978-87 period the agricultural supply elasticity with respect to labour, capital and price were around 0.44, 0.16 and 0.18 respectively. The relatively larger coefficient for the labour input in comparison with the coefficient for the capital input shows that the growth of Chinese agriculture over the study period is mainly propelled by a steady increase in the participation of the labour force. This, of course, is true as the Chinese agriculture is still relatively more labour-intensive.

Table 3.2
Recursive Estimates for the Supply Function of the Agriculture Sector

$$(\ln X_1^s = a_0 + a_1 \ln L_1 + a_2 \ln K_1 + a_3 \ln P_1)$$

Year	Intercept a_0	L coefficient a_1	K coefficient a_2	P coefficient a_3
1978	0.1387	0.4489	0.1568	0.1849
se	(0.0526)	(0.2112)	(0.0490)	(0.0615)
t	(2.6387)	(2.1260)	(3.2055)	(3.0082)
1979	0.1479	0.4449	0.1700	0.1836
se	(0.0559)	(0.2132)	(0.0518)	(0.0591)
t	(2.6455)	(2.0869)	(3.2819)	(3.1063)
1980	0.2513	0.4106	0.1393	0.1816
se	(0.0848)	(0.1774)	(0.0396)	(0.0516)
t	(2.9650)	(2.3142)	(3.5132)	(3.5185)
1981	0.2171	0.4341	0.1798	0.1824
se	(0.0700)	(0.1952)	(0.0515)	(0.0472)
t	(3.1005)	(2.2236)	(3.4926)	(3.8616)
1982	0.2641	0.4139	0.1470	0.1827
se	(0.0847)	(0.2006)	(0.0432)	(0.0452)
t	(3.1191)	(2.0638)	(3.4032)	(4.0448)
1983	0.2137	0.4465	0.1690	0.1852
se	(0.0651)	(0.2151)	(0.0490)	(0.0425)
t	(3.2845)	(2.0761)	(3.4463)	(4.3608)
1984	0.2092	0.4564	0.1804	0.1836
se	(0.0593)	(0.2062)	(0.0504)	(0.0388)
t	(3.5307)	(2.2133)	(3.5781)	(4.7294)
1985	0.2169	0.4508	0.1789	0.1874
se	(0.0559)	(0.1843)	(0.0474)	(0.036)
t	(3.8737)	(2.4458)	(3.7781)	(5.2091)
1986	0.2289	0.4470	0.1813	0.1924
se	(0.054)	(0.1643)	(0.0453)	(0.0338)
t	(4.238)	(2.7214)	(3.9992)	(5.6984)
1987	0.2396	0.4539	0.1853	0.1948
se	(0.0541)	(0.1539)	(0.0457)	(0.0329)
t	(4.4320)	(2.9486)	(4.0516)	(5.9154)

A major problem in interpreting the estimated agricultural supply function is that of distinguishing between increases in supply resulting from increases in the availability of inputs and increases in supply due to technical progress and improved efficiency. There are some studies which explored the reasons behind the recent acceleration in the growth of agricultural output in China. A broad consensus has been reached that the recent phenomenal growth of Chinese agricultural output has been facilitated in large measures through improved incentives. Lardy (1986) reported that the recent rapid growth of the Chinese agriculture has been achieved with an apparent reduction in the amount of investment in agriculture. The accelerated growth of farm output with a lesser infusion of modern inputs surely suggests substantial rise in agricultural productivity since 1978. The increase in productivity may be explained by changing agricultural technologies, increased application of fertilizers, and most importantly, due to more efficient use of resources. This conclusion is confirmed by McMillan, Whalley and Zhu (1989) in their study of the impact of economic reforms on the growth of productivity in Chinese agriculture.

In our study, the parameter,

$$A_1 = \alpha_{01}(\delta\alpha_{01}\alpha_1\beta_1)^{\alpha 1/(z-\alpha 1)} \tag{3.4}$$

and its estimates $\hat{A}_1 = e^{a_0}$, may be interpreted as a measure of efficiency in the agricultural sector during the study period. Given the inputs K_1 and L_1 and the price P_1, the larger the estimate of A_1, the greater is the output X_1^s obtainable. The time-varying parameter estimates show that the estimates of efficiency parameter A_1 are greater than unity (since $a_0 > 0$), implying that the agricultural sector is efficient. More importantly, the efficiency measures increased over the study period as the estimates showed an upward trend. See Table 3.2.

McMillan, Whalley and Zhu decomposed the growth rate of agricultural productivity into two components, namely, increases due to price increases and increases due to incentive changes. Changes in the incentive system like the farm contract did allow peasants to improve their incomes through greater diligence and better management. The higher prices the government has offered, along with decollectivization and the higher free market prices that came into being, all have contributed to greater incentives which increased the productivity of peasants. According to McMillan, Whalley and Zhu (1989), 78 percent of the productivity increase in Chinese agriculture between 1978 to 1984 is attributable to incentive changes and the remaining 22 percent is due to price increases.

Supply functions of the industrial, construction, transportation and commercial sectors

The supply function of the industrial sector estimated by 2SLS estimator is reported below. Note that the subscript 2 denotes the industrial sector.

$$\ln X_2^s = -0.5919 + 0.4475 \ln K_2 + 0.6947 \ln L_2 + 0.2675 \ln(P_2 - \sum_j a_{ij} P_j)$$

se	(1.7751)	(0.0812)	(0.1658)	(0.1323)	$R^2 = 0.8964$
t	(-0.3334)	(5.5089)	(4.1893)	(2.0215)	DW= 1.5374 (3.5)

Over the study period, the supply elasticity with respect to labour, capital and value added, i.e., the variable $(P_2 - \sum_j a_{ij} P_j)$, in the industrial sector are 0.4475, 0.6947 and 0.2675 respectively and are significant at 5 percent level. The intercept a_0 which represents the efficiency measure ($\hat{A}_i = e^{a_0}$) is positive and insignificant at the 5 percent level. The supply elasticity of capital for the industrial sector is well above the value of 0.16 reported for the agriculture sector. This reveals that the industrial sector is relatively more sensitive to changes in capital than the agricultural sector. This is to be expected, especially in the case of China.

In order to discover the occurrence of any significant structural shift in the industrial sector around 1978, the year in which the economic reforms were introduced, we have conducted a series of Chow tests. The F-statistics for these tests are computed using the estimated residuals of 2SLS regressions splitting the sample period of 1952-87 into two subsamples. The two subsamples and the computed values of the F-statistic are reported in Table 3.3. For example, the first entry represents the two subsamples used in computing the F-statistic, namely, the periods 1952-75 and 1976-87. In subsequent calculations, the first subsample is appended with the data that belong to the immediately following year and at the same time deleting that data from the second subsample. It is clear from the entries in Table 3.3 that all the F-statistics are smaller than the critical value 2.69 of $F(4,28)$ at 5 percent level of significance. Accordingly, it is concluded that no structural shift took place in the industrial sector during the period of our study. This conclusion confirms the results of Field (1986). For purposes of comparison, the growth rate of the gross value of industrial output reported by Field (1986) are reproduced below in Table 3.4.

Comparing the growth rates of industrial output before and after 1978, Field did not find any remarkable changes in the performance of the Chinese industry, but a significant change in the structure of industry. From 1958-78, the heavy industry like metallurgy, machinery and petroleum grew faster than the light industry like food processing and textiles, whereas from 1979-83, the light industry grew faster than the heavy industry (Field, 1986). Moreover, the data on the performance of state-operated industrial enterprises -- the most important portion of the Chinese industry -- also failed to show the significant contrast between the pre-reform period and the post-reform period.

Table 3.3

F-statistics for Chow Tests:

the Supply Function of the Industrial Sector

Year	F-Statistics
1952-75/1976-87	0.6462
1952-76/1977-87	1.1560
1952-77/1978-87	0.5355
1952-78/1979-87	0.3952
1952-79/1980-87	0.4054
1952-80/1981-87	0.4652
1952-81/1982-87	0.3744
1952-82/1983-87	0.3961

Table 3.4

Average Annual Rates of Growth of the Gross Value of Industrial Output, By Branch of Industry, 1953-83

	1953-57	1958-78	1979-83
Total Industry	16.1	8.8	9.7
Metallurgy	29.0	9.2	5.2
Electrical Power	20.4	13.3	6.3
Coal	17.1	7.4	1.9
Petroleum	32.7	18.8	2.9
Chemicals	31.2	15.0	9.2
Machinery	29.7	13.1	7.2
Food Processing	13.2	4.7	9.3
Textiles	8.6	6.4	12.9

This is clear from the average annual rates of growth of the main economic indicators of state enterprises reported by Field (1986, p.530) and reproduced in Table 3.5.

Entries in Table 3.5 indicate a tendency which was ignored by Field, namely, a deterioration in the productivity of capital, accompanied by an improvement in the productivity of labour. The gross value per 100 yuan of fixed assets of the state-operated independent-accounting industrial enterprises during the period between 1958-78 declined by 0.2 percent, and continued to slip to 1.6 percent between 1979 and 1983, whereas, the gross value per worker increased from 2.1 percent between 1958 and 1978 to 3.3 percent between 1979 and 1983. Meanwhile, the rate of growth of gross value per 100 yuan of working capital improved substantially from -2.9 percent between 1958 and 1978 to 2.4 percent between 1979 and 1983. This means that the economic reforms in the industrial sector did not bring significant improvements in productivity of fixed capital in the state-operated enterprises, but did improve productivity of labour and working capital. This tendency is further confirmed by the time-varying parameter estimates obtained here. The time-varying parameter estimates of the supply function of the industrial sector between 1970 and 1987 are displayed in Table 3.6.

It is clear from Figure 3.1, that from 1970-87, the capital elasticity of output maintained its level around 0.44, while the labour elasticity of output enjoyed a steady increase after 1977. It is noticeable that the steady increase in the labour elasticity of output is achieved with a lesser infusion of labour input with an annual rate of 3.3 percent between 1979 and 1983, compared with 6.9 percent between 1958 to 1978. See Table 3.5. This reveals that although there is no significant overall structural change in the industry, the economic reforms in the industrial sector certainly improved efficiency somewhat, particularly in regard to labour productivity. It is the labourer's effort, rather than the number of labourers employed that explains the increase in the labour elasticity of output.

The 2SLS estimate of the supply function for the construction sector is given

Table 3.5

Average Annual Rates of Growth of the Main Economic Indicators for the State-operated Industrial Enterprises

	1953-57	1958-78	1979-83
Gross value of industry	16.8	9.1	6.8
Fixed assets	17.7	11.3	8.3
Working capital	14.5	12.4	4.3
Annual number of workers	8.9	6.9	3.3
Gross value per 100 yuan of fixed assets	-0.7	-0.2	-1.6
Gross value per 100 yuan of working capital	2.0	-2.9	2.4
Gross value per worker	7.2	2.1	3.3

Table 3.6
Recursive Estimates for the Supply Function of the Industrial Sector

$$(\ln X_i^s = \theta_0 + \theta_1 \ln K_i + \theta_2 \ln L_i + \theta_3 \ln(P_i - \sum_j a_{ij} P_j)$$

Years	intercept θ_0	K coefficient θ_1	L coefficient θ_2	$(P_2 - \sum_j a_{ij} P_j)$ coefficient θ_3
1976	-0.5746	0.4403	0.5647	0.4278
se	(4.2032)	(0.1275)	(0.2198)	(0.4765)
t	(-0.1367)	(3.4528)	(4.5486)	(2.0986)
1977	-0.5292	0.4406	0.5678	0.3993
se	(3.6676)	(0.1190)	(0.1931)	(0.5070)
t	(-0.1443)	(3.7014)	(5.1801)	(1.6612)
1978	-0.8792	0.4416	0.5778	0.2154
se	(3.29[illegible]4)	(0.1052)	(0.1090)	(0.[illegible]489)
t	(-0.2667)	(4.1998)	(5.3005)	(1.4460)
1979	-1.9038	0.4424	0.5910	0.1698
se	(3.0805)	(0.0907)	(0.1121)	(0.1454)
t	(-0.6180)	(4.8768)	(5.2712)	(1.1675)
1980	-1.9449	0.4425	0.6072	0.1794
se	(2.8206)	(0.0835)	(0.1125)	(0.2110)
t	(-0.6895)	(5.3008)	(5.3964)	(0.8504)
1981	-1.7301	0.4426	0.6204	0.1531
se	(2.5823)	(0.0784)	(0.1127)	(1.3779)
t	(-0.6700)	(5.6476)	(5.5057)	(0.7257)
1982	-1.5650	0.4431	0.6331	0.2330
se	(2.4043)	(0.0743)	(0.1127)	(0.2637)
t	(-0.6509)	(5.9640)	(5.6172)	(0.8837)
1983	-1.3650	0.4444	0.6469	0.2296
se	(2.2693)	(0.0715)	(0.1132)	(0.2151)
t	(-0.6015)	(6.2147)	(5.7161)	(1.0676)
1984	-1.2762	0.4458	0.6654	0.2715
se	(2.1453)	(0.0685)	(0.1142)	(0.2255)
t	(-0.5949)	(6.5070)	(5.8254)	(1.2042)
1985	-1.1676	0.4459	0.6702	0.0205
se	(2.0188)	(0.0656)	(0.1129)	(0.0149)
t	(-0.5784)	(6.8002)	(5.9353)	(1.3717)
1986	-0.9470	0.4460	0.6978	0.1160
se	(1.8864)	(0.0633)	(0.1157)	(0.0687)
t	(-0.5019)	(7.0508)	(6.0288)	(1.6392)
1987	-0.5919	0.4475	0.6947	0.2675
se	(1.7751)	(0.0621)	(0.1146)	(0.1323)
t	(-0.3334)	(7.2006)	(6.0639)	(2.0215)

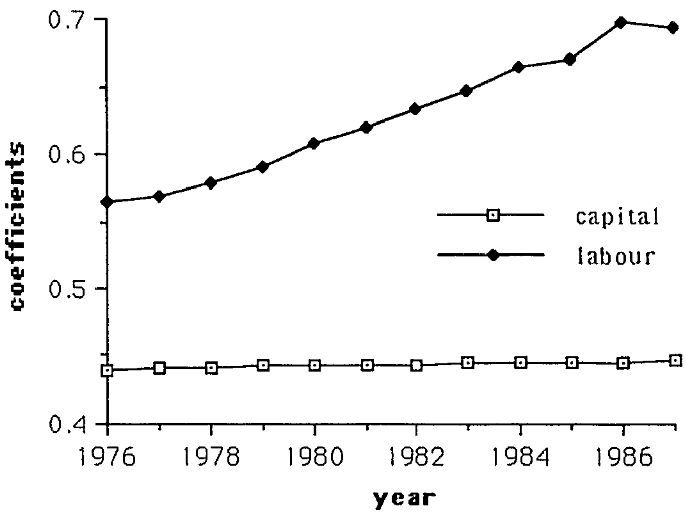

Figure 3.1 Time-varying estimates of labour and capital coefficients for the indusytial sector

below. Note that the subscript 3 denotes the construction sector.

$$\ln X_3^s = -1.2469 + 0.4223\ln K_3 + 0.4608\ln L_3 + 0.1966\ln(P_3 - \sum_j P_j a_{ij})$$

se	(0.4829)	(0.1186)	(0.1265)	(0.7276)	$R^2 = 0.9410$
t	(-2.5817)	(3.5656)	(3.6412)	(0.2702)	DW = 1.8021 (3.6)

In estimating the supply functions for the transportation sector, it has been detected that the disturbances are serially correlated. 2SLS estimate of the supply function for the transportation sector is reported below. Note that the subscript 4 denotes the transportation sector.

$$\ln X_4^s = -8.5232 + 0.0727\ln K_4 + 0.3485\ln L_4 - 6.8785\ln(P_4 - \sum_j P_j a_{ij})$$

se	(1.8704)	(0.2294)	(0.2591)	(9.9645)	$R^2 = 0.8940$
t	(-4.5569)	(0.3171)	(1.3451)	(-0.6903)	DW = 3.5723 (3.7)

The Durbin-Watson test approximation statistic is 4.8602, which is greater than the critical value of 4.6 of F(5,16) at 5 percent level of significance. This indicates that the disturbances are serially correlated and correction for the first order autocorrelation is made and the supply function for the transportation sector is reestimated. The reestimated supply function for the transportation sector corrected for the first order autocorrelation is given below.

$$\ln X_4^s = -0.0603 + 0.6444\ln K_4 + 0.2476\ln L_4 - 0.1692\ln(P_4 - \sum_j P_j a_{ij})$$

se	(0.0078)	(0.1351)	(0.1608)	(0.02498)	$R^2 = 0.9584$
t	(-7.7252)	(4.7697)	(1.5392)	(-0.39372)	DW = 2.1406 (3.8)

These results show that the coefficients of value-added variables $(P_3 - \sum_j P_j a_{ij})$ and $(P_4 - \sum_j P_j a_{ij})$ for the construction and transportation sectors are statistically insignificant at 5 percent level of significance. The negative sign for the coefficient of value-added variable in the transportation sector is contrary what is expected in theory. The possible explanation regarding the insignificance of estimated parameters is that these two sectors are still very much subject to government regulation. The price mechanism in these two sectors has not played as important a role as in the cases of the agricultural and industrial sectors.

The 2SLS estimate of the supply function for the commercial sector is given below. Note that the subscript 5 denotes the commercial sector.

$$\ln X_5^s = -0.9852 + 0.3897 \ln K_5 + 0.6893 \ln L_5 + 0.1705 \ln(P_5 - \sum_j P_j a_{ij})$$

se	(0.0105)	(0.1480)	(0.1881)	(0.0723)	$R^2 = 0.9632$
t	(-1.4277)	(2.6381)	(3.6647)	(2.3596)	DW = 1.5395 (3.9)

All the estimated coefficients of the supply function for the commercial sector are statistically significant at 5 percent level of significance.

3.4. Calibration of income functions

As indicated in the last chapter, the expansion of aggregate demand is constrained by the optimal income, which in turn depends on the optimal effort. More specifically, effort will be increased only when marginal net income of effort increases. The optimal income in the agricultural and in the other four non-agricultural sectors are given by (2.28) and (2.30) respectively. These equations are repeated below.

$$Y^{*}_{ip} = \beta_i \; P_i \, \alpha_{oi}(\delta\alpha_{oi}\alpha_i \, \beta_i \,)^{\alpha i/(\lambda-\alpha i)} P_i^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$+ \; w_i$$

$$= \; \beta_i \;\; A_i \, P_i^{1+\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} \; + W_i \qquad i = 1 \qquad \text{(2.28 repeated)}$$

$$Y^{*}_{ip} = \beta_i \; \{P_i \, \alpha_{oi}(\delta\alpha_{oi}\alpha_i \; \beta_i \,)^{\alpha i/(\lambda-\alpha i)}$$

$$(P_i - \sum_j \; P_j \, a_{ij})^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$- \sum_j \; P_j \, a_{ij} \alpha_{oi}(\delta\alpha_{oi}\alpha_i \; \beta_i \,)^{\alpha i/(\lambda-\alpha i)}$$

$$(P_i - \sum_j \; P_j \, a_{ij})^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} \; - T_i\} \;\; + W_i$$

$$= \; \beta_i \; \{P_i \, A_i \, (P_i - \sum_j \; P_j \, a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} - \sum_j \; P_j \, a_{ij} A_i \, (P_i - \sum_j \; P_j \, a_{ij})^{\gamma 1} L_i^{g 2} K_i^{\gamma 3}$$

$$- \; T_i\} \;\; + W_i \qquad i = 2,\ldots,5 \qquad \text{(2.30 repeated)}$$

Since the estimates of the parameters A_i and γ_i s in the above income functions are readily available from the estimates reported in the last section, the sectoral income functions can easily be calibrated. Calibration is a procedure in which parameter values are determined in a nonstochastic way. Parameter values are usually extraneously chosen for the particular function so that the model will approximately reproduce an assembled equilibrium data set (Mansur & Whalley (1982)).

In calibrating the income functions, the values of the variables L_i, K_i, P_i, T_i and W_i are selected at the bench-mark year of 1980. The year 1980 was chosen because it was around that period that free markets have almost developed and the economic reforms have had their effect on the economy. Parameters A_i and γ_i s for the ith sector are taken from the estimated supply functions in the last section. However, assigning a plausible value to the bonus ratio β_i is wrought with some difficulties as such ratios at the sectoral level are not available. These ratios are calculated by solving the income function using the estimates of parameters A_i and γ_i s and the values of the exogenous variables. The bonus ratio for the agricultural sector after the economic reforms, is assigned a value of unity, since the peasants do not have to submit a portion of their revenues to the government. Their net incomes are simply the total revenue after subtracting the value of the contractal output to the government. The bonus ratios for the other four non-agricultural sectors are given by solving the income functions, (2.30), which can be expressed as follows:

$$\beta_i = \frac{Y^*_{ip} - W_i}{\{P_i A_i (P_i - \sum_j P_j a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} - \sum_j P_j a_{ij} A_i (P_i - \sum_j P_j a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} - T_i\}}$$

$$i = 2,\ldots,5 \qquad (3.10)$$

Since optimal income for each sector Y^*_{ip} is known, β_i for any one of other four non-agricultural sectors can be solved by assigning the estimated parameters of the supply functions and the values of the exogenous variables at the bench-mark year of 1980 for each sector in the equation (3.10). The computed bonus ratios by sectors are reported in Table 3.7.

3.5 Estimation of private consumption functions

Aggregate demand in this study consists of four components, namely, consumption, investment, intermediate demand and net exports. Investment, as already mentioned, is considered exogenously determined due to the fact that major investment activities in China are determined by the government. Net exports depend on the government export policies, and hence are also treated as exogenously determined. The demand for intermediate commodities stems from the assumed underlying Leontief technology. The input-output coefficients defining the the Leontief technology are taken from the World Bank's Chinese input-output model for 1981 (World Bank, 1985). Since three of the components determining demand, namely, investment, net exports and demand for intermediate goods are exogenously determined aggregate demand is actually determined by private consumption. Thus, the endogenous determination of demand is equivalent to the endogenous determination of private consumption.

To study the expenditure allocation over consumption goods among sectors, a homogeneity restriction is imposed on the consumption function, that is, the consumption function is homogeneous of degree zero in prices and total private expenditures. Thus, an equiproportionate change in all prices and total private expenditures should leave the consumption function unchanged. Thus, the homogeneity restriction implies that consumption is a function of relative prices and real expenditures. For purposes of identifying the sectoral consumption functions, only these price variables which are closely related to the commodity in question have been included. The 2SLS estimate of the private consumption demand for agricultural products is given below:

Table 3.7

The Bonus Ratio for Each Sector

Sector	Bonus ratio
Agriculture	1
Industry	0.025
Construction	0.043
Transportation	0.020
Commerce	0.034

$$\ln X^C_{1p} = 7.6845 - 0.1239\ln P_1 - 0.6342\ln P_2 + 0.2702\ln E_p$$

se	(8.1292)	(0.5995)	(0.4100)	(0.1207)	$R^2 = 0.9696$
t	(0.9453)	(-1.6681)	(-1.5473)	(2.2379)	DW = 1.8792 (3.11)

The estimated coefficients for agricultural, industrial prices and private expenditures are significant at 5 percent level. The intercept is positive but insignificant at the 5 percent level. The sign of P_1 is negative, which is consistent with the law of demand. A percentage change in agricultural prices gives rise to opposite change of .1239 in private consumption demand for agricultural products. The sign of P_2 depends on the balance between the income and substitution effects. If the agricultural and industrial goods are substitutes, then, when P_2 rises, assuming that the price of agricultural products and income remain constant, there will be a substitution effect increasing the demand for agricultural products as its relative price falls, and an income effect which reduces demand for agricultural products as real income falls. The net effect depends on which of these two effects dominates. The positive sign for P_2 suggests that the substitution effect is predominant. However, the substitution relationship between the agricultural and industrial goods has not been detected here as is evident from the negative sign for P_2. In fact, the sign confirms a complementary relationship between the agricultural and industrial products. Mansur and Whalley caution the interpretation of substitution effect in the broad, aggregate demand analysis, saying that "the role of prices in determining demand behaviour seems to be less than theory might suggest, although prices become somewhat more important if a finely divided classification of commodities is used. For broad aggregate, however, price indices over time tend to move in the same direction following similar patterns, making substitution possibilities hard to detect from the data" (Mansur & Whalley, 1971).

Furthermore, the estimated results show that the income elasticity of consumption demand for agricultural products is 0.2702. This result is, of course, consistent with the Engel's law which asserts that the income elasticity of demand for food (in our case the agricultural products are typically in the form of food) is typically less than unity. Although the estimate of the income elasticity of demand for agricultural products (i.e., food) of 0.2702 obtained here is considered to be lower than Chow's estimate of 0.79 (Chow, 1985), yet if the entire agricultural sector is considered, it is reasonably close to the estimates of Booth and Sundrum (1985) who reported that estimates of income elasticities of demand for agricultural products in less developed countries vary between 0.20 to 0.30. The income elasticity of demand for agricultural products in China is relatively higher than the estimates for developed countries like France and Germany, and is almost equal to those of the less developed countries like Pakistan and Indonesia. In order to facilitate comparisons of elasticities of demand for agricultural products among economies, both developed and less developed, the estimates provided by Booth and Sundrum (1985) are displayed in Table 3.8.

The 2SLS estimate of the private consumption function for the industrial products is given below.

$$\ln X^{C}_{2p} = 1.1442 - 1.1911 \ln P_1 - 0.6165 \ln P_2 + 1.3668 \ln E_p$$

se	(1.1895)	(0.6883)	(0.2427)	(0.2695)	R^2= 0.8803
t	(0.9619)	(-1.7305)	(-2.5397)	(5.0716)	DW= 1.7462 (3.12)

The estimated coefficients for the agricultural and industrial prices and the private expenditures are significant at 5 percent level. The intercept for private consumption demand for industrial products is positive and insignificant at 5 percent level. The sign for P_2 is negative and indicates the expected inverse relationship between consumption

Table 3.8

Income Elasticities of Demand for Agricultural Products in the Developed and Less Developed Countries

Developed countries	
France	0.13
Germany	0.13
Japan	0.17
Sweden	0.14
Less developed countries	
Sri Lanka	0.34
Pakistan	0.23
Indonesia	0.32
Philippines	0.55
South Korea	0.16
China	0.26

demand for industrial products and its own price. The income elasticity of demand for industrial products is 1.3668 which is substantially larger than 0.2702 for agricultural products. The cross price elasticity of demand for industrial products with respect to agricultural price is negative, which implies a complementary relationship between the industrial and agricultural products.

The 2SLS estimate of the private consumption function for construction goods is given below.

$$\ln X_{3p}^{C} = -\,0.0432 - 0.9336\ln P_2 + 0.7798\ln P_3 + 1.3335\ln E_p$$

se	(0.01242)	(0.4671)	(1.1089)	(0.1968)	$R^2 = 0.9319$
t	(-3.4782)	(-1.9987)	(0.7032)	(6.7759)	DW = 1.7365 (3.13)

The intercept and estimated coefficients for the industrial prices and the private expenditures are significant at 5 percent level. The estimated coefficient for the own prices is positive and the t-value is 0.7032 which implies that the estimated parameter of the own price elasticity is insignificant at 5 percent level. This may reflect the fact that the construction sector is still very much under government regulation and that a free market in that sector has not yet well developed. Negative sign for the cross price elasticity of demand for industrial products with respect to construction price suggests that these two are complementary. The income elasticity of demand for construction products is 1.3335, which is very close to that for the industrial sector.

The 2SLS estimate of the private consumption function for transportation products is given by,

$$\ln X^{C}_{4p} = 0.0373 + 0.6965\ln P_2 + 0.6325\ln P_4 + 1.0456\ln E_p$$

se	(0.0153)	(0.2433)	(0.2356)	(0.1090)	R^2= 0.9803
t	(2.4419)	(2.8622)	(2.684)	(9.5927)	DW = 2.0732 (3.14)

The intercept and all estimated coefficients are significant at 5 percent level. The estimated price elasticity of private consumption demand for transportation goods is positive, which is contrary to the law of demand. This might suggest a strong interference by government and a less important role for market forces in the sector. The positive sign for the cross price elasticity of transportation goods with respect to industrial price shows that these two are substitutes. The income elasticity of demand for transportation is 1.0456.

Private consumption demand for products in the commercial sector is negatively related with its own price and positively related with the price of the construction products. The income elasticity of demand for commercial products is less than one. The estimated coefficients are all significant at 5 percent level. The 2SLS estimate of the private consumption function for commercial products is reported below.

$$\ln X^{C}_{5} = 1.6002 + 0.5896\ln P_3 - 0.6342\ln P_5 + 0.7233\ln E_p$$

se	(0.9996)	(0.4008)	(0.3199)	(0.083)	R^2= 0.9556
t	(1.6009)	(1.4710)	(-1.9821)	(8.7101)	DW = 1.7045 (3.15)

Appendix

The following derivation of the recursive formula of the least squares estimator is taken from Phillips (1977). The discussion regarding the forgetting factors is borrowed from Hughes (1986).

Consider the model,

$$y = X\beta + u \tag{A1}$$

where y is a $N \times 1$ vector of observations on the dependent variable, X is a $N \times k$ non-stochastic matrix of observations on k explanatory variables with rank $k < N$. The u is a $N \times 1$ vector of disturbance terms with assumptions $E(u) = 0$ and $Cov(u) = \sigma^2 I$. The best linear unbiased estimator b_N of ß is given by

$$b_N = (X_N' X_N)^{-1} X_N' y_N \tag{A2}$$

where the subscript N is explicitly introduced to identify the number of observations used in estimating ß. We shall use the subscript N to indicate that a vector or matrix of observations contains N rows. The subscript N when used for an estimator implies that N observations have been used to obtain that estimator.

Let $\mathbf{x}'_N$ denote the Nth row of the $N \times k$ matrix X_N and y_N denote the Nth element of the vector y_N. Thus,

$$X_N = \begin{pmatrix} X_{N-1} \\ x'_N \end{pmatrix} \quad \text{and} \quad y_N = \begin{pmatrix} y_{N-1} \\ y_N \end{pmatrix} \tag{A3}$$

When data are updated as y_N and x_N become available, the estimator b_N based on the N observations is given by:

$$b_N = (X'_N X_N)^{-1} X'_N y_N$$

$$= [X'_{N-1}X_{N-1} + x_N x'_N]^{-1}[X'_{N-1}y_{N-1} + x'_N y_N] \qquad \text{(A4)}$$

Appropriate rearrangement and manipulation results in the following recursion formula given by Phillips (1977, p. 66).

$$b_N = b_{N-1} + L(N)(y_N - x'_N b_{N-1}) \qquad \text{(A5)}$$

with the covariance matrix of b_N

$$\mathrm{Cov}(b_N) = \sigma^2 P_N = \sigma^2 (X'_N X_N)^{-1} = \sigma^2 [X'_{N-1}X_{N-1} + x_N x'_N]^{-1}$$

$$= \sigma^2 \left\{ P_{N-1} - \frac{P_{N-1} x_N x'_N P_{N-1}}{d_{N-1}} \right\} \qquad \text{(A6)}$$

where the gain term L(N) is

$$L(N) = \frac{P_{N-1} x'_N}{d_{N-1}} \qquad \text{(A7)}$$

$$P_{N-1} = (X'_{N-1} X_{N-1})^{-1} \qquad \text{(A8)}$$

and

$$d_{N-1} = 1 + x'_N P_{N-1} x_N \qquad \text{(A9)}$$

It can be seen from (A5) that a new estimate b_N can be computed from the previous estimate b_{N-1}. This method of updating the estimates as an additional observation is available is called the recursive least squares (RLS) estimator. The appealing feature of RLS estimation is that it provides time-varying estimates of the parameters of the model.

Since P_{N-1} in (A8) is a positive definite matrix, updating p_N results in a successive reduction in P_N so that the gain term in (A6) is eventually reduced to zero. Thus, if the objective is to track the parameters through time, the RLS estimator is of little help. One way of overcoming this problem is to introduce what is termed as a forgetting factor which serves to progressively phase out the effects of past data. Accordingly, P_N using the forgetting factors is defined as:

$$P'_N = [rX'_{N-1}X_{N-1} + \mathbf{x}_N\mathbf{x}'_N]^{-1} \tag{A10}$$

where $0 < r < 1$.

The recursive formula for updating P'_N then becomes:

$$P'_N = r^{-1}P_{N-1} - r^{-1}P_{N-1}\mathbf{x}_N(\mathbf{x}'_N r^{-1}P_{N-1}\mathbf{x}_N + 1)^{-1}\mathbf{x}'_N r^{-1}P_{N-1}$$

$$= \frac{1}{r}\left(P_{N-1} - \frac{P_{N-1}\mathbf{x}_N\mathbf{x}'_N P_{N-1}}{d_{N-1}}\right) \tag{A11}$$

$$d_{N-1} = r + \mathbf{x}'_N P_{N-1}\mathbf{x}_N \tag{A12}$$

The effect of the forgetting factor in (A11) is clear in that the covariance matrix and hence the gain L(N) is kept from going to zero since every time P_N is updated, P_N is amplified by r. The algorithm will therefore remain alert to coefficient parameter changes.

In the real economic world, we expect some structural changes in the economic system, and we do not have sufficient data to reflect these changes since many of these structural changes come into being in a very short time. The recursion formula of the least squares estimator with forgetting factors can be used to overcome such a problem. Thus the modified RLS method by incorporating the forgetting factors would solve the data shortage problem by assigning larger weights to recent data and smaller weights to the past data so that estimated structures would reflect the most recent structural changes. After these modifications, the RLS method becomes particularly useful in social and economic research. See Riddell (1975).

The major problem with the forgetting factor algorithm is also apparent from (A10). If the data X is forgotten by a constant ratio, eventually, the most recent data representing the recent economic structure will be forgotten somehow. An easy way to overcome this problem is to use variable forgetting factors, instead of a constant r value. In other words, varying values of r are assigned to different observations, giving values to r which are close to 1 when most recent data are used and values close to zero when data that belong to remote periods are used.

The difficulty in such a case is that forgetting factors will converge on unity only if the initial value of the forgetting factor is close to unity. If the initial value of the forgetting factor is close to zero, it will take a longer time to converge on unity of the forgetting factors from the point we choose to forget the past data, which implies more data are required to estimate the new economic structure. And lack of more data is precisely the problem. Thus, it is imperative that some other behavior restrictions on the forgetting factor which allows it to converge to unity faster should be found to solve the data shortage problem and these are discussed below.

Suppose the forgetting factors follow the first order response scheme:

$$r(t)=1- e^{-t/\tau} \qquad \text{(A13)}$$

In (A13), the forgetting factors might start with zero, and quickly converge on unity. The uniqueness of the first order system response is when $t=\tau$, the value of the forgetting factor is equal to 0.632, that is, we can forget about 36.8 percent of the old data. when $t=2\tau$, $t=3\tau$, $t=4\tau$ the value of the forgetting factor quickly reaches 0.865, .95; and 0.982 respectively. The convergence behaviour of r(t) is depicted in Figure A.1.

This implies that one can start with the point we choose to forget about 40 percent of the past data, then take four periods to quickly approach the unity of forgetting factors. If one wants to start with forgetting more than forty percent of the past data, say, fifty percent, one can use the following first order reponse scheme:

$$r(t) = r + (1 - r)(1 - e^{-t/\tau}) \tag{A14}$$

We obtain results similar to those when using the first order response scheme (A13) but forgetting more of the past data. This is depicted in Figure A.2.

Suppose the assumption of a scalar covariance matrix is replaced by

$$\text{Cov}\,[u(N)] = \sigma^2\Omega_N \tag{A15}$$

where Ω_N is a positive definite matrix. Then, the generalized least squares estimator b_N of ß based on N observations is given by:

$$b_N = (X_N'\Omega_N^{-1}X_N)^{-1}X_N'\Omega_N^{-1}y_N \tag{A16}$$

Since Ω_N is a positive definite matrix, it is possible to find a matrix T_N such that

$$T_N\Omega_N T_N' = I \tag{A17}$$

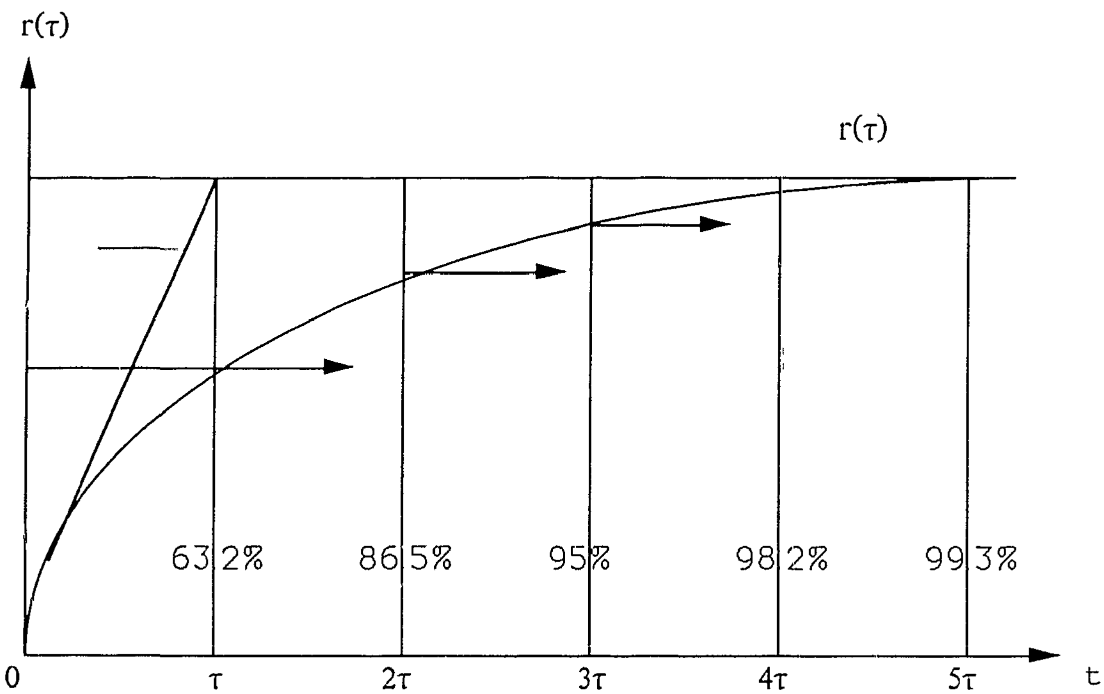

Figure A.1 First Order Response Scheme

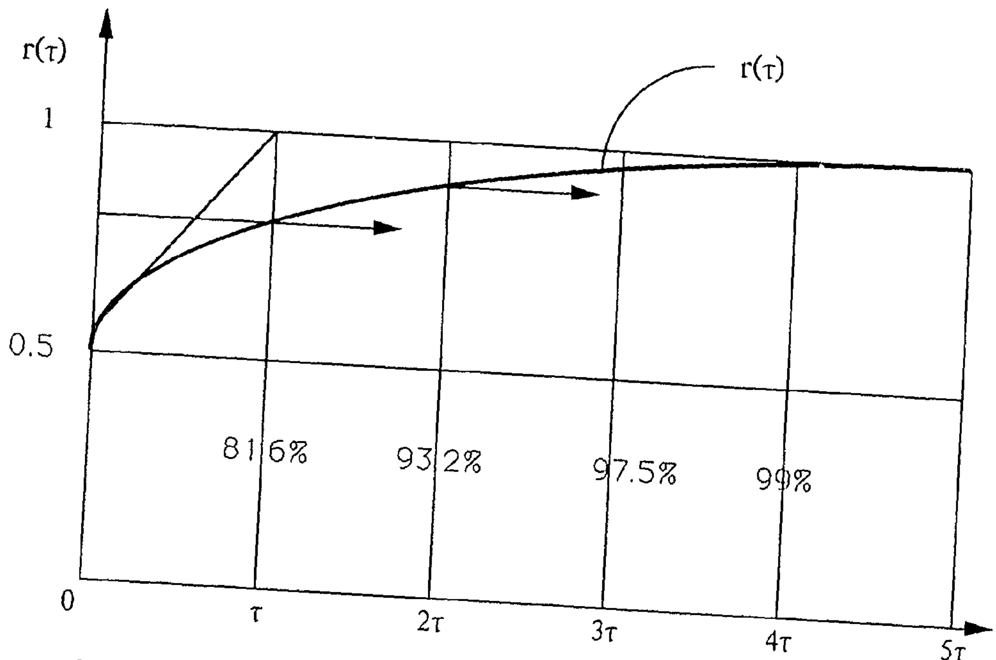

Figure A.2 The modified First Order Response Scheme

Partition the matrix T_N by the first N-1 rows and column as

$$T_N = \begin{pmatrix} T_{N-1} & 0 \\ t_N' & t \end{pmatrix} \tag{A18}$$

The generalized least square estimator can be rewritten using T_N matrix as

$$b_N^* = (X_N^{*'} X_N^*)^{-1} X_N^{*'} y_N^* \tag{A19}$$

where

$$X_N^* = T_N X_N \tag{A20}$$

$$y_N^* = T_N y_N \tag{A21}$$

which, in turn, can be generated recursively with respect to the index N

$$X_N^* = \begin{pmatrix} X_{N-1}^* \\ t_N' X_{N-1} + t\mathbf{x}_N' \end{pmatrix} = \begin{pmatrix} X_{N-1}^* \\ \mathbf{x}_N^{*'} \end{pmatrix} \tag{A22}$$

$$y_N^* = \begin{pmatrix} y_{N-1}^* \\ t_N y_{N-1} + t\,\mathbf{y}_N \end{pmatrix} = \begin{pmatrix} y_{N-1}^* \\ \mathbf{y}_N^* \end{pmatrix} \tag{A23}$$

Based on (A22) and (A23), we simply apply the RLS formula to the generalized least square estimates. The recursive formula for the generalized least squares estimator can be written as

$$b_N^* = b_{N-1}^* + L^*(N)(\mathbf{y}_N^* - \mathbf{x}_N^{*'} b_{N-1}^*) \tag{A24}$$

where

$$L^{*}(N) = \frac{P^{*}_{N-1} \varkappa^{*'}_{N}}{d^{*}_{N-1}} \tag{A25}$$

and

$$P^{*}_{N} = \left((X^{*'}_{N-1} X^{*}_{N-1})^{-1} - \frac{(X^{*'}_{N-1} X^{*}_{N-1})^{-1} \varkappa^{*}_{N} \varkappa^{*'}_{N} (X^{*'}_{N-1} X^{*}_{N-1})^{-1}}{d^{*}_{N-1}} \right) \tag{A26}$$

$$d^{*}_{N-1} = 1 + \varkappa^{*'}_{N} P^{*}_{N-1} \varkappa^{*}_{N} \tag{A27}$$

In the case of the first order autocorrelation of disturbances, the matrix T_N is specified as

$$T_N = \begin{pmatrix} \sqrt{1-\rho^2} & 0 & 0 & \dots & 0 & 0 \\ -\rho & 1 & 0 & \dots & 0 & 0 \\ 0 & -\rho & 1 & \dots & 0 & 0 \\ . & . & . & & . & . \\ 0 & 0 & 0 & \dots & 1 & 0 \\ 0 & 0 & 0 & \dots & -\rho & 1 \end{pmatrix} \tag{A28}$$

its corresponding recursive formula is

$$T_{N-1} = \begin{pmatrix} \sqrt{1-\rho^2} & 0 & 0 & \dots & 0 \\ -\rho & 1 & 0 & \dots & 0 \\ 0 & -\rho & 1 & \dots & 0 \\ . & . & . & & . \\ 0 & 0 & 0 & \dots & 1 \end{pmatrix} \quad \text{(A29)}$$

$$t_N = (\, 0 \;\; 0 \;\; 0 \;\; \dots \;\; -\rho \,) \quad \text{(A30)}$$

and $\mathbf{t} = 1$.

If the forgetting factor is introduced into this recursive formula with the first order autocorrelation, one might simply apply the formula (A10)-(A12) derived earlier to the (A24)-(A28) to compute the recursive estimates of parameters in the GLS model.

The recursive formula of the two-stage least-squares estimators with forgetting factors could be implemented by applying recursive formula of the ordinarily least square estimator to the second stage least squares estimation.

Suppose the equation to be estimated is given by

$$y = Y\beta + X\gamma + u \quad \text{(A31)}$$

where y is an $N \times 1$ vector of observation, Y and X are matrices of N observations on g jointly dependently predetermined variables, respectively. The vectors β and γ are the parameters associated with variables in Y and X. If the first stage least squares estimates of $\hat{Y}$ are known, the 2SLS estimates can be easily computed by the RLS formulas mentioned above in (A5)-(A9).

CHAPTER 4

Simulation Experiment

4.1. Introduction

The main objective of this study is to examine the effects of the economic reforms introduced in China since 1978. To this end, the estimated structure of the CGE model of the Chinese economy reported in the previous chapter is used to conduct a simulation experiment. This simulation experiment is designed to answer the following question: given the fact that the economic reforms have specifically favoured the agricultural sector by allowing the bonus ratio to be unity for the peasants, what will the impact on the Chinese economy be if the same kind of incentive is accorded to the workers in the four non-agricultural sectors? In other words, we wish to examine the incentive effects on worker productivity and relative prices of allowing workers in the non-agricultural sectors a bonus ratio of unity, so that the income they have generated becomes their bonus. Accordingly, the experiment is designed to simulate the effects of setting the bonus ratio equal to unity in all four non-agricultural sectors. We compute a set of relative equilibrium prices and of equilibrium outputs assuming the bonus ratio to be unity in the non-agricultural sectors and comparing these equilibrium prices and outputs with the actual relative prices and outputs when the bonus ratio is equal to a fraction of profits. Such a comparison provides some information regarding the extent to which prices have been distorted and outputs have been inefficiently produced due to the lower incentive to workers in the non-agricultural sectors. Of course, it should be remembered that the economic reforms had already allowed a bonus ratio of unity in the agricultural sector.

4.2 Simulation experiment: prices

The strategy of the Chinese economic reforms is to provide incentives to labourers, thereby allowing labourers to augment their income by virtue of their superior performance. However, as explained in the previous chapters, economic reforms have been undertaken to different degrees in different sectors, so that significant improvements in output and productivity have been achieved in the agricultural sector but few improvements have been made in the non-agricultural sectors of the economy. These differences in performance stem from differences in the payment structure between the agricultural sector and non-agricultural sectors. In the agricultural sector, the reforms allow the peasants who used to sell everything to the government in the pre-reform era to sell their products on free markets after delivering the stipulated quotas to the government. Industrial workers who used to remit all profits they made, are now allowed to retain a fraction of profits as bonuses. Consequently, the bonus ratio in the peasants' income function is equal to unity, whereas it is equal to a fraction of profits in the income functions of workers in the non-agricultural sectors. The peasants' and workers' income functions are repeated below,

$$Y^*_{ip} = \beta_i \; P_i \, \alpha_{oi}(\delta \alpha_{oi} \alpha_i \, \beta_i)^{\alpha i/(\lambda-\alpha i)} P_i^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$+ W_i$$

$$= \beta_i \; A_i \, P_i^{1+\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} + W_i \qquad i = 1 \qquad \text{(2.28 repeated)}$$

$$Y^*_{ip} = \beta_i \; \{P_i \, \alpha_{oi}(\delta \alpha_{oi} \alpha_i \, \beta_i)^{\alpha i/(\lambda-\alpha i)}$$

$$(P_i - \sum_j P_j \, a_{ij})^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)}$$

$$- \sum_j P_j a_{ij} \alpha_{0i} (\delta \alpha_{0i} \alpha_i \beta_i)^{\alpha i/(\lambda - \alpha i)}$$

$$(P_i - \sum_j P_j a_{ij})^{\lambda/(\lambda-\alpha i)} L_i^{(\lambda-1)\alpha i/(\lambda-\alpha i)} K_i^{\lambda(1-\alpha i)/(\lambda-\alpha i)} - T_i) + W_i$$

$$= \beta_i (P_i A_i (P_i - \sum_j P_j a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} - \sum_j P_j a_{ij} A_i (P_i - \sum_j P_j a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3}$$

$$- T_i) + W_i \qquad i = 2,\ldots,5 \qquad \text{(2.30 repeated)}$$

Clearly, peasants are rewarded relatively more for their effort than the workers in other sectors. As a result, peasants are given a strong incentive to work harder and more productively than workers in the other sectors.

Suppose that a reform measure similar to that in the agricultural sector is introduced into the industrial, construction, transportation and commercial sectors, namely, set the bonus ratio, $\beta_i = 1$, i=2,...,5 so that the marginal utility of workers' effort in these sectors increases. Furthermore, we assume that the proportion of the profit that used to be remitted to the government is now delivered to the government in the form of taxes. It is expected that such a reform measure would provide a greater incentive to workers in the non-agricultural sectors, so that they will work harder and produce more output if the market condition allows them to do so. It should be noted that the simulation experiment undertaken is confined to the reinforcement of incentives aimed at eliciting sectoral increases in effort and productivity by a given, fixed, administratively allocated labour force rather than at inducing a real reallocation of resources (e.g. of labour) among sectors. Reallocation of resources (i.e. manpower and capital), which features in most CGE applications, does not occur in this study since the allocation of resources are assumed to be determined by the government only.

Assume that the market for each sector is initially in equilibrium, i.e.,

$$X_i^S = X_i^D \qquad i= 1,\dots,5 \qquad (2.10 \text{ repeated})$$

where

$$X_i^s = A_i P_i^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} \qquad i = 1 \qquad (2.15 \text{ repeated})$$

$$X_i^s = A_i (P_i - \sum_j P_j a_{ij})^{\gamma 1} L_i^{\gamma 2} K_i^{\gamma 3} \qquad i = 2,\dots 5 \qquad (2.23 \text{ repeated})$$

after writing $A_i = \alpha_{oi}(\delta\alpha_{oi}\alpha_i \beta_i)^{\alpha i/(\lambda-\alpha i)}$ $\gamma_1 = \alpha_i/(\lambda-\alpha_i)$, $\gamma_2 = (\lambda-1)\alpha_i/(\lambda-\alpha_i)$ and $\gamma_3 = \lambda(1-\alpha_i)/(\lambda-\alpha_i)$, i=2,...,5. Here, $\beta_i = 1$, i=1 and $0 < \beta_i < 1$, i=2,...,5.

First, we calculate the efficiency parameter A_i at $\beta_i = 1$, i=2,...,5. Let A_i^* denote the efficiency parameter at $\beta_i = 1$, i=2,...,5. Then the ratio of A_i^* to A_i is

$$\frac{A_i^*}{A_i} = \frac{\alpha_{oi}(\delta\alpha_{oi}\alpha_i)^{\alpha i/(\lambda-\alpha i)}}{\alpha_{oi}(\delta\alpha_{oi}\alpha_i \beta_i)^{\alpha i/(\lambda-\alpha i)}} \qquad i=2,\dots,5 \qquad (4.1)$$

Assume that the technical parameters α_{oi} and α_i and the taste parameters δ and λ remain constant, even after the institutional changes have occurred. Then A_i^* can be expressed as

$$A_i^* = \frac{A_i}{\beta_i^{\alpha i/(\lambda-\alpha i)}} = \frac{A_i}{\beta_i^{\gamma_{1i}}} \qquad i=2,\dots,5 \qquad (4.2)$$

after writing $\gamma_{1i} = \alpha_i / (\lambda - \alpha_i)$. Given the estimated value-added parameter γ_{1i} and efficiency parameter A_i in the supply function and the calibrated value of the bonus ratio for each sector, we compute the values of the efficiency parameter A_i^*. Assigning (4.2) the corresponding estimates of γ_{1i}, A_i and β_i, we obtain the value of A_i^* for each sector. The estimates of A_i γ_{1i}, β_i and the computed A_i^* for each of the non-agricultural sectors are reported in Table 4.1. It should be noted that Table 4.1 reports only the industrial, construction, transportation and commercial sectors as the bonus ratio of the agricultural sector is already unity. It is evident that the value of A_i^* depends on A_i γ_{1i} and β_i. Table 4.1 demonstrates the expected linkage between the estimate of A_i^* and the bonus ratio β_i. When the unit bonus ratio is introduced, sectors with a smaller bonus ratio like industry and transportation have greater values of A_i^*, while sector with a greater bonus ratio like construction have smaller values of A_i^*.

Using the computed efficiency parameters A_i^*, we recalculate the real output supplied at the existing prices by each of the four non-agricultural sectors. It is evident that at $\beta_i = 1$, $i=2,\ldots,5$, *ceteris paribus,* the output supplied must be greater than the original output supplied. Hence, with no changes in demand, supply must exceed demand in each of these non-agricultural sectors at existing prices. In particular, the sectors with greater discrepancies of $A_i^* - A_i$, like industry and transportation, are expected to have greater excess supply, while the agricultural sector whose bonus ratio has already been set to unity is expected to have zero excess supply. The original supply (which is equal to demand) and the computed supply by sectors are displayed in Table 4.2. A set of new equilibrium prices is computed by using the Powell algorithm based on the original level of demand and the computed supply reported in the above table. The programme is a subroutine found in the

Table 4.1
The Estimates of Efficiency Parameters A_i and A_i^*

Sectors	A_i	γ_{1i}	β_i	A_i^*	$A_i^* - A_i$
Industry	0.5533	0.2675	0.0250	1.4842	0.9309
Construction	0.2874	0.1966	0.0430	0.5335	0.2461
Transportation	0.9415	0.1692	0.0200	1.8251	0.8836
Commerce	0.3734	0.1705	0.0340	0.6645	0.2912

Table 4.2

Actual and Desired supply by Sectors

Year	Agriculture	Industry		Construction		Transportation		Commerce	
		Actual	Desired	Actual	Desired	Actual	Desired	Actual	Desired
1976	74.2449	411.9113	412.8422	44.7450	44.9911	20.8471	21.7306	29.0301	29.3212
1977	75.9679	456.5572	457.4881	46.8027	47.0488	21.7948	22.6783	29.5045	29.7956
1978	77.2589	492.8466	493.7775	56.7663	57.0124	23.5242	24.4077	31.0520	31.3431
1979	78.1159	556.3967	557.3276	62.8425	63.0886	25.6109	26.4944	33.2773	33.5684
1980	81.5805	699.8036	700.7345	73.1481	73.3942	29.8574	30.7409	35.0835	35.3746
1981	82.2223	745.5902	746.5211	69.1239	69.3700	30.4480	31.3315	34.9389	35.2300
1982	83.6111	807.3392	808.2701	81.9831	82.2292	32.1369	33.0204	35.5859	35.8770
1983	86.1967	915.3293	916.2602	90.5901	90.8362	35.7549	36.6384	37.8740	38.1658
1984	92.9765	1184.912	1185.843	102.731	102.977	41.1825	42.0660	45.2390	45.5302
1985	97.7793	1414.990	1415.921	104.835	105.081	50.0454	50.9289	51.7694	52.0605
1986	100.026	1532.912	1533.843	113.317	113.563	54.6449	55.5284	55.0160	55.3071
1987	102.29	1658.686	1659.617	121.561	121.807	59.5892	60.4727	58.4133	58.7044

Numerical Algorithm Grouping Library (NAGLIB)[1]. The computed relative prices and the actual relative prices are reported in Table 4.3 covering the period from 1976-87.

Figures 4.1 through 4.5 depict the graphs of the actual and computed prices by sectors. In order to compare actual and computed prices, we calculate three descriptive statistics. These are the mean, standard deviation (SD) and the coefficient of variation. The mean is a measure of central tendency. The standard deviation and coefficient of variation (standard deviation/mean) are measures of dispersion with respect to each simulation experiment. Furthermore, we use the mean absolute percentage error (MAPE) (Klein, 1974) as a measure of the discrepancies between the actual and computed prices. The MAPE is defined as

$$MAPE = \frac{1}{N} \sum_{N=1}^{N} \frac{| P_i - P_i^* |}{P_i} \times 100 \qquad (4.3)$$

where P_i and P_i^* represent actual and computed prices respectively, and N is the number of simulation periods. In this context, the MAPE is interpreted as a measure of the degree of price distortion and inefficiency due to the lower incentive to workers in the non-agricultural sectors of the economy.

Figures 4.1 through 4.5 show that when a reform measure similar to that in the agricultural sector is introduced into the industrial, construction, transportation and commercial sectors, or more specifically, the bonus ratio in these sectors is set equal to unity, the computed prices of the agricultural and construction sectors are higher than the

[1] The NAGLIB is an English version of MINIPAC developed by Docanunt Argonne National Labs. See C05NBF-NAG Fortran Library Routine (1983). pp 1-5.

Table 4.3
Actual and Computed Relative Prices by Sectors

Year	Agriculture		Industry		Construction		Transportation		Commerce	
	Actual	Computed	Actual	Computed	Actual	Computed	Actual	Computed	Actual	Computed
1976	0.3176	0.3284	0.1337	0.1302	0.1790	0.1860	0.1520	0.1463	0.2178	0.2133
1977	0.3104	0.3258	0.1315	0.1295	0.1795	0.1807	0.1527	0.1481	0.2209	0.2149
1978	0.3192	0.3326	0.1296	0.1275	0.1793	0.1804	0.1501	0.1456	0.2186	0.2139
1979	0.3629	0.3791	0.1217	0.1152	0.1706	0.1813	0.1387	0.1292	0.2061	0.1952
1980	0.3729	0.3886	0.1175	0.1125	0.1672	0.1740	0.1330	0.1252	0.2095	0.1997
1981	0.3825	0.3973	0.1140	0.1109	0.1669	0.1685	0.1289	0.1232	0.2078	0.2000
1982	0.3842	0.3991	0.1119	0.1088	0.1689	0.1707	0.1267	0.1210	0.2083	0.2004
1983	0.3904	0.4055	0.1088	0.1055	0.1718	0.1740	0.1233	0 117[illegible]	0.2058	0.1977
1984	0.3878	0.4011	0.1047	0.1016	0.1735	0.1755	0.1320	0.1260	0.2021	0.1941
1985	0.3851	0.3985	0.1073	0.1026	0.1720	0.1737	0.1336	0.1274	0.2054	0.1959
1986	0.3878	0.4001	0.1048	0.1015	0.1729	0.1758	0.1322	0.1258	0.2012	0.1968
1987	0.3883	0.4006	0.1083	0.1014	0.1727	0.1759	0.1320	0 1254	0.2026	0.1966
Mean	0.3658	0.3788	0.1161	0.1123	0.1729	0.1760	0.1363	0 1301	0.2088	0.2031
SD	0.0312	0.0310	0.0106	0.0111	0.0044	0.0043	0.0100	0.0105	0.0067	0.0086
CV	0.0022	0.0022	0.0912	0.0985	0.0003	0.0003	0.0007	0 0803	0.0321	0.0425
MAPE	1.68		2.02		3.24		2.07		2.14	

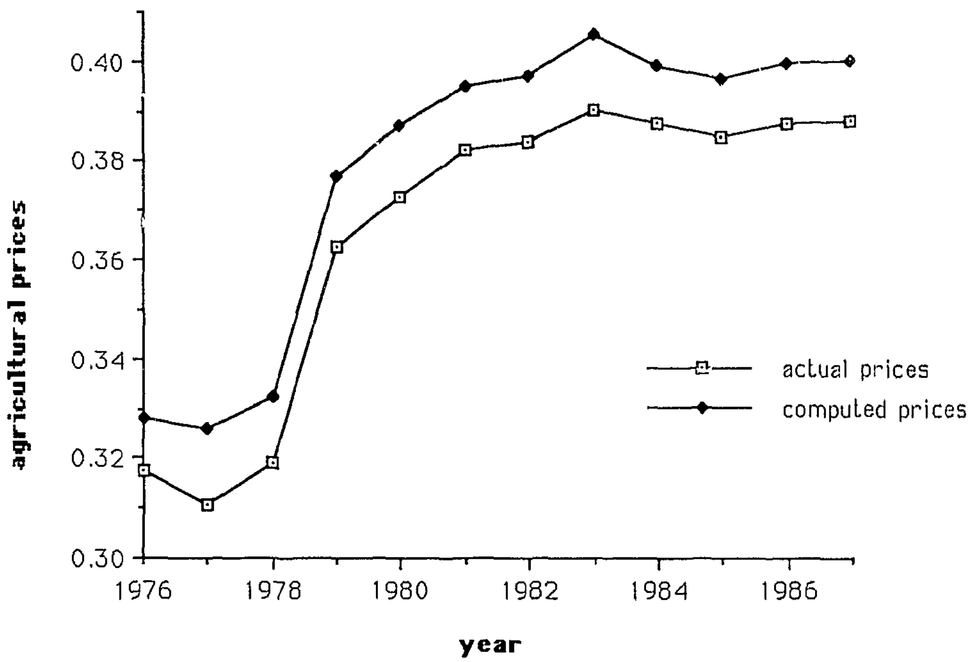

Figure 4.1 Comparison between the actual and computed agricultural prices

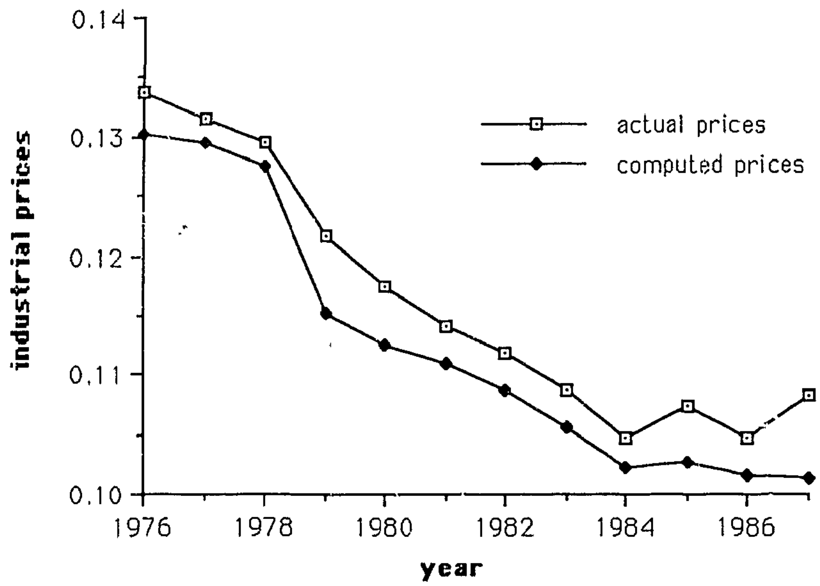

Figure 4.2 Comparison between the actual and computed industrial prices

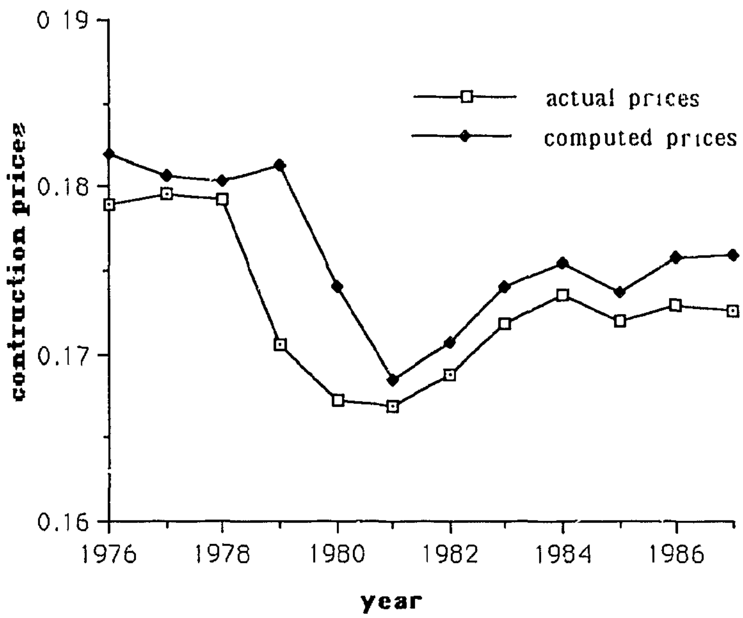

Figure 4.3 Comparison between the actual and computed construction prices

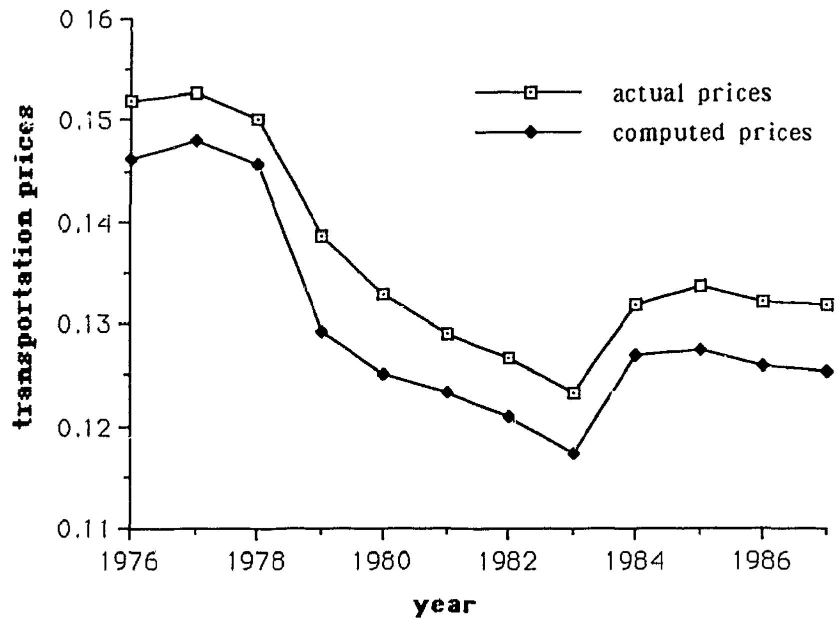

Figure 4.4 Comparison between the actual and computed transportation prices

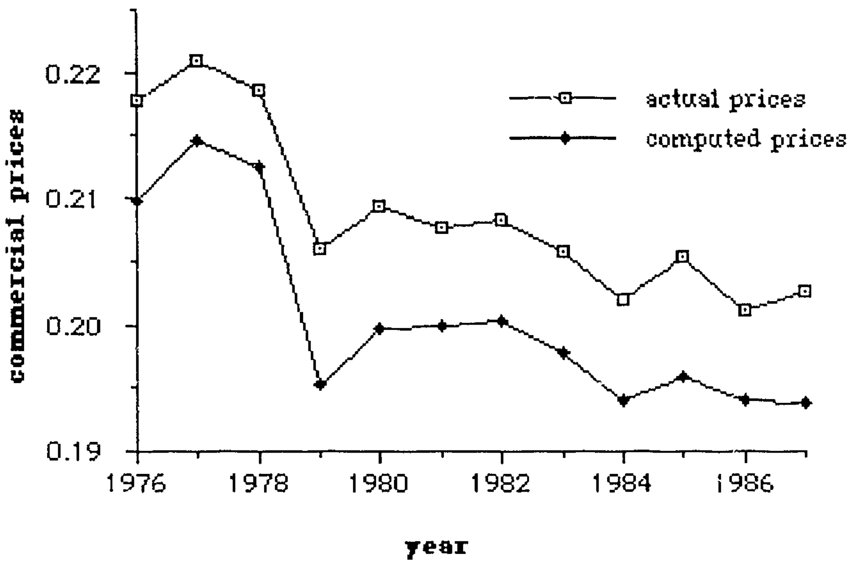

Figure 4.5 Comparison between the actual and computed commercial prices

actual prices, while the computed prices of the industrial, transportation and commercial sectors are lower than the actual prices.

The computed descriptive statistics reported in Table 4.3 show that in the agricultural sector, the mean of the computed prices is 0.3788 which is greater than that of the actual prices, 0.3658. The greater value of the mean for the computed prices indicates that they are higher than the actual prices. The standard deviation of the actual prices is 0.0312 which is very close to that of the computed prices 0.0310. The coefficient of variation of the actual prices is exactly equal to that of the computed prices. They are equal to 0.0022. The value of MAPE is 1.68.

The mean of the computed industrial prices is 0.1123 which is smaller than that of the actual prices, 0.1161, indicating that the actual prices are higher than the computed prices. The standard deviations of the actual and computed prices are equal to 0.0106 and 0.0111 respectively. The coefficient of variation of the actual prices is equal to 0.0912 and is equal to 0.0985 for the computed prices. The value of MAPE is 2.02.

In the construction sector, the mean of the computed prices is 0.1760 which is greater than that of the actual prices, 0.1729, implying that the computed prices are higher than the actual prices. The standard deviation of the actual prices is 0.0044 which is very close to that of the computed prices, 0.0043. The coefficient of variation of the actual prices is exactly equal to that of the computed prices, both being 0.0003. The value of MAPE is 3.24.

The mean of the computed transportation prices is 0.1363 which is greater than that of actual prices 0.1301, indicating that the computed prices are lower than the actual prices. The standard deviation of the actual prices is equal to 0.0100 which is slightly smaller than that of the computed prices, 0.0105. The coefficient of variation of the actual prices is 0.0007 which is significantly smaller than that of the computed prices, 0.0803. The value of MAPE is equal to 2.07.

The mean of the computed prices of the commercial sector is equal to 0.2031 which is smaller than that of the actual prices, 0.2088. The greater value of the mean of the actual prices indicates that they are higher than the computed prices. The standard deviations of the actual and computed prices are equal to 0.0067 and 0.0086 respectively. The coefficient of variation of the actual prices is equal to 0.0321, and is equal to 0.0425 for the computed prices. The value of MAPE is 2.14.

The computed descriptive statistics in Table 4.3 and the graphic results in Figures 4.1 through 4.5 show that the computed equilibrium prices of the agricultural and construction sectors are higher than the actual prices, while the computed equilibrium prices of the industrial, transportation and commercial sectors are lower than the actual prices. The variations of relative prices reflect the changes in demand and supply in the system in response to the increase in incentives to workers in the non-agricultural sectors. Given the initial increases in supply at existing prices for each of the four non-agricultural sectors due to the increase in the bonus ratio as shown in Table 4.1, we expect a decline in prices in these sectors because of the downward pressure from excess supply. In particular, the sector with a smaller bonus ratio, and therefore, a greater discrepancy of $A_1^* - A_1$ is expected to experience a greater decrease in price, while the sector with a greater bonus ratio, therefore the smaller discrepancy of $A_1^* - A_1$ is expected to have a smaller decrease in the price. Furthermore, to satisfy the price normalization rule, the price adjustment system allows decreases in some prices contemporaneous with increases in others, so that the sum of all relative prices is equal to unity. The results of the final experiment show the decreases in the prices of outputs produced by industrial, transportation and commercial sectors which are associated with the greater discrepancies of $A_1^* - A_1$, and the increases in the prices of the agricultural and construction sectors which are associated with zero and smaller discrepancies of $A_1^* - A_1$.

The results of the experiment also suggest some interesting economic implications. The discrepancies between the actual and computed prices indicate the degree of price distortion and inefficiency of production under the original level of the worker's marginal utility of effort. If we sum up the values of MAPE of all five sectors, we obtain the total value of MAPE of the economy which is equal to 11.5 percent. This figure tells us that if the workers in the industrial, construction, transportation and commercial sectors are given the incentive of a bonus ratio equal to unity, one may correct the price distortion and inefficiency of production due to the lower level of the marginal utility of effort by 11.5 percent.

Comparing the value of MAPE for each sector reported in Table 4.3, we see that the value of MAPE of the agricultural sector is smaller than those of the other non-agricultural sectors. The value of MAPE for the agricultural sector is equal to 1.68, while the values of MAPE for the industrial, construction, transportation and commercial sectors are equal to 2.02, 3.24, 2.07 and 2.14 respectively. The smaller value of MAPE for the agricultural sector implies that the difference between the original and the new equilibrium quantity of output is relatively small. In fact, since the bonus ratio of the agricultural sector is already unity, the computed supply at the existing price is equal to the actual level of supply. Such equality of actual and computed supply provides evidence of the greater emphasis placed on the agricultural sector than on the non-agricultural sectors by the economic reforms. The discrepancies between the actual and computed agricultural prices are the results of changes in the structure of outputs in the non-agricultural sectors in response to the increase in the bonus ratio. They are a spillover effect from the price distortion and inefficiency in the other non-agricultural sectors.

The discrepancies between the actual and computed prices in the agricultural sector also suggest that given the economic linkages among sectors, a more comprehensive reform package is required because of the need to change the structure of output. To facilitate such structural changes, economic reforms in any sector must keep the same pace with reforms in other sectors, otherwise sectors in which no deep reforms have taken place will become a burden to sectors in which reforms have been undertaken. A comprehensive reform package helps ensure that the costs and benefits of economic transformation are broadly shared among the sectors.

4.3 Simulation experiment: outputs

Once the equilibrium relative prices for each sector are determined, sectoral equilibrium output at $\beta_i = 1$, i=2,...,5 can easily be derived by assigning the equilibrium price to the supply function for each sector. More specifically, we assign the computed equilibrium prices reported at Table 4.3 to the corresponding supply functions (2.15) and (2.23). The computed equilibrium output and actual output by sectors are displayed in Table 4.4.

The computed descriptive statistics show that in the agricultural sector the mean of the computed equilibrium output is 86.0278 which is slightly greater than that of the actual output 86.0225. The standard deviation of the actual output and of the computed output are equal to 9.8463 and 9.8458 respectively. The coefficient of variation of the actual output is equal to 0.11446, and is equal to 0.0234 for the computed output. The value of MAPE is 0.0063516.

The computed industrial output in each year is smaller than the actual output in the corresponding year. This is reflected in the mean of the computed equilibrium output for the industrial sector which is 906.4344 being smaller than that of the actual output, 906.4395. The standard deviations of the actual and computed output are equal to 438.3362 and 438.3352 respectively. The coefficient of variation of the actual output is equal to 0.48358, and is equal to 0.483582 for the computed output. The value of MAPE is

Table 4.4

Actual and Computed equilibrium output by Sectors (100 million Yuan)

Year	Agriculture		Industry		Construction		Transportation		Commerce		Total Output		Computed output -
	Actual	Computed	Actual	Computed	Actual	Computed	Actual	Computed	Actual	Computed	Actual	Computed	Actual Outputs
1976	74.2449	74.2498	411.9113	411.9072	44.7450	44.7497	20.8471	20.8448	29.0301	29.0274	580.7784	580.7789	0.00050174
1977	75.9679	75.9750	456.5572	456.5548	46.8027	46.8065	21.7948	21.7939	29.5045	29.5009	630.6271	630.6311	0.00395454
1978	77.2589	77.2649	492.8466	492.8441	56.7663	56.7700	23.5242	23.5233	31.0520	31.0492	681.4480	681.4516	0.00357409
1979	78.1159	78.1217	556.3967	556.3884	62.8425	62.8510	25.6109	25.6024	33.2773	33.2716	756.2352	756.2433	0.00814460
1980	81.5805	81.5863	699.8036	699.7971	73.1481	73.1553	29.8574	29.8519	35.0835	35.0781	919.4686	919.4731	0.00445240
1981	82.2223	82.2273	745.5902	745.5861	69.1239	69.1293	30.4480	30.4467	34.9389	34.9353	962.3233	962.3247	0.00135539
1982	83.6111	83.6162	807.3392	807.3350	81.9831	81.9886	32.1369	32.1354	35.5859	35.5820	1040.656	1040.657	0.00108933
1983	86.1967	86.2025	915.3293	915.3249	90.5901	90.5959	35.7549	35.7531	37.8747	37.8695	1165.746	1165.746	0.00034025
1984	92.9765	92.9810	1184.912	1184.909	102.731	102.736	41.1825	41.1809	45.2391	45.2350	1467.041	1467.041	0.00005541
1985	97.7793	97.7838	1414.990	1414.983	104.835	104.841	50.0454	50.0440	51.7694	51.7644	1719.417	1719.419	0.00264790
1986	100.026	100.031	1532.912	1532.907	113.317	113.323	54.6449	54.6426	55.0160	55.0131	1855.916	1855.917	0.00087463
1987	102.29	102.295	1658.686	1658.676	121.561	121.567	59.5892	59.5866	58.4133	58.4094	2000.534	2000.540	0.00517540
Mean	86.0225	86.0278	906.4395	906.4344	80.7038	80.7094	35.4530	35.4505	39.7321	39.7280	1148.350	1148.351	0.0007229
SD	9.8463	9.8458	438.3362	438.3352	25.9814	25.9817	13.1534	13.1538	10.2655	10.2654	496.8420	496.8409	0.0036464
CV	0.11446	0.11444	0.483580	0.483582	0.32193	0.32191	0.37101	0.37105	0.25837	0.25839	0.432657	0.432656	5.0439872
MAPE	0.0063516		0.00063664		0.0074788		0.00829263		0.01071648		0.000034196		

0.00063664.

In the construction sector, the computed output in each year is greater than the actual output in the corresponding year. This is reflected in the mean of the computed equilibrium output which is 80.7094 being greater than that of the actual output, 80.7038. The standard deviations of the actual and computed output are very close to each other, being 25.9814 and 25.9817 respectively. The coefficient of variation of the actual output is 0.32193 and is equal to 0.32191 for the computed output. The value of MAPE is 0.0074788.

The computed transportation output in each year is smaller than the actual output in the corresponding year. This is reflected in the mean of the computed equilibrium output which is 35.4505 being smaller than that of the actual output, 35.4530. The standard deviations of the actual output and computed output are equal to 13.1534 and 13.1538 respectively. The coefficient of variation of the actual output is 0.37101, and is equal to 0.37105 for the computed output. The value of MAPE is 0.00829263.

In the commercial sector, the computed output in each year is smaller than the actual output in the corresponding year. This is reflected in the mean of the computed equilibrium output which is equal to 39.7280 being smaller than that of the actual output, 39.7321. The standard deviation of the actual output is 10.2655 and is equal to 10.2654 for the computed output. The coefficients of variation of the actual and computed output are equal to 0.25837 and 0.25839 respectively. The value of MAPE is equal to 0.01071648.

In the analysis of the directions and magnitudes of changes in the equilibrium outputs described above, it is necessary to focus not only on the sign and size of the relevant direct price elasticities of demand and supply, but also on the sign and size of the cross price elasticities of these same functions. With respect to the latter, a perusal of the estimated equations shows that, on the demand side, not all outputs are pairwise substitutes of each other. For instance, the demand function for the agriculture sector suggests a relation of complementarity with the industrial sector, a possibility that cannot be rejected out of hand, particularly when the statistical results appear to be significant. Note that the increase in the agricultural equilibrium output is not only caused by the increase in the relative agricultural price but also, due to the negative cross price elasticity of demand, by the fall in the relative price of the industrial sector. It has been suggested that, at the level of aggregation of a model like the one developed in this study, substitution effects may easily be lost (Mansur & Whalley, 1971). However, this phenomenon need not always be explained away by reference to the supposedly unsatisfactory nature of the aggregate data; it may well be the logical reflection of underlying structural, economic or technological relationships. There is no apriori reason why each pair of outputs should be substitutes for each other although, clearly, in a system with normalized relative prices, neither is it feasible for all outputs to be complementary. Of course, a detailed study of these possibilities would require access to and the investigation of, more disaggregate demand and supply data than that which is currently available to us.

The changes in the equilibrium output described above could be explained by the following demand and supply analysis. Let us first examine the supply side of the market. Given the structure of computed relative prices, we expect increases in supply of the agricultural, construction and transportation sectors and decreases in supply of the industrial and commercial sectors, as supply is directly associated with the level of prices. It should be noted that the decrease in the transportation price results in an increase in supply in the transportation sector because of the negative value-added elasticity of supply.

The impact of changes in relative prices on demand and eventually on equilibrium outputs can be seen in Table 4.5. In the agricultural sector, a decrease in the industrial price increases the demand for agricultural products, owing to the negative cross price elasticity of demand between the agricultural and industrial sectors. This increase in demand outweighs the decrease in demand caused by the increase in the agricultural price which is

Table 4.5 Price Elasticities of Demand and Supply

	Price Elasticities of Demand					Changes	Price Elasticities	Equilibrium
	Agriculture	Industry	Construction	Transportation	Commerce	in Demand	of Supply	Output
Agriculture	-0.1239	-0.6342				↑	0.1984	↑
Industry		-1.1911	-0.6165			↓	0.2675	↓
Construction		-0.9336	0.7798			↑	0.1966	↑
Transportation		0.6965		0.6325		↓	-0.1692	↓
Commerce				0.5896	-0.6342	↑	0.1705	↓

associated with the negative own price elasticity of demand. As a result, the increases in both demand and supply give rise to a higher level of equilibrium output at the higher agricultural price.

In the industrial sector, where the own price elasticity of demand is negative, a decrease in the industrial price increases demand for industrial output. This increase in demand, however, is offset by the increase in the agricultural price, which coupled with the negative cross price elasticity of demand between the agricultural and industrial sectors, results in a net decrease in demand for industrial output. With both supply and demand decreasing, equilibrium output for the industrial sector falls as the industrial price falls.

In the construction sector, the own price elasticity of demand is positive, whereas the cross price elasticity of demand between the construction and industrial sectors is negative. Hence both an increase in the construction price and a decrease in the industrial price will increase the demand for output of the construction sector. This increase in demand, coupled with the increase in supply due to the higher construction price gives rise to a higher level of equilibrium construction sector output at the higher construction price.

For the transportation sector, demand and supply move in opposite directions. Both the own price elasticity of demand in the transportation sector, and the cross price elasticity of demand between the transportation and industrial sectors are positive. Hence decreasing prices in both the transportation sector and the industrial sector will result in decreases in demand transportation sector output. As mentioned earlier, a decline in the transportation price will, owing to the negative value-added elasticity of supply for transportation output, actually increase supply in this sector. The decrease in the equilibrium output reflects the fact that the decrease in demand dominates the increase in supply.

A decline in the commercial price increases the demand for commercial output, due to the negative own price elasticity of demand in this sector. This increase in demand outweighs the decrease in demand which is caused by a fall in the transportation price operating through the positive cross price elasticity of demand between the commercial and transportation sectors. However, this net increase in demand is offset by the decrease in supply, so that equilibrium output declines.

Finally, we evaluate the efficiency gain of increasing incentives to workers in the non-agricultural sectors. First, we compute the descriptive statistics for the total actual and computed equilibrium outputs. The mean of the computed equilibrium outputs is equal to 1148.351 which is greater than that of the actual output, 1148.350, indicating that the total computed equilibrium outputs are greater than the actual outputs. The standard deviation of the actual outputs is 496.842, and is equal to 496.8409 for the computed outputs. The coefficients of variation of the actual and computed outputs are equal to 0.432657 and 0.432656 respectively. The value of MAPE is equal to 0.000034196.

The computed descriptive statistics tell us that with $\beta_i = 1$, i=2,...,5, the computed equilibrium outputs of the agricultural and construction sectors are greater than the actual outputs, while the computed outputs of the industrial, transportation and commercial sectors are lower than the actual outputs. The total computed equilibrium outputs increase by ¥72290, which is the efficiency gain that results when workers in the non-agricultural sectors are given greater incentives to work. It is true that the magnitude of this efficiency gain is relatively small. However, considering the fact that no reallocation of resources occurs in the experiment since the allocation of resources is assumed to be determined by the government, the magnitude of the efficiency gain provides a reasonable reflection of the improvements in economic performance which are induced purely by changes in workers' effort. In other words, if reallocation of resources were to be allowed, we would expect the efficiency gain to be much larger. Hence these results suggest that economic reforms, by introducing a reform measure similar to that currently in place in the agricultural sector into the non-agricultural sectors, will make a significant contribution to the improvement of productive efficiency in the Chinese economy.

The efficiency gain can be illustrated by Figure 4.6. Assume that there are only two goods in the economy: industrial products x_2 and construction products x_3. PP' is the production possibility frontier representing the maximum amount of any one good that can be produced in an economy given the output of the other good, the resource constraint and technology. A point such as A represents a combination of industrial and construction products which is produced at $0 < \beta_i < 1$, i=2, 3. When the bonus ratio in the industrial and construction sectors is increased to unity, workers in these two sectors are given greater incentives to work so that more output can be obtained from a given amount of labour and capital. The product combination of industrial and construction products shifts from the point A, which is associated with a lower level of marginal income of effort, to a point such as B on the production possibility frontier PP'. This increase in outputs means that previously unattainable combinations of well-being are now possible. The distance between the point A and the point B on the production possibility frontier PP' represents the efficiency gain made by the increase in labourers' effort. It should be noted that this efficiency gain is a result of the increase in incentives to the workers employed in the industrial and construction sectors. Reallocation of resources does not occur since the allocation of resources is assumed to be determined by the government.

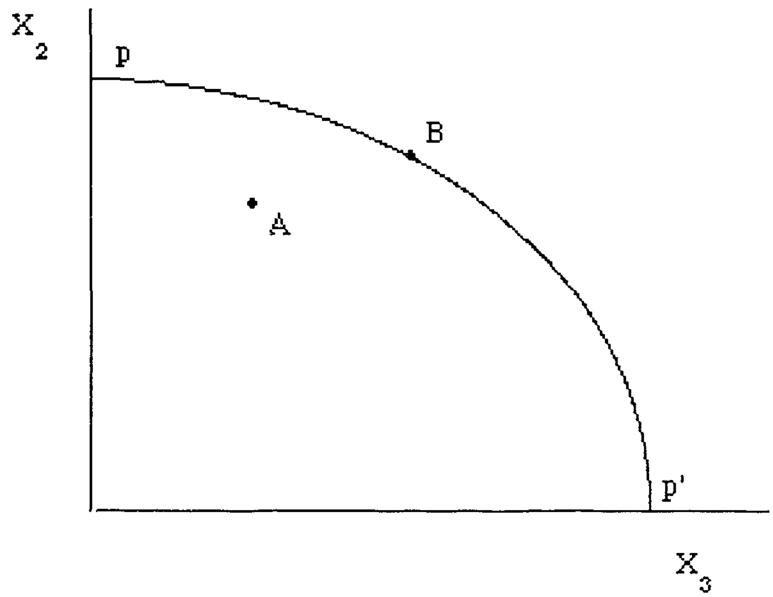

Figure 4.6 A Production Possibility Frontier

CHAPTER 5

Conclusion

In this study we constructed a CGE model for the Chinese economy which is used to examine the impacts of the economic reforms on the Chinese economy.

The economic reforms in China which have been undertaken since 1978 are mainly distinguished by two important reform programs: the contract responsibility system in the agricultural sector and the profit retention system in the industrial, construction, transportation and commercial sectors. Under the contract responsibility system, a typical household in the agricultural sector is allowed to organize resources at its disposable to produce the output required to meet its state contract quotas. Any surplus after meeting the contract quota could be sold on the free market. In the industrial, construction, transportation and commercial sectors, the profit retention system requires a business enterprises to hand over a certain percentage of profits to the state, and the remaining profits could be used to supplement wages in the form of bonuses and other welfare funds. These two reform programs have provided incentives to peasants and workers, thereby allowing them to augment their income by virtue of their superior performance. In addition, decentralization of decision-making led to an expansion of the market activities significantly. Thus, a dual price system has emerged wherein free market prices coexisted with the state controlled prices which are often lower. However, allocation of factors of production is still subject to tight control by the government. The CGE model of the Chinese economy constructed in this study was designed to capture the above institutional traits of the post-reform Chinese economy.

The model consists of five sectors, namely, agriculture, industry, construction, transportation and commerce. For the supply side of the market, the standard assumption that firms maximize profits is replaced by the assumption of utility-maximization by individual agents. More precisely, each labourer's utility is expressed as a function of income and effort. By utility maximization, the individual labourer determines his optimal income and effort level given the prices. Labourer's effort will be increased only if the marginal income of effort is positive. The individual labourer's supply of output is a result of applying his optimal effort level to the production process.

The demand side of the economy consists of four components, namely, consumption, investment, intermediate demand and net export. The behaviour of private demand for consumption goods is explained by a two stage optimization model. In the first stage, given the optimal effort, the typical household determines the optimal level of output he is willing to supply, which, in turn, determines his optimal level of income. Once the optimal income is determined, the consumer then arrives at the second stage of maximization, namely, optimal allocation of the expenditures over consumption goods produced by firms in different sectors. The household makes its choices in the system of dual markets in which the individual may buy a maximum of goods from state-operated stores at the official prices. However, if he wants to consume this goods in excess of that maximum, the additional quantity must be purchased on the free market at higher prices.

The sectoral supply and private consumption functions are estimated by using a simultaneous structural estimator like the two-stage least squares estimator (2SLS). Given the estimated supply and demand functions, the CGE model could be reduced to a set of excess demand equations along with a price normalization rule. The solution to the CGE model is reduced to a problem of finding a vector of equilibrium relative prices such that excess demand is equal to zero in each sector.

To examine the effects of the economic reforms introduced in China since 1978, the estimated structure of the CGE model of the Chinese economy is used to conduct a simulation experiment. This simulation experiment consists in computing a set of equilibrium relative prices and of equilibrium outputs assuming the bonus ratio to be unity in all four non-agricultural sectors and comparing these equilibrium prices and outputs with actual relative prices and outputs. The results of the simulation experiment show that when the bonus ratio setting equal to 1 in all four non-agricultural sectors of the economy, the computed equilibrium outputs of agricultural and construction sectors are greater than the actual outputs, while the computed outputs of the industrial, transportation and commercial sectors are lower than the actual outputs. The results of experiment show that the efficiency gain of allowing the bonus ratio to be unity is small. This is because no reallocation of resources is allowed in the the experiment. If reallocation of resources is allowed, the efficiency gain is expected to be much bigger.

The model's behaviour in the experiment is, basically, theoretically reasonable, and so are the empirical results. The model does indeed provide a valid laboratory for the experiment and yield useful insights into the responses of the economy to the potential reform measure. In developing the CGE model of the Chinese economy, some important implications of our study merit further discussion.

First, in specifying the supply behaviour of an typical labourer, the approach used in this study distinguishes our model from others in the way that some important institutional features of the post-reform Chinese economy are incorporated into the model through assuming dependency of output supplied on labourer's effort. It is assumed that a typical labourer is a utility-maximizer who receives utility from income and disutility from effort. Labourer's effort will be increased only if the marginal income of effort is positive. Supply is determined by applying an optimal effort level to the production process. Thus, changes in supply are the results of the changes in labourer's effort which are induced by changes in relative prices. It is the changes in labourer's effort, rather than reallocation of resources which features in most CGE applications, that play a leading role in determining interaction between demand and supply and the structure of outputs. Reallocation of resources does not occur because the allocation of production inputs are exogenously determined by the government. Hence, output supplied of each sector cannot be derived in the same manner as under the assumptions of profit-maximization or cost-minimization in the conventional microeconomic theory.

Second, in specifying the profit retention program, profit is assumed to be the short-run profit representing the difference between revenue and short-run variable cost which includes intermediate inputs and other operation costs. Capital investment is done by government and hence is external to the firm. Therefore, it is excluded from short-run cost calculation. As a result, "income of the firm" is more restricted than the usual concept of "profit of the firm". "Income maximizing" distinguishes from "profit maximizing" in the way that the firm chooses a production plan which maximizes its income, but that does not necessarily imply that the chosen production plan is also the profit maximizing one in the conventional microeconomic-theoretic sense.

Third, in estimating the supply function for the agricultural sector, we have successfully applied the Chow test to detect a structural shift around 1978 in which the economic reforms have been launched. The outcome of this test is important in the sense that rejection of the null hypothesis implies a significant impact of the economic reforms on the agricultural production in the post-reform period. However, structural shift also implies that the data covering the pre and post-reform period should not be pooled to estimate the supply function and that separate regressions are needed, one for the pre-reform periods and the other for the post-reform period. In the present study, we are precluded from taking this approach as the available number of observations in each sub-sample is small enough to make the parameter estimates less reliable, which is particularly true for the post-reform period. Instead, a time-varying parameter estimation approach is adopted, which specifies explicitly a more general model embodying parameter variability over time. This is achieved by using a recursive formula for least squares estimation with forgetting factors. This method traces the structural changes in the sector by using forgetting factors to gradually phase out the influence of old data, and put more weight on the more recent data. In estimating the supply functions for the industrial, construction, transportation and commercial sectors, no structural shift is detected during the period of our study. This implies that the economic reforms have not brought significant changes in terms of production and productivity in these sectors.

Fourth, in interpreting estimation results of private consumption demand functions, we notice that the substitution effect may be easily lost, particularly at the level of aggregation of a model like the one developed in this study. Price indices tend to move in the same direction following similar patterns, making substitution possibilities hard to detect from the data (Mansur & Whalley, 1971). However, this phenomenon need not always be explained away with reference to the supposedly unsatisfactory nature of the aggregate data; it may well be the logical reflection of underlying structural and technological relationships. There is no apriori reason why each pair of outputs should be substitutes of each other, it is neither possible that all outputs be complementary. The substitution effect may become more important if more disaggregate demand and supply data are used.

Fifth, the negative direct value-added elasticity of supply in the transportation sector and postive price elasticity of private consumption demand for construction and transportation products may suggest a strong interference by government and a less important role for market forces in these sectors. Of course, one cannot be sure that this is the correct explanation.

Finally, as already mentioned in the previous chapters, the computed efficiency gain due to the greater incentives to workers in the non-agricultural sectors is relatively small. The small magnitude of efficiency gain is explained by the fact that no reallocation of resources occurs in the experiment since the allocation of resources is assumed to be determined by the government. It is believed that the magnitude of the efficiency gain is reasonable in reflecting the improvements of economic performance which is simply induced by changes in workers' effort. In other words, if resources are allowed to be allocated freely among sectors, the efficiency gain is expected to be much larger. However, information about reallocation of resources is not available at the present stage of research.

What will the efficiency gain be, when resources are allowed to be freely allocated among sectors coupled with greater incentives to workers in the non-agricultural sectors, requires further exploration. This question is left for the next stage of research when the information about the allocation of resources becomes available.

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