EXTERNAL SHOCKS AND STRUCTURAL ADJUSTMENT IN THE POST-REFORM CHINESE ECONOMY — THE CASE OF THE 1986 OIL PRICE FALL

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SELECTED ABBREVIATIONS

Chinese Acronyms

CASS	Chinese Academy of Social Sciences
CESRRI	Chinese Economic System Reform Research Institute
IERI	Industrial Economics Research Institute
QATERI	Quantitative and Technological Economic Research Institute
Rmb	*Renminbi* (People's money), the name of the Chinese currency. The basic unit of *Renminbi* is "Yuan", equivalent to "dollar".

Energy Units

Bt	Billion tonne
GW	Gigawatts, equivalent to 1×10^6 kilowatts
Kwh	Kilowatt hour
Mt	Million tonne
Mtce	Million tonne coal equivalent
Tcm	Trillion cubic meters

Computing Glossary

GEMPACK	General equilibrium model package
CPU	Central processing unit
Mb	Megabytes
PC	Personal computer
RAM	Random access memory

ABSTRACT

This is a theoretical and empirical study of the structural adjustment to external shocks in the post-reform Chinese economy, focusing on the case of the 1986 oil price fall. Macroeconomic adjustment to the 1986 oil price shock was a crucial section in the path of China's economic development in the 1980s. Depending on how China was able to cope with the unfavourable external shocks, the transition of the economy under reforms could be imperiled or proceed as intended.

The significance of the 1986 oil price shock to China is highlighted in the beginning of the thesis. Oil exports are an important source of foreign exchange to China. In 1985, one quarter of China's total export revenues was generated by oil exports. The 60% fall of the world oil prices in 1986 caused substantial losses to the economy. More importantly, the shock arrived at a time when the economy was facing "structural contradiction" and "economic overheating". The shock reinforced both the structural and inflationary problems in the Chinese economy.

The adjustment is analysed in the theoretical framework of the booming sector model. The theory is applied to the case of a slump, in both real and monetary aspects. The study emphasises the institutional arrangements in the post-reform Chinese economy which alter the results of the standard theoretical model. The analysis shows that the 1986 oil price shock was transmitted to the Chinese economy mainly through a spending effect. The resource movement effect was small as the oil industry was an "enclave" under government protections.

The adjustment in the quantity-constrained Chinese economy was driven by government intervention. In an attempt to sterilise the effect of the slump, the government offset the spending effect through its fiscal deficit. But actions on other controlled variables, such as money supply and exchange rate depreciation

were inconsistent with the sterilisation policy. This made the adjustment more difficult.

To gain an understanding of the adjustment mechanisms in the Chinese model, the study moves to assess the effects of market oriented economic reforms on resource allocation in the Chinese economy, which cover not only the reforms' qualitative impact on economic agents, but also the quantitative significance of the markets. The results show that the evolution of the "two-tier price system" and the expanding role of markets in the allocation of resources greatly improved the flexibility of the economy.

Building on this foundation, a computable general equilibrium model is developed using a market price input-output table as the data base. The specifications of the model captures the "stylised facts" in the Chinese economy, and is specially adapted to reflect the booming sector phenomena considered in the study.

The model is used to provide some insights in the adjustment of the Chinese economy to the 1986 oil price shock. The results of the model are consistent with the booming sector theory. Policy responses are simulated which show that an appropriate combination of real absorption manipulation, exchange rate depreciation and a cut in money supply are the preferred policy options to achieve the structural adjustment in the Chinese economy after the 1986 oil price shock.

Research Declaration

This thesis contains no material which has been accepted for the award of any other degree in any University; to the best of my knowledge and belief, it contains no material previously published or written by another person except where due reference is made in the text.

Zhaoyang Peng

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Chapter 1

Introduction

This dissertation is a study of the adjustment in the Chinese economy following the 1986 oil price shock. When oil prices soared in the 1970s, China enjoyed buoyant oil export revenues. Oil exports became a powerful engine of growth for the Chinese economy following the two oil price hikes in 1973 and 1979. However, the 1986 oil price shock was different. The world oil market collapsed, and the price of oil crashed from about US$ 30 a barrel at the beginning of 1986 to less than US$ 10 by the middle of the year, a fall of over 60%. The implications of this unprecedented fall in the world oil price were significant for China.

Not only the magnitude of the loss in China's foreign exchange revenues was substantial, more importantly, the timing of this oil price shock was almost the worst possible for the Chinese economy. The external shock arrived at a time when the domestic economy was in deep trouble with its economic reforms. Toward the mid-1980s, the rapid microeconomic reforms in China encountered a lack of an appropriate institutional set-up for macroeconomic management. This combination of events led to a series of adverse effects on the Chinese economy, notably a "structural contradiction" and "economic overheating".

How can China facing such a "bad luck" respond quickly to the shock and what policies best facilitate structural adjustment? There is scope for research on the theory of adjustment in the Chinese situation. Existing theories cannot be applied in a simple-minded manner, since the starting point of adjustment was so different, and the economic institutional arrangements in the transitional period of the Chinese economy under reforms depart sharply from those in either market- or centrally planned economies.

1.1 Historical Context: The Chinese Economy Toward Mid-1980s

1.1.1 Success of rural reforms in early 1980s

The Chinese economy underwent great changes since 1978. Initiated in that year, China's economic reforms moved boldly from agriculture to urban industries. The previous centrally planned economy was decentralised as institutional arrangements were transformed in the economic system regarding planning, pricing, marketing of products, supply of raw materials, labour and wages, financial affairs, and taxation. The centrepiece of the effort was to simplify administration and to bring into play the market's role in resource allocation.

Starting with a program of "readjustment and reform",[1] the reforms at the early stage were intended to redress sectoral imbalances resulting from the Soviet-type heavy industry driven development model which dominated economic growth in the 30 years prior to the reforms. Throughout the 1950s to the 1970s, the lopsided administrative investments in the heavy industry were

[1]The readjustment policy was first mooted in the Third Plenary Session of the Eleventh Central Committee of the Communist Party of China (CCCPC) in December 1978. The general consensus of the meeting was to shift the emphasis of the Party's work towards socialist modernisation and construction, in contrast to the one in the past on politics and class struggle. The Fourth Plenum of the Eleventh CCCPC in September 1979 formally defined the new policy as "readjustment, reconstruction, consolidation, and improvement". The emphasis was mainly on economic readjustment, especially on the order and priority of investment in agriculture, light and heavy industries.

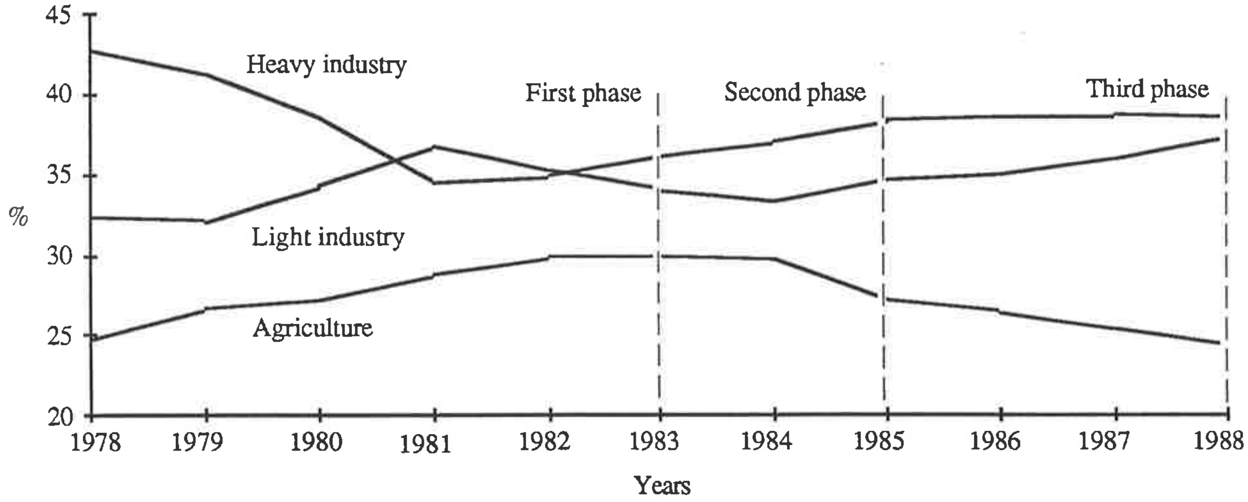
the main driving force leading to the the high concentration of resources in China's gigantic heavy industry sector. The agricultural sector and light industrial sector, which was based on agriculture, were severely underdeveloped due to the limited availability of resources. This irrational economic structure was rectified soon after the launch of economic reforms in 1979. In the first phase of reforms, which is usually referred to as the period from 1978 to 1983, economic growth was well balanced among sectors. As illustrated in Figure 1.1, the heavy industry's share in gross material product declined sharply from 43% in 1978 to less than 35% in 1981, and the shares for agriculture and light industry increased remarkably over the same period. Growth of agricultural production was particularly steady in the first phase of economic reforms. The growth in light industry increased from 1979 to 1981, but then began to decline. This trend was reversed when measures were taken to direct supplies to light industry in mid-1983.[2] The rebound of light industry at a later stage of economic reform will be discussed below.

The changing pattern of sectoral output in the first phase of economic reform indicates a great improvement of resource allocation in the Chinese economy as resources were shifted from the previously overemphasised heavy industry to underdeveloped agriculture and light industry. This is reflected in the healthy growth of China's GDP at a rate of 7.8% from 1978 to 1983, and with a surplus on the current account deficit of around US$ 5 billion, or 2% of GDP, in the early part of the 1980s (IMF, International Financial Statistics, 1989).

The structural adjustment which took place in the early stage of economic reform was directly related to the success of institutional reforms in the rural sector which gave a big boost to light industry through the provision of raw materials. From 1978 to 1983, China's economic reforms were focused on the rural sector. The decisive institutional reform in the rural sector was the new relationship between the planning authority and farm families. The way the

[2]The State Council reasserted the "six priorities" principle to divert supplies to the light industry sector (*Almanac of China's Economy*, 1984, p. IV-2)

Figure 1.1: Changes of Sectoral Shares in Gross Material Product China, 1978-1988



Source: State Statistical Bureau, Statistical Yearbook of China, Beijing, 1989.

rural sector is administered is no longer through a mandatory plan but through the "Production Responsibility System" in which necessary inputs – land, farm equipment, and machinery – are assigned to farm families and, in return, farm families deliver a fixed amount of their produce to the state as "rental". Any amount produced in excess of this fixed quantity belong to the farm families, to consume or to sell in the free market. Under this fixed rental charge scheme, farm families behave like a profit maximising enterprise in a competitive industry since a levy of a fixed value by government is a lump-sum tax. Since a lump-sum tax is a fixed cost which has no effect on marginal decisions, farm families employ inputs efficiently to the point where the value of the marginal product of each input equals its price, and produce at a point where price of the product equals its marginal cost so as to maximise profit. Farm families that for a long time sought mainly to fulfil production quotas began to react to a strong profit incentive. This led to the across-the-board increase in grain and cash crop production in the early 1980s, which secured the supply of raw materials to light industry, and helped to affect the structural shift.

1.1.2 Industrial enterprise reforms

The success of agricultural reform provided much of the momentum for industrial reform. Experiments with urban-industrial reform began in 1979 and continued throughout the early 1980s. But the political impact of the debate over "A Bird Cage Economy" [3] or a even more market-oriented reform slowed the urban reform. Early stage reforms in industrial enterprises were haphazard, often seemingly chaotic, and involved a great deal of local experimentation. Numerous methods and solutions were tried out in different places. Those that fit in well with the existing evolving system and did not generate strong opposition, survived and became part of the system, and others which did not fit in well or led to opposition disappeared. The pace of industrial reform in this process of "natural selection" was slow. In late 1984, the industrial reform once again accelerated and made great progress by drawing on the experience of agricultural reforms.

The reforms instituted in the industrial system were, first of all, a change in enterprises' objective function. As with farm families in rural sector, enterprises are also offered a strong profit incentive. They are allowed to retain a considerable percentage of their profits. Under this profit retention scheme, the primary target in the objective function of enterprises is no longer the fulfilment of quota but "improvement of efficiency and benefits", as suggested by a questionnaire survey (CESRRI, 1986). Enterprise managers are driven by a desire to increase benefits to employees through higher bonuses, better housing and more welfare expenditures. The way to achieve these objectives is to

[3]This was a conservative theory propounded by Chen Yun, then the Vice Chairman of the CCCPC (see footnote 1) and being responsible for economic and financial work. The essence of this theory is that the economic reform in industrial enterprises should only be carried out to the extent that enterprises are given some market power, but the power given must not be too big so that the state can still control the behaviour of enterprises, just like letting a bird fly but only within a cage.

increase profit. The pursuit of profit by enterprises makes enterprises behave in accordance with the rules of the market.

The profit retention scheme not only specifies a new distributional relation between the state and enterprises, but also brings about changes in the income distribution system within enterprises. In many aspects, the changes in the payroll system of China's industrial enterprises over the past ten years can be viewed as a gradual process of reform toward the income sharing system in the labour managed firms in the East European model of market socialism, where "workers do not receive a fixed wage in payment for a specific labour contract. Instead, they earn a share in the net income remaining to the firm after payment of all non-labour operating costs" (Tyson, 1979). In such an arrangement, the individual incomes of workers and managers are from the same source. They have a common interest in "making the cake bigger", and get a due share of it. Even though in some cases the difference in incomes between managers and workers still exist, this is restrained by the fact that managers will be replaced if they abuse their power in distributing income within the enterprise. Thus, income is shared in enterprises according to the effort of labour, and the objective of enterprises becomes to maximise profit per worker, which is the most significant change brought about by the profit retention scheme.

The change of enterprises' objective function is only meaningful if there is recognition of the role of the market mechanism in the allocation of industrial goods and corresponding reductions in the role of planning and administrative allocation. Under the rubric of "autonomy for industrial enterprises", the state mandatory plan receded in its influence on production, marketing, supply of raw materials and other major operations. Enterprises are now given some freedom in the acquisition of inputs and in personnel policy, they are allowed a certain discretion in their production decisions, and they take care of the marketing of products above quota. While certain key inputs are still governed by a central plan,[4] most enterprises require more inputs than are provided for in the plan. These additional inputs are purchased in newly created market, whereas in the pre-reform system these additional inputs were obtained either by going back to the planning authority for a supplementary allocation or by informal barter with other enterprises. Products produced and sold at the market increased considerably in recent years. A survey of 429 industrial enterprises shows that in 1984, output produced under mandatory plans only accounted for 26% of the total, while output under guidance plans[5] made up 27%, for a total of 53%. As for marketing, enterprises distributed 33% of their output themselves. Regarding supply of raw and semi-finished materials, the share acquired through inter-enterprise exchange and cooperative deals, or purchased on the market increased from 16% to 44% from the end of 1984 to mid-1985 (CESRRI, 1986).

With the reform of the planning system and the expansion of the enterprises' decision making power, there was a breakthrough of price reform in 1985-1986. When and how to introduce price changes and according to what criteria were the questions confronting the Chinese reformers from the very beginning of economic reform. The steps taken in the first phase of reform were hesitant with price changes mainly in agricultural goods. Only few price drifts happened in the industrial sector.[6] The price of most industrial products remained frozen.

In January, 1985, the State Price Bureau and the State Materials Bureau jointly issued the "Regulations on Above-Quota Prices of Enterprises' Self-

[4]In 1979, there were 837 kinds of production materials controlled either by the state or governmental departments. The number was reduced to 24 under the state's direct control. However, various departments still hold over 500.

[5]In contrast to the mandatory plan which specifies production quota in quantities, the guidance plan usually refers to a production plan where the production quota is specified in value terms. Enterprises have the freedom of choosing the mix of products.

[6]From 1979 to early 1980s, price adjustments in the industrial sector only took place for coal, iron ore and steel(prices for these products increased approximately 30% to 20% during this period) There were also small decreases in prices (about 5%) for electronic goods and machinery products for agricultural usage. The average price level for textile products remained roughly the same as price increase for cotton textiles was offset by the price decrease of chemical fibre textiles.

Marketing Production Materials", which formally allowed enterprises to sell the above-quota output at prices set by themselves. Therefore, for one product, there were two prices. One was the under-quota price set by the state plan the other was above-quota price set by enterprises. For output over and above the state plan, enterprises' operations in production, marketing and input acquisition are inevitably regulated by market prices that reflect changes in supply and demand. Thus a two-tier price system was established and was practically extended to all industries.

The industrial reforms brought the forces of the market into play to a significant extent and changed the mechanisms of resource allocation in the industrial sector. The enhanced role of profits introduced by the profit sharing scheme led to a greater role for prices as government put reliance on profits as an indicator of enterprises' performance, and substantially reduced administrative interference in enterprises' decision making. Enterprises enjoying certain autonomy in production became very responsive to market demand. In responding to an acute demand for consumer goods following the rise of income of farmers and urban workers, resources flowed into light industry, and the volume and variety of consumer goods in the market increased rapidly. Consequently, rationing schemes in the form of purchase coupons were gradually abolished.

However, new structural contradictions emerged not long after the battlefield of reforms was shifted to the urban sector which involved a greater deal of complexity than rural reforms. The economy started to run out of control from the mid-1980s. In 1985 and 1988, two "economic overheating" periods occurred, which marked the second and third phases in China's economic reforms (Figure 1.1). While the symptoms of the two overheating periods were quite different, the causes of the two economic overheating periods were similar (Nugyen and Peng, 1989), namely, a persistent excess demand, which was closely related to the new structural contradiction.

1.1.3 Structural contradiction and economic overheating

As the economic reform proceeded, the inherent shortcomings of the institutional reforms in urban sector started to have an effect. Following the process of decentralising economic decision making away from central planning and towards provincial governments and enterprises, local governments and enterprises gained increasing autonomy in resource allocation. Data show that mandatory investments carried out through the state budgetary allocation decreased dramatically from as high as 80% in national total investments in 1978 to a merely 16% in 1985 (Statistical Yearbook of China, 1988, p. 559). A majority of the nation's total investments were handled by local governments and enterprises in response to market forces. However, the system gradually degenerated into an unwieldy mass characterised by fragmented control over resources.

Under the new institutional arrangements introduced in the industrial reforms, the response of supply to demand was realised through a joint reaction of enterprises and the local governments. Especially in matters involving new investments, the local governments acted as investors or decision-making authorities. The administrative intervention basically became more decentralised. The local governments' interest in local benefit such as seeking self-contained industries, more employment and higher income within their own administrative areas etc. made it very difficult for factors of production to pass the barriers between regions, and resulted in extremely scattered investments.

The scattered investments, however, were very responsive to market signals. Following the rapid increase of real income for farmers and urban workers, the social purchasing power in China grew by 17.24% annually between 1978 and 1985. This exerted a strong pull in the market. After long years of income stagnation and shortage of market supply, the latent, pent-up demand stimulated a rapid growth of the production of consumer goods. Combined with the reasserted priority by the state to increase supplies to light industry, the capacity of light industry grew at an unprecedented pace as all the scattered investment funds flooded into industries producing consumer goods, and caused a rapid growth of production capacity as well as overlapping investment and strong competition. For example, in 1984, among the 29 provincial-level administrative regions (Taiwan not included), 27 of them produced televisions, 28 of them produced washing machines (CESRRI, 1987).

The above examples also reveals a strong trend of emulation among local governments. Due to the similarity of behaviour of the local governments at the same administrative levels, similar problems emerged in the deployment of production resources in different localities. The introduction of strategy by one locality was quickly emulated by others leading to rapid proliferation of the same production capacity throughout the country. "I must have what you have" represents the trend in the geographic distribution of industries. It even imposed a similar pattern of industrial structure on each of the different localities (Zhang Amei, 1987). Such a horizontal expansion also induced a ratchet effect as local governments tended to adopt protective measures for enterprises within their jurisdictions, and the budgetary constraint by which enterprises were committed to their superior authorities remained soft. Enterprises had no fears of bankruptcy, and production capacities subordinate to different administrative zones would not lend themselves to merging. Therefore, there was no elimination, merging or integration as a result of competition. The lack of scope for regrouping and eliminating enterprises accentuated the problem of surplus production capacity. As a result, the over-expansion of industries producing consumer goods led to excessive capacity in light industry. In 1985, for example, the utilisation rate of production capacities in China for TV sets and washing machines was less than 70% (CESRRI, 1987).

The rapid expansion of the whole spectrum of consumer goods producing industries in the down-stream of the Chinese industry generated correspondingly strong demand for products from the upper stream in the Chinese industry which includes the processing and assembling sectors (middle-stream) and the energy and raw materials sectors (up-stream) in heavy industry. However, the rapid growth of the consumer industries failed to stimulate the utilisation of existing surpluses of production capacities of heavy industry. Still using the example of TV production, China's output of TV sets in the mid-1980s ranked the top in the world in terms of absolute quantity. However, a major part of that production capacity was realised by importing assembly lines, for which main components and parts up to raw materials and technical equipments could not be sourced domestically. In 1985, China produced 16.68 million TV sets, but the domestic supply of a key part for TV sets, the kinescope, was only 8.23 million, and the rest of the supply came from abroad. While the technological gap partly explained the import of industrial manufactures, it would not be too difficult to close the gap given the technological capacity demonstrated by China's machine building sector in the relatively well developed heavy industry. The fundamental problem was that the extremely rapid expansion of down-stream industries pre-empted the attempt to renovate and upgrade the existing domestic production facilities in the middle-stream industries. The rising market demand for consumer goods encouraged producers to divert demand directly to foreign sources of supply. They did not have the patience to wait for readjustment of the domestic supply structure. The middle-stream industries were bypassed. As a result, part of the middle-stream industry facilities became idle, which led to another problem of excess production capacities. For example, the utilisation rate of metal-cutting machine tools in the machine-building industry was only 50.3% in 1985 when production was actually peaking (CESRRI, 1987).

Parallel to the phenomenon of surplus capacity in the middle- and down-stream industries was the shortage of energy and raw material supply, with the shortage became increasingly acute as the down-stream industries expanded. This can be attributed to the fact that local governments' funds and extra-budgetary investment funds were concentrated in the down-stream industries as discussed above, and the fact that the economic reforms failed to direct the scattered extra-budgetary investment funds flow into the up-stream industries. The investment in up-stream industries involves larger scale, longer cycle and greater risk. These technological characteristics, especially their capital intensities, imposed restrictions on up-stream industrial investment. In the lack of factor markets, particularly a capital market, there were obstacles to allocating resources to up-stream industries

The industrial reforms in China made substantial progress in product markets liberalisation. Factor markets, however, have not been opened to a significant degree.[7] This can impede rational resource movement from sectors with surplus factors to sectors short of factors in response to changes in market supply and demand conditions.[8] This is particularly relevant to up-stream industries such as energy, metallurgy and other raw material industries. Despite the signals send out by high product prices, the supply of these products remained short in the absence of a mechanism (e.g., capital market) to pool together the scattered factors (e.g., capital funds) to invest in the up-stream industries. Apparently, investments were tilted away from up-stream industries and fed the rapid expansion of production capacity in the down-stream industries. At the same time, they created a demand for energy and raw material

[7]The labour market has made some progress with increased employment of contract workers and casual labourers in state-owned enterprises. Labour in many of the urban collective and individual service sectors is able to move from job to job. The emergence of auxiliary enterprises such as labour service companies also brings about a certain degree of manoeuvrability in the increase or reduction of the payroll and in the use of the labour force. But, regular employment (in contrast to contract and casual employment or any other kind of temporary employment) in state enterprises is still permanent and allocated by administrative rather by market rules.

[8]It is believed that China could still achieve most of the efficiency gains of a market economy with immobile factors as from an analogy with the Heckscher-Ohlin theorem concerning the gains from international trade (Lal, 1988). However, the standard trade theory is applied in this case in a model where other markets – apart from the factor markets – are fully liberalised and enterprises can choose their output mix. Under common commodity prices, relative factor prices in different industries will be equalised through production diversifications and goods trade. While this is a very useful insight in sequencing the economic reform in China implying that factor market liberalisation can lag behind product market liberalisation, the impact of asymmetric market liberalisations on the economic structure in the 1980s presented an obstacle for the reform process.

supplies that was far greater than the up-stream industry could cope with, thus exacerbating supply scarcity in raw materials.

The two opposite trends of investment in China's up- and down-stream industries put enormous pressure on the Chinese economy, particular on the raw materials sector. However, the hunger for investment in the down-stream industries in causing the structural contradiction should not be overemphasised without mentioning the role the macroeconomic management played in the entire process. Since into the mid-1980s, the monetary control failed to exercise proper restraint in money and credit growth, particularly in lending to enterprises.

As discussed above, 80% of China's total investment was planned by the central government before the economic reform took place in 1978, investment funds were allocated free of charge to local governments and enterprises to carry out the government's investment plan. This mandatory investment system was abolished following the economic reforms. The government transferred the investment responsibility to enterprises who, at the same time, received no more funds free of charge, but to borrow from banks with interest rate charges. The process of converting investment funding from government finance to bank lending was gradually completed in 1985. The mismanagement of the banking sector during this conversion process caused an uncontrolled increase in bank lending to enterprises, which accommodated the hunger of the down-stream industry.

The network of the banking system in China starts with the head offices of various banks[9] located in Beijing and the branches of these banks spread in each province and special city. The management of this network is an ambiguous two-tier system. All bank branches are supervised from both their respective head offices in Beijing and the provincial or special city governments. At the time of mid-1980s, bank branches were probably influenced more strongly by

[9]They include the People's Bank of China, the China Industrial and Commercial Bank, the China People's Bank of Construction, and the China People's Insurance Companies.

their local bosses. The reform of the banking sector lagged the industrial reform. China's various banks and their provincial branches toward mid-1980s bore little resemblance to industrial enterprises which enjoyed increasing autonomy. Most of the banks and branches were more a receipt and disbursement window of the central or local (provincial) government than an independent banking unit. Under the pressure of local governments, bank branches' lending to enterprises expanded rapidly in the face of strong investment demand from down-stream industries. The head offices lost control of this reckless expansion of banking lending (Komiya, 1989).

The difficulty of controlling credit was also reflected in the fact that interest rates were relatively inflexible in China. The rigidity of interest rates was a problem as interest rates in China were generally below the rate of inflation. For example, the rate on bank loans replacing the formerly interest-free investment funds allocated in government's budget was set at a maximum of 3.6% from 1978 to 1984, and readjusted to 4.2% in 1985, but the inflation rate rose from 6% to 18.5% over the same period.

The rapid growth of money and credit, combined with the increase of real income for farmers and workers, led to a complication of both structural contradiction and an excess demand or economic overheating, in the Chinese economy, toward mid-1980s, which found an outlet in inflation and an external deficit.

1.2 The Approach of This Study

The story outlined above is that the Chinese economy was confronting two major interrelated problems in the mid-1980s, namely, structural contradiction and economic overheating. Against this background, the arrival of the 1986 oil price shock hit the Chinese economy hard. Firstly, the crash of the oil export price brought a sudden slump to the energy sector, possibly exaggerating the structural contradiction which was characterised by short supply of energy and raw materials. Secondly, the shock could have increased the current account deficit that emerged in the economic overheating period, and added to inflation. But the extent of these effects depend on how the deficit created by the oil price shock was financed. If the oil export revenues were not handled solely by the central government, and were not deposited in the central bank (People's Bank of China), the money base would actually be reduced following the decrease of foreign exchange as a result of the shock. Changes of institutional arrangements (including financial relations) between the energy sector and the central government during the economic reforms are vital in determining how the effect of the external shock was transmitted from the energy sector to the rest of the economy.

The analytical approach used in this study is to start with the energy sector which bore the brunt of the 1986 oil price shock and initiated complex intersectoral repercussions in the Chinese economy. The approach follows the "booming sector" model framework (Corden, 1984; Neary and Wijnbergen 1986), where one sector booms and initiates a chain of intersectoral reactions that actually retard the growth in other parts of the economy. This asymmetric sectoral growth analysis is reversed to an application in which one sector suddenly *declines* such as the energy sector of the Chinese economy in the 1986 oil price shock. Given the broad background of China's economic reforms in the analysis of the adjustment in the 1986 oil price shock, this approach is an useful way to narrow down the topic to a manageable scope, and to capture the essential issues of adjustment in the 1986 oil price shock.

The fact that energy is a bottleneck in China's economic development dated back in early 1970s. Although China has a vast land with substantial energy endowment (Dorian and Clark, 1987), the energy resource development is far behind the energy requirements of a population over 1 billion. By late 1970s, China became the world's third largest producer and consumer of commercial energy (behind the USA and USSR). However, the large population shrinks this absolute accomplishment to a very modest relative figure.[10] The economic reforms in the 1980s offered little hope to eliminating the chronic problem of energy shortages plaguing the Chinese economy. On the contrary, the reforms aggravated the gap between energy supply and demand. As mentioned above, the decentralisation of investment system tilted away investment from up-stream industries. Although the state planned investments were compelled to move upstream under the pressure of supply shortages of energy and other raw materials, for example, the state's investments in the four major up-stream industries (coal, petroleum, electricity and metallurgical industries) increased from 65.5% in its total industrial investment in 1981 to 70.4% in 1985, investments in the energy sector still declined in China's total investment due to the diminished share of state budget investment in the total investment. To compare the 5th Five-Year-Plan (1976-1980) with the 6th Five-Year-Plan (1981-1985), the share of energy investment in total national investment decreased from 20.9% to 20.4% (State Statistical Bureau, 1989).

The relative slow-down of China's energy development is, however, contrasted with an increased demand. Following the economic reforms, industrial output increased dramatically. As an important input, the demand for energy rose proportionately, and the perception of shortage increased. New rural industrial enterprises who enjoyed more autonomy than the state-owned enterprises, but operated at smaller scale and very often used inefficient technology, competed for limited energy supplies, intensified the impact of existing shortages.

It was estimated by the Chinese Energy Research Association in 1986 that, in the production sector, the inadequate electricity supply caused about 20-30% of the industrial facilities not utilised, and 40% of agricultural machinery to lie idle due to lack of fuel. In the residential sector, 30% of urban residents used wood and brushwood for fuel. In the countryside, about 40% of farmers were

[10]China had about 0.52 tonnes of oil equivalent energy consumption *per capita* in 1987 compared to 8.05 for the USA and 3.1 for Japan (Owen, 1988).

living in areas without any electricity supply. The grave shortage of fuel in the rural area was made up from traditional biomass sources and firewood. Even now, the central heating systems are still only installed in large cities in north China, and they are turned off in mid-March when the outside temperature is still negative.

The aggravated energy problem in the process of economic reforms makes the theoretical and empirical research on the adjustment issues of the 1986 oil price shock all the more important. Accordingly, the objectives of this study are set as:

1. to push the theoretical application as far as possible to gain a good understanding of how the 1986 oil price shock worked through the Chinese economic system, in which the special institutional factors alter the conventional results suggested by existing literature.

2. to use the explicit framework of computable general equilibrium (CGE) model to generate some empirical insights into the linkages of adjustment and economy-wide effects of policy responses.

1.3 Plan of the Thesis

Chapter 1 has outlined the historical context in the Chinese economy when the 1986 oil price shock occurred. The main features and problems of the economic reforms toward to mid-1980s have been sketched out to highlight the significance of the 1986 oil price shock to China. The approach to the topic and the objectives of the thesis have been identified.

Chapter 2 provides a picture of China's energy sector in a comparative perspective, covering key areas of production, consumption, pricing, and international trade. The changes in pricing and trade arrangements that have taken place during the economic reforms receive particular attention. The chapter unveils the contradictory combination of an energy shortage in the Chinese economy and the policy to increase energy export over the years from 1970s. The effects of the oil price shock are then examined in the light of the special position the energy sector occupies in the Chinese economy.

Chapter 3 presents the theoretical structure of this study. It starts with a review of the "booming sector" literature that has itself "boomed" in recent years. The models reviewed deal with the phenomenon of resource-based sectoral booms. The analysis is reversed to understand the mechanisms involved in an opposite situation. A model in which a "declining sector" initiates a chain of reactions is considered. A change of the underlying assumptions in such a situation is crucial to extend the model to economies where quantity constraints apply. Particular institutional aspects of the Chinese economy are identified in developing a theoretical framework for this study.

Chapter 4 attempts to sort through the mechanisms of resource allocation in China. Strong evidence on the significant role of markets in the Chinese economy is presented. There is a brief look at the pre-reform system. Then the chapter focuses on the nature of the two-tier price system introduced in the process of the economic reforms. The resource allocation efficiency of the two-tier price system in the Chinese economy is assessed in a comparative framework, in which two models are considered: pure competition and monopoly. Care is shown with regard to obstacles to well-functioning markets, such as the "labour managed firm" behaviour under a profit retention scheme, the impact of unreformed parts of the economic system, and differences in objectives between enterprises and government, and between producers and consumers, etc..

Chapter 5 moves to a formal analysis of the spending effect of the 1986 oil price shock in the Chinese economy. The rent-taxation scheme in the oil industry complicates the picture. The spending effect is decomposed and transmitted to the rest of the economy in two channels: reduction of investment in the oil sector and enlargement of the government's fiscal deficit. The performance of the Chinese government after the oil price shock is then examined.

Chapter 6 develops a computable general equilibrium model for the Chinese economy. A large proportion of the chapter is devoted to the construction of the data base of the model which involves conversions of the Chinese MPS statistics to the SNA conventions and the incorporation of the market prices in the input-output table. The model built on this data base is specially adapted to reflect the booming sector phenomena considered in this study. Features of the model and detailed modelling specifications are presented in the last section of the chapter.

Chapter 7 presents the simulation results of the model. The experiments carried out in the model are in two stages: a base run and a set of policy responses. To facilitate interpretation, the general effects captured in the simulations are first illustrated diagrammatically. The results are then interpreted in the light of the booming sector theory. The results show that an appropriate combination of real absorption manipulation, exchange rate depreciation and a cut in money supply are the preferred policy options to promote the structural adjustment in the Chinese economy after the the 1986 oil price shock.

Chapter 8 summarises the main conclusions of the study and links the findings of different chapters. The central conclusion is that the structural adjustment in the Chinese economy after the 1986 oil price shock was actually made more difficult by inconsistent government interventions. Policy options suggested by the study are compared to the policies adopted by the Chinese government.

Chapter 2

The Origins of Energy Shortages in China

The Chinese energy sector is described in a comparative perspective in this chapter. Data series and charts covering the key areas of China's energy sector such as production, consumption, pricing and international trade are reported. An effort has been made to put together these data from various sources which are often overlapping and confusing, particularly some of the foreign sources which are misleading as they are based on extremely scarce information. For this reason, the statistics in this chapter are, as far as possible, sourced from the Chinese publications in recent years, and some are sourced from government and ministerial archives with special permission. Two trips made to Beijing in 1987/88 and 1988/89 contributed greatly to this statistical profile of China's energy sector.

2.1 A Brief Overview of China's Energy Resources

China is abundant with energy resources. With a land of different geological belts stretching wide in both longitude and latitude, the great eras of sedimentary minerals left China with a variety of substantial energy reserves such as coal, crude oil and natural gas. At the same time, with a large altitudinal difference between the Tibetan plateau in the southwest of China and the coastal lowlands in the east, China also has an immense hydroenergy potential in its large river system.

Table 2.1 presents a global view of energy resources and reserves. China's shares in the world's total resources of coal and hydropower are significant, with hydropower potential ranks no.1 in the world and coal endowment rivalled only by the Soviet Union and North America. China is also moderately strong in oil and gas resources which are sufficient to support an annual crude oil output large enough to place China among the top half-dozen producers worldwide.

Figure 2.1 shows China's extensive coal reserves, which accounted for about 26~28% of the world's total as in 1986, enough to last over 400 years at current rates of extraction. Moreover, the quality of the Chinese coal is outstanding. Coal is distributed all over China. Almost every province in China produces coal. But major coal production sites are concentrated in northwest China, where other industries are not developed, so coal extracted there has to be transported east for consumption.

The vast bulk of China's oil reserves are located in the heavily-industrialised northeast provinces, which are the "traditional" oil producing locations. Promising basins elsewhere have been largely ignored until recently, and become vital now as the "traditional" fields have all reached maturity stage and production can be expected to decline through the 1990s. Dorian and Clark (1987) applied the Unit Regional Production Value (URPV) technique to infer the potential of China's energy resources. For those provinces in China that do have geological formation analogues with US oil producing areas, Dorian and Clark concluded that there are a number of areas in northwest China worthy of exploration.

This is consistent with the result of a large scale oil and gas resources survey completed by mid-1987 in Tarim Basin which updated China's oil reserves to 78.75 billion tonnes, and the previous estimates of oil resource in north-

Table 2.1: China's Position in World Energy Resources and Reserves, 1976 and 1986*

Region	Raw coal (bt)			Crude oil (bt)			Natural gas (tcm)			Hydropower (GW)		
	Resources	Reserves	% in world res.	Resources	Reserves	% in world res.	Resources	Reserves	% in world res.	Potential	Capacity	% in world cap.
Market economies	3769	283	45.7	65	8.9	9.8	56	12.6	16.8	570	259	23.4
North America	3033	187	30.2	50	4.9	5.4	40	7.6	10.2	290	109	11.9
Western Europe	527	70	11.3	10	3.7	4.1	10	3.9	5.2	193	115	7.9
Australia and N.Z.	200	25	4	5	0.3	0.3	5	1.1	1.4	37	9	1.5
Japan	9	1	0.2	1	0.01	0.001	1	0.02	0.03	50	26	2.1
Mixed economies	7345	301	48.6	70	15.4	17	75	29.4	30.2	847	69	34.7
Soviet Union	5714	137	22.1	40	10.3	11.4	50	26.1	34.8	269	43	11
Eastern Europe	127	62	10	5	1	1.1	5	0.3	0.4	22	8	0.9
China [1976]	**1500**	**100**	**16.2**	**20**	**4**	**4.4**	**15**	**3**	**4**	**500**	**15**	**20.5**
[1986]	**3200**	**782**	**28.8 [26]**	**78.75**	**[2.5]**	**[2.6]**	**33.3**	**[9]**	**[0.81]**	**676**	**30.2**	**n.a.**
Other Asian MEs	4	2	0.3	5	0.1	0.1	5	n.a.	n.a.	56	3	2.3
Third World	192	35	5.7	165	66	73.2	85	32.9	44	1020	63	41.9
Africa	59	16	2.6	20	8	8.9	20	5.9	7.9	437	10	17.9
Asia	92	14	2.3	15	2.4	2.7	10	3.5	4.7	226	16	9.3
Central America	13	1	0.2	20	4.5	5	10	2.3	3.1	52	10	2.1
South America	20	2	0.3	10	1	1.1	5	0.8	1.1	277	24	11.4
Middle East	8	2	0.3	100	50.1	55.5	40	20.4	27.2	28	3	1.2
World	11306	619	100	300	90.3	100	215	74.9	100	2437	391	100

* The1986 estimates are made only for China, based on Chinese sources, except for figures in brackets are sourced from the "Petroleum Economist", August, 1988.

Sources: 1. Chinese Energy Research Association, The Problems and Prospect of China's Electric Energy Development, Internal Publication, Beijing,1986.
2. Wang Qingyi(ed.), Energy in China, Chinese Metallurgical Industry Publication, Beijing, 1988.
3. Woodard K., The International Energy Relations of China, Stanford University Press, Standford, 1985.
4. Zhongguo Shiyou Bao (Chinese Petroleum Newspaper), Beijing, 19 August, 1987.

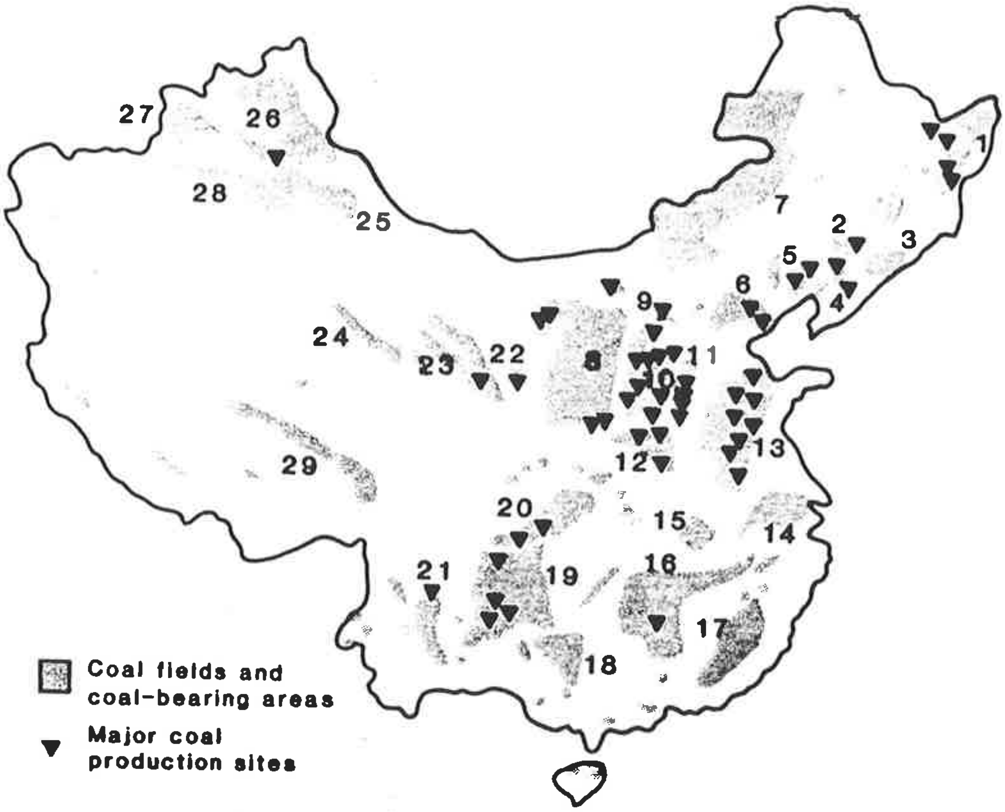
west China were found to be too low. Oil-bearing basins are shown in Figure 2.2. Beside the on-land oil basins, one feature from Figure 2.2 is the large hydrocarbon-bearing basins along China's east and southeast coastlines. Although the oil potential in northwest China has been considered extremely promising, the communication and transport infrastructure is very poor in the region. So far exploration and development efforts in the northwest have only shown a few small successes. Foreign oil companies have been encouraged to explore for off-shore oil as China lacks financial resources and technical expertise to undertake such ventures itself.

Natural gas has been discovered largely as a by-product of oil exploration, and the estimate of gas resources vary widely between the Chinese and foreign sources. The latest Chinese estimate of gas resources is 33.3 trillion cubic metres (tcm), while the World Bank quotes a conservative figure of 131.5 billion cubic metres (bcm), a significant difference. Until recently, natural gas had been largely overlooked as a significant source of energy. Recognition of gas as an alternative source of domestic energy supply has brought about increased exploration activity aimed at boosting production to 30 bcm by 2000.

Figure 2.3 shows China's extraordinarily large resources of hydroenergy: large rivers originating on the world's highest plateau in southwest China have steep gradients during their eastward flow to ocean. The shaded areas are major river basins, the numbers attached are China's latest estimate of annual power generation potentials measured in unit of GW. China has the richest hydropower resources in the world, but only 8% of this capacity is developed, in sharp contrast to the industrial market economy countries that have already developed about half of their hydropower potential.

On the whole, China probably has 5~10% of the world's *total* energy resources. This represents a large energy resource endowment for any single country. However, it should be kept in mind that China also has 23% of the world's population and 7% of the world's cultivated land. This will make the solution of China's energy problem extraordinarily challenging. The growing gap between the demand and supply of energy in China will be discussed in the rest of this chapter.

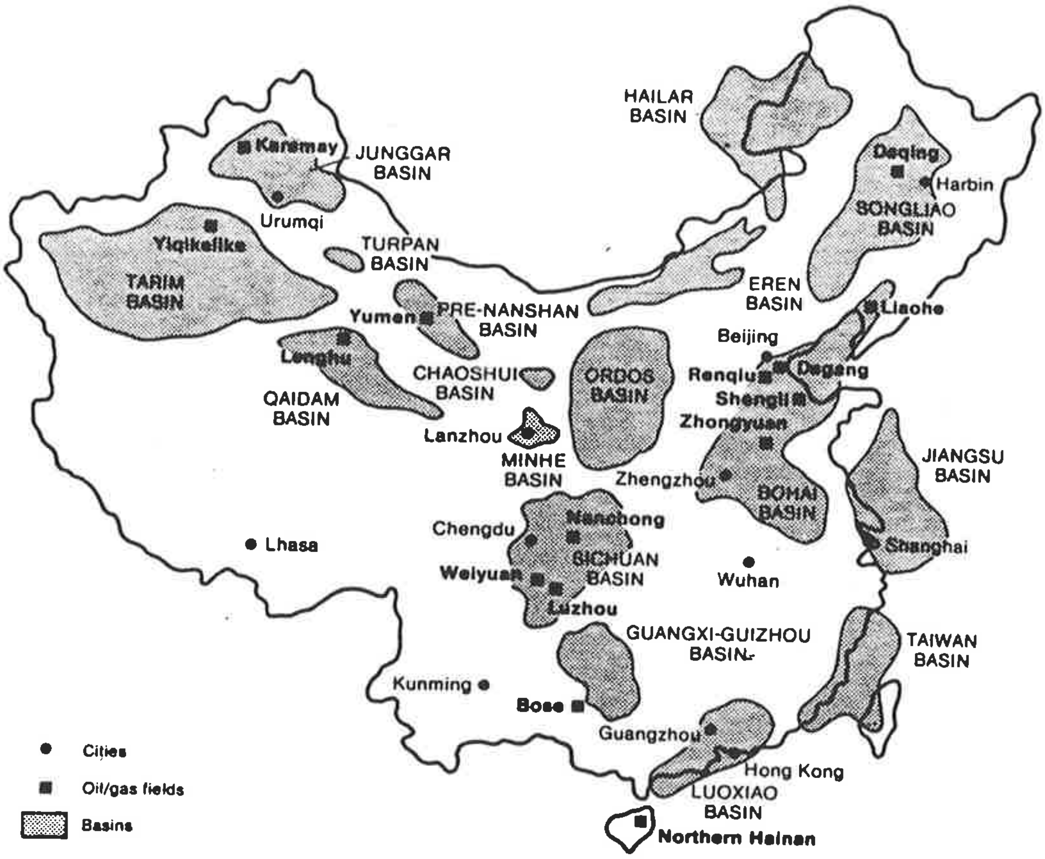
Figure 2.1: China's Coal Resources



1	Sanjiang-Muling area	16	Hunan, Jiangxi, and Guangdong provinces
2	Northern Liaoning	17	Fujian and Guangdong provinces
3	Hun River area	18	Central Guangxi Zhuang Autonomous Region
4	Liao River and Taizi River area	19	Guizhou, Yunnan, and Sichuan provinces
5	Western Liaoning	20	Huayingshan mountain area
6	Beijing-Tangshan area	21	Central Yunnan province
7	Eastern Inner Mongolia Autonomous Region	22	Hexi corridor area
8	Erdousi coal field	23	Datong River area
9	Daning coal field	24	Qaibei area
10	Qinshui coal field	25	Turpan-Hami coal field
11	Eastern foot of the Taihangshan mountains	26	Junggar coal field
12	Western Henan province	27	Yili area
13	Jiangsu, Shandong, Henan, and Anhui provinces	28	Northern fringe to Tarim
14	Zhejiang, Jiangsu, and south Anhui area	29	Northern Xizang Autonomous Region
15	Southeastern Hubei province		

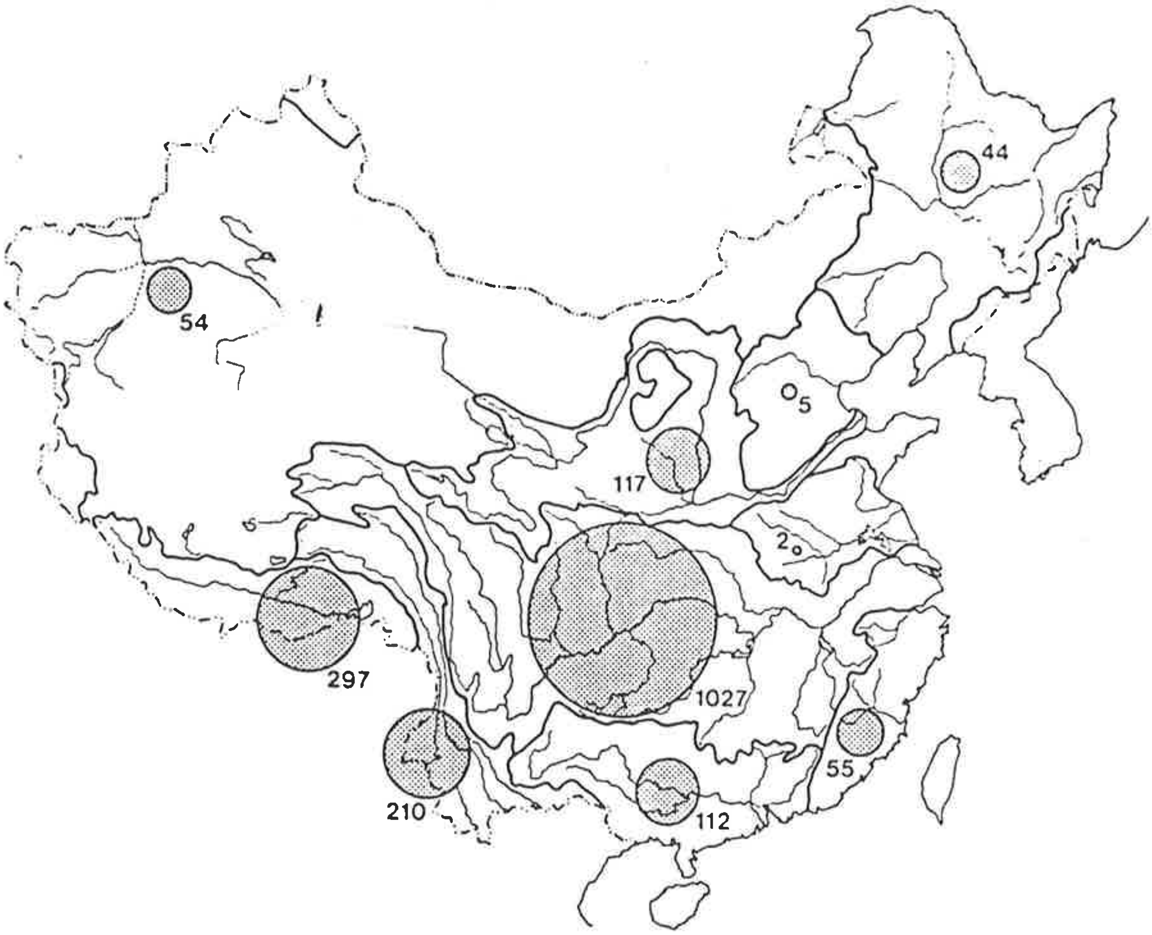
Source: Wang Xianglin, Mineral Resources in China: Geological Exploration and Exploitation, in Dorian J. and Fridley D. (eds.), *China's Energy and Mineral Industries: Current Perspectives,* Westview Press, the East-West Centre, Hawaii, 1988.

Figure 2.2: China's Oil and Gas Basins



Source: Wang Xianglin, Mineral Resources in China: Geological Exploration and Exploitation, in Dorian J. and Fridley D. (eds.), *China's Energy and Mineral Industries: Current Perspectives,* Westview Press, the East-West Centre, Hawaii, 1988.

Figure 2.3: China's Hydropower Potential (in GW)



Source: *Journal of Water Power Generation,* 1982(8), special insert, Beijing.

2.2 Energy Production in China

To obtain a simple and clear view of China's energy production, only *primary* energy output data are presented in this section. Three categories of energy production are excluded. One is secondary energy production, which is not direct exploitation of energy reserves, but reprocessed from previously extracted fuels. Examples of these are coke (from coal), refined petroleum products (from crude oil), thermal electricity (from coal & oil) *et cetera.* The number and variety of secondary energy production statistics could be multiplied indefinitely by sharper differentiation of substages in the flow of energy commodities in the economy, and is therefore ignored to keep the picture simple. The second category of energy not included is noncommercial energy production such as firewood and biomass methane which are almost impossible to assess. But it should be kept in mind that the exclusion of noncommercial energy could be significant for the rural sector as the Chinese countryside is heavily dependent on biomass fuels.[1] Finally, nuclear energy production is not considered as it is basically a blank in China before the completion of the Daya Bay project scheduled for operation in 1992 at a capacity of only 0.9 GW. A smaller nuclear power station is being built in Qinshan near Shanghai by domestic efforts.

Table 2.2 presents China's primary energy production for raw coal, crude oil, natural gas and hydropower in their original units of measurement for ease of the first access to production statistics. These data are then converted into *coal equivalents* to generate an aggregated primary energy production index and the shares of each primary fuel in total primary energy production (Table 2.3). Two charts are projected from Table 2.3 which reveal two outstanding figures in China's primary energy production. The first chart (Figure 2.4) shows the growth rate of China's total primary energy production, and the second chart

[1] Rural China traditionally uses biomass fuels. In 1979, 68.34% of rural energy consumption was sourced from biomass fuels. This ratio decreased to 57.9% in 1984, which was still significant, but reflecting an increasing degree of mechanisation of China's agriculture which has to be fuelled by coal, electricity or oil.

Table 2.2: China's Primary Energy Production in Original Units, 1949-1990

	Raw coal Mt	Crude oil Mt	Natural gas Billion cu m	Hydropower Billion kwh
1949	32	0.12	0.007	0.7
1950	43	0.20	0.007	0.8
1951	53	0.31	0.003	0.9
1952	66	0.44	0.008	1.3
1953	70	0.62	0.011	1.5
1954	84	0.79	0.015	2.2
1955	98	0.97	0.017	2.4
1956	110	1.16	0.026	3.5
1957	131	1.46	0.07	4.8
1958	270	2.26	0.11	4.1
1959	369	3.73	0.29	4.4
1960	397	5.20	1.04	7.4
1961	278	5.31	1.47	7.4
1962	220	5.75	1.21	9.0
1963	217	6.48	1.02	8.7
1964	215	8.48	1.06	10.6
1965	232	11.31	1.10	10.4
1966	152	14.55	1.34	12.6
1967	206	13.88	1.46	13.1
1968	220	15.99	1.40	11.5
1969	266	21.74	1.96	17.0
1970	354	30.65	2.87	20.5
1971	392	39.41	3.74	25.1
1972	410	45.67	4.84	28.9
1973	417	53.61	5.98	38.9
1974	413	64.85	7.53	41.4
1975	482	77.06	8.85	47.6
1976	483	87.16	10.10	45.6
1977	550	93.64	12.12	47.6
1978	618	104.05	13.73	44.6
1979	635	106.15	14.51	50.1
1980	620	105.95	14.27	58.2
1981	622	101.22	12.74	65.5
1982	666	102.12	11.93	74.4
1983	715	106.07	12.21	86.4
1984	789	114.61	12.42	86.8
1985	872	124.89	12.93	92.4
1986	894	130.69	13.38	94.5
1987	920	134.13	13.87	99.5
1988	980	136.87	14.28	106.7
1989	1026	137.45	14.94	117.2
1990	1089	138.00	15.00	123.0

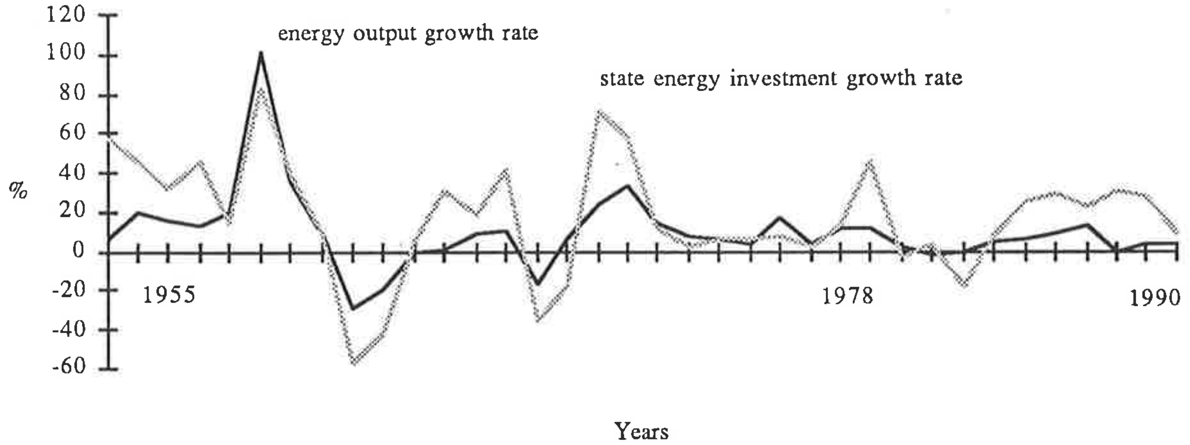
Sources: 1. Wang Qingyi (ed.), Energy in China, Chinese Metallurgical Industry Publication, Beijing, 1988.
2. Energy Policy Research Newsletter, Internal Publication, Beijing, 1986, 1987, 1988, 1989.
3. China's Latest Economic Statistics, Confidential Monthly Report, China's Statistics Information Consultancy Service Centre, CITIC Research International, Shenzhen-Hong Kong Branch, 1988-90.

Table 2.3: China's Total Energy Production and Its Composition, 1949--1990

Year	Total energy production Mtce	Proportion to total energy production (%)			
		Raw coal	Crude oil	Natural gas	Hydropower
1949	23.74	96.3	0.7	-	3.0
1950	31.74	96.8	0.9	-	2.3
1951	39.03	97.0	1.1	-	1.9
1952	48.71	96.7	1.3	-	2.0
1953	51.92	96.3	1.7	-	2.0
1954	62.62	95.8	1.8	-	2.4
1955	72.95	95.9	1.9	-	2.2
1956	82.42	95.3	2.0	-	2.7
1957	98.61	94.9	2.1	0.1	2.9
1958	198.45	97.1	1.6	0.1	1.2
1959	271.61	97.0	2.0	0.1	0.9
1960	296.37	95.6	2.5	0.5	1.4
1961	212.24	93.5	3.6	0.9	2.0
1962	171.85	91.4	4.9	0.9	2.9
1963	170.09	91.1	5.4	0.8	2.7
1964	172.32	89.1	7.0	0.8	3.1
1965	188.24	88.0	8.6	0.8	2.6
1966	208.32	86.4	10.0	0.8	2.8
1967	174.94	84.1	11.3	1.1	3.5
1968	187.15	83.9	12.2	1.0	2.9
1969	231.04	82.2	13.5	1.1	3.2
1970	309.90	81.6	14.1	1.2	3.1
1971	352.89	79.3	16.0	1.4	3.3
1972	377.85	77.5	17.3	1.7	3.5
1973	400.13	74.4	19.2	2.0	4.4
1974	416.26	70.8	22.3	2.4	4.5
1975	487.54	70.6	22.6	2.4	4.4
1976	503.40	68.5	24.7	2.7	4.1
1977	563.96	69.6	23.7	2.9	3.1
1978	627.70	70.3	23.7	2.9	3.1
1979	645.62	70.2	23.5	3.0	3.3
1980	638.21	69.4	23.8	3.0	3.1
1981	632.23	70.2	22.9	2.7	4.2
1982	667.72	71.2	21.9	2.4	4.5
1983	712.63	71.6	21.3	2.3	4.8
1984	778.47	72.4	21.1	2.1	4.4
1985	885.38	72.8	20.9	2.0	4.3
1986	881.24	72.4	21.2	2.1	4.3
1987	912.66	72.6	21.0	2.0	4.4
1988	958.01	73.1	20.4	2.0	4.6
1989	1016.39	74.1	19.3	2.0	4.6
1990	1039.22	74.2	19.0	2.0	4.8

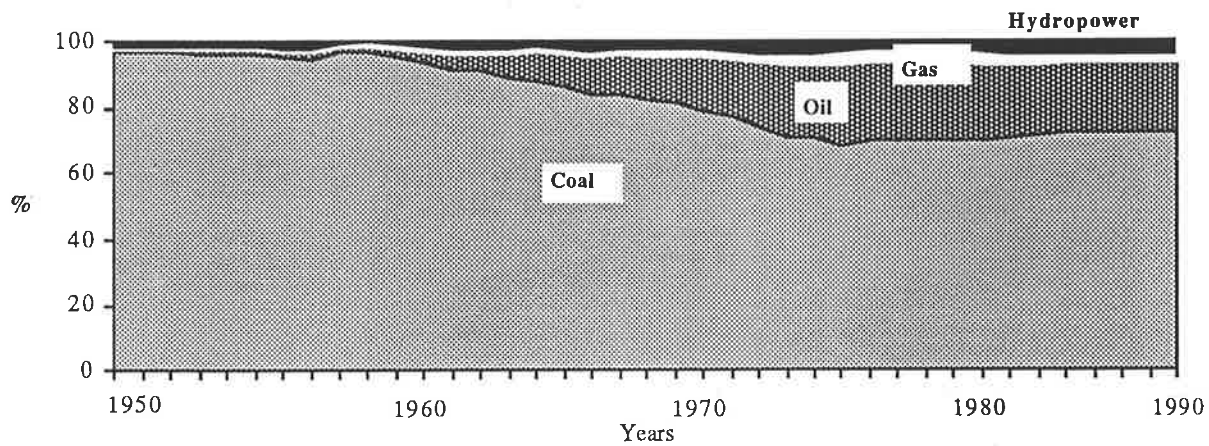
Sources: 1. Wang Qingyi (ed.), Energy in China, Chinese Metallurgical Industry Publication, Beijing, 1988.
2. State Statistical Bureau, Statistical Yearbook of China, Beijing, various volumes.

Figure 2.4: Annual Growth Rate of China's Energy Production and Correlation with State Energy Investment, 1953--1990



Sources: Table 2.3, and Statistics of Fixed Capital Investment in China, State Statistical Bureau, various volumes.

Figure 2.5: China's Energy Output Composition, 1949--1990



Source: Table 2.3.

(Figure 2.5) shows the structure of energy production over the past forty years. The characteristics of these two charts are discussed in turn.

2.2.1 Rapid but unstable growth of China's energy production

The first striking feature of the Chinese energy production is the rapid increase of energy output accompanied by large fluctuations of annual growth rates over the past 40 years (Figure 2.4).

From the inception of the People's Republic in 1949, China has been one of the world's fastest growing regions in primary energy production. With an average annual growth rate of 9.7% from 1949 to 1990 (Table 2.3), China's growth rate was nearly double the growth rate of world energy production as a whole. In 1990, China became the no.1 coal producer and no.6 oil producer in the world, compared to the rankings of no.10 and no.27 for coal and oil productions, respectively, in 1949 (Zhu Youdi and Zhao Minliang, 1990). China's hydropower production position also jumped from no.25 in 1949 to no.5 in 1986, but its natural gas production was placed no.17 in 1986 (Wang Qingyi, 1988). The rapid growth rate achieved in China's energy production is almost unique in the world. However, equally unusual are the large fluctuations of China's energy production growth performance over different periods of time.

The annual growth rates for China's aggregated primary energy production are plotted in Figure 2.4 which shows that there have been about six cycles in China's energy development path, and they can be divided into two groups in time sequence. The growth cycles in the first phase (1949–1978) are characterised by high frequency and large oscillation, while the growth pattern in the second phase (1979–1990) is relatively stable.

The irregularity of the energy production growth is closely related to the unstable economic policy as the energy industry has been closely controlled by the central government, particularly in the first phase. From 1949 to 1978, over 90% of the investment in China's energy sector was from the central government's budgetary fund allocation, and energy production was targeted every year by assigning quotas to energy producing enterprises. The dotted line in Figure 2.4 plots the growth rates of the state's energy investment along with the energy production growth rates, and reveals that the two curves are highly correlated over time.

The up-and-down movements of the two curves can be interpreted as direct results of changes in the government's energy policies. For example, the first peak of both investment and production in energy sector occurred around 1958 when the Great Leap Forward swept across China. The Great Leap Forward involved a three year long steelmaking campaign from 1958 to 1960, which put tremendous pressure on the demand for coke. In response, the government increased investment in the coal industry by 115.7% in 1958, and on top of that a further increase of 33.8% in 1959. Consequently, coal output was more than doubled in 1958, and trebled in 1959, which pulled up the energy production growth rate curve. In the following adjustment period, energy investment was reduced. As a result, production showed negative growth.

This unstable growth pattern of energy production has been largely corrected since 1979 as the economic reforms decentralised the investment system in China's energy sector. Energy producing enterprises started to have certain autonomy in investment and production decision making. The changes occurred mainly in the coal industry as millions of small- to medium-sized coal mines in collective ownership mushroomed in China in recent years, and they now supply nearly 40% of Chinese coal (Ministry of Coal Industry, 1990). The investments in these coal mines are basically guided by market signals, in the dual price system adopted in the process of economic reform. In the oil industry, an increasing proportion of investment is handled by oil fields through the profit retention scheme. These new institutional arrangements act, to a certain extent, to correct or reduce distortions in energy investment and production.

The lack of financial markets in China prevents large capital accumulation for investment in the energy sector due to the large scale characteristics of energy investment. Therefore, the state still handles a considerable percentage of energy investment. But the fluctuations of government budget allocation to energy investment have much less influence on total energy production. As can be seen in Figure 2.4, energy production since 1978 shows more stable growth than the state energy investment.

2.2.2 Structural change in primary energy output mix

Another feature worth mentioning is the change of China's energy output composition over time. As clearly shown in Figure 2.5, China started its primary energy production with an output structure dominated by coal. Coal accounted over 95% of total energy production throughout the 1950s. This unbalanced energy output mix in favour of solid fuel, which required extensive transport infrastructure, put tremendous pressure on the Chinese economy at its early development stage. As pointed out earlier, the bulk of China's coal reserves are located in north and west of China, on the other hand, China's industry is concentrated in east and south-east coastal areas, so the limitation of the rail transport network connecting the two ends of production and consumption present severe constraints to China's industrial development.

China's energy production structure has changed gradually following the discoveries of a number of substantial oil fields in the 1960s such as Daqing (Big Celebration) and Shengli (Victory). The share of crude oil in total primary energy output rose from about 1~2% in the 1950s to about 10% in the 1960s and over 20% in the 1970s and 1980s. In contrast, the share of coal in total energy output declined from 95% in the 1950s to 80% in late 1960s and further to 70% in 1970s and 1980s (Figure 2.5).

The growth performance of China's oil industry is unique. Mainly based on a single oil field of Daqing discovered in 1959, China switched from being an oil-poor country to an oil self-sufficient country by 1963, and started to export oil in 1973. Over this period, the growth rate of crude oil production was pushed above 20% per year. Other oil fields, such as Shengli discovered in late 1960s, did not take up any significant share in total oil production until the mid-1970s, which contributed to the increase in the share of oil production in total energy output to nearly 25%.

Other energies such as natural gas and hydropower also increased their shares in total primary energy production, but far less impressively than oil (Table 2.3). The basic constraint on natural gas production is the lack of a sufficient pipeline network rather than reserves. The world average ratio of proven reserves for oil and gas is about 1.5 : 1, and the typical oil and gas output ratio is about 1∼2 : 1 (in both US and USSR, for example), but these ratios in China are 29∼26 : 1 and 7∼9 : 1 respectively (Energy Research Institute, 1986), implying the possibility of substantial improvement in natural gas exploration and exploitation. The same story is true for China's hydropower generation. With 20% of the world's hydraulic potential, China ranks no.1 in the world for its hydroenergy resources, but only 8% of China's hydropower resources have been exploited so far. Despite the severe environmental and technological constraints,[2] this rate can be pushed up to at least 32% (Wang Qingyi, 1988).

The increase of production shares of energies other than coal brings a more balanced energy output mix for China. Although the Chinese energy production is still largely coal-based, other fuels play increasingly important roles in the energy sector. While the coal production is mainly for domestic market, oil takes up a lion's share in China's energy exports. This has a significant impact on the Chinese economy which will be discussed in the following sections.

[2]For example, the well known "Three Gorges Dam project" to harness the Yangtze river has debated for over thirty years. The electricity which could be supplied by the proposed hydropower station has attracted great attention in China. But the project has been held back so far because of severe environmental consequences such as alienation of land and siltation.

2.3 Energy Consumption in China

2.3.1 Primary energy consumption

Reflecting the energy production pattern, China's energy consumption is also coal based. Table 2.4 shows China's aggregate energy consumption and its composition. The data in the table are projected into a chart (Figure 2.6) which plots China's energy consumption structure (in columns) against energy production structure (shaded area in the background). Each column in the chart has four sections, representing the shares of coal, oil, natural gas and hydropower, respectively, in total energy consumption. Correspondingly, there are four layers of shaded area representing energy production for the four types of energy. The orders of column sections and area layers are the same as labelled.

Generally, the column sections match the corresponding layers, indicating China's energy consumption pattern is largely determined by its energy production structure. This is particularly the case for hydropower and natural gas, China basically consumes what is produced in these two types of energy. But there are noticeable differences in the consumption and production structures for oil and coal. The oil production layer was much thinner than the oil consumption section in the first few columns on the leftside, indicating China imported oil for domestic consumption in the 1950s. The pattern is reversed on the rightside of the graph as China switched to export oil from mid-1970s onwards. As a result of oil exports, coal's share in total energy consumption has been higher than coal's share in total energy production since mid-1970s.

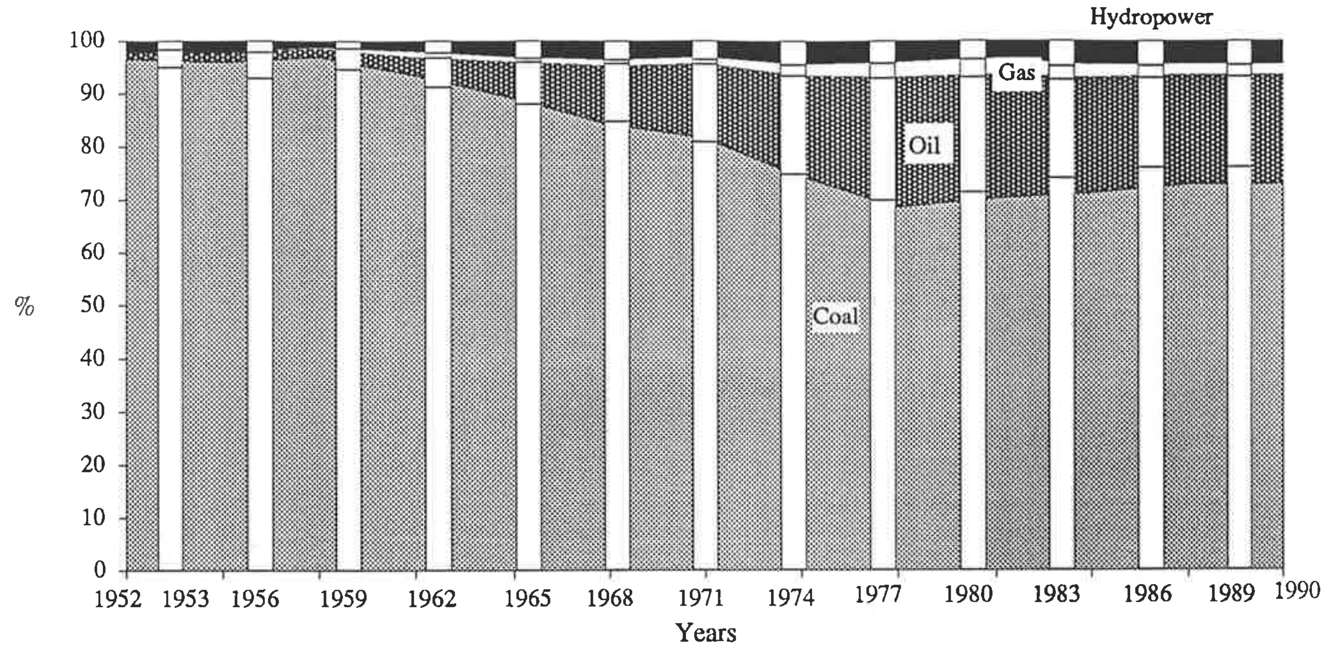
These share differences are also illustrated by Figure 2.7 where the ratios of absolute amount energy consumption to production are plotted. The ratios for natural gas and hydropower are omitted as they are largely constant over time at unity. For oil and coal, the changes in oil production and consumption explain the above share differences.

Table 2.4: China's Total Energy Consumption and Its Composition, 1952-1990

Year	Total domestic consumption Mtce	Proportion to total energy consumption (%)			
		Coal	Petroleum	Natural gas	Hydropower
1952	46.95	95.00	3.37	0.02	1.61
1953	54.11	94.33	3.81	0.02	1.84
1954	62.34	93.45	4.33	0.02	2.20
1955	69.68	92.94	4.91	0.03	2.12
1956	88.00	92.73	4.83	0.03	2.41
1957	96.44	92.32	4.59	0.08	3.01
1958	175.99	94.62	3.92	0.06	1.40
1959	239.26	94.68	4.05	0.14	1.13
1960	301.88	93.90	4.11	0.45	1.54
1961	203.90	91.31	5.47	0.94	2.28
1962	165.40	89.23	6.61	0.93	3.23
1963	155.67	88.93	7.20	0.81	3.06
1964	166.37	87.97	8.04	0.73	3.26
1965	189.01	86.45	10.27	0.63	2.65
1966	202.69	86.24	10.17	0.67	2.92
1967	183.28	84.77	10.89	0.84	3.50
1968	184.05	83.79	12.09	0.76	3.36
1969	227.30	81.93	13.76	0.82	3.49
1970	292.91	80.89	14.67	0.92	3.52
1971	344.96	79.19	16.00	1.44	3.37
1972	372.73	77.51	17.17	1.73	3.59
1973	391.09	74.84	18.58	2.03	4.55
1974	401.44	72.14	20.72	2.49	4.65
1975	454.25	71.85	21.07	2.51	4.47
1976	478.31	69.91	23.00	2.81	4.28
1977	523.54	70.25	22.61	3.08	4.06
1978	571.44	70.67	22.73	3.20	3.40
1979	585.88	71.31	21.79	3.30	3.60
1980	602.75	71.81	21.05	3.14	4.00
1981	594.47	72.74	19.92	2.85	4.49
1982	620.67	73.92	18.67	2.56	4.85
1983	660.40	73.71	18.56	2.47	5.26
1984	709.04	75.10	17.70	2.30	4.90
1985	766.82	75.85	17.09	2.25	4.81
1986	808.50	75.80	17.20	2.30	4.70
1987	866.32	76.20	17.00	2.10	4.70
1988	929.97	76.20	17.00	2.10	4.70
1989	969.34	76.00	17.10	2.00	4.90
1990	980.00	75.60	17.00	2.10	5.30

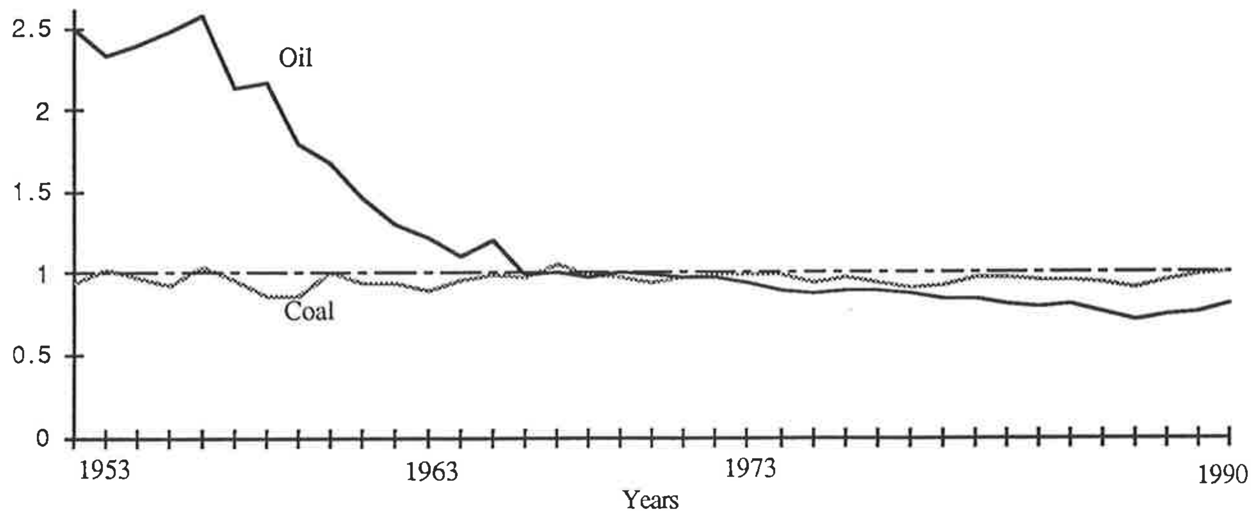
Sources: 1. Wang Qingyi (ed.), Energy in China, Chinese Metallurgical Industry Publication, Beijing, 1988.
2. State Statistical Bureau, Statistical Yearbook of China, Beijing, various volumes.

Figure 2.6: Comparison of the Structures of China's Energy Consumption and Production by Major Types of Energy Product, 1952-1990



Sources: Table 2.3 and Table 2.4.

Figure 2.7: Ratios of Consumption to Production for Oil and Coal 1952-1990



Sources: Table 2.3 and Table 2.4.

It is clear in Figure 2.7 that there are three episodes in China's oil industry history. In the 1950s, China had a consumption to production ratio of about 2.5, large amount of oil was imported to meet production shortage. This changed in the mid-1960s when China became self-sufficient in oil consumption. Since the mid-1970s, the oil industry in China has entered its third episode. Domestic oil consumption has been squeezed for oil export.[3] The ratio of oil consumption to production declined to about 0.75, implying a substantial proportion of oil output is exported. The ratio for coal has generally remained below one over the entire period, but considerably above the ratio for oil since 1973, implying coal has been exported throughout the period, but at a scale much smaller than oil exports since 1973. The substantial oil exports reduced China's domestic oil consumption, the share of oil in domestic energy consumption fell, and coal's share rose.

China's energy consumption pattern can be compared to that of other countries. Table 2.5 shows the composition of primary energy consumption in some major energy consuming countries. The countries are listed according to the coal share. With a share of 73.9% for coal, China ranks the highest in the table. China's surprisingly high share of coal in total energy consumption, due primarily to its large, low-cost reserves, carries serious implications regarding environmental pollution, and hence the health of the population. The environmental impact of coal use also applies to other coal-based countries such as India (64.4%) which also happen to be low-income countries. The heavy reliance on coal in low-income countries compared to the industrialised countries in the table reflects the difference in industrial technology and energy consumption efficiency. For example, an underdeveloped transport sector serves to decrease the share of petroleum products in total energy consumption.

One fact hidden in the above comparison is the way coal is consumed among these countries. Coal can be used either as a source of fuel for direct final con-

[3]The reason of exporting oil despite of domestic energy shortages will be discussed later in section 2.5.

Table 2.5: International Comparisons of Primary Energy Consumption, 1982

Country	Proportion to total energy consumption (%)				Total domestic consumption
	Coal	Petroleum	Natural gas	Hydro and nuclear power	Mtce
China	73.9	18.7	2.5	4.9	619.37
East Germany	71.3	17.9	9.4	1.4	123.32
India	64.4	28.7	2.1	4.8	143.81
Australia	52.7	34.4	11.2	1.7	108.36
Britain	36.5	36.7	24.3	2.5	253.28
West Germany	35.1	43.7	17.9	3.3	338.53
USSR	31.1	33.6	33.4	1.9	1560.67
US	24.0	44.0	28.5	3.5	2186.05
Japan	22.6	63.5	8.4	5.5	414.13
France	21.9	52.9	15.5	9.7	216.36
Canada	14.2	44.4	27.8	13.6	239.50
Total	32.0	42.2	21.9	3.9	8405.45

Source: Wang Qingyi (ed.), Energy in China, Chinese Metallurgical Industry Publication, Beijing, 1988.

sumption or as a source for power generation. One way to use coal cleanly and efficiently is to convert more coal into electricity through application of thermal power generation. While China has the highest share of coal in primary energy consumption, only a small proportion of Chinese coal is used for generating electricity. On the other hand, most of the coal used by industrialised countries is converted into electricity while the rest is put aside for coking purposes. In 1983, the proportion of coal used for power generation in total coal consumption was 84.5% for US, 73.1% for Britain, 51.8% for France, 51.7% for West Germany, but only 21.2% for China (Energy Research Institute, 1986).

The difference in the degree of reprocessing of coal into secondary energy has significant implication for the pattern of energy consumption. It demonstrates that, unlike the discussion on energy production in the last section where *primary* energy output data are preferred for the purpose of clarity and simplicity, an analysis of energy consumption at the level of primary energy consumption is not sufficient to gain a good understanding of energy consumption because most energy consumed is in secondary rather than primary forms. The rest of the section will look at the sectoral structure of *final* energy consumption (the end-use of both primary and secondary energy).

2.3.2 Final energy consumption

Table 2.6 presents a matrix of final energy consumption by sector and by major type of energy. To avoid double accounting, primary energy used for conversion into secondary energy and the loss of energy during this process is not included. In other words, only end-use energy is counted. The matrix provides both a broad picture of final energy consumption across sectors and energy types in China and also provides a detailed picture of the subsectors of the industry sector which dominate China's energy consumption. All energy consumption in the matrix is measured in coal equivalents. This makes it possible to compare all elements contained in the matrix, as illustrated by Table 2.7 and Table 2.8 which explicitly compare the weights of different types of energy in each sector (row percentage from the matrix) and the distribution of each energy across sectors (column percentage in the matrix).

As expected, the weight of directly consumed coal is significant in almost all sectors in Table 2.7. The extent of reliance on coal ranges from 90.5% for the household sector to 43.73% for material production sector. Non-material production sector is relatively less dependant on coal (20.65%), but relies more on petroleum products (45.76%). Other sectors with a considerable share of petroleum consumption in their energy mix are transport (38.82%), construction (22.4%) and agriculture (23.28%).[4] Electricity appears to be required by a much wider range of sectors than petroleum products. Except for transport and household sectors, all other sectors require about 20~30% electricity in

[4] A bias may exist in the data for the rural primary sector (including agriculture, forestry, animal husbandry and fishery) as biomass energy is excluded which serves to increase the weight attached to other energy in the rural sector. Also energy consumption by village industrial enterprises is included in rural sector's final energy consumption.

Table 2.6: Matrix of Energy Consumption in China, by Sector by Energy Type, 1985
(1000 tonne coal equivalent)

	Coal	Coke	Crude	Fuel oil	Petrol goods*	Gas	Heat	Electricity	Other**	Total
Material production sector	242947	45422	5000	21898	43511	24276	12510	138070	21899	555533
Agri., Animal husbandry, Fishery	25378	425	11	44	12875			16565		55298
Industry	190845	44839	3642	19480	12745	22355	11678	114636	21899	442119
Heavy industry	134159	43606	3257	15340	9512	20931	7990	90549	21899	347243
Light industry	56686	1233	384	4140	3232	1430	3689	24087		94881
Construction	3974	76	1057	0	2914	1875	9	2834		12739
Transport & telecommunication	17235	55	289	2059	14072	13	8	2523		36254
Commerce & services	5515	26	1	44	504	32	815	1512		8449
Non-material production sector#	3283	19	6	86	7275	277	109	4844		15899
Household sector	151861				1971	2910	2191	8856	17	167806
Urban	85266				215	2910	1883	4876	17	95167
Rural	66595				1756		308	3980		72639
Heavy industry##										
Metals	16826	32614	5690	4370			1606	22702	306	85822
Electricity	609	30			443	524	103	11283		12993
Coal and coke	10767	168		363	645	1189	146	8780		22058
Petroleum	617	87	2019	2633	976	2687	1075	4915	2627	20636
Chemicals	34209	7003	469	4384	2591	6099	3442	22662	402	81261
Machine-building	17296	2524	100	1344	2105	1192	1170	10479		36210
Building materials	51097	929	100	2173	1148	369	388	7005		63209
Timber	1991	8		27	432			346		2904
Other	747	144	1	46	40	68	60	2376		3581
Light industry										
Food processing	15232	119	27	253	750	259	258	4545		21443
Textile	14205	165	120	887	576	181	2673	7968		26775
Clothing	514	1			67			330		913
Leather	710	7	3	7	60		2	251		1041
Paper-making	7681	9	39	440	155	40		3108		11472
Educational & cultural articles	814	6	1	43	134		333	231		1569
Chemicals	5111	56	7	634	514	256	136	2714		9429
Machine-building	2665	754	36	133	409	173	160	1688		6016
Timber	1106	6	1	29	139		35	338		1654
Other	8648	110	150	1714	426	516	91	2913		14568
Total	398091	45441	5006	21983	52758	27462	14811	151769	21916	739237

* Gasoline, kerosene and diesel.
** Other coking and petroleum products.
\# This includes education, public health, sports, civil administration, scientific researches and polytechnical services, etc..
\## Some heavy industry enterprises also produce consumer goods. For example, many machine-building enterprises produce refrigerators and washing machines. These enterprises are singled out and are classified under the light industry category. This applies to chemicals, machine-building and timber industries.

Source: Energy Statistical Yearbook of China, Internal Publication, Beijing, 1986.

Table 2.7: Energy Mix in China, by Energy Type, 1985

	Coal	Coke	Crude	Fuel oil	Petrol goods*	Gas	Heat	Electricity	Other**	Total
Material production sector	43.73	8.18	0.90	3.94	7.83	4.37	2.25	24.85	3.94	100
Agri., Animal husbandry, Fishery	45.89	0.77	0.02	0.08	23.28	0.00	0.00	29.96	0.00	100
Industry	43.17	10.14	0.82	4.41	2.88	5.06	2.64	25.93	4.95	100
Heavy industry	38.64	12.56	0.94	4.42	2.74	6.03	2.30	26.08	6.31	100
Light industry	59.74	1.30	0.40	4.36	3.41	1.51	3.89	25.39	0.00	100
Construction	30.55	0.58	8.13	0.00	22.40	14.41	0.07	21.78	0.00	100
Transport & telecommunication	47.54	0.15	0.80	5.68	38.82	0.04	0.02	6.96	0.00	100
Commerce & services	65.27	0.31	0.01	0.52	5.97	0.38	9.65	17.90	0.00	100
Non-material production sector#	20.65	0.12	0.04	0.54	45.76	1.74	0.69	30.47	0.00	100
Household sector	90.50	0.00	0.00	0.00	1.17	1.73	1.31	5.28	0.01	100
Urban	89.60	0.00	0.00	0.00	0.23	3.06	1.98	5.12	0.02	100
Rural	91.68	0.00	0.00	0.00	2.42	0.00	0.42	5.48	0.00	100
Heavy industry##										
Metals	19.61	38.00	6.63	5.09	0.00	0.00	1.87	26.45	0.36	100
Electricity	4.69	0.23	0.00	0.00	3.41	4.03	0.79	86.84	0.00	100
Coal and coke	48.81	0.76	0.00	1.65	2.92	5.39	0.66	39.80	0.00	100
Petroleum	2.99	0.42	9.78	12.76	4.73	13.02	5.21	23.82	12.73	100
Chemicals	42.10	8.62	0.58	5.39	3.19	7.51	4.24	27.89	0.49	100
Machine-building	47.77	6.97	0.28	3.71	5.81	3.29	3.23	28.94	0.00	100
Building materials	80.84	1.47	0.16	3.44	1.82	0.58	0.61	11.08	0.00	100
Timber	68.56	0.28	0.00	0.93	14.88	0.00	0.00	11.91	0.00	100
Other	20.86	4.02	0.03	1.28	1.12	1.90	1.68	66.35	0.00	100
Light industry										
Food processing	71.03	0.55	0.13	1.18	3.50	1.21	1.20	21.20	0.00	100
Textile	53.05	0.62	0.45	3.31	2.15	0.68	9.98	29.76	0.00	100
Clothing	56.30	0.11	0.00	0.00	7.34	0.00	0.00	36.14	0.00	100
Leather	68.20	0.67	0.29	0.67	5.76	0.00	0.19	24.11	0.00	100
Paper-making	66.95	0.08	0.34	3.84	1.35	0.35	0.00	27.09	0.00	100
Educational & cultural articles	51.88	0.38	0.06	2.74	8.54	0.00	21.22	14.72	0.00	100
Chemicals	54.21	0.59	0.07	6.72	5.45	2.72	1.44	28.78	0.00	100
Machine-building	44.30	12.53	0.60	2.21	6.80	2.88	2.66	28.06	0.00	100
Timber	66.87	0.36	0.06	1.75	8.40	0.00	2.12	20.44	0.00	100
Other	59.36	0.76	1.03	11.77	2.92	3.54	0.62	20.00	0.00	100
Total	53.85	6.15	0.68	2.97	7.14	3.71	2.00	20.53	2.96	100

* Gasoline, kerosene and diesel.

** Other coking and petroleum products.

\# This includes education, public health, sports, civil administration, scientific researches and polytechnical services, etc..

\#\# Some heavy industry enterprises also produce consumer goods. For example, many machine-building enterprises produce refrigerators and washing machines. These enterprises are singled out and are classified under the light industry category. This applies to chemicals, machine-building and timber industries.

Source: Energy Statistical Yearbook of China, Internal Publication, Beijing, 1986.

Table 2.8: Energy Distribution in China, by Sector, 1985

	Coal	Coke	Crude	Fuel oil	Petrol goods*	Gas	Heat	Electricity	Other**	Total
Material production sector	61.03	99.96	99.88	99.61	82.47	88.40	84.46	90.97	99.92	75.15
Agri., Animal husbandry, Fishery	6.37	0.94	0.22	0.20	24.40	0.00	0.00	10.91		7.48
Industry	47.94	98.68	72.75	88.61	24.16	81.40	78.85	75.53	99.92	59.81
Heavy industry	33.70	95.96	65.06	69.78	18.03	76.22	53.95	59.66	99.92	46.97
Light industry	14.24	2.71	7.67	18.83	6.13	5.21	24.91	15.87		12.83
Construction	1.00	0.17	21.11	0.00	5.52	6.83	0.06	1.87		1.72
Transport & telecommunication	4.33	0.12	5.77	9.37	26.67	0.05	0.05	1.66		4.90
Commerce & services	1.39	0.06	0.02	0.20	0.96	0.12	5.50	1.00		1.14
Non-material production sector#	0.82	0.04	0.12	0.39	13.79	1.01	0.74	3.19		2.15
Household sector	38.15	0.00	0.00	0.00	3.74	10.60	14.79	5.84	0.08	22.70
Urban	21.42	0.00	0.00	0.00	0.41	10.60	12.71	3.21	0.08	12.87
Rural	16.73	0.00	0.00	0.00	3.33	0.00	2.08	2.62		9.83
Heavy industry##										
Metals	4.23	71.77	11.37	19.88	0.00	0.00	10.84	14.96	1.40	11.61
Electricity	0.15	0.07	0.00	0.00	0.84	1.91	0.70	7.43		1.76
Coal and coke	2.70	0.37	0.00	1.65	1.22	4.33	0.99	5.79		2.98
Petroleum	0.15	0.19	40.33	11.98	1.85	9.78	7.26	3.24	11.99	2.79
Chemicals	8.59	15.41	9.37	19.94	4.91	22.21	23.24	14.93	1.83	10.99
Machine-building	4.34	5.55	2.00	6.11	3.99	4.34	7.90	6.90		4.90
Building materials	12.84	2.04	2.00	9.88	2.18	1.34	2.62	4.62		8.55
Timber	0.50	0.02	0.00	0.12	0.82	0.00	0.00	0.23		0.39
Other	0.19	0.32	0.02	0.21	0.08	0.25	0.41	1.57		0.48
Light industry										
Food processing	3.83	0.26	0.54	1.15	1.42	0.94	1.74	2.99		2.90
Textile	3.57	0.36	2.40	4.03	1.09	0.66	18.05	5.25		3.62
Clothing	0.13	0.00	0.00	0.00	0.13	0.00	0.00	0.22		0.12
Leather	0.18	0.02	0.06	0.03	0.11	0.00	0.01	0.17		0.14
Paper-making	1.93	0.02	0.78	2.00	0.29	0.15	0.00	2.05		1.55
Educational & cultural articles	0.20	0.01	0.02	0.20	0.25	0.00	2.25	0.15		0.21
Chemicals	1.28	0.12	0.14	2.88	0.97	0.93	0.92	1.79		1.28
Machine-building	0.67	1.66	0.72	0.61	0.78	0.63	1.08	1.11		0.81
Timber	0.28	0.01	0.02	0.13	0.26	0.00	0.24	0.22		0.22
Other	2.17	0.24	3.00	7.80	0.81	1.88	0.61	1.92		1.97
Total	100	100	100	100	100	100	100	100	100	100

* Gasoline, kerosene and diesel.

** Other coking and petroleum products.

\# This includes education, public health, sports, civil administration, scientific researches and polytechnical services, etc..

\## Some heavy industry enterprises also produce consumer goods. For example, many machine-building enterprises produce refrigerators and washing machines. These enterprises are singled out and are classified under the light industry category. This applies to chemicals, machine-building and timber industries.

Source: Energy Statistical Yearbook of China, Internal Publication, Beijing, 1986.

their final energy consumption. The weight of electricity in China's total energy consumption is about 20.5%. This share is quite low compared to the share of 30~40% for industrialised countries or 25~30% for even other developing countries (World Bank, 1985b). One reason for China's relatively low electricity consumption is the low electricity use by the household sector. 80% of the population in China are living in rural areas where household electrical appliances are hardly used, not even for lighting.[5] Perhaps more important is the relative inefficiency of fuel consumption in the Chinese industry. The use of too much coal as fuel serves to decrease the relative share of electricity in total final energy consumption.

The shares of other types of energy used by each sector are generally small compared to coal, petroleum products and electricity. However, there are some sector-specific high shares. This is shown better by the industrial subsectors. For example, metals industry relies on coke for 38% of its final energy consumption, and there is a strong tendency of self reliance in the energy production sectors, such as the electricity sector (which relies 86.84% on electricity), the coal sector (48.81% on coal) and the petroleum sector (about 40% on oil and gas).

To see a whole picture of final energy consumption in China, the features of energy mix in individual sectors discussed above need to be combined to sectoral distribution of each type of energy. It is possible that a sector relying heavily on a particular energy may only consumes a negligible amount of that energy in the economy as a whole, if the sector is small. If a particular sector is expected to grow, then this analysis will help to identify the main type of energy which will be required. In these cases, it is important to look at the shares received by individual sectors in energy distribution in order to capture the trends in energy consumption.

Table 2.8 presents China's energy distribution across sectors in 1985. The

[5] China consumed 392 kwh of electricity per person in 1985, compared with 4,945 kwh for Japan, 5,525 kwh for USSR, 10,459 for US and 15,317 kwh for Canada (QATERI, 1987).

industrial sector dominates final energy consumption by taking up 59.81% of the total. For individual types of energy, the industrial sector uses about half of the coal, and at least three-quarters of each of the other types of energy except petroleum products (24.16%). Most of the final industrial energy consumption is concentrated in heavy industry. As of 1985, China's metals, chemicals, building materials and machine-building industries accounted for 60% of final industrial energy consumption.

The only type of energy which has a relatively small flow to the industrial sector is petroleum products. The distribution of petroleum products appears quite even across most sectors except the household sector, with 26.67% to transport, 24.4% to rural agriculture, 24.16% to industry, and about 13.79% to the non-material production sector. Although the shares of petroleum products to the transport, agriculture and non-material production sectors are significant, the shares in total final energy consumption for these three sectors are very low. They are 4.9%, 7.48% and 2.15%, respectively, compared to 59.81% for the industry sector.

These sectors with a high share in a particular energy consumption but a low share in overall final energy consumption have significant implications in identifying the trends of energy consumption for different types of energy which will be discussed below.

2.3.3 Trends in China's energy consumption

Let's start with oil. Given the considerable shares of petroleum distribution to transport, agriculture and non-material production sectors (Table 2.8), and as these sectors are also shown having a large weight of petroleum products in their energy consumption mix (Table 2.7), growth of these sectors would increase consumption of petroleum products in the Chinese economy.

International comparisons are made to see the likely trends. Table 2.9 shows aspects of final energy consumption patterns in both developing and developed countries. Although consistent international comparison data are available only for 1980, the estimates for China in 1980 are basically in line with the 1985 estimates as shown in brackets which are extracted from Table 2.7 and Table 2.8. A clear feature in the international comparisons in Table 2.9 is that the share of China's transport sector was surprisingly low in final energy consumption, and the share of oil used by the transport sector was also low for China. Given the fact that developing countries' transport vehicles are technologically more backward, and on average consume a lot more energy than other countries, this finding implies an exceptionally small transport sector in China which is constraining the Chinese economy, and which can therefore be expected to expand, adding to energy demand, particularly demand for petroleum products.

The international comparisons for the composite sector of residential, commercial and public service sectors also suggest that the composite sector in China is very small in terms of energy consumption compared to South Korea and some developed countries. If this composite sector in China is going to catch up, and, in fact, there has already been a big catch-up,[6] the non-material production sector will add to demand for petroleum products.

The agricultural sector is not included in Table 2.9 as the omission of biomass energy makes it inappropriate to compare China's agriculture (with an exceptionally large biomass consumption) with the those of other countries. But it is expected that China's agricultural sector is also going to use more petroleum inputs. Many agricultural inputs such as farm machine fuels (particularly diesel in the Chinese case), fertiliser, pesticide *etc.* are petroleum-based. From 1979 to 1984, petroleum consumption in Chinese agricultural production increased 5.7% (Wang Qingyi, 1988). It is estimated that China's grain production in 1982 consumed 285 litres of petroleum *per hectare,* among which one third is direct final energy consumption (gasoline, diesel and electricity) and

[6]China's household, commerce and services and non-material production sectors together consumed 25.99% of total final energy consumption in 1985 (Table 2.8). This was a big increase compared to 19.7% in 1980 (Table 2.9) (ignoring the possible difference in grouping).

Table 2.9: International Comparisons of Final Energy Consumption, 1980 (%)

	Selected energy type shares		Selected sectoral shares		
	Electricity	Petroleum products*	Industry	Transport	Res/com/pub+
Developing Countries					
China	18.0	24.6	60.4	7.8	19.7
	[20.53]#	[26.67]	[59.81]	[4.9]	[25.99]
Argentina	28.7	55.2	35.0	30.6	22.9
Brazil	39.1	46.4	47.3	26.0	20.0
Mexico	24.3	56.4	37.4	33.9	18.9
India	29.8	44.1	55.1	22.2	13.7
South Korea	22.9	27.7	43.3	12.3	42.8
Developed Countries					
U.S.	33.3	62.0	31.0	25.2	36.2
Canada	39.5	51.2	38.4	20.2	35.9
Japan	42.0	28.6	54.3	14.1	27.0
France	32.9	34.8	42.8	18.4	33.0
West Germeny	34.9	34.4	41.0	15.7	38.4
Italy	33.1	35.8	44.7	18.5	30.8
U.K.	36.5	52.2	33.3	18.6	43.6

* Share of oil used only in transport secotr, not in the economy's total final energy consumption.

\# All figures in brackets are 1985 figures as given in Table 2.7 and Table 2.8.

\+ Residential, commercial and public service sectors. The figure [25.99] refers to residential, commercial and non-material production sectors as classified in Table 2.8.

Sources: 1. World Bank, China: The Energy Sector, Washington D.C., 1985b.
2. Table 2.7 and Table 2.8.

Table 2.10: International Comparisons of Electricity Consumption Elasticities*, 1960-80

	1960-70	1971-80
Developing countries		
China	1.66	1.22
India	2.95	2.16
Philippines	2.35	1.23
South Korea	2.20	1.87
Mexico	1.36	1.33
Developed countries		
US	1.87	1.26
France	1.21	1.59
Japan	1.13	1.01
West Germany	1.58	1.51
Canada	1.18	1.55

* Defined as the ratio of growth rates of electricity consumption over real GDP.

Sources: 1. World Bank, China: The Energy Sector, Washington D.C., 1985b.
2. Wang Qingyi (ed.), Energy in China, Chinese Metallurgical Industry Publication, Beijing, 1988.

the rest is indirect energy consumption by industries producing agricultural inputs (Wen Dazhong, 1987).

Another major trend in China's energy consumption is the expected increase in electricity demand. There are basically three major findings for electricity consumption in China. The first is the high electricity requirement in the final energy consumption mix across all sectors (Table 2.7), while there is a high concentration of China's electricity distribution in the industrial sector (Table 2.8). The third is the low share of electricity in China's final energy consumption mix compared to other countries (Table 2.9). It should be pointed out that China's low electricity share compared to other countries in Table 2.9 does not necessarily establish that China needs to increase the share of electricity. China may be able to achieve economic growth with a different final energy consumption mix compared to those in other countries. The question is whether electricity shortages are constraining the economic growth in China and, if so, what sectoral implications will be?

There is a well defined stable relationship between electricity consumption and the growth of economy (World Bank, 1985b). A common index used to define this relationship is the *elasticity* of electricity consumption which measures the growth rate of electricity consumption over the growth rate of GDP. This index is generally over unity, implying that the growth of the economy results in faster growth in electricity consumption. So the electricity industry is also labelled as a "lead industry" which has to be developed in advance in order to supply sufficient electricity for economic growth.

Table 2.10 shows the elasticities of electricity consumption in both developing and developed countries. The elasticities in the table are all greater than one for the years between 1960 and 1980. The elasticities also tend to be higher at earlier stage of development by comparing the first column to the second column or the developing countries to the developed countries. The electricity consumption elasticity for China was relatively small compared to other developing countries, but still well above unity. However, China's electricity consumption elasticity declined dramatically in recent years. From 1981 to 1985, China's electricity elasticity is only 0.59 (QATERI, 1987). This is an exceptionally low elasticity. There are two major reasons to explain the low electricity consumption elasticity as a consequence of economic growth during 1981 and 1985 in China.

The first is the change of the Chinese industrial structure towards mid-1980s. The Chinese industry used to be dominated by heavy industry which is much more energy intensive than light industry. As shown in Table 2.8, most of China's industrial electricity output feeds the heavy industry sector. The electricity consumed per unit of output by the Chinese heavy industry is 4.5 times that of light industry.[7] From the early 1980s onwards, the rapid expansion of the down-stream industry in China dramatically changed the structure of the Chinese industry. From 1981 to 1982, the share of China's light industry in total industrial output became higher than that of heavy industry. In the years following, China's light industry continued to grow at an average rate of 16% annually from 1982 to 1985. The strong growth of China's light industry and the relative decline of heavy industry reduced electricity consumption in the economy as a whole.

The second is that China imported significant amount of electricity-intensive products over the years from 1980 to 1985. This includes products such as aluminium, steel, fertiliser, ethylene, cement *et cetera*. If measuring these imports by the electricity required to produce them domestically, then the annual growth rate of electricity import contained in these products was 21.3% from 1980 to 1984. In 1984, the electricity contained in import products was equivalent to 20.6% of China's domestic electricity supply (Energy Research Institute, 1986).

Taking into account of the above two factors, the elasticity of electricity

[7]The light industry consumes 0.14 kwh of electricity per Rmb Yuan of output value in 1987 (QATERI, 1987)

consumption for China was still close to unity from 1981 to 1985 (QATERI, 1987, p.5). This indicates that electricity supply in China was far behind the demand. The adjustment of the industrial structure in the years ahead will see the reduction of the share in total industrial output for the relatively over-expanded light industry in the mid- and late 1980s. The development of up-stream industries such as metals, chemicals and building materials will increase their shares. The demand for electricity will increase substantially as the energy intensities (measured by energy consumption per unit of physical output) in these sectors are exceptionally high compared to other countries. Take the metallurgy industry as an example. The iron and steel industry dominates the metallurgy industry in China. In 1980, energy consumption per tonne of crude steel in China was approximately double the level in Japan, and more than double the levels in Italy and Spain. Even compared to developing countries, China was still 60% higher than Brazil (World Bank, 1985b).

Electricity demand from sectors outside the industrial sector will also increase, particularly in the household sector. China's household sector so far uses a negligible amount of electricity. But as the living standards rises in both urban and rural areas, electricity consumption by households will increase. Generally, electricity is clean and, more efficient in converting into other forms of energy such as power, heat and light. In the process of industrialisation, electricity tends to replace other types of energy and play an increasingly important role. All these point to an increased demand for electricity in the years ahead for China.

China's electricity supply is mainly from coal. The composition of sources in China's electricity generation is: coal-60%, oil-15%, gas-2%, hydropower-23%. Coal-fired power stations will continue to be the dominant source of electricity generation in China. The increased demand for electricity implies an increase of demand for coal, which is one of the many other factors lead to the same conclusion. As coal will continue to be the major type of energy in China at least in the foreseeable future, the growth of the Chinese economy will still heavily depend on coal. Besides more coal is needed to generate electricity, coal is also needed for steel production. More metallurgical coal will have to be produced. The tremendous chemical industry in China will also require coal as feedstock. More coal will be needed for cooking and heating in both urban and rural areas. In short, more coal must be produced to meet the ever-increasing domestic demand.

2.4 Energy Pricing and Energy Shortages in China

2.4.1 Energy price distortions

So far we have looked at China's energy production and consumption separately. To put them in one picture, a large gap emerges between China's energy supply and demand. Energy shortages have been a chronic problem in China. Energy is labelled as a "bottleneck" for China's economic development. This bottleneck has been shrinking since into the 1980s following the rapid growth of the reformed Chinese economy. In the 6th Five-Year-Plan (1981-1985), the gross value of agricultural and industrial output grew by 68%, but primary energy increased only 34%, similar rate applied to secondary energy, production of electricity increased 37%. The situation deteriorated in the 7th Five-Year-Plan. From 1986 to 1990, primary energy output increased only 21% while the gross value of agricultural and industrial output increased 71% (State Statistical Bureau, 1990).

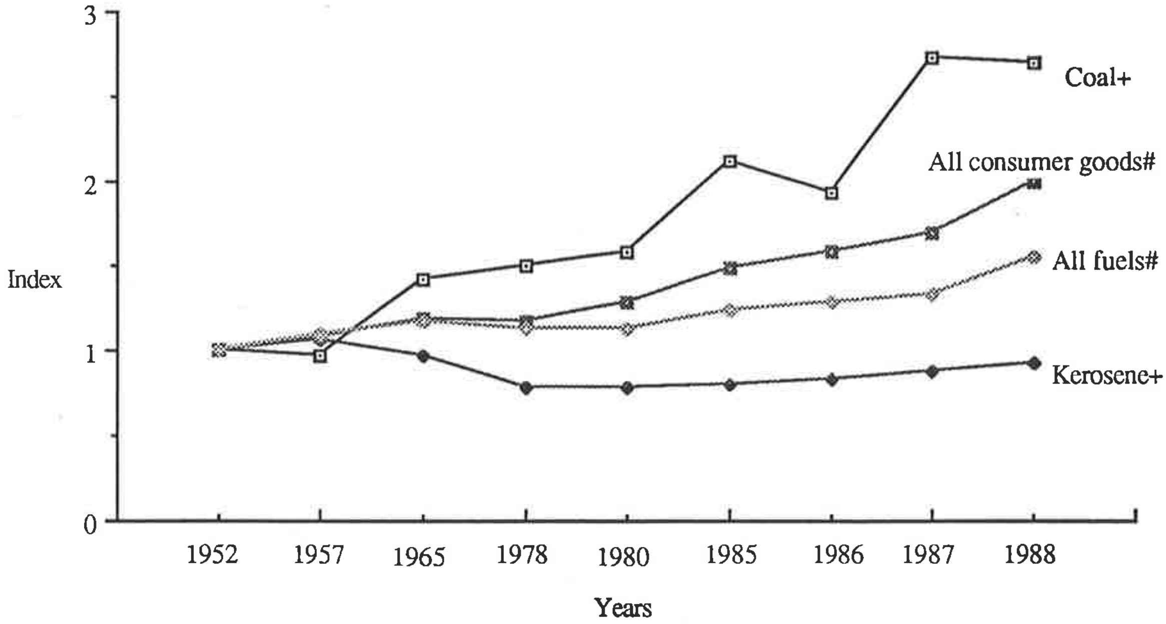
Estimates of excess demand for energy are widely reported, particularly for electricity. China Daily (1/18/1988) reports "the country was about 70 billion kilowatt hours (kwh) of electricity short last year (1987)". That is about 34% of China's present annual electricity generation. Qian Zhengying, the former Minister of Water Conservancy and Electric Power, quoted a more conservative figure of 25 billion kwh (South China Morning Post Supplement, June, 1987).

Quantitative estimates of petroleum or other fuels shortages are somewhat less common than those of electricity. But SINOPEC (the Chinese national organisation responsible for refinery operations) officials estimate that petrol production in 1985 fell short of demand by at least 2~3 million tonnes (Weil, 1986). This would imply a shortfall equal to 14~21% of the total production of gasoline in 1985. Indeed, it seems almost common-place to suggest that industrial production, the major consumer of energy, has been constrained by as much as 20~30%. A study by the Chinese Academy of Social Sciences in the two adjacent provinces of Liaoning and Jilin, the heavy industry base for China, concluded that "energy intensive industries are operating 20~25% under capacity because electric power and coal are in short supply" (Beijing Review, January 14–28, 1988).

One of the important reasons for the gap between energy supply and demand in China is that prices for energy products, especially for industrial applications, have been held very low, which reduce both the incentive to economise on consumption and raise its output. Figure 2.8 provides some background information on energy prices compared to China's domestic prices for consumer goods. Between 1965 and 1988, the *average* price of fuel rose considerably less than the average price of all consumer goods. Two other individual fuel price indexes are plotted for coal and kerosene, which are the only two fuel price data available from the same source as average fuel price index (State Statistical Bureau, 1989). While the coal price seems to increase faster than the average price for all consumer goods, most of this increase occurred after 1980, with the total increase in coal prices from 1965 to 1980 being just 10%. Kerosene fuel prices actually fell over this period which witnessed two oil shocks in the international market.

The low energy prices are also reflected in the comparison with energy production costs. The price calculations for coal and electricity do not include the investment costs for mine and power plants (Xu Shoubo, 1982). Similarly, oil price does not take account of costs incurred in geological prospecting and

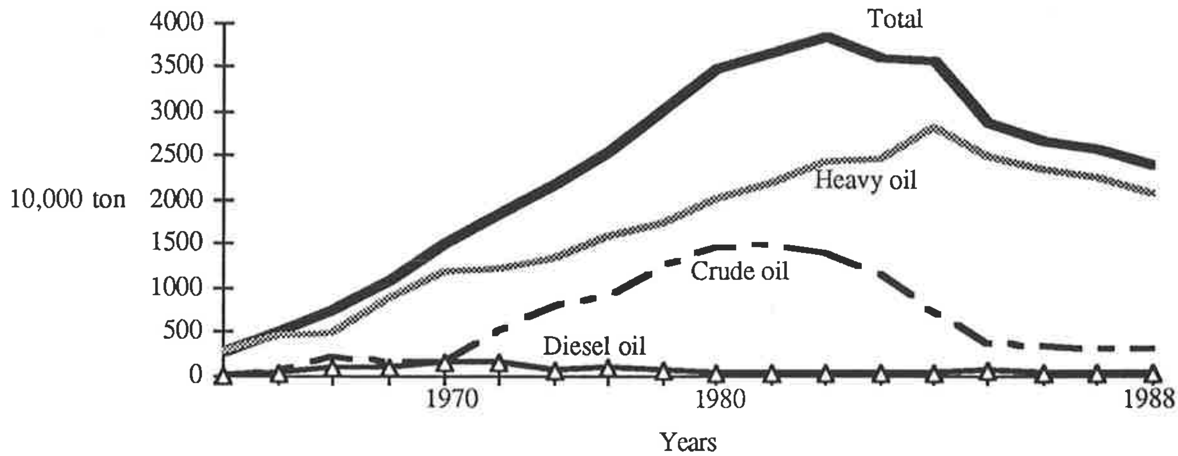
Figure 2.8: Energy Price Indices, 1952-1988, (1950=100)*



Notes: * The scale of the horizontal axis do not represent the same span of years. Rather, typical years are chosen to show the trend in price changes.
+ Mixed average retail prices.
# Retail price indices of state commercial department.

Source: State Statistical Bureau, Statistical Yearbook of China, Beijing, 1986-1989.

Figure 2.9: Oil Burned in China, 1966-1988



Sources: 1. Chinese Energy Research Association, The Current Situation and Prospect of Chinese Energy, Internal Publication, Beijing, 1986.
2. Ministry of Petroleum Industry, A Statistical Survey of China's Petroleum Industry, Restricted Publication, Beijing, 1988.

field construction. From 1984 to to 1988, the cost of coal production increased 26%, but the coal price increased only 16%. Over the same period of years, the unit production cost of oil rose by 150%, while the crude oil price increased 10% (Chen Zhongfa, 1990). The divergences between energy prices and energy production costs have put China's whole energy industry in serious financial situation. The coal industry has long been in deficit. A total loss of Rmb 12 billion Yuan was accumulated in state-owned coal mines from 1985 to 1989. The oil industry has also fell from a surplus sector in 1985 with Rmb one billion Yuan profit to a major deficit sector, incurring a loss of Rmb 2~3 billion Yuan annually since 1986. The electricity industry still manages to generate some profit but at a declining rate. The deteriorating financial situation in the whole energy sector has driven away possible capital investment such as local investment funds, bank loans, various bonds and foreign capital. As a result, the shortage of energy supply is intensified.

On the other hand, the low energy prices lead to excessive demand and inefficient energy consumption. The consumption of both commercial and total primary energy per unit GDP in China was well above two times than that of any other major developing countries, and four to six times higher than OECD countries (World Bank, 1985b). Energy intensities in industry are dependent upon the structure of industrial output. Indeed, the shares of output from the three most energy intensive major industrial subsectors – metallurgy, chemicals, and building materials – were surprisingly similar in China, South Korea and Japan over the period of late 1970s and early 1980s. However, China's energy intensity of industrial production was over twice the levels in South Korea and over three times the level in Japan in 1980 (World Bank, 1985b).

While the inefficient energy utilisation indicated by high energy intensities related directly to the low energy prices in China, it is also related to the irrational price structure within the energy sector. This is illustrated by the case of directly burned crude oil. Massive waste of oil occurred in China as large amount of oil is burned as fuel. Figure 2.9 shows the quantity of directly-burned oil from mid-1960s to late 1980s. Oil burned in the oil industry itself is not included. Taking into account oil consumed within the oil industry, then nearly 50% of China's annual consumption of oil is directly burned as fuel (Zhang Wenzhong, 1988).

The massive waste of burned oil was caused by a distorted energy price structure which gave inadequate attention to the relationship between the prices of the various energy sources and the effect that the relative price structure has on the mix of energy use. The crude oil price was set extremely low with the cost of exploration and capital formation of oil fields excluded. As a result, it was even cheaper to burn oil than to burn coal which was already priced 40% lower than its long run marginal cost (World Bank, 1985b). A tonne of fuel oil was priced at Rmb 60 Yuan. In terms of calorific value, one tonne of fuel oil is equivalent to more than two tonnes of coal. But coal was priced at Rmb 25 Yuan per tonne, and taking into account of higher transportation cost of coal, it turned out that in areas far from coal mines such as northeast or east China, it was more expensive to use coal than to burn oil. The irrational prices for coal and crude oil in China are in sharp contrast to the international prices. The ratio of the oil to coal prices in the international market in 1987 is about 4.5 per tonne (US Coal Weekly, 10/8/87), nearly double the ratio of 2.5 per tonne (Rmb 60 Yuan/Rmb 25 Yuan) in China.

2.4.2 Two-tier price system and international comparisons

The upward trend of the price index curves after 1978 in Figure 2.8 reflects the price reform took place in the process of economic reform. The well known two-tier prices initially adopted in the consumer's goods market to allow above-quota prices to increase for goods in shortage pushed up the average prices for consumer goods. This two-tier price system was later instituted in the whole Chinese economic system and the energy sector was no exception. The coal price was the first energy price subject to reforms in mid-1979, before which only an "official" coal price was applied to all coal output, and it had changed little since the 1950s. To aid profitability and encourage output, coal produced above a "quota" (delivered to the state at official price) can be sold at *above-quota* prices, which are a lot higher than the official *under-quota* prices. Thus a two-tier price system was created for coal. The same system was introduced to the petroleum industry in 1983.

Table 2.11 presents the two-tier prices for China's major energy products. It shows surprisingly wide divergences between under-quota prices and above-quota prices. The divergence is most pronounced in crude oil prices with the above-quota price three fold higher than the under-quota price. The above quota prices for some better quality crude oils are even higher than the national average of Rmb 400 Yuan per tonne listed in Table 2.11. Crude produced at Daqing and Shengli oil fields are sold at Rmb 650 and 520 Yuan per tonne respectively. The price divergence for gasoline appears very small compared to those for other fuels. Care should be taken in interpreting the variations of price divergence across oil related products, as all above-quota prices for crude oil and petroleum products are subject to state supervision. In most cases, the above-quota prices are actually price ceilings set by the government, although these price ceilings are looked upon by producers as the minimum level charged in practice.

In contrast, the above-quota prices for coal are largely determined by market forces. Since 1983 when the government adopted the policy of encouraging rural collective and private mines, coal from the "local" mines has been allowed to be sold on free market prices. To the end of 1989, about half of the coal output was sold under above-quota prices with 91,000 collective and private mines involved (Liu Shujie, 1990). The above-quota coal prices reflect the market allocation of coal at the margin.

The two-tier prices for other energy products such as natural gas and electricity are not available. As far as electricity is concerned, the State Council

Table 2.11: Two-tier Prices of China's Major Energy Products, Early 1985 (Rmb Yuan/Tonne)

	Under-Quota Prices A	Above-Quota Prices B	(B-A)/A %
Crude oil	100	400*	300
Petroleum products			
Gasoline	700	860	14
Kerosene	420	850	102
Diesel oil	275	845	207
Coal#	56	150	169

Notes: * Average price, better quality crude oil such as Daching and Shengli crude oil were sold at higher prices of Rmb 650 Yuan/tonne and Rmb 520 Yuan/tonne, respectively.
\# Average prices as at March, 1990.

Sources: 1. State Material Administration, A Collection of Documents in National Energy Management, Beijing, 1984.
2. World Bank, China: The Energy Sector, World Bank, Washington D.C., 1985b.
3. Liu Shujie, A Research Report on Issues of the Two-Tier Prices of Coal, in the journal of China Price, Beijing, 1990.

abolished the central government's monopoly on large-scale electricity generation in the summer of 1985. Local governments and departments are now allowed to construct and operate their own power plants, as well as joint ventures with foreign companies, and to fix their electricity prices according to local supply and demand conditions.

As pointed out above, the second tier prices for oil related products, even though much higher than the official prices, are still not real market prices as they are under close monitoring by the state. In order to have a better understanding of crude oil and petroleum products pricing in China, it is helpful to compare the Chinese domestic energy prices to international energy prices.

Table 2.12 presents a comparison over time between China's domestic prices and international prices for oil products from 1961 to 1987. The international prices were converted to domestic currency using average annual official exchange rates applicable to the years referred to in Table 2.11 (Cai Dezhong and

Song Hua, 1985; State Statistical Yearbook, 1986-90).

For crude oil, it is believed that before 1971, China's domestic crude oil price was in line with the production cost and the international price level (Zheng Jifuang, 1987). However, there was a significant contrast in the oil price movements inside and outside of China between 1970 and 1980, as shown in the table. Over this period of time, the world oil price soared by more than 18 times, but China's domestic oil price fell by 20% as a result of the "substituting oil for coal" policy adopted in the Cultural Revolution which reduced the domestic oil price to encourage using oil as fuel (Yuan Fuxue, 1986).

The extremely low price for oil compared to the world price level continued to 1983 until the second-tier price was introduced, and the price of Rmb 103 Yuan per tonne was continued to be used in the state plan. The second-tier prices in the table were set by the government at a higher level for above-quota production. The output in 1981 was used as the quota base, so any output exceeding the 1980 production level was sold to the state at above-quota prices. The initial second-tier prices for crude oil and petroleum products in 1983 were actually higher than the international prices as shown in the table. These 1983 second-tier prices remained at the relatively high level to early 1985. In late 1985, the second-tier prices for crude oil and petroleum products (except gasoline) were adjusted downwards.

A third-tier price was introduced for petroleum products in 1987. They were market transaction prices, and were much higher than the international level in the 1980s. But crude oil has remained in the two-tier price arrangement. The under-quota oil price stays at about 20% of the world price level, which has important implications for China's external energy policy as will be discussed in the following section.

Table 2.12: Comparison of China's Home Energy Prices with Energy Prices Abroad (Rmb Yuan/Tonne), 1960-1987

	Crude oil* (Daqing)	(Shengli)	Gasoline	Diesel	Kerosene	Heavy oil
1960-1970						
Average price in China	130		-	-	-	-
OPEC price	32			-	-	-
1971-1982						
Average price in China	103		-	-	-	-
OPEC price	209.5 (468.5)#		-	-	-	-
1983						
Under-quota price in China	100	100	700	275	420	55
Above-quota price in China	650	520	860	845	850	500
World Price	558.8		500	710	784	853
1985						
Under-quota price in China	100	100	700	275	420	55
Above-quota price in China	545	475	880	745	810	460
World price	627		870	774	857	585
1987						
Under-quota price in China	100	100	700	275	420	55
Above-quota price in China	545	475	880	745	810	460
Third tier price in China	545		1030	900	810	-
World price	468		633	569	617	415

* After the introduction of the two-tier price system in 1983, the average oil price only applies to the first tier planned price, the second tier oil prices differ from one oilfield to another according to the quality of oil. In this table two oil prices in two major oil fields in China are used. The two oil fields are Daqing (Big Celebration) and Shengli (Victory).

\# Figure in brackets was the highest price in 1982.

Sources:
1. State Materials Administration, Documents in National Energy Management, Beijing, 1984.
2. Zhang Wenzhong, Comparison of China's Petroleum Prices with International Market Prices, *Journal of Cost and Price*, XXI, Beijing, 1988.
3. Zheng Jifuang, On the Establishment and Reforms of China's Petroleum Price System, *Journal of Price Theory and Practice*, V, Beijing, 1987.

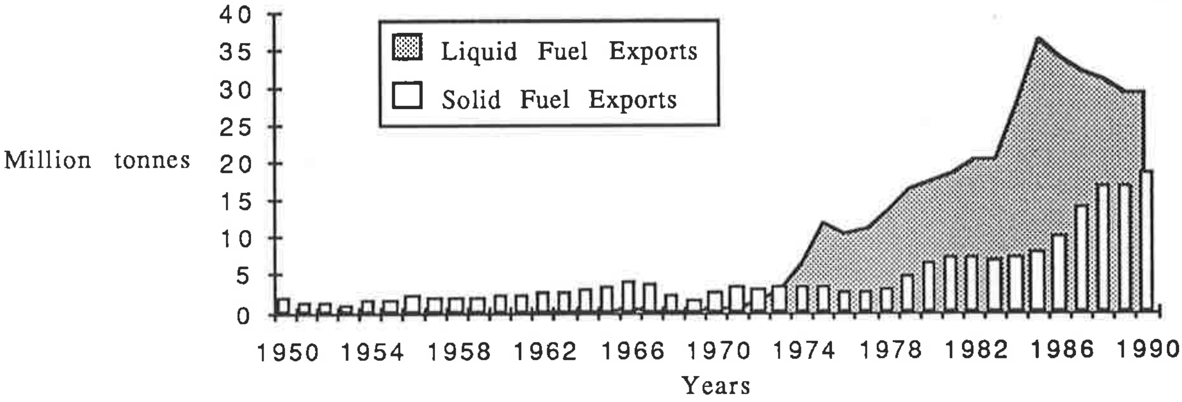
2.5 China's Energy Trade and the World Oil Price Decline in 1986

The gap between the under-quota and above-quota energy prices has significant impact on China's energy trade. An important consequence of the energy price distortions is the government's rent taxation policy in energy trade. Energy products subject to the first-tier prices are delivered to the government for planned allocation. As the under-quota prices are so low compared to international prices, a large amount of energy is exported by the government to reap the profits in foreign currency. The energy price differential becomes effectively an export tax which generated substantial export revenues to the government.

Figure 2.10 shows China's energy exports from 1950 to 1990. While domestic consumers have been faced by energy shortages, China has been an energy exporter since the inception of the People's Republic in 1949. The bars in Figure 2.10 represent China's solid fuel exports (coal and coke). The quantities involved in this trade were quite small by international standards, but the early trade in solid fuels established a network of trade contacts throughout the region that was available when China began considering energy exports on a larger scale in 1973 following the oil price hikes. The shadowed area shows China's liquid fuel exports (crude oil and petroleum products). The sudden increase in 1975 reflects the switch of the national energy policy to use crude oil exports as a powerful tool to gain access to an increasing variety of foreign plants, equipment and technology.

The "energy export - technology import" formula did work for China, but at a high cost. The export orientation of China's oil sector reinforced the energy bottlenecks in the Chinese economy. Unlike other oil-exporting countries, the oil China exports is not surplus production. China's oil consumption is very low in its final energy consumption mix, but abundant resources of coal allow China to meet national energy demand. The supply of oil to most oil users in China is controlled by quotas in the national plan. So the oil exported

Figure 2.10: Volumes of China's Energy Exports, 1950-1990



Source: State Statistical Bureau, Statistical Yearbook of China, Beijing, various volumes.

by China is squeezed from domestic consumption. Strong opposition existed within the government against exporting oil. The opposition described oil export as "selling the country's life blood". But the acute need to balance its bilateral trade with other countries such as Japan, and the need to generate hard currency for the import of technology and necessary materials, and also the obligation of promoting trade relations with certain friendly countries such as North Korea all led China to export a substantial amount of oil. The share of China's oil exports in its oil production increased from 10% in 1973 to 24% in 1985 (Table 2.13). In 1985, China became the largest oil exporter in Asia, and overtook other major oil exporters such as Indonesia in the region (Fridley and Christoffersen, 1988).

The foreign exchange revenues generated by China's oil exports are substantial. About 60~70% of China's energy export revenues are from crude oil exports, while 20% from petroleum products, and 10% from coal and coke. Table 2.14 shows the export revenues by China's liquid fuel exports (combining crude oil and petroleum product exports together). In the peak year of 1985, China's liquid fuel exports reached above 25% of China's total commodity export revenues. However, this figure dropped below 10% in 1986 as the world oil price collapsed from over US$ 30 per barrel to below US$ 10 per barrel. China's crude oil export revenues declined from US$ 5.5 billion to US$ 2.3 billion in 1986, a reduction of about 60%. In the following years China's oil revenues remained at a low level as the world oil price was unable to recover from the crash (Table 2.14).

Owing to the sustained downturn of the world oil market, China adjusted its planned annual exports of oil, cut the volume by about 10% in 1986, and gradually reduced oil export in the following years. At the same time, China increased its imports in both crude oil and petroleum products (Table 2.13). But clearly, the percentage change of China's net oil export is smaller than the percentage change in world oil prices, reflecting the low price elasticity of China's oil export due to China's acute demand for foreign exchange.

Oil held back from exports and additional volumes imported have been quickly absorbed by domestic refineries. This demonstrates that China's shortage in petroleum products is not related to its refining capacity, but inadequate supply of crude oil. The yearly quota allocated to China's refineries is below the processing capacity.

Due to the turmoil in world oil market and the acute demand for oil in China's domestic market, the future of China's oil exports will undoubtedly be the focus of intense attention and concern. In the past few years, China has been importing petrochemical products worth billions of US dollars such as fertilisers, plastics and synthetic rubber. From a long-term point of view, it is not economical to increase exports of crude oil on one hand and import large amount of petrochemicals on the other. The recent slow-down of economic reforms in China and the unfavourable international environment for China after the "June Incident" in 1989 also point to a dim future for China's oil exports.

Table 2.13: Energy Balance for China's Major Energy Export Products, 1980-1990, (million tonnes)

Year	Coal				Crude oil				Refined petroleum			
	Production	Exports	Imports	Consumption*	Production	Exports	Imports	Consumption	Production	Exports	Imports	Consumption
1980	620.15	6.32	1.99	615.82	105.95	13.31	0.37	93.01	34.67	4.20	0.07	30.54
1981	622.00	6.94	1.93	616.99	101.22	13.84	0.07	87.45	33.82	4.58	0.11	29.35
1982	666.30	6.73	2.19	661.76	102.12	15.20	0.64	87.56	33.57	5.27	0.13	28.43
1983	714.50	6.55	2.14	710.09	106.07	14.92	0.37	91.52	37.06	5.40	0.14	31.81
1984	789.20	7.04	2.49	784.65	114.61	22.01	0.25	92.85	37.13	5.70	0.16	31.58
1985	872.28	7.77	2.31	866.82	124.89	30.03	0.72	95.58	37.43	6.21	0.20	31.42
1986	894.04	9.82	2.47	886.69	130.69	28.50	1.08	103.27	40.16	5.46	1.66	36.37
1987	927.97	13.53	1.94	916.38	134.13	27.23	1.72	108.62	44.96	4.94	1.98	42.00
1988	979.88	15.65	1.69	965.92	136.87	26.05	1.96	111.67	49.44	4.79	3.07	47.71
1989	1054.14	15.34	1.95	1040.75	137.64	24.39	3.69	116.51	52.31	4.74	5.43	53.01
1990	1079.90	17.29	2.00	1064.61	138.31	23.99				5.26		

* All consumption data in the table are derived from production minus exports plus imports, changes in stocks are not included.

Sources: 1. Almanac of China's Foreign Relations and Trade, Beijing, 1990/91.
2. China's Statistical Information Consultancy Service Centre, China's Latest Economic Statistics, CITIC Research International,1988-89.
3. Energy Statistical Yearbook of China, Internal Publication, Beijing, 1986.
4. General Administration of Customs, China's Customs Statistics, Economic Information & Agency, Hongkong, January, 1990.
5. State Statistical Bureau, Statistical Yearbook of China, Beijing, various volumes.

Table 2.14: China's Oil Export Revenues, 1958-1990, (US$ million)

Year	Crude oil export revenues	Refined petroleum export revenues	Total oil export revenues	% in merchandise export revenues
1st Five-year-plan (1953-57)	-	-	-	-
2nd Five-year-plan (1958-62)	1.77	2.88	4.65	0.04
Adjustment Period (1963-65)	13.12	14.61	27.73	0.40
3rd Five-year-plan (1966-70)	25.76	52.88	78.64	0.60
4th Five-year-plan (1971-75)	1322.59	554.13	1876.72	7.10
5th Five-year-plan (1976-80)	7164.65	2695.38	9860.03	17.57
6th Five-year-plan (1981-85)	19227.51	7511.98	26739.49	23.20
7th Five-year-plan (1986-90)	14142.59	4005.59	18198.91	7.83
1975	803.19	204.27	1007.46	13.88
1976	671.37	200.41	871.78	12.71
1977	773.14	182.01	955.15	12.58
1978	958.39	262.04	1220.43	12.52
1979	1749.76	693.04	2442.80	17.88
1980	3011.99	1357.88	4369.87	24.12
1981	3304.66	1480.21	4784.87	21.74
1982	3304.87	1602.97	4907.84	21.99
1983	2907.75	1440.32	4348.07	19.56
1984	4261.51	1475.32	5736.83	21.95
1985	5448.72	1513.16	6961.88	25.45
1986	2311.12	768.66	3079.78	9.95
1987	3162.80	837.79	4000.59	10.14
1988	2579.64	764.22	3343.86	7.04
1989	2750.06	757.55	3507.61	6.68
1990	3338.97	877.37	4267.07	6.87

Sources: 1. Ministry of Petroleum Industry, A Statistics Survey of China's Petroleum Industry, Restricted Publication, Beijing, 1988
2. State Statistical Bureau, Statistical Yearbook of China, Beijing, various volumes.

But China may well use oil as a tool to resume ties with other countries, and the semi-official view held by SINOCHEM,[8] that oil exports should be maintained at a base level, and allow adjustments within a certain range (Dong Yongshun, 1988), implies that it is still too early for a clear picture to emerge of the near future for China's oil trade.

Other energy trades such as coal have been small relative to oil. China's coal exports have been very sensitive to oil price changes. Following the world oil price hike in 1979, for example, China's coal exports increased by 48.2% in one year, mainly due to an increased demand for coal in Japan and Hongkong, since oil was more expensive. In the following years, China steadily increased its coal exports (Table 2.13). This has been accelerated since 1986 in an effort to make up the reduced oil exports due to the downturn of the world oil market. But how much coal is China capable of exporting? The analysis in the consumption section of this chapter implies that there will not be any dramatic increase in China's coal exports in the near future because of China's continuing dependence on coal as its major energy source.

2.6 Conclusions

Although China is rich in energy resources, the supply of energy is far behind the demand. Energy shortages are a bottleneck constraining the development of the Chinese economy. The problem has been aggravated in recent years as the economy grows rapidly following the economic reforms. The origins of energy shortages are traced to the distortions of energy prices in China.

Two aspects of the energy price distortions in China are identified. One is that the level of prices for energy products are held very low compared to both domestic prices for consumer goods and international energy prices. The other is that the price relativities between energy products are irrational. The low

[8]The largest state-run foreign trade corporation in China.

energy price level reduces the incentive to economise on consumption and raise output, and also gives rise to the government's rent-seeking policy which forces the export of substantial quantities of energy. The irrational price structure within the energy sector generates inefficiencies.

Price reforms in energy sector are important to correct these distortions and to achieve balance of energy supply and demand in China. Price increases for energy products are essential to reduce excess energy demand in the economy. To put it in the Chinese way, as long as a bottle of *Maotai* [9] costs more than a tonne of oil, people can hardly be expected to economise on the consumption of the scarce energy resources. Low energy prices also prevent energy producers from being able to accumulate capital for investing in the energy sector. While increasing the general price level for energy, it is equally important to establish a price structure reflecting the economic costs of different energy products to prevent inefficient energy utilisation.

The analysis in this chapter shows that while there is a perceptible downturn in the growth of China's energy production as indicated by the energy production data, the rapid growth of the Chinese economy has and will continue to put severe pressure on energy supply, particularly on oil and electricity according to the energy consumption mix analysis. Coal will remain as the major energy source in China in the foreseeable future. This adds to the energy challenge the need to minimise the potential adverse environmental impact associated with coal consumption.

Given the acute demand for energy in China's domestic market, the turmoil in the world energy market since the 1986 oil price shock has reinforced the problems in China's energy sector by reducing energy export revenues as a source of investment funds to increase energy production capacity. At the same time, the change in the world oil market added uncertainties to China's future energy trade. The impact of the 1986 oil price shock on the the Chinese

[9] *Maotai* is Chinese alcoholic spirit.

economy will be discussed in the rest of the thesis.

Chapter 3

The Theoretical Structure

3.1 Booming Sector Economics Literature

A large body of literature has grown up in recent years dealing with the phenomenon of resource-based sectoral booms which initiate complex intersectoral effects that actually retard growth in other parts of the economy. This literature has come to be known as "Booming sector economics" (Corden, 1984), and the phenomenon observed has been termed "Dutch disease" inspired by the case of Slochteren gas discovery in the Netherlands in the 1960s which adversely affected parts of the Dutch economy (Kremers, 1986). The term "Dutch disease" implies that the consequences of a natural resource discovery are harmful. However, the initial impact of a resource boom is beneficial and amounts to a Pareto improvement for the economy as a whole. Concerns arise over the distribution of gains, and the appropriate adjustment of the economy to its new equilibrium. In the Dutch gas boom, the windfall of gas export revenues led to the appreciation of Dutch guilder against other currencies, exposing Dutch manufacturing to more intense foreign competition and causing unemployment.

The symptoms of Dutch disease occurred in many countries with natural resource discoveries. Notably, Australia's gold discoveries in the 1850s (Maddock and Mclean, 1984) and the mineral booms in the 1960s (Gregory, 1976;

Snape, 1977), Britain's North Sea oil discovery (Forsyth and Kay, 1980), all had adverse effects on the traditional exporting sectors and import-competing industries.

Another source of a boom which causes Dutch disease effects is a major price increase for export products. This was highlighted in the 1970s when boom conditions prevailed in world markets for several primary commodities. The two oil price shocks in 1973 and 1979 increased the oil price by a factor of 22 between 1970 and 1980. Prices for several other primary commodities also soared as shown in Table 3.1. For countries exporting one or more of these commodities, buoyant export revenues should have stimulated economic growth. However, there were indeed countries whose export booming sector failed to transmit growth to the rest of the economy. Kuwait (oil), Nigeria (oil), Bolivia (tin, gas) and Tanzania (coffee) were below-average performers, and Jamaica (bauxite, alumina) and Ghana (cocoa, wood) failed to grow at all (Roemer, 1985).

The Dutch disease may also result from large capital inflows associated with commercial borrowings, aid flows and migrant workers' remittances. These were observed early in the 16th century as gold flowed from South America to Spain (Forsyth and Nicholas, 1983), or in the past few years in Bangladesh and Sri Lanka as a consequence of large foreign aid receipts (Lal, 1985). Countries such as Turkey, Egypt were "infected" by income remittances from their overseas migrant workers (Hansen, 1986; Kirwan, 1985).

The impact of the Dutch disease has been studied extensively. A great many models have been developed dealing with various aspects of the Dutch disease, and are applied to specific country cases. The common features of these country studies are contained in the core model of the booming sector economics literature presented by Corden (1984).

Table 3.1: Price Indexes for Booming Commodities, 1970-80

Commodity	Index (1970=100) for 1975	1980*
Aluminium	141	306
Cocoa	192	363 (623 in 1977)
Coconut oil	124	219 (238 in 1979)
Coffee	143	298 (453 in 1977)
Logs	156	447
Petroleum	826	2210
Pulp	287	412
Rice	251	301 (376 in 1974)
Rubber	142	348
Sisal	381	503
Sugar	408	245
Tin	189	466
For Comparison: +		
US Wholesale Prices	159	243
LDC Import Unit Values	217	373
All Primary Commodities#	173	288

* Figures in brackets give high levels for the decade if different from the 1980 level.
+ IMF indexes.
# Excludes petroleum.

Source: International Monetary Fund, International Financial Statistics Yearbook, 1982.

3.1.1 The core model

In a general equilibrium framework, three sectors are defined in the "core model": (1) the "booming" sector which could be the oil sector or any other exporting industry facing a rising price in the world market, or undergoing Hicks-neutral technological changes, or a sector with a major resource discovery; (2) the "lagging" sector or other tradable sector, including other exporting and import-competing industries and agriculture; (3) the non-tradable sector, including services, transports, etc.. To capture the essential features of the repercussion among the three sectors in the disturbance of a boom, the main analysis is simplified by introducing the following assumptions:

i) The small country assumption

The prices of tradable goods produced in the first two sectors are exogenously fixed by world markets, whereas the prices for non-tradable goods are determined by domestic supply and demand conditions.

ii) Short-run assumption

Each sector in the model employs two factors, capital (K), and labour (L). However, capital is *specific* to each sector, K_b, K_l and K_n.[1] Only labour is mobile between sectors. The stock of all factors is fixed, that is, there is no international mobility for either labour or capital. Factor prices are flexible to maintain *full employment.*

iii) Domestic absorption assumption

The model assumes the outputs of the three sectors are all final consumption goods, and the booming sector products are all exported, so the main analysis of the model ignores issues about domestic absorption of the booming sector products, either as intermediate inputs or home consumed final goods. This

[1] The subscripts of b, l, and n for K stand for capital in booming sector, lagging sector, and non-tradable sector, respectively.

makes the model a more general analysis, to which a domestic absorption effect can always be superimposed when relevant in application.

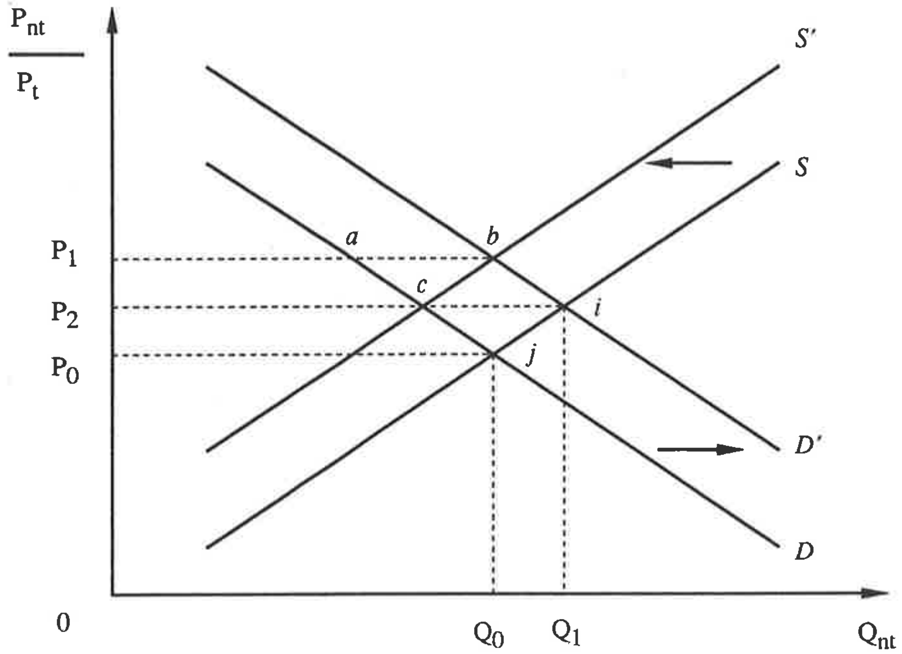
The model then focuses upon the intersectoral repercussions of the asymmetric rapid growth of the booming sector in terms of resource allocation and income distribution. Basically, two effects are identified, the spending effect and the resource movement effect, which we will discuss in turn.

Spending Effect

The equilibrium of the model can be described solely in terms of market clearing for the non-traded goods, for which by definition, domestic demand must equal domestic supply. Following the boom, higher domestic incomes lead to extra expenditure on both tradable and non-tradable goods. The extra income spent in the lagging sector does not raise concern as the boom-induced excess demand does not lead to a rise in prices of tradables, whose prices are determined in world markets; excess demand for tradables is met through additional imports. However, the excess demand for non-tradables can only be eliminated by a rise in their relative price, that is, the price of non-traded relative to traded goods, which is a key variable in the adjustment process. Its inverse, the price of traded relative to non-traded goods, is often referred to as the real exchange rate, which determines the supply and demand of non-traded goods. Following the increase of the relative price of non-traded goods, the real exchange rate falls (a real appreciation). This will draw resources (labour) out of the lagging sector into the non-tradable sector, so that non-tradables output rises and other tradables output falls. The consequent decline in employment and output in the lagging sector is called the "Dutch disease".

The adjustment of the economy to a boom brought about by a move of the real exchange rate can be illustrated in Figure 3.1 which shows the equilibrium in the non-traded goods economy. The vertical axis represents the relative price of non-tradables to tradables, and the horizontal axis measures the output of

Figure 3.1: Non-Traded Goods Market in the Booming Sector Model



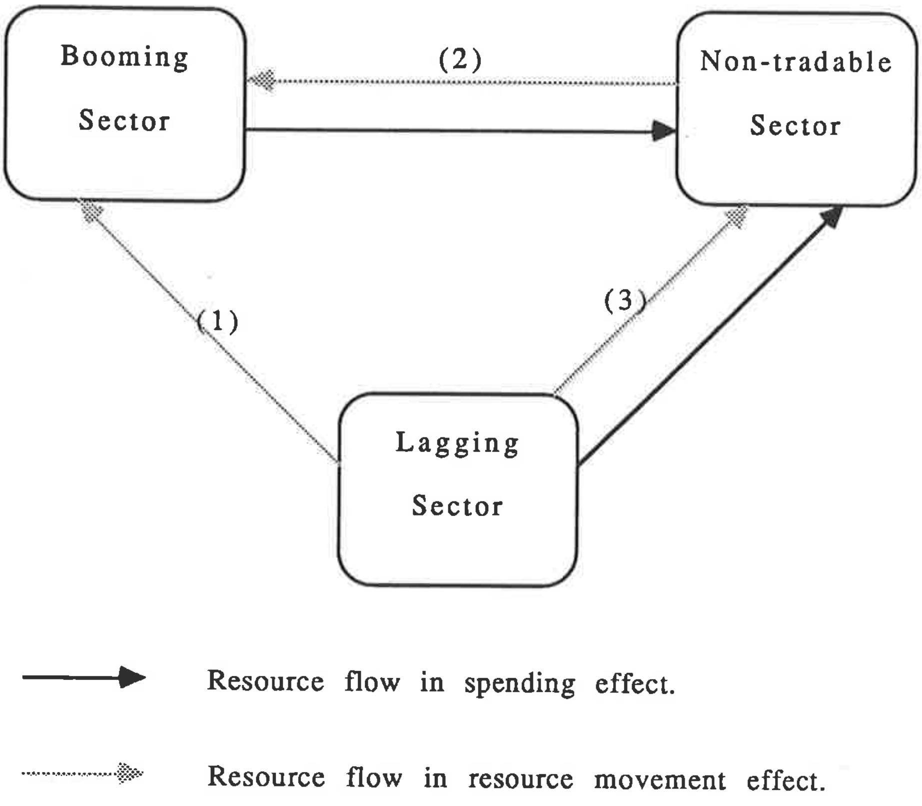
non-traded goods. The initial equilibrium of the non-traded goods economy is given by the intersection of the supply curve (S) and demand curve (D). The supply curve solely depends on the relative price of non-traded goods which determines the transformation of resource between non-traded and traded goods. The demand curve shows the demand for non-traded goods at various relative prices of non-traded goods when expenditure is always equal to income which is fixed exogenously by the assumption of full employment, except that the boom changes the level of income in a once-off fashion.

When the boom brings a windfall of income to the economy, the demand curve shifts out which creates excess demand for non-traded goods at P_0 measured on the vertical axis. This is the spending effect. To move to equilibrium in the non-traded goods economy, the relative price of non-traded goods must increase from P_0 to P_1, that is, the real exchange rate appreciates. This draws resources out of the tradable sector into the non-tradable sector, and the output of the non-traded sector increases from Q_0 to Q_1.

Resource movement effect

The resource movement effect is activated when the marginal physical product or value of labour in the booming sector is increased due to the boom, causing labour to move from both the lagging sector and the non-tradable sector into the booming sector. Three flows of labour are identified in this resource movement effect as illustrated in Figure 3.2. The first flow of labour is from the lagging sector to the booming sector, and is usually labelled "*direct* de-industrialisation" (Corden, 1984) as the lagging sector is generally manufacturing in industrialised economies. This movement of labour does not involve a real exchange rate appreciation. The second flow of labour is from the non-traded sector to the booming sector. It brings about another appreciation in addition to the one resulting from the spending effect. This is illustrated by transforming the second labour flow in Figure 3.2 to changes of the supply

Figure 3.2: Resource Flows in the Booming Sector Model



curve in Figure 3.1. When labour moves out of the non-tradable sector to the booming sector (the second flow of labour in Figure 3.2), the supply curve for non-traded goods in Figure 3.1 is shifted in from S to S', so further excess demand is created in addition to that induced by the spending effect as shown earlier in Figure 3.1. To restore equilibrium in the non-traded goods market, a further appreciation is occurred ($P_1 \rightarrow P_2$). This in turn causes a third flow of labour in Figure 3.2 which is labour attracted from the lagging sector to the non-tradable sector. This third flow of labour in the resource movement effect and the resource flow in the spending effect from the lagging sector to the non-tradable sector are together labelled "*indirect* de-industrialisation".

The term "de-industrialisation" is generally used in industrial economies where the lagging sector mainly consists of manufacturing industries. In developing countries, where the agricultural sector is more important, the lagging sector is likely to include agriculture as well as manufacturing. The boom may then cause both "de-industrialisation" and "de-agriculturalisation" (Timmer, 1982) as has occurred to some extent in Indonesia (Warr, 1986), Papua New Guinea (Jarrett and Anderson, 1989) and Nigeria (Pinto, 1987).

Combining the two effects, it is very clear that there is an unambiguous decline in the output of the lagging sector as there is a net outflow of labour in that sector, but the impact on non-tradables output is uncertain as there are both inflows and outflows of labour in the non-traded sector. While the spending effect tends to increase non-traded goods output, the resource movement effect tends to decrease it. But ultimately the net effect depends on the strength of the spending effect. This uncertainty about the output of the non-traded goods sector is, however, avoided when the Dutch disease is modelled in a slightly different way as we shall see in the next section.

3.1.2 Traditional two-sector model

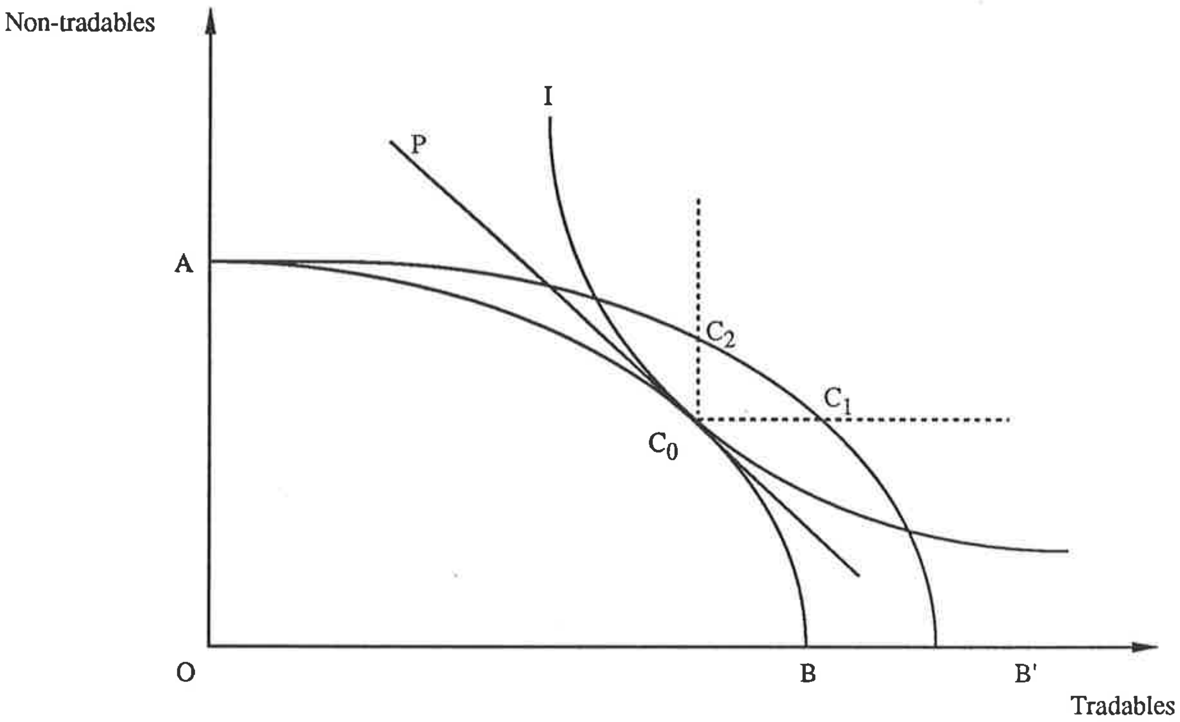
Most of the literature on booming sector economics is firmly rooted in the above three-sector core model. However, a simpler approach in modelling the Dutch disease exists in literature (Salter, 1959; Snape, 1977).

This approach reflects the fact that the booming sector is very often highly capital intensive, for example, petroleum and mineral industries. Under the capital-specific assumption, it may employ only small quantities of the mobile factor (labour). So the boom induced demand for labour in the expansion of the booming sector is negligible. Consequently, the "resource movement effect" in the economy is eliminated, and the boom operates in the economy solely through a "spending effect". Since the booming sector becomes an "enclave" in the sense that it does not really compete with other sectors for factors of production, the effects of a boom can be analysed in a model without a booming sector separately defined, and the three-sector core model collapses into a traditional two-sector model which distinguishes a composite tradable sector whose price is fixed exogenously and a non-tradable sector whose price is determined domestically.

The results of this simple two-sector model are consistent with those derived in the core model, and are more clear-cut. That is, the effect of boom gives rise to both real appreciation and de-industrialisation (and/or de-agriculturalisation), and the pattern of output after the disturbance of boom is unambiguous: the output of the lagging sector drops and the output of the non-tradable sector increases. This may be illustrated by using a production possibility frontier diagram (Snape, 1977).

In Figure 3.3, the traded goods output (including both other traded and booming sector output) is measured along the horizontal axis and non-traded goods output is measured along the vertical axis. The curve AB is the initial production possibility frontier. Before the boom, the equilibrium for production

Figure 3.3: Traditional Two-Sector Model



and consumption is at the point C_0 where P represents the relative price of non-tradables (reciprocal of the real exchange rate) and I is the highest attainable social indifference curve.

The boom shifts the production possibility curve from AB to AB'. The new production possibility curve AB' is drawn in a very special way as it has shifted *horizontally* by the same amount for each value of non-tradables production. Such a shift occurs only when the additional production of tradables shares no factors with non-tradables and other tradables. In this case the marginal cost of tradables is unchanged at any given level of non-tradables production. In other words, the boom is like a gift to the economy in the sense that it does not affect the production of non-tradables, nor does it affect the production of other traded goods as the slope of AB' at point C_1 due east of C_0 equals the initial real exchange rate. This implies that domestic output of both non-traded goods and other traded goods remains unchanged but total domestic availability of traded goods is augmented by the boom in a same manner as an "exogenous transfer".

The outshift of the PPF increases domestic real income, so that consumption of each good will change accordingly. If the non-traded goods marginal propensity to consume is zero, then their consumption remains unchanged even though income is higher. The new equilibrium point would then be at C_1. However, if non-traded goods are normal goods, the new equilibrium will lie on AB' somewhere above C_1, indicating higher consumption of non-tradables. A similar argument establishes that when traded goods are non-inferior, the new equilibrium must lie between C_1 and C_2.

The outcomes of the model summarised by this new equilibrium point are similar to those derived in the core model: (1) There is an excess demand for non-tradables, which causes a real appreciation. This is obvious as all points on AB' to the north-west of C_1 correspond to a flatter slope, implying the relative price of non-tradables increases. (2) The higher relative price of non-traded goods makes domestic production of traded goods less attractive, and a reallocation of resources in the direction of de-industrialisation and/or de-agriculturalisation takes place. The output of non-traded good increases whereas the output of other traded goods falls, even though the production of the composite traded good (the booming commodity and other traded goods as a whole) rises.

3.1.3 Monetary aspect of the "Dutch disease"

Most booming sector theory literature is focused in the real effects of a shock. However, especially in the short run, the allocation of real resources involves monetary considerations. In the simplest case, a boom will generate a balance of payment surplus and accumulate foreign reserves. If the monetary authority adopts a neutral stance, then the base money will enlarge due to the increase in foreign reserves. This will lead to excess money supply in the economy, which will push up the price level. This provides a possible mechanism through which the real appreciation can take place. This aspect of the "Dutch disease" has not been overlooked. A number of studies have gone beyond the real effects of a boom, and emphasised the spillover of monetary effects to the real side of the economy (Neary and Wijnbergen, 1986; Neary, 1984; Edwards, 1985 and 1986).

A simple theoretical framework used by Neary and Wijnbergen (1986) to incorporate both real and monetary factors in the booming sector model is to make explicit the nominal prices for tradables and non-tradables. Therefore, not only the relative prices, but also, the *price level* is also taken into consideration in the equilibrium conditions of the model. The domestic price level P is assumed homogeneous of degree one in the prices of tradables (P_t) and non-tradables (P_n):

$$P = f(P_t, P_n) \tag{3.1}$$

In Figure 3.4, P_t and P_n are represented by the horizontal and vertical axis, respectively. Notice P_t in equation 3.1 refers to the domestic price for traded goods, therefore P_t is given by $e \cdot P_t^w$, where e is the *nominal* exchange rate (the domestic currency price of a unit of foreign exchange), and P_t^w stands for the world price for traded goods. For simplicity, P_t^w is set to unity, so P_t is identified with the nominal exchange rate e.

The schedule NN in Figure 3.4 represents the real side of the economy. The equilibrium of the real side of the economy can be derived from the market clearing conditions for the non-tradable sector as in Figure 3.1. Obviously, a rise in P_n induces an excess supply of non-traded goods, while an increase in P_t will cause excess demand for non-tradables. The schedule NN is therefore an upward sloping line. More over, the introduction of money into the model implies that an equiproportionate increase in P_t and P_n will lead to excess supply of the non-traded goods. This is because spending is depressed by an increase in the price level which will reduce the value of real money balances if nominal money supply is constant. Therefore, schedule NN is flatter than a 45^0 line from the origin.

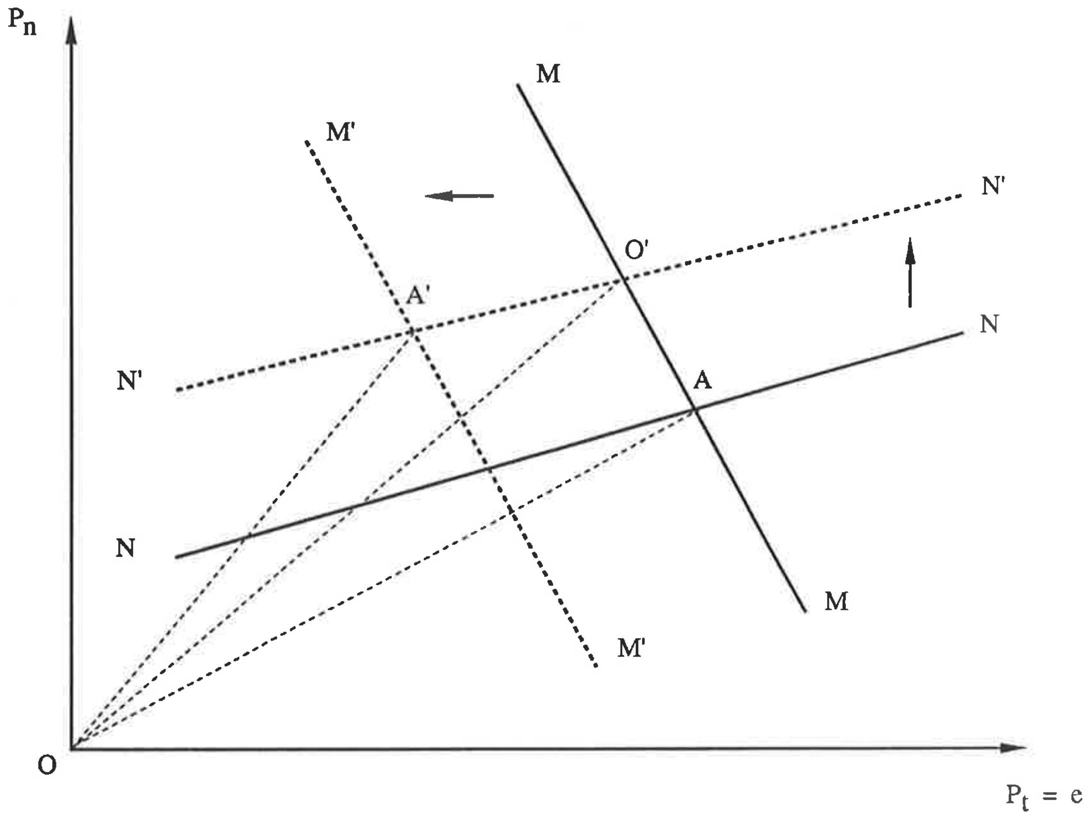
While the NN schedule shows the equilibrium locus for the real side of the economy, the determination of equilibrium in the economy is not complete until the money market is cleared. Following the quantity theory, if the income velocity is assumed constant, then the equilibrium condition for the monetary sector is expressed by equating money demand and supply

$$\frac{M}{P} = \alpha Y \tag{3.2}$$

where M is money supply willingly held, P is price level, Y is real income, and α is a constant.

Equation 3.2 is represented by the schedule MM in Figure 3.4. It is clear that a rise in either nominal price, P_t or P_n will increase domestic price level P (equation 3.1), and cause excess demand for money by reducing the real value

Figure 3.4: Monetary Effects of the Dutch Disease



of money supply (equation 3.2). The MM schedule is therefore negatively sloped. As shown in Figure 3.4, the monetary equilibrium is obtained along the MM schedule, a rise in P_n must be accompanied by a fall in P_t if domestic money supply is to be willingly held when real income is given.

The effects of a boom in this model is shown by the movements of the dotted lines in Figure 3.4. With the initial equilibrium at a given by the intersection of NN and MM loci, a boom will shift the NN schedule upwards as both the spending and resource movement effects cause excess demand for non-traded goods at the initial prices (see Figure 3.1). A boom will increase real income and therefore will also raise money demand. If the domestic money supply is not changed, the price level must fall to clear the money market (equation 3.2). This liquidity effect will then shift MM inwards to $M'M'$.

The new equilibrium will be at a'. The fact that a real appreciation has taken place is reflected in the greater slope of ray oa' relative to ray oa. The mechanisms involved are both an appreciation of the nominal exchange rate (a fall in e) and a fall in the domestic price level brought about by the monetary effect. The role of the monetary sector in facilitating the adjustment is shown by tilting the ray oo' counterclockwise to oa'.

3.2 Application to Oil Price Fall

The models reviewed above invariably focus upon problems associated with abundance. However, the booming sector economics literature also provides a useful framework for understanding problems associated with slumps. As a boom is effectively asymmetric sectoral growth, the analysis can be applied in reverse to situation where one tradable sector suddenly slumps and initiates a chain of reactions in the economy.

A number of attempts were in the 1980s to model a slump in one sector of an economy. An immediate example is the oil price increase. While the oil price hike is a source of boom in oil *exporting* economies, it is a source of misfortune for oil *importing* countries. Gupta and Togan (1984) modelled three oil importing countries of Turkey, Kenya and India which suffered from the first oil crisis. Vincent (1982) examined the effects of the oil price hike for Korea, highlighting the importance of the adjustment process to oil price increase in oil importing countries. Another set of studies analysed the effect of export price decline for primary products resulted from the world wide recession in 1979–80. Condon *et al.* (1985), Dick *et al.* (1984) and Vincent (1985) investigated various policy issues in Chile in response to the reduction in world copper prices in 1980 and 1981 which was considered as an external shock to the Chilean economy. Dick *et al.* (1983) were concerned with the fluctuation of primary commodity prices which soared in the 1970s (Table 3.1), but declined to their lowest levels in some thirty years in early 1980s (Sanderson, 1985). Models of Columbia, Ivory Coast and Kenya were employed to address this issue.

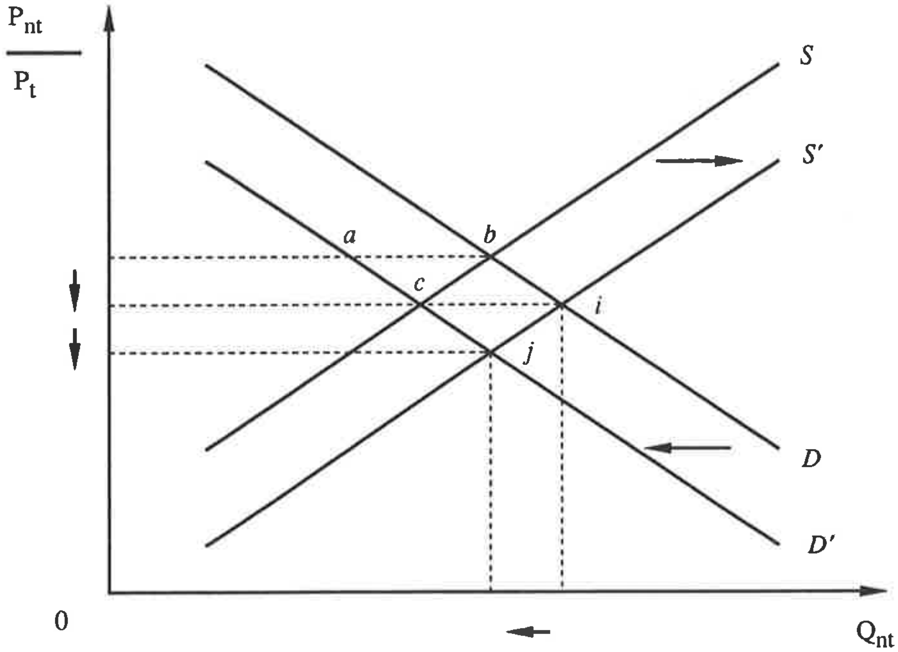
All these studies tried to answer two questions: how can an economy subject to "bad luck" shift quickly out of those sectors hit heavily by an unfavourable shock; and what policies best facilitate structural adjustment? The same questions need to be answered in the 1986 oil price decline for an oil exporting country such as China. To understand the mechanisms involved in absorbing the oil price shock, a model in which a "declining sector" initiates sectoral repercussions in the economy is considered. Without altering the underlying assumptions of the booming sector model, the model is now applied to China as a first approximation to the theoretical structure. A more appropriate application is discussed in the next section and later chapters.

Following Corden (1984), the model consists of three sectors, two tradable and one non-tradable. However, the specification of the model is a reversed version of the "booming sector" model. As the effect of the price shock is negative to China, the asymmetric growth is not of a "booming sector", but of a "declining sector" which we define as the energy sector (E) since energy is exported at lower prices. Consequently, another tradable sector (T) which was a "lagging sector" in Corden's Core Model is now an "expanding sector", as it will be seen that T grows by absorbing resources from other sectors. Particular reference is given to this expanding tradable sector, which is further decomposed in the extension of the model. The non-tradable sector is denoted as NT. For the present, all goods produced in these three sectors are assumed to be for final consumption only. The use of energy as an intermediate input by other sectors will be considered later.

The model must recognise the fact that in China some commodity markets are cleared via quantity adjustment and some are cleared via price adjustment. We assume that the relative prices of all commodities in the model are measured in terms of tradable goods, and are determined by the balance between demand and supply. Special attention is paid to exogenous determinants for prices, which are divided into two sets: the first set are external to the economy such as world markets (prices and volumes), disembodied technical change; the other set of exogenous variables is made up of policy instruments such as the exchange rate, taxes and regulated prices. By the "small country" assumption, tradable goods have their prices in local currency fixed by world market conditions; but some are determined by policy regulations. Crude petroleum is an example where the government has set the domestic oil prices far below the world prices. However, they fall into the category of exogenously set prices. All non-tradable goods prices are determined endogenously by domestic supply and demand conditions.

As the model is used for short run analysis, output is produced by one intersectorally mobile factor, labour (L), and an immobile capital factor (K) specific to each sector - K_e, K_t, and K_{nt} for E, T and NT, respectively. In order to highlight structural adjustment, the model will focus on real variables. Monetary effects are consideration in the next sub-section.

Figure 3.5: Effects of the Oil Price Fall



3.2.1 The spending effect of an oil price fall

The spending effect operates as follows: the fall in world oil prices causes an immediate deterioration in China's terms of trade. The effect of the change in the terms of trade is substantial as China's total value of exports fell by more than 15% in 1986 as a result of the oil price decline. The deterioration in the terms of trade is even more pronounced taking into account the substitution effect which causes prices of other mineral fuels, such as coal, to fall. China also exports a considerable amount of coal. As income drops, less will be spent on domestic products, assuming the income elasticity of demand for non-tradables is positive. There is then a disequilibrium in the market for non-tradables as the reduction of income and demand leaves an excess supply in the non-tradable sector. A real exchange rate depreciation will then take place, and the non-tradable sector is expected to bear the burden of adjustment as resources will move out the non-tradable sector to the tradable sector.

This is illustrated in Figure 3.5. The supply curve is derived from the transformation curve between non-tradables and tradables. The demand curve shows the demand for non-traded goods at various relative prices of P_{nt}/P_t when expenditure is always equal to income. The spending effect shifts the demand curve for non-tradables to the left (D to D'), an excess supply of non-tradables ab occurs at the initial price level. To restore the equilibrium, there must be a real depreciation to remove the excess supply in the non-tradable sector. As the real depreciation takes effect, demand for non-tradable goods increases along D' (a to c).

3.2.2 The resource movement effect of an oil price fall

The resource movement effect is initiated as a result of the decline in the value of the marginal product of labour (MPL) in E as the oil price falls. This will move labour out of E to T and NT. Initially, this increases employment and output in both E and NT depending on the labour intensities in these two sectors. A second round effect is generated through the adjustment in the non-traded goods market. As illustrated in Figure 3.5, once NT's supply curve is shifted to the right ($S \rightarrow S'$), and a real depreciation must occur to eliminate excess supply in NT and restore the domestic equilibrium. The depreciation will induce a fall in the output of NT and at the same time release labour to T. This is represented by the movement along S' ($i \rightarrow j$), an indirect impact on the output of T.

The spending and resource movement effects both contribute to a real depreciation. However, the resource movement effect tends to raise the output of NT sector whereas the spending effect lowers it. NT could rise or fall. However, this ambiguity does not apply to the two tradable sectors T and E. Sector T will experience an expansion, and sector E will contract as its terms of trade deteriorate.

3.2.3 Monetary consequences of an oil price fall

The monetary effect of an oil price fall has some interesting implications for the adjustment of the real side of the economy. The most important consequence of introducing money into the model is that the monetary spillover will work *against* the real adjustment in the case of an oil price fall. Consequently, larger responses are required in order to absorb the shock.

Figure 3.6 uses the same framework as in sub-section 3.1.3 (Neary and Wijnbergen, 1986), but applies the analysis to the situation of an oil price fall. The vertical and horizontal axes in Figure 3.6 are denoted as non-tradable price (P_n) and tradable price (P_t), respectively.

To facilitate the analysis, the nominal exchange rate e is identified with P_t by assuming a world price of unity for traded goods. NN represents the pre-boom equilibrium locus of the non-tradable market, and MM represents the pre-boom equilibrium locus of the money market. The initial equilibrium is determined at point a.

To consider the real and monetary consequences of an oil price fall, we first briefly look at the real side of the economy. From the analysis in the previous two sub-sections, it is clear that both the spending and resource movement effects cause excess supply of non-traded goods at the initial prices. To clear the non-traded goods market, the adjustment of the real side of the economy needs to reduce the price of non-tradables in order to bring about a *real depreciation,* this is reflected in the shift of NN downwards to $N'N'$.

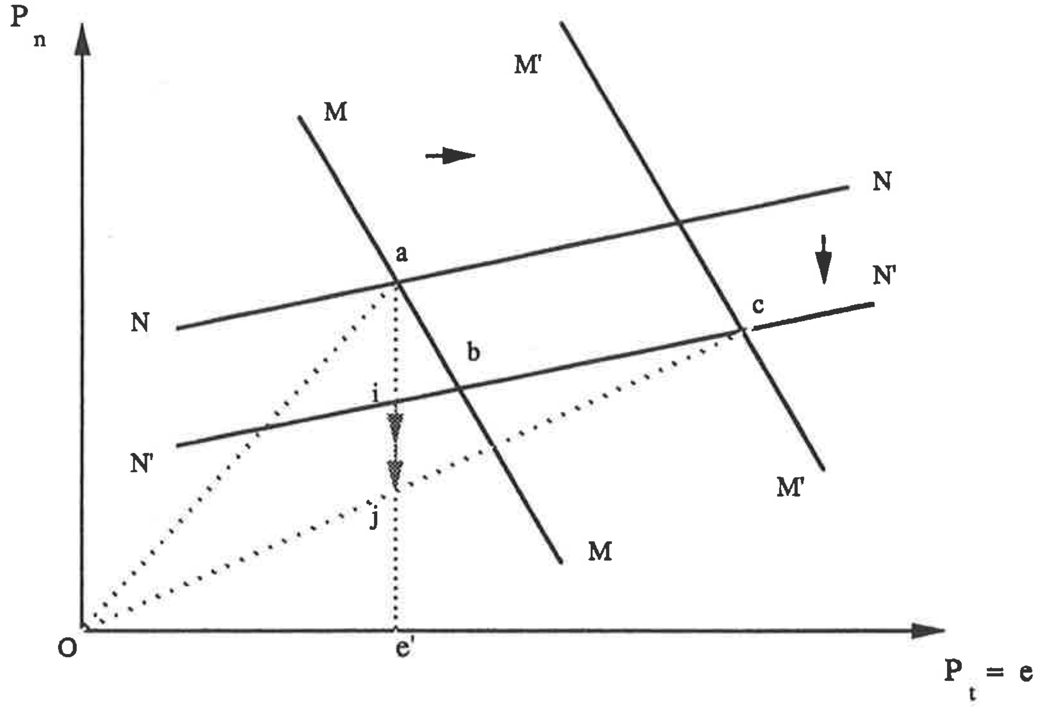
Now to consider the changes in the monetary sector. The decrease in oil export revenues following the oil price fall will lower the demand for money in real terms. To restore equilibrium in the money market, the real supply of money must also be lowered. If domestic nominal money supply is not changed,[2] the price level must then increase. Under the assumption that domestic price level is homogeneous of degree one on the prices of traded and non-traded goods, this implies that P_n will increase. P_t will also rise through a nominal exchange rate depreciation ($e \uparrow$) if exchange rate is allowed to float. As a result, MM shifts upwards to $M'M'$.

Two concerns arise from the restoration of monetary equilibrium in the upward shift of the MM schedule. First, nominal price of non-tradables P_n will increase which will partly offset the adjustment effort at the real side of the economy; and second, the resulting nominal exchange rate depreciation, so as to increase domestic price for traded goods ($P_t \uparrow$), may not take place if there is a fixed exchange rate regime such as in China.[3] This not only intensifies the adverse effects from the adjustment of the real side of the economy, but also imposes adjustment problems on the monetary sector itself.

These two considerations are interrelated. As can be seen from Figure 3.6,

[2]This may actually require policy initiative. See chapter 7.
[3]For detailed discussion of China's foreign exchange rate system, see chapters 5 and 7.

Figure 3.6: Monetary Adjustment to Oil Price Fall with a Fixed Exchange Rate



when MM is fixed, the real adjustment (NN to $N'N'$) lowers the price for non-traded goods from the level corresponding to point a to that at point b, accordingly, nominal exchange rate depreciation occurs from e' to a value corresponding to point b. After the move of MM to $M'M'$, price of non-traded goods increases in order to clear the money market, and a further depreciation of e occurs to a higher value corresponding to c. This will then overcome the increase in P_n (from a level corresponding to b to that corresponding to c) by a further increase of the domestic price for traded good P_t, so an equilibrium relative price of P_n and P_t can still be obtained at point c. However, all these occur due to a flexible exchange rate. What does the adjustment path look like if e is not free to change but is fixed at its initial value e' ?

The equilibrium point will not be able to move from a to c. Instead, the short run equilibrium point will be at point i, reflecting the adjustment of the real side of the economy (NN shifts down to reduce P_n and eliminate excess supply of non-traded goods). However, the change in the relative price of non-traded goods, and hence the degree of the real adjustment is less than that needed for the long run equilibrium which requires the relative price of non-traded to traded goods to be at a rate shown by the ray ojc.

In the long run the negative spending effect of the oil price shock will be augmented under a fixed exchange rate. Normally, the spending effect considered in the booming model is a one-round change in domestic spending under the exchange rate. The re-balancing of the external account after a shock will not feed into the domestic spending as a free exchange rate will float to isolate the effects emanating from changes in foreign exchange reserves. In the case of a boom, a free exchange rate will appreciate ($e \downarrow$), in the case of a slump such as the oil price fall, a free exchange rate will depreciate ($e \uparrow$). So the foreign exchange reserves will be constant. However, under a fixed exchange rate, foreign exchange reserves will accumulate or run down in response to external shocks, and the re-balancing of external account will induce a second round effect on domestic spending when monetary factors are considered. So the short run equilibrium at point i cannot be sustained as the desired money balances are smaller than actual.

To cover the trade deficit resulting from the oil price fall foreign exchange reserves must run down under a fixed exchange rate. Over time, money supply must decrease as the foreign exchange reserves decrease which reduces the money base. As a consequence, the nominal price level will decrease, and the two schedules will gradually drift down and intersect at point j to attain the long run equilibrium real exchange rate. $N'N'$ shifts again because income has to fall in order to bring the relative prices of non-traded goods to equilibrium.

The adjustment path of a fixed exchange rate economy in a model with money built in shows that the monetary spillover will have an adverse impact on the real side of the economy. With a fixed exchange rate, foreign reserves run down. The resulting decrease of money supply lowers the price level in the economy. The economic cost of this adjustment will be the loss of export incentives which would otherwise be brought about by an exchange rate depreciation, and also lower consumption because of a lower level of income.

3.3 Quantity Constrained Models

The reverse of the booming sector model cannot be applied in a simple-minded manner to China as the underlying assumptions of the model better characterise free market economies than controlled economies. The booming sector framework has limitations when it is applied to less developed countries with quantity constraints.

First, the model assumes implicitly that the monetary authorities adjust the money supply in the economy consistent with changes in the domestic price level, and the money market is cleared. This is acceptable in a static model focusing on the real side of the economy in which only relative prices play a major role. However, when many shocks are essentially temporary in character, particular attention has to be paid to investment behaviour. The lack of significant capital markets in economies such as China constrains choices in asset accumulation, and the resulting disequilibrium of asset market causes an unsatisfactory macroeconomic performance, which should be considered in addition to the effects on sectoral structure.

Second, the full employment assumption made in the standard booming sector model raises questions for the outcome of the model applied in less developed countries. If a country such as China has substantial underemployment, either because many rural labours are engaged in low-productivity subsistence agriculture or because there are many waiting for jobs in urban areas,[4] then the model will begin like those described above, but underemployed labour would be absorbed, in the boom case, into the non-tradable sector, whose relative price has risen due to a positive spending effect, and this would moderate the price increase and the real exchange rate appreciation. In the slump case, labour would flood into the traded good sector amplifying the effect of a real depreciation.

Third, neoclassical assumptions such as perfect competition and constant returns to scale etc. are inappropriate for controlled economies where quantity constraints prevail. Government interventions distort a wide variety of transactions in international trade (e.g. import licensing associated with foreign exchange rationing), credit (e.g. interest rate ceiling) and exchange rate control etc.. To cope with these characteristics, the model needs to be extended to analyse the implications of these controls following an external shock.

3.3.1 A theoretical framework of modelling controls

There is a sizeable analytic literature on the implications of various aspects of quantity constraints. A recent study by Bevan *et al.* (1987a) extends the the-

[4] Published urban "job-waiting" statistics in China are available in the Statistical Yearbook of China.

ory of "Dutch disease" to East Africa where government controls are pervasive through tariffs and quotas, money supply and exchange rate determination. This study focuses on Kenya and Tanzania during the 1976-79 Coffee boom. In this model, the concept of the real exchange rate is no longer appropriate as trade distortions (tariff and quotas) change the domestic relative prices of exportable and importable goods substantially for any given world prices. For example, a reduction in an import tariff would lower the relative price of importables to exportables, and would make it impossible to define tradable goods as a Hicksian composite commodity (Prachowny, 1984). Thus three aggregated goods are identified: exportable, importable and non-tradable, all of which are assumed to be produced domestically, though exportables are assumed not to be domestically consumed. The domestic price of the exportables, P_x, is determined by the world price, P_x^w , and the exchange rate, e:

$$P_x = e \cdot P_x^w \tag{3.3}$$

The distortion of exchange rate policy can be captured in the above equation by fixing e at a value which fails to clear the foreign exchange market. The typical case would be an overvalued exchange rate.

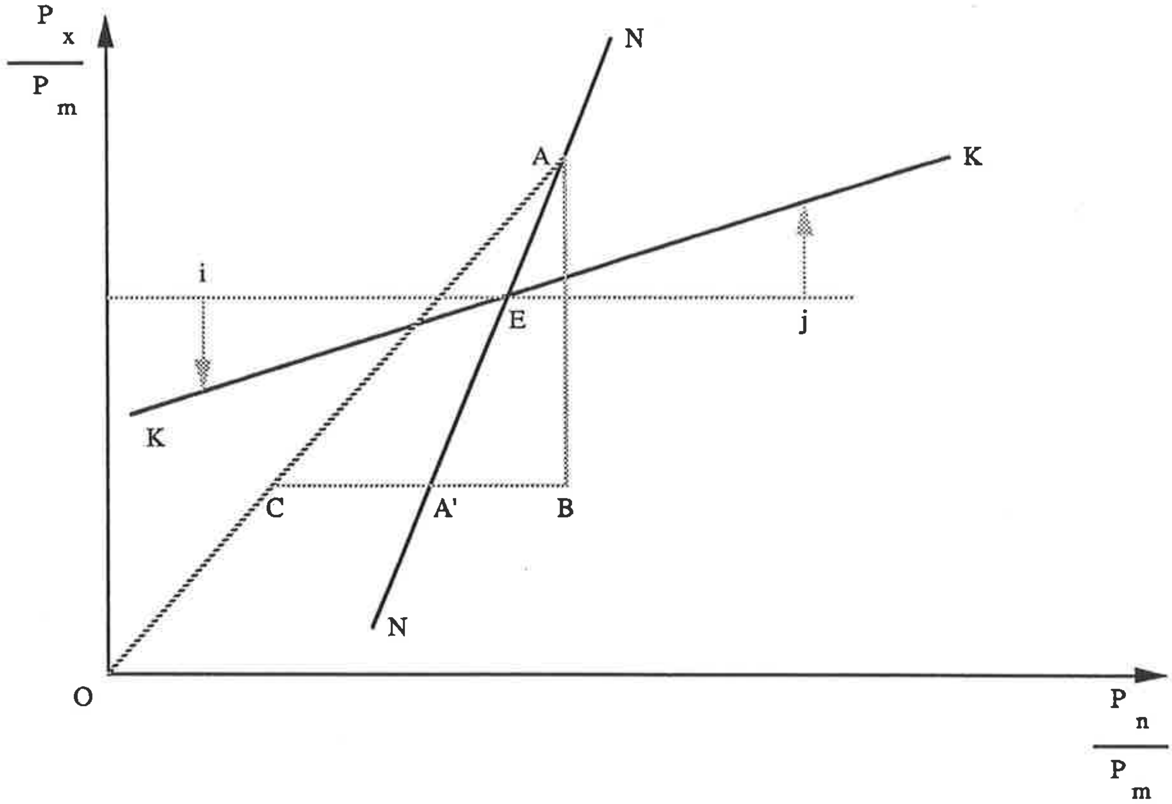
The domestic price of importables, P_m is affected by import restrictions imposed at the tariff-equivalent rate, t:

$$P_m = e \cdot P_m^w(1+t) \tag{3.4}$$

The model can incorporate quantity constraints through interactions of two relative prices: the relative price of exportables to importables P_x/P_m (the vertical axis in Figure 3.7), and the relative price of non-tradables to importables P_n/P_m (the horizontal axis in Figure 3.7). The ratio of the two relative prices is another relative price P_x/P_n, which is constant along any ray from the origin such as OA.

The derivation of the equilibrium of the model subject to policy constraints can start from an arbitrary point such as A. A vertical movement such as A to B

Figure 3.7: A Trade Shock Model with Quantity Constrains



Source: Bevan D., Collier P. and Gunning J. (1987), Trade Shocks in Controlled Economies: Theory with an application to East Africa, *Working Papers in Trade and Development*, Research School of Pacific Studies, Australian National University.

represents a reduction in the relative price of exportables to importables due to an increase in import restrictions. In the case of increased import restrictions, the decline of P_x/P_m in the movement of A to B involves no change in P_n/P_m which induces a shift of resources out of exportables into production of both importables and non-tradables, causing excess supply of the latter.

To maintain equilibrium in the non-tradable sector, a lower P_n is needed. The horizontal movement from B towards C reduces the relative price of non-tradables. Two things happen as a result. On the demand side, the incentive for consumption of non-traded goods increases. On the supply side, t he previous flow of resources shifting from the exportable sector to non-tradable is reduced, and finally eliminated at C where P_x/P_n has reverted to its original value at A. However, the relative price of importables to non-tradables now must be higher than at point B. This implies an excess demand for non-tradables at C. So the equilibrium of non-tradables is between C (excess demand) and B (excess supply). To take into account of a wide range of possible constraints which change relative prices of P_x/P_m, the equilibria of non-tradables are given by the locus NN through the initial point A, and steeper than the ray through the origin.

An important feature of the model is that the equilibrium of the non-tradable sector will not be reached until the money market is cleared. The demand for money (M_D) is a simple linear function of nominal expenditure:

$$M_D = k(P_n \cdot q_n + P_m \cdot q_m) \tag{3.5}$$

where k is a constant factor expressing money demand as proportional to the nominal value of national income, q_n and q_m are quantities of non-tradables and importables, respectively.

Using equation (3.4), the monetary equilibrium is characterised by equalising money supply (M_S) to

$$M_S = k[P_n \cdot q_n + eP_m^w(1+t)q_m] \tag{3.6}$$

The locus of monetary equilibria can be derived by looking at each side of locus NN. Starting from E, a move to the left to i represents a decrease in P_n with P_x and P_m constant, so that at i there is an excess supply of money. To restore equilibrium in the money market, P_m needs to be increased (a decline of P_x/P_m). On the other side, excess demand for money exists at point j, and a decrease of P_m (an increase of P_x/P_m) will clear the money market. So the locus of monetary equilibrium is an upward sloping curve KK which is flatter than NN.

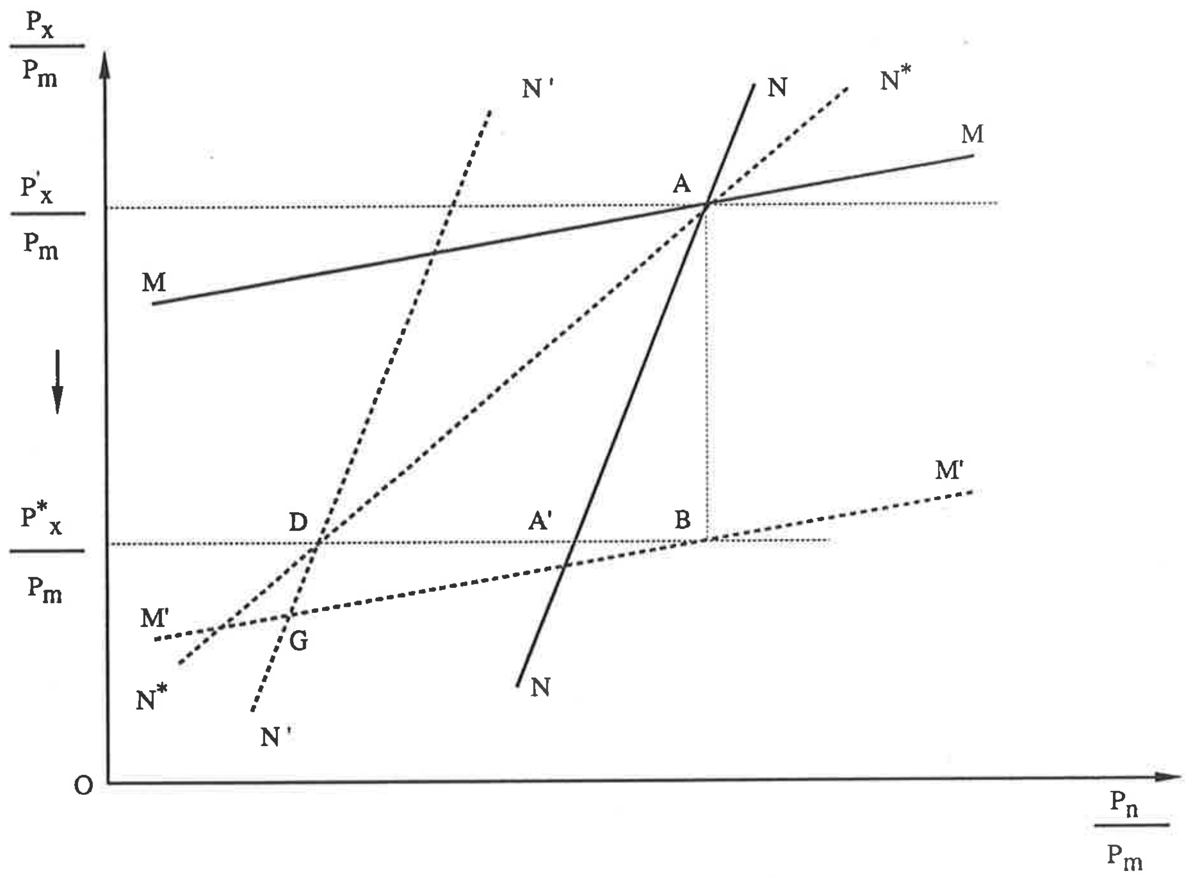
The intersection of these two schedules denotes an equilibrium point where trade, monetary and exchange rate policies are compatible in the way that, for given world prices, P_x is fixed by the exchange rate (equation 3.3), P_m is fixed by import restrictions (equation 3.4) and the money supply is exogenously determined to clear both the money and non-traded goods markets at those prices (equation 3.6). This framework offers a wide range of possibilities to incorporate possible policy distortions.

Let's use the example of oil price fall to show the effect of an external shock in such a constrained model. Instead of overlapping the resulting changes induced by the shock in Figure 3.7, the changes are presented separately in Figure 3.8 for clarity of exposition.

The initial NN and MM schedules are identical to those in Figure 3.7. Recall from Figure 3.7, the schedule NN was derived with constant world prices but varying import controls. In the case of oil price fall, what we need to look at is the effect of varying world prices for a given set of constraints in the model. This raises the question as how much would the schedule NN shift for a change in a fall of oil prices represented by the drop of P_x'/P_m to P_x^*/P_m?

What we need to do is to establish a path along which the initial equilibrium point for the non-traded goods can move to reach a new equilibrium point as P_x changes. Recall again that in Figure 3.7, point B denotes excess supply of non-tradables, and point C denotes excess demand of for non-tradables, and

Figure 3.8: A Terms of Trade Shock in a Controlled Model



Source: Bevan D., Collier P. and Gunning J. (1987), Trade Shocks in Controlled Economies: Theory with an application to East Africa, *Working Papers in Trade and Development*, Research School of Pacific Studies, Australian National University.

both point A and point A' are equilibria for the non-traded goods market corresponding to different relative world prices. To see the effect of a change in export price (a fall in oil price), we choose point A as the initial equilibrium point for non-tradables corresponding to the initial export price P_x. Consequently, at point A' there will be excess supply of non-traded goods as the spending effect must reduce the consumption of non-traded goods due to the loss of income in the oil price fall.

To eliminate the excess supply for non-tradable goods, P_n must fall. This implies that the new equilibrium point for non-traded goods corresponding to a lower export price P_x^* must lie to the left of A'. Hence, the equilibrium locus of non-traded goods corresponding to varying world prices will be a line flatter than NN. We denote this new locus as N^*N^*. [5]

Having established the path for non-tradable equilibrium to move under changing world prices but constant control variables in the economy, the shift of NN is then determined by the intersection of N^*N^* and the new world price of P_x^*/P_m at point D. As shown in Figure 3.8, NN shifts left to $N'N'$ where excess supply of non-traded goods is eliminated.

The equilibrium of the economy is not determined until the money market is cleared. If money supply is constant, then money equilibrium will be maintained with both P_n and P_m are constant. So the MM schedule is shifted down vertically to $M'M'$ which passing through B. The distance AB is equal to the price change from P_x'/P_m to P_x^*/P_m.

It is clear in Figure 3.8 that the two new schedules $N'N'$ and $M'M'$ do <u>not</u> intersect at the new world price P_x^*/P_m. Schedule $N'N'$ crosses the new world price level at D. Schedule $M'M'$ crosses the new world price level at B. This implies that the equilibria of demand and supply for non-traded goods and

[5]Recall from Figure 3.7, NN was derived steeper than the ray from the origin OA. This does not necessarily apply to N^*N^*. The locus N^*N^* may steeper or flatter than ray OA. For simplicity, ray OA is not drawn in Figure 3.8.

money cannot be achieved simultaneously. The equilibrium of one market is accompanied by the disequilibrium in the other market. Any point to the right of the non-tradable equilibrium locus means excess supply of non-tradables, and any point above the money equilibrium locus means excess supply of money. At point D, while the non-traded goods market is cleared, there is an excess supply of money. At point B, while the money market is cleared, there is an excess supply of non-traded goods. Hence, the oil price shock which disrupts the initial equilibrium A (characterised by a fixed exchange rate e, import tariff t, money supply M) requires some combination of (1) a depreciation of the exchange rate, (2) a decrease in money supply, to validate point D; or (3) an increase in import restrictions to validate point G.

3.3.2 Applied case studies

The Robinson and Tyson (1985) model of Yugoslavia which was designed to capture the behaviour of a socialist economy can be regarded as a major variant of external shock modelling. In the model, the traditional neoclassical assumption of profit maximisation is replaced by an "accounting profit" maximisation assumption to capture the behaviour of the self-managed firms in Yugoslavia. Firms are assumed to treat a part of their labour force as fixed in the short-run, indicating that reductions in employment are severely restricted by the rules of self-management in the economy. The other part of the labour force is treated as variable. Firms decisions are guided by a "planning" or "accounting" wage, that is, firms decide the level of employment of variable labour by equating the value of marginal product of labour with its accounting wage, so to maximise their "accounting profit" or "profit per worker".

Another major feature of the Yugoslavia model is the specification of the external sector so that foreign exchange is rationed with a fixed exchange rate. In a mixed "fixprice - flexprice" rationing system, some firms cannot obtain all the imports they desire and are quantity restrained. The model was used to examine the external causes of the foreign exchange crisis which occurred during 1976–1980. The findings of the study indicate that policy errors were among the factors responsible for the crisis.

One instructive result relates to Yugoslavia's constant real exchange rate policy over 1976-1980. Many countries followed a similar policy in changing the nominal exchange rate by the differences in inflation rates with their main trading partners. However, the model reveals that proper foreign exchange policy should take more into account than differential rates of inflation. The results of the model show that the *dinar* was overvalued 42% in 1979 after Yugoslavia was hit by the oil price shock and a concurrent slow down in its exports. A devaluation was needed to avoid a foreign exchange crisis. But the National Bank of Yugoslavia failed to do so. The inappropriate exchange rate policies seem therefore to have been among the most critical contributory factors to the foreign exchange crisis in Yugoslavia around 1980. Reflections of Yugoslavia's experience on China's 1986 oil price shock will have some important implications for China's adjustment policies.

The studies of Dervis (1980), Dervis *et al.* (1982) and Grais *et al.* (1986) for Turkey have taken into account quantitative restrictions (QRs) on imports. To model restrictive trade regimes with QRs in the form of import licensing with foreign exchange rationing, they introduce rent-seeking activity into the Turkish economy. The existence of the import rents generated by quantity constraints makes it profitable for firms to spend resources to obtain a share of those rents. So rent-seeking is identified as a commercial activity like any other production activity (Krueger, 1974).

Import rationing is modelled by dividing imports into three categories, namely, (1) imports subject to tariff (mainly investment goods and government goods), (2) imports subject to tariff and rationing which lead to rent-seeking activity (intermediate imports) and (3) imports subject to tariff and rationing which do not lead to rent-seeking activities (consumer goods). They emphasises rent-seeking activities generated by commodity-specific licenses in the intermediate category of imports. A concept of "virtual" prices is used for both intermediate and consumer good imports that are rationed. The "virtual" prices would induce an unrationed consumer to behave in the same manner as when faced with a given vector of ration constraints. Imports of intermediate inputs under commodity-specific licenses give rise to an environment in which producers can engage in rent-seeking activities in order to absorb the rents associated with the licenses. The results of these studies indicate that the costs of import quotas in the presence of rent-seeking activities are significant. Combined with the failure of the exchange rate to adjust in line with trading partners' inflation rates, licensing contributed to the misallocation of resources in the exporting and importing sectors, and led to the foreign exchange crisis in Turkey during the period of 1978-1980.

→ World Bank staff working paper (No. 627.

A model developed for Thailand by Amranand and Grais (1984) is characterised by its disaggregated treatment of "formal" and "informal" activities in line with the dualistic economic structure recognised in many developing countries. The formal sector is investment driven (financial resources for accumulation are in perfectly elastic supply), the informal sector is saving-constrained (financial resources for accumulation are in perfectly inelastic supply). The most critical specification of this model involves capital markets. Government requirements in public investment are satisfied by public saving and (public) capital imports. If these sources are inadequate, the government requirement is met by absorbing private savings. The remaining private saving pool is then allocated between the formal sector and informal sector. If the formal sector wishes to augment the finance available for investment, a private foreign capital market is introduced to meet the demand of investment. Thus, any event which lowers government revenues will raise private sector borrowing from abroad, worsening the current balance. Furthermore, any event which raises the profitability of investment in the informal sector will be choked off by scarce funds. This may serve to restrict severely any required structural adjustment in the output mix in response to price shocks.

The effects of the drop in world prices of energy after 1982 and the Thailand domestic regulated energy pricing policy were analysed in this model. The results for Thailand conflicts sharply with conventional wisdom that it is preferable for Thailand *not* to drop domestic energy prices in line with world prices. The prime targets are to improve the current account deficit and minimise foreign debt accumulation. In a normal situation, a drop in the domestic energy price would have a far more striking impact on current account by (1) helping meet energy demands, and (2) improving the competitiveness of exports in world markets. But the Thailand domestic energy pricing policies serve mainly to determine who gets the windfall from world oil price declines, and who gets the windfall tends to determine the size of the domestic saving pool and thus foreign capital imports and eventually the balance of payments. This conclusion of the model is closely related to the premises underlying the model. If, instead, the formal sector's borrowing abroad in the private capital market is restricted by policy, or the informal sector's profitability receive active responses, or the capital markets are far less fragmented and the informal sector has far better access to external finance, the results emerging from the model then do not capture the reality of contemporary Thailand.

3.4 Conclusion

The models reviewed in this chapter establish a theoretical structure for analysing the impact of the 1986 oil price shock on the Chinese economy. The usefulness of the booming sector model is clearly illustrated by the applied country studies with various quantity constraints incorporated. In order to apply the theoretical framework to China, the quantity constraints in China will have to be emphasised. This is particularly important when the institutional arrangements and macro-economic management in China are taken into account.

One aspect of the institutional arrangement in China is the two-tier price system adopted in the process of economic reforms. The administrative controls of under-quota prices mean that the goods carrying planned prices have to be allocated by non-market means and this brings with it well-known inefficiencies and rigidities. The effect of controls on relative prices and resource allocation will be examined in detail in the next chapter.

Another aspect of institutional arrangements in China is the decentralisation of the economic system toward local governments. This causes local protectionism and market segmentation. In-depth research is needed to determine the extent of market segmentation and its impact on resource allocation.

Macroeconomic mismanagement is another major issue in the Chinese economy. Government controls in monetary and foreign trade sectors have significant effects in the Chinese economy. The excess money supply, and the overvalued exchange rate after the mid-1980s, suggest that the analysis of the adjustment of the Chinese economy to the 1986 oil price shock requires explicit consideration of these policy distortions.

Chapter 4

Markets in Post-Reform China

4.1 Introduction

This chapter outlines the operation of the market mechanisms in the post-reform Chinese economy. Attention is paid to the institutional arrangements which characterise the equilibrium conditions in the markets. The effects of economic reforms on resource allocation is analysed using available statistics to assess the quantitative significance of markets and their impact on the behaviours of economic agents.

The strategy used is to simplify the analysis by focusing on the two-tier price system. The well-known "two-tier price system" which emerged in the process of decentralising economic decision making away from central planning and towards provincial governments and the producing enterprises, involves increased use of markets as means of allocating resources. The often substantial gap between the plan and market prices induced enterprises to use their newfound powers in production and marketing to improve management so as to reap the above-quota production profit. Other institutional reforms, such as the profit sharing scheme which defines a new distributional relationship between state, local governments and enterprises, are operated exclusively within the two-tier price system.

This chapter will start with a brief look of the pre-reform resource allocation system in China. Changes in the mechanisms of resource allocation are discussed in the second section. The allocative efficiency of the two-tier price system is assessed in a comparative framework in section 3. The final section identifies rigidities in the post-reform system, and identifies obstacles to well-functioning markets.

4.2 The Pre-Reform System of Resource Planning in China

Before economic reform took place in late 1978, the most important mechanism of resource allocation in China was the national annual plan, which assigned a production target to each farm and each factory, and also supplied the inputs required for the output quota. When the planning authority desired an increase of one product, it ensured that sufficient resources were made available from somewhere else. The transfer of resources from the production of one commodity to production of another commodity was organised by the rearrangement of production quotas and reallocation of provisions of inputs to quota-bearing enterprises in the balancing process of the national annual plan. Often the balance between the production and the use of each product was achieved only in the plan. When actual production took place, some materials were in short supply, creating bottlenecks in production, while other materials were in excess supply, creating large inventories. Excess inventories held by one enterprises may not be made available to other enterprises that needed them; there was no incentive and no market mechanism to transfer the excessive inventories. The central planning authority often relied on the autonomous working of the bureaus and enterprises under their control to solve the production and distribution problems through barter and other arrangements.

As for the factor markets, labour was allocated by administrative means to different sectors of the economy, and people were not free to change jobs. Once a job was assigned it was secure. This was the famous "Iron Rice Bowl", a term referring to permanent employment. Decisions on capital accumulation were also made by the planning authority. Investment was carried out mostly by the state with little funds at enterprises' discretion. Data show that the proportion of state budgetary investment in national total investment was as high as 90% to around 80% from 1950 to 1979 (China's Statistical Yearbook, 1985, p.420). So there was virtually no capital mobility outside the central plan. In addition, the distribution of products for final consumption also was controlled either through a rationing scheme or a system in which the purchasing power was limited by the income level which was determined by wage rates set by the authority.

Intimately related to the flow of products were the prices of various inputs and outputs controlled by the Chinese planning authority. Prices of important consumer and producer goods that were distributed through the central planning system were centrally controlled. Although, in principle, administered prices in China were based on costs, the very long intervals between major price adjustments – extending to decades – resulted in major differences between prices and values of outputs. Principles such as the need to maintain low prices for essential consumer goods or to provide high profits for state-owned industry in order to guarantee budgetary revenues also interfered with cost-based pricing. The central planning authority often had to consider three sets of balances in setting prices. First, the total value of all consumer goods produced had to be equal to the total value of the quantities that consumers wanted to buy, given the total value of their income, to avoid supply shortage or inflation. Second, the planning authority had to set prices so as to balance the books for all the enterprises. The total revenues of each enterprise were determined by the production quotas and the prices of the outputs. Its total expenditures were determined by the quantities and prices of inputs that it employed and the capital goods that it needed for the targeted expansion. The planning authority could not let total revenues from all enterprises be less than their total expenditures, unless it had other sources of revenues to be used as subsidies. Third, price setting was also taken into account as a factor in balancing the government budget, mainly in terms of financing any deficit (Chow, 1987).

The resulting price structure was arbitrary, in as much as it did not bear a direct relationship to production costs. In general, prices of primary products – such as energy and raw materials – whose production costs had risen substantially over the period from 1950s to 1970s – were priced much below marginal costs, while prices for many manufactured goods – whose production costs declined with the expansion of outputs – remained at a relatively high level (Zhang Zhuoyuan, 1987). The implication of this price structure in allocating resources is that manufacturing industries using energy and raw materials intensively made profits at the expense of the energy and raw materials producing industries.

A necessary condition for efficiency of resource allocation is that the marginal return to a resource is the same in all its uses. In a competitive market economy, in which market prices prevail and all economic agents are price takers, the profit maximisation by producers and utility maximisation by consumers ensure that marginal returns are equalised across all users. However, in economies with many quantitative restrictions on resource allocation, marginal returns to a resource are unlikely to be equalised in all its uses. In the case of administrative resource allocation in China as outlined above, it was almost impossible for the authority to acquire detailed information on the marginal returns to every allocated product in alternative uses, and the segmentation of markets for capital and labour simply did not allow such comparisons of alternative marginal return to take place. For example, the restrictions on labour migration resulted in substantially different rewards to labour across industries. In long term resource allocation, investment licensing was meant to allocate investable resources according to social priorities laid out in Five-Year-Plans. In a moderately complex economy, a socially and intertemporally optimal invest-

Table 4.1 Return Rates in Selected Chinese Industries, 1978

	Rate of return to capital	Rate of profit and tax to cost
Average return rate for all industries	100	100
Energy		
Coal	11.5	18.5
Electricity	98.4	280.5
Crude oil	310.8	577.0
Refined petroleum	416.3	166.3
Metallurgy		
Iron ore	43.6	144.7
Steel	84.5	123.8
Textile		
Cotton sheet	493.2	58.0
Synthetic fibre	169.6	177.2
Machinery		
Heavy equipment	15.9	51.0
Electrical equipment	131.9	166.3
Chemicals		
Fertiliser	43.4	38.2
Insecticide	639.6	578.0

Source: Zhang Zhuoyuan (1987), *Socialist Price Theory and Price Reform*, p.114.

ment allocation among sectors (or among enterprises within sectors) is hard to achieve. Table 4.1 presents the rates of return to capital and labour for some industries in 1978 before economic reform took place. The substantial differences between the return rates across industries reveal the inefficient resource allocation in the post-reform Chinese economy.

The rate of return to capital in Table 4.1 is defined as the percentage of the industry's total profit and tax to the total capital used in the industry. Capital is measured as the sum of both fixed capital and circulating capital. As the table shows, the rate of return to capital differed significantly from one industry to another, and the rates of return to capital did not necessarily match the rates of profit and tax to cost in the second column due to distortions in input prices. Generally, industries with higher degree of processing had higher return rates as illustrated by case of coal *vs.* electricity or iron ore *vs.* steel.

The wrong signals given by prices resulted in resource misallocation and inefficiency. There was an awareness of importance of "getting the prices right". On several occasions, there were efforts to implement price reforms, but they were stopped short because the concern over the potential effects on inflation. It was not until early 1980s that the government became aware that there was more in making a market work efficiently than just "getting the prices right".

4.3 Institutional Reforms and Creation of Market Mechanisms

The economic reforms launched in 1979 brought the forces of the market into play to a significant extent and changed the mechanisms of resource allocation in China. The first important step was the introduction of a profit sharing scheme. This scheme went through a number of changes since its inception in 1978-1979. Various forms such as fixed lump-sum charge, basic plus incremental profit retention, and profit contract have been instituted. Under the profit sharing scheme, government reduced administrative interference, particularly the role of a mandatory plan, in enterprises' decision making, and put greater reliance on profits as an indicator of enterprises' performance. The enhanced role of profits led to greater attention paid to prices. Market forces started to generate rational price signals and influence resource allocation.

As pointed out in the introduction of the thesis, the economic reforms in China started in the rural sector where a fixed rental charge scheme was implemented. As a fixed lump-sum levy has no effect on marginal decisions on production, the behavioural rule of farmers is clearly defined as profit maximisation. The profit retention scheme introduced in the industrial sector is similar but different from the rural version. It is similar because industrial enterprises have also been offered a strong profit incentive, they are allowed to retain a considerable percentage (up to 40%) of their profits. But instead of fixing a lump-sum charge, the government fixes a profit retention rate which varies across industries and enterprises. The implications of this difference will be discussed with more detail later in the chapter.

Under this profit retention scheme, the primary target in the objective function of enterprises is no longer the fulfilment of quota but "improvement of efficiency and benefits" as suggested by a questionnaire survey (CESRRI, 1986). Enterprise managers are driven by a desire to increase benefits to employees through higher bonuses, better housing and more welfare expenditures. The way to achieve these objectives is to increase profit. The pursuit of profit by enterprises makes enterprises behave in accordance with the rules of the market.

Under the rubric of "autonomy for industrial enterprises", the state mandatory plan receded in its influence on production, marketing, supply of raw materials and other major operations. Enterprises are given some freedom in the acquisition of inputs and in personnel policy, they are allowed a certain discretion in their production decisions, and they take care of the marketing for those products not subject to a delivery quota. While certain key inputs are still governed by a central plan[1], most enterprises, require more inputs than are provided for in the plan. These additional inputs are purchased in newly created market, whereas in the pre-reform system as outlined earlier, these additional inputs were obtained either by going back to the planning authority for a supplementary allocation or by informal barter with other enterprises.

Products produced and sold at market prices increased considerably in recent years. A survey of 429 industrial enterprises shows that in 1984, output produced under mandatory plans only accounted for 26% of the total, while output under guidance plans[2] made up 27%, for a total of 53%. As for market-

[1]In 1979, there were 837 kinds of production materials controlled either by the state or governmental departments. The number was reduced to 24 under the state's direct control in 1987. However, various departments still controlled over 500 items (Liu Wen and Yin Shanwen, 1988).

[2]In contrast to the mandatory plan which is compulsory for enterprises to fulfil, the

ing, enterprises had 33% of their output distributed by themselves. Regarding supply of raw and semi-finished materials, the share acquired through inter-enterprise exchange and cooperative deals, or purchased on market increased from 16% to 44% from the end of 1984 to mid-1985 (CESRRI, 1986).

Table 4.2 presents the shares of some commodities allocated through market transactions and the state plan. The shares are measured in terms of quantity. For many production materials the volumes through the market were higher than those allocated through the state plan. The market shares may be even higher than in Table 4.2 because some plan allocations might still go to the market. This is because the production materials allocated through the state plan are usually concentrated in the hands of large enterprises. These enterprises with access to cheap production materials from the state tend to resell part of the allocated materials at the market or barter with other enterprises, which will increase the market transaction shares of resource allocation. The market shares of most of the final consumption goods are lower than those of intermediate input products, reflecting more efficient allocation of resources in the production of industrial products than that of consumption goods.

With the reform of the planning system and the expansion of the enterprises' decision making power, the breakthrough of price reform arrived in 1985-1986. In January, 1985, the State Price Bureau and the State Materials Bureau jointly issued the "Regulations on Above-Quota Prices of Enterprises' Self-Marketing Production Materials", which formally allowed enterprises to sell the above-quota output at prices set by themselves. Therefore, for one product, two prices exist. One is the under-quota prices set by the state plan the other is above-quota price set by enterprises. For output above the state plan, enterprises' operations in production, marketing and input acquisition are inevitably regulated by market prices that reflect changes in supply and demand. Thus a two-tier price system extends to all industries.

guidance plan usually refers to a production plan in terms of output value rather than product mix.

Table 4.2: Share of Planned and Market Allocation of Products, 1987
(% in terms of volumes)

Products	Market share	Plan share
Industrial Production Materials		
Steel	53.2	46.8
Non-ferrous metals	32.5	67.5
Cement	84.4	15.6
Timber	72.4	27.6
Chemical materials	36.2	63.8
Coal	53.9	46.1
Crude oil	26.0	74.0
Electricity	17.0	83.0
Consumer's Products		
Clothing	40.0	60.0
Durables	51.0	49.0
Articles for cultural, educational and art uses	15.6	84.4
Grain	25.0	75.0
Foodstuff	26.4	73.6

Sources: 1. Liu Wen and Yin Shanwen, The Present Shares of State Allocation in Major Production Materials and Price Movements, *Reference Materials for Economic Research*, Vol. 152, Beijing, Oct. 1988.

2. Dai Guanlai, The Origin and Development of the Two-tier Price System, *Reference Materials for Economic Research*, Vol. 155, Beijing, Oct. 1988.

However, it should be pointed out that long before the breakthrough of price reform in 1985 the embryo of the two-tier price system was present at the very initial stage of economic reforms. In mid-1981, the State Price Bureau opened the first breach in the system of planned pricing for industrial production materials. "Negotiated prices" for materials in short supply were officially tolerated because it was too difficult for the state to implement a planned price control. The margin of negotiated prices deviated from the planned prices was not clearly set in this first experimental policy change. By 1983, the State Council officially made it clear that medium- and small-sized enterprises were allowed to set ex-factory prices 20% higher than the planned prices. "The Ten Points on the Expansion of the Decision Making Power of State-Owned Industrial Enterprises" instituted in 1984 was a key factor in accelerating the process of economic reform in the industrial sector. More power in setting prices was handed over to enterprises, and the state mandatory planning receded in production, supply, marketing and other major operations of enterprises. This finally led to the all-round implementation of the two-tier price system for both producer goods and consumer goods across all industries in 1985.

While the formalisation of the two-tier price system in 1985 was a breakthrough of price reforms in the sense that market prices have been established for practically all products, and have begun to have an impact on the supply and demand of products and the allocation of resources, it is still a partial solution as only part of the market is operating under free prices. More importantly, the political and economic consequences of the two-tier price system such as corruption and high cost of resource utilisation (Wu Jinglian and Zhao Renwei, 1987) even lead to the question of whether the two-tier price system carries out the original intention of price reform. A sensible question in this context is: since the process of the price reform was propelled by the pressure to achieve a more efficient allocation of factors and products through using market mechanisms, why did not China push on to a 100% free market price system in 1985 rather than formalising a two-tier price scheme?

Closely related to the process of urban reform which did not pick up its pace until late 1984 due to the political debate over the "Bird Cage Economy" and market economy (footnote 3 in chapter 1), price reform confronted the same resistance from the conservative forces which wanted to maintain the dominant position of mandatory planning. The two-tier price system represented a compromised outcome in 1985 in preserving planned allocation, while drawing incremental output into a market system. The intention of the two-tier price system was, "on the one hand, to keep pre-existing economic interrelationships coordinated under the state plan, with one eye to avoiding further conflict among the already divided economic interests of the various sectors, while on the other hand drawing a growing part of production and distribution into new orbits within a market economy"(Wu Jinglian and Zhao Renwei, 1987, p.314).

Another important reason a two-tier price system was formalised in 1985 is because it softens the risks of economic reform by "changing a big earthquake into several small tremors". In the transition from a planned allocation system to a market exchange system, the idea of two-tier price scheme may be a useful invention in the sense it provides a bridge that makes it possible for the new system to replace the old. Most of the Chinese economists certainly advocated this partial price reform approach as uniquely Chinese, hopefully leading to a uniform pricing system based exclusively on the market, while some economists worried about its negative consequences (Wu Jinglian, 1984). After all, this transitional device was accepted in a situation where conflicting forces were released. The predictable slowdown of the economic reform as a consequence of the recent political instability in China tells us that the two-tier price system device may not be as "temporary" as it was thought. The significance of the price reform package in China's economic reform process and its effects on resource allocation warrants a separate section.

4.4 The Nature of the Two-Tier Price System

Basically, the two-tier price system means the existence of two prices for one commodity at the same time, one being the price set by the state and the other being the fluctuating market price determined by market forces. Part of output or input under the state plan is purchased, sold or distributed at administered prices, and any amount exceeding the state plan is allocated at market prices. So there is a mixture of planned and market resource allocation. An important question is: which price really shifts around the resources to adjust supply and demand in the economy?

Following Sicular (1988), assume an economy with numerous producers and consumers who choose levels of production and consumption in response to price levels, markets exist for all goods, and prices are determined by demand and supply forces. This general equilibrium type approach permits prices to be determined endogenously. Will this simple model yield equilibrium market clearing prices in a presence of a state plan? This is tested partially in two ways.

Firstly, assume a subset of all possible state planned prices are strictly less than market prices. Under this condition, for every additional unit of output above the plan, which is sold at market prices, the enterprise obtains extra revenue, whereas every unit of raw materials saved means one unit less to be purchased from the market, and this means a cost reduction for the enterprise as market prices are assumed to be higher than the planned prices. Obviously, when an enterprise increases or decreases its output or input, the impact of a marginal change is calculated at market prices. Thus market prices become signals to adjust short-term supply and demand.

Secondly, consider another possible subset of planned prices for which one or more state planned prices are higher than or equal to the market prices. State prices can eventually equal, but not exceed, the equilibrium market price. This is because in a context of higher state prices enterprises could increase their income by buying more for a lower price on the market and selling it to the state for a higher price to fill the quota. This process would continue as long as the market price is lower than the state price. Thus the market price is driven up to exactly equal the state price. Consequently, before the equilibrium is achieved, where state prices can be less than or equal to, but not greater than, the market prices, the planned quota associated with the "too high" state price is no longer binding, in other words, the state plan plays no role in allocating resources. Clearly, the two-tier price system, with the second tier price fluctuating in the input and output markets, plays a great role in adjusting enterprises' demand and supply behaviours at the margin and has an important impact on resource allocation.

The resource allocative efficiency of the two-tier price system in the Chinese economy is assessed in a comparative framework in which the two-tier price system is introduced into two markets, one is pure competition, and the other is monopoly. The question asked is whether the market prices in pure competition and monopoly are changed by adding in a two-tier price scheme.

1. The pure market model [3]

Assume in a perfect competition economy, the equilibrium price P and output Q are depicted as in Figure 4.1, corresponding to the intersection of market demand and supply curves, D and S. Now suppose the government intervenes and sets a price P' for certain output in the market. It is assumed that the total quota commitment for all firms is Q'. behaviours of the unregulated market is then analysed by looking at the "residual" demand and supply, D' and S', in the market.

As firms in a pure market are price takers, the residual supply schedule in the unregulated market will supply the reminder of the aggregate output at the

[3]Analysis in this model draws on relevant results derived in an interest rate model developed by Albon and Piggott (1983).

slope of the original supply curve, requiring price equals marginal cost. So the result for the residual supply is like moving the vertical axis to the right by the amount of Q' which is extracted administratively from the market. To draw in the residual supply S' in the diagram, the intercept on the vertical axis will be then equal to P'.

The determination of the residual demand curve involves two assumptions: The first is that there is no income effect, that is, the receipts of purchase at the regulated prices of P' have on average a zero income elasticity of demand for goods in the unregulated market. The second assumption is more rigid in the sense that only those with the highest willingness to pay bought the goods sold at the regulated market, so that the residual demand curve will shift inward parallelly from the position of D to D'.

The equilibrium point at the unregulated market is given by the intersection of the residual supply and demand curves derived. The result is that the introduction of a two-tier price system will not change the equilibrium price level at the unregulated market in a perfect competitive economy.

2. The monopoly model

Will a two-tier price system change a monopolist's behaviour? Figure 4.2 represents a simple monopolist market where the economic minimum average cost is assumed equal to marginal cost, and the price charged by the monopolist for output Q is at P, the monopolist earns a super-normal profit indicated by the shaded rectangular between price line P and the average cost line AC.

By introducing a two-tier price system, a regulated price P' is applied to output Q'. The result is a transfer of producer's surplus from the monopolist to consumers by the amount represented by the narrow tall box to the left of the regulated quantity line Q', and between the regulated price P' and market monopoly price P. By changing P', the amount of transfer can be equal to or greater than the monopolist's total super-normal profit. So the regulated

Figure 4.1: Two-tier Prices in a Pure Market

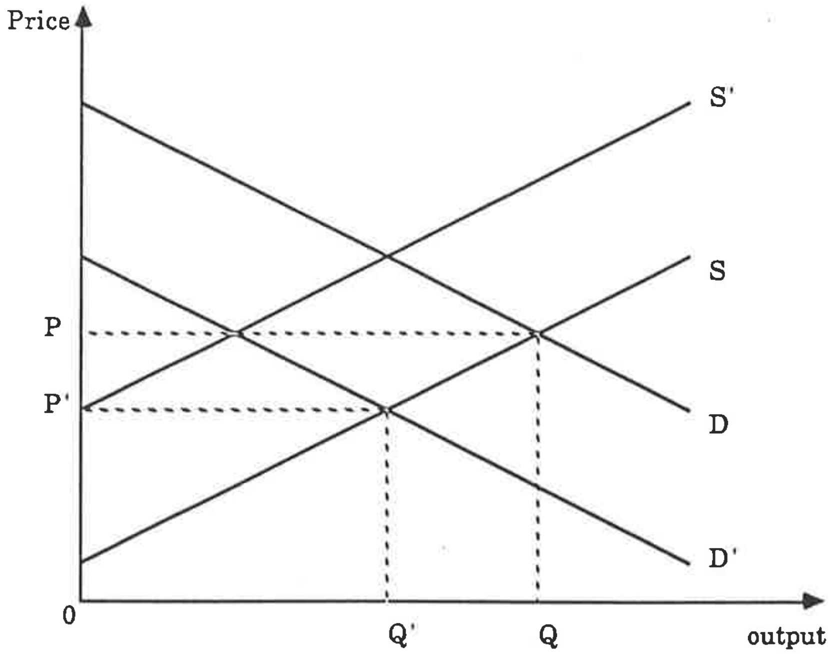
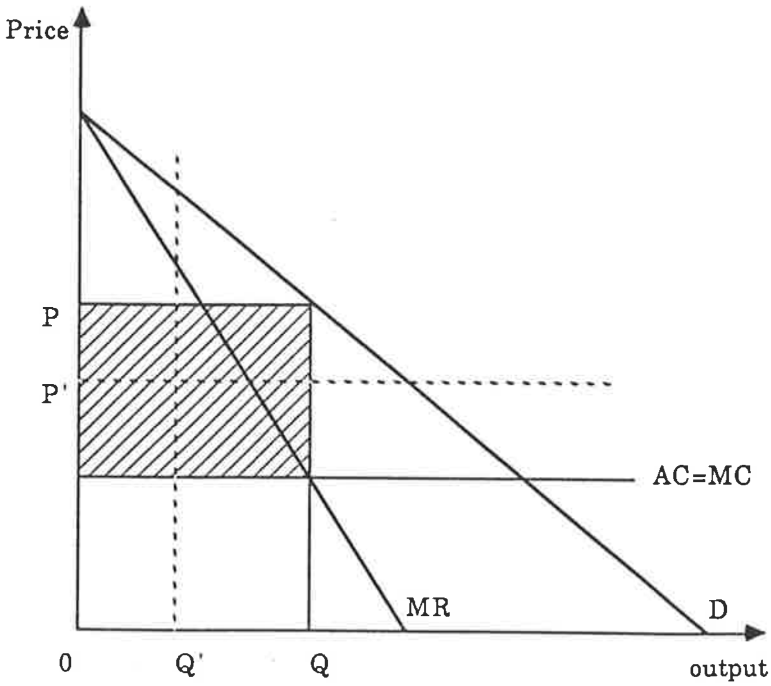


Figure 4.2: Two-tier Prices in a Monopolist Market



price is equivalent to a pure profit tax on the monopolist, which will not change the monopolist's price and output behaviour. Consequently, the imposition of the two-tier price system in a monopoly market will not induce any change in resource reallocation.

In the two models above, the introduction of the two-tier price system does not change the market equilibrium price level, enterprises' responses to the second-tier price will be the same as under the previously existed market price. It is an important result. Based on this result, a CGE model with endogenous market prices is built later in the thesis (chapter 6) to analyse the post-reform Chinese economy. But care should be used in using this result for reasons which will be discussed in the following section.

4.5 Limit of the Two-Tier Price System

The extent the market prices play the role in improving the efficiency of resource allocation is closely related to how well enterprises behave in the market. Without well-defined behavioural rules, market cannot generate rational signals. In this context, the impact of the difference between the fixed rental charge scheme as introduced in the rural sector and the profit retention scheme in the industrial sector is discussed.

In many aspects, the changes induced by the profit retention scheme in the income distribution of China's industrial enterprises over the past ten years can be viewed as a gradual process of reform toward the income sharing system in the Labour Managed Firms in the East European model of market socialism, where "workers do not receive a fixed wage in payment for a specific labour contract. Instead, they earn a share in the net income remaining to the firm after payment of all non-labour operating costs"(Tyson, 1979). In such an arrangement, the individual incomes of workers and managers are from the same source. They have a common interest in "making the cake bigger". Even though in some cases there are still difference in incomes between managers and workers, these are constrained by the fact that managers will be replaced if they abuse their power in distributing income within enterprises. Thus income is shared in enterprises according to the effort of labour, and the objective of enterprises is to maximise profit per worker.

Before 1984, the payroll system in China's industrial enterprises was characterised by a fixed basic wage with a bonus. The fixed basic wage was paid by the state to every employee at a similar level for the same type of labour across industries, and bonuses were only rewarded to the employees at those enterprises which attained the eight targets[4] set in the state plan. The bonus was fixed at the rate of 5% of basic wage. Under this fixed wage-bonus scheme, both wage and bonus were tied to the state plan. It was the bonus which was firstly detached from the state plan when the profit retention scheme was experimented in some enterprises in 1981. The profit retention scheme allows enterprises to dispose of the retained profit to workers as residual income with a ceiling not exceeding the worker's basic wage for two months. Under this scheme, employee's bonus is no longer added to the basic wage at a fixed rate, but depends upon the profit retained, in other words depends upon the management of the enterprise in a more market-oriented environment.

As a higher profit retention by enterprises implies more benefits to their employees, the initial version of profit retention scheme was prone to softening as enterprises bargained with the state for a higher profit retention rate. This was borne out by the upward drift in retained profit in the enterprises involved in the Sichuan Province experiment. Starting from a rate of around 20% in 1981, the retention rate rose to over 85% in 1983. To reduce the negotiability of profit remittance, the profit retention scheme took an important step in formalising the financial relationship between the state and enterprises. Rather

[4]To encourage enterprises to fulfil the plan, a bonus incentive was used by the central authority before the economic reform. Eight targets had to be met before enterprises could claim bonuses. The eight targeted indicators were: output, assortment, quality, raw materials used, fuel used, power used, cost, profit and circulating capital.

than remitting profits, enterprises were taxed on profits. In 1984, a series of taxes such as the product tax, value-added tax, business tax and resource tax was implemented to tax away benefits accruing from factors "external" to enterprises, so that enterprises are rewarded only for profits due to their performance. At the same time enterprises were given greater autonomy in disposing of residual income with no ceiling applied. The size of the bonus was thus completely disconnected from the state plan.

The introduction of the strategy of "hooking an enterprise's total wage to its economic efficiency" cut the linkage between the state plan and payroll in enterprises. This new wage management system has been applied within 30% of state-owned large and medium-sized enterprises since 1985. Instead of allocating total wages to enterprises as planned, the state uses a "hook coefficient" to operate the wage market indirectly. The "hook coefficient" is defined as the previous year's total wage growth rate (r) over the growth rate of enterprise's profit handed to the state (t). After the assessment of two indexes – basic wage bill and basic profit – the base on which the hook coefficient applies is established. The enterprise's total wage is determined by

$$W = B(1 + \pi \cdot \frac{r}{t}) \tag{4.1}$$

where W is total wage bill, B is basic wage bill given as assessed by the state, π is the growth rate of actual profit over the assessed basic profit, and $\frac{r}{t}$ is the hook coefficient.

For the derived total wage W, distribution decisions are made solely by enterprises, and the State has no right to intervene. In early 1988, this wage system reform was instituted in some local enterprises under provincial and departmental leadership.

The final metamorphosis of the profit sharing scheme outlined above is very similar to the income sharing system in the labour managed firm literature. Given the variation of incentive properties of the Chinese version of income sharing scheme, the behaviour of the reformed Chinese enterprises with an objective of maximising individual worker's wage income can be modelled in the same way as in the conventional labour managed firm theory. However, a segmented market system, the whole group of market types from monopoly to monopolistic competition, including the usual forms of collusion, could emerge. To capture the impact of such a market structure on the behaviour of enterprises with an objective of maximising income per worker, the standard labour managed firm model (Ward, 1958) is altered to take account of market imperfections.

Consider first a labour managed firm operating in a pure competitive market. The output of the firm is assumed to be a single-valued function of labour input. The sole source of revenue to the firm is the sale of its product at price P. Two costs are incurred in production: labour costs and a fixed charge for use of capital which is owned by the state. The difference between revenue and cost is profit shared by workers in the firm. Average profits per worker consists of the difference between average revenue per worker, R, and average cost per worker, C. The objective of the firm is to maximise profits per worker, given by

$$S = \bar{w} + \frac{\pi}{x} \tag{4.2}$$

where $\bar{w}$ is wage rate fixed by the government, similar to the assessed wage base as in equation (4.1), π is the enterprise's profits, and x is the number of workers in the firm. The conditions for maximisation of S is the firm chooses the output y at which marginal revenue-per-worker equals marginal cost-per-worker.

$$\frac{dR}{dy} = \frac{dC}{dy} \tag{4.3}$$

Based on Ward (1958), this is depicted in Figure 4.3, where the value of R and C are plotted against x.[5] Profits per worker reach a maximum value when the difference between the two curves is greatest, which determines the

[5]The solution is not altered by making x rather than y the formal choice variable.

equilibrium output corresponding to the employment level indicated by the value of x for which the slopes of R and C are equal.

The equilibrium condition of equation (4.3) is equivalent to the capitalist condition that price will equal marginal cost under rational management. The wage maximising equilibrium of the labour managed firm in contrast to a profit maximising equilibrium of a capitalist counterpart is shown by drawing in a VMP curve. If both firms are assumed to have an identical production function and are operating in purely competitive markets where market prices are equal in both cases. In addition, fixed costs are assumed equal in the two firms, and, importantly, the government fixed wage rate for workers in the labour managed firm ($\bar{w}$) equals the going wage in the capitalist firm (w)

$$\bar{w} = w \tag{4.4}$$

then the capitalist firm's output will be at the point x' where the value of marginal product equals the wage rate.[6]

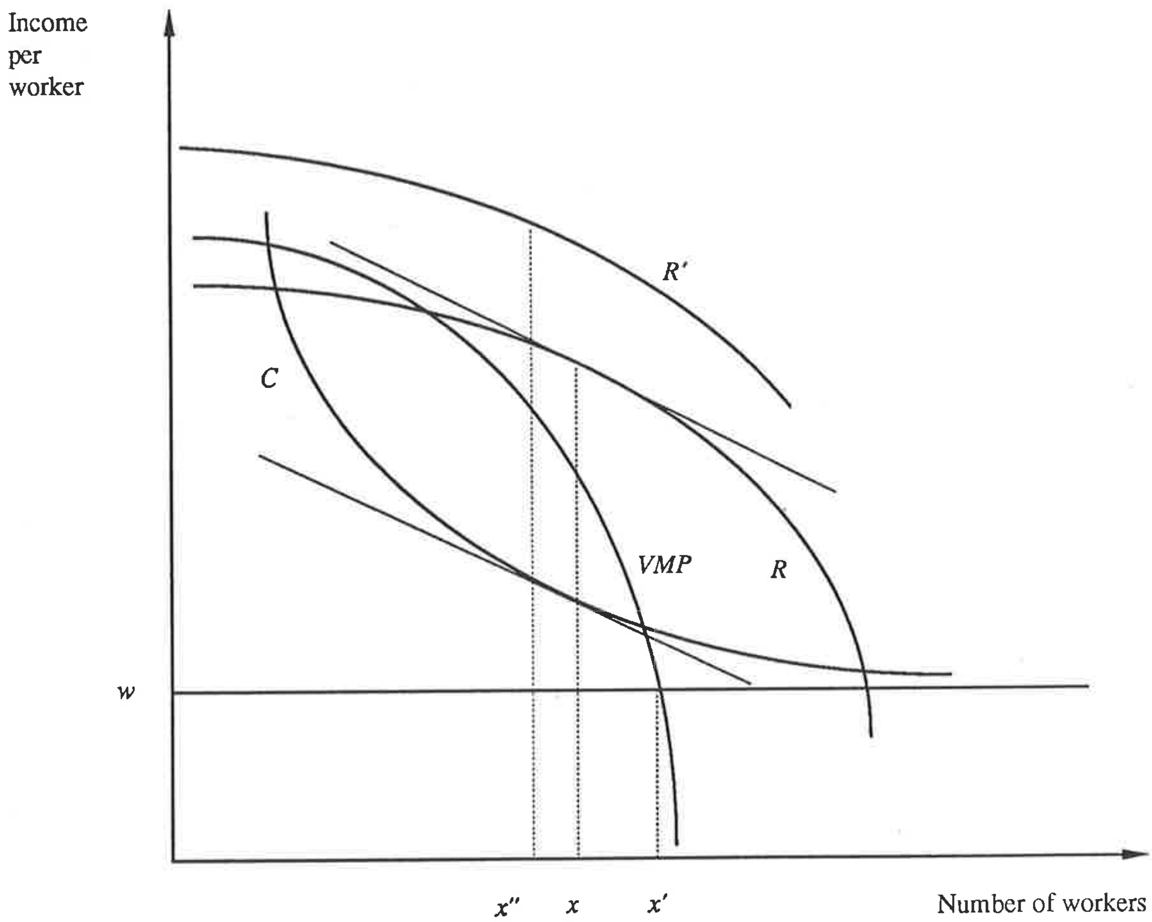
In the diagram, the output of the capitalist firm exceeds that of the labour managed firm. However, it is not necessarily the case since by equalising the income per worker in the labour managed firm to the wage rate in the capitalist firm it would be possible to increase the output of the labour managed firm to equal the equilibrium output of the capitalist firm. As Domar (1966) pointed out that the differences in resource use between twin capitalist and labour managed firms would depend on the differences between the wage rate in the capitalist firm and the dividend (income per worker) in the labour managed firm.

The attitude of a labour managed firm toward labour input differs from that of a capitalist firm.[7] The labour managed firm will hire an additional worker

[6]The capitalist firm is, too, assumed can only vary its output by changing the number of workers employed, not the hours of work.

[7]The criterion of a labour managed firm for hiring additional *non-labour* inputs is the same as that of the capitalist firm (Ward, 1958).

Figure 4.3: Resource Allocation in Twin Capitalist and Labour Managed Firms



Source: Adapted from Ward B. (1958), The Firm in Illyria: Market Syndicalism, *American Economic Review*, Vol. 48.

only if the marginal product of labour will equal the current dividend, whereas the capitalist firm will employ labour as long as the value of marginal product of an additional labour is greater than the wage rate. If the dividend rate in the labour managed firm is equal to the wage rate in the capitalist enterprise, then under the same market and technological conditions as assumed, the outputs of both firms will equal when the equilibrium marginal products are equal. While the capitalist value of the marginal product is equal to w, the value of the marginal product in the labour managed firm is the "full" wage of S as showed by equation (4.2), that is the fixed wage $\bar{w}$ plus the profits share to each worker. Therefore the equality of the outputs implies zero profit in the labour managed firm. As profits in the labour managed firm will tend to disappear in a competitive market. This suggests that in the long run, the labour managed firm under competition could lead to an optimal allocation of resources wherever capitalist competitive regime would.

In the extreme case of monopoly, the above model has to be altered firstly to take account of the fact that price is now a variable rather than a parameter of the system. The curve R represents the average revenue. The monopoly firm can sell at price higher than the market level in the previous model. This will shift R upwards to R'. But at the employment level of x, R' will be steeper than R. That is, at x the rate of decrease in average revenue per worker is greater than the rate of decrease in average cost per work. Output and employment will contract until these rates are again equal as at employment level x''. So the introduction of monopoly will result in a lower level output and a higher price than the competitive situations.

To apply this model to the Chinese enterprises, a preliminary result is that the output and price behaviours of the reformed Chinese enterprises in a restricted market conditions will fall between the equilibrium positions of a labour managed firm in a pure market (x, or x' if given equation 4.4) and a monopolist market (x''), given that the nature of a Chinese enterprise after adopting an income sharing scheme is very similar to that of a labour managed firm as internally they all have an objective of maximising profit per worker; but externally while markets for products and, to much less extent, for factors have been opened up, the market system in China is not yet perfect competitive, and in some cases government monopolies exist.[8] The market structure in China falls into a category between the two extremes of pure competition and monopoly and is characterised by market segmentation, which impairs the efficiency of resource allocation and imposes costs on resource utilisation.

Potential problems with achieving the equilibrium conditions for efficient resource allocation in the post-reform Chinese economy are highlighted by extending the above analysis of objective function for enterprises to other economic agents in the economy. As shown in Chen Kang (1990), differences exist between the objectives of: the enterprises and the government; the different levels of government (central, provincial and local); the producers and the consumers. These differences in objectives, combined with institutional rigidities such as the quota system and limited capital and, to a less extent, labour mobilities, all impose constraints on the second tier price in clearing the markets and on the economic agents in marginal decision making. Caution must be used in modelling the mixed plan/market system in the post-reform Chinese economy as compatible with market clearing conditions.

Despite the constraints discussed above, market mechanisms introduced in the economic reforms have greatly improved the resource allocation in the Chinese economy. This is illustrated in the case of labour mobilisation. Following the earlier discussion of the profit sharing scheme, profit differences between industries are transmitted to employees through the new payroll system, resulting in differences of rewards to the same type of labour across industries. For example, over the period of 1983 to 1986, industries of petrochemicals, metallurgy and textiles showed profit and tax increases of 69%, 70% and -22%, respectively (Fei Yiping *et al.*, 1988). These profit growth rates were reflected

[8]China has introduced the Enterprise Law in 1988. The antitrust regulations forbid firms among other things from monopolising the market except government monopoly.

consistently in the average income per worker at these industries. The average individual annual income (both wage and bonus) in 1985 for petrochemical and metallurgy industries were Rmb 1,522 and 1,398 Yuan, respectively, while workers in the textile industry only had an annual income of Rmb 1,058 Yuan (Labour and Wage Statistics of China, State Statistical Bureau, 1985, P.174).[9]

The variation in wages encouraged workers to move to profitable industries. At the same time, competition between enterprises for labour, especially for specialists and skilled labourers, has become intense, and as a result enterprises are also encouraged to adopt a more flexible management system. A survey of 13 industrial enterprises show that from 1984 to mid-1985 20% of workers and staff members, especially young workers, quit their positions to change jobs (Bai Nanfen, 1986). Many enterprises lifted restrictions on labour mobilisation. In other rigid enterprises, some workers simply left their posts without asking for permission. As a consequence, many labour service companies are set up, and employment of contract workers and casual labourers have been developed rapidly. Of more significance is the labour movement between enterprises under different ownerships. Table 4.3 shows the changes in China's employment structure from 1978 to 1986. Employment in individual ownership and collective ownership enterprises are strongly market oriented. Column 4 in the above panel of Table 4.3 indicates that at least 80% of the present labour force in China is influenced by market. The employment in terms of sectors show that rural labour is the major source of labour flow into other sectors through township industrialisation and widespread service business development.

[9]In 1980, the average individual income in petrochemicals, metallurgy and textile industries were Rmb 949, 995 and 825 Yuan, respectively; so the individual income growth rates from 1980 to 1985 for these three industries were 60.4%, 40.5% and 24.2%, respectively.

Table 4.3: Changes in the Structure of Employment in China, 1978 --1986

	1978		1986		Growth over 1978/1986	
	Employment (million)	Proportion (%)	Employment (million)	Proportion (%)	Employment (million)	Proportion (%)
In terms of ownerships						
State ownership	74.51	18.7	93.33	18.2	18.82	-0.5
Collective ownership	323.90	0.81	78.69	15.3	-245.21	-66.0
Individual ownership*	0.15	0.00	340.80	66.5	340.65	+66.5
In terms of total						
Agriculture						
Planting	276.16	69.3	262.09	52.1	-14.07	-18.2
Other farming#	18.10	4.5	51.02	9.9	32.92	+5.4
Industry	60.74	15.2	113.56	22.1	52.82	+6.9
Services	43.56	11	86.15	16.8	42.59	+5.8

* This includes rural households.

Other farming includes Forestry, Animal husbandry and Fishery.

Source: Yang Xia, Labour Employment: The Challenge and Choices Faced by China, *Reference Materials for Economic Research*, Vol. 157, Beijing, October, 1988.

4.6 Conclusions

The economic reforms significantly changed the mechanisms of resource allocation in the Chinese economy. The changes are important in two areas. The first is the creation of markets where the second tier prices determine the resource allocation at the margin. The second is the reforms in enterprises which gave strong profit incentives to economic agents so that their behavioural rules are governed by market forces. The reforms in these two areas are closely inter-related. Without markets, enterprises cannot use their newfound power to improve efficiency. Without rational economic agents, the markets cannot achieve equilibrium.

The evidence presented in this chapter shows that the share of markets in both total consumer and producer goods transactions and labour allocation are relatively high, indicating that markets appear to have penetrated widely in the Chinese economy. This is of particular importance for the subsequent discussion of a general equilibrium model developed for China in chapter 6.

The analysis of the two-tier price system reveals that the second tier price has the property of achieving equilibrium efficiency in a plan and market mixed economy. In a comparative framework, the imposition of a plan on a perfectly competitive market or monopolist market does not affect the market price level. This establishes the foundation of using the second tier price as the relevant price in a general equilibrium approach. But it is important to be aware of the fact that a monopolist and a perfect competitor both respond in the same way in a two-tier price system but they are not equally efficient. Care should always be taken in the presence of market imperfections in the Chinese economy.

This is illustrated in the analysis of the profit maximisation principle under the profit retention scheme in Chinese industrial enterprises. The characteristics of labour managed firms in Chinese enterprises imply that the price and output behaviours of Chinese industrial enterprises differ from those of a capitalist firm. But, in the long run, resource allocation can be equally efficient if profits in the labour managed firms are competed away in a competitive market.

Given the remaining role of the plan in the economy and other institutional rigidities, the market in China is not perfectly flexible, but is sufficiently so to make a general equilibrium approach relevant. This is supported by the trend of increasing labour mobility in China. The specification of a general equilibrium model for China will be discussed in detail in chapter 6.

Chapter 5

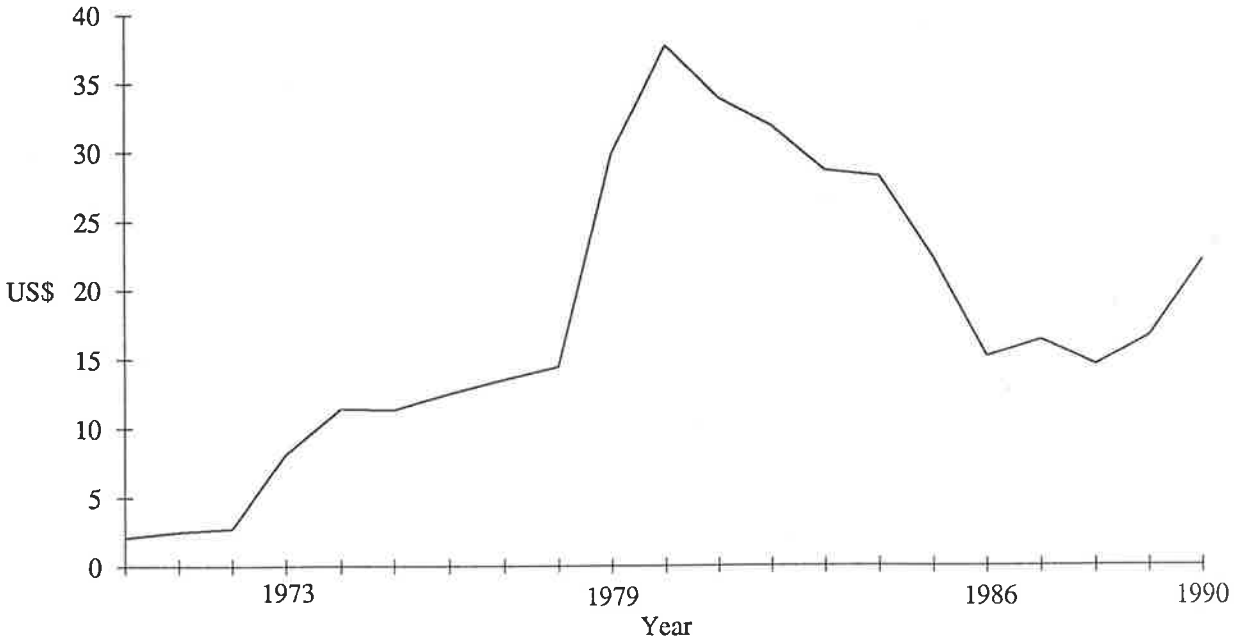
The 1986 Oil Price Fall and the Spending Effect

5.1 Introduction

In the past two decades, oil price shocks have been an important source of instability in the world market. In the 1970s, the world oil prices quadrupled over 1973-74, then fell by almost 20% between 1975 and 1978, and redoubled in 1979-80, peaking at around US $40 per barrel. Following the world-wide recession in the 1980s, the oil price fell by about $8 per barrel during 1980-83, and collapsed in 1986 with a drop of over $15 per barrel in one single year. The total decline of the world oil price from 1980 to 1986 was over 60%. After a short period of stabilising at a moderate level, the oil price has jumped up again since mid-1990 (Figure 5.1).

The oil price shocks had a significant impact on oil exporting countries, particularly on those Third World oil producers whose oil export revenues shoulder the burden of economic development. China is one of these countries. As presented in chapter 2 (Figure 2.10, p. 62; Table 2.14, p. 65), China relied heavily on oil exports as a source of foreign exchange, and accordingly, was affected significantly by oil price shocks. The 1986 oil price fall was, in particular, a major *unfavourable* shock to the Chinese economy given the magnitude and the timing of the shock (see chapter 1). This chapter will analyse the effects of the 1986 oil price shock on China. Using the framework of the booming sector model, this chapter will emphasise how the special institutional arrangements in the Chinese economy alter the outcome of the standard theoretical model. The main focus here is the mechanisms which transmit the spending effect of the world oil price fall to the Chinese economy. The next section discusses the distribution of oil export revenues in the profit sharing arrangements in the Chinese oil industry. The effects of the shock are then analysed in section 3. The government's performance after the price shock is examined in section 4. The question is whether, and if so, why, the government intervened to offset the spending effect. Conclusions appear in section 5.

Figure 5.1: Changes in World Oil Prices (Trade Weighted, US$/Barrel), 1970-1990



Source: International Monetary Fund, International Financial Statistics, various volumes.

5.2 Rent-Taxation in China's Oil Industry

The oil industry is a centrally controlled sector in the Chinses economy. Production and consumption are all planned. A key feature of China's oil industry is the extremely low prices for crude oil set by the government. The planned crude oil prices were at a level less than one-quarter of world oil prices before the 1986 price collapse occurred. With such a big gap between domestic and international prices, about 20% of China's total crude oil output was exported annually before 1986 to earn foreign exchange despite domestic energy shortages (see chapter 2). The share of oil export revenues in national total export revenues reached over 25% in 1985 (State Statistical Bureau, 1986). A large part of oil export revenues accrued to the government; the oil fields were only entitled the planned price of about Rmb 110 Yuan per tonne, compared to the world oil price of around Rmb 500 Yuan per tonne (chapter 2, Table 2.12, p. 60). The difference between the planned oil price and the world oil price was essentially an export tax imposed by the government on oil exports.

The size of the "export tax" was increasing in the 1970s following the increases of the world oil prices. At 1971, China's domestic crude oil was priced at an average of Rmb 130 Yuan per tonne which was in line with the then world oil price (Zheng Jifuang, 1987). However, between 1970 and 1980, the world oil prices sky-rocketed 18 fold while China's domestic oil price fell by 20% to Rmb 103 Yuan per tonne, due to a policy of encouraging substitution of oil for coal as fuel (Yuan Fuxue, 1986). As a result, the domestic crude oil price was only 20% of the world price level. The rents accruing to the government are substantial. To 1986, about Rmb 120 Yuan billion revenues accrued to the government in total. To 1987, US$ 45.67 billion foreign exchange were earned through oil exports (People's Daily, 1/9/1989).

However, the rent-taxation arrangements in China's oil industry were changed in the early 1980s in the process of economic reforms. As market prices started to apply to production output above the planned quota, a two-tier price system emerged in China's energy industry in mid-1980s. In 1983, a second tier price was introduced to above-quota output of crude oil. Strictly speaking, the second tier prices for energy products were not real market prices, as pricing of energy products was subject to state control. But the second tier prices were set high enough to almost close the gap between domestic energy prices and the world energy prices. Since 1987, a third tier price has emerged for petroleum products, while crude oil has remained in the two-tier price arrangement. The third tier prices are market determined. Comparisons of these three tier prices to the world prices are presented in Table 5.1. For unity world prices, the first tier prices for all oil products, crude oil in particular, were much lower than world prices. But the second and third tier prices were all close to or even slightly higher than the world prices.

Under the two-tier price system, new arrangements over the production and trade of crude oil were made. In 1983, the state government made a contract with the Ministry of Petroleum Industry to deliver one billion tonnes of crude oil every year at planned prices of Rmb 110 Yuan. The one billion tonne quota was based on 1981 figure of crude oil production. Output of crude oil above this quota was exported or sold in the domestic market at the second-tier price subject to an export plan. The differential between the two tiers was pooled together by the Ministry of Petroleum Industry (which was integrated into the Ministry of Energy in 1988), and distributed between the state, the Ministry of Petroleum Industry and the oil fields. The decomposition of the revenue for above-quota oil output is illustrated in Table 5.2.

Table 5.2 shows that the bulk of the differential between the two price tiers forms an "Exploration and Construction Fund". This fund is retained in the oil industry and is allocated by the Ministry of Petroleum Industry to various oil fields according to individual needs for investment as approved by the government. The "Exploration and Construction Fund" is meant to largely replace the state's budgetary allocation of investment funds to the oil industry. Since 1983 the government has kept its investment funds allocation to oil industry at

Table 5.1: Ratios of Chinese Oil Prices to World Oil Prices, 1987

	First Tier Price	Second Tier Price	Third Tier Price	World Price
Crude Oil	0.28	0.92	-	1
Heavy Oil	0.34	1.00	-	1
Gasoline	0.94	0.82	1.09	1
Kerosene	0.83	0.96	1.02	1
Diesel	0.61	0.85	1.08	1

Source: Price Research Institute, Preliminary Comparisons of Domestic and International Price Levels, *Reference Materials for Cost and Price*, Vol. 21, Internal Publication, Beijing, 1988.

Table 5.2: Decomposition of the Revenues for Above-Quota Output of Oil*

	Rmb Yuan	%
Average Revenue per Tonne (Second Tier Price)	545	
Average Revenue Distributed within Plan (First-tier price)	110	
Differential	435	100
-- Exploration and Construction Fund	260	60
-- Energy and Transport Fund	65	15
-- Welfare Fund	40	9
-- Retention in Ministry of Petroleum Industry	70	16

* The decomposition is based on the revenue distribution scheme for Daqing oil.

Source: Field work in China, January, 1989.

the same level as in the 1981 budget. This shifting of investment responsibility from the central government to the Ministry of Petroleum Industry is in line with the theme of decentralisation in the process of economic reforms.

Another 15% of the above-quota price revenues forms an "Energy and Transport Fund" which is directly handed over to the government. This fund is collected from all enterprises owned by the state to finance key projects in energy and transport industries.

The rest are retained in the oil industry, with 9% forming a "Welfare Fund", and 16% retained in the Ministry of Petroleum Industry. It is not clear whether any of these revenues replace other central government funds previously allocated to the Ministry of Petroleum Industry. In principle, part of the retention in the Ministry of Petroleum Industry is used to supplement what is seen by the ministry to be inadequate investment in oil fields (Ministry of Petroleum Industry, 1988).

The rent-taxation arrangements in the Chinese oil industry are basically a profit sharing scheme in which the state leaves additional above-quota revenues in the hands of the oil industries, and at the same time reduces their budgetary allocations. In 1986, about 92% of the above-quota oil output was exported.[1] If the fall in oil prices in 1986 was transmitted to the Chinese economy according to the revenue distribution shares as specified in Table 5.2, the 1986 oil price shock would mainly affect the oil industry given the industry's a large proportion of the above-quota revenues. The government would not be severely exposed to the shock given the small share in the above-quota oil revenues.

However, other aspects of the institutional factors in the Chinese economy need to be considered. The trends of declining government budgetary allocation and increasing extra-budgetary financing in investment characterise the

[1]Compared with 1985, China's oil exports in 1986 was reduced about 9% in volume due to the oil price fall.

changes in financial operations of cental and local governments in the post-reform Chinese economy.

As the economic reform proceeded, more power in making investment decisions was handed over from the state government to enterprises and local authorities through profit retention schemes. With more profit retained in enterprises, more investment responsibilities are also transferred to them. The State investment budget, which used to cover the majority of total investment in China, declined from a share of over 50% in total national investment at the beginning of economic reform in 1978 to a mere 14.8% in 1986. In the meantime, other sources of investment such as self-raised investment funds by enterprises and local governments, investment loans from domestic credit system, funds raised through issuing bonds overseas and other sources increased dramatically over the period of 1984 to 1985. Accommodated by loose controls on money supply and credit, this created an environment in which there was every incentive for local governments and enterprises to increase investment. By 1986, extra-budgetary investment reached over 85% in total investment. These extra-budgetary investments sought fast capital returns and high profits, most of the funds flowed into processing and assembling industries, which put enormous pressure on the demand for raw materials.

On the other hand, the investment in energy, transport and raw materials industries dried up as the large scales of investment in these industries presented difficulties for scattered capital to undertake any investment project in upstream industries. The state budget then has to take up the responsibility for investment in basic industries. With a declining share of revenue accruing to the government in the revenue sharing system in the economy, as observed in the oil industry, the state can hardly keep the investments in basic industries in pace with the economic growth. In this sense, the loss of export revenues in the oil industry due to the oil price shock will exaggerate the differential sectoral impacts of decentralisation.

5.3 Effects of the 1986 Oil Price Shock

One of the most salient features of the evolution of fiscal policy since the beginning of reforms has been the continuous decline of total government revenues as a share of GDP, from 34% in 1978 to less than 20% in 1988 (Ministry of Finance, 1988). The main reason has been the steadily fall in government revenues from the enterprise sector. Although part of this fall has been the intended and natural consequence of the decentralisation process, the decline also reflects unintended consequences of the reform (Blejer and Szapary, 1989). One example is local authorities' interest in keeping as much financial resources as possible within their own administrative regions to finance their own preferred projects, and not keen to share with the higher levels of government.

At the same time, the central government's expenditures are constrained by factors such as perceived need to increase consumer subsidies due to price reforms and limited success of the central government in transforming investment responsibilities to enterprises in proportion with their profit retentions. Consequently, the central government was forced into a fiscal deficit of averaging over 3% of GDP in the initial years of the reforms. After fluctuating around 1.5% of GDP toward mid-1980s, a renewed tendency of increasing fiscal deficits has emerged since 1986 (Table 5.3).

The size of the reduction of government revenues resulting from the 1986 oil price decline as a share in total government revenues is unknown. Given the fact that the continuous decline of government revenues as a percentage in GDP, the 60% decline of oil price on the central government's 15% share of the reduced oil export revenues is then considerable to the government. Depending on the composition of government expenditures and the stance of fiscal policy, the reduction in government revenues can produce different effects in the adjustment process.

If government spending is biased toward non-tradables such as construction

Table 5.3: Budget Deficit and Financing, 1979-1988

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
As Percentages of GNP										
Budget Deficit	-5.2	-3.3	-1.3	-1.4	-1.7	-1.6	-0.5	-2.0	-2.4	-2.1
Financing										
Domestic	4.3	2.9	0.6	1.5	1.5	1.3	0.5	1.4	1.8	1.5
Central Bank	4.3	2.9	-0.5	0.6	0.8	0.7	-0.2	0.7	1.3	-
Non-bank	-	-	1.1	0.9	0.7	0.6	0.7	0.7	0.5	1.5
Foreign	0.9	0.4	0.7	-0.1	0.2	0.3	0.1	0.6	0.6	0.6
As Percentages in Total Deficit										
Domestic	82.5	84.9	44.8	102.8	88.5	82.9	97.6	71.7	76.5	72.9
Central bank	82.5	84.9	-39.7	40.8	44.8	42.9	-51.2	38.0	56.4	-
Non-bank	-	-	84.5	62.0	43.8	40.0	148.8	33.7	20.1	72.9
Foreign	17.5	15.1	55.2	-2.8	11.5	17.1	2.4	28.3	23.5	27.1

Source: Ministry of Finance, in Blejer and Szapary (1989), p. 15.

and services, the cut of public spending forced by a decrease in government revenues will facilitate the structural change required by real exchange rate depreciation occurring as a result of unfavourable external shock. This is because labour (as a major mobile domestic productive resource in the non-oil economy in China) will move from non-tradables to tradables following the cut of public spending, which is exactly what a short-run model with sector-specific capital and mobile labour would predict following a real depreciation which induces a rise in the real wage in terms of non-tradables and a fall in terms of tradables.

Another option is to maintain expenditures and finance the lost revenues through borrowing either overseas or domestically. This option is efficient if the price fall is expected to be temporary, as a sterilisation of the effects of a short run boom. But this requires other policies such as exchange rate depreciation to finally eliminate the deficit created.

Table 5.4 suggests that the Chinese government did not cut expenditures following the the 1986 oil price shock. Compared with 1985, the state budgetary allocation to oil sector increased by 31% by 1987. The Chinese government was forced to subsidise the oil industry for a number of reasons; the oil price decline just pushed forward the date of the decision.

The oil sector had been one of the major profit surplus sectors in China up to early 1980s. However, a number of difficulties confronted the oil industry since in the 7th Five-Year-Plan (1986-1990), and as a result, the industry has run into losses. It was estimated by the Ministry of Petroleum Industry that a loss of Rmb 140 million Yuan occurred in the oil industry in 1988 and the size of loss was expected to be enlarged in 1989 (Field work, 1988). Factors contributing to the loss in the oil industry are the following:

1. *Prices for raw materials increased, imposing higher input costs for the oil industry*

Following the introduction of the two-tier price system, China's domestic prices for raw materials increased at an average annual rate of 8% to 10%,

Table 5.4: State Funds Allocation to Oil Industry and Fiscal Deficit (Rmb, million Yuan)

Year	Budgetary Allocation to Oil Industry	Domestic Loans to Oil Industry	Fiscal Deficit	Inflation Rate (% Change over Previous Year)
1978	4020	-	+10.1	0.7
1979	4410	-	-170.6	2.0
1980	1270	103	-127.5	6.0
1981	2560	77	-25.5	2.4
1982	2330	79	-29.3	1.9
1983	2390	52	-43.5	1.5
1984	2350	20	-44.5	2.8
1985	2320	19	+21.6	8.8
1986	2350	279	-70.6	6.0
1987	3050	159	-79.6	7.3

Sources: 1. State Statistical Bureau, Statistical Abstracts of China, Beijing, 1989.
2. Ministry of Petroleum Industry, A Statistical Survey of China's Petroleum Industry, Internal Publication, Beijing, 1988.

while world prices for imported materials such as special steel increased over 20% annually in the mid-1980s.

2. Against the price increases for raw materials, the state's allocation of cheap raw materials (at the planned prices) reduced substantially

From 1981 to 1988, state allocation of steel in the oil industry's total steel consumption dropped from a share of 85% to 19.6%, timber from 77% to 41%, cement from 61% to 21%. The quota of electricity allocated from the state remained at 10.4 billion kwh, but the electricity consumption in the oil industry reached 16.2 billion kwh in 1988, exceeding the price-subsidised electricity allocation by 55.8%. Another important factor contributing to production cost increase in the oil industry is the land fees which increased dramatically as decentralisation made local governments more aware of the value of land and the rent that could be sought. The unfortunate feature of using large land area in oil prospecting and exploration incurs high costs of land fees to the oil industry. It was estimated by the Ministry of Petroleum Industry that the total increase in raw material costs due to price increases were about US $1.3 billion over the years of 1986 to 1988.

3. Downward adjustment of the second-tier price for oil

The second tier price for crude oil was adjusted lower in 1985, which reduced the above-quota production profit retention in oil industry. The second tier oil price for Daqing (the major oil field) was reduced by about Rmb 100 Yuan per tonne.

4. Foreign loan repayment

Since the set up of the contract responsibility system in 1983, the Ministry of Petroleum Industry financed a large part of investment through overseas loans. The repayment of loans peaks in the 7th Five-Year-Plan period (1986-1990). In 1988, 6.15 million tonnes of crude oil was exported for foreign loan repayment, which was around 20% of total crude oil exports in that year.

Adding to these difficulties accumulated over the beginning of the 7th Five-Year-Plan in the oil industry, the would oil price decline in 1986 exacerbated the situation. Given the importance of the oil industry in China, the government came to the industry's rescue by increasing budgetary allocation funds to the oil industry and granting special loans to the Ministry of Petroleum Industry. This is shown in Table 5.4 that the budgetary allocations to the oil industry increased from Rmb 2,317 million Yuan in 1985 to Rmb 3,043 million Yuan in 1987, an increase of 31%. At the same time, loans granted to the oil industry increased more rapidly from Rmb 19.55 million Yuan in 1985 to Rmb 279.35 million Yuan in 1986, which was 14 fold in growth.

The increased government spending in the oil industry after the 1986 oil price shock offset the export revenue losses in the oil industry. As a result, the oil industry became a protected *"enclave"* in the 1986 oil price shock. The government interventions prevented the outflow of resources in the oil industry. Consequently, the "resource movement effect" in the standard booming sector model would not take place, and the shock was transmitted to the Chinese economy through a negative spending effect mainly borne by government.

Given that the state itself suffered a loss in the oil price fall, but also in respect to the general trends of the shrinking share of government revenues in GDP and the upward pressures on government expenditures inherent in the reformed economic system, the state government subsidised the oil industry through its fiscal deficit. As shown in column 3 of Table 5.4, fiscal deficit increased dramatically from a positive Rmb 2,160 million Yuan to a negative Rmb 7,060 million Yuan in 1986 and 7,960 million in 1987. The money and credit growth resulting from the monetisation of fiscal deficit in 1986 and 1987 put enormous pressures on inflation. A number of macroeconomic policies were adopted by the government to adjust the economy to these pressures which are discussed in the following section.

5.4 Government Performance Subsequent to the 1986 Oil Price Shock

The basic story from the above analysis is that, in the absence of government intervention, the effects of the oil price drop would be transmitted to the Chinese economy in two channels: a reduction of investment in the oil industry and an enlargement of the government's fiscal deficit. While the former reinforces the "structural contradiction", the latter leads to higher inflation. The government was forced to not abandon the oil industry, and the negative spending effect was mainly reflected in the government's fiscal deficit. The question is how to adjust the economy to these changes in an attempt to improve balance of payments and slower inflation? A mix of policies can be identified: demand management policy such as fiscal and monetary restraint to reduce aggregate demand; structural policy such as elimination of price distortions to increase efficiency; and exchange rate policy, such as devaluation, to support exports. In this section, we examine the adjustment policies adopted by the Chinese government, and look at the effects of these policies.

5.4.1 Fiscal policy

Following the oil price shock in 1986, the Chinese government actually carried out an expansionary fiscal policy, as suggested by data in Table 5.4. But why not cut the public spending? As argued above, the government was forced to subsidise the oil industry due to the oil price shock and the other accumulated problems. While this contributed partly to the increase of government expenditures, it could not explain why the government did not reduce its expenditures on other sectors, particularly the non-tradables sector.

It is argued strongly in Blejer and Szapary (1989) that, as noted above, a reduction of public spending is constrained by several factors including increased enterprise subsidies and urban dwellers' compensation, and the relatively increased government investment responsibilities in proportion to its share of profit. Another factor associated with the oil price shock is the change of relative price required by the real depreciation in response to the negative spending effect. Given the downward stickiness of prices, the readjustment of relative prices is likely to result in an increased price level, following the theory of price liberalisation (Roemer, 1986). This will intensify the upward pressure on government expenditure on goods and services, wages, subsidies and capital spending in protected industries such as the oil industry. So while the real depreciation is an efficient response to the shock in the long run, in the short run it puts more pressure on government expenditures.

The effects of an expansionary fiscal policy on the adjustment process is, however, hard to assess. It is fairly well accepted that the direct effect of increased public spending will add to aggregate demand, and a monetisation of the fiscal deficit in the domestic economy will generate inflationary pressure, so these are not good policies to be adopted in the face of an unfavourable external shock. But it is also debatable whether a restrictive fiscal policy would reduce domestic demand. While the public spending as a component of domestic expenditure contributes directly to absorption, so that a reduction of government spending domestically means a decrease of aggregate demand, the indirect effect of government purchases in influencing the aggregate demand is unclear. It is possible that a increase in public spending could induce a fall in private spending. At least two mechanisms are at work here.

(1). The "financial crowding-out" proposition

Assuming an increase in government spending boosts domestic economic activity and thereby the demand for money in economy. If interest rates rise to maintain portfolio equilibrium, they will then reduce the interest-sensitive components of demand. Even if interest rates do not rise, or do not respond sufficiently, as is the case in China, and portfolio imbalances persist, the excess demand for money may cause households to spend less in order to accumulate cash (Khan and Knight, 1981).

(2). The "Ricardian equivalence" proposition

The private spending can also fall if the increased government spending increases the private sector's tax liability. This can happen either due to the higher taxes in the present or in the future because of the need to retire public debt (Barro, 1974). As is well known in a simplified Keynesian model, if tax increased sufficiently to finance government's increased expenditure, the multiplier effect of such an expansionary but balanced budget is equal to one. Even in a situation where tax revenues are not increased sufficiently to cope with the increase in government expenditures, if the latter are financed through government bond issues, and if they are purchased by households, enterprises and banks (excluding, however, the central bank), then again a "crowding out" effect on investment in the enterprise sector will take place in a similar fashion as an interest-sensitive demand in the first proposition.

On these grounds, it is uncertain whether the increase of government expenditure in years following the oil price shock increased or decreased aggregate demand. The effects of the government's expansionary fiscal policy require more empirical work.

5.4.2 Monetary policy

Another instrument for controlling demand is monetary policy. The foreign exchange accruing to the government through oil exports is deposited in the People's Bank, which is the central bank in China. The money supply will not increase if the government does not spend the deposits in the central bank. However, the oil export revenues to the oil industry, which are not deposited in the central bank, will influence the money supply through the multiplier effect. Following the reduction in foreign exchange revenues, the money base is reduced, and the money supply is expected to decrease. If exchange controls are effective, the authorities can determine the monetary base through the control over availability of foreign exchange, and over credit from the central bank. Starting from portfolio equilibrium, a fall in the supply of bank credit will cause borrowers to turn to the curb market (Khan, 1987)[2], pushing up the interest rates there. Since those rates represent the marginal cost of finance in the economy, the interest-sensitive components of aggregate demand will decline, which put downward pressure on inflation.

However, the government's effort in tightening money supply was not successful. Two problems arose. The first was that the real interest rates in China were negative over the years from 1985 to 1988. Table 5.5 shows that the yearly interest rates on loans of circulating funds and short term loans on fixed assets were about 7.92%, compared with the inflation rate of 8.8% in 1985 (State Statistical Bureau, 1989). Interest rates charged were essentially negative. With interest rates so low, demand for loans were excessive, and bank loans were effectively rationed. The second problem is that the decentralisation of the banking system resulted in over intervention by local government in lending decisions, which usually lead to credit expansion for local investment projects. Table 5.6 shows China's actual credit growth compared to that in the plan between 1978 and 1988. Since 1986, the increase of credit growth was excessive which can be partly attributed to the increasing fiscal deficit over the same period of time. Clearly, monetary policy failed to tighten money supply in the period following the oil price shock.

[2]The "curb market" assumption is used to analyse the monetary policies in economies to which standard monetary models are not applicable such as in China where financial markets are underdeveloped, foreign exchange controls are in force, interest rates are set below market-clearing levels by the government. Under these conditions, monetary policy can affect the aggregate demand through the mechanism of interest rates in an assumed "curb market" (Khan, 1987).

Table 5.5 Interest Rates in China's Specialised Banks, 1971-1988

	1971	1979	1980	1982	1983	4/1985	8/1985	3/1986	8/1986	1987	1988
Interest Rates on Residential Savings											
Current	2.16	2.16	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88	2.88
Fixed term	-	5.4	6.84	7.92	7.92	8.28	9.36	9.36	9.36	10.8	10.8
Interest Rates on Institutional Savings											
Current	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	2.88
Fixed term	-	-	-	5.04	5.04	5.76	5.76	5.76	5.76	6.48	9.72
Interest Rates on Circulating Funds											
	5.04	5.04	5.04	5.04	7.2	7.2	7.2	7.92	7.92	7.92	9
Interest Rates on Fixed Assets (For Township Industrial Enterprises)											
	4.32	4.32	4.32	5.04	5.04-7.2	5.04-7.2	7.92	9-9.36	9-9.36	9-9.36	10.8-13.3
Interest Rates on Loans Replacing Formerly Interest-Free Funds											
	-	-	-	3.6	3.6	3.6	3.6	4.2	4.2	4.2	4.2

Source: Ministry of Finance, Field Work, Beijing, January, 1989.

Table 5.6: China's Credit Growth, 1978-1988, (Rmb, billion Yuan)

Year	Planned Credit Growth (A)	Actual Credit Growth (B)	Difference (B-A)	% (B-A)/A
1978	12.3	19.24	6.99	56.8
1979	17.7	32.14	14.44	81.6
1980	19.4	48.68	29.33	151.2
1981	24.0	47.62	23.62	98.4
1982	34.1	49.04	14.94	43.8
1983	46.8	63.38	16.58	35.4
1984	51.8	118.01	66.21	127.8
1985	84.1	109.66	25.56	30.4
1986	108	181.51	73.51	68.1
1987	138	181.57	43.57	31.6
1988	180	209.00	29.50	16.4

Source: Mei Longfeng, Replacing Currency Control by Broader Money Supply Management is Imperative, *Reference Materials for Economic Research*, Vol. 146, Beijing, September, 1988.

5.4.3 Exchange rate policies

The exchange rate policy is often the centre piece of adjustment effort in economies subject to terms of trade shock. Following the oil price decline, a major policy response of the Chinese government was to depreciate Rmb in an attempt to restore equilibrium. In July, 1986, Rmb was devalued 13.6% from an exchange rate of 3.2 Rmb Yuan per US dollar to 3.70 Rmb Yuan per US dollar. The logic behind this action is very straightforward as in a country with an excess demand and subject to a terms of trade shock, a devaluation will increase the level of foreign prices measured in domestic currency and thus raise the price of tradable goods relative to non-tradable goods in the domestic economy. This is precisely what the theoretical model predicts in chapter 3. A real depreciation is necessary to spur adjustment to the oil price collapse and restore equilibrium in the goods market.

The effect of a devaluation is simultaneously expenditure-reducing and expenditure-switching; it affects both domestic absorption and domestic supply. On the demand side, the effect of a devaluation on domestic absorption is unambiguously negative: the rise in the price level reduces the real value of private sector financial assets and also of those factor incomes whose nominal values do not rise proportionally with the devaluation. On the supply side, however, devaluation will boost output if the prices of (variable) domestic factors of production rise less than proportionately to the domestic currency price of final output in the short run.

The problem is what magnitude of real depreciation is appropriate, and how to achieve the target rate by calculating the effects of devaluation on the real exchange rate? First of all, whether the shock is seen permanent or temporary makes a difference in determining the extent of real exchange rate depreciation. It is difficult to make the judgment *ex ante*, particularly as the world oil market is volatile. Secondly, a nominal devaluation will not be enough on its own: without supporting policies that limit the increase of domestic prices, the effect of nominal devaluation would be only transitory on real exchange rate. In the long run domestic prices will rise by the full amount of the devaluation, returning the real exchange rate to its original level. The extent to which the movement of nominal exchange rate affects the real exchange rate – and for how long – depends directly on the supporting measures taken, which include fiscal and monetary policies, trade policies etc..

With these considerations in mind, we turn to empirical evidence on real exchange rates, money supply and the terms of trade in China over the period of 1984 to 1988. Six pairs of China's export and import prices for energy, textiles and agricultural products are presented in Table 5.7 to show the general trend in China's terms of trade. They are generally consistent, with four out of six relative export prices to import prices deteriorated in 1986 compared to 1984. The oil price shock is obvious as the relative prices of oil and petroleum product exports to metal imports were significantly lower than other export and import price ratios in 1986. While the oil export price recovered a little in 1987, the general level of all ratios remained low, indicating the terms of trade remained unfavourable for China in 1988. The nominal exchange rate depreciated as the oil price and the terms of trade fell, reflecting the adjustment responses in the exchange rate policy.

The real exchange rate in Table 5.7 is a bilateral real exchange rate *vis-a-vis* the United States, with the Chinese official exchange rate times the U.S. wholesale price index serving as a proxy for the price of tradables, and the Chinese CPI as a proxy for non-tradables. Two problems may arise here concerning the "right" real exchange rate. The first is a measurement problem as the official exchange rate is likely to become increasingly irrelevant as the premium of the foreign exchange in the secondary foreign exchange market grows. From 1981 to 1984, the Chinese government adopted a dual exchange rate regime in which an internal exchange rate and an external exchange rate were used. The internal exchange rate was calculated at the cost of goods exported compared to the foreign exchange generated. The external exchange rate was pegged to

Table 5.7: Terms of Trade, Nominal and Real Exchange Rates and Money Supply

	1984	1985	1986	1987	1988
Terms of Trade*					
Oil/Steel	100	95.4	45.1	54.8	40.6
Petroleum Products/Copper	100	96.9	58.7	62.8	40.1
Filature Silk/Soda Ash	100	91.6	85.8	85.0	95.7
Cotton Yarn/Polythene	100	103.9	104.5	102.1	76.3
Tea/Pulp	100	111.7	98.2	76.6	63.9
Grain/Wheat	100	99.3	106.6	129.5	166.7
Crude Oil Export Prices (Rmb Yuan per tonne)	191.2	174.9	81.5	117.0	-
Nominal Exchange Rate (Rmb Yuan per US dollar)	2.32	2.94	3.45	3.72	3.72
Real Exchange Rate	0.41	0.36	0.34	0.33	-
M_1 (Rmb, billion Yuan)#	296.5	344.3	419.3	489.6	531.1
M_2 (Rmb, billion Yuan)#	423.1	528.6	662.5	810.5	861.6

Notes: * Instead of calculating a trade weighted index of the terms of trade, six pairs of export and import prices are selected to represent the relative prices of China's major exports to imports. The three major exports are energy, textile and agricultural products, each category is represented by two export and import ratios in the table. One of the advantages of separating energy export prices from other export prices in comparing with import prices is that the oil price shock is singled out.

M_1 refers to the concept of narrow money which includes currency in circulation and flexible deposits in banks. M_2 is broad money which is equal to M_1 plus term deposits and other forms of saving deposited in the banking system. The 1988 figures for both M_1 and M_2 are only estimates for the period from January to May in 1988.

Sources: 1. International Monetary Fund, International Financial Statistics, 1988.

2. Mei Longfeng, Replacing Currency Control by Broader Money Supply Management is Imperative, *Reference Materials for Economic Research*, Vol. 146, Beijing, September, 1988.

3. Ministry of Petroleum Industry, A Statistical Survey of China's Petroleum Industry, Internal Publication, Beijing, 1988.

4. CESRRI, Inflation and International Trade Fluctuation, *China: Development and Reforms*, February Issue, Beijing, 1989.

a basket of currencies and behaved like a fixed (adjustable) exchange rate. At 1981, the internal and external exchange rates were 2.80 and 1.53 Rmb Yuan per US dollar, respectively. In 1985, the official exchange rate was devalued to 3.2 Rmb Yuan per US dollar, and the internal exchange rate was abolished. Instead a semi-official system of "Foreign Exchange Adjustment Centre" was introduced, in which the exchange rate fluctuated around 5 Rmb Yuan per US dollar in 1985. The rate on the illegal black market of foreign exchange was even higher at around 7 Rmb Yuan per US dollar. The high premium in the secondary foreign exchange market implies that the official exchange rate was still overvalued, and the devaluation in 1986 was not sufficient to establish a market clearing real exchange rate.

The second problem relates to the supporting policies of devaluation. Table 5.7 shows that the increase of M1 and M2 were phenomenal over these years. The fact that this led to a high rate of inflation suggests that the monetary policy was not consistent with exchange rate policy. Ideally, when the oil market collapsed, and was expected to remain in sluggish for a while, the government should cut public expenditure and devalue the currency. The rate of money supply would decrease and inflation would decline, and the real exchange rate would tend to depreciate directing resources to flow to the traded goods sector. However, despite the fact that the oil receipts levelled off, the government deficit increased after 1986 (Table 5.4), which implies a large doses of new domestic and external debts were needed to close the gap. The monetisation of deficit in the domestic market put upward pressure on domestic prices, which reduces the effect of devaluation on real exchange rate, and is likely to result in an overvalued real exchange rate which gives wrong signals for resource allocation in the economy.

5.5 Conclusions

The institutional arrangements of oil export revenue allocations in China transmitted the effects of the 1986 oil price fall in two channels: a decrease in the Chinese oil industry's investment funds and a reduction of government revenues. In the absence of government action, the reduced expenditures in the oil industry and the government would lower the price for non-traded goods, and induce a real exchange rate depreciation to facilitate the structural change.

But given the "structural contradiction" of the Chinese economy towards the mid-1980s, and motivated by other problems which arose in the process of economic reforms, the Chinese government offset the losses of the oil industry by increasing budgetary allocations and bank loans to the oil sector. Government intervention protected the oil industry, but failed to cut expenditures in the non-traded goods sector, and a large fiscal deficit emerged. As a result, the government isolated the "resource movement effect" by making the oil sector an "enclave", and offset the spending effect through its fiscal deficit.

The monetisation of the fiscal deficit generated inflationary pressure in the economy, and so larger reactions were required to bring about a real exchange rate depreciation. Following the results of the quantity-constrained model as illustrated in chapter 3 (section 3.3.1), the subsequent adjustment policies would then involve a cut in money supply and a depreciation of the fixed exchange rate.

However, the government failed to tighten money supply due to the interventions of local governments in the decentralised banking system and low interest rates. While the depreciation of the official exchange rate was in the right direction, the magnitude of devaluation was not sufficient. The real exchange rate remained over-valued. The empirical significance of these adjustment policy outcomes will be evaluated using a computable general equilibrium model in the following chapters.

Chapter 6

A CGE Energy Model

6.1 Why a CGE Model?

In the theoretical application of the booming sector model to the oil price fall in China, the analysis was focused on the interactions of some key aggregates, and other inter-relationships in the system were obscured. However, the effects of an external shock are economy-wide so that all macro- and micro-variables in the system are affected. Any satisfactory model must then take into account these effects. Often, the interactions of these variables generate competing forces in determining the final effects of the shock. For example, the oil price fall may induce a substitution effect in the energy sector between oil, petroleum and coal. The final outcome depends on the relative strength of positive and negative forces, and its estimation requires a less aggregated analysis of differentiated energy products rather than one homogeneous energy product, as assumed in the theoretical model in chapter 5. The number of variables involved, and the complexity of their inter-relationships, rule out the use of purely theoretical models.

In this chapter, a computable general equilibrium (CGE) model is developed to overcome this problem. A CGE model can take into account all interactions in the system explicitly, as it replicates all commodity and factor markets together with decision making agents in the economy. There are many advantages in using a CGE model to analyse issues related to external shocks which have economy-wide effects, particularly where the shock involves inter-industry linkages. In the case of the 1986 oil price fall, since oil is both an exportable and an intermediate input in China, the effects will include both a switching between traded and non-traded goods and substitutions between energy products. The attempt by Dervis, de Melo and Robinson (1982) in modelling three archetype economies in a common CGE framework demonstrated that a CGE model is fruitful and rich enough to accommodate the wide variety of market and non-market mechanisms that a priori theorising indicates should be important. Beyond that, a CGE model often provides many useful insights by discovering some causal linkages otherwise overlooked, but which matter. Stoeckel's (1979) small CGE model of the Australian economy highlighted the major differences between a resource boom resulting from a mineral discovery and one resulting from a mineral price increase, which would not have been distinguished by a theoretical booming sector model (Corden, 1984).

Another major advantage of the CGE approach is that it provides a consistent way to look at a wide range of policy issues, and makes it possible to blend the theory with policy so as to improve the analytic foundations of policy evaluation and to bring the theory existing in the literature more fully into policy debate. In the case of modelling a slump in an economy, Condon *et al.* (1985) Dick *et al.* (1984) and Vincent (1985) investigated various policy issues in Chile in response to a reduction in world copper prices in 1980 and 1981. Models for Colombia, Ivory Coast and Kenya were also developed analysing the policy implications of fluctuations of primary commodity prices in LDCs (Dick *et al.*, 1983).

In recent years, CGE models have been used widely to analyse the post-reform centrally planned economies (CPEs) (Kis, Robinson and Tyson, 1986). As a matter of fact, earlier modelling work was successful in CPEs during evolution of CGE models (Bandara, forthcoming). Until early 1970s, multi-sectoral models such as Input-Output (I-O) models and Linear Programming (LP) models which emphasised the question of optimal multi-level planning were popular in CPEs where the planners had controls over the allocation of investments. However, the applicability of such models to the *reformed* CPEs became an issue, as resource allocation has become largely determined by market mechanisms and independent decision making agents. In this context, the development of CGE models, which can be treated as a natural extension of I-O models and LP models, offers a better analytical framework for mixed economies, because CGE models overcome the shortcomings of the previous multi-sectoral models by including an endogenous output and price system and the optimisation behaviour of individual agents.

The improvements in CGE models have been highlighted in the area of international trade. The stop-go cycles of the world economy since the first oil price shock have shifted the policy interest towards adaptation to trade shocks. The ability of CGE models to cope with policy issues related to trade shocks makes a CGE model a far more useful tool than earlier models where international trade was treated unsatisfactorily. For example, the I-O models typically limit the role of relative prices in international trade, with exports fixed exogenously with a given level of domestic final demand, and imports assumed non-competing (Leontief, 1936). While prices are introduced explicitly in the LP models, the trade constraints against which a certain objective function is optimised have not been handled in a sufficiently realistic way. This is illustrated by the Evans (1972) model of the Australian economy, which is regarded as a good LP application. Although foreign trade was modelled carefully, trade flow responses were excessively sensitive to minor changes in relative prices (Bandara, forthcoming).

6.2 A China Model and the Data Base

The idea of applying the CGE technique to China with special interest in the case of oil price fall was initiated in the very beginning of the present study. The first thought behind the idea was very simple: to write down everything we know about the problem in a system of equations describing the behaviour of the economy, allow for the special characteristics of the Chinese institutions and conditions in the initial "equilibrium", then superimpose the oil price shock onto this initial equilibrium, and interpret the results of the new equilibrium in the light of the booming sector theory. This idea was developed in ignorance of the difficulties involved in building a CGE model. While the technology for constructing a CGE model has improved dramatically with the rapid growth of transferable software such as GEMPACK, GAMS, HERCULES and OCTASOL etc.,[1] the problem of the data base for the model had to be solved.

In CGE modelling, data requirements are enormous. In general, all CGE models are calibrated to replicate a set of data for a base year. Usually, two sets of values are identified in the data base. The first set of values are related to the share coefficients such as cost shares, sale shares, revenue shares etc.. The second set of values are elasticity parameters consisted of elasticities of substitution, indexation parameters etc.. For many CGE applications, the first set of values can be derived from *input-output tables.* To tackle issues such as income distribution and structural adjustment, the data requirements go beyond input-output data. To fill this data gap, a data framework called the *Social Accounting Matrix* (SAM) was developed during the 1970s (Pyatt and Round, 1985). A SAM captures the flows of income and expenditure, so it can be used to derive values for some of the key parameters necessary for some specific model implementations. The estimation of the second set of values,

[1]GEMPACK was developed by the Impact Project for implementing Johansen type CGE models (Codsi and Pearson, 1988c, 1988d and 1991). GAMS was designed by the World Bank for building both linear and non-linear models (Brooks, Kendrik and Meeraus, 1988). HERCULES is used for models based on transaction value approach (Drud, Grais and Pyatt, 1986). OCTASOL is used for solving a system of non-linear equations (Broadie, 1983).

the elasticity parameters, is another problem in CGE modelling, as it requires extensive econometric work. In many cases, the use of values estimated in previous studies has become the usual practice. A large number of studies also use "best guess" estimates to fill the gaps. In this section, the discussion of the data base for a China model focuses on the first set of value, which is based on input-output data or SAM data.[2]

6.2.1 A simple SAM

The first attempt to build a data base for a China model was made in 1987, during a fieldwork trip to China, while the author was based at the Ministry of Finance in Beijing. Apart from the effort required to get around the problems of bureaucracies and sensitivity about data, two major problems were confronted: one was conceptual, the other statistical.

1, The conceptual problem

The conceptual problem is to do with the differences between the data in the Chinese statistical system and the data required by a CGE model. The Chinese system of national accounts was adopted from the Material Product System (MPS) in the 1950s. Historically, MPS was a system invented in the Soviet Union and later widely used in socialist countries in Eastern Europe (Dervis *et al.,* 1982). Planners in these countries worked in the environment of a command economy. They were thus able to ignore the market system and to rely largely on command instruments. Production targets, investment allocation, intermediate inputs, and even labour were allocated directly in physical terms without much concern with the underlying value flows and market incentives. To provide information on a number of key control variables such as the share of agriculture, light industry and heavy industry in total output, the ratio of investment to consumption etc., MPS focuses on the balance of

[2]Detailed discussions on the elasticity parameters of the model are in Martin (1990a).

the production, distribution, consumption and accumulation of Net Material Product (NMP). So MPS is consisted of a set of material accounts.

This is in contrast with the System of National Accounts (SNA) where market transactions are emphasised (United Nations Statistical Office, 1968). In market economies, prices play a dominant role in clearing the markets for good, services and capital. This requires SNA to take implicit account of prices. So the accounts in SNA are value based, and reflect the market evaluation of economic activities. Corresponding to the concept of NMP in MPS, SNA uses gross domestic product (GDP) to measure the implicit value outcome of market transactions in the economy, whereas NMP measures the material outcome of an economy. Although accounts in MPS are also expressed in value terms, prices are not endogenous in the system.

As pointed out earlier, all CGE models are characterised by including an endogenous output and price system and the optimisation behaviour of individual agents. Therefore, data used in CGE models are all based on SNA conventions. To build a data base for a China model, the Chinese MPS statistics had to be converted to SNA equivalents.

One way to overcome this problem is to convert MPS accounts to SNA accounts implicitly through price adjustments, so to obtain a price endogenous data base. This is particularly useful for analysis of external shocks where the structure of prices – of home goods versus traded goods, real versus nominal exchange rate, and price relationships among various traded goods – is a key issue. Shifts in these relative prices have important consequences, as suggested by the booming sector literature. Given the existence of the two-tier price system in China (chapter 4), it is possible that endogenous price determination may overstate the price sensitiveness and the flexibility of the Chinese economy. However, this assumption is crucial in capturing the main features of the post-reform Chinese economy (Martin, 1990a; Byrd, 1987 and 1989; Sicular, 1988; Wu Jinglian and Zhao Renwei, 1987).

2, The statistical problem

It is obvious from the above discussion that the differences in accounting concepts will be reflected not only in terms of valuation methods, but also in coverage. GDP is a much wider aggregate than NMP as the latter excludes non-material services. There are many other gaps between the Chinese statistics and the required data of SNA type (World Bank. 1985d). In order to fill these gaps, a systematic comparison between the structures of Chinese MPS and the standard SNA (United Nations Statistical Office, 1968) is presented in the first two columns of Table 6.1.

The Chinese MPS consists of a set of balance tables (*Pingheng Biao*), each focusing on one particular aspect of the economy. Five aspects are covered: (1) production; (2) human resources; (3) capital; (4) finance and banking, and (5) international trade. There are altogether 11 tables in the system. These tables aim to provide information for national economic planning, emphasising the balance of production, allocation and accumulation for material products. While the intermediate consumption of products are carefully reported for a wide range of products in the production balance tables, the *final* consumption of these products are left out, except household income flows which are covered in finance and banking balance tables. This reflects the investment driven pattern of growth. [3]

There is no direct linkage between each table in the Chinese MPS. The parameters chosen and information collected in each table are based on different statistical criteria and serve different purposes. It is possible that different values are shown for the same variable in different tables. This type of inconsistency in statistics made the conversion of the data in the Chinese MPS to a set of SNA data extremely difficult. As can be seen in the second column of Table 6.1, SNA provides a picture of the "circular flow" in an economy. All accounts

[3] The Chinese MPS was updated in 1989 with the creation of a new account for "Household Consumption", and the total number of tables in the system increased to 19. The new system also introduced some Western concepts in national accounts, and is more comparable to SNA.

Table 6.1 Comparisons of Chinese MPS *vs.* Western SNA & SAM

Chinese MPS	SNA	SAM
Production	Opening Assets	Production
Products	Financial claims	Activities
Production materials	Net tangible assets	Commodities
Human Resources	Production	Factors
Population mobilisation	Commodities	Labour
Labour utilisation	Activities	Capital
Skilled labour allocation		
	Consumption	Institutions
Capital Balance	Expenditures	Households
Fixed capital	Income and outlay	Enterprises
Circulating capital		Government
	Accumulation	
Finance and Banking	Increase in stocks	Capital Accounts
State budget	Fixed capital	
Credit	Financial claims	Rest of World
Finance	Capital finance	
Rest of World	Rest of World	
	Current transaction	
	Capital transaction	
	Evaluations	
	Financial claims	
	Net tangible assets	
	Closing Assets	
	Financial claims	
	Net tangible assets	

Table 6.2: Structure of a Simplified Social Accounting Matrix

	EXPENDITURES									
			Factors		Institutions					
RECEIPTS	Activities [1]	Commodities [2]	Labour [3]	Capital [4]	Households [5]	Enterprises [6]	Government [7]	Capital account [8]	Rest of world [9]	Totals [10]
Activities [1]		Domestic sales					Export subsidy		Exports	Total production
Commodities [2]	Intermediate inputs				Private consumption		Government consumption	Capital formation		Total income
Factors:										
Labour [3]	Wages									Factor income
Capital [4]	Rentals									Factor income
Institutions:										
Households [5]			Labor income		Transfers	Distributed profits	Transfers		Net factor income	Household income
Enterprises [6]				Capital income			Transfers		Net private flows	Enterprise income
Government [7]	Indirect taxes	Tariffs			Direct taxes	Direct taxes			Net public flows	Government income
Capital account [8]					Private saving	Retained earnings	Government saving		Reserve balance	Total saving
Rest of world [9]		Imports								Exchange outflow
Totals [10]	Total costs	Total absorption	Wages	Rentals	Household expenditures	Enterprise expenditures	Government expenditures	Investment	Foreign exch. inflow	

are integrated in a framework which requires that all real and nominal flows must be consistent. Such a "consistency check" can often reveal problems with data. Comparing column 1 and column 2, it would seem to be an unattainable goal to fill the data gap between the Chinese MPS and Western SNA. To overcome the problem, the more general, and yet simpler framework of SAM is used to bridge the Chinese MPS accounts with the Western national accounts. Like SNA, SAM also provides a complete and consistent picture of the "circular flow" in the economy, but it focuses on the interrelationships among the different "actors" or "institutions" one wishes to distinguish in the form of "flow of funds" defined more broadly than SNA (United Nations Statistical Office, 1968). The format of SAM is simpler than SNA, as there is no such thing as "standard" SAM. The definition of the different accounts, the degree of disaggregation and the accounting conventions used in SAMs vary according to the issues considered, so SAM can make most use of whatever data available (Greenfield, 1985). This makes the reconciliation of the Chinese accounts with Western conventions easier.

A simplified structure of SAM is presented in column 3 of Table 6.1. Intuitively, SAM is more comparable to the Chinese MPS accounts, and also represents a considerable condensation of SNA by precluding the accounts of opening and closing assets and evaluation. The comparison is facilitated by Table 6.2 which is a typical, if not "standard", example of SAM. In the square matrix of Table 6.2, the rows represent receipt accounts and the columns expenditure accounts. The defining characteristic of a SAM is that each corresponding row and column reflects a separate account for which expenditures and receipts must balance.

Following SNA, the production account in SAM is also subdivided into "activities" and "commodities", so that a "make" submatrix, showing industrial production by commodity, and a "absorption" submatrix, showing the use of commodities by industries, are separately estimated, with imports shown classified by commodities. These two submatrixes can be combined into one single submatrix through mechanical algebraic manipulation using either an industry-based technology or a commodity-based technology.

The derived single submatrix, the first cell in SAM, is an input-output table. The accounts disaggregated in this single submatrix, usually labelled "activities" instead of "commodities", correspond to the producing sectors in the input-output accounts. The sum of the input-output accounts of "total intermediate inputs" and "total value added" plus "imports" (including "tariffs") minus "exports" is exactly the total of the "commodities" account in SAM. This cell of input-output table in SAM can be filled up by data sourced from the "products" account in the Chinese MPS. Issues involved in this cell will be discussed in detail later.

Next, the SAM framework uses accounts of "production materials" and "institutions" to accommodate the "consumption" account in SNA, which can make use of the data scattered in the Chinese MPS under accounts of "factors", "human resources" and "finance and banking" where various institutions in the Chinese economy are identified.

In SNA, "consumption" is subdivided into "expenditure" and "income and outlay". While not shown in Table 6.1, "expenditure" is further divided by purpose – for households, government and private nonprofit bodies, and "income and outlay" are subdivided into the subheadings of value added, institutional sector of origin, form of income, and institutional sector of receipt (United Nations Statistical Office, 1968). It would take too long to describe the logic of all the flows arising from these classifications in SNA.[4]

In SAM, all the above accounts are replaced by accounts of "factors" and "institutions". The logic of the flow is intuitively clear. Starting with factors which receive income from hiring their services to production activities (intersection of rows 3+4 and column 1), this income is then channelled to the

[4]For example, the flow of value added can be traced through these accounts: value added → form of income → institutional sector of receipt & rest of world → expenditures & form of income & capital finance (savings).

institutions owning the factors, namely, households, enterprises, government (intersection of rows 5+6+7 and columns 3+4). In studies that focus on distribution of income, the mapping from factor incomes to institutions needs to be more careful to reflect the complexities of distribution process.

Transfers between domestic institutions then occur, such as payments of interest, dividends, and direct taxes, as shown in the institution-by-institution submatrix in SAM (intersection of rows 5+6+7 and columns 5+6+7).

The income of institutions is then spent on domestic production (intersection of rows 1+2 and columns 5+6+7), imports and other payments to the rest of the world (intersection of row 9 and columns 5+6+7), and the balance is saved (intersection of row 8 and columns 5+6+7).

Next, the "capital account" in SAM may lose some detail against the "accumulation" account in SNA, as the distinction of "increase in stocks" and "fixed capital" is not shown in SAM. However, the treatment of "financial claims" is essentially the same as that in SNA, and the basic identity – that savings is equal to capital formation – is retained (row 8 and column 8). The advantage of the simpler treatment of capital account in SAM is that it makes use of the limited data in the "capital" account in the Chinese MPS, whereas conversion to SNA conventions would be difficult.

Finally, the "rest of world" account is used to reflect the sources of foreign exchange (column) and its disposition (row). Both current and capital transactions in SNA are taken into account in SAM. Foreign exchange receipts from exports and foreign borrowing are distributed to various actors. These receipts are used to buy imports or are held by government as increased reserves. The international balance approach in the Chinese MPS is basically consistent with the treatment of foreign trade in SNA and SAM, except the distinction between domestic and imported intermediates in the intermediate use is not estimated in Chinese data.

The major advantage of the SAM approach is that it brings together the accounts in the Chinese MPS into a consistent framework, and the format is simpler than SNA. The consistency property of SAM provides a useful check in reconciling data from disparate tables in the Chinese MPS. Based on the data collected in the 1987 fieldwork in Beijing, a simple Chinese SAM was constructed for year 1980. At the time of the fieldwork, building a SAM was a new thing in China. Only few research and government institutions were attempting to build a SAM for China.[5] The Chinese SAM presented in Table 6.3 was an experimental exercise which used the device of SAM as an organising framework to put together the Chinese statistics in a consistent data base.

Due to variations in definitions between different accounts and discrepancies in coverage and accuracy, data in the Chinese SAM was assembled in sequence. Starting with what were considered to be the more reliable data and forcing data assembled at later steps to be consistent with control totals from former steps.

China's national accounts are compiled at "purchaser's prices". However, the use of true basic values defined as "producer's value of the gross output of commodities and industries"[6] is stressed as essential in SNA as being essential in order to obtain uniformity of valuation. So the Chinese accounts were converted to *producer's prices* which excludes the effect of indirect taxes and subsidies. The Chinese GDP in 1980 was estimated Rmb 425.62 billion Yuan at 1980 producer's prices. This was close to the later official estimation of Rmb 433 billion Yuan published in 1988 (State Statistical Bureau, 1988, p.36). The derived GDP which is defined as net final demand in SNA was then converted to SAM accounts of total value added at market prices (Dervis *et al.*, 1982,

[5]During the fieldwork in 1987, three useful contacts were consulted regarding building a Chinese SAM: Dr Liang Huimin at the Ministry of Finance who was constructing a SAM type "flow-of-funds" matrix for China with his colleagues, Mr Luo Deming at the Research Institute of Fiscal Sciences under the Ministry of Finance (Luo Deming, 1986), and Mr Wang li at the Centre of Social, Economical and Technological Developments under the State Council who was also building a SAM for China.

[6]United Nations Statistical Office, 1968.

Table 6.3 A Simple Social Accounting Matrix for China, 1980 (Rmb Billion)

		[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
		Activities	Commodities	Labor	Capital	Rural households	Urban households	Enterprises	Government	Captital account	Rest of world	Totals
[1]	Activities		865.60								30.50	896.10
[2]	Commodities	470.49				165.42	101.58		32.70	130.30		900.50
	Factors:											
[3]	Labor	220.24										220.24
[4]	Capital	119.48										119.48
	Institutions:											
[5]	Rural households			133.95					35.12		0.25	169.32
[6]	Urban households			86.29					23.04		0.25	109.58
[7]	Enterprises				119.48							119.48
[8]	Government	85.90						43.95			3.90	133.75
[9]	Captital account					3.90	8.00	75.53	42.88			130.30
[10]	Rest of world		34.90									34.90
[11]	Totals	896.10	900.50	220.24	119.48	169.32	109.58	119.48	133.75	130.30	34.90	2833.65

p.19), that is, value added at factor prices (wages and rentals) plus indirect taxes: (220.24 + 119.48) + 85.90 = 425.62. Ideally, tariffs should also be included, but the lack of data about government taxes on imports left the cell for tariffs blank (intersection of row 8 and column 2); the same applies to the cell of government subsidies to exports (intersection of row 1 and column 8).

The fact that it is difficult to draw a meaningful line between indirect taxes and profits, or between subsidies and losses in the Chinese statistics also made it difficult to calculate sectoral shares of GDP (World Bank, 1985d, p.19). Therefore, the disaggregations of "activities" and "commodities" accounts were avoided. Single entries were used for both the "activities" and "commodities" accounts (implying one activity and one commodity). This approach also avoided the problem of substantial discrepancies in the intermediate matrix of the original Chinese MPS estimations. In MPS, the individual intermediate flow elements were in general estimated independently of the row and column intermediate use totals and so resulted in discrepancies. These discrepancies can be eliminated by SNA accounting logic. Given the availability of a complete set of intermediate flows estimated by the World Bank in SNA version (1985d), the single entries for "activities" and "commodities" were considered sufficient in this exercise.

The distribution of factor incomes is characterised by the distinction between rural and urban households which made use of the "population mobilisation" "labour resources" accounts in the Chinese MPS. This disaggregation leads to a more satisfactory treatment of income distribution, as there is a substantial difference of income between rural and urban areas in China. Comparing rural and urban households consumption (165.42 *vs.* 101.58) and savings (3.90 *vs.* 8.00), the higher consumption and lower saving ratios in terms of their respective total incomes (factor incomes plus government transfer) of rural households than urban families (169.32 *vs.* 109.58) reflect the low income level in rural China.

Larger saving by enterprises compared to that by government (75.53 *vs.*

42.88) shows the change of investment structure in China resulted from the rapid increase of "extra-budgetary" investments recorded in the balance tables of "finance and banking" accounts in the Chinese MPS (Table 6.1). The government which used to be the biggest investor in the economy was replaced by enterprises following the decentralisation brought about by economic reforms. Under the assumption of continuous reforms, government "direct taxes" (85.90) and government savings (42.88) could be expected to decline even further (Blejer and Szapary, 1989).

Due to lack of data, institutional transfers among households and enterprises could not be included (the intersection of rows 5+6+7 and columns 5+6+7).

Finally, the "rest of world" account was balanced based on the then available estimations in the Chinese statistics. As can be seen, the trade deficit ($30.50 - 34.90 = -4.4$) was mainly financed by government borrowing overseas (3.9) rather than by running down foreign exchange reserves.

The simple SAM captures the income distributions in the Chinese economy. But for analysis of oil price changes, more attention is on the input-output relations on the economy. Subsequently, a model based on that sort of data became available which will be discussed below. But the simple SAM exercise served two important purposes. First, it demonstrated that the Chinese data, given their conceptual and statistical problems outlined at the beginning of this section, can be put together in one unified set of accounts comparable to SNA conventions to form a consistent data base for a CGE model. Secondly, it helps in understanding the conventions used in a CGE model, and therefore the structure of the data base required. Later, when a simpler data base framework became available for the China model, the compilation and adjustment of data could be handled with ease because of this experience in building the SAM.

6.2.2 The input-output data base

For any given SAM such as the simple one for China presented in the previous section, the underlying system of relationship is likely to be complex and non-linear. With certain limiting assumptions and exogenous determinations of some variables, a set of behavioural and technical equations can be specified to build a SAM type model (Thorbecke, 1985).

As learned from SAM, for a data system to become tantamount to a modelling framework, three basic questions need to be answered in the data base:

(1) what are the economic institutions or "actors" that are included?

(2) what are the markets that are explicitly or implicitly included?

(3) what are the behavioural or technical rules that underlie the accounts?

In SAM, producers ("activities") along with "institutions" represent the major economic actors in the system. There are two markets: products market ("commodities") and factor market ("factors"). The behavioural assumptions underlying the accounts are shown implicitly in the "circular flow" in the system. The income levels of factors, institutions and production activities are endogenously determined as functions of the exogenous demand on the other accounts such as "rest of world" in the data base. According to Thorbecke (1985), it is written as:

$$Y = (I - A)^{-1}X \tag{6.1}$$

where Y stands for total income (receipts) vectors for endogenous accounts, and X represents the vector of injections of exogenous accounts. A is a partitioned matrix representing the interrelationships of the endogenous variables in the system which can be derived from SAM.

Using the SAM in Table 6.2 as an example, if assume "capital account" and "rest of world" are exogenously determined, then the partitioned matrix

A derived from the SAM in Table 6.2 is:

$$A = \begin{bmatrix} A_{11} & 0 & A_{13} \\ A_{21} & 0 & 0 \\ A_{31} & A_{32} & A_{33} \end{bmatrix} \quad (6.2)$$

where A_{ij} represents the expenditures of account j accruing as receipts to account i divided by the sum of vector j.

At first glance, equation 6.1 appears analogous to the Leontief-inverse solution of a static input-output model (Leontief, 1936). The basic difference, however, is that the partitioned matrix A in equation 6.1 incorporates income distributions, whereas the corresponding matrix in the Leontief-inverse solution only captures the production inter-relations. The Leontief-inverse solution is given by:

$$Y' = (I - A_{11})^{-1}X' \quad (6.3)$$

Clearly, the partitioned matrix A incorporates several other matrices in addition to A_{11}. While models with income distribution extension require a SAM data base to derive this partitioned matrix A, models focused on the real side of the economy require a simpler data base to derive the core coefficient matrix A_{11} and other necessary coefficients. This simpler data base is the *input-output table.*

The structure of an input-output data base is presented in Figure 6.1. For convenience, the input-output table is organised into several matrices denoted as Ã, B̃, C̃, ..., etc.. For the moment, the numbers which define the size of each matrix are taken as given, they are used to facilitate discussions later in this section.

Let's examine the input-output data base by answering the three questions as suggested by the SAM framework.

(1) <u>Institutions included</u>

Figure 6.1 Input-Output Data Base

	Domestic industries (current production)	Final Demands: House-hold cons'n	Govern-ment cons'n	Investment	Exports	Imports	
Domestic commodities	← 27 → ↑ 27 ↓ $\tilde{A}$	← 1 → $\tilde{B}$	← 1 → $\tilde{C}$	← 2 → $\tilde{D}$	← 1 → $\tilde{E}$	← 1 → $\tilde{F}$	Row sums=total usage of domestic goods
Labor	↑ 1 ↓ $\tilde{G}$						
Capital	↑ 1 ↓ $\tilde{H}$	$\underline{\underline{O}}$	$\underline{\underline{O}}$	$\underline{\underline{O}}$	$\underline{\underline{O}}$	$\underline{\underline{O}}$	
Land	← 4 → ↑ 1 ↓ $\tilde{I}$						
	Column sums = outputs of domestic industries at basic values	Column sum = total house-hold expen-diture	Column sum = total govt. expen-diture	Column sums = invest-ment expen-diture	Column sum = total exports	Column sum = total imports	

Producers (domestic industries), households and government are the main actors in the input-output system. "Enterprises" do not appear as a separate institution here because they are not treated as behaviourally distinct from producers. This simpler treatment is reasonable given that the input-output data base is for models focused on the real side of the economy. But the treatment of "producers" in input-output tables usually receives more attention than in SAM. Recall in our simple SAM, only one activity and one commodity were assumed. This now needs to be disaggregated. The inclusion of intermediate goods is a major focus of the input-output accounting system, which permits the analysis of both the structure of gross production and of interindustry linkages.

(2) Markets included

As in SAM, both product markets and factor markets are incorporated in the input-output data base. The "domestic commodities" represent the domestic markets for all products. Matrix $\tilde{A}$ shows the flows of domestic goods to domestic industries. Matrices $\tilde{B}$, $\tilde{C}$, $\tilde{D}$, $\tilde{E}$ and $\tilde{F}$ shows the flows of domestic goods to household, government, investment, export and import, respectively. The flows of goods contained in the matrices $\tilde{G}$, $\tilde{H}$ and $\tilde{I}$ provide a breakdown of value added in each sector. The elements of these three row vectors represent the purchase of labour, the rent of fixed capital and land in each industry.

(3) Assumptions used

The assumptions underlying the accounts are the same as specified in the "circular flow" in the system in SAM. The sum of the first column ($\tilde{A}+\tilde{G}+\tilde{H}+\tilde{I}$) in the input-output table is exactly the same as the aggregation of the entries in the first column in SAM (Table 6.2). In input-output table, total absorption can be defined as the domestic supply (the sum of the matrices in the first row) plus imports ($\tilde{F}$) minus exports ($\tilde{E}$), which is exactly the total of the "commodities" account in SAM (row 2 and column 2 in Table 6.2).

The treatment of foreign trade in input-output table is essentially the same as in SAM, but with difference in account treatment. Exports in SAM are sold directly to the "rest of world" by producers ("activities") (see intersection of row 1 and column 9 in Table 6.2). Correspondingly, Matrix $\tilde{E}$ in the input-output table shows direct flow of domestic goods to exports. Note exports are included in the "commodities" account as input-output tables do not separate two sub-matrixes for "activities" and "commodities", but combine them in one matrix as represented by matrix $\tilde{A}$ in Figure 6.1 (See discussions at p. 165-6). The inclusion of exports in "commodities" avoids the problem of treating exports and imports asymmetrically as in SAM (Dervis *et al.,* 1982, p. 159).

The treatment of imports in input-output table is less straightforward than in SAM. In SAM, the "commodities" account corresponds to the domestic market for all products, with supplies coming from both producers and imports (column 2 of Table 6.2). But the row sum of the "commodities" account in input-output table is calculated by *subtracting* imports ($\tilde{F}$). This approach for imports used in input-output table is actually the same as in SAM. The reason imports are subtracted is that imports have been treated as an alternative source of supply of goods classified by the input-output sectors, the intermediate and final demand flows in the input-output data base of Figure 6.1 already include imports, which then have to be subtracted to calculated total domestic supplies (Dervis *et al.,* 1982).

The above approach for imports assumes that imported and domestic goods are the "same", that is, they are competitive substitutes to domestic products (Armington, 1969b). A different approach is to view imports as "non-competitive", so imports are treated as another input that is not produced in the economy. In this case, the intermediate and final demand flows (the first row in the input-output table) refer only to payments for domestic goods. Imports as a non-produced input is then analogous to capital, labour and land.

Instead of appearing in the first row as matrix $\tilde{F}$, imports would appear in the first column of the input-output table along with payments for factors of production ($\tilde{G}$, $\tilde{H}$ and $\tilde{I}$).

The absence of labour, capital and land entries in the household consumption, government consumption, investment, exports and imports columns reflects the convention that primary factors are used only in current production.

6.2.3 Adjustment of the World Bank I-O Table

In 1988, Dr Will Martin at the National Centre for Development Studies, the Australian National University, started to build an ORANI [7] type CGE model for China (Martin, 1989a). For models of the ORANI type (Dixon *et al.*, 1982; Dee, 1989), the data base is an input-output accounting system. The World Bank 1981 input-output table for China (World Bank, 1985c and 1985d) was used as the starting point for the data base of the Martin model.

The major advantage of the World Bank input-output table is that it has been consistently estimated in SNA conventions as needed, these include (1) the estimation of non-material sector data (NMP to GDP); (2) reclassification of depreciation (from consumption in MPS to fixed investment in SNA); (3) reclassification of military investments (from fixed investment to public consumption) etc.. Details are reported in the World Bank (1985d).

However, the fundamental problem in the World Bank input-output table is that the estimates were based largely on "official prices". Even in an attempt to convert these official prices to comparable prices in other developing countries, the adjustment coefficients of prices used were calculated at the official exchange rate (World Bank, 1985d, p.47). In CGE modelling, it is assumed that the economy is in *equilibrium* in the benchmark year. It is then clearly inappropriate to have a data base aimed at replicating such a base year but

[7] A multi-sectoral model of the Australian Economy built by Peter Dixon *et al.* (Dixon *et al.*, 1982).

valued at official prices rather than *equilibrium* prices. Given the significant market share in the Chinese economy, this price treatment is unsatisfactory.

One important step in making the World Bank input-output table a data base for a China CGE model is to adjust the prices in the table so as to replace official prices by free market prices which are the only relevant prices for resource allocation at the margin. Efforts made to improve the World Bank data base is now discussed.

The strategy used to improve the World Bank official price based input-output table was to collect a set of relativities between the official and market prices in the Chinese economy, and use these price relativities to adjust the World Bank input-output table so a data base valued at market prices was obtained. As the World Bank table was constructed for year 1981, the assumption used in this adjustment was that the mixed system of plan and market operating in the 1981 Chinese economy would result in the same set of *quantity variables* as would have resulted from a market system in equilibrium (Martin, 1990a). Some support of this (admittedly strong) assumption is provided by Anderson's (1989, p. 70) conclusion that the pattern of development in the Chinese economy since 1949 has been consistent with the predictions of neoclassical economic theory.

A second fieldwork trip to China was made in 1988. One of the major objectives of the fieldwork was to collect the market price data in the Chinese economy where the secondary markets had been fairly well-developed, but the statistics of market transactions were not systematically recorded, sometimes not even for planned prices. Based at the Industrial Economics Research Institute (IERI) of the Chinese Academy of Social Sciences (CASS), the fieldwork benefited from the close contacts between IERI and the State Price Bureau, the Prices Research Centre of the State Council, and the Editorial Department of the *Journal of Price and Cost* in CASS.[8]

[8]All the institutions mentioned were located in one compound.

Four sets of price relativities for 100 products were collected: two sets for year 1988, and two sets for year 1984 as another reference. In updating the input-output data base, mainly the 1988 price sets were used.

The original data were all in the form of price relativities of domestic prices to world prices. The two sets of price relativities for 1988 were: the relativities of official prices (P_o) to world prices (P_w), and the relativities of market prices (P_m) to world prices (P_w). The official prices were government procurement prices (mainly for agricultural products) and ex-factory prices (mainly for industrial products). The market prices were the prices prevailing in the sccondary markets, both for production materials, intermediate products and consumption goods. The world prices were those at the major international trading centres, or f.o.b. prices of major export countries, or c.i.f. prices of major import countries.

One problem with the original data was that the price relativities were calculated at different exchange rates. In comparisons of official prices to world prices, the official exchange rate (e_o) [9] was used to convert world prices into domestic currency prices. In comparisons of market prices to world prices, the market exchange rate (e_m) [10] was used. So the two original price relativities are given by:

$$R_w^o = \frac{P_o}{P_w \cdot e_o} \tag{6.4}$$

$$R_w^m = \frac{P_m}{P_w \cdot e_m} \tag{6.5}$$

where

R_w^o stands for the ratio of official prices to world prices; and

R_w^m represents the ratio of market prices to world prices.

Despite the inconsistent treatment of exchange rates in the two price ratios, the original price relativities do give some indications of how the official and

[9] In 1988, the official exchange rate was 3.72 Rmb Yuan per US dollar.

[10] In 1988, the market exchange rate in the Foreign Exchange Adjustment Centres in China was 5.7 Rmb Yuan per US dollar.

market prices compared with the world prices. By dividing the 100 products into 7 categories, the deviations of the official prices from the world prices are presented in an ascending order as following:

(1)	Chemical products	+5.6%
(2)	Agricultural products	-20.8%
(3)	Textile and other light industrial products	-30.6%
(4)	Non-ferrous metals	-39.2%
(5)	Ferrous metals	-54.1%
(6)	Building materials	-58.0%
(7)	Energy products	-65.5%

The negative (positive) signs indicate the official price were lower (higher) than the world price by the percentages attached. These gaps were largely closed in the secondary market for most of the products, such as petroleum products in the energy products category, organic chemicals in the chemical products category etc., but some differences of market and world prices still existed for some products such as non-ferrous metals which showed a -33.6% deviation from the world prices.

Instead of looking at the relativities of domestic (planned and market) prices to world prices, our interest is the relativities of the official and market prices in the domestic economy. This is the main difference between our approach and approach used by the World Bank to estimate Chinese prices (World Bank, 1985d, p. 5). To obtain a set of relativities between official and market prices, the inconsistency of exchange rate treatment in the original two relativities are removed. From equations 6.4 and 6.5, it follows:

$$\frac{R_w^o}{R_w^m} \cdot \frac{e_o}{e_m} = \frac{P_o}{P_m} \qquad (6.6)$$

A set of relativities can be calculated from equation 6.6. The obtained relativities are then used to derive the adjustment factors for the World Bank input-output table, 27 factors of adjustment are required as the input-output data base identifies 27 commodities (Figure 6.1). Originally, there were only

23 commodities (industries) in the World Bank input-output table, 3 extra sectors were added in the data base for specific analysis of the wool, cotton and apparel industries in the Chinese economy (Thompson, 1990). The price relativities for 100 products form the largest component of each commodity in the input-output data base. The price adjustment factors finally applied to the World Bank table are presented in Table 6.4.

Table 6.4: Price Adjustments Used to Revise the World Bank I-O Table

Commodity	Adjustment factor
Crops	1.80
Cotton	1.50
Animal husbandry	1.50
Wool	2.00
Metallurgy	1.60
Electricity	1.00
Energy products	1.00
Coal	1.50
Petroleum mining	4.00
Petroleum refining	3.00
Chemicals	2.00
Chemical fibre	1.40
Machinery	1.40
Building materials	1.50
Wood	1.50
Food processing	1.40
Textiles	1.00
Apparel	1.00
Paper	1.10
Miscellaneous manufacture	1.30
Construction	1.45
Freight transport	1.35
Passenger transport	1.28
Commerce	1.10
Miscellaneous services	1.00
Education and health	1.45
Public administration and defence	1.32
Housing	1.00

In deriving the adjustment factors in Table 6.4, other sources of information were also used. The World Bank's estimates of the wage bill in China (1985d, p. 51) were used to account for the adjustment factors in service sectors such as education and health, public administration and defence sectors. Also, reference is made to Lardy's (1983, p. 23) estimation on China's rural market prices which were believed to be about 80% higher than quota prices.

As shown in Table 6.4, the official prices are generally lower than the market prices, so the values in the input-output table were adjusted upwards. Referring to Figure 6.1, the output value was revised for each commodity across the matrices of $\tilde{A}$, $\tilde{B}$, $\tilde{C}$, $\tilde{D}$, $\tilde{E}$ and $\tilde{F}$. The revised row sums are then made the column totals (outputs of domestic industries) with profits and taxes contained in matrix $\tilde{H}$ as the balancing items.

The choice of profits and taxes as the balancing items is based on the fact that the dual (official and market) price system is generally not used in the labour market in China, so the price adjustments are assumed to cause changes in capital return in the forms of profits and taxes. This assumption appears reasonable in light of the widely held proposition that the planned pricing system leads to large distortions in capital profitabilities across industries in China (chapter 4). Typically, industries whose output are intermediate inputs face lower official prices and hence appear to have lower levels of profits. In some cases, this leads to paradoxical results in the capital/labour ratio (as measured by profits and taxes divided by wages). For example, official prices for producer goods such as machinery are particularly low and hence the its labour share of primary factor returns is raised disproportionately. As a result, textile industry, for example, may emerge as even more capital intensive than machinery sector. The factor intensities in the revised input-output table reduces the price distortion effect and is more consistent with expectations (Martin, 1990a).

In addition to the price adjustments to the World Bank input-output table for China, other major adjustments (Thompson, 1990) which should be mentioned are:

First, the incorporation of land as a primary factor used in the four agricultural sectors (crops, cotton, animal husbandry and wool). Factor shares of 59% for labour, 12% for capital and 29% for land (McMillan, Whalley and Zhu, 1987, p. 14) are applied to the four sectors mentioned. This was necessary because of the high self-employment value for agriculture reported in the World Bank table.

Second, the World Bank input-output table was constructed for year 1981, the dramatic structural changes of the Chinese economy in recent years require the original data base be updated. This is particularly needed for the trade structure of the economy. The adjustment in this aspect was made in a rather simple way by resembling a more recent export and import structure in the table. For each commodity in the table, the shares of exports and imports in China's total exports and imports were calculated for year 1986. This created a scaling factor which would scale the 1981 exports/imports to 1986 figures. A second scaling factor was created which reflected the change in China's exports and imports as a share of GDP between 1981 and 1988 (World Bank, 1989). A new 1986 trade structure was then created by scaling the 1981 export/import figures (Matrices $\tilde{E}$ and $\tilde{F}$ in Figure 6.1) with the two scaling factors. The new trade structure has the correct commodity composition of exports and imports for 1986, and also has the correct size in terms of shares of GDP.

The final input-output table is shown in Table 6.5. My contribution at this stage of the construction of the model was to supply the price relativities shown in Table 6.4. Adjustments to factor shares and the trade structure were performed by Martin and Thompson. The data base of the model was implemented by using the MODHAR program in GEMPACK (Pearson, 1986). All data (including both share coefficients and elasticity parameters) are held in GEMPACK on files called Header Array files. These Header Array files are presented as Appendix A attached to the thesis.

Table 6.5: Input-Output Data Base for the China CGE Model (1986 Market Prices, Rmb, billion Yuan)

Sectors	Crops	Cotton	Animal Husb.	Wool	Metal	Elec-tricity	Coal	Crude Oil	Refined Oil	Che-micals	Chem. Fibre	Machine	Building Materials	Wood	Food Processing	Textiles	Apparel
Crops	19.21	0.00	36.00	0.00	0.00	0.00	0.47	0.00	0.00	4.73	0.00	0.02	2.70	4.50	49.77	0.67	0.71
Cotton	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	1.31	0.00	0.00	0.00	0.00	0.00	16.62	0.18
Animal Husbandry	0.00	0.00	1.29	0.21	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.01	0.00	0.00	16.96	1.19	0.03
Wool	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.01	0.00	0.00	0.00	2.47	0.00
Metallurgy	0.29	0.01	0.02	0.00	17.70	0.11	0.72	0.24	0.00	1.44	0.00	39.04	0.64	0.16	0.08	0.02	0.13
Electricity	1.22	0.19	0.29	0.05	2.81	2.87	1.22	0.35	0.17	3.36	0.05	1.40	0.71	0.14	0.44	0.94	0.05
Coal	0.88	0.14	0.21	0.03	3.00	4.34	1.65	0.02	0.00	2.07	0.00	0.78	2.49	0.15	0.65	0.70	0.08
Crude Oil	0.00	0.00	0.00	0.00	1.24	3.40	0.00	2.24	33.08	3.00	0.00	0.64	0.28	0.04	0.16	0.72	0.04
Oil Refining	7.07	1.15	1.68	0.27	1.68	2.16	0.36	0.54	0.60	7.02	0.16	2.46	0.48	0.27	1.17	2.00	0.12
Chemicals	25.02	3.98	0.02	0.00	0.60	0.02	0.50	0.80	0.20	31.86	0.02	5.20	1.00	0.50	5.60	3.58	1.22
Chemical Fibre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.76	0.00
Machinery	1.89	0.21	0.12	0.02	3.92	0.01	0.98	0.70	0.14	2.10	0.01	41.22	1.12	0.35	0.14	2.41	0.18
Building Materials	0.20	0.02	0.06	0.02	0.15	0.02	0.08	0.15	0.02	0.30	0.00	0.45	2.27	0.15	0.08	0.07	0.00
Wood	0.14	0.02	0.06	0.02	0.38	0.02	0.90	0.02	0.02	0.08	0.00	0.60	0.60	2.07	0.02	0.28	0.03
Food Processing	0.72	0.12	0.45	0.03	0.56	0.01	0.14	0.14	0.01	3.50	0.00	0.56	0.14	0.07	5.96	0.03	1.06
Textiles	0.24	0.04	0.06	0.01	1.04	0.01	0.50	0.70	0.03	1.47	0.01	1.00	0.80	0.14	0.21	31.92	35.00
Apparel	0.11	0.01	0.03	0.00	1.01	0.00	0.30	0.10	0.01	0.24	0.00	0.77	0.35	0.07	0.07	0.05	2.33
Paper	0.09	0.00	0.01	0.00	0.53	0.01	0.02	0.11	0.01	0.70	0.02	0.55	0.44	0.11	0.15	0.53	0.13
Misc. Manufacturing	0.12	0.01	0.06	0.01	0.52	0.01	0.26	0.13	0.01	0.59	0.07	0.85	0.26	0.09	0.01	1.21	0.23
Construction	0.66	0.07	0.00	0.00	2.61	0.00	2.32	0.00	0.00	1.09	0.00	2.18	0.87	0.00	0.00	0.00	0.00
Freight Transport	0.87	0.14	0.06	0.01	3.20	0.12	0.41	0.41	0.11	1.96	0.14	4.66	1.22	0.45	1.11	0.00	0.84
Passenger Transport	0.01	0.00	0.01	0.00	0.19	0.03	0.06	0.06	0.03	0.32	0.00	0.52	0.06	0.06	0.38	0.24	0.12
Commerce	1.06	0.07	0.05	0.01	1.58	0.10	0.40	0.57	0.02	2.90	0.02	3.52	2.06	0.24	0.79	2.06	0.24
Misc. Services	0.03	0.01	0.02	0.00	0.25	0.01	0.04	0.03	0.01	0.20	0.00	0.34	0.04	0.02	0.10	0.10	0.03
Education and Health	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Pub. Adm. & Defence	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Housing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Intermediate	59.83	6.19	40.50	0.69	42.97	13.25	11.39	7.31	34.47	70.33	0.53	106.78	18.53	9.58	83.85	79.57	42.75
Labour value added	141.46	11.74	11.87	0.25	3.90	1.09	5.78	0.73	0.10	4.52	0.56	14.27	4.47	2.68	3.73	4.85	4.06
Capital value added	28.77	2.39	2.41	0.05	16.79	3.75	7.53	41.89	7.90	45.64	2.93	16.26	11.71	2.60	4.35	12.44	2.25
Land value added	69.53	5.77	5.84	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gross output value	299.59	26.09	60.62	1.11	63.66	18.09	24.70	49.93	42.47	120.49	4.02	137.31	34.71	14.86	91.93	96.86	49.06

Table 6.5 continued: Input-Output Data Base for the China CGE Model (1986 Market Prices, Rmb, billion Yuan)

Sectors	Paper	Misc. Manuf.	Cons-truction	Freight Transp.	Passen. Transp.	Com-merce	Misc. Service	Educat. Health	Pub. Adm.	Housing	Inter-Mediate	Consumption: Household	Consumption: Govert.	Investment: Fixed	Investment: Stocks	Trade: Exports	Trade: Imports	Gross output
Crops	4.68	3.78	6.30	0.00	0.00	6.66	0.00	1.86	0.00	0.00	142.06	119.99	1.55	5.40	29.45	4.51	2.98	299.98
Cotton	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	18.57	0.00	0.00	1.11	6.06	0.36	0.01	26.09
Animal Husbandry	0.00	0.12	0.00	0.00	0.00	3.00	0.00	0.00	0.00	0.00	22.86	32.25	0.00	0.00	4.47	1.04	0.00	60.62
Wool	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.52	0.00	0.00	0.00	0.00	0.00	1.36	1.16
Metallurgy	0.00	1.28	10.37	0.80	0.00	0.00	0.00	0.00	0.00	0.00	73.05	0.00	0.00	0.00	2.40	1.63	13.43	63.65
Electricity	0.43	0.65	0.17	0.09	0.02	0.47	0.20	0.30	0.00	0.00	18.59	0.35	0.50	0.00	0.00	0.00	0.00	19.44
Coal	0.33	0.45	0.24	0.89	0.14	0.32	0.11	0.54	0.00	0.00	20.21	4.04	0.41	0.00	0.00	0.45	0.37	24.74
Crude Oil	0.04	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.20	0.08	0.00	0.00	0.00	4.64	0.00	49.92
Oil Refining	0.39	0.66	1.35	4.77	3.00	0.00	0.00	0.06	0.00	0.00	39.42	0.99	0.87	0.00	0.00	1.68	0.50	42.46
Chemicals	3.00	1.20	4.80	0.30	1.20	3.80	0.20	14.52	0.00	0.20	109.34	11.94	2.00	0.00	3.12	5.89	11.81	120.48
Chemical Fibre	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.76	0.00	0.00	0.00	0.35	0.00	2.98	9.13
Machinery	0.28	0.42	13.58	1.26	1.44	6.02	0.21	2.24	0.00	0.21	81.18	21.18	11.77	48.58	3.50	9.67	38.60	137.28
Building Materials	0.00	0.15	29.18	0.00	0.00	0.00	0.00	0.00	0.00	0.60	33.97	0.00	0.30	0.00	0.30	0.19	0.03	34.73
Wood	1.95	0.38	3.75	0.00	0.00	0.00	0.00	0.00	0.00	0.38	11.72	4.97	0.75	0.00	0.30	0.47	3.29	14.92
Food Processing	0.07	0.70	0.14	0.14	0.00	5.60	0.28	2.10	0.00	0.00	22.53	72.80	0.90	0.00	0.63	4.11	9.06	91.91
Textiles	0.40	0.98	0.33	0.04	0.00	1.56	0.20	2.30	0.00	0.00	78.99	20.59	0.52	0.00	3.74	4.21	11.20	96.85
Apparel	0.00	0.27	1.18	0.16	0.00	0.14	0.10	1.10	0.00	0.00	8.40	26.16	0.48	0.00	0.76	9.91	0.00	45.71
Paper	5.58	0.44	0.50	0.22	0.00	2.20	0.33	5.17	0.00	0.00	17.85	2.46	0.67	0.00	1.21	0.33	0.80	21.72
Misc. Manufacturing	0.26	3.58	1.82	0.00	0.00	0.26	0.00	4.49	0.00	0.00	14.85	4.04	2.60	0.00	1.82	8.42	5.65	26.08
Construction	0.00	0.15	5.80	5.80	0.00	0.15	0.00	0.44	0.00	1.23	23.37	0.00	3.05	82.51	0.00	0.00	0.00	108.93
Freight Transport	0.54	0.95	2.67	0.54	0.08	1.49	0.24	1.16	0.00	0.00	23.38	3.81	0.16	1.35	1.08	3.58	0.00	33.36
Passenger Transport	0.06	0.06	0.20	0.06	0.00	0.13	0.00	0.00	0.00	0.00	2.60	3.10	2.56	0.00	0.00	0.00	0.00	8.26
Commerce	0.54	1.49	1.77	0.74	0.11	1.14	0.22	1.62	0.00	0.11	23.43	28.53	0.30	2.20	0.72	4.10	0.00	59.28
Misc. Services	0.03	0.03	0.08	0.06	0.00	0.10	0.10	0.35	0.00	0.00	1.98	8.00	2.00	0.00	0.00	0.00	0.00	11.98
Education and Health	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	3.60	75.28	0.00	0.00	0.00	0.00	78.91
Pub. Adm. & Defence	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.70	0.00	0.00	0.00	0.00	12.70
Housing	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.97	0.00	0.00	0.00	0.00	0.00	13.97
Intermediate	18.58	18.21	84.23	15.87	5.99	33.04	2.19	38.50	0.00	2.73	847.86	382.85	119.37	141.15	59.91	65.19	102.07	1514.26
Labour value added	2.14	2.63	11.09	6.77	1.25	11.67	2.04	18.40	11.91	0.57								
Capital value added	1.01	5.25	13.58	10.70	1.05	14.57	7.76	22.02	0.79	10.67								
Land value added	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00								
Gross output value	21.73	26.09	108.90	33.34	8.29	59.28	11.99	78.92	12.70	13.97								

6.3 Features of a China Energy Model

Having established the data base, a model can be specified to operate on the data base. According to Robinson (1986, p. 33-4) the essential components of CGE modelling include:

1. specification of the representative agents whose behaviour is to be analysised (the "actors" in the model matches those as defined in the data base),
2. identification of their behavioural rules and conditions under which they operate (for example, profit maximisation behaviour of producers and utility maximisation behaviour of consumers),
3. specification of the signals which are used by the agents for their decisions (in a neoclassical CGE model, prices will be the important signals), and
4. identification of the "rules of the game" (such as "perfect competition", this assumption allows each agent to act as a price taker).

Along this line of thinking, the major features of the model specifications are discussed below. The model used is a specially adapted version of the CGE model for China developed by Martin (1990a). The model was expanded to include more detail on energy linkages. Key aspects of the model adaptation related to the booming sector phenomena considered in the study are as follows.

The 27 sectors represented in the model can be divided into three broad categories following Corden (1984). The three categories are: the energy category which includes four sectors (crude oil, petroleum products, coal and electricity); the other tradable category with 15 sectors producing traded goods; and the non-tradable category with 8 sectors producing non-traded goods. The classification of these three broad categories reflects the specification of the stylised "core model" in the booming sector theory. The energy category is the sector experiencing an external shock. The behaviour of the non-tradable sector is central to the "booming sector" theory. The fall in demand for factors results in a fall in prices of non-traded good. The other tradable sectors are affected by the shock in two ways identified in booming sector literature: direct change in relative output prices of tradables to non-tradables and through the induced changes in prices of non-traded goods. An additional feature of response not captured in the theoretical models is direct effect of intermediate input prices.

The behavioural rules of the economic actors in the model are neoclassical in nature. These include cost minimisation by producers and utility maximisation by households, and there is sufficient competition for unit profits (at market prices) to be driven to zero. The crucial assumption is that the economic actors respond to market prices for inputs and outputs, rather than official prices. Official prices are thus irrelevant to the behaviour of the model.

The price responsiveness is built in the model with neoclassical tools: a combination of CES and Leontief technology specifications on the supply side, and a complete system of demand equations and price-elastic exports. This allows the model to capture the effects of relative price changes which is a key issue in the analysis of external shock in this model. Shifts in relative prices such as tradable to non-tradable prices have important consequences as suggested by the booming sector economics literature. Given the existence of the official prices in China's two-tier price system, and thus the possible continuing links between marginal returns and output prices, it is possible that the price specifications in the model may overstate the price sensitiveness and the flexibility of the Chinese economy. However, the assumption of the economy's responsiveness to market prices rather than official prices is crucial in capturing the main features of the post-reform Chinese economy (Wu Jinglian and Zhao Renwei, 1987; Byrd, 1987 and 1989; Sicular, 1988; Martin, 1990a).

The price determination specification is centred on the demand-supply balance in two markets: domestic market and export market. Consequently, there are two types of price formation: prices for home goods determined endogenously to attain an equilibrium at the domestic market; and prices for traded goods determined exogenously by world market conditions. The specification of the price determination must recognise the fact that some commodity markets clear via quantity adjustment, therefore the exogenous determinants of the equilibrium in the model include not only external variables such as world markets, but also a set of variables made up of policy instruments such as exchange rate, taxes and regulated prices. Crude oil is an example in which the Chinese government sets the first tier oil price far below the world price, where the gap is equivalent to an export tax for exporters of crude oil (chapter 5). This type of distortion can be incorporated in the model.

The production structure reflects the energy linkages in the model. In Martin (1990a), each material input and the aggregate primary factor are combined in fixed proportions following the conventional procedure in general equilibrium models of the ORANI type (Dixon *et al.*, 1982). This standard framework does not allow for substitution between individual material (including energy) inputs. Consequently, it does not permit any change in relative prices of energy inputs to affect input demands through interfuel substitution process. Given the focus of the study on energy price shock, this Leontief assumption for intermediated inputs was too strong, and is therefore relaxed here to allow for interfuel substitution by introducing CES technology within the separate energy input block.

The flexibility of "nested" production functions in a two-level representation of technology greatly facilitated the incorporation of changes in energy responding behaviours. Using the second level CES "nest", the substitutability among energy inputs is introduced as: [11]

$$q_{ij} = q_{ej} - \sigma_{ij}(p_{ij} - \sum_{j} E_{ij}p_{ij}) \tag{6.7}$$

where

[11] The derivation of the function will be discussed in the next section.

q_{ij} denotes (percentage changes or log changes for all variables in equation) intermediate usage of fuel type i in industry j;
q_{ej} is total use of energy e in industry j;
σ_{ij} is elasticity of substitution between energies in industry j;
p_{ij} is price corresponding to q_{ij} ;
E_{ij} is share of energy i in total energy demand by industry j.

The important implication of the introduction of interfuel substitution is that, with fuel substitution (and/or non-zero production elasticity of fuel demand), the effects of the oil price shock on industrial energy inputs, and therefore the impact on sectoral output, can be captured more satisfactorily through the input-output relations in the model . In the case of oil price fall, depending on the induced changes in energy input i, the activity level in industry $j$can be increased or reduced via interfuel substitution. The intensities with which the different fuels are used by j and the change induced by the exogenous shock in their relative prices are important in determining the sign of the net interfuel substitution term. This consideration is applied to all sectors in the model (4 $\times$ 27 matrix), not just those with significant fuel substitution possibilities.

A benchmark value of 1.2 was used for the interfuel substitution elasticity (σ_{ij}) following the WEDGE model (Industry Commission, 1991). Economic estimates of energy substitution elasticities available are not very reliable. Sullivan and Siemon (1981) estimated elasticities ranging from 2 to 3 for energy substitution in the United States. Their results were based solely on multi-energy technologies, and can be interpreted as upper bound estimates for long run interenergy substitution possibilities. For a shorter time horizon, the recent modelling work on quantifying the costs of curbing CO_2 emissions (OECD, 1991) suggests that a plausible base case elasticity would lie between 1 and 1.5 for interfuel substitutions.

Reflecting the capital specific assumption in the core model of booming sector theory (Corden, 1984), the CGE model is short run in character, with capital fixed in each sector. Investment is assumed to be determined exogenously in line with total real absorption. As is common in short-run models, capital formation is modelled in two parts (see matrix $\tilde{D}$ in Figure 6.1): fixed capital plus capital stock increase, but the new equipment and machinery are not brought into production in the short run as assumed in the model.

While the model focuses on the real side of the economy, as do other ORANI-type models, a skeletal monetary sector is incorporated into the basic Martin model. The monetary aspect of the model used here is a simple application of the quantity theory of money in explaining price level in China. The money demand in the model is set up with an unitary income elasticity, which implies that a 1% increase in the money supply will raise the Gross Domestic Product price deflator by 1%. This specification leaves money neutral in the absence of rigidities such as fixed nominal exchange rate. The unit elasticity used in the model is based on the evidence in Chow (1987) and Feltenstein and Ziba (1987). While Chow estimated that 1% increase in money supply would raise *official* prices by one-third of 1%, Feltenstein and Ziba suggested that the official price indices of the type used by Chow substantially understated the true rate of inflation by about 2.5 times. Combining these estimates, an unit elasticity appears a reasonable representation of the money and price behaviours in China.

The incorporation of money enables the model to go beyond the real effects of an external shock. If the shock is unfavourable in nature, a lower demand for nominal and real money will result following a decline in real income. An important effect of this lower demand for money is that, if an excess supply for money results, some inflationary effect of the shock can take place. This is because if after the shock the supply of money does not change, monetary equilibrium can only be re-established by price increases, which will affect nominal prices of non-traded goods, appreciating the real exchange rate. Consequently, larger reactions are needed than in the real effect case to bring about a real depreciation required in the adjustment of an unfavourable external shock.

Given the greater scope for policy control in the evolution of institutions for management of monetary policy in China (de Wulf and Goldsborough, 1986), it is assumed in the model that monetary policy is able to control the money supply. Similarly, fiscal policies are implicitly assumed to be able to keep real absorption constant, with the balance of trade as an exogenously determined proportion of GDP. The monetary sector incorporated in the model allows determination of the aggregate price level as a numeraire.

In the original model, the balance of trade as a share of GDP was expressed in domestic currency. In certain circumstances, this specification could cause difficulty in interpreting the results in relation to the revenue effects associated with the foreign exchange regime. The static trade distorting effect of exchange rate over-valuation is the same as would result from a uniform import duty or export tax. The potential government revenue generated by the implicit taxation of exports resulted from the distortion of the foreign exchange system implicitly affect the balance of trade expressed in domestic currency. In cases where controlled effects of targeted balance of trade are to be examined, the revenue effect needs to be abstracted by expressing the balance of trade in foreign currency. Accordingly, extra equations were added to the model for base period balance of trade calculated at an estimated equilibrium exchange rate. While the forms of these new equations are similar to the old balance of trade equations, the derivation of the coefficients attached to the variables in the new equations involved quite complicated procedures which will be discussed in detail in the next section.

Last but not least, an important change was made in connection with the database of the model. Following the ORANI-type models (Dixon *et al.*, 1982), the original model is solved by using Johansen style computation. When large shocks are imposed on the model, the results are increasingly subject to linearisation errors. To overcome this problem, a data updating mechanism was built into the model, so the model could be solved in a non-linear fashion through multi-step simulations (Codsi and Pearson, 1991). This was a useful improvement for the present study as the analysis involves very large oil price shock.

In summary, the major adjustments made to the basic Martin model were the incorporation of inter-fuel substitution, the alternative specification of balance of trade as a share of GDP, and the implementation of non-linear solution to the model. The application of the model to the oil price fall also required closer attention to the monetary sector. The new model contains 1420 equations and 1586 variables (see Table 6.6 and Table 6.7). Using matrix notation, the model is expressed as:

$$Az = 0 \tag{6.8}$$

where A is a 1420 $\times$ 1586 matrix of coefficients, and z is a vector of percentage changes of the model's 1586 variables. As the number of variables exceeds the number of equations by 166, this number of variables is declared exogenous. Consequently, vector z is divided into two sub-vectors: z_1 (contains 1420 endogenous variables) and z_2 (contains 166 exogenous). Equation 6.8 is then rewritten as

$$A_1 z_1 + A_2 z_2 = 0 \tag{6.9}$$

The specification of these exogenous variables defines the macroeconomic environment for the model (Cooper, McLaren and Powell, 1985). The closure of the model reflects key features of the standard treatment of the booming sector theory:

Firstly, the nominal official exchange rate is fixed, thereby allowing the real exchange rate to vary with changes in domestic price levels. This specification is consistent with institutional arrangements in China, where the official exchange rate is an exogenous policy variable.

Secondly, the capital stock employed in each industry is fixed, thereby allowing the rate of current capital return to vary to reflect any changes in scarcity value. This capital-specific specification is in line with the short-run assumption made in the booming sector theory.

Thirdly, the real absorption is determined exogenously, thereby allowing balance of trade to vary. This assumption enables simulations of user-specified changes in real absorption, and to obtain results for varying balance of trade cases.

The model was solved by using the computable general equilibrium model solution package GEMPACK version 4.2.02 (Pearson and Codsi, 1991a). With the data-updating mechanism built in, the model can be solved either linearly (a single step) or in a non-linear fashion (multi-step). The one-step solution method follows other ORANI-type models by using Johansen style computation (Dixon *et al.,* 1982), while the multi-step solution method is equivalent to solving general equilibrium problem "in the levels" with a fixed point algorithm (Scarf, 1973). The solution of the endogenous variables z_1 in terms of the exogenous variables z_2 is obtained as

$$z_1 = -A_1^{-1} A_2 z_2 \qquad or \qquad z_1 = B z_2 \tag{6.10}$$

where B is updated at each iteration in the multi-step solution.

The difference of the two solution methods can be best illustrated by a simple example. Consider an equation expressing the value of a commodity (V) as the product of its price (P) and quantity (Q), the levels form (upper case) and linearised form (lower case) of the equation are

$$\begin{array}{lrcl} Levels: & P \times Q & = & V \\ Linearised: & p + q & = & v \end{array}$$

Assume the base levels for price and quantity are all 10 which give a value of 100 for the commodity

$$Baselevel: 10 \times 10 \quad = \quad 100$$

Now consider a 10% increase in both the price and quantity of the commodity, the corresponding changes in the levels and linearised equations are

$$\begin{array}{lrcl} Levels: & 10(1+10\%) \times 10(1+10\%) & = & 121 \\ Linearised: & 10\% + 10\% & = & 20\% \end{array}$$

Clearly, the non-linear result shows an increase of 21% in the value of the commodity, while the linear solution gives an increase of 20%. The error in the linear calculation for the value of the commodity increases when P and Q deviate further from their initial values.

The computing cost involved in solving the model varies considerably depending on the methods used. Using GEMPACK 4.2.02, the model typically solves in 2 minutes of CPU time to obtain linear results (a single step) on a SE/30 Macintosh PC with 8 Mb of RAM. The multi-step solution used in this study increases the CPU time to 40 minutes to solve the model in 28 steps.[12] Further increase of steps was constrained by the memory of the computer. The significance of the differences between the single step and multi-step solutions is discussed in detail in the next chapter when interpreting the simulation results.[13]

6.4 Equations of the Model

As shown in Table 6.6, there are together 38 sets of equation in the model. They can be classified into 6 blocks:

1. equations describing production behaviours, sets [1] to [4];
2. equations describing final demands , sets [5] to [9];
3. equations describing external trade environment, sets [10] to [13];
4. market clearing equations for goods and factors, sets [14] to [18];
5. pricing equations of zero pure profits, sets [19] to [21]; and
6. miscellaneous definitional equations of macro-type, sets [22] to [38].

[12]In the current version of GEMPAC (4.2.02), a multi-step solution is carried out by specifying (i) the steps in the first solution of the model S, and (ii) the number of solutions N used to extrapolate for the final solution of the model. The total number of steps involved is given by $\sum_{i=1}^{N} S2^{i-1}, i = 1, 2, 3, ..., n$. If 4 steps are specified for the first solution, and 3 consecutive solutions are used (which are the maximum allowed in the current version of GEMPACK), then the total steps used in the multi-spet solution are 28.

[13]See Table 7.6 on p. 247.

While most of the equations have simple forms and are easy to understand, few sets of equations are in specific function forms, which will be explained along with the interpretations of the equations.

The distinguishing characteristic of a Johansen-style model is that it is written as a system of linear equations in percentage changes of the variables. Rather than writing

$$F(X_1, X_2, ..., X_n) = 0 \tag{6.11}$$

the linearised version of the above equation can be obtained by firstly differentiating the equation as

$$\frac{\partial F}{\partial X_1}dX_1 + \frac{\partial F}{\partial X_2}dX_2 + ... + \frac{\partial F}{\partial X_n}dX_n = 0 \tag{6.12}$$

where $\frac{\partial F}{\partial X_i}$ is the first-order derivative of function F with respect to variable X_i $(i = 1, 2, ..., n)$.

Equation 6.12 can then be simplified by introducing the concept of percentage change. Denoting lower-case x's as the percentage changes of upper-case variable X's, dX becomes $(X \cdot x)$ when dX is approximated by ΔX [14] where changes in X are very "small" (approaching zero). Equation (6.12) is then rewritten as

$$\varepsilon_1 x_1 + \varepsilon_2 x_2 + ... + \varepsilon_n x_n = 0 \tag{6.13}$$

where x_i is the percentage changes of X_i, and ε_i is a coefficient derived from $\frac{\partial F}{\partial X_i} \cdot X_i$. The initial value of X_i is called base-period value, which can be obtained from input-output table.[15]

[14] $\Delta X = X \cdot x$.

[15] To facilitate interpretation, the rules of linearisation are:

$$\begin{cases} 1. \quad Z = \alpha A & \rightarrow \quad z = a \\ 2. \quad Z = A^{\alpha} & \rightarrow \quad z = \alpha a \\ 3. \quad Z = AB & \rightarrow \quad z = a + b \\ 4. \quad Z = A/B & \rightarrow \quad z = a - b \\ 5. \quad Z = A \pm B & \rightarrow \quad z = \frac{A}{A \pm B}a \pm \frac{B}{A \pm B}b \end{cases}$$

6.4.1 Production behavioural equations

The basic behavioural assumption underlying the production side of the model is that producers are competitive and efficient. They are competitive in the sense that they are all price takers for input and output. They are efficient in the sense that they select the combination of inputs which minimise their costs. Each industry produces a single output and uses intermediate and primary inputs in the production of its output. It is also assumed that each sector exhibits constant return to scale.

Under these conditions, the behaviours of producers are specified in a two-level production technology. At the first level, the Leontief assumption is used. There is a normal behaviour of non-substitutability between intermediate inputs and primary inputs. However, given the emphasis of energy linkages in this study, energy products in the intermediate inputs are identified as a separate block of inputs, and the Leontief assumption is relaxed for this energy block. So there are three blocks of inputs at the first level: material inputs, energy products, and primary factors. The ratio of aggregate inputs of these three blocks is fixed, and also the input coefficients for materials are fixed. The input technology of the other two blocks are treated more carefully at the second level where the CES (constant elasticity of substitution) function form is used to describe the substitution possibilities within each of the two blocks. Following Dixon *et al.* (1982, p. 70), the two-level input technology is represented by the nested set of production functions as below:

$$X_j = Leontief\{Q_{mj}^{(1)}, Q_{ej}^{(1)}, Q_{vj}^{(1)}\} \quad (6.14)$$

$$Q_{mj}^{(1)} = Leontief\{X_{mj}^{(1)}\} \quad (6.15)$$

$$Q_{ej}^{(1)} = CES\{X_{ej}^{(1)}\} \quad (6.16)$$

$$Q_{vj}^{(1)} = CES\{K_j, L_j, D_j\} \quad (6.17)$$

where X_j is the output of industry j; $Q_{mj}^{(1)}$ is material intermediate inputs; $Q_{ej}^{(1)}$ is energy intermediate inputs, $Q_{vj}^{(1)}$ is primary factors inputs; $X_{mj}^{(1)}$ represents the intermediate input of material m used in industry j; $X_{ej}^{(1)}$ represents the intermediate input of energy e used in industry j; and K_j, L_j, D_j are capital, labour and land used in industry j, respectively. The superscript $(1)'s$ denote inputs into current production.[16] The inputs defined by CES functions are *effective inputs*. The notation of $CES_i\{X_i\}$ means the variables in the brackets are to be aggregated according to a CES function with some related parameters:

$$CES_i\{X_i\} \equiv (A\sum_i X_i^{(-\rho)}\mu_i)^{-(1/\rho)} \tag{6.18}$$

where A, ρ, μ_i are efficiency parameter, substitution parameter, and distribution parameters, respectively.

Under the cost minimisation assumption, the producer's problem is to choose the input levels to minimise:

$$\sum_{m=1}^{23} P_{mj}^{(1)} Q_{mj}^{(1)} + \sum_{e=1}^{4} P_{ej}^{(1)} Q_{ej}^{(1)} + \sum_{v=1}^{3} P_{vj}^{(1)} Q_{vj}^{(1)} \tag{6.19}$$

subject to equation (6.14)-(6.17). $P_{mj}^{(1)}$, $P_{ej}^{(1)}$ and $P_{vj}^{(1)}$ are the costs to industry j per unit of intermediate material input, energy input and factor input, respectively.

Following the standard procedure (Dixon *et al.*, 1982, p.79-81) of taking derivatives for the items in equation (6.19) to obtain the first-order conditions, and differentiating the corresponding Lagrangian constraints in (6.14)-(6.17), one can derive the demand equations for intermediate inputs in equation (6.19). They are expressed in linear percentage change forms as equation sets [1]-[3] in Table 6.6.

Equations sets [1]-[3] are amenable to easy interpretation. Other things being constant, a 1% increase in the current output level of sector j, leads to a 1% increase in the requirements for all inputs in that sector. This is explained by the x_j's on the right hand side of equation sets [1] and [3]. Notice that

[16]In the following subsections superscripts (2), (3), (4), and (5) are used to denote inputs in investment, household consumption, exports and government consumption, respectively.

for equation set [2], a composite energy input $q_{ej}^{(1)}$ is included in equation set [1]. Other things remaining the same, an increase in the cost of any particular energy product or primary factor leads to substitution away from that factor in favour of other energy products or primary factors. The substitution elasticity is given by σ in equation sets [2] and [3]. [17] Equation sets [1]-[3] reflect the assumptions used in input demand specifications. Equation set [1] shows the demands for material intermediate inputs respond only to changes in the activity level of sector j, while equation sets [2] and [3] show the responsiveness of energy and primary inputs to price changes.

The production technology described by equation sets [1]-[3] belongs to input technology. Another production technology available to industries is the output technology which specifies the relationship between an industry's output and its overall capacity to produce. If the price for product A increases relative to that of product B, then the industry will choose an output composition with more A to maximise revenue.

This possibility of production transformation is captured by using a CET (constant elasticity of transformation) function (Powell and Gruen, 1968). Just as CES implies a common value for all pairwise substitution elasticities, CET implies a common value for all pairwise transformation elasticities. In this model, the pairs of the products a producer wishes to shift in-between are specified as the supplies to the domestic and export markets. Following Robinson (1986), the model assumes that domestic sales and exports with the same sectoral classification represent goods of different qualities, producers shift in the composition of production between the domestic and foreign markets to maximise:

$$\sum_i P_i^e X_{i1} + \sum_i P_i^q X_{i2} \tag{6.20}$$

subject to

$$CET_s\{X_{is}\} = X_i, \qquad s = 1, 2 \tag{6.21}$$

[17]Relating σ to the CES function in equation (6.18), $\sigma = 1/(1+\rho)$.

where P_i^e and P_i^q are prices of good i at the export and domestic markets, respectively. Correspondingly, X_{i1} and X_{i2} are goods sold at the export and domestic markets, respectively. X_i is the total of good i produced by domestic producers.

The solution of the above problem is expressed in percentage form by equation set [4] in Table 6.6, which completes the block of production behavioural functions. Not surprisingly, the output transformation equation [4] specified by CET technology is algebraically identical to input equations [2] and [3] of CES function form, apart from a difference of sign determining the concavity of production transformation frontier.

6.4.2 Final demands equations

Equation sets [5]-[8] specify the final demands in the model. The superscripts (2), (3) and (5) stand for investment, household consumption and government consumption, respectively. While the forms of equation sets [5]-[7] are simple, equation set [8] needs some explanation.

Equation set [8] specifies the household demands for commodities, which is based on the utility maximisation assumption. The consumption bundle of goods Q_i^3 $(i = 1, 2, ..., 27,)$ for average household is determined as to maximise:

$$U = U(Q_1^3, Q_2^3, ..., Q_{27}^3) \tag{6.22}$$

subject to

$$\sum_{i=1}^{27} P_i^q Q_i^3 = A^* \tag{6.23}$$

where P_i^q is the price for good i at domestic market, and A^* is household nominal absorption.

The first order conditions for a solution of the above problem can be written as:

$$\frac{\partial U}{\partial Q_i^3} - \lambda P_i^q = 0, \tag{6.24}$$

and

$$\sum_{i=1}^{27} P_i^q Q_i^3 = A^* \tag{6.25}$$

where λ is the Lagrangian multiplier.

Solving the first order conditions gives:

$$Q_i^3 = Q_i^3(P_1^q, P_2^q, ..., P_{27}^q, A^*) \tag{6.26}$$

The percentage change from of (6.26) can be written as

$$q_i^{(3)} = \varepsilon_i a^* + \sum_{k=1}^{27} \eta_{ik} p_k^q \tag{6.27}$$

where ε_i and η_{ik} $(i, k = 1, 2, ...27,)$ can be interpreted as expenditure and own- and cross-price elasticities satisfying the usual restrictions – homogeneity, symmetry and Engle's aggregation (Martin, 1990a).

The interpretation of the household consumption equation set [8] is that the demands for each good by households is a function of household disposable income and the (marginal) prices of each good. Equation sets [5], [6] and [7] in Table 6.6 specify the percentages changes in three types of final demands (fixed capital, increase in capital stocks and government consumption) as proportional to the percentage changes in gross real absorption. These simple behavioural hypotheses are reasonably plausible given the considerable uncertainties about how these final demands respond to relative prices. A more satisfactory treatment of these categories requires a well-developed theory of investment and government behaviour in China.

Equation set [9] aggregates all domestic demands for each good specified by equation sets [1]-[8]. The identity is in linear form as Q_i is a simple sum-up of $Q_{ij}^{(1)}, Q_i^{(2)}, QS_i^{(2)}, Q_i^{(3)}$ and $Q_i^{(5)}$ $(i, j = 1, 2, ...27)$. Value share weights are used to convert the identity to percentage change form. Notice that Q_i^4 (export demand for good i) is absent in the equation because goods sold at the export market are differentiated, so export demand is not included in total absorption.

6.4.3 Foreign sector equations

Equation sets [10]-[13] describe China's trade relations: both foreign demand for Chinese goods and China's demand for foreign goods. Equation set [10] specifies foreign demand for China's exports. Following Armington (1969), exports demand for good i from China $Q_i^{(4)}$ $(i = 1, 2, ..., 27)$ is defined as being determined by the price of China's exports (P_{i1}^e) relative to exports from the rest of the world (P_{i2}^e), and the total world demand for good i, $Q_i^w (i = 1, 2, ..., 27)$. This can be expressed in a CES function:

$$Q_i^w = \bar{A}_i[\mu_i(Q_{(i1)}^{(4)})^{-\rho} + (1 - \mu_i)(Q_{(i2)}^{(4)})_i^{-\rho}]^{\frac{1}{\rho_i}} \tag{6.28}$$

where $\bar{A}_i$, μ_i, and ρ_i are technical efficiency, distribution and trade-substitution parameters, respectively. $Q_{(i1)}^{(4)}$ and $Q_{(i2)}^{(4)}$ are export demand from China and from the rest of the world, respectively.

Given the prices of China's exports (P_{i1}^e) relative to that of the rest of the world (P_{i2}^e), the problem facing the buyers in the world market is mathematically equivalent to that facing the firms wishing to produce a certain level of output at minimum cost. Given two sets of substitutes are involved, a simpler way to solve the problem is to define the above CES function as an equivalent unit cost function:

$$P_i^e = \frac{1}{\bar{A}_i}[\mu_i^{\sigma_i^e} P_{(i1)}^{(1-\sigma_i^e)} + (1 - \mu_i)^{\sigma_i^e} P_{(i2)}^{(1-\sigma_i^e)}]^{\frac{1}{1-\sigma_1^e}} \tag{6.29}$$

where P_i^e is the average world price of good i; P_{i1}^e and P_{i2}^e are basic prices of Chinese exports and R.O.W exports, respectively; $\bar{A}_i$ and μ_i are defined in equation (6.28); and σ_i^e is the Armington elasticity.

By applying Shephard's lemma (Shephard, 1953) to (6.29), we obtain:

$$Q_{(i1)}^{(4)} = \frac{1}{\bar{A}_i}\{\mu_i[\mu_i^{\sigma_i^e} P_{(i1)}^{(1-\sigma_i^e)} + (1 - \mu_i)^{\sigma_i^e} P_{(i2)}^{(1-\sigma_i^e)}]^{\frac{1}{1-\sigma_i^e}} / P_{(i1)}\}^{\sigma_i^e} Q_i^w \tag{6.30}$$

where variables and parameters are defined as before.[18]

[18]Similarly, demand for exports from the rest of the world $Q_{(i2)}^{(4)}$ can be obtained. As the model is not a global model, demand equation for $Q_{(i2)}^{(4)}$ in not included in the model. Consequently, $Q_{(i1)}^{(4)}$ can be simply written as $Q_i^{(4)}$ in this model.

The percentage form of (6.30) is shown by equation set [10] in Table 6.6. In turn, the equation for total world demand is given by equation set [11] corresponding to the last item in equation set [10].

Chinese demand for imports is specified in equation set [12] as a simple function of import prices, which allows the possibility that China is a "big buyer" in some particular markets.

Equation [13] specifies imperfect substitution between domestic and imported products. Intuitively, there is a parallel between equation set [10] and [13], the former looks at the substitutions between Chinese goods and foreign goods in a foreign market while the latter looks at the substitutions between the Chinese goods and foreign goods in domestic market.

6.4.4 Market clearing equations

Equation sets [14]-[18] ensure that demand equals supply for domestically produced goods and for the primary factors. As domestically produced goods are differentiated according to the markets they are sold, two equations are specified. One is to clear the domestic market, and the other to clear the export market. Demands for goods in these two markets must equal the quantity of goods produced.

At the domestic market, the demand for good i from all domestic sources Q_i $(=Q_i^{(1)} + Q_i^{(2)} + QS_i^{(2)} + Q_i^{(3)} + Q_i^{(5)})$ is equated with domestic production of good i (X_{i2}). Similarly, export demand from China $(Q_i^{(4)})$ must equal Chinese supply of good i $(X_i^{(4)})$.

Market clearing conditions do not apply to the import market, as imports are treated as a distinct product from domestically produced goods.

Equation set [16] equates the total supply and total demand for labour in the model. This aggregated approach implies that labour is mobile between sectors. This assumption is admittedly strong but necessary in order to capture the features of the post-reform labour market in China. The large share of employment in individual and collective ownership enterprises in China's total employment, 81.8% according to Yang Xia (1988, see chapter 4), implies that the labour mobility has been improved significantly in the Chinese economy. It does not imply, however, that this model is necessarily a full-employment model. Instead of setting $\sum_{j=1}^{27} L_j$ exogenously at the full-employment levels, wages could be set exogenously, and the model can then generate employment levels corresponding to the given wage rates.

Equation sets [17] and [18] equate the supply and demand of capital and land *in each industry*, respectively. Unlike labour, capital and land are assumed nonshiftable between industries. This follows the conventional assumption that capital and land are industry-specific, and this is consistent with the short-run specification of the model.

6.4.5 Pricing equations

Equation sets [19]-[21] specify the price system in the model. As explained earlier, market prices are used in this model because they are relevant for resource allocation at the margin. The implication of using market prices is that in a situation where market prices prevail, pure profits will be competed away through the free floating of market prices, so there is no pure profits in any economic activities. Three activities are recognised in the model: production, importing and exporting. The zero-pure-profit condition for production implies that revenues in industry j equal costs in industry j:

$$\sum_{d=1}^{2} P_{jd}X_{jd} = \sum_{m=1}^{23} P_{mj}^{(1)}Q_{mj}^{(1)} + \sum_{e=1}^{4} P_{ej}^{(1)}Q_{ej}^{(1)} + \sum_{e=1}^{3} P_{vj}^{(1)}Q_{vj}^{(1)} \tag{6.31}$$

where P_{jd} and X_{jd} are the prices and quantities, respectively, of goods produced in industry j and destined to market d. The notations for other variables are as introduced earlier. The left hand side of the equation is the basic value of the output of industry j, and the right hand side of the equation is the total payment for inputs.

It should be emphasised that such an equation does not rule out normal profits but pure profits. Variations in profits are simulated by variations in P_{jd}'s. In percentage form, equation (6.31) reduces to equation set [19] in Table 6.6.

The fact that the input and output quantities in equation (6.31) have been eliminated in equation set [19] can be traced back to the assumption of constant returns to scale implied by the production behavioural equations. Under the constant returns to scale assumption, unit costs are independent of the scale of output.

The other two sets of zero-pure-profit conditions equate the revenues of exports to the cost of exports, and the selling prices of imports to the costs of imports, i.e.

$$P_i^e(1+V_i)\sum_{i=1}^{2} FES_i\Phi_i = P_{i1} \tag{6.32}$$

$$P_{i2} = P_i^m(1+T_i)\Phi_2 \tag{6.33}$$

On the left hand side of the two equations are the revenues of exports and imports, respectively, on the right hand side of the two equations are the costs of doing so. For equation (6.32), P_i^e is the foreign currency price of domestic good i; V_i ($-V_i$) is the subsidy (tax) rate on export i; FES_i is the foreign exchange shares calculated at official ($i = 1$) and market ($i = 2$) exchange rates, $\sum_{i=1}^{2} FES_i = 1$; clearly, $\sum_{i=1}^{2} FES_i\Phi_i$ is a weighted index of official exchange rate (Φ_1) and market exchange rate (Φ_2); P_{i1} is the domestic price of good i. For equation (6.33), P_{i2} is the domestic price of imported good i; and P_i^m is the foreign currency price of import i; T_i is the tariff rate on import i.

In linear percentage forms, equations (6.32) and (6.33) become equation sets [20] and [21] in Table 6.6. Notice that the official and secondary market exchange rates (Φ_1 and Φ_2) are treated asymmetrically in the export and import equations. At the margin, the opportunity cost of all imports are assumed to relate to the market exchange rate, while the export revenues are calculated at the weighted rate of both official and market exchange rates. As will be seen in the next chapter, this asymmetric treatment will have some interesting implications on exporting and importing activities in response to changes of foreign exchange market.

6.4.6 Macroeconomic equations

The last block of equations contains 17 macroeconomic equations to facilitate the implementation of the model. Following the order of numbering, equation sets [22]-[25] define GDP and total absorption in both real and nominal terms, and equation sets [26] and [27] sum up the total volumes of exports and imports, respectively. While these equations are familiar identities which need not much explanation, the next six equation sets [28]-[33] require some detailed discussion.

As pointed out earlier in section 6.3, equation sets [28]-[30], which measure the balance of trade as a share of GDP in domestic currency, are not appropriate in circumstances where the distortional effects of the dual foreign exchange rate regime need to be abstracted. So equation sets [31]-[33] were added to express the balance of trade in foreign currency. However, complication of deriving correct foreign currency values for exports and imports in the model arose given the distortion of the foreign exchange rate system as highlighted in the model (see more discussion in chapter 7). Following Martin (1990c), for an over-valued official exchange rate, a secondary market exchange rate much higher than the equilibrium exchange rate is required to clear the exchange market. In the model, the base values of 3.72 and 5.7 Rmb Yuan per US dollar are used, respectively, for the official and market exchange rates. To derive the equilibrium exchange rate, therefore to calculate the non-distortional foreign currency trade balance, the following procedures were adopted:

First, by increasing the exogenous variable of the official exchange rate by 1% (devaluation of Rmb), the original model generates an elasticity ε for the market exchange rate in the solution. The equilibrium exchange rate implied by the solution of the model is then given by

$$3.72(1+k) = 5.7(1-\varepsilon k) \qquad (6.34)$$

where k is the extent to which the official exchange rate needs to be depreciated in order to eliminate the gap between the official and market exchange rates. Solving the above equation for k will give an equilibrium exchange rate Φ^* in the model.

With the equilibrium exchange rate obtained, adjustment can be made to the base period export and import values to calculate the correct foreign currency values for exports and imports.

For the value of exports, the relevant base period price of exports is the price received by exporters plus the government revenue generated from the implicit export tax. In the model database, exports were valued at the 3.72 Rmb yuan per US dollar official exchange rate. This implies an effective tax rate of ($\Phi^*/3.72$ - 1). Adding in the value of this taxation allows us to obtain an estimate of the value of the exports, including the tax revenues. This export value can then be expressed as a share of GDP, with both valued in foreign currency at the equilibrium exchange rate.

For the value of imports, the effects of the implicit taxation of imports implied by the model are calculated by removing the implicit import tax from the base period value of imports. This was done by first multiplying the base period value of imports by $\Phi^*/5.7$ and then calculating the ratio of imports to GDP which was also adjusted with the new estimates for the values of exports and imports. The computations of other shares in equations [31]-[33] are straightforward based on the above estimates.

Equation set [34] introduces a simple monetary sector into the model. This equation essentially applies the quantity theory of money to China (Chow, 1987; Feltenstein and Ziba, 1987). The price and money behaviours are specified with an unitary income elasticity. This specification rules out the role of interest rate behaviours in money demand and supply changes, and leaves money neutral in the absence of rigidities such as fixed nominal exchange rate.

The final four equation sets in the model specify the price indexes for GDP, total absorption, absorption of good i, and total output, respectively.

All equations discussed above are implemented in the model by using the TABLO program in GEMPACK (Codsi and Pearson, 1987 and 1988a; Pearson and Codsi, 1991a). This was done by preparing a text file called TABLO Input file containing a linearised representation of the model in a syntax following the algebraic notation defined in Codsi and Pearson (1988b) and Pearson and Codsi (1991b). The TABLO program analyses the information on the TABLO Input file and generates Fortran code to calculate the coefficients of the equations in the model. The TABLO Input file of the China model is presented as Appendix B attached to the thesis.

Table 6.6: Equations of the China CGE Model (in Linearised Forms)

No.	Equation	Subscript range	Number	Description
[1]	$q_{ij}^{(1)} = x_j$	i = 1,2,...,23 + 1 j = 1,2,...,27	648	Intermediate demands including a composite energy product, $q_{ej}^{(1)}$.
[2]	$q_{ij}^{(1)} = q_{ej}^{(1)} - \sigma_{ij}(P_i^x - \sum_{k=1}^{27} EikP_i^x)$	i = 1,2,3,4 j = 1,2,...,27	108	Intermediate demands for energy inputs.
[3]	$q_{vj}^{(1)} = x_j - \sigma_i^p(p_{vj}^p - \sum_{v=1}^{3} S_{vj}^p p_{vj}^p)$	v = 1,2,3 j = 1, 2,...,27	81	Primary factor inputs.
[4]	$x_{id} = x_i + \sigma_i^T(p_{id} - p_i^x)$	i = 1,2,...,27 d = 1,2	54	Transformation in production.
[5]	$q_i^{(2)} = a_R$	i = 1,2,...,27	27	Fixed investment demand.
[6]	$qs_i^{(2)} = a_R$	i = 1,2,...,27	27	Investment in stocks.
[7]	$q_i^{(5)} = a_R$	i = 1,2,...,27	27	Government demand.
[8]	$q_i^{(3)} = \varepsilon_i a^* + \sum_{k=1}^{27} \eta_{ik} p_k^q$	i = 1,2,...,27	27	Household consumption demands.
[9]	$q_i = \sum_j B_{ij}^{(1)} q_{ij}^{(1)} + B_i^{(2)} q_i^{(2)}$ $+ BS_i^{(2)} qs_i^{(2)} + Bi^{(3)} q_i^{(3)} + B_i^{(5)} q_i^{(5)}$	i = 1,2,...,27	27	Domestic absorption of good i from all sources.
[10]	$q_i^{(4)} = qw_i^{(4)} - \sigma_i^w(p_{is}^e - \sum_{s=1}^{2} ES_{is} p_{is}^e)$	i = 1,2,...,27	27	Export demand from China.
[11]	$qw_i^{(4)} = \beta_i(\sum_{s=1}^{2} ES_{is} p_{is}^e)$	i = 1,2,...,27	27	World demand.
[12]	$q_{i1} = E_i p_i^m$	i = 1,2,...,27	27	Import supply to China.
[13]	$q_{is} = q_i - \sigma_i^m(p_{is} - p_i^q)$	i = 1,2,...,27 s = 1,2	54	Domestic/import substitution.
[14]	$q_{i2} = x_{i2}$	i = 1,2,...,27	27	Domestic market clearing.
[15]	$q_{i1}^{(4)} = x_{i1}$	i = 1,2,...,27	27	Export market clearing.
[16]	$q_1^p = \sum_{j=1}^{27} L_j q_{1j}^p$		1	Factor market clearing for labour.
[17]	$q_{2j}^p = k_j$	j = 1,2,...,27	27	Factor market clearing for capital in j.
[18]	$q_{3j}^p = l_j$	j = 1,2,...,27	27	Factor market clearing for land in j.
[19]	$\sum_{d=1}^{2} J_{jd} p_{jd} = \sum_i H_{ij}^{(1)} p_i^q + \sum_{v=1}^{3} H_{vj}^p p_{vj}^p$	j = 1,2,...,27	27	Zero pure profits at the margin in production.
[20]	$p_{i1} = p_i^e + v_i + FES_1(RC * rr_i + \phi_1)$ $+(1 - FES_1)(rr_i + \phi_2)$	i = 1,2,...,27	27	Zero pure profits at the margin in exporting.
[21]	$p_{i2} = p_i^m + t_i + \phi_2$	i = 1,2,...,27	27	Zero pure profits at the margin in importing.

continued...

No.	Equation	Subscript range	Number	Description
[22]	$gdp_r = \sum_i K_i x_i$		1	Real GDP.
[23]	$gdp = \sum_i K_i(p_i^x + x_i)$		1	Nominal GDP.
[24]	$a_R = \sum_i SN_{i3}q_i^{(3)} + \sum_i SN_{i5}q_i^{(5)} + \sum_i SN_{i2}q_i^{(2)} + \sum_i SN_{i6}qs_i^{(2)}$		1	Real absorption.
[25]	$a = \sum_i SN_i a^* + \sum_i SN_{i5}(p_i^q + q_i^{(5)}) + \sum_i SN_{i2}(p_i^q + q_i^2) + \sum_i SN_{i6}(p_i^q + qs_i^{(2)})$		1	Nominal absorption.
[26]	$e_R = \sum_i V_i x_{i1}$		1	Total export volume.
[27]	$m_R = \sum_i M_i q_{i1}$		1	Total import volume.
[28]	$\pi = SXe - SMm$		1	Balance of trade as a share of base case GDP at official prices.
[29]	$e = \sum_i V_i(p_{i1} + x_{i1})$		1	Total export value at official prices
[30]	$m = \sum_i M_i(p_{i2} + q_{i2})$		1	Total import value at official prices.
[31]	$\pi f = SXFef - SMFmf$		1	Balance of trade as a share of base case GDP in foreign currency.
[32]	$ef = \sum_i VF_i(p_{i1}^e + x_{i1})$		1	Total export value in foreign currency.
[33]	$mf = \sum_i MF_i(p_i^m + q_{i2})$		1	Total import value in foreign currency.
[34]	$p^q = ms - a_R$		1	Price level determination.
[35]	$p^x = \sum_i K_i p_i^x$		1	Price deflator for gdp.
[36]	$p^q = \sum_i W_i p_i^q$		1	Price deflator for total absorption.
[37]	$p_i^q = \sum_{s=1}^2 A_{is} p_{is}$	i = 1,2,...,27	27	Price deflator for absorption of i.
[38]	$p_i^x = \sum_{d=1}^2 J_{id} p_{id}$	i = 1,2,...,27	27	Price deflator for output of i.

Total number of equations in the model: 1420

Table 6.7: **Variables, Parameters and Coefficients in the China CGE Model**

Endogenous Variables (in percentage change forms)

Variable	Subscript range	Number	Description
a		1	Nominal absorption.
a^*		1	Household nominal absorption.
e		1	Export value in domestic currency (nominal).
ef		1	Export value in foreign currency.
e_R		1	Export volume.
gdp_r		1	Real gdp.
gdp		1	Nominal gdp.
m		1	Import value in domestic currency.
mf		1	Import value in foreign currency.
m_R		1	Import volume.
p^e_{is}	i = 1,2,...,27 s = 1	27	Foreign currency price of export i from China ($s = 1$).
p^p_{vj}	v = 1,2,3 j = 1,2,...,27	55	Return to primary factor v in industry j, with only one wage rate in the model.
p^m_i	i = 1,2,...,27	27	Foreign currency price of import i.
p^q		1	Composite price for absorption.
p^q_i	i = 1,2,...,27	27	Price for absorption of i.
p_{ik}	i = 1,2,...,27 k = 1,2,3	81	Price of i for 1, export; 2, import; 3, domestic products.
p^x_i	i = 1,2,...,27	27	Price for production of i (composite of domestic and export).
p^x		1	Aggregate price of output (gdp deflator).
q_i	i = 1,2,...,27	27	Total absorption of i.
$q^{(1)}_{ij}$	i = 1,2,...,28 j = 1,2,...,27	756	Intermediate use of i by industry j, including total use of composite energy e in industry j, $q^{(1)}_{ej}$.
$q^{(2)}_i$	i = 1,2,...,27	27	Fixed investment demand for good i.
$qs^{(2)}_i$	i = 1,2,...,27	27	Investment in stock i.
$q^{(3)}_i$	i = 1,2,...,27	27	Household demand for i.
$q^{(4)}_i$	i = 1,2,...,27	27	Export demand for i from China.
$qw^{(4)}_i$	i = 1,2,...,27	27	World demand for good i.
$q^{(5)}_i$	i = 1,2,...,27	27	Government demand for i.
q_{is}	i = 1,2,...,27 s = 1,2	54	Demand for i from source $s = 1$, import; 2, domestic.
$q^{(1)}_{vj}$	v = 1,2,3 j = 1,2,...,27	81	Demand for primary factor $v = 1$, labour; 2, capital; 3, land by industry j.
x_j	j = 1,2,...,27	27	Output level of industry j.
x_{id}	i = 1,2,...,27 d = 1,2	54	Supply of good i to destination $d = 1$, export; 2, domestic.
π		1	Balance of trade as a share of gdp in official prices.
πf		1	Base period balance of trade as a share of gdp in foreign currency.
ϕ_2		1	Secondary market exchange rate.
Total number of endogenous variables:		1420	

Exogenous Variables (in percentage change forms)

Variable	Subscript range	Number	Description
a_R		1	Real absorption.
k_j	j = 1,2,...,27	27	Capital stock in industry j.
l_j	j = 1,2,...,27	27	Land use by industry j.
ms		1	Money supply.
p_{is}^e	i = 1,2,...,27	27	Foreign currency price of good i, s = 2, R.O.W.
q_1^p		1	Total labour force.
rr_i	i = 1,2,...,27	27	Foreign exchange retention rate for exports of i.
t_i	i = 1,2,...,27	27	Power of the tariff on imports of i (1 + nominal tariff rate).
v_i	i = 1,2,...,27	27	Power of the export tax on exports of i (1 - nominal export tax).
ϕ_1		1	Official exchange rate (Yuan/US dollar).
Total number of exogenous variables:		166	

Elasticity Parameters

Parameter	Subscript range	Number	Description
β_i	i = 1,2,...,27	27	Global elasticity of excess demand for good i.
E_i	i = 1,2,...,27	27	Elasticity of import supply for good i to China.
ε_i	i = 1,2,...,27	27	Household expenditure elasticity for good i.
η_{ij}	i = 1,2,...,27 j = 1,2,...,27	729	Price elasticity of household demand for good i with respect to price j.
σ_{ij}	i = 1,2,3,4 j = 1,2,...,27	108	Elasticity of substitution between energies in industry j.
σ_i^m	i = 1,2,...,27	27	Elasticity of substitution between import and domestic products of good i.
σ_i^p	i = 1,2,...,27	27	Elasticity of substitution between primary factor inputs in sector i.
σ_i^T	i = 1,2,...,27	27	Elasticity of substitution between domestic and export production of good i.
σ_i^W	i = 1,2,...,27	27	Elasticity of substitution between Chinese and R.O.W. products in world market for i.
Total number of parameters:		1026	

Value Share Coefficients

Coefficient	Subscript range	Number	Description
A_{is}	i = 1,2,...,27 s = 1,2	54	Share of absorption of i derived from source s.
$B_{ij}^{(1)}$	i = 1,2,...,27 j = 1,2,...,27	729	Share of intermediate use in j in total absorption of i.
$B_{i}^{(2)}$	i = 1,2,...,27	27	Share of investment in total absorption of commodity i.
$BS_{i}^{(2)}$	i = 1,2,...,27	27	Share of stock demand in total absorption of commodity i.
$B_{i}^{(3)}$	i = 1,2,...,27	27	Share of household consumption in total absorption of commodity i.
$B_{i}^{(5)}$	i = 1,2,...,27	27	Share of government in total absorption of i.
ES_{is}	i = 1,2,...,27	54	Share of China and R.O.W. in world export markets for i.
E_{ik}	i = 1,2,3,4 k = 1,2,...,27	108	Share of energy i in total energy demand by industry k.
FES_1		1	Share of export revenue obtained from sales at official exchange rate, $((1-R_0)\phi_1)/(R_0\phi_2+(1-R_0)\phi_1)$ where $R_0 =$ base period retention rate.
$H_{ij}^{(1)}$	i = 1,2,...,27 j = 1,2,...,27	729	Share of intermediate good i in total costs of industry j.
H_{vj}^{p}	v = 1,2,3 j = 1,2,...,27	81	Share of primary factor v in total costs of industry j.
J_{id}	i = 1,2,...,27 d = 1,2	54	Share of good i production to destination 1, export; 2, domestic.
K_i	i = 1,2,...,27	27	Share of sector i in total value added.
L_j	j = 1,2,...,27	27	Share of industry j in total employment.
M_i	i = 1,2,...,27	27	Share of i in total imports.
MF_i	i = 1,2,...,27	27	Share of i in total imports in foreign currency.
RC		1	Conversion factor from proportional change in retention rate (R) to change in $(1-R)$ i.e. $(-R_0/(1-R_0))$.
S_{vj}^{p}	v = 1,2,3 j = 1,2,...,27	81	Share of primary factor v in primary factor inputs of j.
SM		1	Imports as a share of nominal *gdp* at official prices.
SMF		1	Imports as a share of *gdp* in foreign currency.
SN_{ij}	i = 1,2,...,27 j = 1,2,...,27	729	Share of end-use demand j for commodity i in final absorption.
SX		1	Exports as a share of nominal *gdp* at official prices.
SXF		1	Exports as a share of *gdp* in foreign currency.
V_i	i = 1,2,...,27	27	Share of i in total exports.
VF_i	i = 1,2,...,27	27	Share of i in total exports in foreign currency.
W_i	i = 1,2,...,27	27	Share of good i in total absorption.
Total number of coefficients:		2922	

Chapter 7

Model Simulation Results

This chapter presents the simulation results of the model. The experiments carried out with the model are in two stages. The first stage is a base run of the model, in which the economy-wide effect of a 60% decrease in oil price is simulated in the absence of explicit policy responses. Policy changes are introduced at the second stage where several policy adjustment packages are experimented. These simulations compare different "states of the world". That is, the model is used to simulate comparative static results and present a comparison between the *status quo* and the hypothetical situation that would arise as a consequence of an external shock or policy changes. This kind of counterfactual equilibrium analysis provides insights into the implications of various shocks to the economy.

7.1 General Effects

Before embarking upon the interpretation of the simulation results, it is useful to discuss the major qualitative effects captured in the model, and illustrate the linkages between the simulations and the booming sector theory.

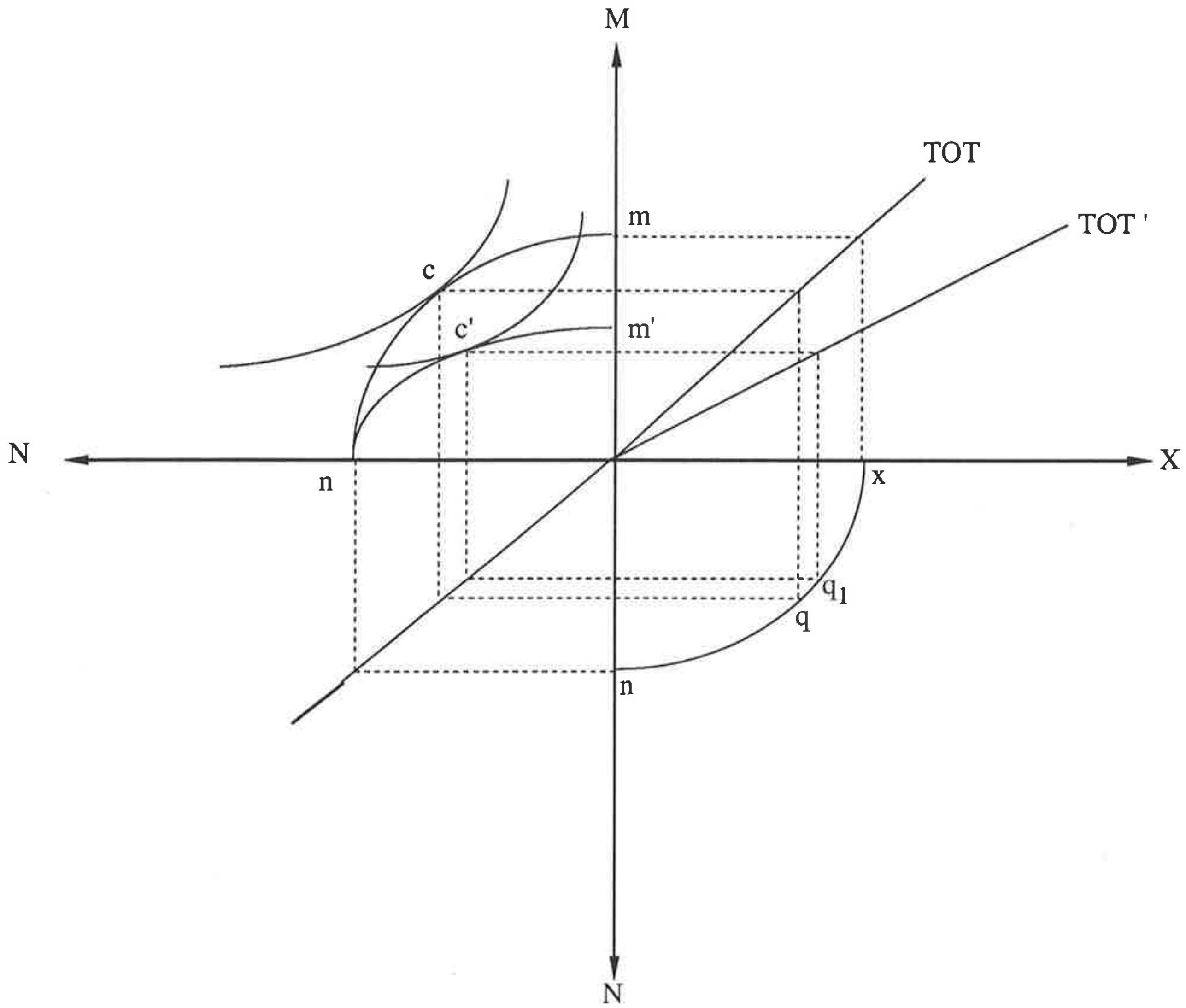
Figure 7.1 utilises a simple, one sector general equilibrium framework suggested by de Melo and Robinson (1989) to examine the effect of the oil price shock captured in the simulations. This model abstracts from intersectoral linkages, factor movement effects and the foreign exchange system operation in China, but does illustrate the nature of the major adjustments required in response to spending and relative price changes.

Consistent with the product specifications in the CGE model, domestically produced goods in this model are differentiated between those sold on the export market and those sold on domestic market. Export goods are not consumed domestically, but are used to purchase imports. So the economy produces non-traded goods and exports. They are represented by axes denoted as N and X, respectively, in Figure 7.1. The vertical N axis represents the supply of non-traded goods, the horizontal N axis represents the consumption of non-traded goods. The supply and demand of non-traded goods are equal in the model. The output of exports measured by axis X are sold in exchange for imports which are measured by axis M. This takes place at a relative price given by the terms of trade.

The changes are initiated in the first quadrant where the foreign offer curve is graphed, showing the terms of trade. The initial terms of trade *(TOT)* is represented by a 45 degree foreign offer curve with world prices for both exports and imports set to be equal and the balance of trade equal to zero. In the first step, the oil price shock can be viewed as a terms of trade deterioration which tilts the initial terms of trade line (TOT) clockwise to TOT'. This change in quadrant 1 induces changes in quadrant 2 where the consumption possibility curves are drawn simultaneously satisfying the balance of trade constraint in quadrant 1 and the production possibility frontier in quadrant 4. The initial consumption frontier (nm) is a mirror image of the production possibility frontier (nx) when the TOT curve is a 45 degree line. The decline of terms of trade reduces the quantity of imports which can be purchased for any given quantity of exports. As a consequence, the consumption possibility curve nm shrinks to nm'.

The first changes in the diagram illustrate the negative spending effect

Figure 7.1: Adjustment to an External Shock in a Simple General Equilibrium Framework



from a negative terms of trade shock. In standard theory, the oil price shock generates two effects: the spending effect and the resource movement effect (Corden, 1984). In the general case, the spending effect is to decrease the demand for non-traded goods following the fall in real income associated with the oil price collapse. The resource movement effect is normally initiated as the marginal product of labour in the oil sector declines following the fall of oil prices. This will move resources (mobile labour as defined in the model) out of the oil sector to the non-oil economy. However, given the high capital intensity in the oil sector, the resource movement effect will be trivial. More importantly, the domestic energy shortage and the institutional arrangements (including price arrangements) over China's oil industry tend to make the oil sector an "enclave" in the model (Peng, 1987). Therefore, the spending effect is likely to be much more important than resource movement effect, and the latter is ignored in the diagram.

The substantial decrease in China's export revenues following the oil price shock reduces spending on non-traded goods in the domestic market. Assuming the income elasticity of demand for non-traded goods is positive, there is then a disequilibrium in the market for non-tradables as an excess supply of non-traded goods occurs at the initial price level. To restore the equilibrium, there must be a relative fall in the price of non-traded goods. The shift of the consumption point from c to c' in quadrant 2 reduces consumption of non-traded goods, and followed by reduction in production due to the induced real depreciation.

The adjustment is illustrated in quadrant 4 of Figure 7.1 where the production point moves in favour of exports indicating an expansion of the non-oil tradable sector economy. On the axis of exports, the new export point moves to the right, implying the increase in exports of other tradables more than offset the decline in oil exports.[1] The non-tradable sector bears the burden of adjustment in the negative spending effect as the market for non-traded goods

[1] The move of the export output point on the X axis depends on the extent of shift in the terms of trade curve and the income elasticity on non-traded goods.

contracts in quadrant 3.

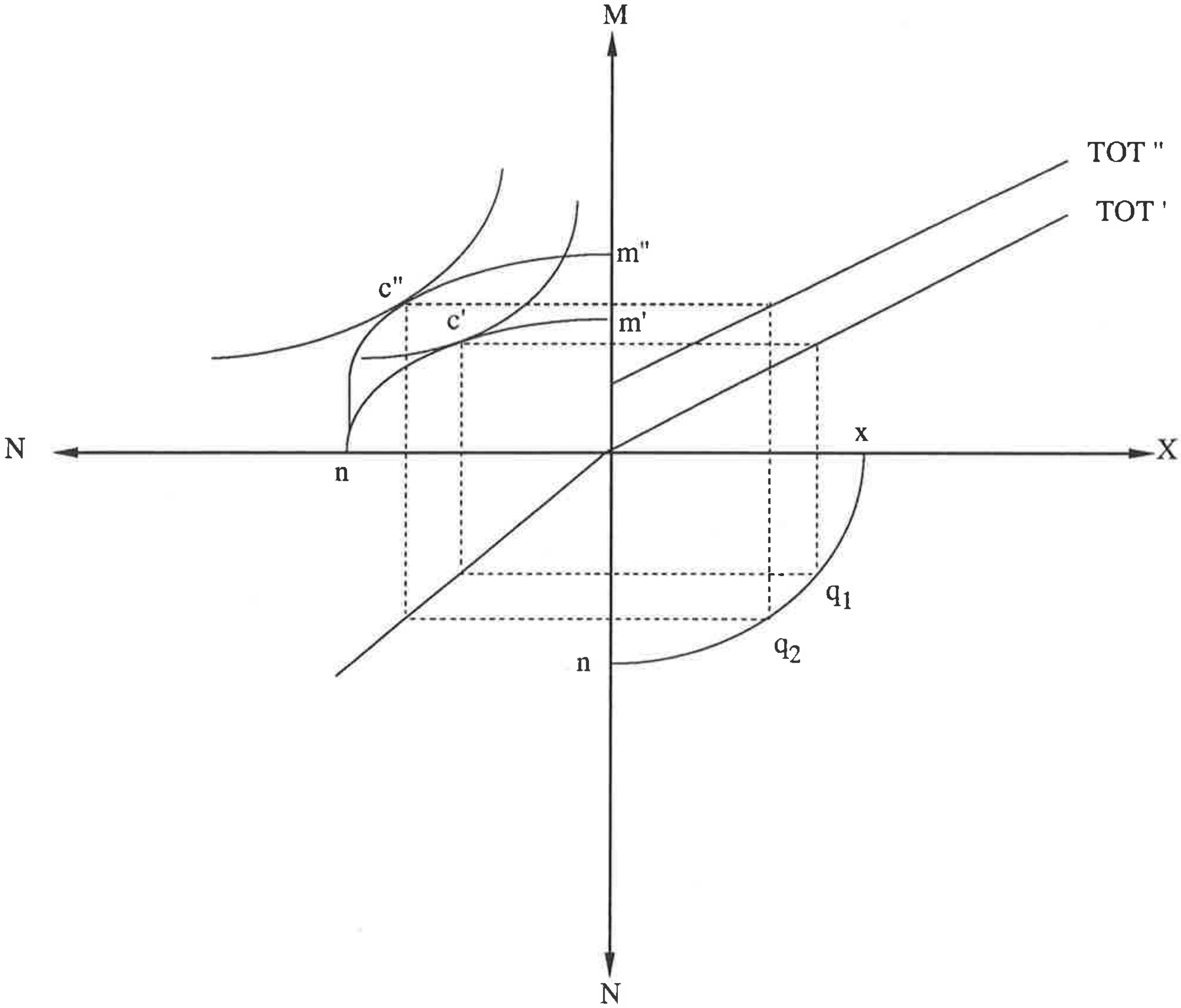
The standard booming sector theory implicitly assumes the negative spending effect is transmitted into the economy through a reduction in the domestic absorption and therefore a real depreciation takes place to spur adjustment and restore equilibrium in the goods market. However, in application to the Chinese economy, one question is whether domestic spending decreases after the oil price shock. It is certainly a policy option for an oil exporting country *not* to reduce domestic spending following an oil price shock such as the one in 1986. Since oil is an asset, it can facilitate intertemporal trade, allow the economy to run current account deficits now and repay them through surplus in the future.[2] In a country such as China, the government is invariably the biggest borrower, even if not the biggest investor any more. The government can make up the loss of oil export revenues by borrowing. Furthermore, optimistic private agents may choose not to reduce spending. In this case, a reduction in real absorption will not occur unless induced by policy responses.

To capture the effects of policy responses in the adjustment process, the base run of the model assumes that real absorption is fixed. Changes in real absorption in order to facilitate adjustment in the oil price shock are considered at the second stage of experiment. The effects of a fixed real absorption can be illustrated by modifying the simple framework presented in Figure 7.1. For clarity of exposition, these changes in Figure 7.1 are shown in a separate picture presented as Figure 7.2.

In quadrant 1 of Figure 7.2, the tilted terms of trade line TOT' is shifted vertically up to TOT'' so that the new shrunken consumption possibility curve NM' is lifted up tangential to the initial indifference curve to maintain a constant domestic real absorption. The new consumption point is given by c''. The distance of $m'm''$ on the axis of imports represents the magnitude of foreign

[2]This strategy is quite reasonable if slack years and boom years alternate at roughly the same frequency. In a period of sustained sluggishness in the oil market, it could lead to serious dislocations. Implications of this are discussed later in the chapter.

Figure 7.2: Effects of a Fixed Absorption in the External Shock Adjustment



borrowing incurred under the fixed real absorption assumption.

To eliminate this external deficit requires that the present discounted value of future expected trade surpluses to equal the value of foreign debt. However, in the short run, with the foreign borrowing, the price for non-tradables need not decrease. So given the fall of the export price as a result of the terms of trade shock, the pattern of production will shift from q_1 to q_2 on the production possibility curve in quadrant 4. As a result, there is a decrease in exports due to the shock, in the presence of borrowing.

The slope of the production possibility frontier represents the *real* exchange rate in the form of export price relative to non-tradable price, eP_x^*/P_n, e is the nominal exchange rate, P_x^* is the price of exports in foreign currency, and P_n is the price of non-traded goods. Changes in the real exchange rate will move the production point along the nx curve. Under a flexible exchange rate regime, for a given trade deficit as induced by the terms of trade shock, e would depreciate to an extent that brings about an increase in the price of exports in domestic currency ($e \uparrow \Rightarrow eP_x^* \uparrow$) to encourage exports, and finally eliminate the external deficit. This assumes a flexible exchange rate operating in a foreign exchange market without distortion. However, it is important at this stage to understand the distortions existing in the Chinese foreign exchange market which will affect the adjustment path as captured in the CGE model simulations.

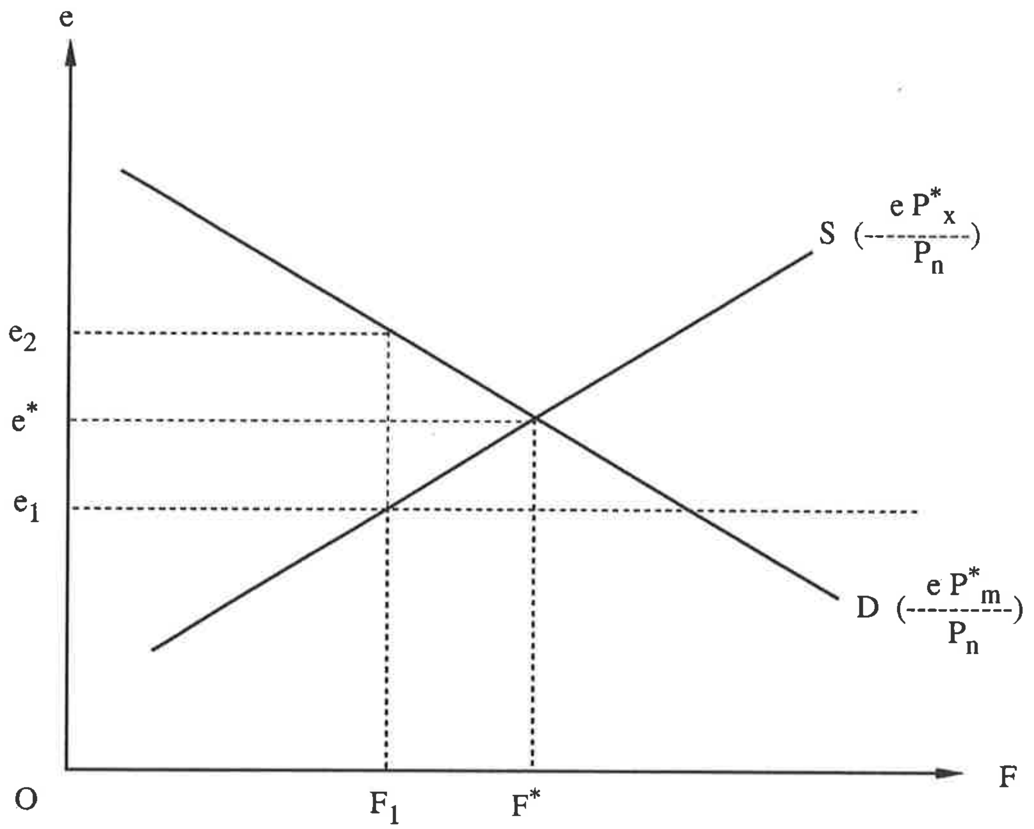
7.2 Implications of the Dual Foreign Exchange Rate System in China

The Chinese foreign exchange market operates in a dual exchange rate system consisting of an official exchange rate and a secondary market exchange rate. The official exchange rate is fixed by the government and is adjusted periodically, while the secondary market exchange rate is determined by market forces. A substantial amount of foreign exchange is traded at the secondary market rate in the Foreign Exchange Adjustment Centres established throughout the country since 1985. The proportion of government controlled foreign exchange and the foreign exchange in the market is largely determined by the foreign exchange retention scheme. Under this scheme, export enterprises are entitled to retain a specific percentage of foreign exchange earned, the rest is surrendered to the State Administration of Exchange Control. The foreign exchange in China is allocated between the government and the enterprises at the foreign exchange retention ratio which is around 25%.

The exchange rates applied to these two parts of foreign exchange diverge sharply, and is characterised by an overvalued official exchange rate and a high market exchange rate. To understand the mechanisms of exchange rate determination in China, a stylised short-side disequilibrium model is used (Martin 1990c, Desai and Bhagwati 1979). In its simplest form as depicted in Figure 7.3, the upward sloping curve $S(\frac{eP_x^*}{P_n})$ represents the supply of foreign exchange at any given nominal exchange rate. It could be thought of as representing the transformation possibilities between exports and non-traded goods in the single sector general equilibrium model as in Figure 7.1 and Figure 7.2. The downward sloping curve $D(\frac{eP_x^*}{P_n})$ in Figure 7.3 represents the demand for foreign exchange at a given total absorption. Similarly, the demand curve for foreign exchange could be thought of as the substitution possibilities between imports and non-traded goods as in the model presented earlier.

In the absence of exchange controls, the supply and demand of foreign exchange will reach an equilibrium at a quantity of F^*, and at a price of e^* which is the equilibrium exchange rate. However, with a dual exchange rate system introduced, the foreign exchange market is distorted by the fixed official exchange rate which has been typically set below the equilibrium rate in China. As all exports take place at the official exchange rate, the supple of foreign exchange is given by F_1. Foreign exchange supply compared to the free market exchange rate situation is lower because a lower exchange rate discourages exports as it reduces the domestic currency returns from exports.

Figure 7.3: Effects of a Dual Exchange Rate System



The short supply of foreign exchange results in high scarcity value of foreign exchange which is reflected in the secondary market exchange rate. As shown in Figure 7.3, the secondary market exchange rate determined by the "short side" of the market (the decreased supply at point F_1) would not only be expected to be above the official rate e_1, but also above the equilibrium rate e^*. [3]

With the distorting effect of an overvalued official exchange rate reflected in the high secondary market exchange rate, it is not difficult to visualise that a depreciation of the official exchange rate ($e_1 \uparrow$) will bring down e_2, reducing the gap between e_1 and e_2, as exports are encouraged, and the foreign exchange supply increases. If the depreciation of the official exchange rate is sufficiently large, the gap between e_1 and e_2 will be eliminated, and one rate e^* will prevail at the market.

One of the policy implications of these theoretical discussions is that an appropriate exchange rate policy to reduce the distortion in the Chinese foreign exchange market will be to depreciate the official exchange rate, so to close the gap of e_1 and e_2 and facilitate the structural adjustment, which are considered in the model simulations.

7.3 Base Run Simulation

The economy-wide effects of a 60% decline in the oil price shock without explicit policy responses is simulated in the CGE model. The results obtained are reported in the first column of Table 7.1. First we note that the market exchange rate shows a considerable depreciation as the terms of trade shock reduces the foreign exchange supply in the foreign exchange market, which increases the shortage of foreign exchange and pushes up the market exchange rate in the dual exchange rate system due to the higher scarcity value. This is

[3]There is no risk premium associated with a black market since market transactions of foreign exchange is legal in the Foreign Exchange Adjustment Centres.

equivalent to a shift in of the supply curve in Figure 7.3. With a fixed official exchange rate, a decrease of foreign exchange supply due to the oil price shock will produce a higher scarcity value, and results in a higher market exchange rate. This explains the 3.21% depreciation. The depreciation of the market exchange rate has important implications in the adjustment process of the oil price shock as a depreciation will increase the level of foreign prices measured in domestic currency terms and thus, in the domestic economy, the price of traded goods to non-traded goods (a real depreciation). This is precisely what the booming sector theory would predict; a real depreciation is necessary to spur adjustment to the oil price collapse and restore equilibrium in the goods market.

However, with the official exchange rate still fixed, the effectiveness of market exchange rate depreciation is limited. This is reflected in the decline of export volume of -3.59%, indicating the fall in oil exports under the oil price shock outweighs the increase of non-oil exports induced by market exchange rate depreciation. But notice the volume of imports is reduced considerably by -2.64%, reflecting the more effective role played by the market exchange rate on the import side. As specified in the model, the opportunity cost of all imports involves the secondary market exchange rate, the market exchange rate depreciation therefore increases the import cost and reduces imports. On contrast, export returns are a function of world price and a weighted average of the official and market exchange rate in foreign exchange retention shares. With a foreign exchange retention rate of 25% as specified in the model, the depreciation of the market exchange rate is not effective enough to stimulate sufficient non-oil exports to offset the impact of oil price shock on total exports. The -3.59% decline in export volume is magnified to -5.94% when exports are measured in value, as the decrease in total exports is dominated by the 60% decline in oil export price. As a result, the economy goes into a trade deficit, indicated by the -0.38% decline in the balance of trade measured in foreign currency.

Table 7.1: Simulation Results of an Oil Price Shock to the China Energy Model and Adjustment Experiments (in Percentages)

	60 Percent Decline in World Oil Prices	1 Percent Cut in Absorption	1 Percent Devaluation in Official Exch. Rate	1 Percent Decrease in Money Supply	Experiment 1 ($\Delta\pi$=0, Δa=-0.37)	Experiment 2 ($\Delta\pi$=0, $\Delta\phi 1$-$\Delta\phi 2$=0; Δa=-0.36, $\Delta\phi 1$=0.16)
MACROECONOMIC IMPACTS						
Market Exchange Rate	3.21	6.27	-0.63	-1.63	5.55	5.42
Export Volume	-3.59	2.13	1.33	1.34	-2.79	-2.59
Import Volume	-2.64	-6.48	0.90	0.90	-5.06	-4.89
Export Value (US$)	-5.94	1.91	1.19	1.20	-5.22	-5.04
Import Value (US$)	-2.67	-6.54	0.90	0.91	-5.11	-4.94
Balance of Trade (US$)	-0.38	1.01	0.03	0.03	0.00	0.00
Real GDP	-0.94	-0.70	0.08	0.08	-1.20	-1.18
Price Deflator for GDP	-0.94	0.31	0.08	-0.92	-0.82	-0.81
Absorption Price Index	0.00	1.01	0.00	-1.00	0.38	0.37
Wage Rate	1.98	-1.09	0.15	-0.85	1.57	1.60
SECTORAL OUTPUT EFFECTS						
Energy Sectors						
Crude Oil	-0.42	0.03	0.00	0.00	-0.41	-0.41
Coal	-5.50	0.78	0.50	0.05	-5.21	-5.13
Electricity	-1.23	0.38	0.00	0.00	-1.08	-1.09
Petroleum Products	0.28	0.02	-0.00	-0.00	0.28	0.28
Tradable Sectors						
Crops	0.07	-0.00	-0.01	-0.01	0.07	
Cotton	0.16	0.06	0.05	0.05	0.19	0.19
Metals	0.72	0.90	-0.09	-0.09	1.06	1.04
Chemicals	0.23	0.23	-0.01	-0.01	0.31	0.31
Machinery	0.58	0.63	-0.05	-0.05	0.82	0.81
Food Processing	0.29	0.28	-0.06	-0.06	0.40	0.39
Textiles	0.28	0.35	0.06	0.06	0.40	0.41
Misc. Manufacturing	0.59	1.04	0.08	0.08	0.98	0.99
Non-Tradable Sectors						
Construction	-0.07	-0.76	0.00	0.00	-0.35	-0.35
Freight Transport	0.42	0.41	0.07	0.07	0.58	0.59
Passenger Transport	0.04	-0.22	-0.00	-0.00	-0.04	-0.04
Education and Health	-0.00	-1.00	-0.00	-0.00	-0.38	-0.37
Housing	-0.01	-0.17	-0.00	-0.00	-0.07	-0.07

The deterioration in the external sector has important consequences for the economy. Real GDP (defined as nominal GDP deflated by the price of absorption) falls by -0.94% because of the adverse terms of trade shock. With the real absorption fixed in the model closure, the balance of trade must therefore deteriorate.

The changes in the price indexes reflect changes in relative prices which the booming sector theory suggests are important in resource reallocation. As mentioned above, the domestic price of imports rises due to the higher opportunity cost of foreign exchange and greater shortage of these goods, and the price of exports to a lesser degree is also increased via changes in the weighted average of foreign exchange retention due to the market exchange rate depreciation. With the price of aggregate absorption held constant and the price of imported goods increasing, the price of non-traded goods must fall absolutely to bring about the required fall in the price of non-traded goods relative to imports. This fall in the price of non-traded goods brings about the decline of -0.94% in the price deflator for GDP. As a result, resources are shifted to non-oil tradable goods, and particularly to import competing goods.

This transfer of resources to the tradable sectors is mainly in the form of employment as labour is defined as the only mobile factor in the model. The increased demand for labour in the tradable sector bids up the wage rate. The job creating effects of increased output in the tradable sectors can be mapped out by combining the sectoral output results in Table 7.1 with the sectoral employment multipliers provided in Table 7.2.

As suggested by the simulation results of sectoral output effects in Table 7.1, the percentage changes in the output of tradable sectors are positive, while the energy sectors and non-tradable sectors generally show negative signs. The employment creating effects of the expansion in the tradable sectors depend on how labour intensive the tradable industries are. The sectoral employment multipliers presented in Table 7.2 show the employment would be generated per

Table 7.2: Sectoral Employment Multipliers and Base Run Impacts

	Total Labour		Direct Labour		Base Run Impact
Tradable Sectors:					3.14
Animal Husbandry	0.534	[2]	0.196	[9]	0.05
Crops	0.532	[3]	0.472	[2]	0.04
Wood	0.515	[4]	0.180	[10]	0.17
Cotton	0.493	[5]	0.450	[3]	0.83
Food Processing	0.485	[6]	0.041	[24]	0.14
Paper	0.448	[7]	0.098	[18]	0.13
Wool	0.403	[9]	0.225	[6]	1.18
Misc. Manufactures	0.352	[13]	0.101	[17]	0.21
Machinery	0.325	[14]	0.104	[15]	0.19
Building Materials	0.318	[16]	0.129	[14]	-0.01
Apparel	0.307	[17]	0.050	[22]	-0.09
Metals	0.246	[19]	0.061	[20]	0.18
Chemicals	0.180	[22]	0.038	[25]	0.04
Chemical fibres	0.171	[23]	0.139	[13]	0.04
Textiles	0.160	[25]	0.083	[19]	0.04
Non-Tradable Sectors:					0.10
Pub. Adm. & Defence	0.938	[1]	0.938	[1]	0.00
Commerce	0.423	[8]	0.197	[8]	-0.02
Edcation and Health	0.383	[11]	0.233	[5]	0.00
Construction	0.354	[12]	0.102	[16]	-0.02
Freight Transport	0.323	[15]	0.203	[7]	0.14
Passenger Transport	0.264	[18]	0.151	[12]	0.01
Misc. Services	0.232	[20]	0.170	[11]	0.00
Housing	0.161	[24]	0.041	[23]	0.00
Energy Sectors:					-2.39
Coal	0.387	[10]	0.234	[4]	-2.13
Electricity	0.208	[21]	0.060	[21]	-0.26
Oil	0.044	[26]	0.015	[26]	-0.02
Petroleum	0.042	[27]	0.002	[27]	0.01

dollar of new sectoral output. The multipliers are calculated from the input-output data base of the model. They are measured in wage payment instead of physical labour which allows the possibility of differing wage rates in different sectors. The indexes under the heading of *total labour* take into account of both *direct* wage payments of the sector's labour input and also the *indirect* wage payments embodied in that sector's other inputs. Using W_j to represent total dollar value of labour inputs per dollar's worth of output, we have

$$W_j = \sum (I - A)^{-1} L_j \tag{7.1}$$

where $(I - A)^{-1}$ is the Leontief inverse of the input-output coefficient matrix A in the data base, and L_j is the direct labour input in sector j.

The numbers in brackets in Table 7.2 rank the order of employment multipliers among the sectors in the economy. It is clear that the ranking changes dramatically for some sectors in terms of W_j and L_j, implying that it is crucial to take the indirect labour inputs into account. With few exceptions, the ranking of total employment multipliers reflects the generally higher labour intensity in most tradable sectors relative to non-tradable sectors, and the low labour intensity in energy sectors, particularly in oil industries.

By applying the total labour multipliers W_j to the output simulation results in the first column in Table 7.1, the impact of sectoral output changes on employment is calculated. The results are presented in the last column in Table 7.2. As would expected, tradable sectors generate a net of 3.14% increase in employment, while employment in non-tradable grows 0.1%, and employment in energy sectors contracts by -2.39%. The shift of employment towards relatively more labour intensive tradable sectors generates strong demand for labour which bids up the wage rate by 1.98%.

The new output structure highlights the energy linkages in this model. Following the decrease of crude oil output in response to oil price fall in the world market, coal output decreases significantly by -5.5% which reflects the energy substitution effect induced by cheaper oil. At least two mechanisms of substituting oil for coal can be identified. The first is the shift of indigenous oil supply from export market to domestic market, given the CET production transformation specified in the model (see more discussion later in this chapter). The increased oil supply to the domestic economy will lower domestic oil prices, and encourage using more oil and less coal. While technological factors may constrain the substitution in the short run, an immediate consequence of the oil price shock is the reduced demand for China's coal exports in the world market, as world demand for coal decreases following the fall in oil price.[4] The decrease of coal output leads to the decrease of electricity production which is mainly based on coal. However, the output of refined petroleum increases by 0.28%. This reflects both the cheaper input in the oil refining industry and, probably more importantly, the shift of oil supply between domestic and export markets.

Table 7.3 presents the interindustry energy flows obtained from the Leontief inverse of the input-output coefficient matrix in the data base of the model. Analogous to Table 7.2, the figures in Table 7.3 show the total energy requirement to deliver one unit of product for each energy type, both directly as the energy consumed by an industry's production process and indirectly as the energy embodied in that industry's inputs. The numbers in brackets rank the order of the energy requirement magnitudes. The energy flows in Table 7.3 are measured in value terms. A similar way to construct an energy requirement matrix is to measure energy in physical units, for example, coal equivalents. This is done by first converting the value transaction matrix of the input-output table into a "hybrid-units" matrix, that is, to trace energy flows in physical units and non-energy flows in dollars, then to derive the Leontief inverse. For

[4]China's coal exports are sensitive to oil price changes. Following the world oil price hikes in 1973 and 1979, for example, China's coal export s increased by 32.2% and 48.2%, respectively, mainly due to an increased demand for coal in Japan and Hongkong as oil was getting dearer. In the following years, China steadily increased its coal export in the rising of world oil prices. In the declining of world oil prices in the 1980s, substitution of oil for coal took place, which cut the world coal demand, and China's coal export fell by 5.6% over 1981-83 (State Statistical Bureau, 1990).

Table 7.3: Interindustry Energy Flows in Leontief Inverse

	Total Energy		Crude Oil		Refined Petroleum		Coal		Electricity	
Energy Sector:										
Electricity	2.091	[1]	0.382	[3]	0.170	[5]	0.321	[2]	1.218	[1]
Oil refining	1.905	[2]	0.848	[2]	1.033	[1]	0.008	[25]	0.016	[21]
Coal	1.306	[3]	0.065	[17]	0.053	[18]	1.107	[1]	0.080	[3]
Crude Oil	1.110	[4]	1.069	[1]	0.021	[25]	0.007	[26]	0.013	[24]
Tradable Sectors:										
Wool	0.647	[6]	0.244	[5]	0.280	[3]	0.055	[7]	0.068	[4]
Metallurgy	0.414	[7]	0.123	[8]	0.086	[9]	0.110	[3]	0.095	[2]
Chemicals	0.357	[9]	0.140	[7]	0.110	[6]	0.049	[11]	0.059	[6]
Machinery	0.331	[10]	0.109	[9]	0.087	[8]	0.068	[5]	0.066	[5]
Paper	0.290	[11]	0.095	[11]	0.085	[10]	0.053	[8]	0.058	[7]
Misc. Manufactoring	0.228	[12]	0.099	[10]	0.079	[12]	0.053	[9]	0.057	[8]
Building Materials	0.273	[13]	0.066	[16]	0.052	[20]	0.107	[4]	0.047	[9]
Apparel	0.247	[14]	0.093	[12]	0.084	[11]	0.032	[14]	0.038	[11]
Timber	0.202	[17]	0.071	[15]	0.069	[13]	0.033	[13]	0.030	[13]
Cotton	0.168	[18]	0.064	[18]	0.066	[15]	0.017	[20]	0.020	[19]
Food Processing	0.168	[19]	0.062	[19]	0.061	[16]	0.024	[17]	0.022	[17]
Animal Husbandry	0.133	[22]	0.050	[21]	0.055	[17]	0.013	[21]	0.015	[22]
Chemical fibre	0.127	[23]	0.048	[23]	0.053	[19]	0.008	[24]	0.019	[20]
Crops	0.099	[24]	0.038	[24]	0.039	[23]	0.011	[22]	0.012	[25]
Textiles	0.066	[26]	0.024	[25]	0.022	[24]	0.010	[23]	0.009	[26]
Non-Tradable Sectors:										
Passenger Transport	0.831	[5]	0.350	[4]	0.409	[2]	0.042	[12]	0.031	[12]
Freight Transport	0.396	[8]	0.151	[6]	0.173	[4]	0.050	[10]	0.022	[18]
Construction	0.246	[15]	0.077	[14]	0.067	[14]	0.061	[6]	0.041	[10]
Housing	0.208	[16]	0.082	[13]	0.090	[7]	0.021	[19]	0.014	[23]
Education and Health	0.155	[20]	0.053	[20]	0.044	[21]	0.030	[15]	0.028	[15]
Commerce	0.148	[21]	0.048	[22]	0.042	[22]	0.028	[16]	0.030	[14]
Misc. Services	0.087	[25]	0.021	[26]	0.016	[26]	0.022	[18]	0.027	[16]
Pub. Adm. and Defence	0.000	[27]	0.000	[27]	0.000	[27]	0.000	[27]	0.000	[27]

details see Miller and Blair (1985).

The energy flows in Table 4 are consistent with the sectoral output pattern in Table 2 which highlights the reversed pattern of resource allocation as in a booming sector model. The output of all energy sectors declined except for petroleum refining industry as explained above. Nearly all tradable sectors show increases in output. The trend of expansion of tradable sectors are unambiguous as would be predicted by theory. While the output of non-tradable sectors is expected to fall, the output of the passenger transport and freight transport sectors show slight increase which reflects the increased domestic supply of petroleum products and the energy linkage between the transport and oil refining sectors.

7.4 Macroeconomic Adjustment Packages

The basic story from the above analysis is that, in the absence of explicit policy response, the oil price shock has two effects on the Chinese economy. One is an income effect. The real income declines, resulting in deterioration in the balance of trade with fixed absorption. This requires reduction in the spending of the economy. The other is the substitution effect which causes the changes in prices and shifts resources between industries. While the general pattern of structural change is consistent with adjustment theory, the depreciation of the secondary market exchange rate implies that the distortion associated with the exchange rate regime is exacerbated.

How should the economy respond to these changes in an attempt to maintain internal and external balances? Since the shock affects two targets, the income-expenditure balance and the relative prices, we expect that at least two instruments will be required to restore equilibrium. A mix of policies can be identified: demand management policies such as fiscal and monetary restraint to reduce aggregate demand; structural policies such as elimination of price distortions to increase efficiency; and exchange rate policy such as devaluation to support exports. In this section, we examine two macroeconomic packages designed to achieve these objectives. We set two targets, firstly, to eliminate the negative income effect of the oil price shock on the balance of trade, and secondly, to reduce distortions in the foreign exchange market thereby improving price structure and facilitating structural adjustment. To achieve these two targets, two instruments are chosen, real absorption manipulation and devaluation of the official exchange rate.

7.4.1 One-target and one-instrument package

The first package is aimed at neutralising the effect of the oil price shock on the external balance. The target is set as

$$\Delta\pi^* + \Delta\pi = 0 \tag{7.2}$$

where

- $\Delta\pi^*$ denotes percentage changes (Δ) in the balance of trade after the oil price shock;
- $\Delta\pi$ is the outcome of the macroeconomic package on the balance of trade.

Both $\Delta\pi^*$ and $\Delta\pi$ are measured in foreign currency to abstract from the revenue effects associated with the foreign exchange regime. As the secondary market exchange rate changes in response to the absorption shock, and hence changes the government revenues associated with the trade regime, the balance of trade cannot simply be expressed in domestic currency terms. Rather, it is the foreign currency value of the trade balance which must be held constant, either in absolute terms or as a share of base period GDP. In the model, the foreign currency trade balance is specified as an endogenous share of base period GDP (calculated at the equilibrium exchange rate implied by solution of the model). [5]

[5] See section 6.3 in chapter 6.

In this experiment, it is assumed that the government can control total absorption, so that the quantities of household consumption, investment, and government spending are adjusted to maintain the initial trade balance. The relation between the instrument and the target variable is

$$\Delta\pi = k\Delta a \tag{7.3}$$

where

k	is a coefficient attached to the instrument;
Δa	is the percentage change in real absorption.

The coefficient k is the elasticity of an one percentage change in real absorption ($\Delta a = 1$ %) on the targeted variable ($\Delta\pi$). The value of k can be estimated from the model simulations. Column 2 in Table 7.1 shows the elasticities of selected endogenous variables in the model with respect to a one percentage reduction in real absorption.

The instrument chosen in this one-target and one-instrument package is basically a Keynesian approach by manipulating aggregate demand in the economy. The orientation is that the cut of real absorption reduces aggregate demand and so lowers the price of non-traded goods relative to traded goods. But a paradoxical effect of this approach is that the price of absorption rises in this simulation because of the way money demand is set up in the model. The money supply in the model is determined by real absorption and a composite price for absorption. A cut in real absorption increases the ratio of money supply to real absorption, and is just like a money supply increase, which raises the absolute price of non-traded goods.

Therefore, to obtain an increase in the price of imports relative to non-traded goods requires a further rise in the price of imports compared to the passive response simulation. Consequently, a significant 6.27% devaluation of the secondary market exchange rate takes place, which leads to a substantial fall of -6.48% in imports. By applying the big rise in the market exchange rate to the 25% foreign exchange retention rate as assumed in the model, the impact of the market exchange rate depreciation on export price is also significant, which outweighs the rise in the price of non-traded goods associated with the paradoxical effect of absorption cut, and results in an increase of export price relative to non-tradable price as reflected by the considerable increase in exports of 2.13% in volumes and 1.91% in value. The improvement of the performance in external sector leads to a 1.01% increase in trade balance. The increase in the balance of trade implies an increase in nominal GDP. But the rise in the price of real absorption by 1.01% deflates the growth in nominal GDP. Real GDP still falls as in the base run, but at a smaller magnitude of -0.7%.

The structure of sectoral output is adjusted as non-tradable sectors show signs of declining, and on the other hand, the trend in the growth of tradable sectors (including energy sectors) is clear due to the improvement of export competitiveness with the depreciation of market exchange rate.

Having understood the effects of the policy instrument in cutting real absorption, the instrument is applied to the oil price shock. The size of real absorption cut required to achieve the target is given by solving equations 7.2 and 7.3 [Δa = -0.37]. The outcomes of the policy package are presented in column 5 of Table 7.1. The first thing to note is the target is achieved, so the balance of trade shows no change compared to its benchmark value in the model. The magnitude of depreciation required to maintain an unchanged balance of trade in this experiment is 5.55%. This leads to the decrease of imports in both volume and value by -5.06% and -5.11%, respectively, due to the increased costs on imported goods imposed by the devaluation. On the other hand, the market exchange rate depreciation increases the weighted average of foreign exchange retention which increases non-oil exports and offsets the impact of oil price shock on total export volume and, less effectively, on total export value, as reflected in the comparisons of export volume and export value between column 1 and column 5. The increases of non-oil exports explain the 1.57% increase in wage rates as employment shifts into export sectors. However, real GDP decreases due to both the loss of real income in the oil price shock and the increase of absorption price index.

7.4.2 Two-target and two-instrument package

While the real absorption approach overcomes the external balance difficulties arising from the decline in the price of oil, it exacerbates the distortions in the foreign exchange market. With the official exchange rate fixed, the induced depreciation of the market exchange rate increases the gap between the official and market exchange rates in the dual foreign exchange system in China. This outcome illustrates the more general need for two policy instruments if the two policy targets considered in this chapter are to be satisfied. To establish a market clearing real exchange rate, thereby facilitating structural adjustment, a devaluation of the controlled exchange rate is often the centrepiece of the adjustment effort in economies subject to a terms of trade shock.

The effect of a devaluation is simultaneously expenditure-reducing and expenditure-switching. It affects both domestic absorption and domestic supply. On the demand side, the effect of a devaluation on domestic absorption is unambiguously negative: the rise in the price level reduces the real value of private sector financial assets and also of those factor incomes whose nominal values do not rise proportionally with the devaluation. On the supply side, however, devaluation will boost output if the prices of (variable) domestic factors of production rise less proportionately than the domestic currency price of final output.

The problem is what magnitude of real depreciation is appropriate? In this two-target, two-instrument experiment (Tinbergen and Bos, 1962; Dixon, Powell and Parmenter, 1979), we show the extent required in the depreciation of the over-valued official exchange rate in order to not make the distortions of foreign exchange market worse. The magnitude of the official exchange rate depreciation is set to equal to that of the market exchange rate depreciation, and at the same time the target of a balanced trade account is maintained. So there are two targets in this package

$$\Delta\phi 1 - \Delta\phi 2 = 0 \tag{7.4}$$

$$\Delta\pi^* + \Delta\pi = 0 \tag{7.5}$$

where

$\Delta\phi 1$ denotes percentage changes of the official exchange rate;

$\Delta\phi 2$ is the percentage change in the market exchange rate.

Two instruments are used to achieve the two targets set. One is the real absorption (Δa), the other is the official exchange rate ($\phi 1$). The two-instrument, two-target problem is formally written down as

$$[(k_{11}\Delta a + k_{12}\Delta\phi 1) + \Delta\phi 2^*] - \Delta\phi 1 = 0 \tag{7.6}$$

$$(k_{21}\Delta a + k_{22}\Delta\phi 1) + \Delta\pi^* = 0 \tag{7.7}$$

the variables in equations (7.6) and (7.7) are best explained by the following table:

	Instrument I (+1% for Δa)	Instrument II (+1% for $\Delta\phi 1$)		Oil price shock (-60% for oil price)		Targets
$\Delta\phi 2$:	k_{11}	k_{12}	+	$\Delta\phi 2^*$	=	$\Delta\phi 1$
$\Delta\pi$:	k_{21}	k_{22}	+	$\Delta\pi^*$	=	0

Clearly, the coefficients k_{ij} in equations (7.6) and (7.7) are elasticities of the two targeted variables $i = 1, 2$ (market exchange rate and balance of trade respectively) in respect to the two instrument variables $j = 1, 2$ (real absorption and official exchange rate). They are shown in column 2 and 3 in Table 7.1. The effects of the oil price shock on the two targeted variables $\Delta\phi 2^*$ and $\Delta\pi^*$ are also available in column 1 of Table 7.1. The values of all these variables are obtained from model simulations.

The solution of the two-target, two-instrument problem for $\Delta\phi 1$ and Δa is given by:

$$\begin{bmatrix} \Delta a \\ \Delta\phi 1 \end{bmatrix} = \begin{bmatrix} k_{11} & k_{12} & - & 1 \\ k_{21} & k_{22} & & \end{bmatrix}^{-1} \begin{bmatrix} \Delta\phi 2^* \\ \Delta\pi^* \end{bmatrix} = \begin{bmatrix} -0.36 \\ 0.16 \end{bmatrix}$$

The results of the experiments are presented at the last column in Table 7.1. Both the volume and the value of exports increase by about 0.2% than in the one-target, one-instrument case following the removal of distortion in the foreign exchange market, and a balanced trade is achieved with less reduction in imports compared to the previous policy package. This implies more imports are allowed in this policy experiment which enables China gain more access to foreign capital and technology. The beneficial effect of the two-target, two-instrumrnt policy package is also reflected in the reduced pressure on price increase and the improvement in real GDP. The negative growth rate of real GDP is reduced marginally from -0.36% to -0.34%. The wage rate increased slightly from 1.57% to 1.60% indicating a structural adjustment takes place in a more flexible economy as the price structure is expected to improve following the reduction of the distortion in the overvalued official exchange rate, which will induce relative price changes that increase output for traded goods, particularly for export products. The sectoral output pattern is consistent with the adjustments in macroeconomic variables as output of tradable sectors in general increases and non-tradable sectors decline.

7.5 Fiscal and Monetary Policy Issues

Most booming sector theory literature is focused on the real effects of a shock. However, in many cases, there are important monetary effects which spill over to the real side of the shock. For example, an export boom will typically result in a balance of trade surplus and in the accumulation of foreign exchange reserves. If this increase in reserves is not sterilised, the monetary base will enlarge and lead to excess money supply in the economy. This will increase the price level, and provides one possible mechanism through which the real appreciation can take place (Neary, 1984). The example shows that the monetary implications in the adjustment process cannot be overlooked.

The incorporation of money in the model enables us to go beyond the real effects of the oil price shock, and capture its monetary effects. Given the unfavourable nature of the 1986 oil price shock for China, a lower demand for nominal and real money will result following a decline in real income. An important effect of this lower demand for money is that, if an excess supply for money results, an inflationary effect can occur. This can be illustrated using the equation

$$M \cdot v = P \cdot Y \tag{7.8}$$

where M is the stock of money, v is income velocity, P is the price level, and Y is national income in real terms. Following the decrease in real income ($Y \downarrow$), if the supply of money (M) does not change, and v is constant, the monetary equilibrium can only be re-established by an increase in price ($P \uparrow$), which will raise nominal prices of non-traded goods, appreciating the real exchange rate. Consequently, the distortion in the foreign exchange market is increased, since the supply curve of foreign exchange in Figure 7.3 would be shifted inward. Even larger responses, such as further depreciation of the market exchange rate, are needed in order to bring about the real depreciation required in the adjustment to an unfavourable external shock.

This analysis is based on a big if, that is, nominal money supply is assumed constant. As specified in the model (equation set [34] in Table 6.6), money supply is exogenous, any change in real absorption is then reflected in price adjustment. This was illustrated in the one instrument, one target experiment that a cut in real absorption requires an increase in price level to clear the money market, which generates adverse effect on the adjustment of the real side of the economy. An interesting exercise is to endogenise money supply, and see how the money market changes if real absorption is fixed, as to formulate an appropriate monetary policy response.

Assuming the monetary authority takes a neutral stand, changes in money supply after the oil price shock will depend critically on how the trade deficit is transmitted into the economy. Therefore, it is important to understand the linkages between oil export revenues (in foreign exchange form) and the domestic money supply. China's oil export revenues are allocated between the government and the oil industry through a profit retention scheme. So the mechanisms are either via government budget or enterprise spending. In the former case, the foreign exchange accruing to the government is deposited in the People's Bank of China, which is the central bank in China. There will be no effect on money supply if the government sterilises the deposit in the central bank in either an oil boom or slump.[6] However, the part of oil export revenues retained in the oil industry enterprises, which are not deposited in the central bank, will effect the money supply when they are converted to Chinese currency. Several scenarios are considered on the changes of money supply in China during the oil price shock.

(1) The twin deficit case

A large proportion of China's oil export revenues accrue to the government, and forms a significant part of income in the government's budget. The decline of foreign exchange revenues following the terms of trade shock for oil exports created a trade deficit in the first instance. This trade deficit would then be reflected in the government's budget deficit. This follows the familiar identity

$$Y = C + I + G + X - M \qquad (7.9)$$

where Y, C, I, G, X and M stand for national income, private consumption, private investment, government expenditure, exports and imports, respectively.

[6] For example, in a boom, if the government is committed to a fixed nominal exchange rate, it may then attempt to sterilise the inflow of foreign exchange reserves out of concern about the inflationary consequences. The central bank acts to suppress the real appreciation and to protect the tradeable sector by not letting the nominal exchange rate appreciate. This is the so called "exchange rate protection" policy (Corden, 1981). In our discussion following, policy implications in a reverse situation are considered.

As national income minus private consumption and government tax (Y-C-T) is defined as private savings (S), the above equation can be re-arranged as

$$(T - G) + (S - I) = X - M \qquad (7.10)$$

where T and S stand for government tax and private savings, respectively. For the time being, assuming the gap between private saving and private investment (S - I) is constant,[7] then the trade deficit will cause a fiscal deficit, a twin deficit, emerge.[8] If the Chinese government chooses not to reduce expenditures, but to finance the budget deficit through borrowing, then there are three options: (i) to sell government bonds; (ii) to borrow from the central bank; and (iii) to borrow overseas.

Option (*i*)

The choice of borrowing from the public by selling government bonds would have no effect on money supply, as the excess government spending over income is offset by the withdrawal of money from the banking system when the public purchase the government bonds. The net outcome on money supply is zero. This approach, however, can not be used by the Chinese government due to the lack of a bond market in China.

Option (*ii*)

The only way to finance the budget deficit domestically is to monetise the budget deficit through the central bank, that is, the Ministry of Finance borrows from the People's Bank of China. In a central bank system, the spending

[7]Changes of the gap between private saving and private investment are considered later in relation to change in the investment behaviour of oil industry enterprises after the oil price shock.

[8]Another linkage between the trade deficit and fiscal deficit is the widely discussed "Twin deficit hypothesis", which looks at the relation of the two deficits from another perspective, and argues that a fall in the government budget deficit is a necessary and sufficient condition for the current account deficit to decrease. For a detailed discussion of the "Twin deficit hypothesis", see Nguyen (1990).

of the government borrowing will increase the reserves of commercial banks,[9] as government agencies will make deposits in commercial banks when the government starts to spend the borrowed money. The increase of domestic reserves will enlarge the base money, and money supply will increase.

Option *(iii)*

Another option for the government to finance the budget deficit is to borrow overseas. In this case, the government sells bonds in the international capital market, and in turn buys domestic currency from the central bank with foreign money. The same process of domestic reserves growth starts, as in the previous case, and money supply will increase.

However, the total effect on money supply also depends on how the other deficit (trade deficit) is covered. Money supply is determined by base money times the money multiplier. Base money consists of three parts

$$B = C + R_d + R_f \tag{7.11}$$

where B stands for base money, C for currency in circulation, R_d for domestic reserves, R_f for foreign reserves. While the financing of the budget deficit by either domestic monetisation or overseas borrowing increases domestic reserves (R_d), the effect of trade deficit on foreign reserves (R_f) may go in the other direction. Under a fixed exchange rate, the central bank can only cover the trade deficit by running down foreign exchange reserves. In the Chinese case, the Ministry of Foreign Trade withdraws money through the State Administration of Exchange Control (an agency of the People's Bank of China), as a consequence, R_f decreases, which will offset the increase in R_d in the fiscal

[9] China's central bank system was established in 1984. The peoples Bank of China, the central bank, controls the money and credit growth by requiring all other specialised banks to hold reserves with it. These specialised banks in China include: Industrial and Commercial Bank of China, Agricultural Bank of China, Construction Bank of China, Bank of China, Bank of Communications, People's Insurance Company of China, Industrial Bank of China International Trust and Investment Corporation, and Investment Bank of China (a counterpart institution of the World Bank).

deficit case, and the final outcome of the overall effect on money supply will be zero.

However, the increase of R_d will not be offset under a free exchange rate system, as R_f can be isolated in the base money equation by the floating of exchange rate. In a terms of trade shock such as the 1986 oil price decline, a free exchange rate will depreciate to the extent that the current account is re-balanced. The foreign exchange reserves R_f will remain constant. Any government borrowing used to finance the fiscal deficit will then increase money supply.

The effects of fiscal deficit finance on money supply are summarised in Table 7.4. $\bar{M}$ stands for an unchanged money supply, $M \downarrow$ and $M \uparrow$ represent a decrease and an increase in money supply, respectively. If option (i) (government borrows from the public) is not considered due to the lack of bond market in China, then Table 7.4 gives a clear picture that in the absence of any active monetary policy reaction, the financing of the fiscal deficit will lead to an increase in the money supply if the exchange rate depreciates, or no change in money supply if the exchange rate is fixed.

Table 7.4: Effects of Fiscal Deficit Finance on Money Supply

	Option (i)	Option (ii)	Option (iii)
Fixed exchange rate	$M \downarrow$	$\bar{M}$	$\bar{M}$
Flexible exchange rate	$\bar{M}$	$M \uparrow$	$M \uparrow$

(2) Excess spending of oil enterprises

As pointed out earlier, the loss of oil export revenues in the oil price shock fell on both government and oil industrial enterprises. Under a foreign exchange retention scheme, the trade deficit $(X - M)$ in equation 7.10 is borne partly by the government and partly by oil enterprises according to the retention ratio. In the above discussion, the trade deficit (X - M) is assumed to be transmitted fully into the government budget deficit (T - G). For simplicity, we continue to use the one to one approach in the following discussion, and assume the trade deficit only affects the private sectors saving and investment gap (S - I).

Like the government in the previous case, if autonomous enterprises do not cut their expenditures after the oil price shock, then the excess investment over saving can only be financed either through credit creation or direct borrowing abroad. It should be pointed out that the oil export revenues retained in oil enterprises are largely used for importing equipment and machinery. The borrowing of foreign exchange to make up the shortfall in foreign exchange retention on imports will have no effect on domestic money supply. However, concerns arise with domestic credit creation and overseas borrowing spent domestically.

The effect on money supply is obvious for credit creation. Credit creation will not take place unless two things happen: excess reserves exist (ΔR) or the required reserve ratio is lowered ($r \downarrow$). In the first case, which is unlikely in the Chinese situation, money supply will increase by the amount of excess reserves used times the money multiplier. In the second case, a lower reserve ratio will result in a higher value of its reciprocal, which is the money multiplier, and money supply will increase through a multiplier effect.

If enterprises borrow overseas, and convert those funds into domestic currency through the central bank or the foreign exchange centres, then it is similar to the case of the government borrowing overseas, the same process of a domestic reserve increase will occur, leading to a money supply increase.

Again, under a fixed exchange rate, these money supply increases will be offset when the central bank covers the trade deficit by running down foreign reserves. But it is less clear how these effects will cancel out one another in regard to leakages of money for imports, and in the lower reserve ratio case, the net outcome of the money increase due to the multiplier effect and the money decrease due to foreign exchange rundown depends on the ratio of money stock to GDP and the size of the change in the money multiplier. Nevertheless, money supply will remain largely the same under a fixed exchange rate. But a flexible exchange rate will not offset the effects of enterprises' excess spending, and money supply will increase. These effects are summarised in Table 7.5 below.

Table 7.5: Effects of Enterprises' Excess Spending on Money Supply

	Credit creation ($r \downarrow$ or ΔR)	Overseas borrowing
Fixed exchange rate	$\bar{M}$	$\bar{M}$
Flexible exchange rate	$M \uparrow$	$M \uparrow$

Comparing the results in Table 7.5 with those in the second and third column in Table 7.4, we find that the monetary effects of excess spending by enterprises are consistent with the case of a budget deficit. So a fixed real absorption after the oil price shock leads to either an increase or no change in money supply depending on the exchange rate regime. Given the fact that money supply is exogenous in the model, an interesting experiment is to cut money supply, so the monetary response is compatible to the exchange rate depreciation policy adopted in the two instrument, two target package, and also to offset the inflationary pressure in the one instrument, one target policy package.

The economy wide effects of a tighter money supply are reported in column 4 of Table 7.1. For a 1% cut in money supply, the changes in both price level and real variables (real balance and output etc.) are considerable. Changes in real variables imply that money is not neutral in the model. This non-neutrality of money is explained by the rigidity of the fixed official exchange rate in the model. Given the overvaluation of the official exchange rate, a cut in nominal money supply does not decrease the exchange rate equiproportionally, and hence changes the relative prices of exports and other goods. The response of the market exchange rate in this experiment shows an unusual appreciation of -1.63%. The fall in the market exchange rate is due to two reasons: the fall in all absorption prices of -1% following the cut in money supply and the reduction in the extent of overvaluation of the official exchange rate. The decrease of the general price level reduces the adverse consequences of overvaluation by increasing the price of export goods received by domestic enterprises relative to prices of domestic goods, and so mitigates the export-inhibiting effects of the official exchange rate, and the export volume increases by 1.34%. The import volume also increases by 0.9% due to the 0.63% appreciation of market exchange rate which decreases the price of imports. The order of magnitude in the expansion of both export and import value is similar to those in volume terms, and the balance of trade increases by 0.03%. The improvement in the trade balance is reflected in nominal GDP which rises relative to the absorption price index so there is a slight increase in real GDP of 0.08%. The fall in wage rate of -0.85% is related to the sectoral output results where a large number of both tradable and non-tradable sectors show signs of negative growth, and therefore decrease the employment in the economy following the adoption of contractionary monetary policy.

7.6 Robustness of the Model Results

As one of the few CGE applications to China (OECD, 1991; Industry Commission, 1991), it is natural to ask how robust the results are in the model. Two areas of model test are identified. The first is the symmetrical property of the model in analysing trade flows. The model has been used to analyse the reactions of the Chinese economy to a "declining sector". It is useful to determine how the model behaves with respect to a "booming sector". The symmetry of such two applications will test the flexibility of the applied general equilibrium model in elaborating the theoretical framework of the "booming sector model". The second test is sensitivity analysis to assess the validity of parameterisation in the model. The model used in this study embodies specific parameter values obtained from econometric studies of China and also other countries where Chinese studies were not available. The question naturally arises as to how sensitive the results are to changes of the parameter values. These two tests are discussed in turn.

7.6.1 Symmetrical test

Given the basis of the study is the analysis of the impacts of world oil price changes on China, an interesting experiment is to shock the model with a rise in world oil price as well as a shock of world oil price fall, with both shocks at the same magnitude. This is to simply reverse the sign of the shock performed in the base run of the model.

This test shock is, however, meaningless if the model is solved linearly by using Johansen style computation. As any pairwise linear solutions of a CGE model with the same size of shock but different signs will be perfectly symmetrical. This can be easily demonstrated by the simple example used in chapter 6. Consider the equation

$$P \times Q = V \tag{7.12}$$

where P, Q and V are price, quantity and value, respectively, all in levels. The linearised form of equation (7.12) is

$$p + q = v \tag{7.13}$$

where p, q and v are the percentage changes in P, Q and V , respectively. Now consider both a 10% increase and a 10% decrease in P and Q, the changes in equation (7.13) are

$$10\% + 10\% = 20\% \tag{7.14}$$

for 10% increase in P and Q, and

$$(-10\%) + (-10\%) = -20\% \tag{7.15}$$

for 10% decrease in P and Q.

Clearly, the results are perfectly symmetrical between equations (7.14) and (7.15). This is verified by solving the China CGE model twice linearly, with ±60% changes in oil export prices. The results are shown in column 1 and 2 in Table 7.6.

The symmetrical test proposed is only of interest when the linearisation errors are removed, that is, when the model is solved non-linearly. Consider equation (7.12), assume the base levels for P and Q are all 10, equation (7.12) becomes

$$10 \times 10 = 100 \tag{7.16}$$

A 10% increase and a 10% decrease in both P and Q will see the changes in equation (7.16) as

$$10(1 + 10\%) \times 1(1 + 10\%) = 121 \tag{7.17}$$

for 10% increase in P and Q, and

$$10(1 - 10\%) \times 10(1 - 10\%) = 81 \tag{7.18}$$

for 10% decrease in P and Q.

Compared to the base level value for V of 100 in equation (7.16), equations (7.17) and (7.18) show the changes in V are +21% and -19%, respectively, in response to ±10% changes in P and Q. This makes the symmetrical comparison more convincing as linearisation errors are removed.

The non-linear results of the model with respect to ±60% changes in oil export prices are presented in column 3 and 4 in Table 7.6. Notice column 4 in the table is reproduced from column 1 in Table 7.1 which has been discussed in earlier sections. The analysis here is focused on column 3.

Table 7.6: Results of Symmetrical Test of the Model (in Percentages)

	Linear Results		Non-Linear Results	
	+60% in Oil Price	-60% in Oil Price	+60% in Oil Price	-60% in Oil Price
MACROECONOMIC IMPACTS				
Market Exchange Rate	3.07	-3.07	-2.82	3.21
Export Volume	-3.51	3.51	3.30	-3.59
Import Volume	-2.60	2.60	2.48	-2.64
Export Value (US$)	-6.54	6.54	6.68	-5.94
Import Value (US$)	-2.63	2.63	2.50	-2.67
Balance of Trade (US$)	-0.46	0.46	0.46	-0.38
Real GDP	-0.98	0.98	0.94	-0.94
Absorption Deflator	0.00	0.00	0.00	0.00
Wage Rate	1.98	-1.98	-1.90	1.98
SECTORAL OUTPUT EFFECTS				
Energy Sectors				
Crude Oil	-0.32	0.32	0.24	-0.42
Coal	-4.90	4.90	4.30	-5.50
Electricity	-1.15	1.15	1.07	-1.23
Petroleum Products	0.41	-0.41	-0.72	0.28
Tradable Sectors				
Crops	0.06	-0.06	-0.05	0.07
Cotton	0.15	-0.15	-0.14	0.16
Metals	0.72	-0.72	-0.69	0.72
Chemicals	0.23	-0.23	-0.22	0.23
Machinery	0.56	-0.56	-0.53	0.58
Food Processing	0.27	-0.27	-0.25	0.29
Textiles	0.26	-0.26	-0.24	0.28
Misc. Manufacturing	0.56	-0.56	-0.52	0.59
Non-Tradable Sectors				
Construction	-0.05	0.05	0.04	-0.07
Freight Transport	0.41	-0.41	-0.40	0.42
Passenger Transport	0.04	-0.04	-0.05	0.04
Education and Health	0.00	0.00	0.00	0.00
Housing	-0.01	0.01	0.01	-0.01
ENERGY FLOWS				
Energy Exports				
Crude Oil	49.52	-49.52	42.58	-69.80
Petroleum Products	-37.31	37.31	-30.81	50.47
Coal	-19.45	19.45	-18.10	26.01
Domestic Energy Supply				
Crude Oil	-4.71	4.71	-4.10	6.69
Petroleum Products	1.04	-1.04	0.51	-1.77
Coal	4.85	-4.85	4.71	-6.08
Electricity	1.01	-1.01	1.72	-1.23

Given the apparent symmetry in the signs between column 3 and column 4, the results of the 60% oil price increase in column 3 can be interpreted with ease in the light of the booming sector theory. The rise in oil export price is clearly reflected in the 6.68% increase of export value measured in foreign currency. This leads to an increase of foreign exchange supply in the market. As a result, the secondary exchange rate appreciates 2.82% to clear the market. The implications of the market exchange rate appreciation is significant as it reduces the domestic prices of foreign goods which leads to an increase in imports of about 2.5% in both volume and value terms. More importantly, the appreciation of the market exchange rate decreases the general level of foreign prices measured in domestic currency, and thus the price of tradables to non-tradables, resulting in a real appreciation. This is precisely what the "booming sector" theory would predict, that a real appreciation is necessary in response to both the spending effect initiated by the oil export windfalls and the resource movement effect caused by the improved marginal productivity in the oil sector following the oil price rise. Consequently, the price of non-tradables increases relative to the price of tradables to restore equilibrium in the goods market.

As implied by the term "Dutch disease" in the booming sector theory, the sectoral output results show that non-oil tradable sectors decline following the oil export boom. Through the input-output linkages in the model, the "de-industrialisation" of the non-oil tradable sectors causes transport sectors also to decline, while other non-tradable sectors show growth. Energy sectors expand as resources are attracted to the booming sector as explained by the resource movement effect. The 0.72% contraction of the petroleum product sector suggests that oil production is shifted towards the export market. This is shown in the energy flow results where crude oil exports increase by 42.58%, but domestic oil supply is reduced by -4.1%.

Overall, the results in column 3 of Table 7.6 show that the model behaves properly in a "booming sector" experiment as in a "declining sector" experiment. The test establishes desirable symmetry between export and import trade flows in the model under different external shocks. This property of the model is directly related to the symmetrical treatment of exports and imports in the structure of the model as discussed in chapter 6 (See section 6.2.2, p. 176). The analysis in this section verifies the trade structure specified in the model.

7.6.2 Sensitivity analysis

Applied general equilibrium model commentators have often seemed obsessed with questions of how believable the results are and under what conditions. The intellectual origins of these issues are, however, deeply rooted in the econometric basis of CGE models where specific parameter values are used. Sensitivity analysis is usually conducted to assess the validity of these parameter values. It is important to point out that sensitivity analysis is not to find out the correct values for parameters to justify "believable" results, since economists normally leave these issues to econometricians. Sensitivity analysis is used to test the assumptions used in the model. Changes of key parameter values essentially change the assumptions used in the model. By changing the elasticity for input substitution, for example, from zero to unity or above one, the production structure changes from Leontief to Cobb-Douglas or CES specifications.

Complete, unconditional systematic sensitivity analysis is extremely costly, requiring m^n model solutions, where m is the number of different levels at which n parameters of interest are to be examined (Hertal, *et al.,* 1991). It is therefore more common to vary one parameter at a time to carry out conditional systematic sensitivity analysis.[10] Given the focus of the study, the emphasis of the sensitivity analysis is four sets of key parameters relevant to energy trade flows, namely, the elasticity of substitution between energy inputs (σE), elasticities of production transformation between domestic and export markets

[10]As pointed out by Hertal *et al.* (1991) that "even this more modest approach is costly and is thus often reserved for special applications of well-established models".

(σT), elasticities of substitution between domestic and imported goods (σM), and elasticities between exports from China and exports from the rest of the world (σW).

Following Pagan and Shanon (1984), the method used is to compute "sensitivity elasticities" to measure the percentage changes in model results for a 1% change in the parameter to be tested. For models consisted of linearised equations, the minimum magnitude of change in the parameters to be tested is ±33% (Rodriguez, *et al.,* 1991). Model results are considered sensitive if the absolute value of the sensitivity elasticity is greater than one. In the present analysis, a deviation of -50% is used for the four parameters. Given the benchmark values of σE, σT, σM and σW are 1.2, 5, 2 and 10, respectively (See Appendix A), a set of new values of 0.6, 2.5, 1 and 5 are used for the four parameters.

To test the overall sensitivity of the model results, all experiments reported in Table 7.1 were repeated, with the value of only one parameter reduced, *in turn,* by 50% while the other parameters were held at their benchmark values. This gives a total of $m \times n$ simulations where m is the parameters tested, n is the experiments repeated. The results of the $m \times n$ simulations were then used to compute the sensitivity elasticities using the standard results reported in Table 7.1 as the basis.

Given the large output of sensitivity test runs, it is sensible to concentrate on two areas of the sensitivity test results.

First, all the sensitivity test results related to the base run experiment. The sensitivity elasticities of the base run results under alternative assumptions of the key parameters are presented in Table 7.7. Clearly, all sensitivity elasticities, with two exceptions, are less than one in absolute terms, indicating that the base run results reported in the first column of Table 7.1 change by less than 1% for a 1% change in the four key parameters listed across the table. This suggests that the base run results are relatively robust around the current

Table 7.7: **Sensitivity Elasticities of Base Run Results**

	Elasticity of Substitution between Energy Inputs (1.2 reduced to 0.6)	Elasticity of Transformation between Domestic and Export goods (5 reduced to 2.5)	Elasticity of Substitution between Domestic and Imported Goods (2 reduced to1)	Elasticity of Substitution between Chinese Exports and ROW Exports (10 reduced to 5)
MACROECONOMIC IMPACTS				
Market Exchange Rate	0.04	0.23	-0.51	0.44
Export Volume	0.16	0.30	0.51	0.46
Import Volume	0.18	0.28	0.47	0.45
Export Value (US$)	0.01	0.02	0.27	0.40
Import Value (US$)	0.18	0.28	0.47	0.45
Balance of Trade (US$)	-0.13	-0.20	0.10	0.36
Real GDP	-0.46	0.19	-0.10	0.45
Price Deflator for GDP	-0.46	0.19	-0.10	0.45
Wage Rate	-0.24	0.12	0.08	0.37
SECTORAL OUTPUT EFFECTS				
Energy Sectors:				
Crude Oil	-0.68	0.25	0.00	0.55
Coal	-0.69	0.35	0.01	0.42
Electricity	0.66	0.10	-0.03	0.40
Petroleum Products	0.83	-0.06	-0.04	0.31
Tradable Sectors				
Crops	1.16	-0.02	-0.27	0.35
Cotton	0.54	-0.06	0.09	0.28
Metals	0.14	0.15	0.14	0.40
Chemicals	0.12	0.10	-0.01	0.37
Machinery	0.24	0.12	0.28	0.39
Food Processing	0.60	0.18	0.20	0.43
Textiles	0.41	0.01	0.26	0.31
Misc. Manufacturing	0.31	0.14	-0.18	0.44
Non-Tradable Sectors				
Construction	0.93	-0.01	-0.02	0.35
Freight Transport	0.58	0.36	-0.35	0.53
Passenger Transport	0.01	0.13	0.33	0.36
Education and Health	-0.09	-0.06	0.37	0.26
Housing	-0.38	0.00	0.42	0.28
ENERGY FLOWS				
Energy Exports				
Crude Oil	0.35	0.40	0.01	0.58
Petroleum Products	0.33	0.89	-0.10	0.83
Coal	0.73	1.10	-0.14	0.85
Energy Imports				
Crude Oil	-0.42	0.20	0.89	0.37
Petroleum Products	0.23	0.06	0.78	0.33
Coal	0.52	0.12	0.61	0.37
Domestic Energy Supply				
Crude Oil	0.43	0.42	0.01	0.60
Petroleum Products	0.49	0.98	-0.11	0.90
Coal	0.66	0.18	-0.04	0.43
Electricity	0.83	-0.06	-0.04	0.31

Table 7.8: Further Test of Energy Flow Sensitivities in Other Experiments

	Energy Exports			Energy Imports		
	Crude Oil	Petroleum Products	Coal	Crude Oil	Petroleum Products	Coal
Real Absorption Experiment						
Sigma T: 5 reduced to 2.5	-0.30	-0.18	0.42	-0.15	-0.16	-0.16
Sigma W: 10 reduced to 5	-0.33	-0.30	0.35	-0.09	-0.10	-0.10
Devaluation Experiment						
Sigma E: 1.2 reduced to 0.6	0.53	0.07	-0.17	-0.08	-0.01	0.11
Sigma T: 5 reduced to 2.5	0.09	0.40	0.49	0.39	0.43	0.45
Sigma M: 2 reduced to 1	0.58	0.64	0.59	0.78	0.71	0.65
Sigma W: 10 reduced to 5	-0.02	0.19	0.28	0.23	0.26	0.27
Money Supply Experiment						
Sigma E: 1.2 reduced to 0.6	0.53	0.07	-0.17	-0.08	-0.01	0.10
Sigma T: 5 reduced to 2.5	0.09	0.39	0.48	0.39	0.42	0.44
Sigma M: 2 reduced to 1	0.58	0.64	0.59	0.77	0.71	0.65
Sigma W: 10 reduced to 5	-0.02	0.19	0.28	0.22	0.25	0.27

values of the four tested parameters. Applying the analysis to the macroeconomic and sectoral output results in other experiments reported in Table 7.1 reveals the same sensitivity test results.

Second, sensitivity elasticities are also calculated in Table 7.7 for energy trade flow results which are reported in Table 7.6 in the symmetrical test. The same positive conclusion can be drawn for this set of results based on their less than unity sensitivity elasticities. Further sensitivity tests on energy export and import results in other experiments are reported in Table 7.8. These sensitivity tests focus on the behaviour of energy trade in the model although they were not explicitly reported before. The sensitivity elasticities in Table 7.8 for energy trade across all experiments are consistently below one in absolute terms.

Having considered the sensitivity elasticities in absolute terms, it is also useful to understand the signs attached to the sensitivity elasticities which require careful interpretation. For example, consider the sensitivity elasticity of +0.04 in Table 7.7 for the market exchange rate (row 1) with respect to energy substitution elasticity (column 1). A 1% reduction in the energy substitution elasticity leads to a 0.04% increase in market exchange rate relative to the base run result. The mechanism behind this change is that the lower the energy substitution elasticity, the less will be the potential in the energy sector to substitute oil for other energy; this imposes a cost constraint on the economy compared to the base run where more oil at the new lower price can be absorbed domestically to increase productivity and export competitiveness. Therefore lower energy substitution is likely to lead to lower foreign exchange supply compared to a higher energy substitution situation, resulting in increase of the market premium for foreign exchange.

Finally, notice the two exceptions of 1.16 and 1.10 in Table 7.7 for crops output and coal export with respect to the energy substitution elasticity and production transformation elasticity, respectively. For a sensitivity elasticity greater than unity, the results are considered sensitive. But it is useful to detect the relationship between the parameter value and the sensitivity elasticity. If the relationship is linear, it will enable us to simply scale the results for a given parameter value according to the slope of the linear function. However, if the relationship is non-linear, then the determination of the existence of a parameter value range within which the sensitivity elasticity is less than one will be useful in interpreting the results. While all these tests can be performed by trial experiments as discussed in Peng (1992), the two above-unity sensitivity elasticities are, given the focus of the study, considered to be insignificant for the overall robustness of the model results.

7.7 Conclusions

This chapter aims to explore policy options for adjustment to oil price shocks in the Chinese economy. The theoretical framework adopted is that of the booming sector model which is applied to the fall of China's oil export price in 1986 following the collapse of the world oil market. Both the real and monetary effects of this oil price shock are significant and unfavourable for China. The question asked is what policy responses best facilitate the structural adjustment. By using a CGE model, three macroeconomic policy experiments are simulated.

The One-target, One-instrument policy package is designed to achieve a balanced trade account by shifting resources to tradable sectors through a cut in real absorption which lowers the relative price of non-traded goods to traded goods. While this policy is effective in restoring equilibrium in the external sector after the oil price shock, the cut of real absorption causes an increase in the price level because money is assumed to be demanded to finance spending on real absorption. As a result, the absolute price level in the economy is pushed up, and a large depreciation of market exchange rate is required to facilitate relative price changes.

The large depreciation of market exchange rate in responding to the above policy package increases the distortion in China's dual foreign exchange rate system where the official exchange rate is fixed. This distortion is reduced in the two-target, two-instrument package in which, together with real absorption manipulation, the official exchange rate is devalued to not widen the discrepancy between the market and official exchange rates. The beneficial effects of this policy package are obvious as the real GDP is improved and the balance of trade is maintained at the benchmark level while allowing more imports which are important for China to gain more access to foreign capital and technology. The reduction of exchange rate distortion improves the price structure in the economy and brings about relative price changes in facilitating structural adjustment.

The fiscal and monetary accommodation to oil price shocks is another important policy response. Given the unfavourable nature of the 1986 oil price shock considered in this study, a decrease in money supply is simulated in the model to capture effects of tightening fiscal and monetary policies in the Chinese economy. The decrease of the price level following the cut in the money supply mitigates the export-inhibiting effect of the over-valued official exchange rate, the major positive impact on real variables in this experiment is the increase in export volume and the improvement in real balance. The contractionary effect of this policy is reflected in decrease of employment in both tradable and non-tradable sectors.

The model results are tested in both a symmetrical test and a sensitivity analysis. The findings from the tests establish desirable symmetry between the model's responses to a "booming sector" experiment versus a "declining sector" experiment, and also show that the overall results of the model are robust around the current values of the key parameters specified in the model.

Chapter 8

Conclusions

This thesis has analysed the structural adjustment of the post-reform Chinese economy following the 1986 oil price shock. It has approached this important topic on the development of the Chinese economy in the mid-1980s applying both theoretical and empirical analyses. This chapter will summarise the main conclusions of the study and link the findings of different chapters.

8.1 Summary of the Study

The 1986 oil price shock arrived at a critical time when the Chinese economy was facing severe domestic economic difficulties. Toward the mid-1980s, the economic reforms in China caused a series of adverse effects, notably a "structural contradiction" and "economic overheating". The structural contradiction is characterised by the shrinking of up-stream industries, such as the energy and raw materials industries, and the over-expansion of the down-stream industries which in turn put more pressure on the up-stream industries. Accommodated by the lack of an appropriate institutional set-up for macroeconomic management, the structural contradiction, together with other factors, led to excess demand which found an outlet in inflation.

Against this background of economic reforms in China, the effects of the 1986 oil price shock are analysed following the approach of "booming sector" model where one sector initiates a chain of reactions in the economy. In the case of an oil price fall, the energy sector prompts the intersectoral reactions. Chapter 2, looking at the Chinese energy sector in a comparative perspective, presents the linkages of the energy sector with the rest of the economy. The analysis suggests that the distortions of energy prices in China caused energy shortages. The low energy prices and irrational energy price relativities reduce the incentive in energy production and lead to inefficiency in energy consumption. Moreover, the low domestic energy prices give rise to the government's rent-seeking policy which forces the export of substantial amount of energy in order to earn foreign exchanges. Oil became China's no.1 export commodity towards the mid-1980s. In 1985, oil exports accounted for 25% of China's total export revenues.

Given China's heavy reliance on oil exports, the collapse of world oil market was a major unfavourable shock to the Chinese economy. To gain an understanding of the effects of the 1986 oil price fall, chapter 3 applies the booming sector theory to an opposite situation in which a "declining sector" initiates repercussions in the economy. The analysis goes beyond the real effects, and takes monetary effects into considerations. More importantly, the market economy model is extended to a quantity-constrained model where controlled variables, such as exchange rate and money supply, are introduced, and the simple concept of real exchange rate is no longer appropriate. The results of the theoretical analysis show that the quantity constraints significantly alter the outcome of a standard theoretical model, and compatible changes in the controlled variables are required in the adjustment to external shocks.

Chapter 4 explores some aspects of the resource allocation mechanisms in the post-reform Chinese economy. The analysis covers both the qualitative impact of market-oriented reforms on economic agents and the quantitative significance of the markets. Strong evidence is presented to show the large shares of market allocation in both total consumer and producer goods transactions and labour allocations in the economy. The focus of the chapter is the two-tier price system which is one of the most important innovations of the Chinese economic reforms. The analysis shows that the second tier price has important implications for efficiency in a mixed plan and market system. The imposition of the plan in a competitive market does not change the equilibrium price, and only the second tier market prices are relevant in allocating resources at the margin. This is an important result which establishes the foundation for using a general equilibrium approach for the Chinese economy. While caution should be used regarding market imperfections, given the remaining role of plan and other factors such as labour managed firm characteristics under the profit retention scheme, differences in the objectives between enterprises and government and between producers and consumers etc., the analysis in chapter 4 concludes that it is relevant to take a general equilibrium approach to modelling the post-reform Chinese economy.

The emphasis of the study is shifted from theoretical discussion to a case study application in chapter 5. The question is how the 1986 oil price shock worked through the Chinese economic system. The chapter finds that the institutional arrangements transmitted the oil price shock mainly through a spending effect. A number of factors forced the government to protect the oil industry which became an "enclave", and the resource movement effect was minimised. Under the profit sharing scheme, the direct impact of oil export losses is absorbed through two channels. One is the decrease of oil industry's investment funds, and the other is the reduction of government revenues. While the former reinforces the structural contradiction, the latter is likely to intensify inflation in the presence of fiscal deficit. The analysis shows that the adjustment was made difficult by inconsistent government interventions. In an attempt to sterilise the oil price shock effect, the Chinese government offset the spending effect through a large fiscal deficit. But other policy actions were not compatible. The central government failed to tighten money supply, due to the intervention of local governments in the decentralised banking system and to low interest rates. While the depreciation of the official exchange ra te was in the right direction, the magnitude of devaluation was not sufficient.

A computable general equilibrium model is developed in Chapter 6. The model is ORANI-type, using a World Bank input-output table for China as the data base. Following the results of chapter 4, an important adjustment was made in the World Bank input-output table to incorporate market prices. The construction of the data base forms an important part of the empirical work in this study. This includes the collection of market pr ices during field work in China. The model built on this data base is specially adapted to include more detail on energy linkages and to reflect the booming sector phenomena considered in the study. Alternative specification of the balance of trade is use d to abstract the effect of foreign exchange rate distortions on the trade account. Given the large magnitude of oil price change which needs to be imposed exogenously to the model, a multi-step solution is implemented in the model to remove linearisation errors.

The model is used to explore policy options in the macroeconomic adjustment of the Chinese economy to the 1986 oil price shock. The results of the simulations show that a number of policy instruments could be used to facilitate the structural adjustment of the economy. An appropriate combination of real absorption manipulation, exchange rate depreciation and a cut in money supply are the preferred policy responses. Generally, the more instruments are used, the better policy outcomes are expecte d, provided they are compatible, as pointed out in the theoretical discussion of the quantity-constrained model.

8.2 Central Conclusion and Policy Implications

The central conclusion of this study is that the effects of the the 1986 oil price shock on the Chinese economy were largely determined by the special institutional factors introduced in the economic reforms, and the adjustment to the shock was actually made more difficult by inconsistent government interventions. The analyses of both theor etical and empirical models suggest that better policy options could be used to facilitate the structural adjustment.

In contrast to the policies adopted by the Chinese government after the 1986 oil price fall, namely, government spending expansion, uncontrolled money and credit growth, and insufficient devaluation, three policies responses are experimented in the CGE model. The first policy, called a one-target, one-instrument package, is designed to achieve a balanced trade account by shifting resource s to tradable sectors through a cut in real absorption. This policy will lower the relative price of non-traded goods to traded goods, and so bring about a real depreciation which is consistent with the conventional adjustment theory. Given the excess dem and in the mid-1980 Chinese economy, a reduction in real absorption will also help to reduce aggregate demand. This is in sharp contrast with the fiscal deficit policy adopted by the Chinese government. While the Chinese government's increased spending in the oil industry was a forced protection, an increase in government spending on non-traded goods will intensify inflation.

The second policy package brings one more instrument into play, namely depreciation of the official exchange rate. The Chinese government devalued the domestic currency (Rmb) by 13.6% in 1986. As pointed out in Chapter 5, this magnitude was not sufficient to establish an equilibrium real exchange rate as the official exchange rate of 3.72 Rmb Yuan per US dollar. after the devaluati on remained over-valued compared to the market exchange rate of 5 Rmb Yuan per US dollar or higher. The significance of the official exchange rate depreciation is demonstrated in the two-target, two-instrument package where the case of not widening the di screpancy between the official and market exchange rates is simulated. The beneficial effects of official exchange rate depreciation is reflected in improved price structure following the reduced distortion in the exchange rate market, which facilitates s tructural adjustment. It would be interesting to see the improvements in simulation results if the dual exchange rate is replaced by a single rate through further depreciation of the official exchange rate.

The third policy response experiment carried out was a cut in money supply. This follows the results of the quantity-constrained model in chapter 3. This again contrasts with the uncontrolled money and credit increase after the 1986 oil price shock. Given the remaining over-valuation of official excha nge rate, the cut in the money supply decreases the price level which will mitigate the export-inhibiting effect of the over-valued exchange rate, and so improve the balance of trade.

Appendix A

HEADER ARRAY FILES OF THE CHINA CGE MODEL

```
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XXCR1CFULL
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CREATION INFORMATION
     2
<MODHAR   Version 3.2       July 1987>
<GEMPACK  Release 4.1.01(ABSOFT2.4)   June 1987>
SIGe2RFULL
     2     1     1
Elasticity of substitution for energy
     1     1
  0.120000000000E+01
BETA2RFULL
     2    27     1
Elasticity of global excess demand for good i
    27     1
 -0.200000000000E+01 -0.200000000000E+01 -0.200000000000E+01 -0.200000000000E+01
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 -0.200000000000E+01 -0.200000000000E+01 -0.200000000000E+01
DEMA2RFULL
     2    27     8
Demands for good i
    27     8
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  0.000000000000E+00  0.350000000000E+00  0.404000000000E+01  0.800000000000E-01
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  0.000000000000E+00  0.240000000000E+01  0.000000000000E+00  0.000000000000E+00
  0.000000000000E+00  0.000000000000E+00  0.312000000000E+01  0.350000000000E+00
  0.350000000000E+01  0.300000010000E+00  0.300000010000E+00  0.630000000000E+00
  0.374000000000E+01  0.760000000000E+00  0.121000000000E+01  0.182000000000E+01
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 0.800000010000E+00 0.565000000000E+01 0.000000000000E+00 0.000000000000E+00
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EM 2RFULL
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elasticity of supply of imports to China
   27     1
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ES 2RFULL
    2    27     2
Share of China and ROW in exports of i to ROW
   27     2
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Income elasticity of demand
27 1
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eta 2RFULL
2 27 27
Price elasticity of demand
27 27
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0.000000000000E+00	-0.670000000000E-03	-0.820000010000E-03	-0.630000020000E-03
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3 27
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0.700000000000E+00	0.590000000000E+00	0.109000000000E+01	0.196000000000E+01
0.320000000000E+00	0.290000000000E+01	0.200000000000E+00	0.000000000000E+00
0.000000000000E+00	0.000000000000E+00	0.000000000000E+00	0.000000000000E+00
0.000000000000E+00	0.000000000000E+00	0.000000000000E+00	0.500000000000E-01
0.000000000000E+00	0.000000000000E+00	0.160000000000E+00	0.200000000000E-01
0.000000000000E+00	0.100000000000E-01	0.000000000000E+00	0.000000000000E+00
0.000000000000E+00	0.100000000000E-01	0.000000000000E+00	0.200000000000E-01
0.700000000000E-01	0.000000000000E+00	0.140000000000E+00	0.000000000000E+00
0.200000000000E-01	0.000000000000E+00	0.300000000000E-01	0.000000000000E+00
0.000000000000E+00	0.200000000000E-01	0.000000000000E+00	0.100000000000E-01
0.100000000000E-01	0.390400000000E+02	0.140000000000E+01	0.780000000000E+00
0.640000000000E+00	0.246000000000E+01	0.520000000000E+01	0.000000000000E+00
0.412200010000E+02	0.450000000000E+00	0.600000020000E+00	0.560000000000E+00
0.100000000000E+01	0.770000000000E+00	0.550000010000E+00	0.850000020000E+00
0.218000000000E+01	0.466000000000E+01	0.520000000000E+00	0.352000000000E+01
0.340000000000E+00	0.000000000000E+00	0.000000000000E+00	0.000000000000E+00
0.270000000000E+01	0.000000000000E+00	0.000000000000E+00	0.000000000000E+00
0.640000000000E+00	0.710000000000E+00	0.249000000000E+01	0.280000000000E+00
0.480000000000E+00	0.100000000000E+01	0.000000000000E+00	0.112000000000E+01
0.227000000000E+01	0.600000020000E+00	0.140000000000E+00	0.800000010000E+00
0.350000000000E+00	0.440000000000E+00	0.260000000000E+00	0.870000000000E+00
0.122000000000E+01	0.600000000000E-01	0.206000000000E+01	0.400000000000E-01
0.000000000000E+00	0.000000000000E+00	0.000000000000E+00	0.450000000000E+01

0.000000000000E+00	0.000000000000E+00	0.000000000000E+00	0.160000000000E+00
0.140000000000E+00	0.150000000000E+00	0.400000000000E-01	0.270000010000E+00
0.500000000000E+00	0.000000000000E+00	0.350000000000E+00	0.150000000000E+00
0.207000000000E+01	0.700000000000E-01	0.140000000000E+00	0.700000000000E-01
0.110000000000E+00	0.900000030000E-01	0.000000000000E+00	0.450000000000E+00
0.600000000000E-01	0.240000000000E+00	0.200000000000E-01	0.000000000000E+00
0.000000000000E+00	0.000000000000E+00	0.497700000000E+02	0.000000000000E+00
0.169600000000E+02	0.000000000000E+00	0.800000000000E-01	0.440000000000E+00
0.650000000000E+00	0.160000000000E+00	0.117000000000E+01	0.560000000000E+01
0.000000000000E+00	0.140000000000E+00	0.800000000000E-01	0.200000000000E-01
0.596000000000E+01	0.210000000000E+00	0.700000000000E-01	0.150000000000E+00
0.100000000000E-01	0.000000000000E+00	0.111000000000E+01	0.380000000000E+00
0.790000020000E+00	0.100000000000E+00	0.000000000000E+00	0.000000000000E+00
0.000000000000E+00	0.670000010000E+00	0.166200000000E+02	0.119000000000E+01
0.174000000000E+01	0.200000000000E-01	0.940000000000E+00	0.700000000000E+00
0.720000020000E+00	0.200000000000E+01	0.358000000000E+01	0.117600000000E+02
0.241000000000E+01	0.700000000000E-01	0.280000000000E+00	0.300000000000E-01
0.319200000000E+02	0.500000000000E-01	0.530000000000E+00	0.121000000000E+01
0.000000000000E+00	0.000000000000E+00	0.240000000000E+00	0.206000000000E+01
0.100000000000E+00	0.000000000000E+00	0.000000000000E+00	0.000000000000E+00
0.710000000000E+00	0.180000000000E+00	0.300000000000E-01	0.000000000000E+00
0.130000000000E+00	0.500000000000E-01	0.800000000000E-01	0.400000000000E-01
0.120000000000E+00	0.122000000000E+01	0.000000000000E+00	0.180000000000E+00
0.000000000000E+00	0.300000000000E-01	0.106000000000E+01	0.350000000000E+02
0.233000000000E+01	0.130000000000E+00	0.230000000000E+00	0.000000000000E+00
0.840000000000E+00	0.120000000000E+00	0.240000000000E+00	0.300000000000E-01
0.000000000000E+00	0.000000000000E+00	0.000000000000E+00	0.468000000000E+01
0.000000000000E+00	0.000000000000E+00	0.000000000000E+00	0.000000000000E+00
0.430000000000E+00	0.330000010000E+00	0.400000000000E-01	0.390000000000E+00
0.300000000000E+01	0.000000000000E+00	0.280000000000E+00	0.000000000000E+00
0.195000000000E+01	0.700000000000E-01	0.400000000000E+00	0.000000000000E+00
0.558000000000E+01	0.260000000000E+00	0.000000000000E+00	0.540000020000E+00
0.600000000000E-01	0.540000020000E+00	0.300000000000E-01	0.000000000000E+00
0.000000000000E+00	0.000000000000E+00	0.378000000000E+01	0.150000000000E+00
0.120000000000E+00	0.000000000000E+00	0.128000000000E+01	0.650000000000E+00
0.450000000000E+00	0.320000000000E+00	0.660000020000E+00	0.120000000000E+01
0.000000000000E+00	0.420000000000E+00	0.150000000000E+00	0.380000000000E+00
0.700000000000E+00	0.980000010000E+00	0.270000010000E+00	0.440000000000E+00
0.358000000000E+01	0.150000000000E+00	0.950000000000E+00	0.600000000000E-01
0.149000000000E+01	0.300000000000E-01	0.000000000000E+00	0.000000000000E+00
0.000000000000E+00	0.630000010000E+01	0.000000000000E+00	0.000000000000E+00
0.000000000000E+00	0.103700000000E+02	0.170000000000E+00	0.240000000000E+00
0.000000000000E+00	0.135000000000E+01	0.480000010000E+01	0.000000000000E+00
0.135800000000E+02	0.291800000000E+02	0.375000000000E+01	0.140000000000E+00
0.330000010000E+00	0.118000000000E+01	0.500000000000E+00	0.182000000000E+01
0.580000010000E+01	0.267000000000E+01	0.200000000000E+00	0.177000000000E+01
0.800000000000E-01	0.000000000000E+00	0.000000000000E+00	0.000000000000E+00
0.000000000000E+00	0.000000000000E+00	0.000000000000E+00	0.000000000000E+00
0.800000010000E+00	0.900000030000E-01	0.890000000000E+00	0.000000000000E+00
0.477000000000E+01	0.300000010000E+00	0.000000000000E+00	0.126000000000E+01
0.000000000000E+00	0.000000000000E+00	0.140000000000E+00	0.400000000000E-01
0.160000000000E+00	0.220000000000E+00	0.000000000000E+00	0.580000010000E+01
0.540000020000E+00	0.600000000000E-01	0.740000000000E+00	0.600000000000E-01
0.000000000000E+00	0.000000000000E+00	0.000000000000E+00	0.000000000000E+00

0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.200000000000E-01 0.140000000000E+00 0.000000000000E+00 0.300000000000E+01
0.120000000000E+01 0.000000000000E+00 0.144000000000E+01 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.800000000000E-01
0.000000000000E+00 0.110000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.666000000000E+01 0.000000000000E+00
0.300000000000E+01 0.000000000000E+00 0.000000000000E+00 0.470000000000E+00
0.320000000000E+00 0.000000000000E+00 0.000000000000E+00 0.380000000000E+01
0.000000000000E+00 0.602000000000E+01 0.000000000000E+00 0.000000000000E+00
0.560000000000E+01 0.156000000000E+01 0.140000000000E+00 0.220000000000E+01
0.260000000000E+00 0.150000000000E+00 0.149000000000E+01 0.130000000000E+00
0.114000000000E+01 0.100000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.200000000000E+00 0.110000000000E+00
0.000000000000E+00 0.000000000000E+00 0.200000000000E+00 0.000000000000E+00
0.210000000000E+00 0.000000000000E+00 0.000000000000E+00 0.280000000000E+00
0.200000000000E+00 0.100000000000E+00 0.330000010000E+00 0.000000000000E+00
0.000000000000E+00 0.240000000000E+00 0.000000000000E+00 0.220000000000E+00
0.100000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.186000000000E+01 0.250000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.300000010000E+00 0.540000020000E+00 0.000000000000E+00
0.600000000000E-01 0.145200000000E+02 0.000000000000E+00 0.224000000000E+01
0.000000000000E+00 0.000000000000E+00 0.210000000000E+01 0.230000000000E+01
0.110000000000E+01 0.517000000000E+01 0.449000000000E+01 0.440000000000E+00
0.116000000000E+01 0.000000000000E+00 0.162000000000E+01 0.350000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.200000000000E+00
0.000000000000E+00 0.210000000000E+00 0.600000020000E+00 0.380000000000E+00
0.000000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00 0.123000000000E+01 0.000000000000E+00 0.000000000000E+00
0.110000000000E+00 0.000000000000E+00 0.000000000000E+00 0.000000000000E+00
0.000000000000E+00
RCON2RFULL
2 1 1
conversion factor
1 1
0.333333310000E+00
Rhat2RFULL
2 1 1
Retention weight on official and secondary market returns
1 1
0.100000000000E+01
SIGm2RFULL
2 27 1
Elasticity of substitution in demand between dom & imp good i

```
   27      1
 0.200000000000E+01  0.200000000000E+01  0.200000000000E+01  0.200000000000E+01
 0.200000000000E+01  0.200000000000E+01  0.200000000000E+01  0.200000000000E+01
 0.200000000000E+01  0.200000000000E+01  0.200000000000E+01  0.200000000000E+01
 0.200000000000E+01  0.200000000000E+01  0.200000000000E+01  0.200000000000E+01
 0.200000000000E+01  0.200000000000E+01  0.200000000000E+01  0.200000000000E+01
 0.200000000000E+01  0.200000000000E+01  0.200000000000E+01  0.200000000000E+01
 0.200000000000E+01  0.200000000000E+01  0.200000000000E+01
SIGp2RFULL
     2     27      1
Elasticity of factor substitution
   27      1
 0.500000000000E+00  0.500000000000E+00  0.500000000000E+00  0.500000000000E+00
 0.500000000000E+00  0.500000000000E+00  0.500000000000E+00  0.500000000000E+00
 0.500000000000E+00  0.500000000000E+00  0.500000000000E+00  0.500000000000E+00
 0.500000000000E+00  0.500000000000E+00  0.500000000000E+00  0.500000000000E+00
 0.500000000000E+00  0.500000000000E+00  0.500000000000E+00  0.500000000000E+00
 0.500000000000E+00  0.500000000000E+00  0.500000000000E+00  0.500000000000E+00
 0.500000000000E+00  0.500000000000E+00  0.500000000000E+00
SIGt2RFULL
     2     27      1
Elasticity of transformation in production
   27      1
 0.500000000000E+01  0.500000000000E+01  0.500000000000E+01  0.500000000000E+01
 0.500000000000E+01  0.500000000000E+01  0.500000000000E+01  0.500000000000E+01
 0.500000000000E+01  0.500000000000E+01  0.500000000000E+01  0.500000000000E+01
 0.500000000000E+01  0.500000000000E+01  0.500000000000E+01  0.500000000000E+01
 0.500000000000E+01  0.500000000000E+01  0.500000000000E+01  0.500000000000E+01
 0.500000000000E+01  0.500000000000E+01  0.500000000000E+01  0.500000000000E+01
 0.500000000000E+01  0.500000000000E+01  0.500000000000E+01
SIGw2RFULL
     2     27      1
Elasticity of substitution between Chinese & ROW good i in world mkt
   27      1
 0.100000000000E+02  0.100000000000E+02  0.100000000000E+02  0.100000000000E+02
 0.100000000000E+02  0.100000000000E+02  0.100000000000E+02  0.100000000000E+02
 0.100000000000E+02  0.100000000000E+02  0.100000000000E+02  0.100000000000E+02
 0.100000000000E+02  0.100000000000E+02  0.100000000000E+02  0.100000000000E+02
 0.100000000000E+02  0.100000000000E+02  0.100000000000E+02  0.100000000000E+02
 0.100000000000E+02  0.100000000000E+02  0.100000000000E+02  0.100000000000E+02
 0.100000000000E+02  0.100000000000E+02  0.100000000000E+02
sef 2RFULL
     2      1      1
Share of exports in GDP in foreign currency
     1      1
 0.118109000000E+00
smf 2RFULL
     2      1      1
share of imports in GDP in foreign currency
     1      1
 -0.120660000000E+00
Te  2RFULL
     2      1      1
Share of exports in balance of trade at official prices
```

```
    1     1
 0.286500000000E+02
Tm  2RFULL
    2     1     1
Share of imports in balance of trade at official prices
    1     1
 -0.276500000000E+02
V2  2RFULL
    2    27     1
Share of good i in total exports at official prices
   27     1
 0.700000000000E-01  0.100000000000E-02  0.200000000000E-01  0.000000000000E+00
 0.500000000000E-01  0.000000000000E+00  0.900000000000E-02  0.000000000000E+00
 0.100000000000E+00  0.600000000000E-01  0.100000000000E+00  0.000000000000E+00
 0.100000000000E+00  0.500000000000E-02  0.100000000000E-01  0.600000000000E-01
 0.100000000000E+00  0.800000000000E-01  0.600000000000E-02  0.600000000000E-01
 0.000000000000E+00  0.600000000000E-01  0.000000000000E+00  0.700000000000E-01
 0.000000000000E+00  0.000000000000E+00  0.000000000000E+00
XXHS1CFULL
    2    51    60
HISTORY OF THIS HEADER ARRAY FILE
   51
 ***  USER  Peng                        **********
 ***  DATE  19 Feb. 1992                **********
 The present file was created by running MODHAR
 The file modified was: peng86.dat
```

Appendix B

TABLO INPUT FILE OF THE CHINA CGE MODEL

```
! THIS IS THE TABLO INPUT FILE OF THE CHINA ENERGY MODEL !

!      Text between exclamation marks is a comment        !

!      Text between hashes # is labelling information     !

! SETS !

SET COMMOD # Commodities #
      ( crops,cotton,anhusb,wool,metal,elect,coal,petmin,petref,chem,
        chemfib,mach,bldmat,wood,food,text,apparel,paper,miscmanf,
        constr,frttran,pastran,comm,miscser,edheal,PAD,hous,energ );

SET SECT # Sectors #
     ( crops,cotton,anhusb,wool,metal,elect,coal,petmin,petref,chem,
       chemfib,mach,bldmat,wood,food,text,apparel,paper,miscmanf,
       constr,frttran,pastran,comm,miscser,edheal,PAD,hous );

SUBSET SECT IS SUBSET OF COMMOD;

SET COMMOD1 # Commod. at 1st level, incl energ excl elect,coal,petmin,petref #
       ( crops,cotton,anhusb,wool,metal,chem,chemfib,mach,bldmat,
         wood,food,text,apparel,paper,miscmanf,constr,frttran,
         pastran,comm,miscser,edheal,PAD,hous,energ );

SUBSET COMMOD1 IS SUBSET OF COMMOD;

SET ENERGY # Set of energy commodities #
      ( elect,coal,petmin,petref );

SUBSET ENERGY IS SUBSET OF COMMOD;

SUBSET ENERGY IS SUBSET OF SECT;

SET FACT # Primary factors #
     ( labour,capital,land );

SET KL # Primary factors whose returns vary by industry #
    ( capital,land );

SUBSET KL IS SUBSET OF FACT;

SET DEMAND # Demand source #
       ( HH,govt,fixin,stockin,exp,imp,dom,row );

SET ABSORB # Domestic absorption site #
      ( HH,govt,fixin,stockin );

SUBSET ABSORB IS SUBSET OF DEMAND;
```

```
SET PLACE # Place #
        ( exp,imp,dom );

SUBSET PLACE IS SUBSET OF DEMAND;

SET SOURCE # Sources # ( imp,dom );

SUBSET SOURCE IS SUBSET OF PLACE;

SET DESTIN # Final destination # (exp,dom) ;

SUBSET DESTIN IS  SUBSET OF PLACE;

SET WORLD # China or ROW # (exp,row);


! FILES !


FILE base # The file containing all base data for the economy #;


! Define variables !


! DEMAND SYSTEM !


VARIABLE (all,i,sect) RR(i)
       # Retention ratio for good i #;

VARIABLE (all,i,sect) q3(i)
       # Household  demand for i # ;

VARIABLE  aR  # Real absorption #;

VARIABLE (all,i,sect)  pq(i)
       # Price for absorption of i #;

VARIABLE (all,i,sect) q2(i)
       # Fixed investment Demand for good i # ;

VARIABLE (all,i,sect) qS2(i)
       # Demand for investment in stocks for good i # ;

VARIABLE (all,i,sect) q5(i)
       # Government demand for good i#;

VARIABLE (all,i,sect) q4(i)
       # Export demand for product i # ;

VARIABLE (all,i,sect) qw4(i)
       # ROW total imports of good i # ;
```

```
VARIABLE (all,i,sect) (all,s,world) pe(i,s)
        # Foreign currency price of export i from China and ROW #;

VARIABLE (all,i,commod) (all,j,sect)  q1(i,j)
        # Intermediate demands #;

VARIABLE (all,j,sect) x(j)
        # Output level of industry j #;

VARIABLE (all,i,sect) q(i)
        # Absorption of good i from all sources # ;

VARIABLE (all,i,sect) (all,s,source)  qs(i,s)
        # Demand for  good i by  sources , domestic and imported # ;

VARIABLE (all,i,sect)  (all,s,place) p(i,s)
        # Price of domestic & imported products# ;

VARIABLE (all,i,sect) (all,d,destin)  xd(i,d)
        # Supply of good i to domestic or export mkt. # ;

VARIABLE (all,i,sect) px(i)
        # production price of i # ;


! PRIMARY FACTOR INPUTS !


VARIABLE (all,v,fact) (all,j,sect) qP(v,j)
        # Demand for primary factor v  by industry j # ;

VARIABLE (all,v,KL) (all,j,sect) pP(v,j)
        # Return to primary factor v in industry j#;

VARIABLE  pP1 # Wage rate #  ;


! MARKET CLEARING CONDITIONS !


VARIABLE  qP1 # Total labour force  #;

VARIABLE (all,j,sect) Kp(j)
        # Capital # ;

VARIABLE (all,j,sect) la(j)
        # Land # ;


!ZERO PURE PROFITS !


VARIABLE (all,i,sect)  pm(i)
        # Foreign currency price of imports of i to China#;
```

```
VARIABLE (all,i,sect) tr(i)
        # Tariff rate on import of i# ;

VARIABLE PHI2 # Secondary market exchange rate#;

VARIABLE (all,i,sect) v1(i)
        # Export tax on exports of i#;

VARIABLE PHI1 # Official exchange rate #;


! IDENTITIES & NOMINAL SYSTEM CONSTRAINTS !


VARIABLE gdpr;

VARIABLE gdp;

VARIABLE  ex # Total exports at official prices # ;

VARIABLE  im # Total Imports at official prices # ;

VARIABLE exv # Total export volume #;

VARIABLE imv # Total import volume #;

VARIABLE  bt # Balance of trade at official prices #;

VARIABLE exf # Total export value in foreign currency #;

VARIABLE imf # Total import value in foreign currency #;

VARIABLE  btf # Base period balance of trade at foreign currency prices #;

VARIABLE pxx # Price deflator for gdp #;

VARIABLE pqq # Price deflator for absorption #;

VARIABLE  an # Nominal absorption#;

VARIABLE anstar # Calculating HH disposable income #;

VARIABLE  ms # Money supply #;


! Define coefficients!


COEFFICIENT fes   # Foreign exchange shares #;

UPDATE (EXPLICIT) FES = FES*(1+ (1-FES)*(PHI1 - PHI2)/100);

COEFFICIENT rconv # Exchange rate ratio #;
```

```
COEFFICIENT (all,i,sect)(all,d,demand) dd(i,d)
            # Demand #;

UPDATE (all,i,sect) DD (i, "HH") = pq(i)*q3(i);

UPDATE (all,i,sect) DD (i, "govt") = pq(i)*q5(i);

UPDATE (all,i,sect) DD (i, "fixin") = pq(i)*q2(i);

UPDATE (all,i,sect) DD (i, "stockin") = pq(i)*qs2(i);

UPDATE (all,i,sect) DD (i, "exp") = pq(i)*q4(i);

UPDATE (all,i,sect) DD (i, "row") = pq(i)*qw4(i);

UPDATE (all,i,sect) (all,s,source) DD (i, s) = pq(i)*qs(i,s);

COEFFICIENT (all,i,sect) epsilon(i)
            # Income elasticity of demand # ;

COEFFICIENT (all,k,sect) (all,i,sect) eta(i,k)
            # Price elasticity of demand# ;

COEFFICIENT (all,i,sect) ws(i)
            # Share of good i in total absorption # ;

COEFFICIENT (all,i,sect)(all,j,sect) inter(i,j)
            # Intermediate use of good i in sect j#;

UPDATE (all,i,sect) (all,j,sect) INTER(i,j) = pq(i)*q1(i,j);

COEFFICIENT (all,i,sect)(all,c,absorb) abso(i,c)
            # Domestic absorption of good i by absorb c #;

COEFFICIENT (all,i,sect)(all,c,absorb) sn(i,c)
            # Shares of total absorption #;

COEFFICIENT (all,i,sect) sigmaw(i)
       # Elasticity of substitution between chinese & ROW good i in world mkt #;

COEFFICIENT (all,i,sect) em(i)
            # Elasticity of supply of imports to China #;

COEFFICIENT (all,i,sect)(all,s,world) es(i,s)
            # Share of China & ROW in exports of i to row #  ;

COEFFICIENT (all,i,sect) beta(i)
            # Elasticity of global excess demand for good i#;

COEFFICIENT sigmae # Elasticity of substitution for energy #;

COEFFICIENT (all,k,energy)(all,j,sect) ens(k,j)
             # total energy used in industry j #;
```

```
COEFFICIENT (all,i,sect)(all,j,sect) b1(i,j)
        # Share of inter use by ind j in total dom abso of good i #;

COEFFICIENT (all,i,sect) B2(i)
        # Share of fixinvest use in total domestic absorpotion of good i #;

COEFFICIENT (all,i,sect) BS2(i)
        # Share of stockinvest use in total domestic absorpotion of good i #;

COEFFICIENT (all,i,sect) B3(i)
        # Share of houshldcon use in total domestic absorpotion of good i #;

COEFFICIENT (all,i,sect) B5(i)
        # Share of govtcon use in total domestic absorpotion of good i #;

COEFFICIENT (all,i,sect) SIGMAm(i)
        # Elasticity of substitution in  demand bet. domestic & imported #;

COEFFICIENT (all,i,sect) SIGMAT(i)
        # Elasticity of transformation in production # ;

COEFFICIENT (all,i,sect) (all,f,destin) SJ(i,f)
        #Share of domestic and export products in total production of i #;

COEFFICIENT (all,i,sect)(all,f,destin)DESTN(i,f)
        # Domestic and export sales of good i #;

COEFFICIENT (all,i,sect) SIGMAp(i)
        # Elasticity of factor substituion # ;

COEFFICIENT  (all,v,fact) (all,j,sect) Sp(v,j)
        # Share of primary factor v in primary factor inputs in j # ;

COEFFICIENT (all,j,sect) SL(j)
        # Share of industry j in total employment #  ;

COEFFICIENT (all,v,fact)(all,j,sect)IFACT(v,j)
        # Use of factor v in industry j #;

UPDATE (all,j,sect) IFACT ("labour",j) =
       pp1*qp("labour",j);

UPDATE (all,v,kl) (all,j,sect) IFACT (v,j) =
       pp(v,j)*qp(v,j);

COEFFICIENT (all,i,sect) (all,j,sect) H1(i,j)
        # Share of intermediate good i in total costs of industry j #  ;

COEFFICIENT (all,v,fact) (all,j,sect) HP(v,j)
        # Share of primary factor v in total costs of industry j # ;

COEFFICIENT (all,j,sect) KS(j) # share of sect i in tot VA in the economy # ;

COEFFICIENT (all,i,sect) V2(i)
```

```
        # Share of export i in total export in domestic currency # ;

COEFFICIENT (all,i,sect) Vf(i)
        # Share of export i in total foreign currency value of exports # ;

COEFFICIENT (all,i,sect) M(i)
        # Share of import i in total imports in domestic currency #;

COEFFICIENT (all,i,sect) Mf(i)
        # Share of import i in total foreign currency value of imports #;

COEFFICIENT (all,i,sect)(all,s,source)SCE(i,s)
        # Value of good i from source s (dom or imp) #;

COEFFICIENT (all,i,sect) (all,s,source) A(i,s)
        # Share of absorption of i derived from source S # ;

COEFFICIENT Te;

UPDATE (EXPLICIT) Te = Te*(1+ex/100-bt/100);

COEFFICIENT Tm;

UPDATE (EXPLICIT) Tm = Tm*(1+im/100-bt/100);

COEFFICIENT SEF
  # Base period share of exports in GDP expressed in foreign currency#;

UPDATE (EXPLICIT) sef = sef*(1+exf/100-btf/100);

COEFFICIENT SMF
  # Base period share of imports in GDP expressed in foreign currency#;

UPDATE (EXPLICIT) smf = smf*(1+imf/100-btf/100);


! BASE DAT !


READ SIGMAE          FROM FILE base HEADER "SIGE";
READ FES             FROM FILE base HEADER "FES";
READ RCONV           FROM FILE base HEADER "RCON";
READ epsilon         FROM FILE base HEADER "epsi";
READ eta             FROM FILE base HEADER "eta";
READ BETA            FROM FILE base HEADER "BETA";
READ SIGMAw          FROM FILE base HEADER "SIGw";
READ SIGMAm          FROM FILE base HEADER "SIGm";
READ SIGMAT          FROM FILE base HEADER "SIGt";
READ SIGMAp          FROM FILE base HEADER "SIGp";
READ IFACT           FROM FILE base HEADER "FACT";
READ DD              FROM FILE base HEADER "DEMA";
READ INTER           FROM FILE base HEADER "INTE";
READ EM              FROM FILE base HEADER "EM";
READ Te              FROM FILE base HEADER "Te";
```

```
READ Tm            FROM FILE base HEADER "Tm";
READ SEF           FROM FILE base HEADER "SEF";
READ SMF           FROM FILE base HEADER "SMF";


!Define formulae!


FORMULA (all,i,sect)
     es(i,"exp") = dd(i,"exp") / ( dd(i,"row") - dd(i,"exp") );

FORMULA (all,i,sect)
     es(i,"row") = 1 - es(i,"exp");

FORMULA (all,i,sect)(all,c,absorb)
     abso(i,c) = dd(i,c);

FORMULA (all,i,sect)(all,f,destin)
     destn(i,f) = dd(i,f);

FORMULA (all,i,sect)
     ws(i) = ( SUM(j,sect,INTER(i,j))+SUM(c,absorb,abso(i,c))) /
          ( SUM(n,sect,SUM(u,sect,INTER(n,u)))+
           SUM(n,sect,SUM(e,absorb,abso(n,e))) );

FORMULA (all,i,sect)(all,c,absorb)
     sn(i,c) = abso(i,c)/SUM(n,sect,SUM(e,absorb,abso(n,e)));

FORMULA (all,i,sect)(all,j,sect)
     b1(i,j) = INTER(i,j)/
           (SUM(c,absorb,abso(i,c))+SUM(u,sect,INTER(i,u)));

FORMULA (all,i,sect)
     b2(i) = abso(i,"fixin")/
           (SUM(c,absorb,abso(i,c))+SUM(j,sect,INTER(i,j)));

FORMULA (all,i,sect)
     bs2(i) = abso(i,"stockin")/
           (SUM(c,absorb,abso(i,c))+SUM(j,sect,INTER(i,j)));

FORMULA (all,i,sect)
     b3(i) = abso(i,"HH")/
           (SUM(c,absorb,abso(i,c))+SUM(j,sect,INTER(i,j)));

FORMULA (all,i,sect)
     b5(i) = abso(i,"govt")/
           (SUM(c,absorb,abso(i,c))+SUM(j,sect,INTER(i,j)));

FORMULA (all,i,sect)(all,f,destin)
     sj(i,f) = DESTN(i,f) / SUM(g,destin,DESTN(i,g));

FORMULA (all,k,energy)(all,j,sect)
     ens(k,j) = INTER(k,j) / SUM(g,energy,INTER(g,j));
```

```
FORMULA (all,v,fact)(all,j,sect)
      sp(v,j) = IFACT(v,j) / SUM(r,fact,IFACT(r,j));

FORMULA (all,j,sect)
      sl(j) = IFACT("labour",j) / SUM(u,sect,IFACT("labour",u));

FORMULA (all,i,sect)(all,j,sect)
      h1(i,j) = INTER(i,j) / (SUM(n,sect,INTER(n,j))+SUM(v,fact,IFACT(v,j)));

FORMULA (all,v,fact)(all,j,sect)
      hp(v,j) = IFACT(v,j) / (SUM(n,sect,INTER(n,j))+SUM(r,fact,IFACT(r,j)));

FORMULA (all,j,sect)
      ks(j) = SUM(v,fact,IFACT(v,j)) / SUM(v,fact,SUM(o,sect,IFACT(v,o)));

FORMULA (all,i,sect)(all,s,source)
      sce(i,s) = dd(i,s);

FORMULA (all,i,sect)
      m(i) = sce(i,"imp") / SUM(n,sect,SCE(n,"imp"));

FORMULA (all,i,sect)(all,s,source)
      a(i,s) = SCE(i,s) / SUM(t,source,SCE(i,t));

FORMULA (all,i,sect)
      v2(i) = DESTN(i,"exp") / SUM(g,sect,DESTN(g,"exp"));

! The following two formulas are identical to V2(i) and m(i).
  They are used to define the added two coefficients VF and MF, respectively. !

FORMULA (all,i,sect)
      vf(i) = DESTN(i,"exp") / SUM(g,sect,DESTN(g,"exp"));

FORMULA (all,i,sect)
      mf(i) = sce(i,"imp") / SUM(n,sect,SCE(n,"imp"));


DISPLAY a;
DISPLAY bs2;
DISPLAY b1;
DISPLAY b2;
DISPLAY b3;
DISPLAY b5;
DISPLAY beta;
DISPLAY dd;
DISPLAY em;
DISPLAY ens;
DISPLAY es;
DISPLAY epsilon;
DISPLAY eta;
DISPLAY hp;
DISPLAY h1;
DISPLAY ks;
DISPLAY m;
```

```
DISPLAY sigmae;
DISPLAY sigmap;
DISPLAY sigmat;
DISPLAY sigmaw;
DISPLAY sj;
DISPLAY sl;
DISPLAY sn;
DISPLAY sp;
DISPLAY te;
DISPLAY tm;
DISPLAY v2;
DISPLAY ws;
DISPLAY vf;
DISPLAY mf;
DISPLAY sef;
DISPLAY smf;


! EQUATIONS !

! DEMANDS!

EQUATION  HSECOND # Household consumption demand #
        (all,i,sect)  q3(i) =epsilon(i)*anstar + SUM(k,sect,eta(i,k)*pq(k));

EQUATION  FIXINVD # Fixed investment demand #
         (all,i,sect) q2(i) = aR;

EQUATION  INVSTKS # Investment in stocks #
         (all,i,sect) qs2(i) = aR;

EQUATION  GOVTDD # Government demand #
         (all,i,sect) q5(i) = aR;

EQUATION GLOBALDD # Global demand for good i #
       (all,i,sect) qw4(i) = BETA(i)*(SUM(s,world,ES(i,s)*pe(i,s)));

EQUATION  EXPOTDD # Export demand #
         (all,i,sect)  q4(i) = qw4(i) - sigmaw(i)*
         (pe(i,"exp")-SUM(s,world,ES(i,s)*pe(i,s)));

EQUATION  INTERDD # Intermediate demand #
         (all,i,commod1) (all,j,sect) q1(i,j) = x(j);

EQUATION IMSUPPLY # Import supply #
        (all,i,sect) qs(i,"imp") = EM(i)*pm(i);

EQUATION ENERGDD # Intermediate demand for energy types #
       (all,i,energy) (all,j,sect) q1(i,j)=q1("energ",j)-SIGMAe*(pq(i)
       -SUM(k,energy,ENS(k,j)*pq(k)));

EQUATION  DOMEABS # Domestic absorption of good i from all sources #
         (all,i,sect) q(i) = SUM(j,sect,B1(i,j)*q1(i,j))
        +B2(i)*q2(i)+ BS2(i)*qs2(i)+B3(i)*q3(i)+B5(i)*q5(i);
```

```
EQUATION  SUBSTIT # Substitution in demand between domestic and imported #
    (all,i,sect)  (all,s,source)  qs(i,s) = q(i)-SIGMAm(i)*(p(i,s)
   -pq(i));

EQUATION  TRANSFO # Transformation in production #
   (all,i,sect) (all,f,destin) xd(i,f)
   = x(i)+SIGMAT(i)*(p(i,f)- px(i));


!PRIMARY FACTOR INPUTS!

EQUATION  CAPILAND # Demand for capital, land #
    (all,v,kl) (all,j,sect) qP(v,j) = x(j)-SIGMAp(j)*(pP(v,j)
   -SUM(w,kl,Sp(w,j)*pP(w,j))-Sp("labour",j)*pP1);

EQUATION LABOUR #Demand for labour in industry i#
  (all,j,sect) qP("labour",j) =x(j) - Sigmap(j)*(pP1-
   SUM(v,kl,Sp(v,j) *pP(v,j))-Sp("labour",j)*pP1);


!MARKET CLEARING CONDITIONS!

EQUATION  DOMEST #Domestic market clearing#
    (all,i,sect)  qs(i,"dom") = xd(i,"dom");

EQUATION  exPCLR # Export market clearing #
    (all,i,sect)  q4(i) = xd(i,"exp");

EQUATION  LABmktCLR # Labour market #
    qP1 = SUM(j,sect,SL(j)*qP("labour",j));

EQUATION  CAPCLR # Capital#
   (all,j,sect) qp("capital",j) = Kp(j);

EQUATION  LANCLR # Land #
   (all,j,sect) qp("land",j) =  la(j);


!ZERO PURE PROFITS!


EQUATION  INPRODN # In production #
    (all,i,sect) SUM(f,destin,SJ(i,f)*p(i,f)) =
    SUM(n,sect,H1(n,i)*pq(n))+SUM(v,kl,Hp(v,i)*pP(v,i))
   +HP("labour",i)*pP1;

EQUATION  INMPORT  # In importing #
    (all,i,sect)  p(i,"imp")=pm(i)+tr(i)+PHI2;

EQUATION  INXPORT # In exporting #
    (all,i,sect)  p(i,"exp") =
   pe(i,"exp")+v1(i)+ FES*((-RCONV*RR(i))+PHI1)+(1-FES)*(RR(i)+PHI2);
```

! IDETITIES & NOMINAL SYSTEM CONSTRAINTS !

```
EQUATION  REALGDP # Defining real GDP  #
        gdpr = SUM(j,sect,KS(j)*x(j));

EQUATION  NOMIGDP # Nominal GDP #
        gdp = SUM(j,sect,KS(j)*[px(j)+x(j)]);

EQUATION  REALABS # Real absorption #
  aR = SUM(i,sect,SN(i,"HH")*q3(i))+SUM(i,sect,SN(i,"govt")*q5(i))
     +SUM(i,sect,SN(i,"fixin")*q2(i))+SUM(i,sect,SN(i,"stockin")*qs2(i));

EQUATION  NOMIABS # Defining HH disposable incomr as residual #
an  = SUM(i,sect,SN(i,"HH")*anstar)+SUM(i,sect,SN(i,"govt")*[q5(i)+pq(i)])
  +SUM(i,sect,SN(i,"fixin")*[q2(i)+pq(i)])+SUM(i,sect,SN(i,"stockin")*[qs2(i)+pq(i)]);

EQUATION  TOTexPo # Total export value #
        ex=SUM(i,sect,V2(i)*(p(i,"exp")+xd(i,"exp")));

EQUATION  TOTexPof # Total export value in foreign currency#
        exf=SUM(i,sect,Vf(i)*(pe(i,"exp")+xd(i,"exp")));

EQUATION  TOTMPTSo # Total import value #
        im = SUM(i,sect,M(i)*(p(i,"imp")+qs(i,"imp")));

EQUATION  TOTMPTSof # Total import value in foreign currency#
        imf = SUM(i,sect,Mf(i)*(pm(i)+qs(i,"imp")));

EQUATION  EXVOL #Total export volume #
        exv = SUM(i,sect,v2(i)*xd(i,"exp"));

EQUATION  IMVOL # Total import volume #
        imv = SUM(i,sect,M(i)*qs(i,"imp"));

EQUATION BOT # Balance of trade in domestic currency #
        bt = Te*ex+Tm*im;

EQUATION BOTf # Base period balance of trade in foreign currency #
        btf = SEF*exf+SMF*imf;

EQUATION  PriceDEf# Price deflator for GDP #
        pxx = SUM(j,sect,KS(j)*px(j));

EQUATION ABSDEF # Price level deflator for absorption #
        pqq = SUM(j,sect,Ws(j)*pq(j));

EQUATION PRICELVL # Price level determination #
        pqq = ms-ar;

EQUATION ABSsect # Price deflator for absorption of i #
        (all,i,sect) pq(i) = SUM(s,source,A(i,s)*p(i,s));

EQUATION PRODDEF # Price deflator for production of i #
        (all,i,sect) px(i) = SUM(f,destin,SJ(i,f)*p(i,f));
```

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[1] Phonetic spelling (*Pinyin*) is not used for Chinese references. They are translated into English and noted in brackets as "(*in Chinese*)". Following the Chinese convention, the names of Chinese authors are listed with surnames in front, and full given names are used instead of initials.

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