DOCTOR OF PHILOSOPHY

Strategic study of forest development policy : a model for balancing demand and supply of forest resources in China.

Liu, Aying.

Award date:
1995

Awarding institution:
Bangor University

STRATEGIC STUDY OF

FOREST DEVELOPMENT POLICY

A Model for Balancing Demand and Supply of Forest Resources in China

A Thesis Submitted to the University of Wales for the Degree of Philosophiae Doctor

By Aying Liu

BSc(Econ) P.G.Dip(Econ) Dip(Ed)

School of Agricultural and Forest Sciences
University College of North Wales
Bangor, U.K.

In affectionate memory of my father,
and with lots of love to my mother

谨献 给 我 敬 爱 的 父 母 亲

DECLARATION

I hereby certify that this thesis, submitted in candidature for the degree of "Philosophiae Doctor" of the University of Wales, has not already been submitted in substance for any degree, and is not being currently submitted for any other degree. The thesis is the result of my own investigation, and any help I have received is acknowledged overleaf.

Candidate:________________
(Aying Liu)

Director of Studies:________________
(Dr Colin Price)

Date:________________

ACKNOWLEDGEMENTS

I am obliged to a number of people and institutions whose direct and indirect help has enabled this thesis to be produced.

First and foremost, I am indebted to my supervisor, Dr Colin Price, for his outstanding guidance, encouragement, assistance and patience throughout my study. Instead of asking me to take a course of study, he allowed and encouraged me to set my own direction, and whenever new ideas emerged, he devoted his full attention to improve and refine them. I am exceedingly grateful to Dr Colin Price.

I am indebted also to Dr Shanti Chakravarty, Mr Terry Thomas, Mr Roger Cooper and Mr Geoff Bright for their invaluable advice and encouragement throughout my stay in UCNW. Their help also comes from many practical ways, without which it would be impossible for me to complete this study.

I wish to record my gratitude to Prof. Laurence Roche for his encouragement to me. I would also like to thank staff members of the School of Agricultural and Forest Sciences whose presence and close companionship have helped to create the kind of atmosphere much needed in any academic pursuit.

I feel privileged to have studied at UCNW and to have been accommodated in a friendly Welsh community -- Neuadd John Morries Jones. I owe special gratitude to Rev. Mr Alwyn Roberts, Prof. Eric Sunderland, Mr David Chapman, Miss Evelyn Abdy, Ms Evelyn Williams, Mrs Mavis Jones, Dr John Williams and Mr Barry Sanderson for their help in many ways.

The enthusiastic interest of my friends has been a perpetual source of encouragement. To all of them I am most grateful. I have received particular help from my best friends, Gethin and Nancy Rees, their meticulous and parent-like care of me has been energizing and made me feel Wales as my second home.

My sincere thanks go to Ms Elspeth Aubrey for her comments and suggestions, she read through part of the draft chapters of the thesis; and to Mr Shirong Chen whose great help makes the work on the final version a wholly enriching and enjoyable experience.

Furthermore, thanks are due to my former employer, Beijing Forestry University, for giving me study leave and providing part of the fees for this study, and to the Vice-Chancellor and Universities Committee for providing me with the Overseas Research Student (ORS) award. In particular, I thank the Great Britain - China Friendship Society for financing my study when I was in an unexpected and emergent circumstance in 1989. I will never forget their great help.

I am indebted to my sisters for being understanding and for taking full responsibility of looking after our parents.

Finally, I would like to say thank you and sorry to my wife, Rose Yanhong Li, for her direct and indirect contribution to this study, and for her suffering from my terribly busy period of the study.

Any errors and mistakes, of course, remain mine.

ABSTRACT

A major problem confronting forestry in China is the conflict between the increasing demand for and short supply of forest products. Despite an immense effort on tree plantation during the last forty years, the shortage of forest resources has been more acute than ever. The problems are deeply rooted in the nation's economic system, which functions efficiently neither in controlling overcutting, nor rationalising resource utility, nor creating producers' incentives. Specifically, certain features of China's forestry economy are discussed in connection with demand and supply.

This study also discusses the possibility of deepening the concepts of the demand and supply theory and improving the system dynamics methodology.

Based on these discussions, a systematic model of policy on wood products Supply and Demand, and Forest Resource Development, SD-FRED, has been developed using the system dynamics methodology in conjunction with other techniques, to provide long-term trends of production and consumption and to formulate strategic scenarios for sustainable forest development in China.

SD-FRED focuses on the following issues: demand and supply of forest products; sustainable use of natural resources; lead times in production and the effect of various policy changes and structural adjustment on forest development. It contains about 210 variables, some of which are lagged. They are related by 230 equations, some of these are non-linear and valid only within a specified range of values for the variables. The total model has 35 phases, 3 development schemes are formulated based on the sensitivity analysis of 8 sets of selected policies.

The results of running this model indicate that:

1. The problem of supply and demand for wood products is much more persistent than current thinking acknowledges, and much less amenable to straightforward solutions. Several practical choices and programmes are evaluated in this study to increase public understanding of causes of demand-supply imbalance.

2. The study implies that the development of contemporary forestry in China is a sophisticated social process which relates to many macro-economic and institutional aspects; a fundamental way out for China's forestry lies in reforming the current policies. Of those policies, three are critical: (1) investment policy; (2) pricing policy; and (3) management system. The study also finds that, given China's current situation, wood imports play a significant and imperative role in meeting the country's increasing wood demand and in saving the domestic resources for the future sustainable development.

3. A system dynamics model, connected with other mathematical methods, such as econometric models, linear programming, and cost-benefit analysis, is ideal for the analysis of social system which is characterised by multiple phase, nonlinear, diversified feedback and complicated time-varied system.

CONTENTS

Tables and Figures

Tables

Figures

INTRODUCTION

1987 was an eventful year in China's forestry history.

Whereas some western foresters, economists and bureaucrats applauded enthusiastically China's achievement in afforestation as "the mightiest afforestation effort the world has ever seen" (Westoby, 1987), and that it shows "the ability of even nonwealthy countries to resist and reverse the pressures toward deforestation" (Sedjo, 1987), what was really happening in China was, ironically, two historic disasters:

1. In the north, a huge fire occurred in the nation's most important and state-owned forest base between 6 May and 2 June; it destroyed 1.01 million ha of mostly mature, productive coniferous forest, and also burnt 855,000 m^3 of stored timber.

2. In the south, an extensive and progressive deforestation spread throughout most parts of the collective-owned forest which has been considered as the most prosperous and secondary important forest district of the country, and it could not be stopped by any means. An immense amount of young forest was cut down and sold out for 'getting rich'.

These two events proved academics' longstanding warning (He, 1978), broke optimists' wishes, and provoked the public's unprecedented concern about the country's forestry and environmental issues. The "two crises of forestry" (i.e. the crisis of forest resources and the crisis of investment in forestry) has become an important topic in China since then. Chinese foresters, scientists and economists have themselves been questioning the real forestry situation in China.

1. With a total population of 1.2 billion (1992) and a rapid growth of income per capita in recent years, the demand for forest products is increasing at a rate of 5.3%

per year. However, forest resources in China are quickly decreasing. It is said that during the fifth five-year period (1975-1980) the total forest area was reduced by 5.6%, and the area and growing stock of timber producing forest dropped, respectively, by 21.6% and 10.9%. The total annual cutting of forest is 6.9% more than the total annual increment and is 31.6% more than timber-land growth, especially in state exploited forest regions, where it is 37.2% greater than timber-land growth (Huang, 1985; NFPA, 1986).

2. As a result of over-cutting, the degeneration and depletion of forest resources continues unabated. Although 120 million ha are classified as forest, covering 12.0 % of the total land area, there are very large reserves of unexploited forest in the extreme north of the country, in south west China and in Tibet. In northern China, for example, there are about 580,000 ha of inaccessible forest and in Tibet there is estimated to be 1400 million m^3 of over-mature unexploited growing stock, most of which is located in the upper reaches of the Yangtze and Yellow Rivers, where the preservation of large areas of forest is very important for water and soil conservation and hence for the eco-environment in a large part of China.

There is no doubt about the size and scale of annual mass tree-planting campaigns of China's forestry, especially in what are known as "Four-around" planting and the "Green Great Wall" programmes. In some periods and some regions, these programmes have led to their extension into the use of trees in rural development, in beautifying towns and cities, in the reversal of soil erosion and the establishment of a favourable micro-climate for national economic construction and for people's daily life. There is, however, an increasing number of people doubting about the real achievement of the campaigns in the country as a whole (Smil, 1992).

Moreover, the limitations of both land and capital in China impose a number of constraints. In these circumstances, there is intense argument as to whether the Chinese government should put more money into southern China to develop fast-growing forest or into the north to extend the function of shelterbelts, or whether it should compromise between these two options. There is an urgent need for decision-making by means of technical, economic, and social appraisal.

3. China has become the second largest importer of logs in the world. According to Chinese import/export statistics, the amount of log importation during the sixth five-year period was 30.38 million m^3, which is 18.47 million m^3 more than total timber imports during the previous 30 years. Total log imports in 1985 were 20.21 million m^3, which was about one third of the planned home production. With respect to this increase in the importation of forest products, there is much debate amongst the relevant authorities in China. Some claim that there is an obvious and significant benefit to be had from importation in balancing the supply and demand of forest products in China, and that it has proved to be a dynamic element in the development of forestry. As in the case of Japan, it is suggested that China should import more forest products by buying on the international market in order to save its forest resources from over-cutting. Arguments against imports, on the other hand, rest on the following points:

(a) There is domestic oversupply of some processed wood products, measured by the amount of timber kept in storage. Storage of those products which could not be sold on the domestic wood market because of their wrong types increased to about 22.14 million m^3 in 1985 from 15.04 million m^3 in 1980 while the state spent a large amount of foreign exchange on importing timber (Jin-Yan, 1987).

(b) Security of supply would be threatened by dependence on imports. The future supply of forest products in international markets may not be adequate due to the shortage of forest resources in the world. At best, international prices are likely to rise sharply.

(c) Foreign exchange expenditure constraints will restrict the Chinese government's importation of more forest products in the near future.

(d) The unfavourable trade balance of forest products is not helpful in stimulating Chinese forestry development, with respect to the utilisation of fast-growing wood planted in central and southern parts of China. It is also claimed that the effect of short-term saving of resources by importation will be to shift the crisis into other regions, etc.

4. Given China's vast size (about 5000 km from south to north and 5200 km from east to west, spanning 50 degrees of latitude -- including the islands within Chinese territorial waters -- and 62 degrees of longitude), numerous tree species (more than 5000 woody species in almost 700 genera), varied physical environment, and differing socio-economic conditions, economic forestry management in China is a complex system. For example, from the economic management point of view, forest can be classified in two ways: the first of these is the division by functional type into:

(1) timber producing forest;
(2) shelterbelt forest;
(3) non-timber tree crop;
(4) bamboo and
(5) amenity forest.

The second is a division according to ownership classes into:

(1) collective forests;
(2) state forests;
(3) private forest;
(4) joint state-private forest;
(5) state-capitalist forests, etc.

Since 1979, China has implemented policies of opening to the outside world to revitalise the domestic economy, and it has been restructuring the economic system. Consequently, the economy of national forestry has changed from a mono-planned economy pattern to a combination of planned economy and market economy; forest commodities traded in the market are not only produced by state enterprises, but also by collectives and individuals; products are exchanged according to different price systems; and investment in reforestation comes from a variety of sources.

The fact that forestry has many functions is now recognised by an increasing number of people. Forestry for human beings by no means refers to wood only. It supplies the need for fuel, wood, fodder, fruit and shelter, while surplus produce can be sold for cash. As living standards rise and leisure time increases, an increasing number of Chinese people, like those in the West, now require forest not only for its direct benefits, such as timber, fruits, and fuel, but also for its indirect benefits, such as outdoor recreation--"the primary purposes of enjoyment and physical or mental well-being" (Gregory, 1972) undertaken in a relatively non-urban environment characterised by natural settings. The concept of the uniqueness of forest resources in providing various products is, therefore, of fundamental importance in strategies of forestry development.

Although at the national level the necessity of demand and supply of wood products and the strategies of development in forestry have been more or less intensively discussed, and researches have been done by number of people (Huang, 1985; Zhong, 1985; China's Academy of Forest Sciences, 1986), it is only recently that the whole complexity of problems has won the simultaneous attention of academics and authorities. Nevertheless, the literature in national planning or operative control of forestry is still relatively small.

When, however, economic development approaches the stage where the 'intensive' type of growth begins, the activities of different branches become increasingly intertwined. Long-term studies are confronted with a host of questions that can be examined and decided upon only by a more sophisticated approach, assessing the situation and prospects of whole forest production concerned: e.g. what quantities of timber in what sort of products at what prices will be needed? what is a possible amount of forest products? which will be produced by exploiting the domestic resources? what will be the prospects of import/export? how will the competition between wood and the substituting materials evolve?

These question are related to a variety of issues concerning demand, supply, and international trade in wood products. Such issues include the growth of population and the national economy, the development of the forest resource utilization and the substitutes for wood products, the future growth and supply of the resources, the development of new technologies for forest and forestry industry, the nation's trade policies including exchange rate, tariffs and non-tariff trade barriers, the trends of the country's economic and political reforms, and even social stability.

It has been evidenced that the problems of the forest sector can not be properly understood and solved without considering these problems within the national economic context. The sustainable development of forest resource and wood supply, the demand for wood products and forest-based services are inevitably affected by main decisions made outside the sector. It has also been recognised that the shortage of forest resources in China has become a critical problem which can not be evaded any longer.

Whereas theoretical analysis helps us to obtain a better understanding of these relations, systems analysis and behavioural models may provide insight into how changes within the sector and forces originating outside the sector affect the key concerns of the resource development and allocation, forest product prices, production, consumption, profit, the current state and the future trends of the country's forest development.

Given the above considerations, this study is centred on an aggregated analysis of long-term development of forest in China at the national level; the particular focus is on demand and supply of wood products and the issues closely related.

The specific objectives of this programme of study will be:

(1) to provide a broad brush picture of China's forest production, and to discuss some distinctive aspects of demand and consumption of wood products in China, and

(2) to develop a simulation model which should be informative and useful to policy makers and academics to discuss strategies for balancing supply

and demand of China's forest resources by the projection of future demands for forest-related commodities, and of future forest resources supplies and capabilities. However, the objective is not to produce an operational model of China's forest sector, as such a model would require more field work, more policy makers' participation and more interaction than this study can afford in terms of time and financial budget.

This thesis consists of a brief introduction and 10 chapters which are divided into 3 parts. Part I (Chapters 1 and 2) provides a background setting of this study. This is followed by part II (Chapters 3, 4, and 5). In Chapter 3 and 4, an examination is carried out on the theoretical aspects of demand, supply, resource management, and international trade in wood products; in Chapter 5, a review of modelling methodologies and a relatively detailed discussion of system dynamics approach are provided. Part III contains 5 chapters (Chapter 6 to Chapter 10). Chapter 6 gives a brief description of SD-FRED; Chapter 7 illustrates the detailed structure of SD-FRED, the data used and the computer programme applied in the modelling process. Chapter 8 shows results of the model's baseline simulation and the sensitivity analysis of selected policies. It also attempts to show how a set of parameters is likely to change in response to alternative decisions made by the government or by the forestry industry, and in response to other exogenous variables (e.g., the world market). This is followed by Chapter 9, the scenario variations, which formulates three possible trends of China's forest development in the next 20 years under various policy alternatives. This chapter implies a serious suggestion for policy-makers about policy changes needed for sustainable forest development in China. The last chapter contains the main findings, remarks of this study and discussions about the model and the methodologies employed in this study; it also suggests a direction for future research in the field.

PART I

CHINA'S ECONOMY: SYSTEM, REFORM AND FOREST SUBSECTOR

CHAPTER 1

ECONOMIC SYSTEM AND REFORM IN CHINA

The following points are introduced in this chapter:

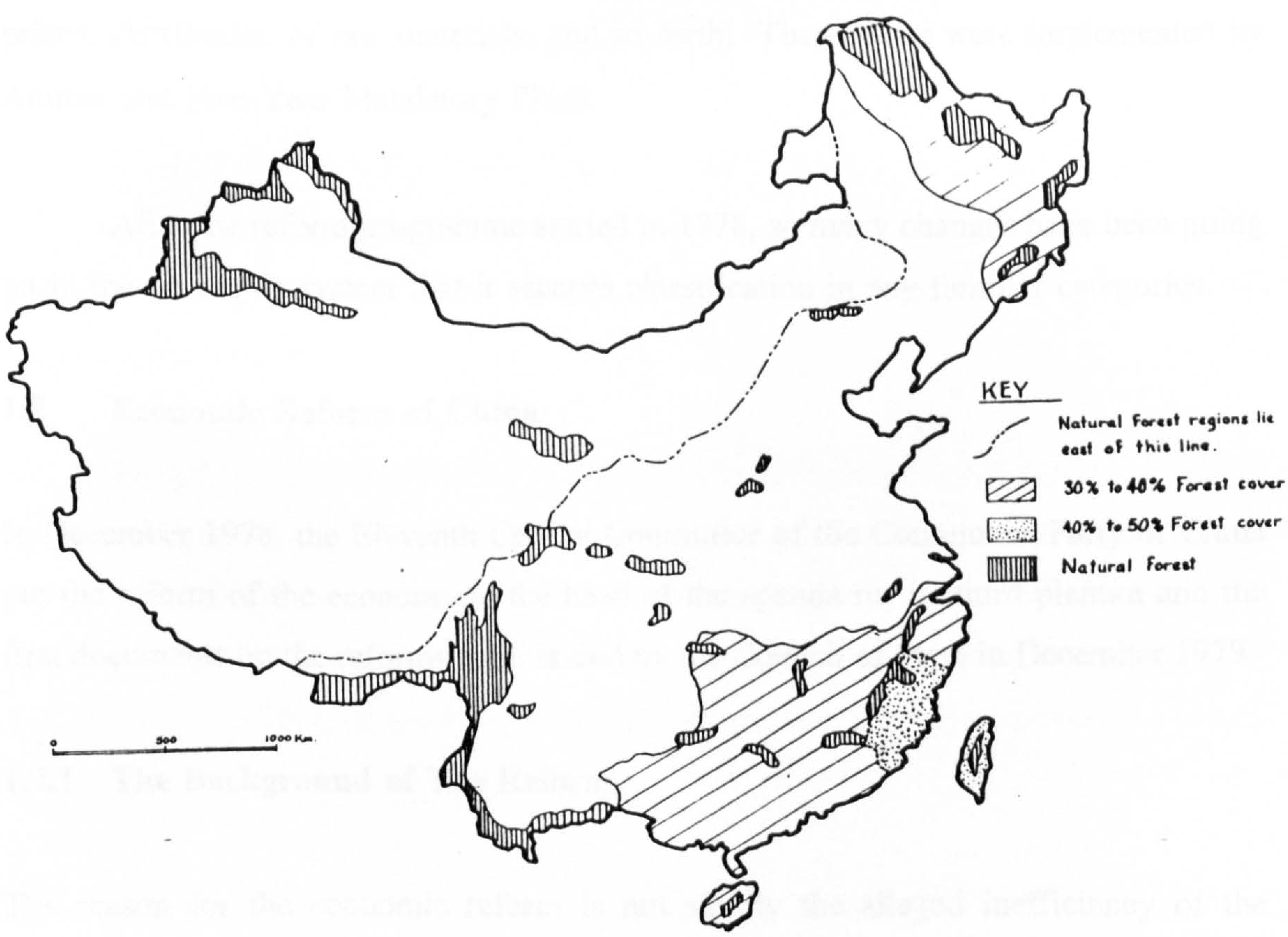
1.1 General
1.2 Economic Reform of China
  1.2.1 The Background of The Reform
  1.2.2 The Determinant Factors of Economic Reform
  1.2.3 Economic Reform and Its Progress
1.3 Growth and Change
  1.3.1 Objective
  1.3.2 Macroeconomic Changes and Problems
  1.3.3 Microeconomic Changes and Questions
  1.4 Market or Planned Economy: Problems and Debates
  1.4.1 Main Features of CPE System
  1.4.2 Obstacles to Developing the Market Under CPE System
1.5 Market or Planned Economy? A Dilemma

Theoretical discussions on economic system and modelling, either because of their perspectives or of practical difficulties, tend to provide concepts and models mostly in the abstract, which may not based on systematic analysis of problems in hand and have limited, if not harmful, applicability. Therefore, in this study, an effort is made to pay close attention to the specific economic system and concrete reality of the problems under discussion, in order to formulate a model that takes consideration of and reacts sensitively to such a complex issue as forest development policy in China. A comprehensive understanding of the economic system and its related policy as adopted in China in general and aspects of China's forest subsector in particular, will pave the way for a systematic sensitive analysis and modelling of the China's forest development policy, which is the key task of this thesis.

1.1. General

The People's Republic of China (PRC) is the third largest country in the world, extending 5200 km from east to west and 5000 km from north to south. The total area is 9.6 million square km. But only 11% of the land is arable, just 12% of her area is forested, and two-thirds of this is inaccessible.

China extends across the cold-temperate, temperate, warm-temperate, sub-tropical and tropical zones and has a climate suitable for many different species (Map 1).



Map 1. The People's Republic of China: Natural Forest Regions

China's massive population (1.2 billion in 1990) has more than doubled since 1949 and puts strains on forest resources. The construction industry is booming, adding more than a billion square metres of new construction each year, increasing the demand for forest products.

As many developing nations, China is basically a poor agricultural country. Over 70% of the population still lives in rural areas as self-sufficient peasant farmers. Although it has risen slightly in the past ten years, according to the World Bank (1990), the per capita national income averages $380.

China is a socialist country with centralised government which is under the leadership of the Central Committee of the Chinese Communist Party (CCP). Before 1978, the economy belonged to the category of the socialist command economic system, run under mandatory planning in all industrial sectors, including forestry and the forest product industry. State planners set wages, production quotas, distribution patterns, prices, distribution of raw materials, and so forth. These plans were implemented by Annual and Five-Year Mandatory Plans.

After the reform programme started in 1978, so many changes have been going on in the economic system that it escapes classification in any familiar categories.

1.2 Economic Reform of China

In December 1978, the Eleventh Central Committee of the Communist Party of China put the reform of the economy at the head of the agenda for its third plenum and the first documents on the reforms were issued by the Council of State in December 1979.

1.2.1 The Background of The Reform

The reason for the economic reform is not simply the alleged inefficiency of the previous 'model'. Contrariwise, the overall results obtained over the previous 25 years (1952-1978) are considerable, especially if we exclude the periods of the 'great leap forward' and the 'cultural revolution'. Recent official economic indicators suggest an overall rate of growth of national income between 1952 and 1978 (based on sectoral output) of 4.4% at 1981 prices. This is not a very high rate of growth, but it is respectable if these events of the period are taken into account, and income per head did rise by 2.5% per annum. As a whole, this period saw an expansion of 25% points in the share of industry in national product over the two decades. As K.C. Yeh (1988) points out, it took Great Britain 40 years (from 1901 to 1941) to increase its industrial share in national product by 11% points, and 45 years for Japan (1878-82 to 1923-27) to raise this indicator by 22% points. However, there were negative aspects:

(a) the poor progress of agricultural productivity due to rural over-population. Poor utilisation of the work force slowed down industrial development potential.

(b) a reduction of the share of services in the national product, which fell from 24.5% to 20.4% during the period under consideration, contrary to the experience of other developing countries.

(c) the growth not only of rural over-population but also of urban unemployment, which has not been properly estimated; by 1978 unemployment reached approximately 10 millions, out of a total working age population of 172 million in urban areas.

(d) the reduction in marginal efficiency of investment, which fell from 0.75 in 1962-65 to 0.25 in 1970-75, indicating a growing under-utilisation of capital due to the duplication of production capacity arising from the state of transport infrastructure. This under-utilisation is also linked to insufficient production of energy and raw materials, as well as the frequent breakdowns of overworked and poorly maintained plants.

1.2.2 The Determinant Factors of Economic Reform

The factors which directly determined the reform of the 'old model', inspired by the Soviet model established in the 1930s, are many. It would be a gross over-simplification to search for a single cause, or even to suggest that any one factor was more decisive than others. It is not even possible to establish a hierarchy of the factors which have influenced the adoption of the 'new economic course'; in effect, this 'adoption' was a continuous process during which the reform and economic measures interacted, so that each measure or reform was subject to influence of factors different from those which influenced the measures adopted early on. Among these factors there are certain consequences of the 'new course' itself, which frequently required further reform measures.

The principal factors which contributed directly to the economic reforms may be listed briefly as follows:

(1) factors connected to agricultural structures and policies. Among these factors, the system of communes with imperative planning was most harmful to agricultural production. The system obliged farmers to produce crops they considered to be unprofitable, and was not conducive to rapid agricultural development; the system also reduced investment to where it could have done most good (especially if it had received higher state purchasing prices) and discouraged local initiatives.

(2) the excess of effective demand over aggregate supply, due to an extremely centralised and inefficient planning system, to a very high rate of investment, and to a system of administered prices which did not reflect either the costs of production or the relation between supply and demand. These problems led to widespread scarcity and the imposition of rationing, as well as the growth of heavy bureaucratic apparatus and a deterioration in efficiency of resource use.

(3) the administration of 'detailed imperative planning' which grew more unrealistic to the extent that production became more complex and diversified, and involved an increasing waste of resources and the appearance of bottlenecks preventing the development of the economic sectors necessary for more rapid growth of production as a whole and a greater satisfaction of the basic needs of the population.

(4) a system of state enterprise administration which, faced by the demands of complex technologies and the need for diversification, did not leave initiatives to the

managers nor itself promote the absorption of new techniques and the modernisation of equipment, production systems and products.

The Third Plenum of the Eleventh Central Committee, held in December 1978, was the critical turning point. It was officially declared that the era of turbulent class struggles was over, and a new era of economic reform started.

1.2.3 Economic Reform and Its Progress

Compared with the situation before 1978, China's economic system has undergone significant changes. The most important change which has occurred during this period is the change in the ownership structure. The major changes in this respect include the popularisation of the household based production responsibility system in rural areas, the introduction of the management contract system in more than 90% state-owned enterprises, and the experimentation with stock ownership in a few state-owned enterprises. It is worth noticing that up to the end of 1988, the number of private commercial and industrial enterprises has reached 14.5 million, and more than 23.4 million population were employed in these private enterprises. In 1988, the total amount of transactions made by private enterprises was *Renminbi Yuan* (RMB¥) 128.8 billion , which, compared with only 0.15% in 1978, accounted for 13.84% of total retail sales in the whole country in that year. As a result of the above-mentioned changes, the patterns of economic behaviour of enterprises and households in China have changed significantly, and the pursuit of maximum benefit has become one of the major objectives of their economic activities.

The transformation from a highly centralised planned economy to a sort of mixed economy is another major change occurring in China's economy. The amount of products which are subject to mandatory plans has been reduced steadily. Up to 1984, the amount of products included in government plans had been decreased from several hundreds to 120; and since then the amount has been further lessened to 60. The amount of products allocated directly by the government was shortened from more than 200 in 1984 to less than 20 up to 1987. Furthermore, increasingly products which are still subject to government control have been allowed to be sold directly to markets by producers. Taking steel and plate as an example, 82% of the products is sold directly to market by producers. The corresponding figures for cement and coal are 48% and 25% respectively. Among agricultural products, the share of the products which are subject to floating or free prices is 85%; and the corresponding figure of factor inputs is 40%. The ratio of in-budget investment (namely the investment controlled by the central government) to the total investment of the whole economy was reduced from 80-90% in the past to 17.6% in 1988. In short, in recent years, the government's control over prices, investment and income distribution has been weakened significantly; and markets have been playing an increasingly important role in regulating the economy.

The third major change in China's economy is the further opening up to the outside world. China's total export and import was only $20.64 billion in 1978. In 1988, the corresponding figure reached as high as $102.86 billion in current prices. The annual growth rate of China's foreign trade has been about 20% in real terms in this period. It is worth noticing that the import structure has also undergone important changes. The import of raw materials has increased. For example, compared with the previous period (1976-1980), in the period from 1980 to 1985, the import of steel and plate expanded by 48.6%, and corresponding figures for timber, chemical material, fertiliser were 600.4%, 150.0%, and 84.2% respectively. In the same period, the number of items of technology transfer from foreign countries reached 1372, amounting to $4.956 billion. In the past, foreign investment was virtually non-existent, but the total foreign investment from 1979 to 1987 reached $10.956 billion. Foreign investment in 1988 alone was $2.6 billion.

Consequently, in Guangdong province alone, there are more than 2 million people who are employed by Hong Kong businessmen.

1.3 Growth and Change

1.3.1 Objective

China's ultimate economic objective is to catch up with the developed countries, while maintaining a socialist system in which the benefits of prosperity are widely shared. The objective envisaged in the near future is to give most Chinese people a relatively comfortable living standard and eliminate the worst manifestation of poverty. Toward this goal, quadrupling of agricultural and industrial output between 1980 and 2000 has been set as a target, with per capita GNP to increase from about $300 to $800 (in 1980 dollars).

It was witnessed that from 1979 to 1984, the initial period of economic reform, largely as a result of much accelerated agricultural growth, per capita national income grew at 6.8% per year.

1.3.2 Macroeconomic Changes and Problems

Ten years of economic reform have changed China's economic structure and have yielded marked results and important experience that can be roughly summed up as follows:

(1) Enterprises have acquired new strength and vitality through the expansion of forms of ownership, the possession of greater decision-making powers and the right to retain a greater share of their profits.

(2) The expansion of enterprises' decision-making powers and the decrease in the number of commodities subject to the state's mandatory planning and unified prices have steadily increased the role of the market mechanism.

(3) Accompanying the expansion of enterprises' decision-making powers and the formation of various markets, the government has been steadily replacing direct control of enterprises with indirect regulation through the market.

(4) In economic exchanges with other countries, the implementation of the open policy has freed China from a rigid and closed economy.

The changes in China's economic structure have had a powerful impact on the country's economic development. GNP, state revenue and average per-capita income have all more than doubled. Economically, the last decade has witnessed the most dynamic and rapid growth since new China was founded in 1949, while living standards have risen faster than ever before.

However, many problems have also occurred in China's economic life, of which three in particular have caused much discussion. The first is the emergence of inflation. Following the over-rapid economic growth of 1984, prices rose at an average annual rate of 7.3% for the following three years. Then in 1988, they jumped by 13%.

The second is unfair income distribution. On the one hand, income gaps between different trades or occupations have widened unreasonably, in particular with factory workers far outstripping government employees; on the other hand, for most Chinese income gaps have not been reasonably widened, with everyone earning an equal share regardless of their individual performance.

The third problem has been the increase in profiteering, corruption, bribery and abuse of power for personal gain, which have contributed to a drop in social morals across China.

1.3.3 Microeconomic Changes and Questions

The decision made by the Central Committee has identified the task of 'invigorating enterprises as the key to reforming the national economy', and acknowledges that 'socialism with Chinese characteristics, should, first and foremost, be able to install vitality into the enterprises.' Attention has been focused on state-owned enterprises; however, policy toward non-state enterprises -- collective and individual -- will also be critical in China's reform of the urban economy and could indirectly contribute to reform of state enterprises.

Over the past seven years, various reforms in the management of state-owned enterprises have been introduced, mostly on an experimental and piecemeal basis. These have included: enterprises retaining a proportion of profits for workers' bonuses, collective welfare expenditures and small-scale investment; some freedom for enterprises in selling part of their output and in securing inputs; some flexibility in setting price; recognition of marketing mechanism and competition among enterprises being crucial to efficient growth; and increases in management authority over production decisions and personal matters. These changes, similar to reforms tried in most socialist countries, have produced some good results. They represent only marginal changes, however, and the fundamental problem remains of the proper relationship between the state and the enterprise.

In the past, 'ownership by the whole people was taken to mean direct operation by state organs.' As a result, the relationship between the state organs and the enterprises was strictly hierarchical, with the former frequently interfering in, and even excessively and rigidly controlling enterprise operations. An important step has been taken, therefore, with the recognition in China that 'ownership right can be duly separated from operating right.' The direction of reform will be toward a more complex system of management in which a multitude of state agencies, as well as the enterprise itself, assume various responsibilities. Since the state retains the authority to determine the division of responsibilities among the various state organs, including enterprises, it will, of course, retain ultimate control.

Though the principle that state enterprises should have much greater autonomy than in the past is accepted, important and difficult questions remain:

(1) should it be confined to day-to-day operating and marketing decisions, or should it extend to appointment of managers, major investment and diversification decisions; and the right to close down part or all of the enterprises?

(2) how could or should the state regulate the activities of autonomous enterprises? what kind of social and economic system is necessary and critically important for government to monitor these enterprises? what should be the relationship between these enterprises and the governments or the ruling party, between managers, staff and workers?

All these questions relate to a broad institutional context. The reform will not go forward unless these questions are answered in practice. Reform will require not only changes in policy, but also fundamental change in the attitudes of many people. Socialist reform in China is at the cross-roads.

1.4 Market or Planned Economy: Problems and Debates

The market mechanism works in both capitalist economy and centrally planned economy (CPE). This has been acknowledged by most economists and authorities of governments in CPE nations (Sik, 1967). But because of different historical and institutional backgrounds, the scope and extensions of the market mechanism differ in the national economy.

The general attitude towards the market in China's economy was first explained in 1956 by Chen Yun as that "central planning is primary, market regulation is supplementary", which has been developed as the underpinning of the "bird-cage economy". This conception acknowledged the need for market-relation in a socialist economy. But it was a need seen as the converse of Western arguments in favour of planning and from opposite ends of the paradigmatic spectrum. Whereas Western advocates of planning regarded it as a correction to the limitation of markets, such as public goods, market failures due to externality and other problems of what is often related to the non-convexity of the production function, Chen Yun's ideas similarly but in a reciprocal fashion regarded the market as a corrective or supplement to cases of "planning failure", such as the impossibility of total central command planning (the so-called million equations problem). This conception tolerated market relations, but only at the periphery, and regarded central planning as dominant. Such a conception was shelved in 1984 without explicit replacement.

The net result of the host of measures introduced in 1984-86 was the creation of a transitional hybrid economic system which is partly command planning and partly market. Such a system comprised three constituent components distinguished by the degree of exposure to market force:

(a) enterprises fully subject to command planning;

(b) enterprises dictated by market forces, but with some obligatory targets of planning, and

(c) enterprises (all of them are collectively or privately owned) without obligatory targets and fully subject to the market.

But the effect of this was the lifting of dialectical obstacles to considerations of and experimentation with more radical conceptions of market-oriented reforms. Before moving to the discussion of the market mechanism in centrally planned system, like China's economy, it is worthwhile to depict the main elements and characteristics of the CPE system.

1.4.1 Main Features of CPE System

Generally speaking, the essential elements which define a centrally planned economic system and differentiate it from other systems are the following (Barnett, 1986; Sik, 1976):

1. Nationalization of resources and enterprises: almost all land and raw materials are owned by the state and the state is the major employer of labour in industrial, construction, communication, and commercial enterprises owned by the state. Households may be the basic unit of production in the agriculture sector and a large and active private sector may exist side by side with the state sector in the non-

agricultural economy. Nonetheless, state ownership of the means of production and economic units throughout the economy dominate economic activity. This is a basic principle of socialism.

2. The allocation of resources and operation of enterprises within the state sector is largely carried out according to centrally determined plans. The plans include the budget, credit plan, input allocation, output quotas, trade and transportation, foreign trade and employment. Those plans could be based on information or decisions made at a lower level of economic bureaucracy, or even the level of production units themselves. But no matter how strongly influenced by low levels, the plan is the result of conscious decisions about the central planners' priorities, concerning the allocation of resources and, once approved, is assigned as a target for the lower level units of production. These plans could also be assigned to production units outside the state sector, i.e. as quotas to be met by households. On the other hand, once it meets its target, a unit of production or enterprise in the state sector may produce for and sell on a private market. Nonetheless, in a centrally planned economic system, the planned allocation, i.e., production and economic activities undertaken to "meet the plan", of resources and commodities is determined by the preferences of the planners. This was the major purpose for originally developing the Soviet-type economic system.

3. Obviously, given the two principles above, prices play a very limited role in the allocation of resources. The importance of that role, theoretically speaking, may be acknowledged by academics, and even by some planners, but it is not the dominant one. Under this system, the plan targets are determined in quantities and as non-substitutable entities, while prices and values largely play an accounting function in the planned sector of the economy. When a gap appears between the supply and demand of an important commodity in the planned sector, the planner in the system reacts by changing the plan targets, not by changing prices. This is the vital difference.

Bearing in mind these characteristics of the economic system listed above and referring to China's economic reform highlighted in the previous part of this chapter, one may draw a conclusion without much difficulty that the economic reforms undergone in China attempt to increase the efficiency of the economy while maintaining the main feature of the centrally planned economy. In order to overcome the problems that occurred under an over-centralised, too rigidly controlled and inefficient economic system, a combination of the planned economy and market mechanism has been proposed and is being carried out. But it is obvious that this system will not simply work without further changes required in the institutional system where some inevitable obstacles originate.

1.4.2 Obstacles to Developing the Market Under CPE System

After ten years of reform, China's economic situation has changed. It is, however, too early even to consider China's economy as a market system as some forest economists did in the IIASA Model of the Global Forest Sector, widely known as the Global Trade Model (GTM) (Kallio, etc., 1987). During the past decade, the centralised administrative control system has been broken down, and the economy has been given more free performance than ever. While the old system could not operate effectively, the new market-oriented system has not yet been fully established. As a result, it is very difficult to rationalize the allocation of resources in various sectors, regions and enterprises. There are several serious obstacles which misallocate and waste scarce resources:

1. Mechanism obstacle. The market mechanism is of course by no means the only pricing mechanism, but the latter is the fundamental and principal content of the former. Economic reform in China was mostly focused on pricing reform in the past few years by the release of price controls for many goods. The partial liberalisation of the price system results in the "dual-pricing" system which in some sectors, including forestry, is in fact a "triple-pricing" system. That means:

- i the pricing system is only partially opened, in which some commodities are traded at the market, while others still under administrative control;
- ii within one commodity, there are market (floating) prices and planned (fixed) prices. (In some cases, there is also plan-regulated prices which

is one kind of planned prices used for regulating market. Planned prices can be either ceiling prices or floor prices depending upon cases).

The state planned price system is a hangover from the rigid pricing mechanisms solely used by the central government until 1979. Once set, prices were extremely hard to readjust.

Within the last seven years the government has introduced a floating price in the wood market, which is about double the state allocation price, and takes into account stumpage values for standing timber, accurately reflects processing and transportation costs, and allows for profits (Liu and Jin, 1989). Price ceilings for floating prices are set by the government.

The "dual-pricing" system forms the basic pricing structure throughout China. Although there are various pricing levels between these two, they are not consistent from area to area, and usually do not fall lower than low state planned prices, or exceed the high floating prices.

This system has seriously distorted the price system. Its impacts have been threefold:

a an abnormal phenomenon under the "planned price system" is that the more the products are in short supply, the lower their relative prices are. In forestry, this has stimulated the expansion drive of the profitable manufacturing industries as they can buy raw materials at fixed prices and has discouraged the resources regeneration and protection because of the low stumpage price;

b the multiple prices of the same kind of product under the system have provided a basis for the activities of those using the distribution power of administrations and various price gaps (including differences in commodity prices, interest rates and foreign exchange rate) to seek exorbitant profits, and thus disturb the economic order;

c the price reform as at its initial stage was limited to structural adjustment of pricing through administrative means, and the original mechanism has not been changed very much. In other words, with regard to price levels, the new pricing system rarely works effectively to relate demand and supply. This aspect of the price reform was still desired in the later stages.

2. The obstacle from regional or sectional separatist regime. The excessive delegating downward of the central government's power on the basis of indistinguishability between government administration and enterprise management turns administrations (including local governments and ministries) into entities which combine government administration with enterprise management. Since the introduction of the system of separating budgets for the central government and local authorities (*Fen zao chi fan*, separating canteens for meals) in 1980, localities have raced to put up their own establishments and "independent industrial system", and have used their administrative power to monopolize low-cost raw materials and set up their own processing manufactures. This has restrained the comparative advantages of various regions and deteriorated the regional structure of economic specialisation and the economy. In addition, government intervention obviously has trends of anti-marketing. Under the centrally planned economic system, this intervention could be strong enough to destroy the rational marketing force, i.e., most of material coordinating and the compensating trade, if not all, is taken between regional material departments on behalf of their own governments. These actions are taken not just to prevent market failure, but also to obtain regional interests on some dubious specific principles, such as official 'achievements', institutional power, etc.

3. The obstacle from the functions of State-owned enterprises. The state-owned enterprises were, and still are, the main body of marketing in China. A slight competitive aspect introduced since economic reform has already made those enterprises uneasy. The problem may come from the government's unrealistic expectation - to change the functions of State-owned enterprises from a dominant force within a planned economy to the combination of both the market competitor and the adjuster of market price, demand and supply in a mixed economy. Given China's current circumstances, it may be true that the desired economic goals can not be achieved by free markets or simply by market regulation via indirect levers such as interest rates, taxes and subsidies, important as these are in guiding the economy. Indeed, a great deal of

government intervention in the market occurs through enhancing the role of state-owned enterprises. But the key issue is that most of the state enterprises are under administrative management, and have no competitive power in the market. With this restriction, how can they be expected to play a role in the market as an adjustor? If the government takes all losses of these enterprises, the outcome will be entirely against the original purpose of the reform, and will destroy the whole market environment.

4. The obstacle from marketing organisations. In the initial stage of reform, the State-owned enterprises, as a mixture of official body and enterprise, were the only source of market organizers with a monopoly force. With the rapid development of the private and collective economies, on the one hand, a large number of sellers and buyers have participated in the market competition and are pushing the economy in the market-oriented direction; on the other hand, the institutional defects and the backward capital construction, including limited transportation capacity, have limited the development of markets. In this circumstance, the market mechanism in China's economy is inherently deficient.

5. The obstacle from the scarcity of resources. In a big country like China, the existence of a strong desire for rapid development is very natural. However, given a large population and poor possession of natural resources per capita, with less development of the fundamental sectors (such as agriculture, energy and transportation industries) and more advanced development of some sectors (e.g., heavy industry), China's economy has distinct characteristics of large resources consumption. The government has to resort to its administrative power to distribute the scarce resources to differing sectors according to their priorities. Therefore, in a short-supplied economy with the socialist ideology, only part of commodities can freely enter the market; even for those, the market mechanism may not be fulfilled entirely in a regular manner. The proportion of traded goods is so small that it restricts the growth and development of the marketing system.

In conclusion, a major virtue of a market system is that it performs a check-and-balances function to enhance allocating efficiency, but this attribute of the market system in China's economy has been negated by the failure to address fundamental issues. The market in China currently operates largely in an asymmetric fashion: it provides new opportunities for production and investment, but can not perform a penalising or controlling function.

1.5 Market or Planned Economy? A Dilemma

Theoretically, a planned economy does not develop in an elementary way, but its development is guided and directed by the conscious will of organized society. Planning is the means of subjecting the operation of economic law and economic development of society to the direction of human will. In the initial step of the rapid industrialization process, China, like most undeveloped and socialist countries, faced a political requirement of national defence and strived to solve all kinds of political and social problems due to backwardness. Therefore, it was necessary for the country to adopt the planned economic system with centralised disposal of resources, in order to concentrate all resources on certain objectives. But the system described as a method of *sui generis* war economy (Lange, 1965) becomes an obstacle to further economic progress when it is perpetrated beyond its historic justification, as has been mentioned above. It is rigid, and leads therefore to the waste of resources resulting from its inflexibility; it requires a wasteful bureaucratic apparatus and makes it difficult to adjust production to the needs of population. However, it seems that the greatest obstacle to further development comes from the lack of adequate economic incentives in this bureaucratic centralisation type of management. This hampers proper economic utilisation of resources, encourages waste and also hinders technical progress.

Changes in the methods of planning and the management of the economy, as one of the economic reforming contents, occurs today in all commanded or planned economic systems, although ways, contents and directions of these reforms differ from each other. All those nations now acknowledge that the market mechanism plays an inevitable role. But it would be naive to think, as many economists both in the West and in socialist countries do, that the transformation from planned system to market mechanism is the only prescription for curing all socialist diseases. The third way, planned market economy as described by Sik (1976), still exists, because of both market failure and planning obstacles. This has been proved by experiences in both the Western world and socialist countries.

In terms of economic use of resources and equilibrium of demand and supply, there is a big difference in different economic systems. The state of equilibrium can be reached at either a higher level or a lower level (namely surplus equilibrium or short equilibrium). From resource economics' viewpoint, neither the former nor the latter is better. The normative economists like to use economic jargon to define the economic use of resources, such as: to maximize utility by consuming a given amount of resources; or to achieve a certain amount of utility by using minimum resources. But this is meaningless unless given a clear definition of the concept of utility and an applied and proper method to measure and combine the utility for different consumers and/or in different periods. While it is irrational for the developed nations to increase consumption by using increasing energy to gain higher productivity, it is no better for the developing socialist countries to waste more resources to produce a unit of products. For any country, developed or developing, resources (i.e. land, labour and capital) used to produce goods and services are not available in unlimited supply. The scarcity of resources leads inevitably to the need to make a series of choices about quantities of different commodities and about the way in which those commodities are to be produced. Given a country's limited resources, to produce one unit of those goods at a cost of more resources means to reduce the opportunity for producing more or alternative goods which could have otherwise been produced. This is to say, the unit of goods is produced at a high opportunity cost of resources; high opportunity cost results in low productivity, hence in less satisfaction of society. In many developing countries, for a variety of institutional or ideological reasons, actual resource prices are a poor reflection of their economic scarcities. In some developing socialist countries, prices of natural resources themselves are to be measured as zero, as it is believed that natural resources do not embody any labour input. Low (even zero) prices of resources result in a huge waste, this is also the case in China. For example, Prybla (1986) reported that China used three times more energy per unit of national income than any other country in the world, production was "at an enormous expenditure of waste, monumental waste ...".

In fact, there are two kinds of disequilibrium: micro-disequilibrium and macro-disequilibrium. The former occurs within the commodity production sector (including consumption goods and production goods). It can be observed from the market and can be adjusted by the market mechanism. The latter happens between production sectors and consumption sectors, i.e., between aggregate demand and aggregate supply of production goods and consumption goods, between private goods and public goods. The disequilibrium may stem from unfair distribution, irrational sector structure, regional structure and industrial organisation structure, as well as low operational efficiency. This sort of disequilibrium has broad and long-term effects. Solving this problem depends not only on the income distribution policies, but also on the price policy, the investment policy, and so forth. All of these show that market and planning could be muturely supplementary, and not always in conflict with each other.

The market mechanism plays a role of regulation to balance the economy. This function, as Lange (1970) pointed out, has two features: divergency and convergency, which are based on positive and negative performance of a great number of micro-economic units in market. The market has a built-in tendency to reach economic equilibrium through the price mechanism which serves to ration goods among consumers and to provide incentives for production. However, market failure arises when the equilibrium generated by a free unregulated market fails to produce a socially efficient allocation of resources. This is mainly because of:

(1) an individual unit rarely makes any decision or takes any action entirely according to their own willingness or criteria (private cost), while a society measures social cost based on the opportunity cost to the whole society of the resources that firms use. Frequently, divergences occur between private and social cost;

(2) unfavourable social-protection system, such as imperfect (or entirely lacking) legislation or institutional rules, disturbance of monopoly factors in market;

(3) lack of (or misguided) information which results in misunderstanding or wrong decision-making. In that case, markets will not work efficiently if consumers/producers are misinformed about the products they buy/sell ;

(4) existence of a large proportion of external economy. Externalities arise when one individual's production or consumption decisions affect either the production or consumption decisions or the welfare of other individuals other than through market prices; and

(5) certain goods or services. If they provide benefits to anyone, they necessarily provide them to a large group of people. Such goods are called public (or collective consumption) goods, and in general have important social value, but the value does not reflect in market prices. For example, education and health services are provided at low prices, or even free of charge. Thus there is no incentive mechanism for individual producers to produce those commodities. This is particularly true in many developing countries where social services are very poor.

Since the existence of these poses the threat of market failure, government planning (which is no more than avoiding the market failure, promoting the rationale of social production and regulating and strengthening the function of the market mechanism) becomes necessary.

On the other hand, it is worthwhile, here, to remember what Lenin said about the market: "wherever the commodity production exists, there must be the marketing". If Lenin's idea is correct, there is no reason to exclude the market mechanism from planned production in such a system. However, it must be pointed out that in socialist countries, like China, the market mechanism does not solely exist and act due to the realm of what can be broadly called the political and economic "culture"; and government planning would not work if there was no market regulation as it is an "invisible" hand. It is in this sense that the socialist economy should be the planned market economy based on the dual mechanism.

The planned market economy here means that:

(1) This is a market economy with planning implementation, not a market economy which is entirely regulated by market forces. The market economy is in general a surplus-economy owing to highly unequal distributions of income and power, but the planned economy is a short-economy which results from the inefficiency of the command controlled system. Therefore, to solve the problems of macro-equilibrium depends not only on the readjustment of income distribution, but also on the regulation of production structure in order to increase supply to meet the increased demand.

(2) Market forces completely regulate production and exchange in most sectors except some which play important roles in some critical aspects of a society and may be not suitable to be regulated by market mechanism or to be entirely controlled by private decisions, or which may not be operated effectively by private individuals because of long-run capital return with low marketing benefits. Operational planning and effective direction of the development of the national economy are quite possible without planning in detail. The plan is a method of macro-control at the high (say national) level which determines the general rate of economic growth by the division of national income between accumulation and consumption, and determines the direction of economic development by the allocation of investments to the different branches of the economy.

(3) Planning must take account of underlying economic laws which show naturally the economic relationship between different aspects (such as input and output; demand, supply and prices; substitution and prices, timing preference; and so forth). It is in this sense that market mechanism should play a principal role in the economy and the planning should play a supplementary role to the market mechanism.

(4) The market price must obviously be such as to establish equilibrium on the market to equalise demand and supply, and must indicate the scarcity of resources and the difference in quality of some products.

(5) Within the system, different ownerships are allowed to exist and should be in an equal position with regard to competition. It is evidenced by the past experience of

socialist countries (Liu, 1991) that an economic system with only state ownership or common ownership is not a complete and healthy one, since it has been proved that common ownership is actually non-ownership, and this is one of the important reasons why the economic efficiency in the planned economy was so low.

Based on the argument above, the question of the economic system in China should no longer be what is the choice between the planned and market system, but what is their scope, how does planning correct the market failure, and what are the methods which ensure the realisation of the plan?

In sum, the misunderstanding of the functions of planning and market mechanism for many economists was the neglect of the difference between macro- and micro-disequilibrium, excepting the ideological reasons. The market mechanism, which is the most effective measure to balance micro-disequilibrium, has some crucial limitations, so-called market failures, which limit the equitable distribution of income and the maximisation of social welfare; similarly, planning, which is a capable means of regulating the macro-disequilibrium, cannot replace the market mechanism, which is a device that, when working well, can play a positive role to balance demand and supply through the price mechanism. Wherever the exchange of a commodity exists, there must be a market mechanism dominating the whole process of exchange. Market mechanism is not the bourgeoisie's patent, China should not be fretted or puzzled by the ideological dilemma, but should adopt the market mechanism in her drive towards what is called a "socialist market economy".

CHAPTER 2

FOREST ECONOMY SUB-SECTOR

This chapter highlights the following points:

2.1 General Introduction
2.2 Forest Resources
  2.2.1 Main Characteristics
  2.2.2 Annual Growth and Reverses
  2.2.3 Forest Resource Consumption
  2.2.4 Man-made Forests
2.3 Administrative Structure and Wood Product Balance Planning
  2.3.1 Administrative Structure
  2.3.2 Wood Product Balance Planning
2.4 Distribution and Allocation System
  2.4.1 The Unified Distribution System (UDS)
  2.4.2 The Distribution Process Through UDS
  2.4.3 Demand and Supply of Wood Products under UDS
2.5 Price System and Price Levels
2.6 Wood Trade: Evolution and Current Situation
  2.6.1 Evolution of Wood Trade
  2.6.2 Current Situation
  2.6.3 Import Control

2.1. General Introduction

Forestry is an important part of China's agricultural economy. In addition to providing timber and timber products, forests regulate weather conditions, preserve soil and water, act as a barrier to wind and shifting sands, protect fauna, promote farm and animal husbandry production by providing environmental protection and food, and play an important ecological role. Moreover, given the rising unemployment among school-leavers and the uncontrollable rural population expansion, the roles that forestry plays in several other aspects remain as important as ever in the economy, and may grow in social as well as economic value, particularly in creating new employment and in meeting the needs of the rural poor -- whether through multipurpose trees, fuelwood, jobs, income, or economic use of land. These new contributions of forestry, among other sectors, to economic development in China have been recognised by both the local people and visitors (Richardson, 1990).

China's vast land area is suitable for various kinds of tree growth, and large areas of land remain to be opened up. At present, there are some 2,800 varieties of trees, including species unique to China such as dawn redwood, water pine, Taiwan cedar, Fujian cypress, and Chinese cedar. The most economically valuable non-wood products are tung-oil, tea-oil, Chinese tallow, varnish, rubber, and eucommia trees. The main broadleaf timber trees include, black walnut, camphor, and manmu trees.

Three thousand years ago, the country was largely covered by forests. However, natural disasters (such as forest insects and diseases) and human factors (such as the great increase in population, indiscriminate felling, and the damage caused by fires, war and domestic upheaval) have seriously depleted the forest resources.

In 1949 when the Communist government took power, China was confronted with a whole range of forestry problems, although what the exact situation was is still arguable (see next section of this Chapter for detail). It is fair to say that the new government had long been aware of at least some of these problems, and that efforts had been undertaken towards afforestation since then. Nevertheless, the outcome of the efforts had been dichotomic: on the one hand, the importance of forest protection and afforestation laid down in the first and most important document of the new government (Article 34 of the Common Programme of the Chinese People's Political Consultative Assembly), and a campaign, called 'making green the motherland', to mobilize mass participation in tree-planting activities, had been launched and continued since the 1950s. Consequently, enormous numbers of trees were planted every year. On the other hand, the results of the mass movement were rather disappointing: the survival rate was about 25% according to Yong, a former minister of forestry. The reasons for the low survival rate were many (Li, 1961), but the most critical one, which can be spoken out only recently, was the policy failure. For example, producers did not possess the ownership of the trees they planted, and the subsidies farmers obtained from plantation was based not on its success rates, but instead on the number of trees they planted. Moreover, the forest depletion had been accelerated by the political movements including the collective movement in the mid-1950s, the Great Leap Forward at the end of 1950s, the Cultural Revolution, and even the early stage of the current reform. These power transformations (either centralisation or decentralization) or ownership switch-overs were invariably accompanied by severe deforestation. Consequently, the immense efforts in forestry, as well as in overall economic development, had been offset by the political catastrophes -- forestry development in China today is under appallingly poor conditions.

There is little doubt that the crisis is real, despite the apparently enormous extent of China's forest resources in absolute terms. Although the forest land area is more or less equal to that of the United State and is exceeded only by the former USSR, Brazil, and Canada, when it is expressed per capita, the crisis comes into focus. With the rapidly increasing demand for wood products required by the present fast economic growth, and with the limited foreign exchange and experience of international forestry and wood trade, how China can solve the problems is a comprehensive question involving many economic policy issues.

What follows is a detailed description and discussion of three broad aspects: forest resources (2.2) which will be treated as endogenous factors in later parts of the thesis, administrative structure and its associated systems (2.3, 2.4 & 2.5) to be treated partly as endogenous variables and partly as exogenous variables, and wood trade (2.6) treated mostly as exogenous factors in this study.

2.2. Forest Resources

2.2.1. The Main Characteristics of Forest Resources

The main characteristics of China's forest resources are their insufficiency, their uneven distribution over the country, and the inadequate protection they provide to agriculture, animal husbandry and the environment (including recreation). China has large areas of mountainous land, but only a small area of forests (115 million ha) with a total standing volume of 9.3 billion m^3. Taking into account of population in China, the problem of forest shortage in China is acute (Table 2.1).

Table 2.1 Comparison of China's Forest Resources with the World Average

	Cover %	Area (ha)/capita	Volume m^3/capita
China	12.7	0.12	9
World average	22.0	0.78	65
Difference	-9.3	-0.65	-56

Source: State Statistics Bureau (1985), *Statistics Year-book*, Beijing.

The percentage of forest cover rate is lower than the world average of 22%, and the per capita areas of forest and growing stock volume are also very low, namely, 0.12 ha and 9.3 m^3 respectively.

A second characteristic of forestry is the large percentage of timber producing forests and the small proportion of non-timber tree crops, fuel and shelter forests in the total forested area (Table 2.2).

Table 2.2 The Composition of China's Forest Area

	Area		Storage	
	million ha	%	million m^3	%
Timber producing	80.63	73.2	7783.9	86.2
Shelter	10.00	9.1	1002.3	11.1
Fuel	3.69	3.4	81.3	0.9
Non-timber tree crops	11.28	10.2	NA	NA
Special use	1.30	1.2	162.5	1.8
Bamboo	3.20	2.9	NA	NA
TOTAL	115.00	100.0	9030.0	100.0

Source: Ministry of Agriculture (1985), *China's Agricultural Year-Book.*

Although timber producing forests account for a large percentage of the total, they are poor in quality. Most are natural forests, which cover 80 million ha and have been depleted by excessive felling and insufficient replanting. Natural forests are expected to remain the primary source of timber production for another 10 years. Sustained yield is the goal, with a harvest ceiling set at 50 million m^3 yearly. Of the timber producing forests, the 'old' class accounted for 69.3% of forest stock, the 'mid-aged' 23.7%, and the saplings 7.0%. Thus the forest reserve will be low (Zhai & Yin, 1981). Theoretically, natural forests could supply nearly all of the current demand for timber products, but the problem of accessibility limits the economic usefulness of many stands. Forest plantations are expected to become the major source of China's timber in the near future.

Thirdly, the feature of China's forestry is geographically uneven distribution (Map 1, and Table 2.3). Natural forests in China are restricted to mountains and areas difficult to access.

Table 2.3 China's Timber Reserves and Forest Area by Province

Province	Region	Timber Reserves			Forest Area			Forest cover rate	
		bill. m^3	%	Rank	mill. ha	%	Rank	%	Rank
HLJ	N. east	1.44	16	1	15.3	13.3	1	34	3
Tibet	S. west	1.40	16	2	6.3	5.0	6	5	22
Yunnan	S. west	1.10	12	3	9.2	8.0	3	24	9
Sichuan	S. west	1.05	12	4	6.8	6.0	5	12	15
I. Mongo.	N. east	0.85	9	5	13.7	12.0	2	12	16
Jilin	N. east	0.66	7	6	6.1	5.0	7	32	6
Fujian	S. east	0.30	3	7	4.5	4.0	11	37	1
Shannxi	Central	0.25	3	8	4.5	4.0	12	22	11
Jiangxi	South	0.24	3	9	5.5	5.0	9	33	4
Guangxi	South	0.22	2	10	5.2	5.0	10	22	10
others		1.52	17		37.9	33.0			
TOTAL		9.03	100	–	115.0	100.0	–	12	–

Source: *Agricultural Year-Book*, 1985. FAO, from survey in 1977-1981.

The predominant industrial timber supply area lies in the north east horseshoe of mountains bounded by the Greater and Lesser Xingan and Changbai ranges in Heilongjiang, Inner Mongolia and Jilin provinces. Other forest-rich areas lie in the upper reaches of Yangtze River (Sichuan, Yunnan) and in the mountainous south west plateau (Tibet).

Finally, China's forestry is characterised by the extensive and poor management. This can be illustrated from the following five aspects:

(1) Low survival rate in plantation

It is now widely believed, by both officials and scholars in China that from 1949 to 1979 the afforested area was about 90 million ha, but the current area of new woodlands was less than 30 million ha in 1979. This is to say, the survival rate of afforestation was somewhere between 25-30% (Yong, 1981, 1985; Zhai & Yin, 1981).

(2) Huge fire loss

It is estimated that from 1949 to 1979, 10 million ha of forest was destroyed by fire, resulting in a loss of 240 million m^3 of timber capacity and RMB¥8.85 billion (Wang & Lin, 1981). The estimated loss excludes the loss from a more serious fire in Heilongjiang province in 1987 as mentioned earlier.

(3) Wide spread disease and insect attacks

According to the MOF, the area affected by tree disease and attacks from insects and pests is about three times as high as the area damaged by forest fires, has been increasing every year and reached about one-quarter of the afforested area at present. About 2.67 million ha of pines are infested by pine moths. Poplars and Kirks have also been seriously harmed by plant diseases and insects, with more than 0.33 million ha of them being destroyed every year, leading to a loss of 10 million m^3 of wood.

(4) Low land utilisation

Of the total forested area, only 47.3% (i.e., 122 million ha) is productive woodland. This shows a very low land utilisation compared with some developed countries, e.g. 94.97% in the USA and near 100% in the former FR Germany and Japan (Zhai & Yin, 1981).

(5) Illegal and inefficient logging

In 1986, this amounted to almost twice as much as the state planned consumption.

There may be technical and technological causes behind the poor management. Richardson (1987), for example, summarised the reasons for low survival rate of afforestation as:

(1) prodigious numbers of trees were planted, but sites were not well chosen,

(2) seed sources were unselected and tending after planting was virtually ignored.

But most Chinese foresters believe that the main reason for the failure lies in policy and management aspects, and in the lack of incentives for producers.

Presently, the nation's strategic focus of forestry development is on the southern forest region, including the provinces of Hunan, Hubei, Anhui, Jiangxi, Zhejiang, Fujian, Guangdong, and Guizhou, and the Guangxi Autonomous Region. This area has a long tradition of forest production and trade. Most of the forests in the region are man-made and widespread, and a large percentage of the forested area consists of non-timber tree crops and bamboo groves. Due to its geographic features such as low hills and a convenient water transportation network, and due to its sub-tropical climate, forest production in this region has the feature of intensive management, high survival rate of plantation and high natural productivity. Because the management and felling of forests are decentralised and on a small scale, timber products are close to the main consumer areas and forest regeneration is carried out properly, but the labour productivity is low.

The region has been traditionally one of the main timber supply bases in China, and nowadays it produces 20% of the country's total output of timber each year, second only to the northeast region. Nevertheless, because of its increasing high population density and intensive land management, the potential of forest development in this region may be very limited.

2.2.2. Annual Growth and Reserves

It is difficult to estimate the overall annual increment of China's forests; the government's requirement that provincial production limits must not exceed their annual growth is impossible to enforce or to monitor. Various statistics about resource growth/consumption in China have been published by FAO, the World Bank and the MOF, but these statistics generally relate to plantations, not natural stands, and highlight potential rather than actual growth rates. Table 2.4 gives a token selection of mean annual increment data for three provinces in which a World Bank forestry development project is operating. They are optimistic, and cannot be applied directly to existing plantations.

Table 2.4 Tree Species, Mean Annual Increments and Rotations by Province

Region	Species	Mean Annual Growth (m^3/ha)	Rotation (year)
HLJ	Larch	6.0	40
HLJ	Korean pine	6.0	40
HLJ	Scots pine	4.0	50
HLJ	Manchu. ash	4.0	50
HLJ	Manchu. walnut	4.0	50
Sichuan	Chinese fir	7.5	25-30
Sichuan	Armand's pine	6.0	30-35
Sichuan	Japanese cedar	11.0	30-35
Guangdong (North)	Chinese fire	5.0	25-30
Guangdong (North)	Masson's pine	6.0	30-35
Guangdong (South)	Euca. exserta	12.0	15
Guangdong (South)	Euca. citriodora	12.0	20
Guangdong (South)	Euca. leizhou No.1	15.0	20

Source: World Bank, 1985.

Various statistics are cited for total annual growth in China's forests. According to NFPA (National Forest Products Association), the overall annual volume growth is 220 million m^3, the growth rate is only about 2.88% and 180 million m^3 of forest growth is in the commercial timber producing forests. Consumption of domestic reserves is about 290 million m^3 per year, 32% more than annual growth, and 61% more than growth in the commercial timber producing forests. High quality accessible reserves are diminishing. In Heilongjiang (HLJ), which has 16% of total timber reserves, for example, reserves have fallen 38%, from 2.5 billion m^3 in the mid-70s to the present level of 1.44 billion m^3. Eight of the 40 forest stations under the provincial Department of Forestry have already exhausted supplies, and 22 others will have nothing to cut by 2005. It is estimated that exploitable reserves in HLJ could actually be as low as 400 million m^3.

Commercial timber producing forests account for 73% of all forest land, or 83.95 million ha. The timber reserves are 7.7 billion m^3 with a density of 92 m^3 per ha. However, insomuch as more than 60% of these timber producing forests are inaccessible, these figures do not represent realistic commercial potential. Actual yield from exploitable areas is estimated to average between 35-45 m^3 per ha. The distribution of timber reserves is unbalanced, with mature and close to maturity stands accounting for 77% of reserves (Table 2.5).

Table 2.5 Ages of China's Commercial Timber Reserves by Area and Quantity

Type	Area (million ha)	%	Reserves (bill. m^3)	%
Young growth	28.4	34	0.62	8
Middle growth	30.1	36	2.33	30
(close to maturity)	(6.0)		(1.2)	(15)
Mature and over-mature growth	25.2	30	4.75	62
TOTAL	83.6	100	7.70	100

Source: *Contemporary China's Forestry*, 1985.

2.2.3. Forest Resource Consumption

There is variation in estimates of wood products consumption - depending on what is included within the definition. A time series based on different sources is given in Table 2.6.

Table 2.6 Industrial Roundwood Production (Plan) in China (1979-1985)

Unit: million m^3.

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
FAO	48.4	50.8	53.8	56.0	58.8	61.7	64.1	67.3	70.7	71.7	-
NFPA	-	-	-	-	47.0	54.0	49.0	50.0	52.0	64.0	67.0
MOF(1)	47.0	45.7	49.8	51.6	54.4	53.6	49.4	50.4	52.5	63.8	63.2
MOF(2)	41.3	-	-	44.2	46.9	46.7	42.54	3.4	44.8	52.3	53.4

Notes: MOF(2) excludes pulpwood and industrial fuelwood.
Source: Richardson D. (1986), *The Cotchell Report*.

In 1985 roundwood harvest was 63.23 million m^3. This was a 73% increase in production since 1981. The most important producers of roundwood in China are listed in Table 2.7.

Table 2.7 Roundwood Harvest by Province, 1979-1985

Unit: million m^3.

Province	Location	1979	1980	1981	1982	1983	1984	1985	1986	In'84
Total	--	54.4	43.6	59.4	50.4	52.2	63.8	63.2	65.0	--
HLJ	NE	14	16	15	16	16	17	--	--	1
Fujian	SE	4	4	4	3	4	7	--	--	2
Jilin	NE	5	6	6	6	6	6	--	--	3
I.Mongolia	NE	3	4	4	4	5	5	--	--	4
Sichuan	SW	4	4	3	3	4	5	--	--	5
Guangdong	SE	2	3	3	3	4	5	--	--	6
Human	S	2	2	2	2	2	4	--	--	7
Jiangxi	S	3	3	3	3	3	4	--	--	8
Yunnan	SW	2	2	2	2	2	3	--	--	9
Zhejiang	SE	1	1	1	1	1	2	--	--	10

Source: MOF (1987), *Statistics of China's Forestry.*

Of harvested wood in 1986, 65 million m^3 was for planned consumption in priority state industrial and capital construction projects. It is estimated that outside the plan another 50 million m^3 was harvested for fuelwood and 70 million m^3 for agricultural industry. Another 100 million m^3 was cut illegally, or lost to fires, inefficient logging, and so forth.

Within all consumption of roundwood, it is also estimated that fuelwood consumes over 30% of China's roundwood per year. Fifty million m^3 is known to be distributed annually as firewood and that at least an additional 40 million m^3 of commercial timber is used from other harvests outside the State Harvest Plan. In spite of those high consumption levels, experts admit that 42% of the peasants lack fuelwood for 3 months every year.

Other agricultural uses of wood consume an estimated 70 million m^3 annually. At least 45 million m^3 of this wood goes into the 9-10 million rural housing starts a year. The remainder is believed to contribute to agricultural industries -- workshop, tools, irrigation projects, and so on.

2.2.4. Man-made Forests

As the problem of supply and demand for wood products becomes more and more severe, it is hoped that the need of the nation for the ever increasing flow of goods and services from forest can be ensured through the national management of existing forests and especially through the creation of new man-made forests.

It is fair to say that huge numbers of trees were planted and the afforestation campaign was the most ambitious in world history. But the effects of these efforts are another matter. Table 2.8 gives an MOF time series for plantations, together with the proportions of various types.

Table 2.8 Area of Planting Per Annum

Unit: 1000 ha.

Year	Timber	Economic Crops	Shelter	Other	TOTAL
1957	1733	1350	993	279	4355
1964	1392	824	437	258	2911
1975	3651	532	428	363	4974
1978	3130	881	418	61	4496
1980	2927	824	514	287	4552
1981	2531	629	637	313	4190
1982	2631	652	863	350	4496
1983	3825	1100	822	597	6324
1984	3500	600	1000	500	5600
1985	4000	500	1000	500	6000

Source: MOF, (1985) *Statistics of China's Forest.*

Given the current situation of China's forest resources, how much success China has achieved during the past four decades entirely depends on how much forest resource there was in the end of the 1940s before the communist party took power. Some economists, both in China and in the West, accept the current government's inconsistent claims. Various official sources put the forest cover in 1949-50 as low as 5% (Westoby, 1987) and as high as 8.6% (Yue, 1980). However, these figures are questionable. Indeed, there are many reasons for disputing the statement:

1. According to the nationalist (Kong Ming Tang) government's statistics, the forest cover rate in 1949 was 13.1% (Huang, *et al.* 1984).

2 It has been admitted by both Chinese officials and Chinese academics that during the last four decades, almost every year, the annual consumption of forest resources exceeded the annual growth.

3. It has also been widely agreed that the average survival rate of new plantation was always somewhere between 25% and 30% during the last 40 years.

With regard to the above facts, the share of forest land in 1949 was most likely close to 10% with 83-95 million ha forest. An increase to 115 million ha in the early 1980s implies total afforestation of 20-30 million ha during the last 30 years, rather than the officially claimed 104 million ha.

The difference between official figures and independent estimates is important for evaluating the success achieved under the Chinese forestry policies and estimating the national consumption levels of forest reserves during the last four decades, and hence, for forecasting the possible consumption level and drawing up strategies of forestry development in China in the future.

With a recognition of a wide gap between the forest resource consumption and growth, and of serious environmental problems throughout the country today, the MOF was attempting to increase forested land to 14% by 1990 and 20% by 2000. The forest policy is to follow a non-declining even flow sustained yield. All forests have been put on a so-called 'Single Ledger' system, a planning device, by which a balance between the consumption and growth would be expected to be achieved at the national level, and log harvests are not allowed to exceed annual growth.

Substantial changes in planted areas can be expected in the future. According to China Daily reports, by the middle of 1986, over 30 million ha of mountain land had been allocated to households for afforestation and management under 30-50 year renewable and heritable leases. This land is generally poor land, however, and the growth in increment will not be commensurate with additions to the forest area.

2.3. Administrative Structure and Wood Product Balance Planning

2.3.1 Administrative Structure

At the highest level, national development targets and priorities are set by the State Council. Actual planning matters are formulated by the State Planning Commission (SPC) in co-ordination with the State Economic Commission (SEC). The Ministry of Forestry (MOF) is one of a series of economic ministries which function at state level below SPC (Fig. 2.1). The other important organisations in the present context are Foreign Economic Relations and Trade (MOFERT) which develops policy and guides the import and export trading corporations; the Ministry of Commerce which is responsible for supply marketing cooperatives in the provinces; and the user ministries--Light Industry, Railways, Communications, Coal and Mines, and Construction (The Ministry of Rural and Urban Construction and Environmental Protection--MOURCEP). Outside this structure is the Peoples Liberation Army (PLA), a major user of timber, also involved in harvesting, processing, and forest regeneration in remote areas.

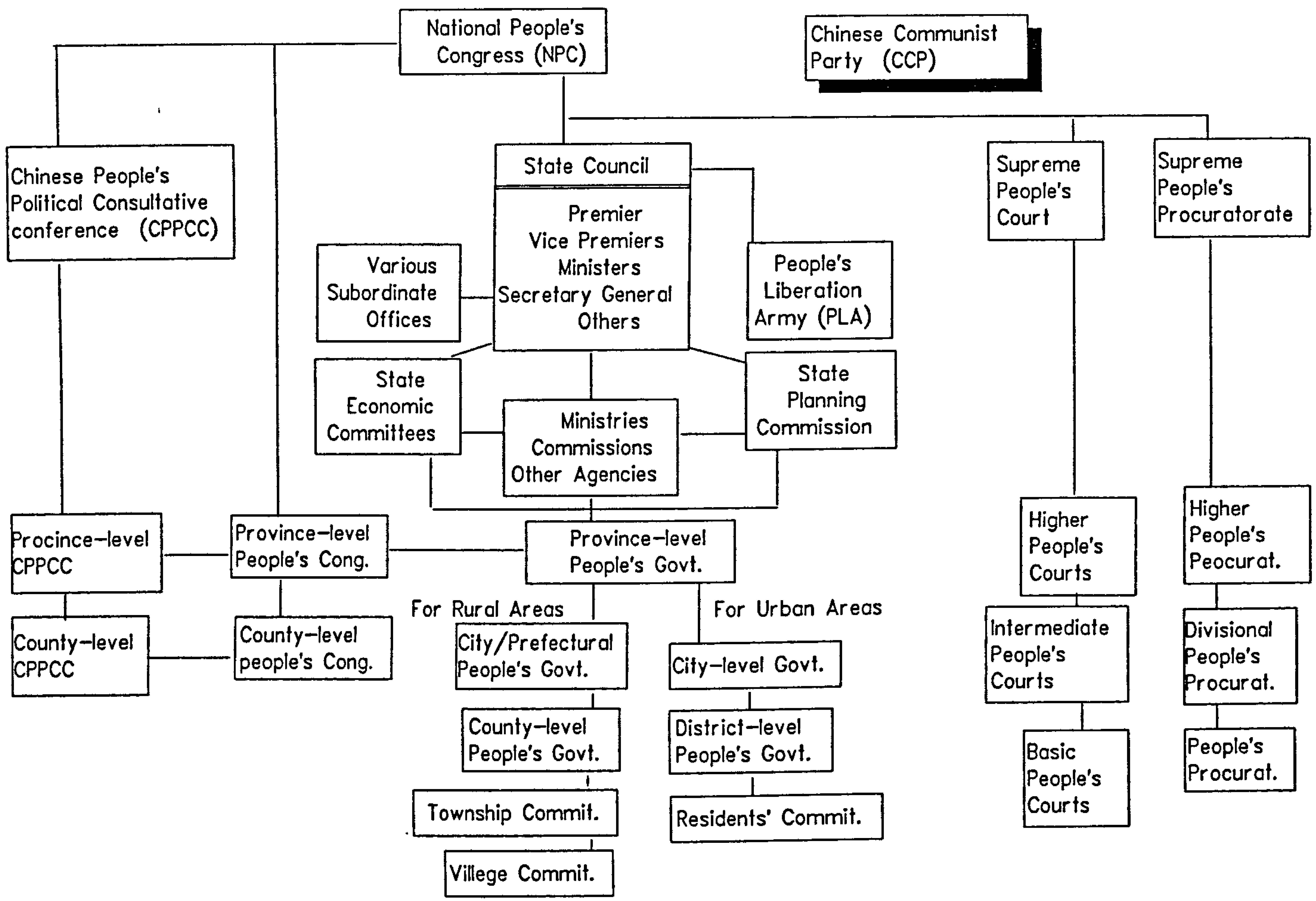


Fig. 2.1 Structure of the PRC's Social System

The MOF is responsible for the administration of state forestry throughout China and for forestry research and education as well (Fig. 2.2). The MOF also operates sawmills, plywood mills, particle-board and fibreboard plants and a number of the so-called 'integrated wood factories', (most of which are anything but that). It administers nature reserves, 'forest farms' covering 50 million ha and including 4 million ha of wood production forests.

The provincial organisation replicates that at the centre, including research and training activities, and is itself replicated, but in a simple form, at district (prefecture and county) levels.

Forest production is the responsibility of the forestry bureau under the Ministry of Forestry, except for some 6.6 million ha in Heilongjiang, where forests in production are overseen by a quasi-autonomous forest industries bureau.

Harvesting from state forests is targeted by the State Planning Commission (SPC) and production is assembled at log-yards for grading and pricing by the China Timber Corporation (CTC). The CTC administers supply and distribution centres on behalf of the central government. Imported logs mostly (80%) enter the system via the CTC.

Production from collective or private plantations and secondary forest assigned under the production responsibility system is no longer under tight control. Felling licences are required for removals greater than 10 m^3 per year, but there are virtually no formal restrictions on the disposal of logs.

Operating at the ministerial level, though not ministries, are the influential CITIC (the China International Trust and Investment Corporation) and the Materials Distribution Bureau (MDB). CITIC runs an investment corporation which is involved in joint ventures in China and Overseas Investment Corporation (COIC). COIC has negotiated timber concessions, investments in pulp and paper, etc.

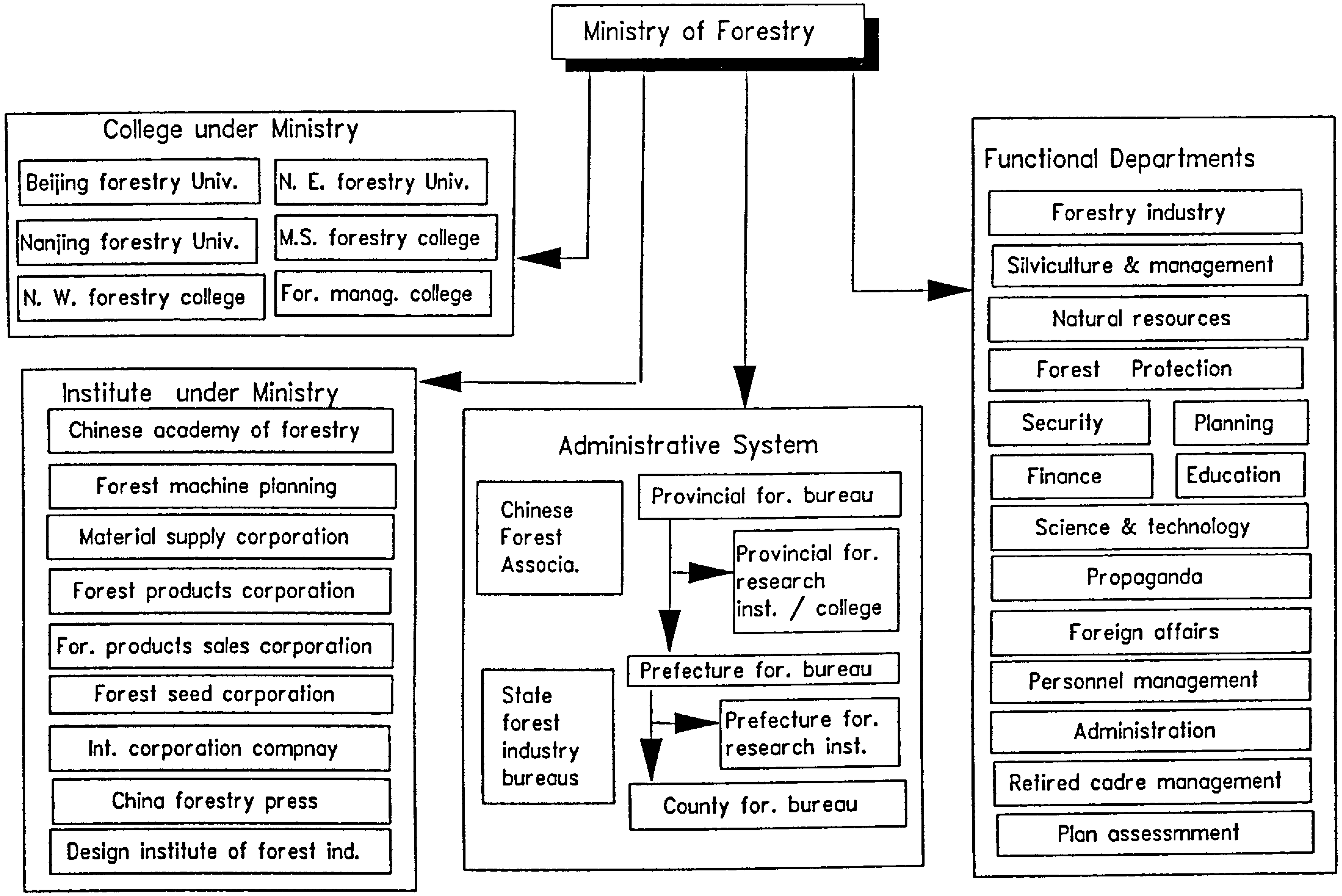


Fig. 2.2 Structure of the Ministry of Forestry

The user-ministries have some influence on product specification though it is difficult to know how much. The Ministry of Railways is serviced by an administrative bureau for 'materials and supplies' through which imported sleepers and wagon building timbers are procured. The Ministry for Coal and Mines is a major user of Siberian and locally grown larch. The China National Packaging Import/Export Corporation is responsible for the supply of export packing.

Finally, MOURCEP has a major influence on building design, urban construction systems, and materials. It approves all planned capital construction in China.

2.3.2 Wood Product Balance Planning

As discussed in Chapter 1, in a centrally planned economic system, almost all products including consumption goods and production factors are controlled by the central government through the central planning mechanism, whether it worked effectively or not. This usually results in a huge waste of materials. Wood products, like others, are brought into a highly complex and somewhat obscure procurement and distribution system; wood use decisions are based primarily on the central state policy. In this section, discussion is focused on the following issues: how wood products are distributed through the planning channel; how demand and supply in the central planned system are balanced; and how the system affects forest resource management.

Main Features

China has experienced a long-term wood shortage, wood quantity demanded has always exceed that supplied. The planned wood demand was met by overcutting forests, as well as by very limited import, while consumers' demand was simply ignored by the planners.

Equilibrating the planned demand and supply of wood products in China was entirely based on the material balance planning system. The planning was to produce a plan which, at best, was consistent. Consistency meant that the planned supplies of each type of wood product in the balance were equal to planned demands, both intermediate and final.

The wood products balance plan includes two categories, five-year plan (FYP) and annual plan:

(1) Five-year plan (or long-term plan) includes two types. The first is called the state unified supply-demand plan, which focuses on the wood products including the state planned harvesting and the imported wood products; the second type is the integrated wood product balance plan, which is expected to consist of all wood products (including the state procured products, the products retained by provinces and sectors for their self-sufficiency, products from thinning and tending, and products imported by both the state and provinces).

(2) The annual (short-term) plan contains five complementary sub-plans. They are:

(a) Requisition plans, which are submitted by the demanding sectors (such as coal industry, construction industry, etc.) and enterprises, through their corresponding ministries or provinces to the National Material Distribution Bureau (MDB). The Bureau balances the demand and supply of wood products at the national level, referring to those requisition plans.

(b) The balanced plan (or balanced supply-demand sheets) which is drawn by the central MDB on behalf of the SPC. The plan is the result of a bargaining process between the SPC and the provincial planning commissions. The plan should be based on the current government's resource policy, production possibilities, and the consumption quotas for different production sectors.

(c) The product allocation plan, which is presumed to embody the balanced plan, and to detail the balanced plan into the sectoral, provincial and enterprise levels. As the plan indicates who will get how much of what products from where and from whom at what price systems, this is the most complicated plan.

(d) The products supply plan as an executive programme, which is usually implemented by the Ministry of Forestry.

(e) The commodity circulation and management plan, which aims to smooth the product allocation channels to rationalise the necessary stock of wood products, and to speed up capital flow circulation, hence to improve the management of forest enterprises.

The Procedure

1. In every August, the planning agenda is pronounced by the SPC and MDB. According to the agenda, demanders start to make their own requisition plans, then propose their plans from bottom to top through a bureaucratic hierarchy by the deadline.

2. By compiling all requisitions summarised in the provincial levels, the MDB generates the national wood supply balancing plan according to the amount of the current year's investment, the number of capital construction projects, their priorities, and the amount of products available for supplying, with some adjustment at the national level. So long as the plan is approved by the central government, the plan will be transmitted from top to bottom in January every year, and will become a compulsory document for wood production and allocation covering the whole country.

This process was the so-called "twice bottom-top" procedure, and was considered to involve replacing the anarchy of the market with a state-administered plan.

In order to fulfil the national plan, the Ministry of Forestry need to set the sectoral development plans, which embrace:

(a) the production plans (including the afforestation plan and the regeneration plan and the forestry industry plan);

(b) the science and technology plan (including forestry education, research, technological progress and promotion plans);

(c) the capital construction plan;

(d) the staff training and wage plan;

(e) the commerce plan;

(f) the finance, cost and revenue plan, etc.

The forest sectoral plans are supposed to be the programmatic documents guiding the country-wide forestry development.. Given the production tasks and the financial budget (including investment, wages and various fees) which are decided by the SPC, forest planning is another bargaining process between the ministers of forestry and the directors of provincial forestry departments and forestry industry bureaus. This bargaining is critically important to everybody within the forest sector from the ministers of forestry to tractor drivers on the harvesting site, or seasonal contract workers on dry-land afforestation, because it is to determine every individual's benefit for the coming year. Obviously, the ministers prefer to keep some margin for their own flexibility. They want each province to contribute as much product, and require as little finance as possible. On the contrary, the provincial departments and forestry enterprises try to obtain more money and undertake fewer production tasks. The same procedure will carry through down to sub-administrational level.

Problems of the Wood Product Planning System

In such a system, almost all the means of production are nationalized. They are either allocated by MDB or transferred between ownership by 'collectives.' Planners determine all significant variables directly, including enterprise inputs, output levels, product mix and prices. Competition, entrepreneurship and the pursuit of profit are eliminated.

Such a system has fundamental problems.

1. It produces a tendency towards conservatism in planning (administration rather than purposive planning), as it is easier to work from the previous plan than to attempt major changes of direction, regardless of changed conditions or policies. But in forest industry, conservatism is by no means certain to save resources. Given production

possibilities, a conservative plan may sometimes apparently reduce planned supply, but in fact it results in increasing off-planned products. Enterprises tend to understate their production since off-planned products can be sold (or procured) at floating prices which are usually much higher than prices for planned goods. Hence they bring more 'legal' benefit to enterprises without 'illegal' cutting. Thus it is not peculiar that enterprises downgrade sawnlogs into pulpwood material when markets warrant such a shift and low grade (small size) products can escape from the plan categories.

2. The sheer complexity of planning is coupled with the necessity to construct 'phantom' plans, so that it is impossible to produce a plan which does indeed balance inputs and outputs, or balance supply and demand. Instead there is simultaneously shortage and/or surplus throughout the system. As mentioned in the first chapter of this thesis, there was increased domestic oversupply of wood products in 1985, while the state spent a large amount of foreign exchange on importing timber.

3. If the plan is to balance at all, output (gross value or in physical units) must be the key success indicator for evaluating enterprises' performance and for judging who is to be rewarded. Many problems and difficulties result from this. First, this criterion applied in forestry would, if anything, only encourage enterprises to deplete forest resources and degrade the long-term production foundation of forestry (a further discussion of this point will be given in the next chapter). Second, the primacy of output targets, combined with other factors, such as the unreliability of material supplies and state administration of prices, produces a powerful anti-innovation bias. Third, the cumulative impact of other distortions generated by this criterion is enormous: quality of products suffers; there is no incentive for equipment renewal; there is no motivation for technical progress and management improvement; wastage is enormous. All of those occur because the evaluation system ignores many other indicators of enterprises' performance, e.g. input-output ratios, quality of products, etc.

4. From the nature of the planning described above, it is easy to see that enterprises, even the governments at the basic levels, have a strong incentive to provide false information in order to obtain easily attainable targets (Nolan, 1990) or to obtain

maximum real income. Based on false information, how can the plans be expected to be useful?

5. The most harmful impact of the administrative planning on the national economy is to eliminate the "Schumpeterian" effects of competition (Nolan, 1990), which stimulate entrepreneurs to produce better products more cheaply for fear of bankruptcy and in order to gain the profits derived from market success. It has long been believed that competition is one of the cruellest elements of capitalist society, and China only needed socialist labour emulation, not competition. It has also been believed that as long as plans are made, the scales of productions, costs, and revenues will fall into place, so, obviously, there is no need to have any competition at all.

2.4 Distribution and Allocation System

Due to both limited foreign exchange and forest reserves, usage of wood in China is controlled tightly by a network of government organisations which are all subject to the same State Plan. Wood use decisions are based primarily on central state policy regarding both supply and demand, substitution, import, log v. timber, and priority end-user groups, etc., so consumer demand is only a secondary factor. The system of control on planned wood usage is called the Unified Distribution System (UDS).

2.4.1 The Unified Distribution System (UDS)

All of China's planned wood is distributed through the UDS. 'Unified' means that wood is distributed through a single, centralised plan. In the UDS channel, wood is not marketed, purchased or sold in a market system, but rather is supplied only to selected government processors and end-users in quantities predetermined by the state plan.

The UDS is administered by the MDB, which is in charge of nation-wide materials distribution according to the State Plan. The department within this bureau that is in charge of timber and wood products is the Timber Corporation (TC) network, which is composed of the State-level China Timber Corporation (CTC) and municipal and provincial Timber Corporations. CTC is solely responsible for UDS administration: planning, approval, and supply (see Fig. 2.3).

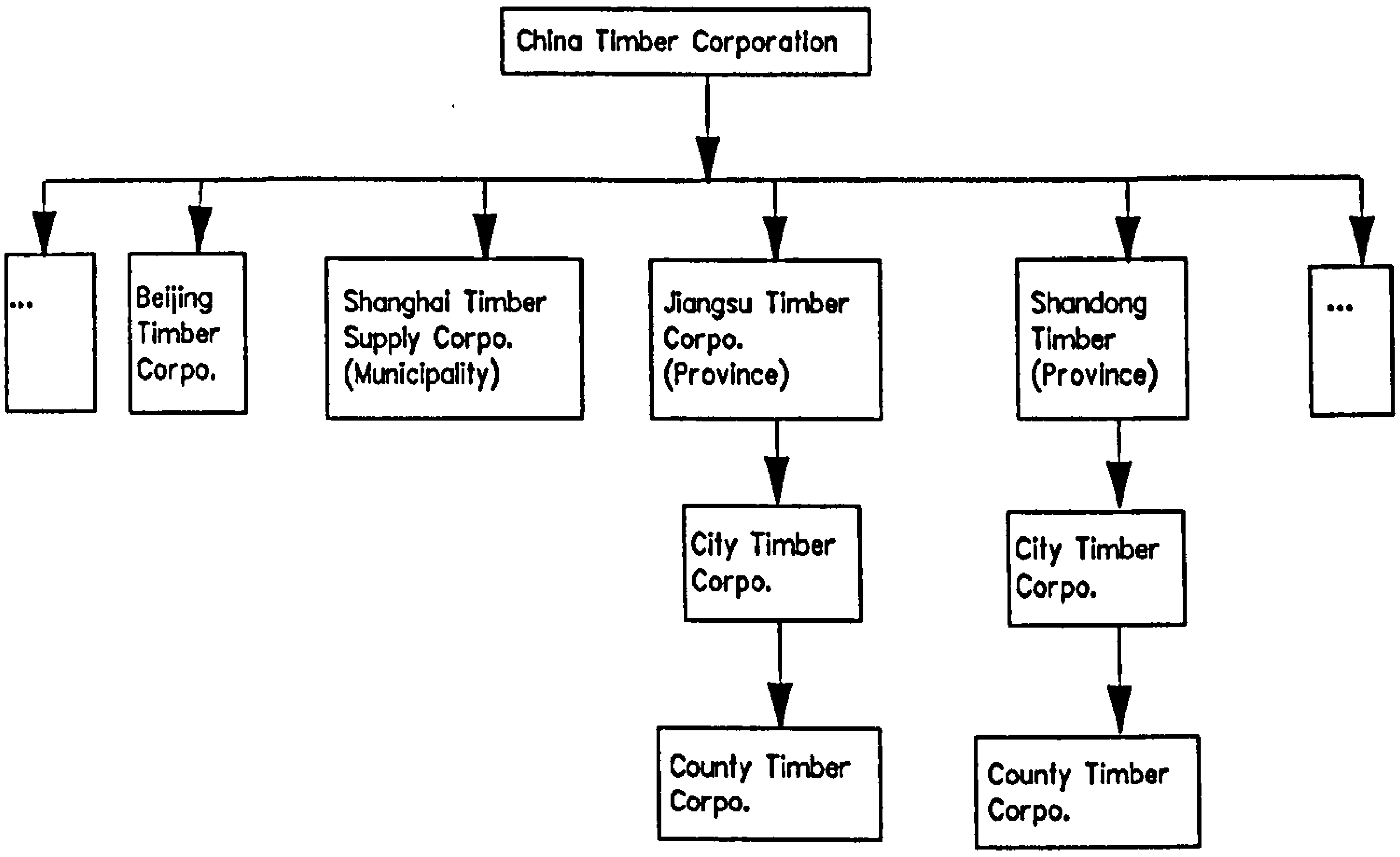


Fig. 2.3 Structure of the Unified Distribution System

2.4.2 The Distribution Process Through UDS

UDS has played a critical part in balancing the supply and demand of wood products in China. In general, wood requirements of the entire country are determined through requisitioning procedures from the bottom up, from county to city, city to province, and so on, and at each level, they are reviewed and consolidated by the Timber Corporation offices at the corresponding level.

The requisitions are consolidated by local TC for end-users and processors under local government control, and by the MDB of the various ministries for factories and users under ministerial control. Consolidated requisitions are sent to planning commissions on the local level, where adjustments as necessary are made, and plans approved. This process continues at each level all the way to the highest level of planning, the SPC. Fig 2.4 gives a schematic presentation of this process.

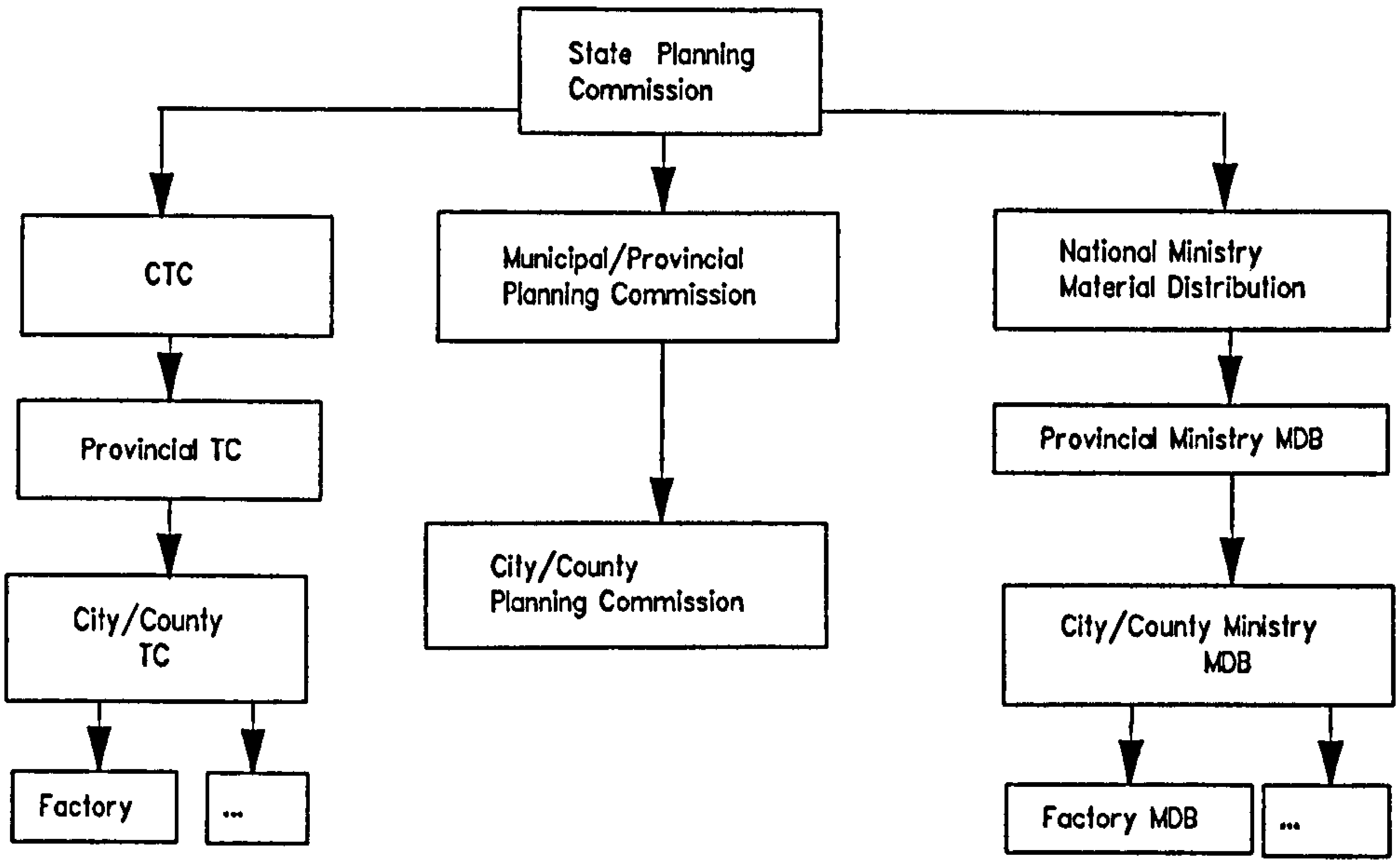


Fig. 2.4 Structure of China's Requisition, Planning, and Approval System for the Supply and Distribution of Forest Procucts

2.4.3 Demand and Supply of Wood Products under the UDS

The concept of demand and supply may differ under different systems. In the centrally planned economy with the unified distribution system (UDS), demand only means how much of a given commodity will be needed by selected processors and end-users predetermined by the state plan; similarly, supply indicates the amount of a commodity (including domestically produced and imported) the government decides to distribute to limited users. Obviously, under this system, demand and supply are something which implies no close relationship between the market price and quantities required to be bought or offered for sale: they are replaced by requisition and allocation/distribution. The process for timber has been well described by U.S. National Forest Products Association (NFPA) in its detailed study of China's timber market (NFPA, 1986). For deepening our understanding and modelling of China's economic system on forestry, attention here is focused on the analysis of the UDS itself.

UDS has passed through several stages. In the initial stage (1950-53), there were two ownerships, (i.e., common ownership and private ownership) and four channels of wood products trade, which were:

1. direct trade under command planning. Through this channel, the state-owned enterprise's demand could be directly met by supply from state-owned wood producers.

2. indirect trade via market system. Apart from direct trade, there were still other wood products. The supply of those products came from collective or private forests, to meet requisitions consolidated by the State Timber Corporations for users under local government control.

3. trade through local collective corporations. The collective corporations obtained wood commodities either from allocation of local governments, or from procurement of producers. This channel played a complementary function to the central distribution system.

4. trade between private owners. Before 1954, it was possible for private owners to purchase or transport wood products from production regions to consumption regions. The purpose of allowing this channel to exist was to give a chance for private merchants to survive and to supplement the deficits of the centrally planned system.

In the second stage, UDS experienced a few ups and downs following the country's disastrous political and economical campaigns. The establishment in 1953 of the Timber Corporation (TC) network composed of the state-level China Timber Corporation (CTC) and the municipal and provincial timber corporations (Fig. 2.5), was intended for centralising the control on demand and supply of wood products, but this network was to become the landmark of reform in China's forestry, transferring from a mainly command organisation to a market oriented corporation in the 1980s, helping marketisation through its well organised network all over the country.

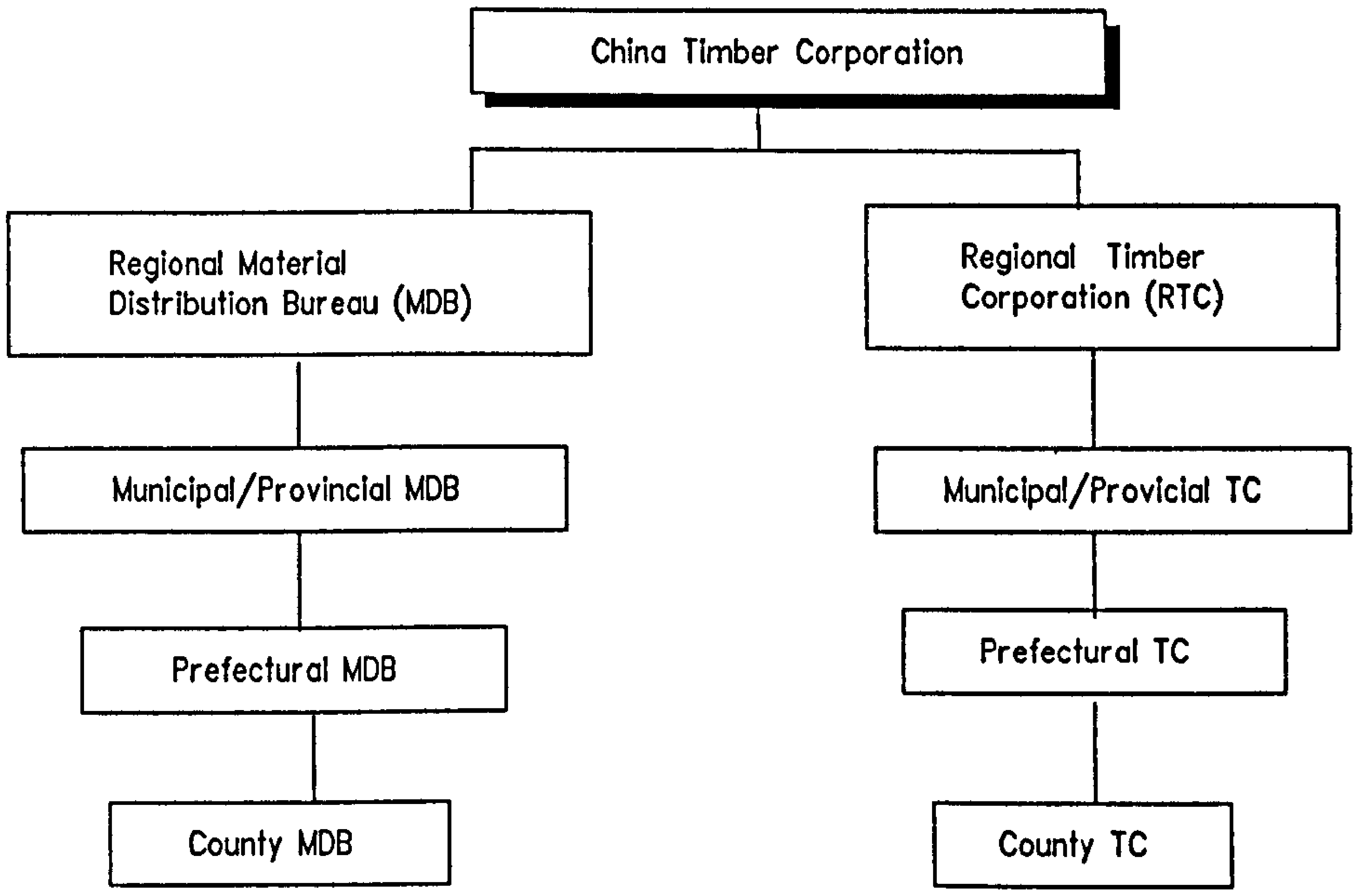


Fig. 2.5 Administrative System of China Timber Corporation

Meanwhile, in order to eliminate the private merchants' profit from long distance transportation of timber, a price policy was set to reduce the difference of prices between production regions and consumption regions. The policy was based on Marx's value theory that transportation could not increase the value of timber since it did not increase the input of the *direct* labour force to timber production. Products from farmers and collectives could be sold through the State-controlled marketing system, but quotas were set rigidly and prices were fixed at levels below what would have been required to elicit voluntary sales.

During the early 1950s, the consumption of timber was less and the forest resource was relatively rich. There was no crisis of demand for and supply of timber at that time, but deforestation and abuse of the resource started from that period as the consequence of the collectivization movement and planted the seeds of the supply-demand crisis of the forest resource for today.

The TC network was then dismantled and replaced with the MDB system in parallel with the convulsive changes of the cooperative system, the Great Leap Forward of 1958-59, and decentralisation of decision-making power. That change meant two things. First, the market mechanism was entirely eliminated from wood demand and supply: wood products were treated no longer as commodities, but as something simply distributed by administrative will. Second, wood production and consumption were no longer controlled by the central government, but by local governments at various levels. That change resulted in the first and largest disaster of deforestation since 1949. There is increasing evidence of ecological damage during that period of woodland destruction to fuel the backyard furnaces and also degradation of pasture in order to "take grain as the key link".

By the early 1960s, the TC system had reverted to being much like what had existed pre-Great Leap, although there were some trivial changes within the system. The balance of demand for and supply of wood products relied on central planning which was based on physical input and output targets. The decision on material distribution was made by governments through the MDB system, but fulfilled by the TC system. The State attempted to restore the TC system as a large trust in charge of national processing and circulation of timber products. Meanwhile, the most allocated wood products had changed from log to sawn-timber, except for some specific uses; it was the first time that government called for substitution and economic use of forest resources, and that the decision was made by a group of people including a few experts. Unfortunately, the Cultural Revolution brought another large deforestation, with the movement of "clearing away the last residual of capitalism". The revolution destroyed everything except the central power. TC system disappeared again. It was recorded that forest cover in Gongxian county was reduced from 27.3% to 9.6% of the land area between 1958 and the mid-1970s (Brown,1985); in another place, Gulin, it was reduced from 48% to 10.7%, most of it on steep slopes subsequently abandoned because of erosion (Richardson, 1987).

Surprisingly, in the Cultural Revolution period (1966-76), there were many forces interfering with any attempt at systematic planning, but, by some mechanism, inputs and output and their allocation between enterprises within the centrally planned system were co-ordinated in such a way that the chaos of the Great Leap Forward was avoided. This co-ordination was in no sense achieved through a revival of the market mechanism. It does not matter just who was in charge of bureaucracy, or did much of the planning and control of enterprises, but that planning and control through the bureaucracy did take place; the prices were set by this bureaucracy as was the case prior to the Cultural Revolution.

At the present stage, TC system has been restored and is seeing the UDS enriched by the market mechanism. After the death of Mao Zedong and the end of "the Gang of Four", especially after the CCP Third Plenum held in 1978, an ideological liberation was launched, with the discussion of "practice is the sole criterion of truth". Consequently, there were several interesting topics debated among forest economists to a national extent. The most important two of these were:

(1) whether wood products were commodities which should be exchanged in the market circulation system;

(2) on which pricing mechanism the prices of wood products and stumpage prices should be based.

As a result of this debate, several steps were taken:

(1) TC was once again in charge of the distribution and allocation of wood products, and all wood and wood product importations;

(2) in the early 1980s, wood products were acknowledged, for the first time in China, as commodities like other exchangeable goods, and the remainder of timber under the State plan could be traded at negotiated (floating) prices which were higher and more flexible than fixed prices for priority users, but under the TC system.

(3) in 1985, the central government allowed a timber market in southern China to open. Thus, the three-way-price system began to exist in timber marketing, and

still negatively influences both production and consumption decisions as a distorted signal.

Table 2.8A (the next page) lists some major events related to the development of UDS, it shows how the system had evolved over the 35 year period.

By briefly reviewing the demand for and supply of wood products in China, it becomes clear that the timber commodity circulation has at most times been controlled under central planning and forestry has always been characterised by administrative management and allocation of resources on the basis of priorities centrally established. The market mechanism has merely played a guiding role.

2.5. Wood Prices and Price Levels

There is much confusion in China's present pricing system. Prices of many commodities, including wood products, reflect neither their value nor the relation of supply to demand. As noted in Chapter 1, among agricultural products the share of products which are subject to floating or free prices is 85%, but until recently most of wood is sold at state allocation prices (fixed price), which are subsidised by the State, and do not take into account the value of standing timber, profit margins or the relative efficiency of logging and processing.

Wood products sell in the retail market at floating prices. Floating prices are divided into retail and wholesale, the latter usually consisting of a 10% discount for quantity.

Among all wood products, 75% of imported wood, and 33% of planned domestic wood, are distributed as 'allocations' at the subsidised state allocation prices to priority end-users. The remainder of the imported wood and domestic wood is distributed to priority end-users at the floating prices, or at some preferential supply price in between the state allocation and floating prices. Table 2.9 shows the differences.

Table 2.8A Some Major Historical Events Related to the Evolution of UDS

Time	Event	Source
1950.2	The State Council (SC) decided to establish China Coal & Construction Material Cooperation in charge of marketing & distributing coal, timber & other materials.	MOC, 1950 PD No. 6
1951.4	SC made decision that MOF was solely in charge of the procurement, distribution of wood products, and the Ministry of Trade (MOT) controlled timber marketing.	MOC, 1950 PD No. 64
1953	MOF & MOC made joint announcement that since July 1, 1953, all business of timber production & sells should be dealt with by MOF entirely.	CTC SID: 1953-55, p.1.
1953	MOF decided to establish its national wide network, the provincial TCs, in charge of all timber market management and distribution at the provincial levels on behalf of MOF.	CTC SID: 1953-55, p.5
1954.3	SC decided to establish CTC.	CTC SID: 1953-55, p.20.
1954.4	CTC made a policy of procuring all off-planned wood products.	CTC SID: 1953-55, p.19.
1954.11	SC promulgated a decree, decentralising wood market control.	CTC SID: 1953-55, p.43.
1955.4	Collectivization Period Began. MOF issued a regulation of socialist transformation of private timber companies.	CTC SID: 1953-55, p.123.
1957.7	CCP decided to decentralise the wood distributing and marketing control.	MOF PD No.263
1957.12	Great Leap Forward. SC decided to decentralise the power of local CTCs to local governments.	MOF 1957 Docu. No.263
1960.8	SC abolished CTC & established MDB to centralise the control of wood distribution.	MDB 1960 PD No.1
1961.6	Economic Adjustment. MDB gave the priority of wood allocation to agricultural users, marketing & exporting.	MDB 1961 Docu. No.12
1962-63	SC issued several documents calling for saving wood resources.	MDB 1962-63 PD
1969-70	Cultural Revolution period. Central revolutionary committee merged MOF into MOA & decentralised wood allocation.	MDB 1969-70 PD
1977.11	established Timber Bureau responding wood allocation under MDB's monitoring.	MDB 1977 PD No.1
1978.12	Economic Reforms initiated. SC approved the proposal of renaming TB to CTC again.	MDB 1978 PD No.42
1981.3	CCP & SC jointly issued a document: protecting forest resources to ensure sustainable development of forestry.	MDB 1981 PD No.2
1985.1	CCP & SC jointly issued a document: Further reforming rural economy, diminishing the state monopoly on wood market, and establishing socialist wood market system.	CCP 1985 Docu. No.1
1986	Forest Law effected; Timber markets put under government regulating.	Forest Law

Note: MOC - Ministry of Commerce; SID - elected Important Document;
PD - Permanent Document; MOA - Ministry of Agriculture;
MDB - Material Distribution Bureau; CCP - Chinese Communist Party (Central Committee).

As a double-track price system (a co-existence of market pricing and planned pricing) has been introduced in 1984 as a transitional step, this has been proved extremely helpful in boosting production, but because of the wide gap between centrally planned price and market price, the essential problems of that system arise: wood materials were often unavailable, and when they were, they were often resold with massive mark-up; illegal cutting occurred everywhere; it opened the road for bribery and the reselling of goods over and over again. The low price of allocated wood materials has been a long-standing problem.

Rationalising these prices by rational policies and market forces as quickly as possible should have a knock-on effect throughout the entire price structure, and so in turn facilitate the development of production, and the readjustment of the structure of investment and industry.

The freeing of markets in China has resulted in rising price for both logs and timber. The values illustrated in Table 2.9 are not stable enough to draw firm conclusions about the likely future levels and future relations between log and sawnwood prices, but log prices are beginning to reflect species scarcity and quality (e.g. higher prices for pine than larch), while sawnwood prices tend to equal the free log price plus cost of processing and distribution.

Table 2.9 Table of Price[1] (1985)

Commodity: Timber (rough sawn, green, 4-6 cm thick, 400 cm long, varying widths 10-30 cm).
Unit: RMB¥/m^3

Location	Species	Allocation Price			Floating Price	
		Grade A	Grade B	Grade C	Wholesale	Retail
Shanghai	Masson's pine	181	130		399	
	Douglas fir				550	608
	SPF N.american				501	517
	S.E.A. lauan				620	639
	S. pine mixed	164	117		345	
Beijing	Douglas fir	390			510	
	Chinese spruce	166				410
	Chinese R&W pine	208				580
	Chinese Y. pine	182			420	498
	Canadian spruce	400				600
	I. Mongo. larch	200				440
	N.E. hardwoods	200				460
Wuhan, Hubei	China fir	201	143			550
	Masson's pine	161	114			400-420
	Chinese spruce	223	159			540-600
Naijing, Jiangsu	Douglas fir					676
	Canadian hemlock					550
	Chilean pine					453
	Masson's pine	181	130			380
Guangzhou, Guangdong	SPE N. america				650	700
	D. fir					680
	Malay. lauan				620	640
	Masson's P. pine	178	127		380	
	S. softwoods	204	146		410-450	
Jinan, Shandong	Masson' pine	166	119			500
		182	130			556
Shaown, Fujian		181	130		280-300	

Source: *NFPA Report* (1986) and *The Cotchell Report* (1987). Compiled by the author.

[1] According to Chinese official source (People' Bank of China, Research and Statistics Department), the yuan (RMB¥)-dollar ($) exchange rate in 1985 was RMB320.12 = $100.

2.6 Evolution and Current Situation of Wood Trade

2.6.1 Evolution of Wood Trade

China has had a long history of wood trade (See Table 2.10 and Fig. 2.6). It is recorded that around 1860, some foreign traders imported hardwood from Malaysia and Singapore to Shanghai. In 1895, perhaps the first wood trade company, China Wood Import/Export Ltd, owned by the German business man, was established. This company was transferred to a British Company--Xiang Tai Wood Ltd in the early 1900s, and established its branches in Nanjing, Wuhan, Qintao, etc. in 1915. It also had two ships for wood transportation from North America and Southeast Asia. During the first part of the century, China imported large amounts of Douglas fir and western hemlock mainly from North America and other species from S.E. Asia. The quantity of annual import was about 890,000 m^3 from 1931-1940, and 1232,700 m^3 from 1946-1948 (Ministry of Commerce, 1950).

Table 2.10 China's Wood Trade Before 1949

Unit: million Franc.

Year	Import	Export	Balance
1927	20.936	20.936	0.000
1928	27.838	23.446	-4.392
1929	42.868	23.734	-19.134
1930	35.693	16.193	-19.500
1931	53.241	10.869	-42.372
1932	37.709	3.986	-33.723
1933	37.356	1.951	-35.405
1934	34.152	2.688	-31.464
1935	34.768	2.605	-32.163
1936	28.918	3.452	-25.466
1937	23.239	3.379	-19.860

Source: Northeast Forest Survey Report, the Ministry of Commerce, Documentation No.54.

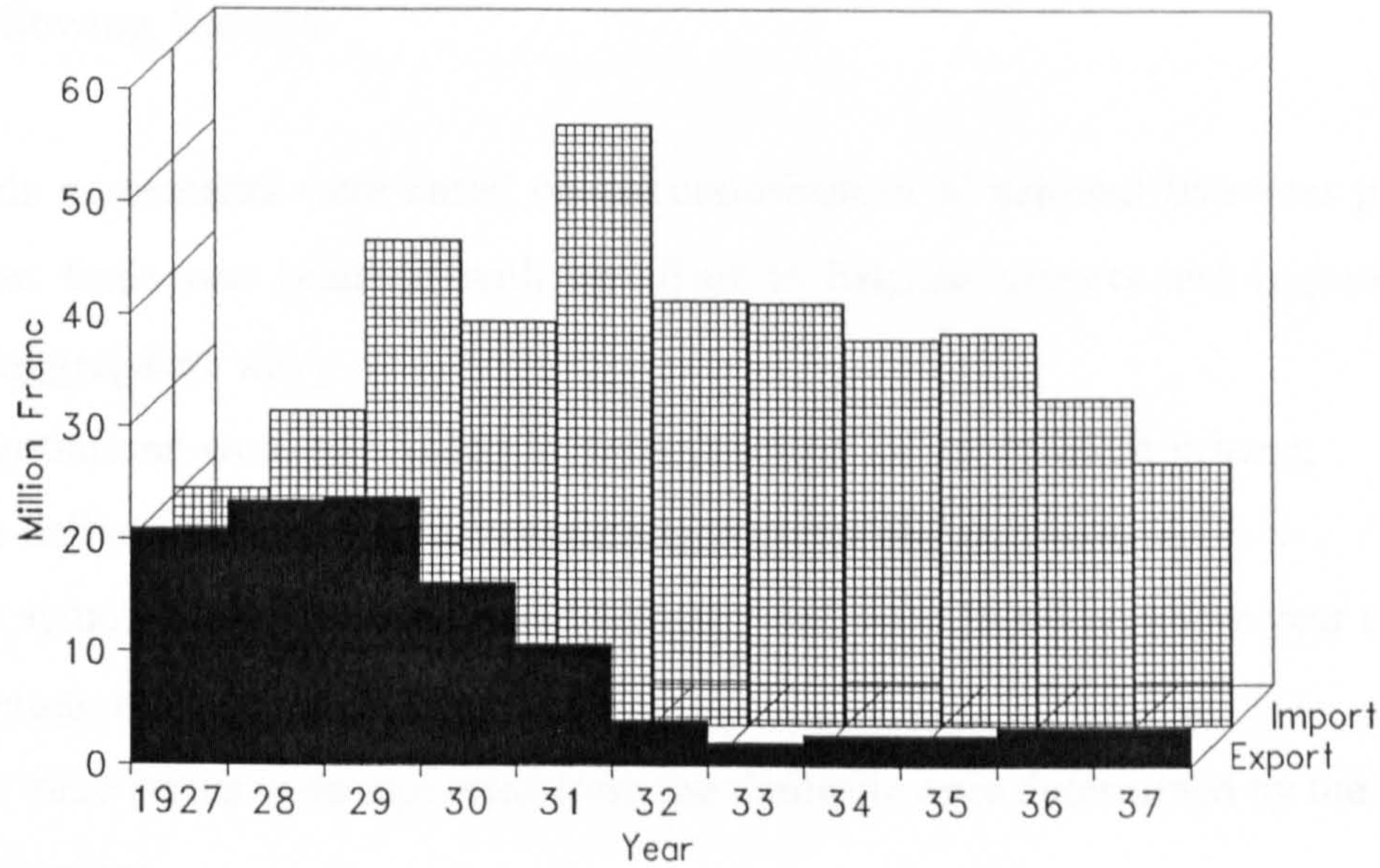


Fig. 2.6 China's Wood Import & Export 1927–1937

During Mao's period (1950--1976), China's trade regime was dominantly with socialist countries and a few other developing countries. The major wood exporters to China were Vietnam and Cambodia in the early 1950s, and the former USSR since then, except a short period break in the 1960s, which was due to the ideological disparity between two communist parties (Table 2.11).

Table 2.11 China's Annual Logs Import: 1952-1975

Unit: 000 m^3.

Year	Total	USSR	Vietnam	Cambodia	S.E.Asia	Ghana	Albania	Romania	Other
1952	11.70	1.90	6.32						3.49
1953-57	30.67	2.97	20.76		0.51				6.43
1958-62	164.88	76.10	31.81	45.33	1.62		0.91		9.11
1963-65	890.60		15.09	22.26		18.03	6.29		828.94
1966-70	1587.30			11.48		20.47			1555.36
1971-75	433.04	274.57				12.75	0.70	2.10	142.93
1976-80	840.44	329.46			180.38	0.33	0.60	1.02	

Source: Ministry of Commerce, *Northeast Forest Survey Report*, Documentation No.54.

China's regime was borrowed from the former Soviet Union in the 1950s, and had the following features:

(1) trade agreements were based on the coordination of national five-year plans;
(2) most trade was bilateral with an effort to balance exports and imports in a disaggregated way;
(3) negotiations were conducted in volume terms (or in constant prices);
(4) the deliveries agreed upon were obligatory for the partners;
(5) the actual prices were negotiated annually and were based on a five year moving average of the world market prices;
(6) the trade prices were separated from the domestic ones determined by the central authorities.

2.6.2 Current Situation

Trade in wood products until the 1970s was dominated by imports of pulp and paper from Scandinavia, Japan, and New Zealand, and from Canada following the establishment of diplomatic relations in 1970. China imported logs sporadically in the 1970s--softwoods from Siberia and hardwoods from a range of tropical countries in Asia, Africa and Latin America. But even at the end of the decade, China's imports amounted to less than 1 million m^3. Due to the limitation of domestic wood supply which is basically limited by forest reserves, and the increasing demand of wood products since economic reform, a growth of wood imports into China began an explosion in 1980, reaching more than 10 million m^3 in 1985. And the increasing trend seems set to continue for a considerably long time. Table 2.12 illustrates the structure of wood product imports by types:

Table 2.12 Wood Imports to China by Product Types: 1979-85

Unit: million m^3.

Year	Total	Log	Sawnwood	Plywood	% of Imports/Total*
1978	--	0.58	--	--	--
1980	--	1.81	--	--	--
1981	2.62	1.87	0.08	0.26	5.3
1982	6.17	4.62	0.18	0.51	12.2
1983	7.55	6.29	0.35	0.31	14.4
1984	10.30	7.91	0.67	0.57	16.1
1985	12.35	9.69	0.42	0.82	19.5

Note: In total, sawnwood and plywood have been converted into log, e.g., 1 m^3 log = 0.7 m^3 sawnwood; 1 m^3 log = 0.4 m^3 plywood.

*: Imports as % of total consumption of forest products.

Since the beginning of the reform, with the growing demand for more wood imports, not only has import increased rapidly but the composition of trade partners has widened (see Table 2.13 and Fig. 2.7) to include anyone who is willing to export wood products to China at cheap prices, as ideological considerations no longer play a significant role in the trade.

Table 2.13 China's Annual Wood Import by Regions: 1980-1985

Unit: 000 m^3.

Year	Total	USSR	N.Amer.	S.E.Asia	I. Mongolia	Chile	Others
1981	2198	285	1179	364	259		145
1982	5360	425	3242	795	513	156	411
1983	6907	981	4329	939	304	201	396
1984	9152	1811	5461	966	573	154	381
1985	10985	1835	6663	1275	830	78	418

Source: The Ministry of Commerce, *Northeast Forest Survey Report*, Documentation No.54.

In 1985, softwood imports comprised 85% of total wood imports and U.S.A. became the number one (62.1%) in China's log import partners, with a share of US$287 million. The U.S.S.R. supplied some 18.7% of the log market, with Malaysia (9.1%), Canada (4.7%) and Chile, Indonesia, Brazil, Philippines and others (4.8%) in the trail.

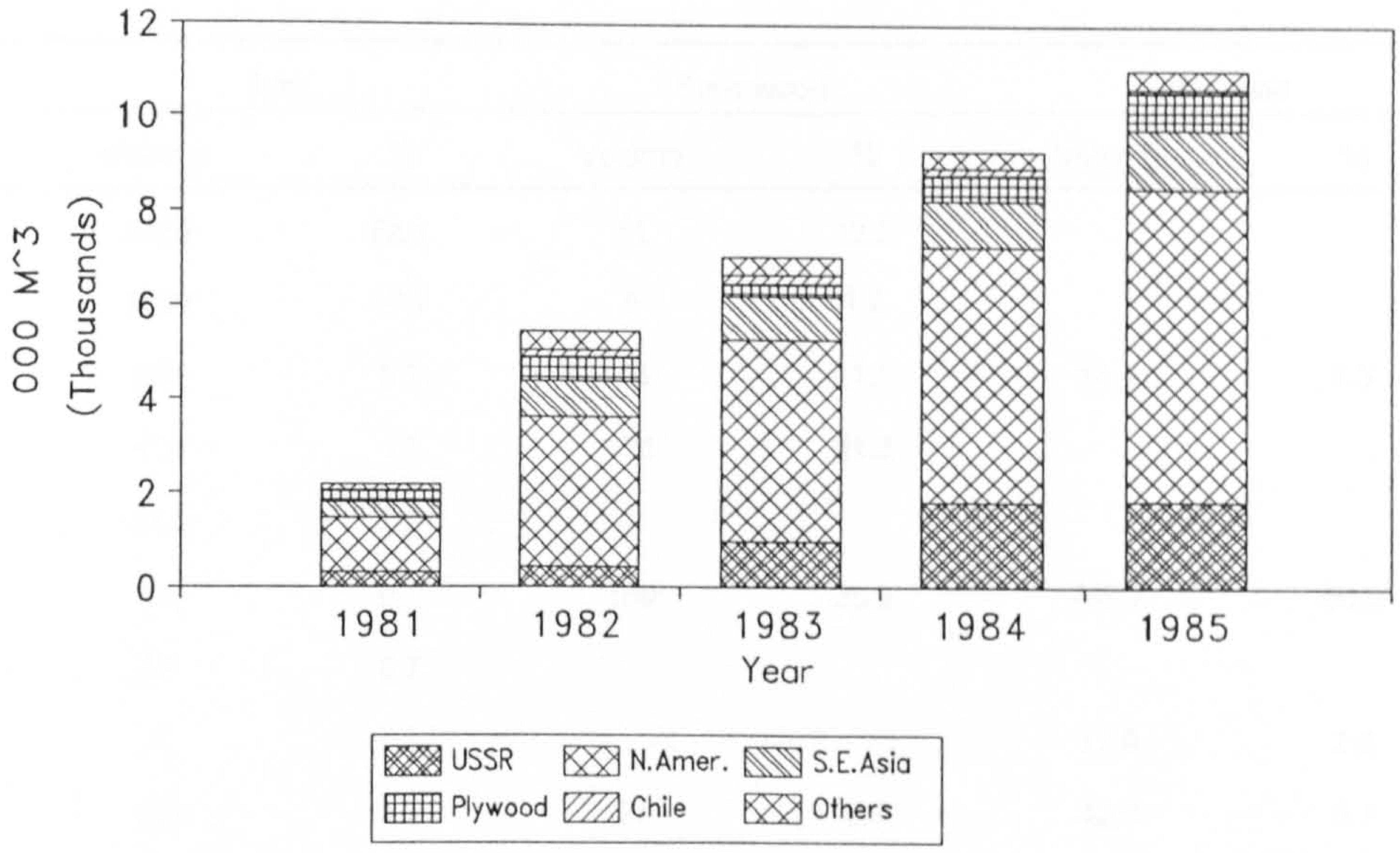


Fig. 2.7. China's Annual Wood Import: 1980 - 85

Of softwood timber imports totalling 0.3 million m^3, Canada supplied 0.25 million m^3.

Plywood imports have also increased and reached 1 million m^3 in 1980. This is virtually all hardwood from Indonesia and, until 1985, had to be trans-shipped through Singapore and Hong Kong. Some plywood (in small quantities only) is imported from Malaysia, the Philippines, Taiwan and New Zealand (see Table 2.14).

Exports from China have scarcely featured in international trade in forest products. The purpose of exports of forest products is not only to generate foreign currency but to improve processing technology. The items of export products are mainly of hardwood. Because of the limited capacity of the forest production, China's wood export has been tightly controlled and largely reduced during the last decade.

Table 2.14 Share of China's Import Market in Log, Sawnwood and Plywood (1985)

Unit: 000 m^3.

	Log		Sawnwood		Plywood	
	Volume	%	Volume	%	Volume	%
U.S.A.	6020	62.1	51	12.2		
U.S.S.R.	1808	18.7	5	1.2		
Malaysia	884	9.1	43	11.5	14.4	1.3
Canada	459	4.7	131	31.3		
Chile	243	2.5				
Indonesia	11	0.2	160	38.3	747.7	90.9
Brazil	67	0.7				
Philippines	6				17.9	2.2
Other	133	1.4	23	5.5	42.9	5.1
TOTAL	9690	100.0	418	100.0	822.8	100.0

Source: China's Customs Office, 1986. *Trade Statistics.*

2.6.3. Import Control

China's foreign trade (including imported wood products) is controlled by central government through the MOFERT which grants import authority to only a handful of organisations. Recently the authority has also been delegated to provinces and municipalities, but even here, foreign trade is strictly controlled by the local branches of MOFERT.

The actual 'purchasing agents' under MOFERT are China Import and Export Corporations (CIEC). In the case of wood, the corporations are the China National Timber Import and Export Corporation (CTIEC), and China National Light Industrial Products Import/Export (Light I/E). The former handles logs and lumber and the latter handles plywood and veneers (Fig. 2.8).

Exclusively, a small percentage of imports are made without passing through either the CTC or ministerial networks, or the standard channels for planning/approval,

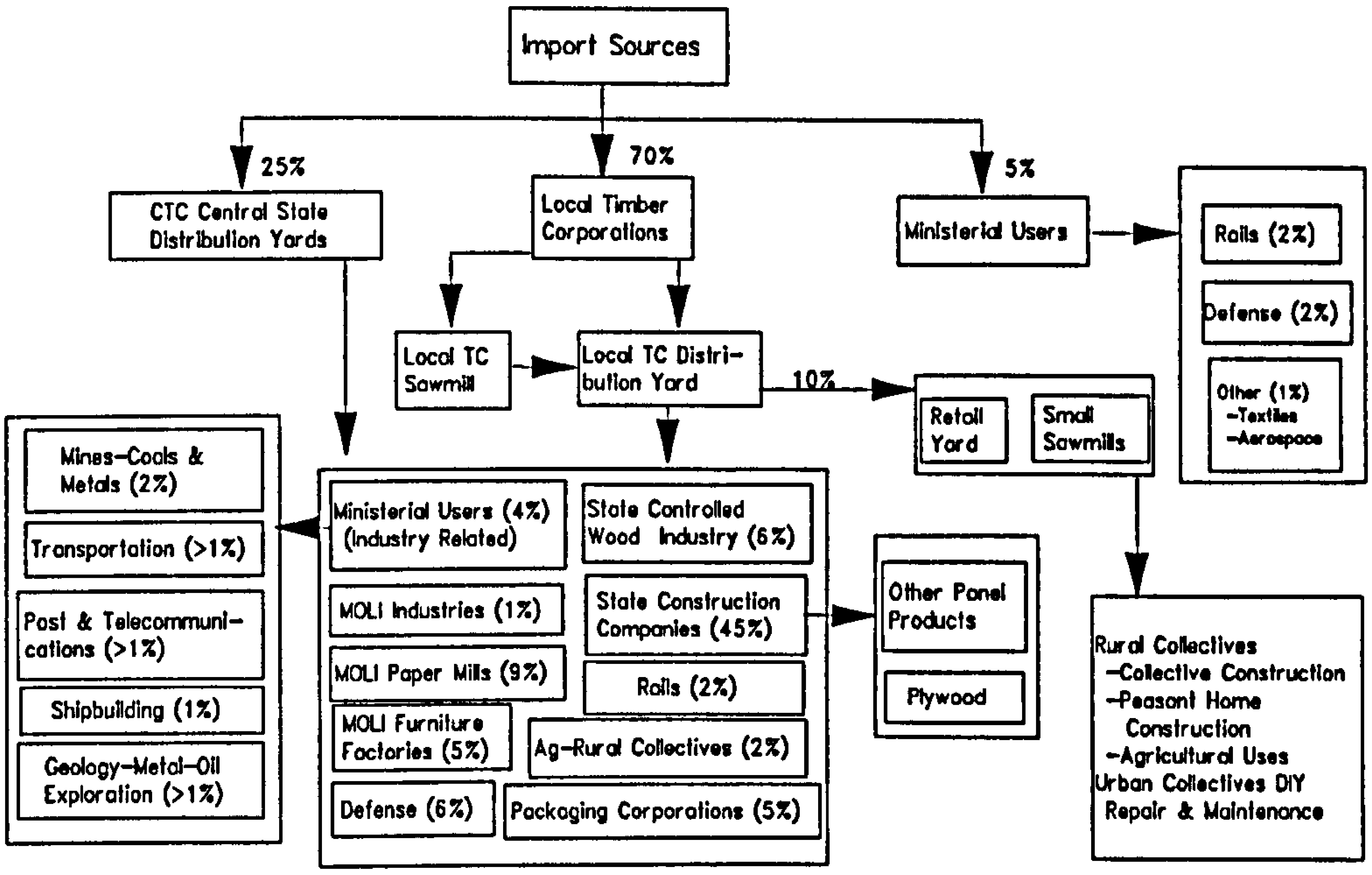


Fig. 2.8. 1985 Import Distribution Channel and Quantity

but by China International Trust and Investment Corporation (CITIC), the military, and some foreign currency earning organisations.

PART II

SUPPLY AND DEMAND FOR WOOD PRODUCTS: THEORY AND METHODOLOGY

CHAPTER 3

DEMAND, SUPPLY AND MARKET MECHANISM

This chapter focuses on the discussion of the following points:

3.1 A Key Issue of Forest Development in China: the Increasing Demand and Decreasing Capacity of the Forest Resource Supply

3.2 Conceptual Problems in Balancing Supply and Demand

3.2.1 Demand

3.2.1.1 Specification of Product Demands

3.2.1.2 Approaches Used for Estimating Wood Product Demand

3.2.1.3 Some Issues in Considering Demand Analysis

3.2.2 Supply

Despite great efforts made in afforestation during the last 40 years, China is still facing many problems. The key issue is believed to be the widening gap between the increasing demand for and the decreasing supply of forest resources. Thus, an appropriate assessment of the current state of the resource, and the levels of future resource use, may have far-reaching effects on the country's forestry development. This study attempts to undertake the task by developing a simulation model.

Before the modelling process, it is desirable to take a brief review of the forest economics literature, i.e., what the forestry economics literature has said about the demand and supply of wood products, the efficient management of forest resources, and what kind of economic theory can be used to explain China's forest development reality.

3.1 A Key Issue of Forest Development in China: the Increasing Demand and Decreasing Capacity of the Forest Resource Supply

It is a general Malthusian expectation that growth in human demand would outstrip the fixed availability for any basic resource, though this has been rejected for good economic reasons. The concern of forest depletions (timber famine) can be traced through the Chinese Guanzi in the fourth century B.C. (Hyde and Newman, 1991), who expressed the belief that the whole continent was running out of timber. Expectation of 'timber famine' has also been rejected for two reasons:

(a) historical evidence that it has not occurred,

(b) economic arguments that increasing scarcity induces higher relative prices and attracts economic and social adjustment rather than famine and hardship.

Nevertheless, as the world-wide deforestation continues, (and tropical forests have been depleted with an alarming speed), the shortage of forest resources has become a basic tenet of today's more global, more environmental, concerns with resource availability. This is because, fundamentally, all utilities (timber or non-timber services) that forest provides arise from its resource; no forest, no timber and forest service. The concern may include:

(1) non-sustainable commercial and industrial harvests in some countries (eg. the Philippines and Indonesia), or

(2) non-sustainable harvests for domestic consumption in some poor and rural countries (eg. Nepal and Malawi), or

(3) excess harvests for both (e.g. China).

Yet, whether or not the relative prices will be high enough to be able to attract economic and social adjustment, hence to reduce the scarcity, is a questionable topic with regard to forestry's nature, but evidence from most parts of the world so far shows that the scarcity is increasing rather than decreasing. This is particularly true in the case of China.

The problems of China's forestry are obviously severe. Many complex issues of the country's forest development are raised by the conflict between the increasing wood demand and the shortage of wood supply. The conflict has been attributed as the major cause of resource depletion and environmental deterioration. It is also widely believed that the conflict has slowed down the speed of economic development in rural areas.

It is now recognized that the annual timber harvest in China is significantly in excess of the growth increment. However, there is no consistent, even approximately estimated statistical data indicating by how much the annual wood harvest exceeds the annual wood growth. The official statistics mainly included the planned demands and supplies, and were always manipulated for ideological purposes. Several primary analyses of China's demand and supply of wood products in the future have been done (Huang, 1985; Zhong, 1985; Hou, 1985; etc.). Some consistent features of those studies resulted from either the concept of the information needed or lack of appropriate technical methods or data. The problems raised from these studies are as the following:

1. The concepts of demands and supplies of wood products employed in these studies embody different contents. For some, the demands simply equal the planned demand, and the supplies mean the united allocation; for others, the demands include not only the planned demand, but also the off-plan demand, firewood demand and 'illegal' cutting, and the supplies consist of the united allocation, as well as the supply through market.

2. These studies depict demands and supplies as fixed requirements and resource flows, unaffected by market forces of prices and other factors.

3. Because of no relatively detailed analysis, these studies present only indirectly the personal feeling and justification of forest policies from individual experience. The methodologies used in the studies were a simple comparison of historical statistics, and were not capable of demonstrating the dynamic impact of programmes, or of evaluating

the programmes' merits in terms of changes in demand, supply, or price, or in increased personal income and distribution of benefits and costs.

4. Since the data used in the studies exclusively come from the official statistics, without further identification, exploitation, and analysis, the results of these studies seem rather to portray the authorities' ideology and provide a less valuable base for discussions.

These and other shortcomings of the studies may be attributed partly to the inadequacy of the approaches used, partly to the prevailing political environment at that time. The current changes brought by the reform provide an opportunity allowing us to rethink the research in this topic.

The highly mixed economic system, with some obvious features of a transitional period, implies that demand and supply in China now are increasingly influenced by market forces of prices. This is especially the case for demand and supply of final wood products. The ranges of both income elasticity and price elasticity have been widening the difference of demands among product types, and the difference of their qualities within same types.

Partially adopting the market mechanism into many parts of China's system has also dramatically changed the economic, even political setting in the nation. Thus, Western economic theory and Western economists' experience in the field apparently become useful for solving the current problems of China's forestry. This theory and experience may at least grant a new angle from which Chinese forest economists can rethink the problems of demand and supply of wood products in China. Therefore, this and the next chapter attempt to discuss several important conceptual problems of modelling wood demand and supply in general, and refer to China's case and its difference or similarity with fundamental economic theory in particular.

3.2 Conceptual Problems in Balancing Supply and Demand

The economic characteristics of the shortage have both supply and demand features, although the supply features receive greater attention. They may also relate to broad ex-sector policy issues, such as the policy problems of price system, or security of land tenure.

In classic economic texts the problem of balancing demand and supply is illustrated by the familiar Marshallian diagram of demand and supply. The intersection of a downward sloping demand schedule and an upward sloping supply schedule indicates the relationships of consumption and price. Supply and demand are assumed to be equated by dynamic mechanisms in a succession of present markets (if at a positive price). All one can directly measure are points of intersection, indicating consumption (and inventory adjustment) and price.

While the concept has substantial usefulness, it is not easy to apply the principle to many empirical economic analyses, and its over-simplification poses enormous difficulties. Let us discuss several specific difficulties in applying it to model various forest resources.

3.2.1 Demand

3.2.1.1 Specification of Product Demands

Modelling of demand behaviour begins with an interpretation of basic demand responses to prices and incomes, i.e., the associated price and income elasticities. Even in market economic systems, direct price elasticities vary between commodities and markets. Some of them are lower for products without close substitutes (e.g. salt) than for others with such substitutes (e.g., fuelwood, building materials, etc.). More critically, those elasticities vary with time. Coupled with the relative instability of commodity prices, this makes measurement of demand behaviour difficult. A further difficulty of this measurement is the complication due to income fluctuation. The degree to which demand responds to changes in income or industrial activity depends on the income elasticity of the end products which the primary commodities serve as inputs. Those products with a relatively low income elasticity tend to experience less demand fluctuation than those with a high one. Thus, the transmission of international demand cycles to commodity producing countries comes through these stage-of-process effects as well as through exchange rates and trade arrangement.

Apart from the influential factors mentioned above, the commodity-substitution patterns also influence demand measurement considerably. The price elasticity of a competitive or complementary commodity, termed the cross-elasticity, also varies with commodities, markets, and time. Where commodities easily substitute for one another, as in the case of timber and cement for railway sleepers, cross-price elasticities are relatively high. Substitution tends to be of an economic as well as a technical and quality or taste propensity. Economic substitution normally results where material costs can be reduced by varying the proportion of a material used in the products. It can also take place between a natural commodity and its synthetic equivalent because the price of the former tends to be relatively higher and more unstable. Technical substitution, being of a more long term nature, occurs because of a change in the production process which permits the utilisation of a less costly commodity. Quality substitution arises because of consumer influence on the final goods composition.

It is clear that the demand for timber is a derived demand which is derived from the market demand for final goods produced from wood; the consumer demand for those goods creates a demand for the materials needed to produce them (Pearse, 1990; Mckillop and Wibe, 1987). This can be shown by Fig. 3.1.

It can be seen from Fig. 3.1 that any change in the demand for consumer goods made of wood will change the derived demand for logs. For example, the increase of population may result in an increase of housing demand, and this may drive up the wood demand for building materials. Given demand for other wood products, the total

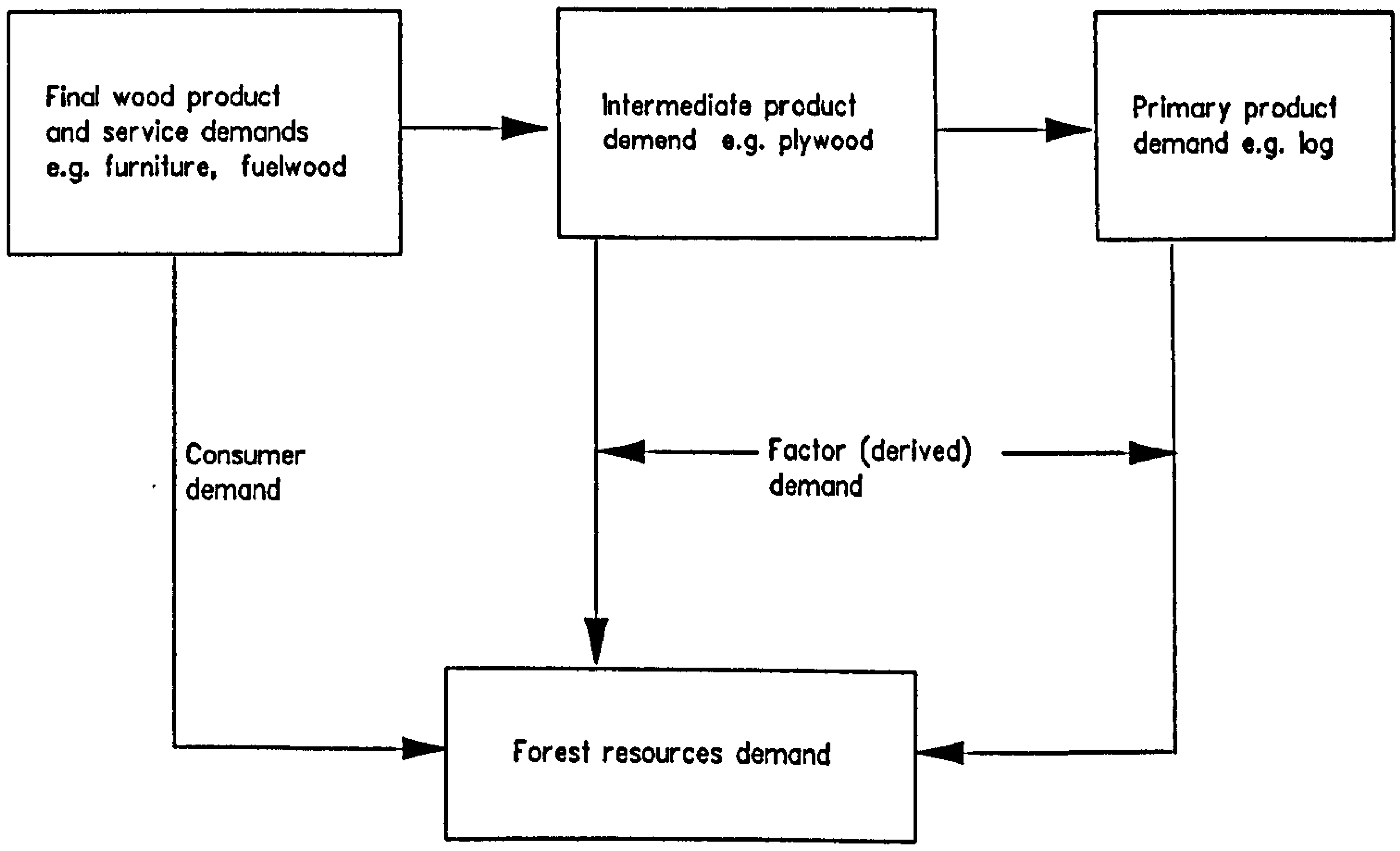


Fig. 3.1 Demand Alternatives of Forest Products

demand on the forest resource will increase.

A large proportion of demand for forest products is derived demand, which is not final demand, but demanded as factor inputs. Both derived demand and final demand are required in different product forms, therefore, the equilibrium analysis of demand for and supply of forest products will be sensible only if all product demand and supply are converted into resource demand and supply.

The relationship of change in the demand for specific products, however, is not a proportional shift to the total derived demand, since:

$$Q=\sum q_j=q_1+q_2+\ldots q_m \qquad (j=1,2,\ldots,m) \qquad (3.1)$$

Q: total quantity demanded,

q: the demand for goods

Suppose q_1 increases from q_1 to $q_1+\Delta q_1$, then

$$Q=\sum q_j=(q_1+\Delta q_1)+q_2+...+q_m \qquad (3.2)$$

the increase rate $\alpha(Q)$ for Q

$$\alpha(Q)=\frac{\Delta q_1}{Q} \qquad (3.3)$$

but the increase rate $\alpha(q_1)$ for q_1

$$\alpha_1(q_1)=\frac{\Delta q_1}{q_1} \qquad (3.4)$$

since,

$$Q=\sum_{j=1}^{m} q_j > q_1 \qquad \textit{if any } q_j \ (j\neq 1) > 0 \qquad (3.5)$$

therefore, $\alpha(Q) < \alpha_1(q_1)$.

This may imply:

(1) the research on wood demand should study not only the trends of total wood demand, but also the trends of the demand for specific products and/or by individual consumer groups.

(2) the specification of production demand for use in a forest sector model should go down to a certain disaggregate level as the demand for some goods or by some end-use groups may have a greater influence on total demand than the demand for other goods or by other groups.

(3) the influence of individual end-use groups on total demand may have dynamic features, i.e. it changes as time passes, as population grows, or as income per capita increases. Let us take China's case as an example, in the 1980s, when the increases of per capita income and population required a housing construction boom, the demand for wood as construction material has been attributed as the most influential factor on the increase of total wood demand. It is also projected that when the share of marriaging

population to total population reaches a peak in the middle of 1990s, the wood demand by the furniture industry will grow faster than the demand for other production.

Highly disaggregated approaches have several advantages as summarised by Cardellichio and Adams (1990). They may:

(1) reduce problems of collinearity among prices and indicators of market activity,

(2) permit estimation of more specific market behaviour so elasticity estimates may vary among different market segments, and

(3) allow use of more varied data from various sources, that would be of help to improve our understanding of demand behaviours.

The levels of aggregation/disaggregation are limited by data availability or subject to the purpose of different studies. This will be discussed in detail later on.

3.2.1.2 Approaches Used for Estimating Wood Product Demand

The adoption of approaches for specificative demand relations may depend upon the theoretical economic principles employed in deriving specific functional forms. The approaches used fall into three broad categories:

(1) essentially *ad hoc* specification, using theory only to indicate which variables should be included in the relation, e.g. the applying of correlation coefficiency;

(2) application of some specific functional form based on assumptions about the production technology of the end-use sector, e.g. Cobb-Douglas function;

(3) derivation of demand relations by duality methods from some general specification of the cost or profit functions of the end-using sectors.

Most of these approaches used in wood demand studies, in fact, are based on econometrics (statistics based) models. A detailed discussion about these methodologies will be given in Chapter 5. Four models, which may, to some extent, be able to represent the development of the modelling studies of wood demand, are highlighted and briefly discussed as the following:

In theoretical demand modelling studies, a well-known model is derived from the analysis of Slutsky (1952) and Hicks (1946). This model deals with utility maximisation and consumer choice under budget constraints:

$$q_j^i = f(y^i, p_1, \ldots, p_m) \qquad (3.6)$$
$$(i=1,2,\ldots,n;\ j=1,2,\ldots m)$$

q_j^i: the demand for good j for individual i;
y^i: the income level of individual i;
p_j: the price of q_j.

Lancaster (1971) proposed a new approach. From observation, Lancaster found that all goods possessed characteristics, and that it was these characteristics, and not the products per se, that the consumer demanded. Therefore, Lancaster's approach implied that the qualities of products also should be included in the demand function:

$$q_j = f\ (y,\ p_1, \ldots, p_m,\ z_{11}, \ldots, z_{1m}, \ldots, z_{nm}) \qquad (3.7)$$

z_{ij}: the 'amount' of quality i in good j.

It is said that the observation is rather trivial, but the theory makes it possible to go further and derive shadow prices of different qualities, and improve our understanding of the deeper forces behind the determinants of demand (Mckillop, 1987).

The third modelling approach of demand based on the theory of information, which emphasizes the importance of time rather than of prices and incomes, is called the logistic model:

$$q(t) = \frac{B}{1+\alpha e^{\beta t}} \qquad \alpha>0\ \wedge\ \beta<0 \qquad (3.8)$$

where, α and β are coefficients.

This model assumes that:

(1) total sales (demand) up to time (t) equal q(t);

(2) remaining market at time (t) equal B-q(t); and

(3) the market limit is B.

This model is usually useful for situations in which demand depends mainly upon time development and an analysis of the market shares for the product.

Mckillop and Wibe (1987) contributed a model, which combined factor demand models with consumer demand models. The main feature of this model is that time is introduced as an argument in demand functions. The model, in matrix notation, is:

$$Q=AQ+C \qquad \vee \qquad Q=(I-A)^{-1}C \tag{3.9}$$

where,

Q: an n x 1 vector of gross productions;

A: an n x n matrix of technical coefficients;

C: an n x 1 vector of final goods.

and based on the following relations:

$$\begin{aligned} q_1 &= a_{11}q_1 + a_{12}q_2 + \ldots + a_{1m}q_m + c_1 \\ q_2 &= a_{21}q_1 + a_{22}q_2 + \ldots + a_{2m}q_m + c_2 \\ &\vdots \\ q_m &= a_{m1}q_1 + a_{m2}q_2 + \ldots + a_{mm}q_m + c_m \end{aligned} \tag{3.10}$$

where,

(1) q_j is the gross production of product j (j = 1,2,... m), and is defined by the production function:

$$q_j = f(L,\ V_1, \ldots, V_k) \tag{3.11}$$

L: labour input,

V: input of factors (i = 1,2,...k)

(2) c_j is the final consumption of j and is obtained from the following equations:

$$c_j = f_j(y, p_1, \ldots p_m,\ t) \tag{3.12}$$

it was assumed that the logistic model was added neutrally giving:

$$C_j = \frac{f_j(y, p_1, \ldots p_m)}{(1+\alpha e^{\beta t})} \tag{3.13}$$

then, after simplification, the model became as following:

$$C = \alpha e^{\beta t}\, f_j(Y,\ P) \tag{3.14}$$

(3) a_{ij} is the input coefficient of factor i in the production of product j, and

(4) here is also assumed that all production functions are of the Leontief type with fixed input coefficients:

$$q = \min(L/\alpha_1,\ V_1/\alpha_1, \ldots,\ V_m/\alpha_m) \tag{3.15}$$

The Mckillop-Wibe model purposed to overcome two problems they realized from previous studies: firstly, that the decisive weakness of consumer demand models, when applied to intermediate products, is that they neglect all reactions within the production system and secondly that the weakness of factor demand models is that they neglect the link to the consumer. The basic idea of this promising alternative is that, by using factor demand models to estimate the demand models, the link to the consumer can be established.

Undoubtedly the Mckillop-Wibe model made progress in introducing the time dimension (t) and in establishing the links between consumer demand sectors and factor demand sectors.

When time is employed within demand models, for example, the Mckillop-Wibe model, it becomes a significant variable (in perhaps a majority of cases). This should signal to modellers that one or more explanatory variables may be unspecified, or may change their relationship within the variable set because of time lag effects, and that it may or may not be possible to obtain statistical measures of causal variables. These fascinating and not well appreciated subjects deserve a separate discussion, later on.

However, in the context of its application, the Mckillop-Wibe model has two important specification problems. One is that consumption is estimated as a function of real income (y_i) only. This single measure of output does not adequately portray the varied array of end uses for which forest products are employed. Another is that cross-price elasticities have been omitted from the demand specification. Moreover, linear demand curves applied in their model may not be appropriate for portraying the long-term trends of wood demand either.

3.2.1.3 Some Issues in Considering Demand Analysis

Whereas the existing literature provides us with valuable insights and approaches in the field, the problems in wood demand studies are enormous, especially when one tries to employ these theoretical models in empirical studies:

(1) many studies in the field estimate wood demand by using statistical techniques. In those studies, demand for one specific product may depends entirely upon one or a few independent variables with a correlation between those variables, and elasticities are usually treated as constants. This is obviously not adequate for demand studies. A discussion about this will be seen in Chapter 5.

(2) the demand and supply of some products (e.g. fuelwood) may not be met through the marketing process. This is particularly the case in many developing countries. In this case, the market mechanism does not work.

(3) demand patterns are also influenced by macroeconomic changes. In any long-term trend studies, it may not be sufficient to hold exogenous factors constant.

(4) wood substitution should be incorporated endogenously within a demand-supply model, if the model aims at the long-run studies. However, while many forest economists have stressed the importance of substitution in estimating wood demand, to

date, there is no effective way to deal with the problems of wood substitution, i.e. the sensitivity of wood demand to changes in the prices of competing products.

3.2.2 Supply

Approaches utilized in modelling supply vary with the ecological, geological, technological and socio-economic nature of the production process. Taken broadly, the modelling process is based on the classical economic theory of the optimal allocation of resources, which include land, labour, capital, and perhaps technique as well, to the production of timber. This also depends on the time span between investment and production, and between current harvest levels and future forest productivity, distinctions between short and long term price response being difficult to capture.

In parallel with demand models, Binkley (1987) reviewed the current supply models of forest sector analysis, and classified the models into four categories: long-run, steady-state models, short-run models, transition models and household production models.

1. Long-run supply models have the equation form:

$$\begin{aligned} Q(p) &= \sum_{j=1}^{n} A_j S_j(p) \qquad j \in J(p) \\ S_j &= f\,(p,\ V) \\ V &= f\,(E,\ t) \end{aligned} \tag{3.16}$$

where

A_j:	area of land type j;
$S_j(p)$:	supply per unit area for land type j;
Q(p):	long-run supply of product;
J(p):	set of land units in production;
p:	current price, with a positive sign in equations;
V:	current timber yield;
E:	management level;
t:	time.

This examines a steady-state world in which prices and costs were known and enough time was available for the inventory level to adjust to economically optimal levels, but two types of problems arise from specific assumptions of this model:

Firstly, by focusing on long-run production costs, the approach ignored the important question of resource dynamics and short-run adjustment to changing economic conditions. Therefore it had particularly serious limitations in attempts to use it for policy analysis.

Secondly, objectives of non-timber benefits, which in some cases are important criteria in decision-making, were neglected.

2. Short-run models recognized that significant fluctuations in harvest levels accompany the observed annual fluctuation in timber prices. The general form of the aggregated short-run timber supply model was given by:

$$Q=f\ (P,\ I,\ Z) \tag{3.17}$$

where

Q: annual harvest;

P: price;

I: current inventory level, with a positive sign in equations;

Z: a vector of other factors influencing supply, including discount rates, ownership characteristics, average household income, etc.

In spite of wide application in forest sector analysis, as an empirical model, it possesses two critical weaknesses:

(1) lack of theoretical foundations,

(2) constraints of available data.

The problems arise especially when the model is applied to welfare analysis.

Both long-run and short-run models introduced above are static, therefore they do not attend to the time dimension.

3. Transition models attempt to unify the long- and short-run theories of timber supply. They explicitly link supply in one period to forest growth and supply in other periods, i.e., they model the transition from current time inventory to the long-term state. Within those models, a demand change in one period affects supply in all other periods. The method used in this model is comparatively simple, non-linear programming with one nonlinear objective equation and several linear constraint equations. The model is a partial equilibrium type used to examine the operation of a competitive stumpage market by choosing the harvest levels that maximize the discounted value of consumer's surplus (Johansson and Lofgren, 1985). However, although the behavioural assumptions of this approach are restrictive a small body of empirical work supports its use. The problems occur from the assumptions and the rational expectations within the models, such as perfect anticipation of demand and supply by forest owners, assumed demand structures, a stable equilibrium with an even distribution, and a very long planning horizon. Furthermore, application of the models also ignores management intensity and land-use questions.

4. Household production models are established on the theory of maximizing utility defined over income and non-timber forest outputs. This model employs the nonlinear programming technique, and a general form of the model is:

$$\max \int u \ R(t) \ Y(t) \ e^{-it} dt \tag{3.18}$$

subject to:

$$\begin{aligned} &Y(t)=y^{e}(t)+wl^{w}(t)+p(t)Q(t)-C(t) \\ &r(t)=f\ (I,\ Q,\ K,\ l^{r}) \\ &I'=G\ (I,\ K,\ l^{F})-Q(t) \\ &L=I^{w}+I^{r}+l^{f} \end{aligned} \tag{3.19}$$

where

u(R,Y): the utility function, $u_r>0$, $u_y<0$, $u_{rr}<0$, $u_{yy}<0$, $u_{ry}>0$;

R: non-timber forest output;

Y: income;

t: time period;

$y^e(t)$: exogenous income;

p: stumpage price;

Q: harvest level;

C: land-holding cost (including taxes);

f: the multiple use function;

G: forest growth function;

I: the level of forest inventory, ($I' = dI/dt$);

i: discount rate;

L: labour endowment;

w: off-forest wage rate;

k: capital endowment;

l^w, l^r, l^F: the labour force allocated to off-forest work, leisure, and forest work, respectively.

Household production models considered both landowner's income from timber production and non-timber aspects of forests. They link the forest sector to the economic sector, via income and wages. One feature of the model, which may be worthwhile to point out, is that price has an ambiguous effect on timber supply. It is supposed that price affects owner's income positively, a higher income leads to more recreation, and less timber production in order to increase non-timber outputs. Therefore, four results were drawn from this model:

(1) An increase in timber price may lead to a decrease in timber supply;

(2) Supply is greater at the lower levels of income;

(3) Increases in fixed cost, such as taxes, lead to a higher level of supply;

(4) A reduction in the wage rate leads to a higher level of timber supply (Binkley 1987).

An ambiguous price effect on timber supply creates equivocal results. Any meaningful conclusion must be obtained from the studies under given circumstances over a given time span, since price elasticities and income elasticities of supply, production cycles, and inventories of forest resource vary from region to region, and from country to country.

Another feature of the model is the method used for modelling. The model, with one objective function of the utility in nonlinear form, and several technical constraints (including multiple use constraint) functions in the form of econometric equations, is a combination of econometrics with nonlinear programming. Three problems thus arise from the model technically.

Firstly, utility has an important psychological component, because people obtain utility by getting things that give them pleasure or by avoiding things that give them pain. The question of how one quantifies or measures the nontimber-benefit in terms of basic units in line with timber benefit or provides an ordinal ranking of alternatives, in order to combine them with fully quantified mathematical programming, is still one of the thorniest problems.

Secondly, to establish the technical constraints, which are in the form of econometric equations, requires detailed, quantitative information in all associated fields; this is also a world-wide and acute problem facing economists.

Thirdly, supply analysis is more cost-oriented; it is difficult to provide a linkage between long-run cost of exploitation and environmental disruption with short-run costs of production.

Since forests valued for industrial timber are both productive capital and product (Pearse, 1990), a model of supply of forest products in the future is a methodology for projecting the development of forest inventories. Future forest inventories are determined by several factors, such as:

(1) present resource characteristics,
(2) forest growth/drain relationships,
(3) intensities of forest management, and
(4) input of land investment.

The comparative importance of these elements depends, to some extent, upon how far into the future forest conditions are to be projected. If the projection period is shorter than the average rotation length of the forest under analysis, then the balance between net growth and removals dominates the other factors in determining timber inventories. Some forest economists argue that a long period, say one rotation length, would be a reasonable time-span, better to describe a consistent, alternative view of the future that is conditional on the biological response to forest harvest and forest management activities. But the longer the period covered by modelling, the more difficult is the formulation of the conditions under which the analysis is valid. What is an acceptable modelling period length is still an open question to forest economists not only in developing countries which do not have a long time-series data, but also in developed countries which do have them. More detail about this will be discussed in the next chapter (Chapter 4).

Dynamics are an important feature of the wood supply simulation, and the age-class structure of the forest inventory is a critical element, as wood supply models link the ecological and economic components of forest sector analysis. Only if the age-class structure and its dynamic features are properly represented in the simulation model, will it be possible for the model to reflect the features of wood production, and hence to generate realistic results. However, these critical elements have been ignored by many, even some well-known models (e.g. the Global Trade Model (GTM), designed by IIASA to simulate the long-run economic behaviour of the global forest sector) due to their highly aggregated nature (Cardellichio and Adams, 1990).

The wood recovery rates is another issue in the wood supply studies: whether in converting trees to specific wood products (as the way adopted in GTM) or in converting different wood products to forest inventories, the recovery rates should reflect the level of production techniques and resource management, and should change over time.

Probably, the most difficult task is to model wood supply and demand for some countries like China, where political or ideological power frequently distorts society's economic behaviour. In some cases, economists find that the classical economic principles can not be applied directly to explain some economic phenomenon unless a further and empirical analysis has been done. For instance, in 1980 an increase of wood prices in China led to an increase in both wood production and consumption. Furthermore, there are also many macro-economic policy issues, such as forest ownerships, land market and land use policies, taxation, subsidies, stumpage prices, and international trade, etc. All of these affect wood supply and they are not easy to tackle. These will be discussed in the following Chapters.

CHAPTER 4

TIMING, PRICING, RESOURCING AND INTERNATIONAL TRADE

The following points are discussed in this chapter:

4.1 Time Horizon

As has already been mentioned, the concept of time is relevant to both demand and supply. In fact, most subjects of economic studies, such as interest payment, discounting and compounding, inflation, economic rotation, resource allocation, equilibrium of demand and supply, are related to the concept of a time span. It is in this sense that the time period of production is the heart of economic studies (including forest economics) (Price, 1989; Pearse, 1990).

The significance of time may be due to changes in consumption tastes which can not be directly measured, technical progress which has not yet been represented efficiently, the effects of competitive, complementary or substitutive goods or services, or the effects on some economic variables including demand and supply.

Price (1989) pointed to the importance of the time dimension in supply and demand for wood products:

> "In the short term, not all the timber that could profitably be harvested at a given price is actually available (even if owners were willing to sell) because machinery and staff take time respectively to manufacture and train. In the long term the available timber does not represent supply either because it is a stock, rather than a capability for continuous supply. ... Long term supply focuses on volume yield per year that can be made available at a range of prices. This relates to increment, not standing volume" (p367).

The conception of time used in forest economic studies may be classified into four categories:

(1) time variables as the input of models;

(2) time preference as representative of human beings' economic behaviour in the models;

(3) time boundaries as constraints in the models; and

(4) time lags as important effects on the models' behaviours.

4.1.1 Time Variables As the Input of Models

Time variables as the input of models can be found both in demand and supply models in forest economic studies (Batten and Johansson, 1987; Mckillop and Wibe, 1987; Johansson and Löfgren, 1985; etc.). However, there is very little specific discussion of the economic problems of time in books on the general principles of economic analysis. A typical textbook may contain a reference to time as a scarce resource but the concept is not usually developed further. There are, of course, a number of important issues that have been discussed widely in the economics literature where some aspect of the passing of time does enter the analysis (Price, 1989). Ricardo and Marx started the discussion of the process by which the length of the working day is determined; Samuelson (1948) argued that :

> "Economic activity is future-oriented ... current productive efforts ... produce for the future in order to repay past for present consumption" (pp.46-7).

Much more recently, the other part of our daily ration of time has been dealt with by studying the choice between work and leisure and the problem involved in the allocation of leisure time in recreation economics work.

Time has been regarded as a form of input required in production, which uses time as a proxy variable:

(a) for measuring changes (for example, technical progress) which have no obvious or closely statistical relationship with one or more variables, but may be described quantitatively by using time as an independent variable,

(b) for forecasting the future level of some economic activities, or

(c) for understanding economic behaviour regarding inter-temporal issues.

It is clear that in some natural production processes, such as forestry, time is one of the most important and productive factors acting with natural conditions to generate natural productivity. Time is an essential element in the process of maturing trees just as it is in building up animal populations, stabilising water yields, or manipulating landscape. After a 2-3 year period of factor inputs in plantation, trees grow alone primarily by natural force until they will be suitable for harvest. Marx defined these two distinguishing stages as the human working period and the natural production period, respectively. Long growth periods, hence, long planning horizons, as a requirement of forest production, create a greater uncertainty of productivity and future market conditions. Not only will the passage of time change the forest environment -- physical, social, political, ethical, and economic -- but it brings other changes in the nature of the resource itself (Mclean, 1984). The longer the production period, the greater the likelihood of unexpected input effects like fire, or unexpected technological breakthroughs (e.g. new fertilization application), or unexpected economic outcomes (e.g. price fluctuations) will be. Longer periods of forest productions (ranging from 2 to longer than 100 years) also imply greater potential for changes in final product demand by the time the product is ready for harvest.

4.1.2 Time Preference as Representative of Human Beings' Behaviour

This is a usual way of considering time preference as representative of human beings' behaviour for economic analysis in which time has been brought into the analysis of interest (Clawson, 1975), particularly by those who regard interest payment as a reward for waiting. Closely allied to this concept has been the discussion of the choice between present and future satisfaction, or time preference, or time utility (Price, 1989), which has included technical arguments about methods of discounting and the more interesting debate on how society should determine the rate at which the value of future benefits should be discounted or scarce resources should be rationally used. It seems that the fact of time preference has been accepted by most, if not all, economists, but there are a series of questions about the interpretation and measurement of time preference in economic analysis and modelling processes. This is further discussed by Price (1988, 1993).

4.1.3 Time Boundaries as Constraints in the Models

Another concern of the concept of time is time horizons, that is, time boundaries, for planning, production and decision-making. Obviously, no scientist or economist aspires to solve a problem for the long distance future. One draws the temporal boundaries around the systems which interest one in order to exclude a host of problems and focus one's attention on a given period. The question of choosing temporal boundaries exists on two levels. At the superficial level, it is a rather dry, methodological issue: over what time span shall the behaviour of a particular system be studied? But this question also has meaning at a more profound level, leading us to ask: what are the roles and goals of these studies?

The existing literature contains little discussion of the methodological issue of how one chooses the temporal boundary of a system to be modelled. One of the few comments on that choice is made by Meadows *et al.*, (1974, p90):

> "The time horizon of a model is the period over which the modeller is interested in the system's behaviour. That period usually corresponds either to the time required for the system to manifest a behaviour mode of interest or the time required for the system to respond fully to some proposed new set of policies".

Klein (1956) stated that extrapolations should not be carried too far into the future, perhaps not more than two years. Theil (1960) pointed out that there was some kind of social pressure that led forecasters to produce estimates acceptable to their audience. Mckillop (1967) chose a 15-year prediction period and claimed that ambitious length was suggested by need rather than by statistical considerations. In recent years there has been a trend to the use of perspective planning, which sets out broad outlines and provisional targets for up to fifteen or twenty years, as a background for current planning. The planning process is dynamic and is modified and adapted in accordance with new data on needs and possibilities and in particular in the light of achievements of past planning periods (Westoby, 1987).

With very ambitious intentions, Forrester (1971) and Meadows (1972) chose a very long time span, 50 and 200 years, respectively, in their studies. One of the motives behind the lengthy time span was the fact that conventional econometric models either studied static situations or made projections only a few months or years into the future. They argued that within the time horizon of 1-5 years, the macro-problem of 'limits of growth' simply did not appear; within 200 years, limits of growth became evident. Many of the critics of their work focused on this issue: they argued that since conventional econometric models were not very accurate over a span of even a few months, the projections of Forrester and Meadows could not possibly be accurate over a century or more.

It seems that the selection of a temporal boundary is as arbitrary as the selection of a spatial boundary. But if this is considered further, one may find there may be something influencing the choice, such as:

(1) the purpose of the modeller, e.g. forecasting, policy analysis, or scenario generation;

(2) the objective system of research, e.g. experimental or non-experimental research; natural, social or mixed systems;

(3) the modellers' knowledge and available information about model structure and possible changes of structure in the modelled period;

(4) the demand for (or social pressure of) time-span to be modelled.

Concerning the modelling of demand and supply of wood products, the function of this study is to investigate the relevant economic facts to the extent that they are important and indispensable for assessing future development of supply and demand. It must depict the qualitative and quantitative structure of the timber market and must direct its attention to changes in the timber market in the course of time. Tracing this back to some important studies in this field, one may find that the trends of choosing the time-span have a feature: the later they were made, the longer the time-spans were (Table 4.1).

Table 4.1 Time Span Chosen in Some Studies of Demand-Supply of Forest Products

Year	Author	Title of Studies	Time Span
1950	FAO	European timber trends and prospects	10 (1950-60)
1958	F.S. (US)	Timber resources for America's future	23 (1952-75)
1958	F.S.(US)	Analysis of the timber situation in the US	48 (1952-2000)
1958	Stockholm	World timber and prospects	45 (1955-2000)
1967	Mckillop	Supply & demand for forest	15 (1961-75)
1969	AFO/ELE	Timber trends & prospects	30 (1950-80)
1980	Adams & Haynes	1980 softwood timber assess assessment market	50 (1980-2030)
1982	F.S.(US)	Analysis of the timber situation in the US	78 (1952-2030)
1984	Sedjo & Clawson	The resourceful earth	20 (1980-2000)
1987	IIASA	The global forest sector	50 (1980-2030)

Certainly, there are so many uncertain factors, such as future price trends, consumers' behaviour, political change, substitution of wood products, development of international trade relationships, all of which make the studies complicated and problematical, but this should not prevent us from attempting a policy analysis, since it is always action directed towards some conceptions of the future. To what extent those conceptions are valid or erroneous remains an open question.

4.1.4 Time Lags as Important Effects on the Model's Behaviour

The fourth concern of the concept of time related to the demand and supply analysis is time lag, hence the stock and flow variables in equilibrium and disequilibrium models.

The question arises of how to represent basic demand-supply forces that affect each other, as well as production rate, price movements, input of production factors and other economic changes in both equilibrium and disequilibrium models. Most demand-supply studies treat supply and demand as a rate of flow, measured in goods units (or converted into currency) per unit time. This is the traditional and dominant economic thinking (Keynes, 1936). The static theory of the firm regarded supply as a flow of production determined by the equalisation of price and marginal cost. Analogously, the theory of the household treated demand as a flow of consumption governed by relative prices and marginal utilities. Both of these theories evolved out of a set of equilibrium concepts of profit and utility maximization, respectively. Consequently, there are no inventory discrepancies to generate upward or downward pressure on rates of production and transaction.

Large numbers of models in economic literature derive equilibrium prices and quantities based upon an assumed equality of demand and supply. In such models, supply and demand are both usually considered as rates of flow, measuring equilibrium rates of activity. Even in dynamic models, most modellers tend to concentrate on the relationship between rates of flow to the exclusion of stock concepts. These models may allow for the possibility of disequilibrium between production and consumption, but they account neither for changes in inventories, backlogs and other stock variables that would occur in a disequilibrium model, nor for the way by which changing stock variables feed back to influence supply, demand and price. More specifically, a number of broad implications for economic theory and modelling practice are raised:

(1) Flow equilibrium and stock equilibrium, as conventionally defined in economics, will generally not arise constantly. Thus, stock variables will frequently be out of equilibrium, thereby causing continuing change in rates of flow, even once flow equilibrium between production and consumption has been attained. Consequently, dynamic behaviour and stability characteristics of an economic system can be analyzed only by comprehensively interrelating stock and flow variables.

(2) Economic systems are characterized by interactions between stock and flow variables that yield complex adjustment paths to system equilibrium. These paths operate between supply and price, demand and price, between endogenous factors and exogenous factors. Such systems can not be considered stable in the sense that an initial disequilibrium will be countered within a very short time. Some demand and supply of wood product models, such as the Global Sector Model (Kallio *et al.*, 1987), do include some stock variables and dynamic features. Unfortunately, some assumptions of the model, such as the important elasticity of timber supply with respect to the

inventory level, the fixed price elasticity of timber supply, and constant cost, are so oversimplified that the model has a less realistic sense than it should otherwise have.

(3) The efficacy of policies designed to influence such disequilibrium economic behaviour as economic growth or instability, can be assessed properly only in a model that interrelates stocks and flows. Therefore, stock-variable concepts of demand and supply must be incorporated explicitly in economic models in order to capture the rich disequilibrium behaviour characteristic of real socioeconomic systems.

In general, stocks of in-process goods and final output intervene between the process of production and consumption. If production exceeds consumption, inventory will accumulate and increase, or vice versa. It is well known that the forest resource is not only the output, but also the productive factor of production, due to the fact that reproduction of the forest, in a large sense, relies on the stock of resource, or potential yield. Discrepancies between actual and desired forest stock generate pressure to expand or contract production by exploiting or protecting the current resources. Therefore, the existence of a stock links production and consumption rates, allowing them to be unequal at different time points, while typical resource policies tend to equalize production and consumption from a long-term point of view. But if production exceeds consumption, stock will rise above desired levels, thereby signalling a need to contract output. Conversely, production below consumption will cause falling stocks and pressure to expand output. Consequently, disequilibrium between production and consumption could be adjusted through the changes of production levels according to stock shortages or excesses, as well as through price changes. Such quantity adjustments to a market imbanance can exert important effects on disequilibrium behaviour. Eventually, price changes arising from demand-supply pressures should be based on the magnitude of stock variables, i.e., derived supply, rather than flow variables. For example, upward price pressure may reflect low stocks or high order backlogs, and lead to a high production rate. Stock variables trigger price and yield regulations. Any theories capable of describing system behaviour as a temporal process, in or out of equilibrium, require a prior account of how trade is organized in a complex production-consumption-distribution system (Clower and Leijohufvud, 1975).

4.2 The Role of Price as An Adjustor or Allocator

4.2.1 The Role of Price in General

Obviously the long-term behaviour of prices is a matter of great importance to balance the supply and demand. Price (1989) argued that the course of future change of price is one thing no serious forest economist would be foolish enough to predict, and none would be stupid enough to ignore. Clawson (1976) pointed out that the prices of goods and services play several indispensable roles in any society and in any economy, although the roles are different to a great extent.

(1) Prices are a signal to producers, telling them how much to produce and by what combination of inputs. Even when there are output targets, as in a centrally planned society, the prices received for outputs go a long way towards influencing producers, and actual output may reach planned output only when prices are reasonably attractive to producers.

(2) Prices are a guide to consumers, helping them to decide how much and what kinds of goods and services to consume, and how to allocate their limited consumption income among various products and services.

(3) Prices are part of the income-allocating function, at least in reasonably free societies and economies.

In a free market economy, it is assumed that resource owners, producers, and consumers behave in a way that is economically rational; the institutional link between these three groups of decision makers is provided by the market; the feedback mechanism, which is so critical for the operation of the system, is provided by prices: producers would not sell their products, say timber, unless they were assured that the return would match or exceed their reservation price, including their production and transportation costs, interest charges, and the rent of land.

It is at this point that political economists take the theory into normative realms. Adam Smith 200 years ago suggested that the market mechanism was like an "invisible hand" which is seen to achieve an allocation of resources that maximizes the satisfaction, or economic welfare, of society as a whole. The idea of Adam Smith, that the market produces the best allocation of resources from society's point of view, relies on the condition that the market is purely competitive. But in real world terms, since the market system is driven by individual benefit motives, certain market failures, such as the externality, unequal income distribution and imperfect competition, still exist. If unfair advantages can be obtained through the imperfect market, e.g., monopoly, inertia, restrictive practices, and so on, the allocation mechanism will be distorted (Price, 1987).

In addition, it is not always reasonable to assume that producers operate on the boundary of their production possibilities. Producers not only lack full details of all possible production relationships, they also operate in a non-deterministic world, where stochastic events, such as floods, fires and diseases, can cause major discrepancies between realized output and that intended. Another exception from general theoretical assumptions is that producers do not operate according to marginal principles at all, they are very sensitive to the changes of government's policies, such as the change of ownership, and their own current financial situations.

Almost all studies of demand-supply of final forest products in the Western world treat price as the first important, even the only one determinative, variable. All of them estimated and/or examined price elasticity of demand for final products. But the problem of estimating the elasticity, as Price (1989) pointed out, is the broad range of its value: from -3.5 for sawnwood (Mckillop, 1967) to -0.01 for paper (Buongiorno, 1977), without evident consensus.

Despite these and other real-world observations that point up the practical shortcomings of price theory, price theory, as a general explanatory model, is under no real threat provided that markets are perfectly competitive. A great deal of accumulated empirical and also theoretical knowledge makes us cautious about these paradigms in general. In many nations, especially in the Western world, currently the market system plays an important role in determining the national economy. It is highly organized, with many steps involved in moving goods from producers to consumers. Following the experience of the depression years in the 1930s, Keynes argued that governmental actions significantly influence production with the aim of preventing failures of the invisible hand, even if this results in new problems, typically, inflation. As discussed previously (in Chapter 1.4), there are several grounds on which the failure occurs in the actual world: monopolies of many types, incorrect signals given by disequilibrium prices in market, public goods, and externalities which may be imposed by some agents on others through the existing structure of property rights, and which distort the incentives for the use of resources.

The importance of price is indubitable in the balance of demand and supply in a free market system. The question is whether price plays a similar role in different economic systems and in different production sectors and what is its impact on short- or long-term run of production?

4.2.2 The Role of Price under CPE System

The market economies -- however they might differ -- all have some common basic rules, such as the profit motive and the informative and allocation function of price, which can be considered axiomatic in model building. Quite different is the world of the centrally planned economic system, where all resources are nationalized, and where the economy is hierarchically structured and operates through central planning and planning instructions that are obligatory for the socialist enterprises. The volume and distribution of products are decided by central authorities, but these decisions reflect compromises, as they result from bargaining between the respective ministries and the lower levels of management. Under traditional central planning the market is very imperfect (with the exception of personal consumption). Foreign trade is centrally controlled by administrative methods rather than by financial regulators. The producers are isolated from the world market, and it is not their task to sell the goods produced by them. The products designed for export are channelled to foreign trade enterprises that are specialised according to product-types and have monopolies in foreign trade transactions.

Price and the market mechanism played a very limited role in China, in terms of adjusting resource allocation and balancing demand and supply. For a long period before 1978, prices were wholly or partially frozen. In a constantly changing economic situation, this allowed the price system to sink gradually into a state of general disequilibrium, with underpricing of agricultural products, energy and raw materials (including wood products), and overpricing in the processing industries. This led to a worsening of resource allocation and a large imbalance in the economic structure. Under the administrative pricing system with a feature of so-called double-track prices, forest producers did not have incentives to expand their production and ignored demand conditions for wood products of various sizes, shapes, grades and species that vary from region to region; on the other hand, wood consumers had no incentives to conserve forest resources, as wood products were allocated at extremely low prices (Li *et al.*, 1988).

An increasing number of Chinese economists considered pricing to be the most fundamental problem in the Chinese economic system. The problems include:

1. The planner's prices of forest products were set too low for producers to acquire sufficient incentive to reinvest in forestry. The prices were set in the early 1950s, based on the ideology that the natural resources had no value since there was no input of human labour force to them, thus they were natural gifts.

2. Under the Unified Distribution System, prices did not shift either reflecting the demand and supply, or considering production costs. As shown in Table 4.2 (p.109), retail prices actually remained constant from 1955 to 1972, and did not rise appreciably before 1985.

3. Timber price differentials for variations in timber species, quality and size were also too narrow (Li *et al.*, 1987). Moreover, in some circumstances, the larger the size

and the higher the quality, the lower the prices became. This was because timber of superior quality and large size would be procured and distributed at the planned prices, which were and still are much lower than floating price and market price; while timber with inferior quality and small size was allowed to be sold at the market price or floating price. Thus, it should not be surprising that the producers processed large timber into small size, since they were still driven by the invisible hand, but in indirect ways.

4. The price disparity was also evident relative to world prices. It was reported that China imported hardwoods from southeast Asia in 1979 for about US$150 per m^3, while domestic timber was selling for about RMB¥ 150 per m^3 at time. At the exchange rate of about RMB¥ 2 to US$ 1 of that time, Chinese timber was selling at about 50% discount to the world market price at Chinese ports of entry. When the overvaluation of the Chinese currency is considered, the disparity was in fact much greater. This makes economic evaluation or comparative studies impossible to conduct normally or directly.

5. The distorted price even lost its function of economic accounting and evaluation of enterprise managerial activities, simply because it is easier to log profits by obtaining low-price materials, low-interest loans and official-price foreign exchange or even reselling quotas, certificates and ration coupons than by improving management. Consequently, this sort of abuse of administrative power has not only aggravated existing unfair income distribution, but also seriously corrupted the body of the government.

4.2.3 Price Adjustment, Economic Equilibrium and the Modelling Process

More generally, a pattern of behaviour, which exhibits opposing short-term and long-term price responses, is frequently observed. Conventional economic theory asserts that an increase in the marginal cost of producing a commodity should lower supply so that a lower quantity is elicited by a given price; low supply in turn should drive up prices due to excess demand. This may be true for explaining the marketing mechanism in some situations, especially in some production sectors with a short production cycle. However, real economic systems display a much more complicated pattern of interaction among price, supply and demand.

Market price could be adjusted to equilibrium price by the market mechanism automatically, and the quantity actually produced to the equilibrium quantity. The change in price and the produced quantities are subject to oscillations which can be illustrated by the well-known "cob-web theorem". Whether this adjustment process converges to or diverges from the equilibrium point, depends upon the value of elasticities of demand and supply. However this process is, in fact, not so natural as people have believed. Moreover, the price mechanism can be a cruel disciplinarian, when production processes are subject to a long time period with a great uncertainty or with some features of a public goods (such as forest services). Violent price fluctuations may have a devastating impact on its future development. The price mechanism may fail to provide the 'right' incentives, or may adjust an imbalance state into a balance one, but under a high opportunity cost -- by using more resources than it should -- as discussed in Chapter 2.4. In this sense, as Lange (1966) pointed out, the idea of economic equilibrium as a state towards which, in the absence of a change in essential factors, the economic system actually tends to move, has only a restricted meaning.

The experience of Chinese reform, started since 1979, indicates that there may be another kind of adjusting process of demand and supply, if a general supply adjustment is possible by increasing the quantity of domestic production or importation.

Let SS be the supply curve, as a Marshall long-period supply curve, and D_1D_1 the curve of the planned (controlled) demand; E' is the equilibrium point (ignoring whatever sort of equilibrium it is), and P_e' and OQ' are the equilibrium price and the equilibrium quantity, respectively (Fig. 4.1).

Now the demand curve shifts into the position D_2D_2. The new equilibrium point is, therefore, E", and P_e" and OQ" are the new equilibrium price and the new

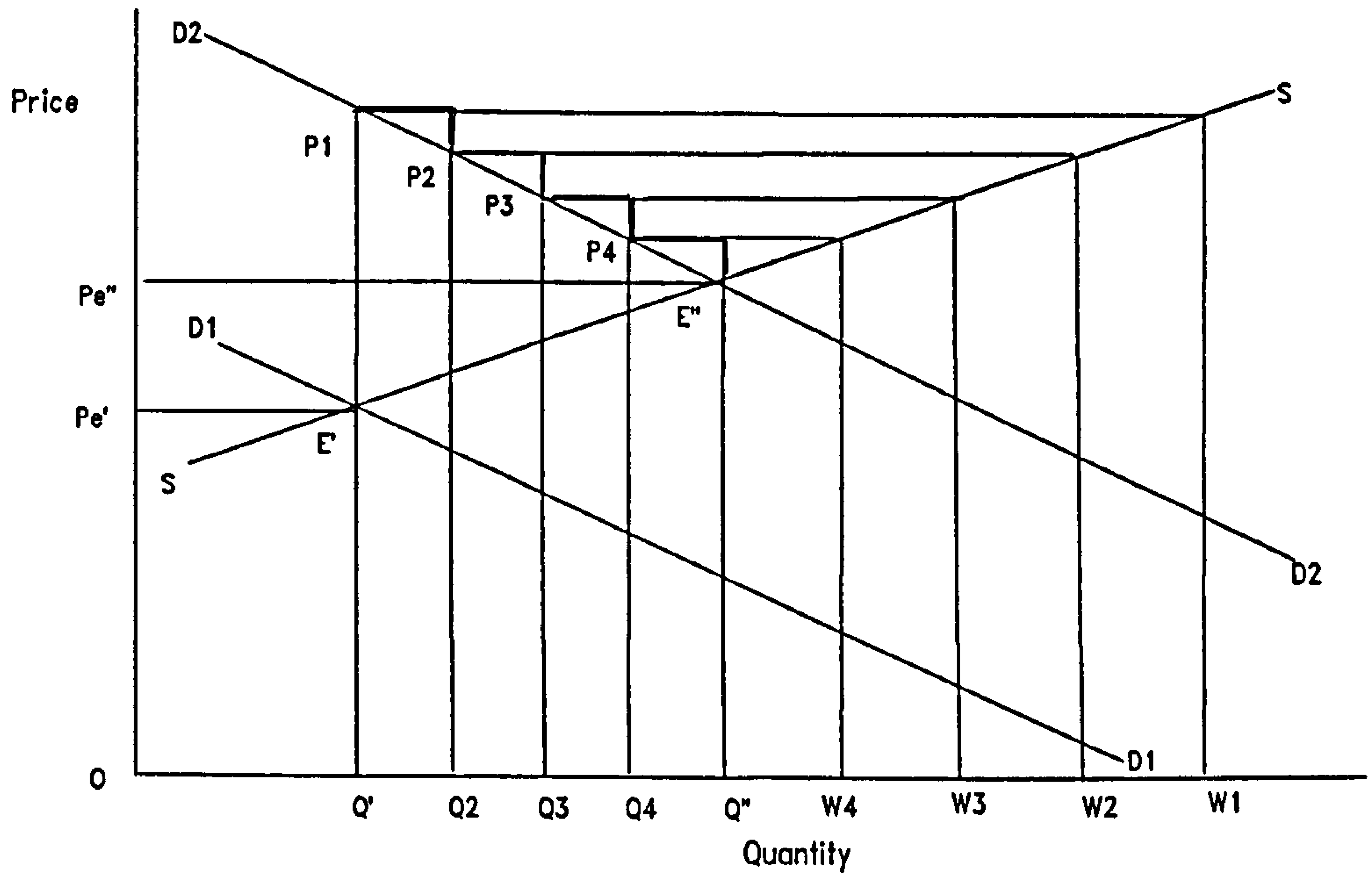


Fig. 4.1 A Possible Adjusting Process of Equilibrium

equilibrium quantity.

Once the market conditions changed, taking China's example, from planned marketing to competitive, the potential demand, which was defined by Linnemann (1966) as the demand which would occur if all impediments to trade are absent, arose. While the equilibrium point jumped from E' (controlled equilibrium) to E" (actual equilibrium), the price climbed from P_e' to P_1. When the quantity supplied to market can not immediately rise to W_1 due to, say, limitation of production possibility or import, but only to Q_2, in consequence, the price will immediately fall down to P_2. If suppliers adapt their production to the market price, they will be willing to offer W_2 to market, and so forth. In this way, market would finally reach a new equilibrium point E". Adjustment, therefore, would not proceed by oscillations, but by steps plotted on P_1E" section of demand curve. This kind of adjustment process may be relevant to the case of many products (especially wood products), where the increase of supply (apart from import) may take place with a long time delay, and supply may be varied gradually. An example of this kind of adjusting process and a discussion will be given in 4.2.4.

For modelling purposes, this process of the continuous (or gradual) supply adjustment may also be expressed mathematically. Let P be price, x the quantity supplied and t the complete adjustment period. Further, let t_n be the entire adjustment period, i.e. the time necessary for the creation of optimum combination of all the production factors, and x_0 the quantity determined by the supply curve at a given moment. Thus for each value of t_i, i.e. for each adjustment period, there corresponds a supply curve. If considering t as a parameter, therefore, one can obtain a group of supply curves which may be expressed by the equations:

$$P_i = \varphi(x, t_i, x_0) \qquad (i = 0, 1, \dots n) \tag{4.1}$$

This equation contains not only the parameter t, but also the parameter x_0, since all those curves must pass through the intersection point of supply curve at the given moment and the long-term supply curve. Assuming

$t_i = t_0$, the equation (4.1) shows the supply curve at the given moment;

$t_i \geq t_n$, the equation shows the long-term supply curve;

$t_0 < t_i < t_n$, the equation shows a group of short-period supply curves.

The slope of supply curves is determined by the differential quotient *dP/dx*. The supply adjustment takes place continuously if *dP/dx* is a stable function of t, otherwise it takes place discretely.

$$\begin{array}{lll} \dfrac{\partial^2 P}{\partial x \partial t} < 0 & E_s = [0, \delta] & \text{if } t_0 < t_i < t_n \\ \dfrac{\partial^2 P}{\partial x \partial t} = 0 & E_s = \infty & \text{if } t_i > t_n \\ \dfrac{dP}{dx} = \infty & E_s = 0 & \text{if } t_i = t_0 \end{array} \tag{4.2}$$

where, E_s denotes the price elasticity of supply.

If one expresses the long-term supply curve by $p=\phi(x,t_n)$, (the parameter x_0 can be omitted here since the intersection point of the supply curve of the given moment lies on the long-term supply curve), then, given $t_i \geq t_0$, one has:

$$\frac{\partial p}{\partial x}=\frac{\partial \varphi(x,x_n)}{\partial x} \tag{4.3}$$

If, now, the demand function is assumed to be $P=\phi(x)$, then the adjustment process may be expressed by:

$$f(x)=\varphi(x_1,\ x_n) \tag{4.4}$$

For each t, one can obtain a definite value of x, and by substituting this value in the demand function, a definite value of p is obtained. As t varies from t_0 to t_n, the adjustment process will be described; equation (4.4) assuming $t_i \geq t_n$, shows a new equilibrium point has been reached. Therefore, equation (4.4) expresses both the adjustment process and the final equilibrium position. Obviously, when i becomes infinite, the step-curve, which shows adjustment process, will become smooth and finally lie on the D_2D_2.

The process described above is a purely theoretical deduction based on general equilibrium theory. Despite its indication of a possibility which could reach the equilibrium point by avoiding the oscillation adjustment of demand and supply through gradual or continuous increasing supply, there are quite a lot of problems within the assumptions in the analysis, considering the forest product market in China.

In terms of supply adjustment and economic equilibrium, forestry is different from most industries or even agriculture. This is not only because of the long production rotation, but also because of indefinable forms of forest products.

4.2.4 Price Adjustment of Demand and Supply of Forest Product: An Example

The supply adjustment process demonstrated in Figure 4.1 seems able to explain the phenomenon which has happened in China since the partial opening of the wood market in 1985.

The classical theory of demand and supply indicates a relationship between market price and quantities wanted for purchase. However, the amount of commodity wanted by buyers depends on many factors apart from its price. Among them are current tastes and fashions, the prices of substitute commodities, the prices of input factors and the incomes of potential buyers. Furthermore, the amount of a commodity people are willing to buy is different from the amount of commodity trade in the market. Tracing back to the wood product market in China during the last decade, the limitations of employing classical theory to explain China's distorted case may appear obvious. (Table 4.2 and Fig. 4.2).

Table 4.2 and Figure 4.2 show a distorted relationship between price and consumption. It is also reported that in 1987 in the south, pine timber price increased from RMB¥240 in 1986 to RMB¥500, and China fir from RMB¥600 in 1986 to RMB¥1200, while the demand kept on an increasing trend and wood import prices were constant (Liu, 1990). It may not be possible or proper to draw any obviously useful conclusions directly from these statements. What could be seen is contrary to the classical theory: while the price of wood products increased, consumption did not decline but increased stably. Apart from inflation and the increase of per capita income, the principal cause behind the phenomenon is the explosion of suppressed demand, which was inhibited under the unified distribution planning system. As soon as the market mechanism operates, the demand must be met, and the conventional relationship between demand and price would not be established until potential demand had been met. Therefore it can not be represented simply by an upward shift in the demand curve and resultant increases in both the equilibrium price and the equilibrium level of supplies. The classical result encompasses only the considerably long-term response to supply, while the short-term response runs in the opposite direction.

Table 4.2 Consumption and Retail Prices for Timber and Bamboo 1952-1985

Year	Annual Consumption (m^3 million)	Average Prices (RMB¥/m^3) Procurement	Retail
1952-1956	21	20	91
1957-1961	34	22	100
1962-1966	41	35	100
1967-1971	38	37	100
1972-1976	47	39	106
1977	50	37	108
1978	52	37	109
1979	54	43	120
1980	55	56	149
1981	51	62	197
1982	58	72	216
1983	63	78	215
1984	71	–	265
1985	76	–	313

1. Note: Price are nominal or current prices. Procurement prices are average prices across all species and grades and represent a mix of posted procurement prices, negotiated prices, and above-quota prices, at least since 1978. Retail prices are average prices are average prices for all species and grades of timber and bamboo.

2. Source: State Statistical Bureau (1984:450, 456); National Forest Products Association (1986: 97)

Nevertheless, some insights can still be gained even from the information provided in Table 4.2.

(1) The phenomenon indicates that there is a potential of a huge demand for wood products in China in the near future.

(2) Considering the fact of increasing imports of wood products and an assumption that the importing prices reflect the supply and demand for wood products in the world market, the phenomenon may also indicate that there must be something wrong with the government's policy: either RMB¥ is overvalued, or the wood market is still controlled;

(3) It may also prove an important, but often forgotten, theory of western

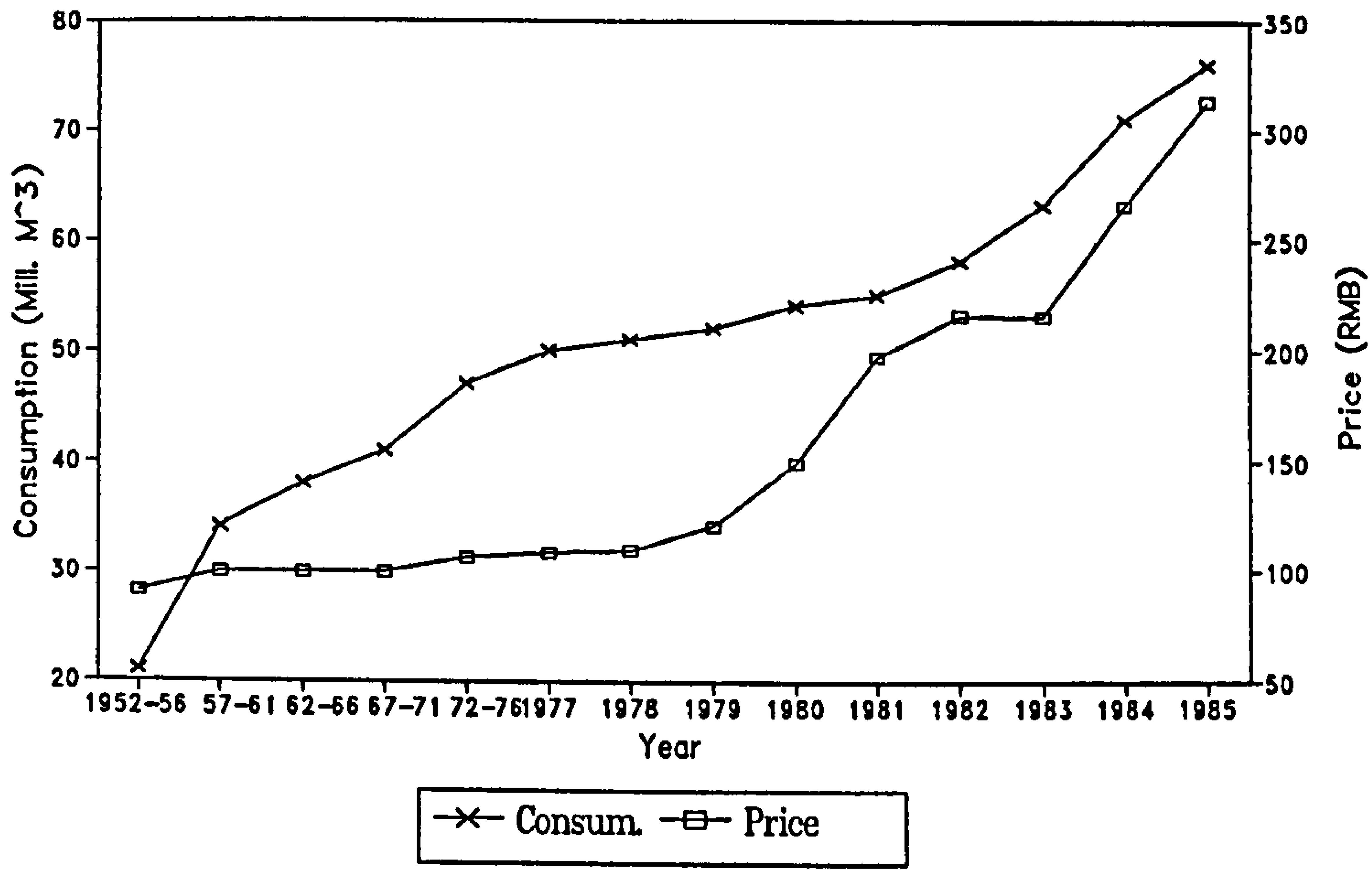


Fig. 4.2 Planned Price and Consumption of Wood Products: 1952-85

economics: the general theory of the second best, i.e., removing some distortions in an economy while leaving others undisturbed may only make things worse rather than better. This is particularly relevant in China today, where some features of a market system are being introduced into a socialist institutional setting.

The official statistics limit any further analysis. However, a recent development on this aspect provides us with some meaningful information. It was reported that, by 1989, there was a sign that prices were moving toward stabilising owing to market adjustment, coupled with price supervision and the availability of more imported wood to buffer imbalances between supply and demand. A recent report (Liu, 1991) exposes a further evolution of the relationship between the prices and the demand and supply of wood products in China's wood markets. The new development shows that while wood imports have been increased continually but slowly, the wood market prices have been decreasing gradually from their peak in 1989, and the domestic market demand and the imports of timber are now closely reflecting the change of prices. Given the same qualities of wood products, there is also a tendency for domestic prices to change along with the fluctuation of the world market prices.

To sum up:

(1) The results of China's price reform relating to wood prices are not the 'big bang' or 'one step towards the position', rather gradual changes. This implies that the supply adjustment by pricing may not necessarily be oscillating, as the 'cob-web theorem' described.

(2) On the one hand, the distorted price system provides any research in this field with neither valuable time-series data nor clear correlation to carry out an econometric analysis. On the other, fortunately, the recent few years of change provide us with a possibility and a basis to tackle wood prices in modelling China's wood demand and supply by referring to the world market prices.

4.2.5 The Impacts of Price Change on Forest Resources Production and Consumption

Forest economists notice that, while low timber prices cause ample wastage of timber in logging and processing and thus accelerate future logging (Palo, 1987), high timber prices, under the circumstances of poverty and frequently radical policy change, result in increasing the supply of timber in the short-term, but destroy resources and supply in the long-term.

This has been the case of China's forestry since 1985. From January 1985 onwards, forest land was rented by households through the production responsibility system; the free market was opened in many places of southern China; and authority was granted for sale of timber through the free market from individually controlled plots and from collective enterprises. This resulted in a sharp increasing of price. Red pine was RMB¥ 105 per m^3 (approximately US$28) for a long time, in 1987, it reached RMB¥ 214 (US$58); by July 1988, it reached RMB¥ 300 (US$82) per m^3 and RMB¥

500 (US$135) per m^3 for timber allocated under the state plan and for timber in the free market respectively. In the beginning of the opening of the free market, many people, including authorities and economists, expected that the increasing of prices of forest products should increase the supply, increase producers' income, hence give an incentive to forest investment and expand the forest resource stock. Unfortunately, the higher price on the free market did encourage excessive (and illegal) harvesting outside the state plan and increased the supply of forest products, but it simultaneously caused severe deforestation of immature resources in almost all parts of the country; forest stock, even forest area, decreased very quickly.

From the standpoint of static equilibrium analysis, such a pattern of price behaviour appears anomalous, but the behaviour becomes readily explicable through expanding the traditional flow-oriented concepts of supply and demand to encompass the level variables (stocks) in a typical commodity system.

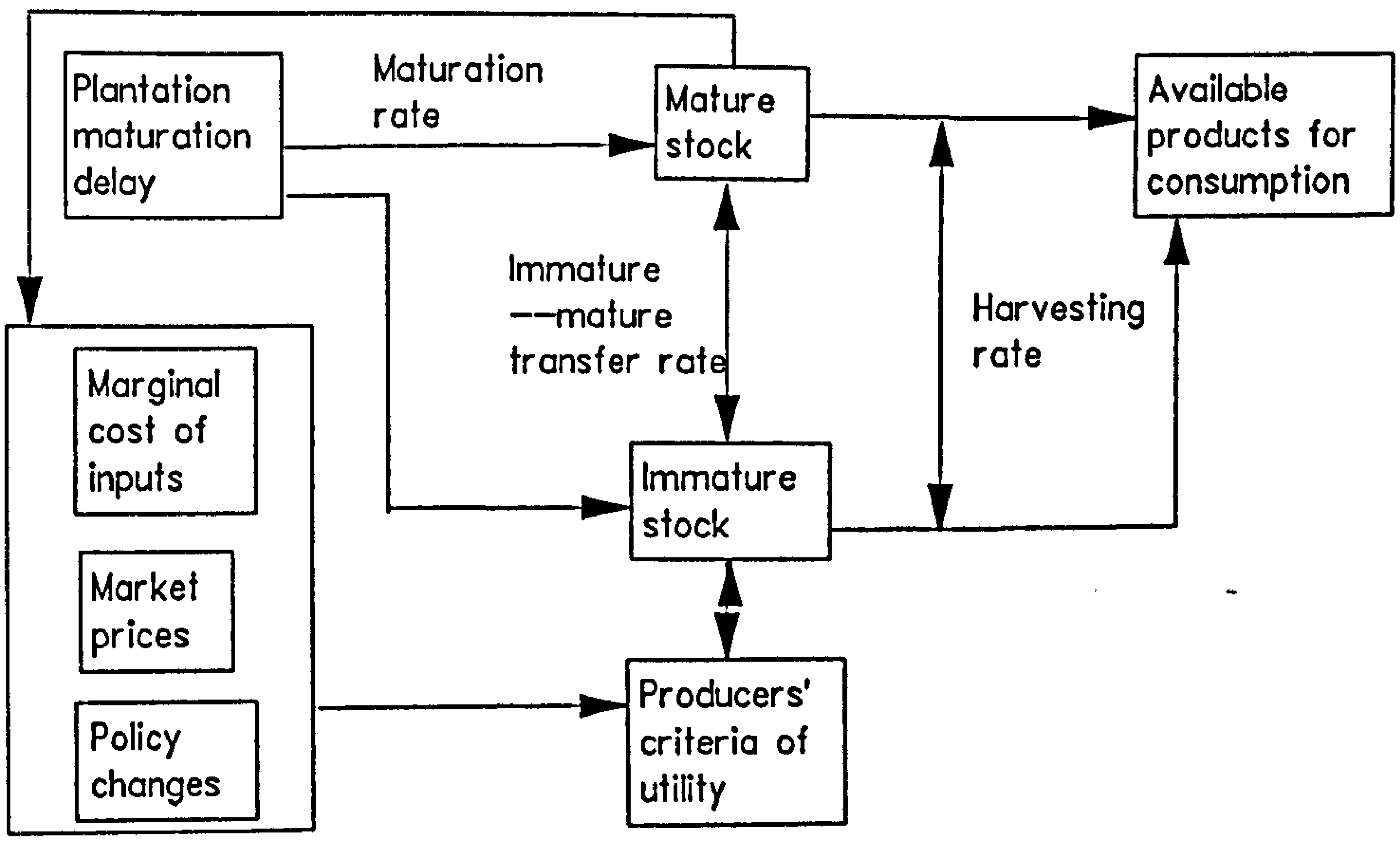


Fig. 4.3 Relationship Between Stocks and Flows of Forest Production System

Figure 4.3 shows the essential relationship of the stocks and flows of the forest production system. As Fig. 4.3 indicates, available products for consumption consist of two parts: mature stock which represents rational harvesting, and immature stock which represents, in most cases, irrational cutting. The concepts of rational and/or irrational harvesting, of course, differ under different criteria for different utilisation and economic purposes, but the concepts here are assumed as given conditions. Under an irrational circumstance, the timing of cutting is not always necessarily related to age, major felling is often not at the conventionally measured optimal time (Price, 1989).

The reasons for irrational cutting in China in the later 1980s vary from case to case, but the main reasons may be summarised as the following:

(1) The most direct cause was attributed to the common ownership problem. The commons probelm exists everywhere over the world, but it was much severe in China in the early 80s when the nation had experienced more than 30 years Communist campaign, such as the Collectivization Movement, the Great Leap Forward, and the Cultural Revolution, and was in the early stage of the market-oriented economic reform. As Price (1989) pointed out, under the common ownership each individual perceives only the benefit obtained from individual exploitation: the opportunity cost is communal, falling largely on other individuals. This was exactly the case in China at that time.

(2) individuals wanted to maximise their profits or utilities in the short run (instead of maximising the operating net social benefit) by increasing the harvest of private forest goods or by increasing forest clearance in-order to expand the production of private agricultural goods, since the relative prices of wood products to those of agricultural goods were still low (Li *et al*, 1988);

(3) farmers had learned from the instability and the discontinuity of the government's policies during the past 30 years;

(4) farmers or collectives treated their forests as government's gifts or free goods, in contrast to the scarce resources they actually were. In the purchase of free

goods, no stumpage prices needed to be paid. An individual's total utility can always be increased by consuming more of any good that has a positive marginal utility.

Of significance in Figure 4.3, no single variable can be termed the output of wood. Instead, costs of inputs, market prices, policy changes, resource stocks, potential market demand, farmer's time preference, foreign trade, and so forth, all of these different variables can be moving in opposite directions at the same time, thereby generating short-run and long-run pressures on price. Given the currently increasing plantation costs, the increased prices for wood products in China induce producers to increase the irrational cutting of existing trees since the stumpage prices of those trees were excluded by producers from the calculation of net fiscal benefit of the harvesting, but not to increase plantation. As a result, the short-term response to increased price, as well as to increased cost and the expectation of policy changes, reduces forest resource reserve (including immature stock) below its optimal normality, decreases reforestation and expands supply market. Over the longer term, as immature stock is reduced, growth and maturation rates will decline. Finally, the total forest resource stock will thereby decline, and society will pay more opportunity cost to recover the sustained yield levels.

The example illustrated above indicates that: firstly, in an economic system, supply and demand may have multiple manifestations; secondly, supply and demand can each change in opposite short-term and long-term directions; thirdly, in China's current circumstance, increasing wood product prices can bring either positive or negative effects on forest development whether from the short-term viewpoint or from the long-term concern.

The price reform is the heart of China's economic reform. A rational pricing system is critically important to China's forestry development. It is clear that low prices of wood products played a negative role in the forestry in the past, and that the price reform has to go ahead, but it is unclear what level of wood prices would rationalize resource allocation and stimulate both efficient production and economic use of forest resources. Some concerns about the price reform are listed in the following, and may be of help for predicting the future trends.

4.2.6 Price Reform: Some Concerns

1. Further progress in the price reform is impeded by chronic shortages of many goods. It is feared that those shortages, if prices were no longer subject to direct state control, would cause general price inflation, and obstruct the allocation of materials to key projects, as well as deplete the resources (e.g. forest reserves). For this reason, it is often argued in China that further price decontrol should be postponed until rising production has eliminated most of the shortages.

Some believe, however, that shortages are not the temporary result of inadequate production capacity, but an enduring feature of administrative economic management -- inefficiency which can be eliminated only by systematic reforms, including price decontrol. This view is supported both by Soviet and East European experience, and proved by China's experience in the past few years, especially in agriculture, where relaxation of direct controls has turned long-standing shortages into abundance. Increases in specific prices could eliminate specific shortages by stimulating supply and reducing the demand. These price increases, moreover, should tend to reduce purchasing power over (and hence the prices of) other goods provided that the government kept strict control of the budget balance and credit.

2. Nonetheless, there is substance to the fear of immediate and general decontrol of prices in China. The full response of demand and supply to price changes may takes years, especially for some production sectors (e.g. forestry) with longer rotations. To bridge the gap between demand and supply of wood products, however, would also require sustained forest reserves and stronger motivation to invest in forestry, which can not be brought about overnight. For these reasons, price decontrol probably has to be gradual though steady - perhaps in conjunction with the gradual rationalisation and improvement of annual production planning and dismantling of the allocation system.

To achieve the rational and economic use of forest resource and the increase of motivation of development in forestry, some steps, however, could be taken more quickly: large increases, either administratively imposed or market-determined, in the prices of forest products, are a case in point. There is concern in China that large increase of wood product prices would have ripple effects. Since the industries and enterprises, which consume the wood product either as raw material or as energy could not absorb all the increased cost through conservation and profit reduction, they would therefore have to raise their prices. But most people believe - and experience elsewhere suggests - that increases in the prices of wood products, by discouraging their use, can make a vital contribution to conserve the forest resources.

3. The third problem concerns the relationship among the three-tier price system, in which a portion of output is subject to purchase by state procurement; a decreasing portion remains subject to purchase by the state at higher, above-quota prices; and a third portion is made available for market purchase. However, it must be realized that:

(a) the general increases in market and floating prices have also pushed up the procurement price for the state enterprises and these prices also remain an increasing trend;

(b) market sales have not completely eliminated price controls: the markets are regulated, with buyers and sellers both subject to registration; floating prices have been established to limit upward price fluctuations.

Actually, the quantities of all felling (except illegal cutting) are limited in the name of conserving resources, through authorizing forestry officials to ensure that the size of the local harvest does not exceed growth on an annual basis.

4. The fourth instance concerns prices that influence the spatial location of economic activities. Theoretically, price should accurately reflect long-run marginal economic costs to provide incentives to reduce the present waste of forest resource (especially for fuelwood consumption), to encourage efficient use of all resources and

facilities, and to enable proper assessment of the costs and benefits of locating particular activities in particular places. The price differential reflecting the natural and geographic conditions and/or locations may be a necessary means for reflecting the national interests in terms of the economic use of resource from the long-term viewpoint, and in terms of regional environment protection. For the scale of this study and the limitation of data available, several highly aggregated average prices have been employed in the model. Those prices of course are not adequate for detailed studies, such as commodity trade models, but acceptable for the purpose of this study.

5. Further and important strengthening of the linkage between internal and world prices may be another concern. Despite allocated timber, which still accounts for at least half of state planned production, being priced below international prices, domestic negotiated prices for timber in some places of southern China now equal, and sometimes even exceed the prices of imports. This indicates a remarkable change of China's forest economic system, and it must be taken into account in forecasting demand and supply of forest product in the future. This phenomenon is due to the so-called "seller's market" which prevails for most commodities in socialist economies. There are more deep-rooted causes of generalized excess demand as previously noted, which include the inefficiency and rigidity of centralized material allocating and production planning, the lack of concern among enterprise managers about cost and profitability, the absence of competition, and the investment hunger.

6. The last but not least important concern of price is the influence of the international market for wood products. It can not be ignored in any demand-supply analysis unless a national economy is a tightly closed one. For convenience, it will be discussed in section 4.4, the determination of foreign trade.

4.3 Forest Resource Management Under CPE

Forestry is a part of the national economy. Forest commodity production in China, therefore, is inevitably subject to the dual-mechanism. However, due to the complexity of forest production, such as the long life span of trees, the geographical extent and biological features of forest estates, the wide range of types and harvesting time of forest products, the uncertainties of natural and marketing conditions and multi-benefits of forest, the operation of the dual-mechanism in forest product markets seem much more tangled than it is in other sectors.

4.3.1 Theoretical Models of Optimal Resource Management

A general figure of the demand and supply relationship in economics textbooks shows that, in responding to price changes, the behaviour of producers and consumers tends to result in movement along the supply and demand curves toward the point where supply and demand are equalized. But for the supply of self-reproducible resources, like forests, the result of this movement, in the long-term point of view, is considerably different.

At one time, forest management was only a question of determining optimal harvest strategies for timber production. As the result of natural forest depletion, through out the world, forest regeneration and plantation have become more important in reproducing forest resources to meet a variety of human needs. Thus, forest management today is facing a full range of production options/problems. These problems include short-run and long-run problems; single stand production or aggregate supply problems (Duerr, 1976); and timber (single-purpose) production versus non-timber (multi-purpose) production problems.

Given increasing demand trends, the key issue of the demand-supply relation should obviously be focused on the efficient management of forest resources. In fact, the issue has captured forest economists' concern for a long time. In 1849, Faustmann developed the long-run theory of the production model for forestry. Then, Ohlin formulated the "Faustmann" model independently in 1921 (Samuelson, 1976; Lofgren, 1983). This model is now the well-known 'Faustmann-Pressler-Ohlin formula'.

Many models (Howe, 1979; Munro, 1981; Binkley, 1987; Johansson and

Lofgren, 1985; and others) have been derived from a similar principle - maximum net present value. Based on this principle, several criteria and the formula for calculating optimal harvest volumes and optimal harvest time have also been proposed .

With a variety of assumptions such as the variations of regeneration cost levels, tax rates and the various accessibilities to timber stands, these models may have brought some insight helping us to understand better the relationships. Nevertheless, there are some important limitations to applying the models in practice, especially in China's case. The limitations are obvious:

1. By focusing on long-run production costs, this type of model ignores the important questions of resource dynamics and short-run adjustments to changing economic conditions. This limitation is particularly serious in attempts to use the models for policy analysis (Binkley, 1987).
2. Forest management decisions may be taken with reference to objectives other than the maximization of timber receipts alone.
3. There are many simplifying assumptions, on which these models are based, such as perfectly elastic demand and supply functions (Cardellichio and Adam, 1990).
4. Stumpage prices required for application of these models are not be available in practical terms and would not be meaningful in any case because end-product prices are set by the State arbitrarily.

In principle, the long-term availability of forest resources may be conditioned by many factors, including resource reserves, technological factors, consumption behaviour, and institutional factors, and forest management is meant to achieve and maintain a balance between the need to conserve a resource for future generations, and the contemporary needs of society and of forest dependent communities. Thus the most important issue of resource management may be to ensure the rational allocation of resources by controlling or stimulating these factors. Accordingly, the resource management is relevant not only to managerial skills, but also to policy issues. Both controls and incentives are necessary means to achieve these tasks, and both can play positive or negative roles. This is particularly true in a mixed economy like China's, where most resources are subject to common property ownership.

Administrative controls and economic incentives in a forest management system are intended to produce a mix of goods and services from the forest distributed in a way which is considered to be in the "public interest", or "people's interest" in Chinese ideological terms. Administrative controls regulate utilisation of the resource to achieve the desired objectives, while economic incentives are expected to encourage foresters or forest residents to act in such a way that the same objectives will be reached. In the following discussions, the analysis of both the controls and incentives is carried out within the context of China's forest management system.

4.3.2 Administrative Control

The administrative controls in forest management can be implemented through several means, e.g, land distribution, species control, harvesting quantity and time control, marketing accesses, etc. Of the three, land distribution is the most influential means.

1. Land Distribution. Land tenure in China has undergone several changes since the 1949 revolution. Prior to this time, 70-80% of rural land was owned by landlords and rich farmers. After 1949, several forms of land tenure level were introduced: in 1950-52, land belonging to rural landlords was confiscated and distributed to the peasants through land reform.

All the forest land in the forest regions was transferred from various ownerships into mono-state-ownership and managed by the state forest bureaus or the state forest farms. Then, during the collectivisation campaigns, peasants were, willingly or unwillingly, forced to put their plots together, and production activities were undertaken by cooperatives. In the initial stage of collectivisation land was still owned privately and invested by peasants as a share in the cooperatives, with peasants receiving a dividend on the land invested. Private ownership of land was later abandoned, and land and other means of production including forests, tree nurseries, orchards, and economic (tea, bamboo, tung, others) plantations were handed over to the collective. By the year of the Great Leap Forward (1958) rural collectives had been organized into communes and land was transferred into commune's assets. Since the 1979 reform, the responsibility system has been in operation, whereby peasants are assigned specific plots of land and farm individually, though the land is still collectively owned, and cannot be bought or sold. There is no officially recognized price for land, and generally, land can not be sold. Only if the collective-owned land is crossed to undertake civil works, should the state pay compensation to farmers for land that is requisitioned. There is another exception: the state can sell land to foreign companies in order to attract foreign investment. The latter has happened in recent years in the special economic zones.

Forest land policies and the ways in which they have been carried out have reflected the changes of the national land policies. The tenureship of forest land and the ownership of trees have been changing hands frequently during the last 40 years. Catastrophic changes occurred three times: the first one was during the Great Leap Forward period; the second one was during the Cultural Revolution; and the third one was in the beginning of the economic reform in the early 1980s. In principle farmers in forest regions had been allowed to manage less than 5% of communes' hilly wasteland, but during the Cultural Revolution, even such a small portion of wasteland was collected back to communes as it was the last vestiges of undesirable bourgeois ownership. The reversal came in the spring of 1980 when a state council directive confirmed that the trees planted by the villagers will belong to them, rather than to a collective: 'whoever afforests the land owns the trees' (quoted by Smil, 1992). A good example can be found from Li (Li *et al.*, 1988). By 1990, the forestland managed by households with contractual agreement or directly owned by peasant families increased to almost 60% of the collective forestland from less than 5% before 1979, and the inheritance right of some of those lands has been ensured. The remainder, including virtually all mature growth in the four key wood-producing provinces, continues to be in the state ownership and managed by the national network of forest bureaus under the MOF. However, in line with deepening and broadening of reform, some effort has also been made to transfer the management of specific tasks or sites to workers or family members in groups or as individuals. There have also been some experiments in converting state forest farms into more profit-oriented enterprises, including partially worker-owned joint stock enterprises.

2. Forest Resource Control. In principle, all harvesting activities should be under authorities' control. The rule was set by the central government that the annual harvesting must not exceed annual growth. This regulation was applicable to all forest including forests owned by collectives and privates. In practice, it is impossible either to enforce or to monitor; this is because:

(a) Planners never know even roughly either the annual growth, or the annual consumption, when they set the country-wide resource control targets, as discussed in Chapter 2.4.

(b) For the state forests, the actual administration management control is primarily done by the provincial and local authorities. Since the growth-drain balance was based on the provincial level, obviously, the balance can be easily achieved in the resource-rich provinces, but very difficult or even impossible to achieve in the provinces with a poor forest endowment. For the latter, they had to overcut their forests in order to meet the local fundamental needs for wood, through the way of self-sufficiency, since those needs could not be met by the planned supply and there was not any other source available, either. For rural farmers, overcutting occurred simply because a big proportion of local revenues came from wood products although their prices were extremely low.

(c) For the collective forests, in rural and remote areas, the situation was even worse. In the government's planning there was no account of wood supply to meet the basic need of rural residents, which accounted for about 80% of the country's total population. Because these needs were so basic (such as fuelwood) that life can not carry on without them, they had to be met one way or the other, in most cases through illegal cutting. The administrative control in these areas was handicapped, in some cases, even functionless. The government frequently launched "stopping overcutting and illegal-cutting campaigns", but in these areas, it is "business as usual". In local people's words:

"the mountains are high, and the emperor is far away; we are subjects of a feudal ruler, but controlled by nobody."

3. Economic Activity Control. With its historical and cultural characteristics, Chinese society has always been affluent of coercion, but poor in incentives. Since the revolution, the centralized state power, channelled through a powerful party structure, came to control the whole society very tightly. The rationale for this stricture was drawn from Marxist-Leninist theory which considers that leaders (cadres), who are deemed to be representatives of the people (proletariat), should be able to define the public interest better than farmers whose individualistic peasant mode of production limits their capacity to comprehend the needs of the whole of society. The economic philosophy, on which the economic control is based, was a misunderstanding of the theory of economy of scale: the larger the scale of public production, the better it is.

Under the centrally planned economy, the labour force could not move from one place to another; decision-making about management and production (even the choice of species and time to plant and harvest trees) was taken over by the authorities from the hands of producers; products could not be sold at or bought from markets freely.

Nearly a decade after the breakup of the commune system and the reallocation of land to households, farmers and forest enterprises now have much more freedom than they had before to make their own decisions, with some restrictions. They are free to move around, and to sell whatever they produce on the free market.

It is in this sense that, in normal circumstances, incentives may be more crucial to resource management than coercion. However, loosening of control is not necessarily always a good thing, if it can not bring incentives to improve productivity.

4.3.3 Economic Incentives

Basically, within the old forest management system, there was no economic incentive at all. For a long period, the authority denied any economic incentive but 'spiritual encouragement'.

(1) Forest farms functioned as the administrative units rather than enterprises. They were financed by governments. On the one hand, forest farms did not face any economic loss or gain from their performance directly, the government was the loss-taker; wages were fixed and the level of wages was made according to workers' age, not to their ability or contribution. On the other hand, these forest farms faced enormous burdens, creating employment for new entrants, funding hospitals, schools and other services, financing the pension and health care obligations.

(2) As discussed previously (chapter 2.4 and chapter 4.2), the prices were set too low for growers to acquire sufficient incentive to reinvest in forestry. Plantation forestry was always loss-making; so was forestry based on natural forest resources, sometimes.

(3) Time value had been disregarded in the past, when the banking and credit systems were peripheral elements in the capital formation process and depreciation charges were unrealistically low. This disregard for time values worked to the disadvantage of a long-lead-time industry like forestry.

(4) Forest management and forest industry had been separated as two functioning branches. The industry side was responsible for logging, local processing, and enjoyed the bulk of state investment. By contrast, the management side was responsible for afforestation, regeneration, and cultivation, and is worse funded. The separation led the industry side to adopt logging procedures and slash disposal practices without regarding forest replacement costs and conditions. This not only handicapped regeneration, thus accelerating the exhaustion of forest resources, but also badly curtailed the incentives for afforestation, regeneration and cultivation in the management side, hence draining out the supply source and in turn, shrinking the productivity of forestry as a whole.

(5) The situation in the collective sector was even worse. The communization movement (1958) and the Great Leap Forward (1959-1961) fundamentally undermined

the collective forestry's vitality from grassroots. After this period, there was hardly any sizable tree left in most agricultural area in the mid-north and the northwest regions. Due to the frequent change of ownership, the desperate shortage of fuelwood, and the rapid expansion of population, local farmers had no incentive to plant trees. Instead, farmers fought for access to cut trees rather than to plant trees, and conflicts between the local rural consumers and the local forester constantly happened. Without incentives, the coercive mass afforestation resulted only in careless planting, with no or highly inadequate follow up care, thus lowering the survival rate of planting.

By the end of Mao's epoch, China's economic system was in a functionless static state. The objective of the reforms was to loosen the controls over people and land, and to encourage high productivity by strengthening or creating incentives. Reforms in land tenure and the administrative system were coupled with reforms in several economic aspects. The following means have been taken in order to stimulate the forest development:

(1) opening up rural markets including the forest product market,
(2) sharply increasing the planned prices of raw materials, which in turn reflect the increase of market prices,
(3) reducing the taxation for wood products,
(4) increasing afforestation fees (subsidies), and
(5) encouraging investment (including foreign investment, overseas Chinese investment, investment from other sectors) in forestry.

Yet, the effects of these policy changes remain unclear. On the one hand, contractual management of plantings and re-establishment of private forestry during the 1980s have, to some extent, improved the recent apparent survival rates and the resource management, and price increases have attracted more investment, and improved the forest resource utilisation; on the other hand, the unexpected burst of tree felling which initially took place has caused further deforestation and alarmed the authorities. Opinions about the current deforestation are varied. Some attribute it to the reformed policies, which lead to the government losing the necessarily administrative control; while others complain that the reformed policies have not gone far enough and that the current deforestation occurs only because producers no longer have any confidence in the government's policies, as a cumulative result of the frequent policy changes. They suggest that, rather than falling back on coercive control, the policy reform should go ahead to look for incentives to manage forests for long term sustainable harvest.

4.3.4 Summary

The management task is to allocate the stream of return from resources in order to maximise expected net social benefits. On the one hand, just as a private producer theoretically may only engage in resource development if the net discounted returns from the investment exceed the costs involved, so a public agency should invest in future renewable resource flows if the benefits exceed the costs (Rees, 1985). There is a need of incentives. On the other hand, renewable resource depletion had no absolute meaning common to all people in all countries, 'because the world is environmentally and economically diverse, problems are rarely universal... societies will rightly differ in the detail of their priorities' (Holdgate, 1979, p. ix), therefore, there is also a need of controls on behalf of public. The controls and incentives themselves, as two management means, can not be considered as either good things or as bad things, but the degree of balance between the two, and the levels which the effects of these two means reach, remarkably affect resource management either positively or negatively.

The history of the changing management system in China during the last 40 years shows the effects of policy shifts between administrative control and economic incentives. During the collective and communes period, the change of ownership from private to collective, then to communes, destroyed hundreds of thousands of trees, at the collective level of decision-making. During the national-wide Great Leap Forward, a huge number of trees were burned in the backyard furnace or in the collectives' kitchen-room for the national priorities. Soon after, the economic readjustment policies encouraged the nation to replant a considerable amount of trees. Unfortunately, these efforts were in vain as a result of the Cultural Revolution, an anarchic period. Since the reform, various forest policies have been tried - according to Deng Xiao-pin's philosophy: 'no matter the white cat or the black cat, whoever can catch mice is the good cat' and 'cross the river by touching foot-stones'. These policies have two-fold aims:

(a) increasing forest stock by strengthening incentives,

(b) reconciling present and future needs through application of controls.

With some improvements in terms of the increase of incentive, the apparent outcome of these policies seems to be that the current enthusiasm is focused on cutting trees rather than planting trees, or on planting trees to obtain subsidies from the government rather than to increase forest reserves for the future.

The picture of China's forest development is unclear as can be seen from the discussions so far. Naturally, the question may arise: is the problem of forestry in China insoluble? What, if any, is the solution?

The answer to the question is the task this study is going to tackle in the remaining chapters, although it is not easily obtainable. Here some initial conclusions may be drawn as follows:

1. The centrally planned economic system with its unified material allocation network, as a whole, is not able to either bring incentive to foresters, or manage sustainable forest resource on behalf of the public interest. So far, the system has done much damage to forestry rather than construction.

Given the nature of China's mixed economic system, however, universal success of market forces is by no means certain, nor is the continuity of the mercantile philosophy assured, especially in forestry. Marketing forest products with the uncertainty of continued rights to forest use and of land tenure have already led to illegal forest destruction. Markets are imperfect everywhere: in the industrialised world the absence of a "price" which effectively controls pollution is a classic example of market failure; in China, such failure is exacerbated by the lack of a necessary marketing periphery and marketing mechanism. The lesson from China is that free markets need an appropriate infrastructure as well as responsible operators.

2. The market economy is not necessarily equal to privatisation, and private enterprises are not always run with rationality and effectiveness; this has been proven by the facts from different systems in the world. For example, in Great Britain, the state owned forestry estate, in terms of restocking and wood production, amount to 2/3 of the total (Forestry Commission, 1988). Even if after 1985, the Thatcher government disposed of some of its assets in order to reduce its call on public funds for management of the forestry enterprise, forestry is still supported by the government through the Grant Scheme, and the government recognised that the main basis of policy for the future would remain the successful and harmonious partnership between the private sector and the state-owned sector. In this aspect, Marx (1885) argued that forestry was not suitable for private owners to manage as it needed forty-fold stock of resources for its sustainable reproduction, private owners generally could not wait for such a long circle of capital return. This seems still to make sense. China should not swing from one extreme to another. In any case, however, ownership, responsibility and beneficiaries must be clearly demarcated.

3. The long-period nature of forestry production implies the far-reaching effects of policies on forestry. Thus, it may be too early to applaud the overall effects of the current policies. To re-establish producers' confidence in the government's policies may take longer than one would wish.

4. Forest resource management is a very complicated process, relating to many long-term social aspects and affected by many factors. Stumpage price and owners' discount rate are only two among many. Forest management decisions may be taken with reference to objectives other than the maximization of timber receipts alone. This is especially true in the event that the management of common-property resources to meet desirable social objectives is laden with controversy and multiple conflicts (Hardin and Baden, 1977). Further, optimal stock level has a geographical meaning. The concept at the level of individual plots may be different from that at the level of regions or a nation as a whole, though the latter has its basis in the former. Moreover, as forestry is a long-term and wide-ranging production process with dynamic characteristics, the Golden Rule for Optimal Conservation (or Investment) is neither

universal, nor perpetual: its scope can be changed with the lapse of time.

Therefore, there may not be a single formula, as Faustman's or the like, capable enough for describing the behaviour of such a complicated management system. Instead, a set of systematical behaviour equations may do so.

4.4 Foreign Trade

According to the Fundamental Theorem of Exchange, voluntary trade is mutually beneficial. Trade causes a reallocation of resources which involves adjustment in an economy. Trade also gives rise to equalisation of relative price in the trading countries. It improves welfare as combinations of commodities which are outside the country's own production capacity can now be obtained through specialisation and trade. The second view is the "exploitation theory": in exchange one party's gain is the other party's loss. The third view is development theory (Todaro, 1979). On the one hand, the development theory recognises that trade can be an important stimulus to rapid economic growth; on the other hand, it argues that the principal benefits of world trade have accrued disproportionately to rich nations and within poor nations disproportionately to both foreign residents and wealthy nationals; it also asserts that Third World countries have benefited disproportionately less from their economic dealing with developed nations and may have in fact even suffered from this association. Nowadays, the proof of the Fundamental Theorem, and disproof of the exploitation theory, would not seem to require much reasoning. The questions addressed by the development theory may need to be taken into account in world trade, especially for developing countries. It is true that there are many problems (e.g. the most commonly encountered arguments for protective tariffs), resting upon failure to appreciate the truth that exchange is mutually beneficial, while there are many philosophical aspects of this sweeping theorem which are debatable (Hirshleifer, 1980). Trade is important because it can permit a more efficient allocation of national resources, reallocate existing stocks of consumption goods so that each achieves a preferred bundle, and specialise in production so as to increase the social totals of goods available. However, the optimal extent of trade is to be determined by decisions about the costs and benefits of production and consumption at the margin (Smith, 1776; Ricardo, 1817). All theories agree on the importance of trade; the main disagreement among them is either over how the trade link works, or over whether the external environment, working through international trade, determines the performance of the domestic economies of developing countries.

China's policies of opening to the outside world and revitalising the domestic economy has brought China into the international environment, and given rise to an upsurge in trade. While her trade policy still emphasises technology, there is quite an acknowledgement of her need for some raw material import in order to balance the gap between domestic timber production and the increasing demand to speed up the restructuring of the economy since China has suffered for many years from an acute shortage of forest resources.

There is no country today which can regard its forest economy as a closed one. A significant proportion of the world's wood needs is already being satisfied through international trade (Westoby, 1987). As has already been mentioned, China has become the second largest importer of logs in the world, while domestic demand is going up and domestic supply is limited because of the shortage of resources. For the purpose of this study, modelling the demand and supply of wood products in China, it is critically important to analyze the trade trends and to determine the potential of foreign trade for the long-term balance of demand and supply.

The potential trade in this study is defined as the possibility of new exchange, in which some domestic demand may be met by import and some domestic supply may be utilized through export. If all participant countries were exactly subject to the same degree of trade resistance in their dealings with the world market, the cost of bringing a unit of any product to the world market would be equal for all exporters. That is to say, the incidence of all trade obstacles together would be the same for all countries and for any unit of supply. Unfortunately, they are not. The obstacles vary from country to country, from economy to economy.

4.4.1 Openness Ratio

Theoretically, a country's production takes place partly for the domestic market and partly for foreign markets. It follows that a country's potential foreign supply and demand depends upon its national production possibility affected by the limited input of production factors such as natural resources, labour force, capital, and techniques, and also relates to a country's openness which is expressed by the openness (or trade) ratio -- the ratio of exports (V_{xi}) plus imports (V_{mi}) relative to gross national product (GNP) or national income which can be shown as the following formula:

$$O=\frac{\Sigma V_{xi}+\Sigma V_{mi}}{GNP} \tag{4.4}$$

The openness ratio has been conventionally used by economists as an indicator for two purposes:

(1) measuring the degree of openness of an economy changing over time;

(2) comparing the degree of openness of different economies.

Balassa (1983) claimed that 'large' countries had lower ratios of openness than small countries did. This is to say, given the existence of economies of scale, the higher the population, the lower the openness ratio. He also argued that, with a given population size, the openness ratio was not significantly different at different levels of per capita income.

Balassa's argument may be true for several reasons. First, large countries are less likely to depend on imports of raw materials. Second, they are more likely to have levels of domestic demand sufficiently large to take advantage of economies of scale, especially in manufacturing. Finally, relatively higher transportation costs in large countries tend to provide domestic producers a greater degree of natural protection against foreign competition (Perkins and Syrquin, 1989).

However, intercountry comparisons by using the ratio are somewhat problematic.

This is because of the uncertainties involved in measuring the trade volume and GNP of an economy, such as China's, in a common currency. If the relative prices of non-tradeable goods and particularly services are fixed by governments at unusually low levels, converting the GNP to a common currency is likely to mislead because the official exchange rate usually overestimates the true value of the local currency as measured by its purchasing power parity.

Furthermore, higher per capita income will lead to an increased demand for most consumed commodities and services. The increased demand has a tendency to increase demands for both domestic products and foreign products. Because of the difference of the domestic market sizes, the production or substitution costs, and/or the possibility of finding a substitute for certain production factors or conditions which are lacking, even absent domestically, it is difficult to say that to what extent large countries rely more on their own supply of such factors and services than small countries do.

Finally, the openness ratio is usually used for measuring an economy as a whole. When it is applied to sectoral studies, particular care has to be taken into account. For example, it seems that the existence of economies of scale is much more certain in manufacturing industries than in agriculture and forestry. The demand for agricultural products is proportionately a more important element of total domestic needs in countries with low per capita income than in countries with high per capita income, according to Engel's law. Consequently, the demand structure of richer countries offers more opportunities for realising economies of scale when population expands than that of poorer countries does. In poorer countries, the production of primary needs is more important than economies of scale.

In sum, the openness ratio can be used to indicate changes of the dependence of an economy on the world market, but its usefulness is usually limited when used to compare one economy to another. There is some evidence to suggest that, for studies of this sort, the change of trade volume may be a more direct and meaningful indicator than the ratio.

4.4.2 Comparative Advantage

The theory of comparative advantage is closely related to general equilibrium theory, claiming that each country tends to specialize in those commodities in which it has a comparative advantage in terms of costs of supply or productivity of resources. This means that it is not the absolute but rather the relative degree of superiority that determines in which commodities a country or a region should specialize.

The principle of comparative advantage provides the traditional case for the desirability of unbalanced growth. Balanced growth pursued to the extreme of equal growth in all sectors would be virtually sure to result in a lower living standard than what some degree of specialisation accompanied by increasing international trade would do.

There is no doubt about some specialisation in general. But specialisation based on the comparative advantage theory involves risks that may be worth avoiding even at the loss of some income, since it can make an economy highly vulnerable to cyclical fluctuation in world demand and supply.

Comparative advantage also changes with technology, this is to say, technological change both creates and destroys comparative advantages. If technological or taste changes render a product partially or wholly obsolete, the country can face a major catastrophe for generations.

Comparative advantage may mean present comparative advantage or future comparative advantage. Lipsey (1977) argues that unplanned growth will usually tend to exploit the former, and a planned economy, through the planners, may well choose a pattern of growth that involves changing the latter since it is believed that the planners can evaluate the future more accurately than the countless individuals whose decision determine market prices. Prebisch (cited in Lipsey, 1977) believes that current market prices fail to anticipate fully a worsening in the terms of trade for agriculture, and thus planners should intervene and shift a country out of what is sure to be an overreliance on agriculture in the long term.

Although widely accepted, the concept of comparative advantage remains a product of abstract economic thought and quantifying comparative advantage has been proven to be elusive. In practice, the concept of comparative advantage, which may be quantified by comparative loss, or comparative cost, is a very difficult one to work out.

Leamer (1974) pointed out that the size of the foreign sector in a general-equilibrium context will be determined by GNP, resource endowments, utility structure, and resistance factors. He argued that all countries have roughly the same resource endowments and demand structure except in so far as the countries differ in population and income, so population and income are used as proxies for resource endowments and utility structure. If only capital and labour are considered as resource endowments, countries at similar levels of economic development -- that is to say, countries within the same per capita income groups -- have roughly the same resource endowments. Countries with high GNP per capita have more capital relative to labour; countries with large population and relatively lower GNP have more labour relative to capital. It is in this sense that resource endowments may be partly proxied by GNP and population size.

In forestry, comparative cost may be defined as the cost of investment directly into the forest sector in order to raise national industrial wood supply by a certain amount before a given target date less the cost of generating the same amount of supply in another part of the world. But such an approach, as Westoby (1987) pointed out, would run into difficulty as an adequate information basis is woefully lacking.

Sedjo and Lyon (1983) examined the shifts in comparative advantage that occur as a timber-rich region draws down its old growth forests and is forced to focus on the task of tree growing; while, simultaneously an inventory-poor region with extraordinary growth potential gradually undertakes the investments necessary to move into significant timber production. The first phenomenon is obvious and indubitable, but the second one is questionable: an inventory-poor region may not necessarily either be provided with extraordinary growth potential or sufficient capital for investment in forestry. All elements of comparative advantage, such as enough foreign exchange, cheap labour force, advanced technique, suitable climate, usually do not exist within or endow one country/region.

In conventional forest economics textbooks, it is said that the principle of comparative advantage is less obvious (Gregory, 1987). Price (1989) argues that:

> Economists have different criteria of judgement, which often leads them to assert that it would be better (for most countries) to import timber (but from which countries?) using foreign exchange gained by growing the crops or manufacturing the goods or providing the services in which the country really does have comparative advantage. Other countries may have more comparative advantage than we do, but if they are so foolish as to continue growing timber and exporting it to us at less than cost (including interest) of growing it, so be it: it is not our job to put other countries' forests in order. Efficiency, like charity, begins at home (p369)".

In fact, whether one country has comparative advantage in forest production or not depends upon what sort of criteria one may use to make a judgement. If marketed revenue from forestry is less than cost, or if discounted revenue from re-establishing a crop is not sufficient to justify its cost, does it mean that forestry should not be undertaken at all? The principle of comparative advantage represents no more than a conceptual framework for interpreting patterns of specialisation. At the national level, governments would be ill-advised either to ignore it, or to make it a basis for specific policy decisions (Ballance, 1988). What economic analysts can do usually is to designate a reasonable range of action, and to get rid of as many if's and but's as possible, and to quantify the remaining if's and but's as far as possible (Westoby, 1989).

4.4.3 Natural Resources and Natural Obstacles

Leontief's model of the US economy (1956), which is based on the two factor (labour and capital) assumption of the Heckscher-Ohlin-Samuelson (H-O-S) theorem, is considered a simplification (Tharakan, 1984) of the reality, and some economists have raised the question of whether the omission of natural resources from Leontief's calculations could explain the Leontief paradox which was Leontief's original findings, revealing the case of a capital-abundant economy turning out to be a chief exporter of labour-intensive goods. Vanek (1959) defined natural resources as products of extractive industries such as agriculture, forestry and mining and investigated the importance of such products in US trade during the period 1870-1955. One of his findings is a strong positive correlation between capital and natural resource requirements. Diab (1956) also argued that the resource-based, non-manufacturing group of the US economic sectors would account for a large part of the high capital content of American imports. By investigating the comparative advantage of Belgium, Tharakan and Vandoorne (1979) found that natural resource requirements were negatively and very significantly correlated with export/import ratios of Belgium with the developing world. Many theoretical studies implicitly recognise or ignore the problem posed by the omission of natural resources from the framework.

An impact closely related to natural obstacles to trade is that of geographical distance. The question arising from distance includes not only transportation costs, but also other factors:

(1) the dynamic factors based on the element of time, which for forest products constitutes the supply delay (irregularities in supply), and interest costs involved;

(2) the factor related to the economic horizon of a country, such as the degree of communication, similarity in tastes of products, etc.

A great deal of literature in this field has been well reviewed by Weeks and Wisdom (1987). They pointed out that from the perspective of exporting countries, transportation costs are a barrier to trade in much the same way as tariffs: both arise from the cost of delivering the products to the potential importer and both reduce the volume of trade.

It is in this sense that distance is considered as a proxy for many variables other than transportation costs. From the modelling point of view, it can be treated as a proxy variable for the total natural trade impediments in their wide sense statistically.

4.4.4 Political Considerations and Artificial Obstacles

Obstacles to trade may appear in different forms, such as tariffs, quotas, dumping, exchange controls, shipping restrictions, or a combination of these.

The general theory of international trade indicates that free trade almost always improves the well-being of nations. Kindleberger and Lindert (1978) pointed out that the main aspects of gain are consumption effects (being able to increase consumption) and welfare effects (by shifting from more expensive domestic products to cheaper imports). But they argued that the apparent welfare benefits had not reached the consumer because of:

(1) a small part of benefit of the imports passed on to the consumer;
(2) the strong influence of oligopoly price preventing the cheaper prices being passed on to the consumer;
(3) the existing higher exporting price.

While the literature on the theoretical aspects of tariff and non-tariff protection is abundant, empirical studies are infrequent and lacking in detail. Olechowski (1987) described both of those in the wood sector on the basis of information drawn from the UNCTAD data base. He concluded that the trade effects from the removal of those tariffs are estimated to be considerable--imports would increase by over US$950 x 10^6 in 1976 terms and that non-tariffs as applied in 1983 would have covered about 19% of 1981 imports in the major developed countries and the quantitative restriction of non-tariff obstacles would affect 29% of categories of primary and 37% of categories of secondary wood products in the developing countries.

Linnemann (1987) analyzed the artificial impediments to trade on the basis of an assumed regularity of their trade-reducing effects on the world at large. He assumed that the trade-reducing effects are normally distributed. The trade flow between any pair of countries is supposed to be subject to:

(1) an average trade-reducing effect which is the same for all trade flows;

(2) a random deviation from the average trade effect.

The assumption implies that there are no systematic differences in artificial trade-resisting forces with regard to trade flow between different pairs of countries. Artificial obstacles to trade do not disrupt the basic pattern of world trade as it is determined by the systematic economic order; but they do disrupt particular flows. However, this assumption excluded the situation where a partial or complete embargo on trade with inimical nation(s) existed because of political hostility or distrust.

4.4.5 Domestic and World Prices

In general equilibrium analysis, prices are endogenous and merely adjust to equate supply and demand. As Leamer and Stern (1974) pointed out, this does not imply that prices are not effective in allocating resources. On the contrary, prices are assumed to adjust quickly, and demand and supply are assumed to be responsive enough to price change to rapidly bring about an equilibrium. In any open economy with a competitive market one would expect to find that domestic prices for a broad range of goods, generally referred to as tradeable goods, would be closely related to world market prices. In the absence of tariffs, quotas or other quantitative restrictions there would be a tendency for domestic and world prices of tradeable goods to be equalised. The prices in the trading patterns will become more equal as free trade progresses and will eventually be equalised if both countries continue to produce both the commodities with the same technology.

Adams and Haynes (1987) employed equilibrium prices which were adjusted to the currency and location of a particular reference country by exchange rates and transport costs between each country and reference country. The price adjustment process was described as:

$$P_{ij}=x_{ij}p_i-c_{ij} \tag{4.5}$$

where,

P_{ij}: price in country i, expressed in country j's currency;

x_{ij}: exchange rate between i and j;

c_{ij}: transportation cost from i to j;

p_i: price in i in terms of local currency.

Since the model is used for equilibrium analysis and only equilibrium prices are considered, all items related to price have an effect on demand level, and prices always adjust instantaneously to conditions of supply and demand. Moreover, in all perfectly competitive general equilibrium models, the 'terms of trade' (international commodity price ratio) adjusts to equate supply and demand for a country's exportable and importable products so that trade is always balanced. But the realities of the world economy are such that balance of payments deficits and the consequent depletion of foreign reserves are a major cause of concern for all nations, both rich and poor. Transport costs and other imperfections, as well as exogenous shocks that move markets away from equilibrium, complicate the theory above. Particularly in the centrally planned economy, there are a variety of distortions that cause systematic divergences between world and domestic prices; domestic prices are determined artificially, and hardly reflect the world prices. As described in Chapter 1 and 2, China's prices were largely cut off from the influence of world prices by the mid-1950s; even during the current transition period, price adjustment seems to take many steps, rather than being accomplished in one move. All of those considerations should be taken into account by any serious modeller; and reference prices need to be made for measuring those distortions.

4.4.6 China's Trade System Reform and Trade in Forest Products

1. Trade System Reform

There are, of course, significant differences in the trade regulations and practices of the centrally planned economies. The basic difference is that variables triggering behavioural responses of the economic units in production and trade are not the same as those in market economics. In the centrally planned economies, the profit motivation in the trade decision making is either nonexistent or has a very subordinated role, and prices do not reflect scarcities or have no allocating function. Foreign trade is centrally controlled by administrative methods rather then by financial regulator. Exports/imports are channelled through foreign trade offices which have monopolies in foreign trade transactions. Foreign trade corporations purchase goods pre-specified by the plan from domestic producers at officially established prices, either ex-factory prices in the case of manufactured goods or procurement prices in the case of agricultural goods. Thus, the producers are isolated from the world markets. They receive the same price for an item whether it is sold domestically or in the international market. The consumers are provided no choice by the short (supply-driving) economy.

The isolation was partly due to an inward-looking, autarkic industrialization policy of the government itself, partly due to the variety of economic embargoes from the West. The isolation gave those countries very limited access to the world market, and drove them to a self-sufficiency policy.

Considering China as a socialist country and a planned economy, Sergeyev (1964) declared that its purpose in foreign trade was not to make profit, but to pave the way for the expansion of socialism, the growth of socialist industry, and the continual improvement of the living standards of working people (p.227). This is partly political propaganda, but it is partly true that China has a different motivation for establishing import duties and other elements of trade policy.

The decade of the 1980s was one of far-reaching reform of China's foreign trade system, a copy of the Soviet trade system. Much of the traditional structure was profoundly changed. The old reliance on a handful of foreign trade corporations acting on behalf of the Ministry of Foreign Trade was transformed. Literally thousands of trading companies were authorized to carry out trade transactions. The number of these companies has increased from 800 in the mid-1980s to more than 5000 only a few year later. Equally important, the relaxation of the stringent exchange control provided access to sources of foreign exchange that did not exist in the pre-reform era. By the end of the last decade about one fifth of all foreign exchange earnings were reallocated via the swap market to importers willing to pay a marketlike price for foreign exchange. For this class of importers and for others, the trade "airlock system", China's pre-1978 foreign trade organization that traditionally separated world and domestic prices as characterized by the World Bank (1985), has vanished.

The mirror image of this emergence of decentralized trading which proceeded particularly rapidly on the import side, was a shrinkage of the traditional foreign trade plan. Increasingly, the state used a system of import and export licenses to regulate the commodity composition of imports and exports, rather than specifying import and export products in great detail in physical terms in the foreign trade plan. The system was frequently viewed as a step away from centrally controlled one toward more managed trade in market economics. However, in regard to the previous direct monopoly on all trade transactions, the adoption of licensing is a measure reflecting a gradual transition from a rigid control to a liberalization of an import substitution trade regime. The number of commodities subject to licensing was increased remarkably. For import goods, the number increased from 21 in 1982 to 53 in 1989; for export goods, increased from 24 in 1981 to 235 in 1987, and then fell to 173 in 1989. This measure shrank and diminished the scope of planning to a large extent.

Perhaps most importantly, China has begun to adopt a more realistic exchange rate policy and reformed the pricing of traded goods. The value of the domestic currency in trade transactions was cut almost in half near the outset of reform and this was followed by further significant devaluations in 1985, 1986, 1989 and 1990, culminating in semi-free floating in 1994. Although progress was initially slow, by the end of 1990 the domestic prices of most imports were based on world market prices.

As China has different motivations for establishing import duties, Chinese tariffs have more to do with controlling the use of foreign exchange and promoting economic sufficiency than with protecting domestic industry (NFPA, 1986). If the prices of imported goods on the domestic market are forced so high through tariffs that no one can afford them, there will be no incentive to import. It is said that reducing tariffs is to encourage wood import to meet the dramatically increasing demand for wood products for modernisation in industry and agriculture, thus to slow down the depletion of domestic reserves of timber. It is reported that the range of tariffs is from 3% for rough sawnlogs and cants to 9% for rough green lumber and 4% for finished lumber. Most veneers and plywood have tariffs of 12% to 30%. In addition, product taxes imposed average about 10% for all forest imports (NFPA, 1986): these taxes make the total tariff obligation among the highest in Asia.

It must be stressed that one characteristic of the Chinese wood trade is barter trade with the USSR since it requires no use of foreign exchange. It was considered by many economists as a favoured way to increase domestic supply for countries like China which has very limited foreign exchange (Jin-yan, 1986; Li and He, 1988). It does not seem a likely prospect even for enterprises in the boundary areas between north-east China and the Asia part of USSR, but non-tariff obstacles, such as barter licensing and assorted red tape, slow down this sort of trade. This may be not only because of high opportunity costs, but also due to potential unfavourable effects of permitting bureaucrats to engage in arbitrary and unfair practices in issuing licences.

It is difficult to estimate the effect of tariff and/or non-tariff barriers to trade flows, because of the difficulties involved not only in collecting enough data, but also in predicting the balance of payments position in convertible currencies. This effect will be estimated later in the policy analysis of this study.

CHAPTER 5

MODELLING OF DEMAND AND SUPPLY: QUANTITATIVE APPROACHES

This chapter covers the following points:

5.1 An Overview: Modelling and Model Construction

In the past fifty years, models have played and will continue to play a major role in the development of economic theory. Kaplan (1964) noted that models save us from self-deception by forcing our ideas out into the open at an early stage of inquiry.

A model, in the light of Chappelle's (1966) definition, is a representation of a system and is used to explain the behaviour of some aspects of the system. It is an expression of the individual researcher's view of a target system based upon experience, a working knowledge, and data. To be useful, the model must be less complex than reality itself and at the same time be sufficiently complete to approximate those aspects of the real world in which one is interested (Miller and Starr, 1966). Over the years, several models have been proposed to provide a systematic and structured forest management planning system, either implicitly or, hopefully, explicitly.

The models employed by forest economists may be classified under the following:

5.1.1 Econometric Model

This model is one in which the relations are stated in terms of probability distributions, and the recognition of variance is an essential feature. The studies, using simultaneous equations for demands and supplies and developed by econometric procedures to simulate paths of consumption and price, have been very useful in the analysis of the wood products market (Mckillop, 1967; Adams, 1973; Buongiorno, 1977; and others). But it should be pointed out that:

(1) the technique is applicable only to markets where flexible prices are the major means of adjusting demands or supplies;

(2) it requires a reasonably long series of consistent price and consumption statistics;

(3) a problem also arises from its own restrictions of use in social science, such as heteroscedasticity, multicollinearity, and self-correlation.

However, the econometric or regression model may be of major assistance in developing an empirical function for either demand or supply, even if a complete set of equations for simulation purposes can not be developed.

5.1.2 Linear Programming (LP) Model and its Variations

Applying LP to formulate demand-supply balancing is now commonplace. It is the most highly developed (Hall, 1967), extensively and widely used single method in timber management planning and in integrated regional timber modelling (Greber, 1985; Fowler, 1978; etc.).

LP is "a general model for optimum allocation of scarce or limited resource to competing products (or activities) under such assumptions as certainty, linearity, fixed techniques and constant profit per unit" (Loomba, 1978). The philosophy based on the technique is to try to maximize or minimize the value of some mathematical expression subject to a number of restricting equalities or inequalities, all of which must be solved simultaneously for the values of the variables found in all expressions. These variables are amounts of factors and products, some of them controllable. Its techniques applied to forestry economic studies have a number of major drawbacks, which stem partially from the nature of the model itself:

Firstly, the difficulty results from the objective (goal) function required by LP model. For some problems, it is not too difficult to formulate their objective functions, such as maximizing total revenues or minimizing total costs; some problems, however, are complex or with broad and ill-defined boundaries (Lichman, 1976). Hence, it is conceivable that not all aspects of the problem can be adequately captured with a mathematical programming framework (Allen and Gould, 1984). Some issues or concerns may be omitted because they are inherently qualitative in nature or because inadequate scientific information precludes their incorporation. Moreover, other objectives may be hidden, unrevealed, or possibly unknown to the model builder or analyst (Brill, 1979).

The second limitation of LP is that it imposes a very definite time horizon. The model permits planning only for a restricted number of periods, because of its static feature — fixed and linear relationship between variables.

The third difficulty arises from the large size of realistic scheduling problems. To formulate the reality, matrices tend to become of inordinate size and multicollinearity and non-solution phenomena frequently appear in those studies. In addition, output from very large problems can be difficult to interpret.

The fourth problem is the capability and suitability of the LP model in demand and supply studies. Uncertain knowledge of coefficients is related to insufficient understanding of objective systems. Generally, forestry economy systems embody not only production factors, such as labour, land, resources, capital, but also some institutional elements, such as markets, and various governmental policies. Forest economists must develop those into smoothly functional units, defining their goals and fitting them into the larger economic and social environment upon which they depend and which depends upon them. Non-linear social practices often make economists question the employment of linear programming models in some research areas.

The conventional mathematical programming paradigm as used in the form of linear programming is inadequate to deal with real planning problems when multiple goals and objectives are important elements of the situation (Rehman and Romero, 1987).

Many of those approaches mentioned above may be overcome or improved at least partly by other programming or special techniques, such as integer or mixed-integer programming (Kirby, 1975; Navon, 1975), or spatial formulations (Holley, *et al.*, 1975; Haynes, 1975) which can be used to analyze markets in different regions by multiplying process stages. But only with great difficulty can linear programming incorporate variable demand and supply functions (Haynes, 1975). The obstacles arise in demand-supply analysis in which

(1) price, which is fixed in linear programming as an exogenous variable, affects the demand.

(2) it is difficult to explicitly measure and imply the goals, or, even when it is not, to weigh the goals against each other is still not easy.

(3) the balancing of demand and supply is a process in which demand tends to equal supply. A balancing status can be achieved at a low level or a high level, thus it may not be measured properly by maximizing or minimizing the objective functions of LP.

Based on LP, two versions called Goal Programming (GP) and Multi-objective Programming (MOP) have caused excitement among forestry researchers in recent years. GP replaces the usual cost minimisation or revenue maximization function with an objective function that minimizes the differences between specified goals (outputs, environmental indexes, revenues and others) using a weighted priority scheme (Porterfield, 1976). Some experience in applying GP to forestry studies has indicated that the method has certain advantages in problem formulation and interpretation of results though it does not change the fundamental nature of the problem. Further application, experience and evaluation of goal programming should be a major effort undertaken in order to specifically inquire whether GP may be a valuable tool for national or regional demand and supply balancing.

In theory, multi-objective programming (MOP) is well suited to the problem of public forest management, which is inherently a multiple objective problem, involving trade-off between efficiency, environmental protection, and equity objectives. But as yet MOP has made a relatively small contribution, and its applications to forestry have been criticized as unwieldy and inflexible; a preference-based multi-objective solution requires a single known utility function which is difficult to construct for forests with multiple and sometimes inaccessible users, while the more informative generating techniques offer present decision makers with a bewildering array of solutions and means to choose from among them.

It is reported (Allen, 1986) that using the non-inferior set estimation (NISE) method, the difficulties could be avoided by using repeated LP solutions to generate an estimate of the true non-inferior set, with a known error. It is also said that the improved MOP can be applied to centralised forest planning in both developed and developing countries. Its applicability remains to be seen through more applied examples.

5.1.3 Quadratic and Other Mathematical Programming Techniques

Linear programming can not solve the problem of balancing several linked markets in which both supply and demand are continuously variable. Quadratic or Non-linear Programming (NP) techniques have been useful, though difficult to formulate and solve, in some areas such as agriculture. In the forest area, some economists used the NP approach to deal with the optimisation problem. Roise (1986) applied a general mathematical programme (MP) with nonlinear objective function and constraints. After simply comparing several NP methods, he concluded that no one NP method will consistently converge on a higher objective function value; if there are no externally derived constraints, the problem is reduced to unconstrained nonlinear programming; a penalty or barrier function can be used if there are constraints. One of these applications of NP was tried on spatially separated softwood markets in the 1980 Resource Planning Act (RPA) analysis, in which the method was in simplified form, called reactive programming. The formation of the problem is similar to quadratic programming, but the difference is that the system is solved by systematically varying functions until an optimal set of price/quantity solutions in each market is obtained.

Dynamic programming (DP) techniques have been tried in several applications of timber management research (Amidon and Akin, 1968; Hall, 1966; Drodie and others, 1978; Chen and others, 1980). The method is the dynamic or intertemporal extension of LP and deals with the sequential problem. DP is related to other dynamic optimisation techniques used in economics such as the continuous maximum principle. It has proven flexible in including activities. But three problems arise from the method, such as:

(1) DP results depend to a large extent on the definition of a sequential network;

(2) the range of possible decision variables is limited for DP by the state variables, which are the results of decision-making from last stage and the starting points of decision-making at this stage. Estimating the state variables is the key step in the whole modelling process of DP, which depends upon the further understanding of the system studied;

(3) an optimal solution from DP is only part of the full answer (Roise, 1986).

Therefore, the technique has been applied only to a limited extent. This, however, should not preclude research on application within special situations.

5.1.4 System Dynamics (SD)

SD is another approach for system analysis which comes from work in industrial analysis, primarily by Forrester at MIT (Forrester, 1961; 1968). It is a method of modelling the complex interactions that characterise biological, engineering, managerial, economic, organisational and social systems. It is the derivation of a set of linked differential equations to represent changes in the component variables and processes in a dynamic system. Projection or simulation of time paths of relevant system variables is accomplished by continuous integration starting from an initial set of conditions. There are many employments of SD in the agricultural field, only a few specifically related to forestry in recent years (Randers, 1976; Boyce, 1983; Cavana and Coyle, 1984; Edelman *et al*, 1985), though some simulation models for forest planning, based on the system approaches (not particularly on the SD method), have been built during the last two decades, such as the Global Trade Model (GTM) by IIASA (Kallio *et al*, 1987), TIMPLAN (Gane, 1986), VOLPLAN and GROPLAN (Gane, 1995), and others (FAO, 1976; FAO, 1977; Kumar, 1985; Haynes *et al*, 1992). A detailed description and evaluation of the SD approach will be given in the following section.

5.2 The Components of SD

A SD model, like other models, consists of parameters, variables, structures, and the process of analysis. As the nature of the parameters used in SD has no specific difference from that used in other models, the emphases of this section is on the description of other three.

5.2.1 Variables

In a SD model, variables are the elements of the system simulated and can be considered as the logical propositions of the problem. Variables change with time, and can be classified into four categories: level, rate, auxiliary and control variables.

1. Level Variable (L)

Level variable is a quantity that accumulates or integrates within the system during a period, and that also defines or helps to define the state of the system at the given period in time. For example, forest stock (V) is a typical level variable. If forest area (H) and total wood products (V) have the relationship like:

$$V=\sigma H \tag{5.1}$$

where, σ is a constant, then one would use either V or H as the independent level variable. A system model must include all level variables which are components of the real system.

2. Rate Variables (R)

Rate variable is a quantity that causes the levels to change and defines some process within the system at a given point in time: rates always have dimension of quantity per unit time; they can not be measured instantaneously (as can a state variable), but only over an increment of time Δt. The processes in the system occur at given rates. Only rate variables can change level variables with time. From the viewpoint of speed, the level variable stands between the constant and rate variables. Given a knowledge of the level variables of the system, and the other parameters and constants of the model, the rates of the processes occurring can be calculated. Often the most important assumptions of the model are concerned with how the rates of processes depend on the state variables. Thus, the formula can be written as:

$$R=f(L) \tag{5.2}$$

where f indicates a function.

The system levels fully describe the state or condition of a system at any point in time.

3. Auxiliary Variables (A)

In most dynamic models, an auxiliary variable is a sort of extra variable which usually assists one in understanding the system and perhaps in complementing with measurement. It also varies with time and is frequently used as a building block for rate equations. A concept that has real world significance and that is an element of a rate equation is computed as an auxiliary and used in the rate equation in place of a complicated expression. For example, if forest stocks *(V)* are assumed to adjust the difference between the rate of production *(R1)* and the rate of consumption (*R2*), *R1* is affected mainly by the level of investment (*I*), land available (*L*) and the survival rate of plantations; R2 is determined by income per capita (*N*) and wood product prices (*P*). Thus, the equation for describing these relationships may be formulated as the following:

$$V_k=V_j+DT(R1_{jk}-R2_{jk}) \tag{5.3}$$

$$R1_{jk}=\zeta(I_{jk},L_{jk},S_{jk}), \tag{5.4}$$

$$R2_{jk}=\xi(N_{jk}, P_{jk}) \tag{5.5}$$

where j refers to a point in time previous to k and production and consumption rates are taken over the intervening period. The parameter DT is a time adjustment constant.

Both $R1_{jk}$ and $R2_{jk}$ are rate variables in equation (5.3) but auxiliary variables in equation (5.4) and (5.5), since they are functions of other factors.

4. Parameters and Constants (C)

Parameters and constants are quantities in the equations of a model that do not vary with time. Usually, constant quantities have reliably and accurately determined values, which remain the same when the simulated conditions are varied; the term parameter is applied to quantities whose value is less certain, but are kept constant throughout a run of the model. The value of parameters often varies with simulated conditions. Some or all of the parameters may be approximately known from available statistical data or from work done by others.

The selection of variables is very important to the appropriateness of a given technique. Variables may be selected by several criteria. Generally, variables selected on the basis of their ability to contribute to point-predictive accuracy suggest the use of aggregate data and highly aggregated relationships, but variables in SD studies are usually chosen because they can reproduce the cause of the problem being analyzed, and because they can be recognised and validated by participants in the system being modelled.

5.2.2 Structural Components

The model structure is represented as a functioning of the relationship between the elements, and may be thought of as the logical operations utilised in tracing through the system. For an internal system structure, Coyle (1977) enumerated three distinct sectors. They are: the controller, the environment and the complement.

The controller (or decision variable) is characterized by having its own decision-making process and may be changed if there are some advantages in doing so.

The environment is a relative concept: it consists of the elements whose influence the controller can interact with but cannot directly change. The complement contains those parts of the system which do not belong to either the controller or the environment: it is completely independent of the two.

To build the structure of a SD model, further attention is needed to specify the boundary for a system model. A system's boundary is a line of demarcation that determines what is included in the system and what is not. Identifying a system's boundary is a complex process of defining the size, scope, and character of the problem being studied. Different analysts may disagree on what a system's boundary actually is, and a slight change in the way the study is defined may lead to a dramatic shift in the system boundary.

5.2.3 Process of Analysis

The process of analysis differs slightly for different problems and individual analysis (Luenberger, 1979; Roberts and others, 1983). In general, there are four stages in dynamic systems analysis. They are: representation of phenomena which includes the problem definition, the system conceptualization and model representation; generation of a solution; exploration of structural relations; and refinement and application. The process is shown in Fig. 5.1:

1. <u>Representation of Phenomena</u>

This stage involves the following three steps:

(a) *Problem definition*, which includes recognizing and defining a problem to study that is amenable to analysis in system terms. Important properties of dynamic problems are that they contain quantities that vary over time, that the forces producing this variability can be described causally, and that important causal influences can be contained within a closed system of feedback loops.

(b) *System conceptualization*, which includes identifying the important influences believed to be operating within a system. Systems may be represented by

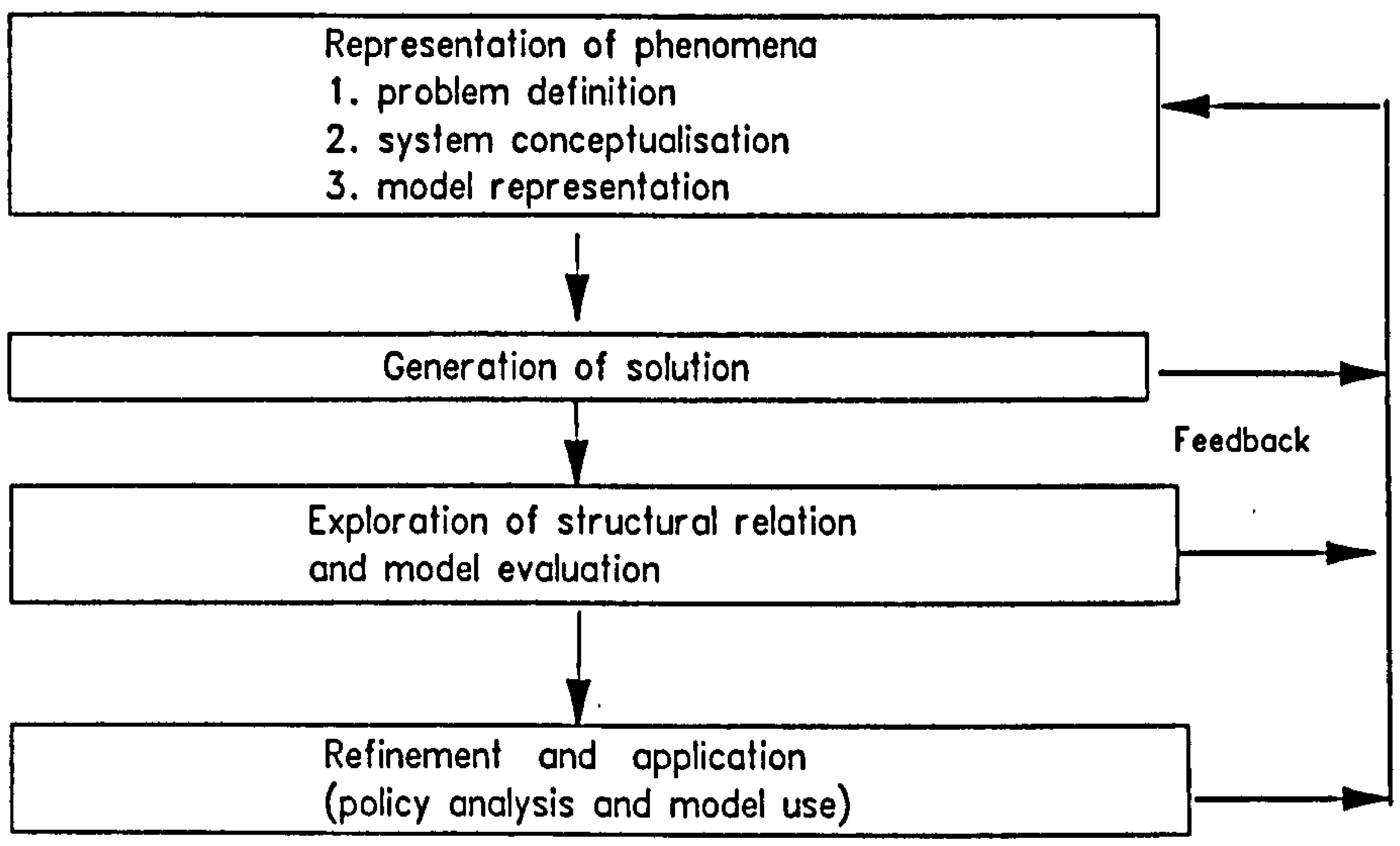


Fig. 5.1 Stages in the SD Model–Building Process

causal-loop diagrams, plots of variables against time, and computer flow-charts.

(c) *Model representation*, which includes the postulation of detailed structure - selecting levels and rates, describing their determinants, selecting parameter values, and formulating their relationships which can be operated generally by computer.

2. Generation of solution

The task of the second stage is to determine how all of the variables within the system behave over time, and to generate the behaviour of major system variables by using the computer simulation model.

3. Model Evaluation and Exploration of Structural Relations

In this stage, numerous tests must be performed on the model to evaluate its quality and validity, and to explore further recognition of relationships between variables and between a variable and the whole system's behaviour. The processes range from checking for logical consistency to matching model output against observed data collected over time, to more formal statistical tests of the parameters used within simulation.

4. Refinement and Application

In the fourth stage of the model-building process, the model is refined and used to test alternative polices that might be implemented in the system under study. Analysts might be able to investigate the possible impacts of government policies, hence to propose some valuable suggestions to decision-makers. Here systematic and empirical analysis based on the analysts' knowledge and experience is vitally important.

5.3 Model Validation

Before the application of the model in practice, its validation, that is the degree of the 'soundness and usefulness' (Forrester and Senge, 1980), must be taken into account. This depends not only on the technical and behavioural relationships (structure) which make up the model, but also on the availability and quality of the information and data input in the model. Obviously, there are two possible errors occurring in a modelling process — the error in parameter estimation and the error in modelling structure, and they can only offset each other in rare, fortunate circumstances. Conversely, any one error can lead to a wrong result, and a correct answer may sometimes be made for the wrong reasons.

For an econometric model, the validation usually takes place by so-called standard statistical hypothesis tests which involve direct comparison of the individual model equation to statistical data. For the system dynamics model, Forrester and Senge (1980) provided 17 confidence-building tests (5 for model structure tests; 8 for model behaviour tests and 4 for policy implication tests); Coyle (1980) discusses 3 'main tests' which include:

(1) verification test,

(2) validation tests, and

(3) legitimatizing test.

However, a number of approaches have been suggested and used, but the model validation, particularly in social and economic studies, has been the subject of a long-standing debate.

While the validation of structural error mainly depends upon the model builder's knowledge and understanding about the inter-relationships within the system studied, the validation of assumptions relies mostly on the correctness of information data. In this sense, the simulation model (including system dynamics) may have the advantage because it is a scenario analysis. Therefore, it can sidestep the risk associated with using the 'wrong' assumptions by providing analytic scenarios for different situations. Each scenario using the same model is based on a different set of assumptions or sets of stepwise or increased values of the control variables. The simulation models try to answer the question: what happens if things go this way. This is one of the reasons why system dynamics has been chosen as the main methodology in this study.

The statistical test method has been applied in the model wherever it becomes feasible; the structure verification is fulfilled by comparing the structure of the model closely with the structure of the real system that the model represents, and with much work in the field done by others. The behaviour test on this model is conducted intrinsically by comparing the behaviour generated by the model with the historic performance of the system during the last decade (1980-1990).

It must be stated that as validation is the process of establishing confidence in the soundness and usefulness of a model, validation of system dynamics models is complicated by the many relevant audiences, each having its own objectives and criteria for evaluation of a model (Forrester, 1980). A model should be considered useful if it generates insight into the structure of real systems, provides some reasonably analytic scenarios for policy makers, and stimulates meaningful questions for future research.

5.4 Evaluation of SD

SD as an approach to problem analysis was formerly confined to industrial management problems and to industrial policy-analysis problems. But since its versatility became apparent, the approach has been quite widely used in other fields, such as economic dynamics, corporate dynamics (Coyle, 1977), medical systems, social systems, commodity markets and the behaviour of research and development of organisations (Forrester, 1973), as well as agriculture and forestry.

However, there is much debate amongst economists in the world. Some claim that SD is "a powerful new approach to understanding the dynamics of complex social systems" (A.A.A.S. Bulletin, 1973), "a method of forecasting the future which I consider as of the greatest importance and promise" (Gabor, 1972), and "......likely to be one of the most important documents of our age" (Lewis, 1972). But its opponents were extremely sceptical about the application of SD. Among critical articles the most representative may be the Nordhaus (1973) paper, entitled "World Dynamics: Measurement Without Data". In his paper, attention was mostly focused on the Forrester's work — World Dynamics, rather than on SD as a methodology itself. He concluded that there were five critical points which are defects of the application of SD. He questioned such things as:

(1) the rationality of assumptions;
(2) the reliability of data;
(3) the identification of relationships between the model and the real world;
(4) the identification of relationships between the mathematical equations and the economic concepts;
(5) the standardisation of using economic terminology (i.e, ill-defined concepts such as "pressure to expand", or "quality of the firm").

The principal criticisms of SD, as of other modelling approaches, fall into two categories. Firstly, there are general criticisms of the process of model-building itself. Secondly, there are specific criticisms of certain assumptions used in particular models. The concern about the criticism in this study focuses on the first one, i.e., the rethinking of the technique used in the SD model, since it is a critical precondition for any application of the method.

5.4.1 Mental Model and Simulation Model

As the complexity of a system increases, our ability to make precise and yet significant statements about its behaviour diminishes, especially in social system studies. This is because the social system is tightly interrelated. An action in one sector of the system can produce consequences in another sector. The mental models which have been based on individual knowledge and/or individual thinking are not enough, or could sometimes mislead the estimation of trends. "Many persons are coming to believe that the interactions within the whole are more important than the sum of the separate parts" (Forrester, 1971).

A simulation model, which the SD is based on and holds and recalls vast amounts of information and follows the changing state of many interacting variables over time, can have operational advantages over the mental simulation model. Provided the data base is adequate and the computer-based simulation model is appropriately constructed and programmed, the assessment of alternative decisions will be more comprehensive. One can not simply reject the computer based simulation models intuitively by using primitive mental models, and contemptuously reject the help which the computer can give to our thinking. The rational and responsible way of choosing a model should depend on factors such as the features of the problem to be studied, the objectives the study requires, the cost of its construction, the ease with which the decision maker can have access to it and the added potential value from a more comprehensive assessment of options. In fact, the computer is an extension of human mental capacity (not a replacement for it) and the computer-based simulation model permits a more formal consideration of the information pertaining to a decision. Without accurate information and reasonable assumptions, neither the mental, nor the SD model is better. Concerning the critiques of Forrester's work, the responsibility of all SD modellers is to ensure that the data base is compatible with the complexity of the system under study, the use of data is valid, the construction of the model is related to current knowledge and the understanding of systems, and the computer programming is accurate.

5.4.2 Simplicity and Complexity

Critiques of SD also stem from the scale of the SD model. While criticizing the complexity, such as "great scale", long-term predicting, critics suspect the simplicity as well (Shubik, 1971; Nordhaus, 1973).

The SD model, on the one hand, usually contains more factors than other models do; while on the other hand, it omits some factors in the real world. Models are necessarily simplified reflections of the real world. One can not disagree with those broad points as they stand, but it is necessary to evaluate the effects of simplification (or possibly, distortion).

Omission can be essential and useful for economics researches; it can be harmful only when it is treated improperly. Papps and Henderson (1977) classified six types of omission. They are:

A. Voluntary

- (1) simplification,
- (2) lack of interest,
- (3) information assumed to be available elsewhere in a more convenient form,
- (4) misleading the audience.

B. Involuntary

- (5) limitations of the medium,
- (6) limitations in perception.

Among the six types of omission listed above, the first one — simplification — is very important in economic modelling. That is, because of the complexity of system behaviour, it would be impossible and useless to include all possible factors. The inclusion of more variables, or the disaggregation of a single variable into several different ones, to a certain extent, may increase the accuracy of the model, but only at the cost of increasing its complexity. The degree of complexity-accuracy depends on:

(1) the scale of problem studied;

(2) the limitation of the medium;

(3) the benefits of the increased accuracy;

(4) the cost of the increased complexity; and

(5) the availability and quantity of information.

It is worthwhile to bear in mind that while increasing the number of variables may increase either the descriptive accuracy of the model or its predictive accuracy, increasing one type of accuracy does not automatically increase another.

Because simplification is the point most significant criticisms of SD focus on, it has been discussed above in relative detail; the other five types of omission are common questions applying not only to SD but to all simulation approaches, thus this study does not intend to tackle those broad issues. It is important to re-emphasize the extent to which omissions can be harmful in model building. They are only harmful when one is not aware of them. If one is aware of the factors that are being omitted and, at the same time, understands the reason for their omission, one will not be misled into thinking that the model is a narrow image of reality.

5.4.3 Models and the 'Facts'

As argued earlier, a useful model must be less complex than reality itself, but sufficiently complete to approximate those aspects of the real world in which people are interested. Chappelle (1966) pointed out that a model is not identical to a theory. A model becomes a theory only when it passes the test as an adequate representation of some real world system. A model can be right or wrong only on logical grounds, whereas a theory is right or wrong on the grounds of the predictability of the behaviour of a real world system.

The modelling of economic activities is frequently limited by the availability of data and/or by the quality of data available. This limitation appears to arise from two aspects:

(a) the concepts used in theoretical formulation may not be directly observable. For example, the future opportunity cost of importing wood products can not be estimated directly by calculating the average cost per unit of wood presently imported.

(b) necessary data may not be available.

Identifying the relationship between the model and the real world is a vital point in using models for decision making or policy analysis. Because of their abstract and simplified nature, no model can claim complete accuracy; neither does the SD model.

Concerning the model test, scientists and economists have divided this process into two stages, some give them terms "verification" and "validation" (Naylor, *et al,* 1966; Naylor and Finger, 1967; Dent and Blackie, 1979; others); some "positive judgement" and "normative judgement" (Papps and Henderson, 1977). The verification, at its fundamental level, tackles philosophical questions regarding the concept of truth and the manner in which one can establish perfect representation. In practice, one is rarely concerned with absolute truth or the perfect representation of reality, but an approximation to the functioning of the real system; therefore the problem is not to establish the "truth" of the model in any absolute sense but to determine whether the model one has built is an adequate representation for one's purpose or to compare the model's responses with those which would be anticipated to appear if indeed the model's structures were programmed as intended. For example, if a model is built for analysis of the trends of demand for and supply of the wood products at the national level, this model may be quite adequate for assessing alternative forestry-policy decisions for the country as a whole, but would not suffice for either the provincial level or the detailed responses of individual species.

The adequacy of a model then must be seen in relation to its purpose and not from an absolute viewpoint, that is, the concern is mainly with a process of validation rather than verification.

However, the problem of validating a simulation model is still difficult, since it involves a host of practical, theoretical, and statistical complexities, even if one avoids philosophical problems. Specific measures and techniques must be considered for testing the "goodness of fit" of a simulation model; some criteria must be devised to indicate when the time paths generated by a model agree specifically with the observed or historical time path so that agreement cannot be attributed merely to chance.

5.4.4 Theoretical Evaluation of SD

5.4.4.1 Philosophical Underpinning of SD

SD is based on the philosophy that the behaviour of a system is principally caused by the system's structure, including policies that dominate decision making within the system. It focuses on the structure and behaviour of systems composed of interacting feedback loops.

A second related underlying philosophy is the concept of cause and effect within the system under study. It is viewed most prominantly in terms of their underlying flows of labour, capital, materials, information, and so on. A relationship between cause and effect then results from tracing the cause-effect chains through the relevant flow paths of the system.

Causal loops and time delays are characteristic of all feedback processes. The feedback loops, based on the full understanding of the nature of the system that is faced, are employed to show the major cause-effect links between the system variables, and indicate the direction of linkage. Those links in turn come back as information to influence future action and change in the system from the simplest to the most complex.

A closing of the loop occurs when a delay intervenes between the initial action and the feedback results. This process helps us to understand how a group of activities and the time delays in interconnected components can lead to system behaviour.

There are two kinds of feedback loop in SD. One is the negative feedback loop which seeks a goal and responds as a consequence of failing to achieve the goal; the other one is the positive feedback which generates a growth process wherein action builds a result that engenders still greater action.

The third philosophy of developing causal explanation in SD is the accumulation principle. According to this principle, all dynamic behaviour arises from the explicit accumulation of flows in level or stock variables. The phase lag decouples the instantaneous value of a flow from its effect on other variables in a system; such decoupling accounts for all dynamic behaviour in SD models.

The importance of the accumulation principle can be well understood through comparison to the way econometric models typically generate dynamic behaviour. Dynamic behaviour in econometric models generally arises through Y_t, "distributed lag function" — a relationship which gives a dependent variable as a function of current and past value of an independent variable, X_t:

$$\begin{aligned} Y_t &= B_0X_t + B_1X_{t-1} + B_2X_{t-2} + \ldots + B_nX_{t-n} \\ &= \sum B_iX_{t-i} \end{aligned} \qquad (5.14)$$

The distributed lag function represents a general scheme for correlating current values of one variable with past values of another variable. Even if one has a causal theory for why X_t affects Y_t, the technique requires no theory for why there should be a delay in effect or what the nature of the delay is. By contrast, the accumulation principle would force the modeller to supply a causal explanation for why a delay occurs between X_t and Y_t and to specify the nature of the delay. For example, forest stock does not respond instantaneously to the desired change in investment since time is required to plant trees and to obtain new biomass growth. In a SD model, the desired change in investment might lead to a flow of new investment projects in planning. The model might assume a constant average planning time, after which the response of change in forest stock would take place with growth. Acquisition of new forest resource stock would then only occur with an increase of existing forest or of new plantations. This example shows how the accumulation principle forces the SD modeller to provide a causal explanation for dynamic behaviour while the distributed lag approach leads only to a correlation. Therefore, it is reasonable to say that the causal explanation is preferable because it increases points of contact with reality and makes corroboration or refutation more possible.

5.4.4.2 Advantages of SD

SD, based on simulation principles, certainly has advantages, which may be briefly summarised as follows:

1. One of the chief advantages of SD model is that it provides a procedure for formulating and testing hypotheses. A SD model, theoretically speaking, can be much more realistic than some conventionally mathematical types of models. SD models are solved by tracing the time paths of the endogenous variables, and can be as complex and realistic as the underlying theories require, while mathematical models require an analytic solution and must of necessity be kept simple if not overly so, and most of them, if not all, are static and linear. Specifically considering forest studies, the long time delays between investment and return, the non-linearities in the policies and the growth rates, the large number of stock variables within the system (e.g. area, volume of forests by age group; quantity and type of various products required by different demand sectors), and the multiple feedback loops in the system, "all make the evaluation of forest policies very suitable for analysis by SD method" (Cavana and Coyle, 1984).

2. SD is a method to structure and organise knowledge about the problem from model builder(s) and others, facilitating the solution of complex problems by exploiting the systems method and a substantive knowledge of the problem at hand. It emphasizes the study of structures within the system to deepen the understanding of the system behaviour. The criteria for selecting the variables in the modelling depend not on

whether the variables can be easily quantified, but on the relevance to the problem being studied. To some extent, it reduces the reliance on time-series and detailed statistical data through the analysis of indirectly related data, experts' experience and government's long-term programming, and it is relatively desirable to combine the quantitative and qualitative analysis together in the model.

3. Like other simulation processes, SD model makes it possible to conduct analysis of the model by running the model numerous times. SD permits the varying of "time" in order to handle objects which move at different rates, and observes long periods of dynamics being simulated in a much short period of time, thus enabling the forecasting of problems before they develop. In this manner, one or more assumptions, relations, or variables can be changed or modified as necessary.

4. SD is easy to learn, and can be employed by non-mathematical analysts; in its simplest form, it is characterised by the ability to model a sequence of events; since it is composed of blocks, it has the feature of flexibility to change decision variables and to answer "what-if" questions, thereby widening their effectiveness in the study of complex social systems. This may be why it is called a "policy laboratory".

5.4.4.3 Problems of SD in Application

Although SD has some advantages outlined above, the method is by no means completely free of problems and difficulties. From the criticism, even if mostly focused on Forrester's works rather than SD itself, one can learn lessons and face the challenge of improving it. Basically, the problems fall into two broad classes: empirical and methodological.

1. The empirical problems relate to the rationality of assumptions, the collection and reliability of adequate data, and the identification of the relationship between the model and the real world. All relationships or variables should be drawn from actual data or empirical studies, or existing literature. If the assumptions about functional forms for

the future are reasonable and the data are accurate, simulations will lead to acceptable predictions; otherwise, there is no assurance that SD is better than other methods.

2. The methodological problems which arise in the construction of SD models involve three aspects of considerations.

(a) SD models, unlike mathematical models requiring analytical solutions, encourage the use of complex, non-linear relations. Since a non-linear function can have any one of many possible forms, efficient methods are needed for determining or specifying the proper forms of functions. Progress along these lines will probably come with the growth of better empirical data and statistical criteria, as these are developed in conjunction with the construction of improved SD model.

(b) Once the equations in SD models have been specified, some parameters remain to be estimated. Since the model (especially models in economic and policy analysis) purports to simulate evolutionary behaviour over many successive time periods, and the endogenous variables are jointly determined, the simultaneous nature of the equations of the model will have to be recognised if validations are to be made.

(c) Tests must be devised to evaluate the goodness of fit the model has to the real world, or in other words the model's validity. This problem becomes even more difficult, however, when the available data regarding the "actual" behaviour of reality are themselves subject to error, as is usually the case.

5.5. Improvement of SD

It is now clear that given its advantages, the SD model, like all other individual sets of algorithms and particular model designs, has its own limitations. A way must be found to cope with or avoid these constraints or disadvantages, i.e., to improve the SD model in studies in the field. Hence an effort has been made in this study to search out the possibilities of integration with others, such as econometrics, mathematical programming and/or statistical models.

5.5.1 Parameter Estimation in SD Modelling

Like any model, SD models require one to estimate a series of parameters, which is critically important for the goodness of the model, but is still a weak point in SD modelling.

Parameter estimation techniques can be classified by the assumptions they require and the data they utilise. Graham (1980) divided the technique into three categories, based upon the extent to which they require assumptions about the correctness of the model equations.

The first type of technique described requires no such assumptions, since model equations are not used in computing the parameters. This technique is used for estimating parameters by using the data below the level of aggregation of model variables, i.e., information on the individual events and items which might correspond to the model variables only after being aggregated together. In this case, the problem can be reduced to the sub-problems of estimating extreme values and slopes, specifying the normal point, and drawing a smooth curve through the extreme and normal points. TABLE function, which is a DYNAMO algorithm for expressing a usually nonlinear relationship between two or more variables, and *ad hoc* computation (Graham, 1980) in SD model fall into this technique (see the application of TABLE function in Appendix II of this thesis).

The second type of technique is that in which the correctness of the model equation is assumed; and parameters are estimated by using the equation. These techniques are based on data that correspond to model variables (aggregate data). A typical example of this technique is the regression method. This technique is used in this study for estimating some sectoral demands (e.g, demand for constructional wood and demand for fuelwood and for agricultural use).

The third type, in contrast to the second, shows techniques of estimation to set a parameter value by manipulating several equations. It is said (Graham, 1980) that the second type and the third type are distinguished because they are usually distinct in practice, and in the pitfalls resulting from applying these two techniques, see Graham (1980) for an example.

There are often some pitfalls in all of those alternative techniques. The principal pitfall of the first type is structuring the model on a level of aggregation too high to allow observers within the system to reliably translate their experience into parameter values, i.e., the modeller creates a model structure and parameters that are aggregated to the point where the processes characterized by the parameter values cannot be reliably observed. As a result, the parameters have little real-life meaning, and to estimate them, the estimator must draw conclusions based on a mental model of the system behaviour, rather than simply reporting observations. Forrester's studies (1961, 1969, 1973) which were criticised by a considerable number of people, fall into this type. The two other techniques estimate parameters by using a single model equation or several model equations. Both assume the correctness of the given equation(s). By using the equation(s), parameter values are inferred from data corresponding to model variables. The techniques assume the accuracy of the equation(s) and the data. The pitfalls in these techniques are:

(1) that the use of aggregated data of model variables diminishes the ability to validate, and

(2) that those techniques are vulnerable to systematic errors when assumptions are violated.

These pitfalls are also encountered by econometricians in estimating simultaneous-equation models. Multiple-equation methods theoretically deliver greater accuracy than multiple application of single-equation methods. However, the former invoke more assumptions and hence are more sensitive to minor violations of assumption than the latter. Similarly, a parameter estimate from the aggregated data of model variables is less robust than that from disaggregated data.

Any analytical technique has certain advantages and is suitable for dealing with some problems to a given extent. But as no one methodology is perfect for answering economic questions, such as how to develop China's forest resources, which usually relate to integrated and complex problems with social aspects, so the SD method also falls short. From a practical viewpoint, it is possible to employ various techniques at different steps or in different sectors of a given study to improve the application of one approach and hence to improve the method itself. System dynamicists must admit that other techniques, such as econometrics, etc., can be useful for problem identification, parameter estimation and statement validation.

While the SD simulation model provides a good illustration of model hybridization, model linkage involves hooking together two or more distinct models in a systematic fashion. The individual models that are linked can be constructed using the same or different methodologies. The criteria for choosing the approach depends upon both the feature of individual technique and the given objectives of the studies. The techniques should facilitate, and be facilitated by, the other phases of the modelling effort: the model should be formulated in such a way as to avoid the pitfalls or limitations of the techniques as much as possible; the model testing should guide estimation efforts by maximum utilisation of the advantages of simulation properties; and information should be used in estimation in a way that facilitates validation.

Therefore, a lot of work needs to be done for the estimation of parameters and identification of systematic equations before SD simulation. The idea of combining other techniques into the SD model in this study is based on a stepwise method of system description for problem development and qualitative and quantitative analysis which is shown by the following (Fig. 5.2):

The starting point of the idea shown here is the identification of key variables, which is formalised and broken down into the individual steps of identifying the resources, relevant to observed problem symptoms. This is followed by identifying the forces (variables) which control, drive and transfer resources between different states, by classifying the resultant flow modules produced, and by estimating parameters

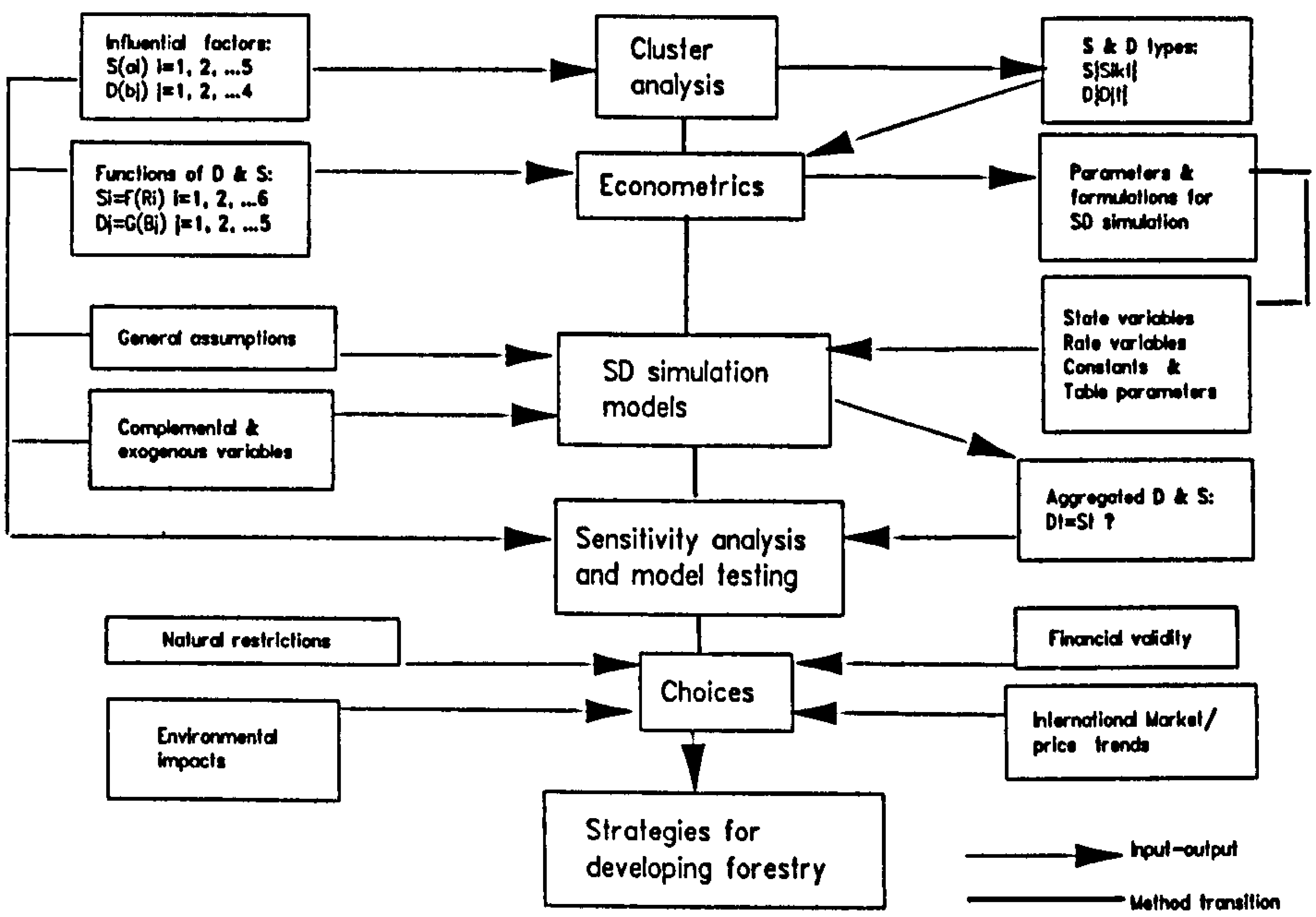


Fig. 5.2 The Flow-chart of Modelling Process

required by the SD model.

The supply of forest products varies due to different types of forests, geographical location, climates, social and economic conditions, etc., and the demand, due to population densities, economic development, technical substitute possibility, cultural backgrounds and customs, etc. Due to these variations it would be rational to classify the demand and supply into different types to improve the formulae comprised in the SD model, in order better to represent the relationship to reality.

In this study, the supply is classified according to forest types and age-groups. This is based on a consideration that different types of forests and the distinct age-classes within one type, are different in term of productivity, costs and production period. For an ordinary timber-production forest, product supply is modelled as a horizontal-step function, and consists of three steps corresponding to 'old', 'mid-aged' and 'young' forests, in considerable detail, since the timber-production forest shares about 85% of total forest stock. Fast growing forest is treated as a separate class in consideration of its high input levels and relatively short production periods, while the remaining types of forest (i.e, environment-protection forest, non-timber tree crops, and forest for special use) are classified into one aggregated group because of their small share of both the land and the stock, and their complexities in terms of their growth behaviours and product-orientation.

The planned demand is mainly classified according to its end-use categories. This approach obviously has advantages whenever it becomes available:

(1) problems of collinearity among prices and indicators of market activity decline with disaggregation;

(2) disaggregation permits estimation of more specific market behaviour, as elasticity estimates may vary among different market segments;

(3) disaggregation allows use of more varied data, including market survey and industry information, that improves understanding of demand behaviour.

However, the agricultural sector's demand and the off-planned demand are categorised into two highly aggregated groups in this study, although they have big shares of total resource consumption. This is again because of the limitation of data availability, and the ambiguity of distinguishing one end-use group from others within those two kinds of demand.

Then, the main influential variables of the demand and supply types are identified according to cause-effect and in a few cases, correlation relationships of variables within each type, and these variables are estimated by using disaggregated data and statistical techniques.

The combination of different methods here is based on the belief that they are complementary to each other: SD provides a theory of causal structure, and its relation to dynamic behaviour is a powerful guide to model specification; econometrics offers numerous techniques for finding empirical parameters and for formal comparison of model results with historical data or real-world observations. While one technique may be particularly applicable to long-term and complex systematic analysis of possible changes in historic trends, the other may be suited to short-term precise prediction in situations that do not differ substantially from the historic. It would seem that using different techniques together in this stage might generate a model that combines relatively realistic structure with comparatively accurate parameters, and a model that is useful at every stage of the decision-making process, particularly for middle-term problems which are not easily analyzed by either method alone.

5.5.2 Identification of Formulae in SD Model

Another key issue of modelling in SD, as well as in other modelling methods, is the identification of formulae. This is critically important because those formulae represent the understanding of problems faced in studies and the determining of system behaviour, hence the validation of the model structure.

All validations of model structure relate to the purpose of modelling studies. Apart from testing a theory of system behaviour, the common features of simulation models deal with the future behaviour of a given system, such as projecting the general behaviour of a system, forecasting specific system parameters, and designing policies to affect system behaviour. Most models, however, are built mainly upon past information and past relationships between variables within the system, and based on regression analysis. These models may be useful only for exploring the very near future. For long-term prediction, however, they are obviously inadequate, and sometimes may ultimately be wrong. This is because statistical data represent only a small fraction of what can be measured rather than all that can be known about past and present situations, and because the future will not simply be a reflection of past.

Long time production cycles, such as forestry, imply that intertemporal behaviour is a critical dimension of the model: the solution of one period affects what happens in the next period. It is true that, in many cases, the only important forces within a system are continuous forces that can be modelled without considering discrete events. But in many other cases, a system responds not only to continuous forces but also to discrete events, and the influences of events occurring either within or outside the system may become the most important influences on the system over time.

Nonlinear relationships, comprised in the models, often depend both on historical data for part of the timing range and on other information (such as scientific parameters, experts' opinion, or national development plans) including the modeller's perception of the future shape of the relationship for another part of the timing range. While relationships among variables may be included in the model structure because they are assumed to be important in the future, an important class of information about future events is not usually considered. These events are discrete, specific occurrences that have not necessarily occurred in the past but might occur in the future. In order to project the behaviour of a system, it is necessary to include such influential variables within a model wherever they are important to the models' behaviours. SD modelling offers an attractive tool for policy evaluation (Hunter, 1984). Policy alternatives can be simulated by computer; thus, the policies could be tested under completely controlled conditions. A special programming language, DYNAMO, is helpful and widely available and simplifies the mechanics of computer simulation (Shubik, 1971; Pugh, 1973). Technically, SD models provide some devices for considering information about the future through TABLE functions.

Many SD modelling projects, to some extent, do consider some future events, even if arbitrarily and exogenously, but the events are not a part of the model itself (except events dealt with in the RANDOM NOISE function which gives random numbers uniformly distributed between -0.5 and +0.5). They are usually considered one at a time in a series of sensitivity runs. Commonly, the result of model simulation offers several outcomes (scenarios) with different assumptions, such as at a basic rate, a higher rate and a lower rate of decision variables (e.g. investment). The scenarios show what the outcomes of the current tendency would be if given events did occur at different rates. The process is essentially one of considering each event in isolation from all of the other events or policies. Thus, this approach to assessing the influences of events is not always adequate, because of the influences of isolated treatments.

Three types of interactions which have been ignored by most modellers were investigated by Stover (1980):

(1) the influences of model variables, especially trends, on event probabilities;

(2) the event-event interactions which may be missed unless events are made a part of the model;

(3) the combined effects of several events occurring in sequence which may be missed unless they are included in the model.

In DYNAMO, apart from the TABLE function and RANDOM NOISE function mentioned previously, there are other functions which can be used to deal with future events, such as the CLIP function and SWITCH function. The CLIP function works in the form of CLIP(A_1, A_2; C_1, C_2) and clips one of two variables (A_1 or A_2), depending on the conditioning value of two other variables (C_1, C_2), it selects the first argument (A_1) if C_1 is greater than or equal to C_2, otherwise it selects the secord (A_2); the SWITCH function has a form of SWITCH(A_1, A_2; C_1) and selects the first argument (A_1) if C_1 is zero, otherwise it selects A_2. (detailed explanations of all functions in DYNAMO can be found in system dynamics textbooks, such as Pugh, 1973). Each function indicates a specific relation among variables. Since the coefficients and the parameters (including probabilities) required by those functions are given exogenously, the technique of cross-impact analysis is needed to describe the probabilistic interactions of current events with events in future. The detailed application of this technique can be found in Appendix II of this thesis.

Having introduced the impacts of model variables on event probabilities and event occurrences on the model variables into the basic model, one of the critical determinants of the choice between events would be the future probabilities of the event. However, most events and changes are in some way related to other events and developments. Any single event, for instance, the import of wood products, may be influenced or determined by many factors, such as domestic demand and supply, price level in the world market, economic situation, political attitude and trade policies, the pressure for environmental protection, and so forth. The complex relationship between events and the dynamic movement can mentally be shown by cause-effect loops in the SD model, but the loops are not able to indicate the probabilities ($\propto_i$) of future events and the impact of one event on others. Therefore, the estimate of probabilistic best-guessing becomes one of the important steps in the modelling.

These probabilities may be estimated by individual experts, but more commonly are done by groups containing experts from various disciplines concerned with the events. Delphi questionnaires or interviews also can be used to collect these judgements. Linked with the SD model, this process can also refer to cause-effect analysis, which considers the introduction of new policies or actions, the unexpected occurrence of an event, changes in system behaviour, etc. Consequently, the conditional probability matrix would be estimated in response to the question: "if event A_1 occurs, how would changes affect the entire set of events", and "what is the new probability of event A_2" by using the Bayesian formula.

$$P(A_2/A_1) = \frac{P(A_1 \cap A_2)}{P(A_1)} \tag{5.6}$$

where, P = Probability,

$\cap$ = intersection.

The impact of the occurring event is indicated in terms of odds ratios (Stover, 1980). The odds of an event are the ratios of the occurrence probabilities of the event $P(A_i)$ to the nonoccurrence probabilities $P(\bar{A}_i)$.

$$O_i = \frac{P(A_i)}{P(\overline{A_i})} \tag{5.7}$$

The odds ratio, $O_r(A_1/A_2)$, is simply the odds of the event given the occurrence of another event divided by the initial odds of the event:

$$O_r(A_1/A_2) = \frac{P(A_1/A_2)}{P(\overline{A_1}/A_2)} \Big/ \frac{P(A_1)}{P(\overline{A_1})} \tag{5.8}$$

since

$$P(A_1)=P(A_2)P(A_1/A_2)+P(\overline{A_2})P(A_1/\overline{A_2}) \tag{5.9}$$

and $\bar{A}_2$ is the complement of A_2, therefore $P(\bar{A}_2)=1-P(A_2)$. Substituting $1-P(A_2)$ for $P(\bar{A}_2)$ and rearranging the equation (5.9), one will get the following equation which is used for calculating the nonoccurrence probabilities:

$$P(A_1/\overline{A_2})=\frac{P(A_1)-P(A_2)P(A_1/A_2)}{1-P(A_2)} \tag{5.10}$$

The nonoccurrence odds ratio can be calculated from the occurrence probabilities in the same manner as the calculation of the occurrence odds ratio.

Both occurrence and nonoccurrence odds ratios, then, are used to calculate event impact on other events which will be following events. Thus, a new probability for event A_2 is calculated using the following equation:
If event A_1 occurs,

$$P(A_2/A_1)=P[\xi(A_2)\xi_r(A_2/A_1)] \tag{5.11}$$

otherwise,

$$P(A_2/A_1)=P(A_1)P(A_2/A_1)+P(\overline{A_1})P(A_2/\overline{A_1}) \tag{5.12}$$

where,

$\xi(A_2)$: Odds of event A_2;

$\xi(A_2/A_1)$: Odds Ratio of event A_2 given the occurrence of event A

If event A_3 subsequently occurs, a new probability is calculated for event A_2 by using same formula:

$$P(A_2/A_1,A_3)=P[\xi(P(A_2/A_1)\xi_r(A_2/A_3)] \tag{5.13}$$

when an event does not occurs the nonoccurrence odds ratios are used to calculate the new probabilities of all other events.

By calculating both occurrence and nonoccurrence impacts the final probabilities of events will be identical to the initial probabilities which were originally estimated as a balanced set. That is, influences of events on each other are taken into account in estimating the initial probabilities, when these probabilities are employed in the SD models for simplifying the modelling process. When changes are imposed on this balanced set, however, by changing the initial probabilities of one or more events, the final results of a cross-impact run will be different from the initial probabilities reflecting the changes in the entire event set caused by the changes made to only a few of the events. Practically, it is necessary to consider impacts of events on each other only when events occur: nonoccurrences cause no change in probabilities. Based on this consideration, the determination of when or if an event occurs within the SD model can be handled by using random numbers. For each solution interval a random number between 0 and 1 is created and compared with the probability of an event occurring during that interval. If the random number is less than or equal to, the probability of the event, the event "happens" and its impacts are calculated, otherwise the event does not happen during the interval. As mentioned previously in this section, the CLIP function, provided by DYNAMO, can be used to deal with this problem.

The impact of model variables on event probability can be easily handled with the use of odds ratios. These odds ratios would be multiplied by the odds of the affected event to derive new odds for that event. The estimates of initial probability and impacts could either be calculated exogenously, then expressed in the equations of the SD model as the parameters, or obtained within the SD model by rewriting the original formulae as SD model equations. The strength of the impact could be expressed as a TABLE function of DYNAMO in terms of the percentage of total capacity.

Once the estimates of initial probability and impacts have been made, the SD model could be made more realistic by reducing the arbitrary determination of parameters about the future, and approach more closely the probabilistic best-guessing.

In this study, the model is modified by adding some future events and linking the events to the related sectors. The events considered in this study are shown in Table 5.1.

Table 5.1 Some of the Events Used in the Study to Modify Some Relationships in the Model

1.	Transition probability of age structure of forest types.
2.	Transition probability of forest land use structure.
3.	Increase in the success rate of plantation due to policy changes and technical improvements.
4.	Additional supply of forest resources from fast-growing forests and from substitution of fuel-wood consumption.
5.	Possibility of substituting forest resources from other consumptions, such as building materials, furniture materials, etc.
6.	Impact of an increase in personal income on demand for forest products.
7.	Possibility of increasing investment in forestry from international sources, the State, local governments and individuals due to the change of policies and ownerships.
8.	Increasing forest product costs.
9.	Extent of increasing forest product prices due to increase of costs and change of pricing policies.
10.	Change of foreign exchange rates.

5.6 Forest Economy System and System Dynamics

5.6.1 The Characteristics of Forest Economy System

As an economy is a dynamic system with targets and desired paths, so too is the forest economy (Westoby, 1987): it is a system with multiple goals — it seeks better environmental and recreational conditions and enough forest resource for human needs; it is a dynamic system with lags — trees planted today to meet the demands of environmental improvement and timber supply require many years to grow and enter the inventory of forest resources; it is a dynamic system beset with uncertainty from policy changes and natural disasters; it is also a dynamic system related to its biological subsystem, economic subsystem and social system.

The characteristics of the forest economy — multiple goals, dynamics, uncertainty and subsystems — make it a dynamic system that is not easily analyzed with any single traditional mathematical method, such as linear programming, or econometrics, but that seems to be made easier by using SD, a technique applying feedback control and system analysis methods to a complex policy or development strategy determination. This will be discussed through the following discussion and an applied example in the coming chapters.

5.6.2 The Suitability of Applying SD in Forest Policy Analysis

Based on statistical data, simulation methodology and understanding of the current realities, SD has been used in many areas as a tool to expose the operation of a complex system by duplicating and tracing the performance of the elements of the system and the relationship between those elements. But how does SD fit the forest economic policy studies? This section attempts to answer the question through four aspects, i.e., systems, goals, dynamics and uncertainty.

5.6.2.1 Systems: The Relationship Between Components

Systems are shown by a closing of the cause-effect loops, which indicate the relationship between different sections of forest production processing. The loops do not function separately, but rather are coupled together to form complex feedback systems that are complete interacting entities. The continuing operation through time of those loops creates the performance time patterns of the system's variables. The research process is helpful in understanding how the amount of corrective action and the time delays in interconnected components can lead to system behaviour. The SD is based on the philosophy that the behaviour of a system is principally caused by the system's structure. The structure includes not only the physical aspects of the system, but, more importantly, the "policies" that dominate decision making within the system.

Because the interrelationships are so important, the whole system is more complex and more comprehensive than the sum of the individual components. This is a functional fact applying to all systems and is the unifying theme in system theory

(Wright, 1971). Any defined system will have its own specific characteristics, but all systems will conform to the following general features:

(1) A system is fully defined both by a set of identifiable entities (or components) and interconnections between them and by the limits to their organisational autonomy.

(2) A system is a hierarchical structure comprising a number of subsystems each capable of autonomous definition; in turn subsystems similarly embody the next layer of detail in autonomous sub-subsystems. The point of entry into the hierarchy in any systems study is related to the objectives for which the system is being studied.

(3) The most important characteristics of systems emerge over time so that the understanding of systems requires explicit consideration of time and rates of change.

(4) Systems are sensitive to the environment in which they exist. This environment is usually unpredictable and certainly variable.

The principle and features of SD seems to suit well with many aspects of forest resource studies. Deforestation is one of the examples. Palo (1987) described 20 propositions of tropical deforestation. He summarized most (17 of 20) propositions in a systematic way (Fig. 5.3) and described those by behavioural equations.

Fig. 5.3 shows that tropical deforestation is caused by a set of systematic reasons rather than a single one. Population growth and environmental deterioration in the form of deforestation and soil erosion are the basic factors. Together with inadequate land-use and forest policies, and with apparent market failures in the economic system and with lost forest-based development opportunities, a vicious circle of continuous and accelerating rural depression and deforestation has been identified with either positive or negative feedback loops.

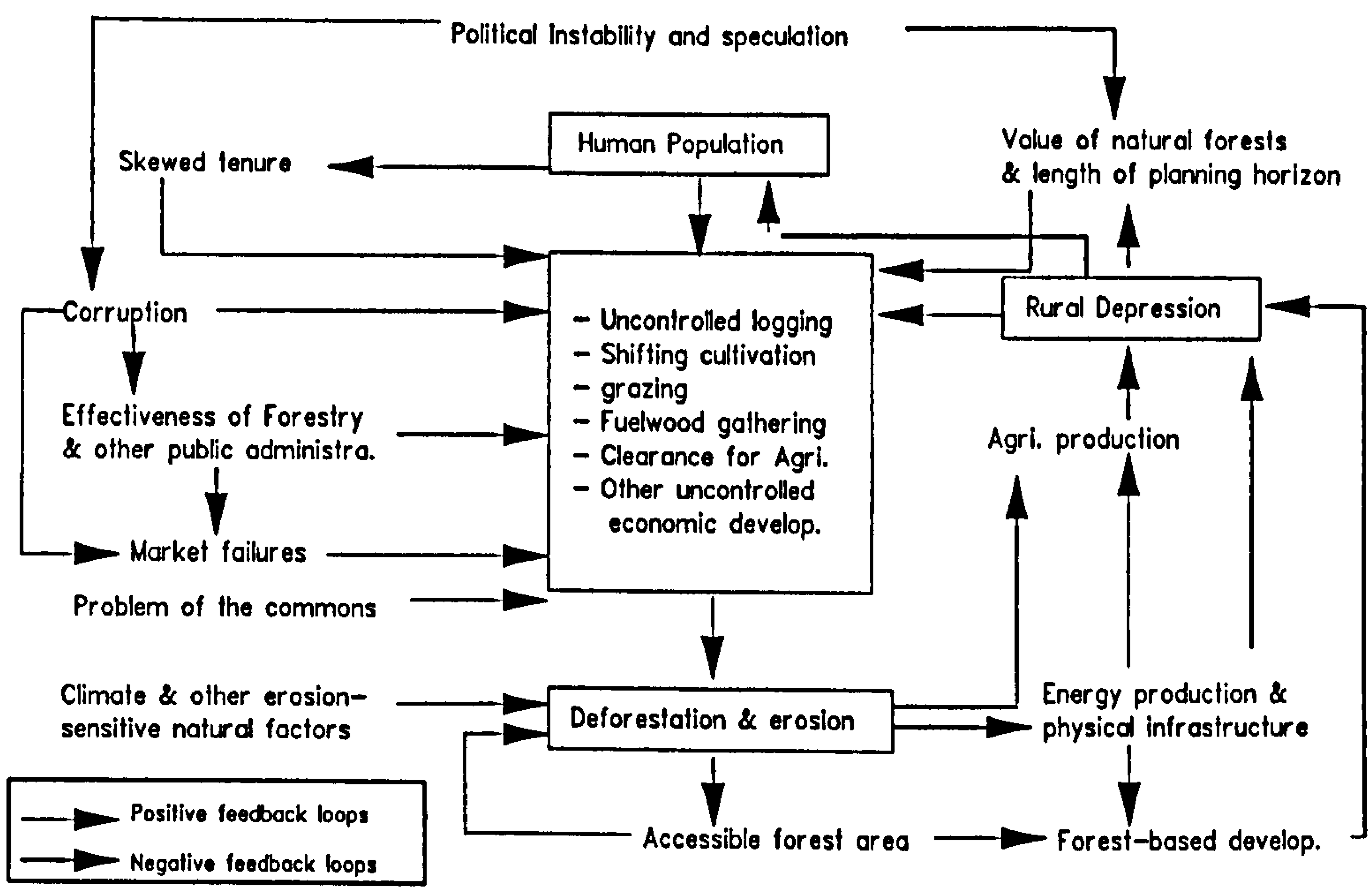


Fig. 5.3 The Vicious Circle of Population Pressure, Deforestation, and Rural Depression

5.6.2.2 Goals: The Desired Path of Development

Multi-objectives is one of the typical features of forest production. Goals for strategic studies of forest development have been normally stated as "a balanced situation in demand for and supply of wood products" or "forestry's share of GNP will be x% of total GNP" or "the forest coverage will be x% of total land", etc. All these sort of goals do not include any indication of timing as they are static. In the forest economy, the goal may be a combination of a series of targets which indicate the different functional aspects, such as financial, economic and social effects and desired paths, which may be achieved through a period of time.

The basic method of mathematical programming (including LP and programmes derived from LP) is to try to maximise or minimise the goal(s) or objective(s) of some mathematical expression subject to a number of restricting equalities or inequalities. All these must be solved simultaneously for the values of the variables found in all expressions.

Problems arise from the difficulty of establishing the goals in the studies on demand and supply of wood products. The balancing of supply and demand itself, whatever the means, is certainly not optimisation and should not imply goals (Duerr, 1976). A commonly cited instance is the 19th century potato famines. The planned-equilibrium of demand and supply of wood products in China may be another example which gives us insight from another angle. Both imply that the balance alone may not necessarily be a "good" or "bad" thing.

Instead of maximizing one explicit objective (or one criterion) as many other methods do, an SD model may include many implicit objectives and involve numerous criteria. Moreover, through the simulation process, SD models usually provide different conditional paths. Whether those paths are desirable or not depends upon the level at which analysts' original objectives aim, and the weight assigned to different objectives. It also depends upon the comparison of the outcomes from one scenario with those from others, and upon production possibilities under certain circumstances. This may bring some difficulty to validate and use the model as a policy analysis tool, but avoid the mistake analysts often make - when one focuses on a composite 'scalar' measure of performance, some of the important component changes in the system are overlooked. For example, when one criterion, say, GNP per capita, does well through time and another, say 'Gini ratio' does poorly, the effects may cancel out each other.

Therefore, the specification of the desired paths alone is not sufficient to describe the goals in the demand and supply studies. Rather, since the desired paths for various indicators such as a balanced status of demand and supply, the maximum benefit, the share of GNP, or the coverage of forest may conflict with each other, forestry policies analysis is a process of trade-off between the different goals and it is thus necessary to assign weights to the various time periods or priorities to desired paths.

5.6.2.3 Dynamics: Intertemporal Changes

Dynamics is another important feature of SD. The concept of 'dynamics' in SD refers to intertemporal changes. As used in this study, the 'dynamics' refer to intertemporal changes in forest resources and in the resource aspects specifically related to the movements of long-term and short-term wood supply. The dynamics appear in two types of lag: decision (or information) lags and material lags.

Decision lag is the time between an adverse change in the economy and a decision to do something about it. For example, decision lags extend from the time when the prices of wood products are too low to encourage the farmers to plant trees until the government proposes a reform of the price system or the farmers can obtain a reasonable amount of benefit by selling their products at the adjusted price.

Material lags cover the period between the time when a plantation activity is undertaken and the time when new planted trees become the forest resources which can be harvested rationally as the supply of wood products.

Because of these lags, a proper specification of the dynamics in forestry becomes an essential component of a study like this one. That is, forest policy analysis must consider policy effects in both short-run and long-run. While short-run wood supply may be determined by economic factors, long-run supply is determined by the interaction of short-run harvest, forest management decisions, forest related policies, and forest growth relationships.

5.6.2.4 Uncertainty and Feed-Back Simulation

In his definitions of uncertainty and risk, Price (1989) distinguished them theoretically by whether we know about the relative probabilities of each state of nature or not. However, it is not always possible to distinguish them practically. In this study, the concept of uncertainty may be less precise than Price's.

Uncertainty comes in many forms but three types will be singled out for special treatment in this framework. These are shocks, behaviour and measurement.

Shocks are unexpected events like forest fire or unusual climate; behaviour uncertainty is the uncertain response of agents in the economy to changes in policy or the way it behaves, for example, the response of consumers to a price increase or a response of demand for wood products through an increase of population; measurement uncertainty is used to indicate that our knowledge of the economy or current techniques is less than perfect, for instance, the substitution rate of wood products is revised as a more advanced technique is obtained, or the demand for future wood is actually larger than what was estimated as additional data are received.

In SD, the uncertainty is portrayed by cause-effect loops and sensitivity simulation. The application of SD in the analysis of demand and supply of wood products is intended not to predict what will actually take place in the future, but to describe possible development paths in an internally consistent way. The results can be shown with confidence intervals over time. In fact, no economist can predict the future state of the economy with precision, and advice should be given that reflects this fact. Therefore, the advice is not exactly what will happen at given time points, such as: *if current harvesting of the forest resource continues, the forest resource in one country will be depleted in year 2010,* rather a confidence interval, such as: *if current harvesting of the forest resource continues, the forest resource in one country will be depleted in the period between 2005 to 2015.*

Uncertainty is tackled here by using a combination of feedback systems and probability estimation. The resulting information is used for the purpose of model behaviour control. Kendrick (1988) argued that the greatest gains from the use of a feedback control framework may not come about from the employment of feedback rules or confidence intervals, but rather from common-sense changes in institutions and policy procedures that will come about once the economy is viewed through this framework, thereby influencing future decisions (Forrester, 1961). Feedback control is fundamental to all decision-making analysis. Because of the inevitable distortions which a decision may undergo from analysis to action, it is often considered necessary to control the result of the analysis. By feeding back the results of the plan to a common point, it is possible to compare the result of analysis with the original plan. If the comparison shows that the original plan was feasible, then, on the basis of the analysis, it can be issued as authoritative instructions for action to take place. On the other hand, if the comparison shows that the plan was not feasible in the light of the existing situation, then those creating the plan must decide whether this is because of an unrealistic assessment of all the conditions, or it is the result of inadequate or distorted analysis of the plan, thereby resolving a conflict between subjective beliefs and objective analysis.

To sum up, the typical features of systems, goals, dynamics, and uncertainty as discussed above, especially in the context of Chinese forest economics, pose problems and challenges to modellers. It is in these aspects that SD shows advantages compared with other methods and provides a logical and effective approach for the present study.

PART III

SD-FRED: A MODEL
FOR CHINA'S FORESTRY POLICY ANALYSIS

CHAPTER 6

MODELLING CONSIDERATION OF SD-FRED

This chapter gives a brief description of SD-FRED from the following aspects:

Based on the current situation in China and the theoretical discussion in previous parts of this thesis, a systematic policy oriented model of wood products Supply and Demand, and Forest Resource Development, SD-FRED, has been developed in this thesis. The model is not simply confined by either the market economic theory or the rigidly planned economic dogma. Instead, it is based on the general equilibrium theory, and reflects the features of China's mixed economic system. The model has been developed mainly by using the system dynamics approach; it also employs other mathematical methods, such as econometrics models, to deal with data processing required by the modelling. The model, SD-FRED, focuses on the following issues: demand and supply of forest products; sustainable use of forest resources; lead time in production and the effect of various policy changes and structural adjustment on forest development. It aims at providing long-term trends of production and consumption and formulating strategic scenarios for sustainable forest development in China.

6.1. Objectives of the Model

As stated in the introductory chapter, China is facing a severe shortage of wood supply and a severe deficit of forest resources. Given the current state of forest resources in China, the pressure of environmental protection has also been reducing the capacity of the domestic wood supply on the one hand; the rapid economic growth during the last decade and the steady population increase have also hastened a fast increase of demand on the other. Thus, there is an urgent need to reformulate the policies for the forest sector in relation to the national economic objectives for the transitional period.

The overall objective of the model is to provide some informative insights on policy making in order to formulate better forest development policies for the nation. The objective can be broken down into the following:

1. To describe the current state of demand and supply of wood products in China. The emphasis is focused on the systematic relationship between different elements influencing the demand and supply of wood products, with some specific features of the CPE system.

2. To evaluate the impacts of a broad range of alternative forest polices on their trends, if the exogenous factors, such as prices, investment, international trade, management and trade system, change over time.

3. To formulate a set of indicative scenarios, i.e, a set of conditional predictions which are based on several possible policy alternatives. The model's solutions are expected to provide consistent long-range projections of the trends of production and consumption of forest products, based on the associated states of the forest resource base.

As a demand and supply analysis project, this study does not intend to produce historical chronicles as an end in themselves, but to investigate the relevant facts to the extent that they are important and indispensable for assessing future development of supply and demand. It means that:

1. Forest policy can not be formulated solely on the basis of timber market considerations (endogenous factors). The results of a timber market analysis are only one of many possible factors affecting the laying down of forest policy, although often the most important factor.

2. Such an analysis should not only consist of investigation of a territorial cross-section of the timber market, but also should pay attention to changes in the timber market in the course of time. There is no sense in current market research unless it gives an indication of future market trends. In addition, because of a long production cycle, the aims of forest policy can be achieved, and the effects of these policies can be seen as a rule, only over relatively long periods. Therefore, a considerable time span has to be chosen for the purposes of the analysis, even though it is obviously true that the longer the period covered by prediction, the more difficult is the formulation of the conditions, under which the prediction is valid.

3. With a broad range of applications, the timber products are used not only in the nature of final demands in private households (e.g. furniture, fuelwood), mines (pit props), railway engineering (sleeping ties), postal services (poles), but also in the productive sector (derived demands), for instance, in the building trade, and in the cellulose and paper industry. It is a prerequisite for timber market analysis that all these markets be included in the survey, and their development is by no means uniform. Thus, the problems involved are immense, consisting of classification schemes of the producers and various types of products, their number, type, ownership, size, condition class, their regional distribution, the special features of their organization, the standard of living etc. If the classification is too fine, the system may become unwieldy, but if too coarse, the system may be insensitive.

4. The wood market analysis depends upon the movements of both the demand and supply of timber product with their price fluctuations. These movements are not only influenced by many other variables (including endogenous and exogenous factors), but also influence each other simultaneously, i.e., the dynamic movement of forest resource and product substitutional relationships is a critically important feature of analysis of the demand for and the supply of wood products.

5. Many studies in the field, which address the problem of demand and supply of wood products, have been done during the last two decades. Among them, most are based overwhelmingly on the market economics theory. Some studies, like Forest Sector Project (FSP), do include a planned economy sector in the model (Fedorov, *et al.*, 1987), but the feature of the analysis may be summarized as the following characteristics: the forestry system in those studies is generated or specified exogenously from long-term state plans or scenarios; and it is developed independently from the world economic system. For the situation in China, consumption is specified by a demand function, in which the demand for wood products is based only on the relation between consumption and price (Kallio, 1987), and production is handled as a target level. Referring to the analysis made in Chapter 4, this oversimplified approach obviously is not suitable for modelling China's situation.

6.2 Important Elements and Basic Assumptions

Assumption plays a crucial role in economic modelling. A general belief about assumptions in economic studies is: the fewer, the better (Price, 1987). The assumptions in the SD-FRED fall into two types:

(1) about the future path of the numerous variables that are in the model, but not determined by it (examples of such exogenous variables being population and GNP growth in this model),

(2) about numerous causal linkages governing the variables that are determined by the model.

It is recognized that accurate predictions about long-run population, price fluctuation, economic growth, or any of the other determinants of demand for or supply of timber products are unattainable. Nevertheless, some assumptions are made in the model based on historical trends, current knowledge about developments which will affect these trends, and present expectations (or probabilities) about future changes which can be generally accepted as reasonable at present.

6.2.1 Population and Wood Consumption

Among many factors, the growth of population may be the most influential factor causing change in demand for forest-based outputs for the foreseeable future. It influences the per capita income, as well as the size of labour force -- a major determinant of the level of economic activity and related materials consumption.

For countries like China, even if per capita consumption remains at the current level, the total consumption will increase steadily and markedly on account of an increase in population. The evidence from some poor countries/regions (Westoby, 1987) shows that, for some goods (e.g. sawnwood and wood-based panel products), demand does increase with income, and, at low levels of income, increases at a rate equal to or greater than the rate of increase in income. Furthermore, a rise in population not only increases the consumption of wood, but also may reduce the forest area because more land will have to be converted into agricultural and settlement usage.

Transition of population from rural to urban and from agriculture to the village and township industries accounts for a significant part of wood products especially for the out-planned consumption, such as fuelwood. For instance, since 1984, millions of surplus agricultural labourers poured into cities from farm land: for a period this slowed down the fuelwood consumption in rural areas on the one hand, while speeding up the substitution of wood by coal in urban areas on the other. In 1987, however, the return of agricultural labourers to rural areas, as the result of retrenchment of urban industries, had the effect of increasing the firewood consumption again. This phenomenon indicates that the rural/urban population ratio significantly affects the consumption and substitution pattern of wood products. This sort of fluctuation has also been taken into account in the modelling process.

The age structure of population is another important influence upon demand. A number of studies (Hou, 1985; Ma, 1987; etc.) show that demand for some wood products, such as furniture and housing, has a close relationship with the population of marriageable age rather than the total.

In addition, the geographical distribution of population has a strong influence on regional demand for some products made in whole or in part from wood and particularly those that must be produced and consumed at the same place. This is particularly true for both demand and supply of wood products in rural areas with very poor transportation conditions.

Although the Chinese government carries out a "one-family, one child" policy, the national census of 1990 shows that population in China has already reached 1.2 billion. According to the Ministry of Civil Affairs, the population of marrying and child-bearing age is predicted to reach a peak in 1991-1993 (see Fig. 6.1).

The change of population depends to a large extent upon the net increase rate. In GTM, annual net rate of population increase adopted for China is 1.2%, 1.1% and 1.0% for the periods 1980-1990, 1995-2000, 2005-2030, respectively (Kallio etc., 1987). Richardson (1987) projected population increases by using 1.5%, 0.8%, 0.0% for rural regions and by using 1.3%, 0.7%, and 0.0% for urban areas for the periods 1982-2000, 2001-2025, and 2026-2040, respectively.

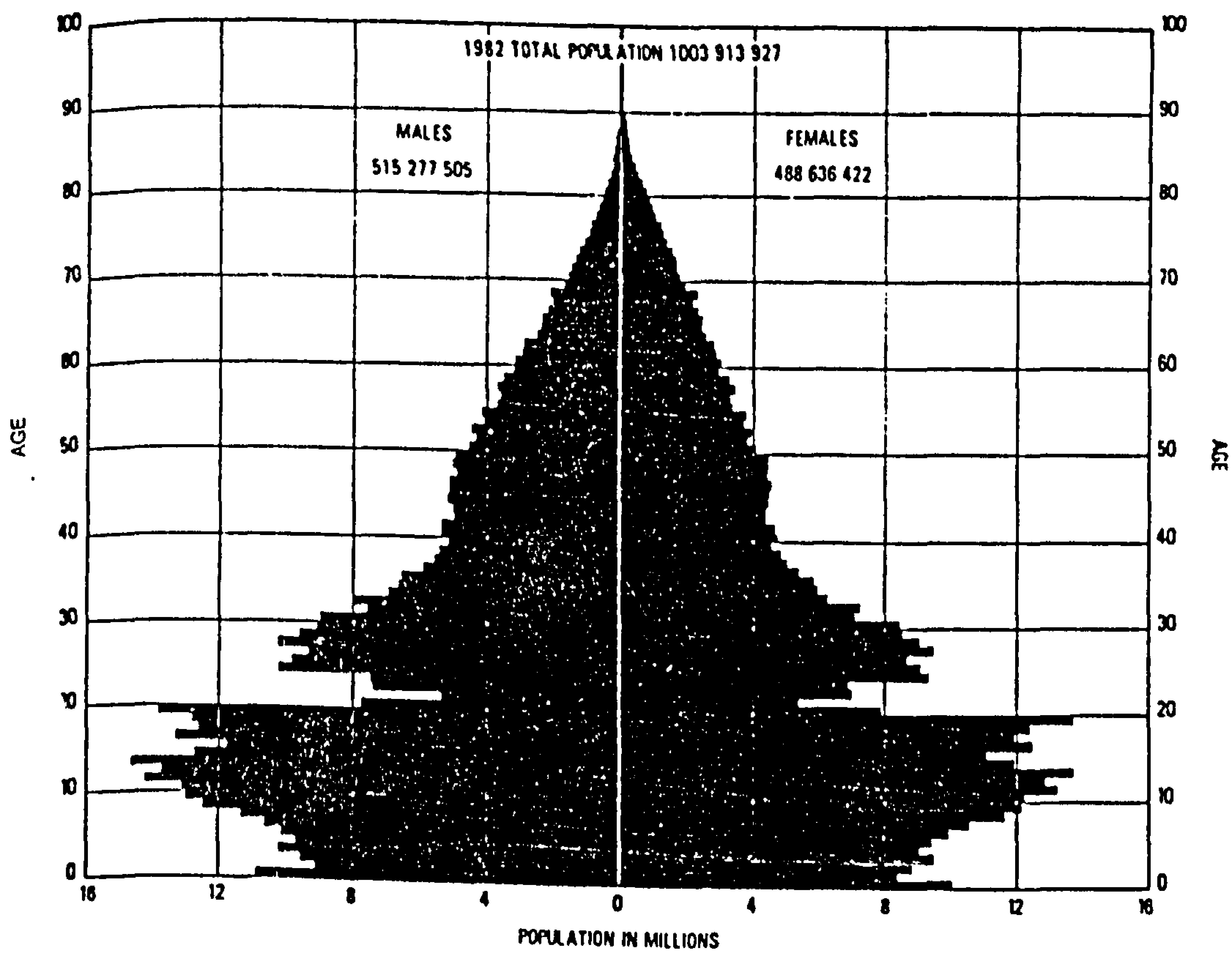


Fig. 6.1. Age Structure of the Population in 1982 (Population Pyramid)
Source: Jowett in Cannon and Jenkins (eds.), 1990. *The Geography of Contemporary China*, London.

Apart from a disparity between these two sets of figures, the net increase rate of population adopted in both GTM and Richardson's project might rely too much upon official expectation and might underestimate the inertia of population movement. In fact, the estimate of the net increase rate of population reflects not only the expectation of current policies and life expectancy, but also the age structure of populations which implies the lagged result of family control policy during the last period. The forecast of population, on which the prediction of demand for wood products is based, must reflect those dynamic natures. Therefore, the net increase rate of population in this study is not a declining linear trend, but fluctuates reflecting the dynamics of population structure. This includes the lower fertility rate during 'the Great Leap Forward' period, and the population boom during the Cultural Revolution period.

6.2.2 Gross National Product

Previous studies have shown that changes in consumption of most timber products have been closely associated with changes in the nation's gross national product (GNP). Madas (1974) claimed that, roughly, a US$ 100 increase in per capita GNP involved an increase of consumption by 0.1 m^3 per capita. He summed his findings as shown in Table 6.1:

Table 6.1 Per Capita Consumption of Industrial Wood as a Function of Per Capita GNP in The Importing and Exporting Countries

	Per capita GNP (US$ of 1960-1963 purchasing power)								
	200	400	600	800	1000	1200	1400	1600	1800
Per capita consump. (importer)	0.17	0.30	0.44	0.55	0.65	0.72	0.79	0.83	0.86
m^3 of WRME (exporter)	0.38	0.63	0.86	1.08	1.25	0.30	1.50	1.58	1.63

Source: Madas, 1974. *World Consumption of Wood* (p.39).

Statistical analysis of the Chinese situation also provides a close correlation between wood consumption and per capita income. It is, therefore, possible to use a time series model involving the GNP and timber consumption per capita to work out the behaviourial trend. This is, however, a valid procedure only if the economic structure which underlies the growing GNP changes during the prediction period in the same way as during the observation period. Many studies in this field have revealed that once a certain level of GNP has been reached, a further increase in GNP will no longer bring about a corresponding increase in consumption. Anderson and others (1987) stated that there was a marked difference between uses of forest sector products, which could not be explained by difference in standard of living or in relative prices. But this consideration does not trouble the present study very much, as the present GNP per capita in China is, and will still be by the end of the period covered by this study, far lower than 'a certain level' which those studies indicated.

GNP is an important and useful indicator of economic development, and a source from where the national investment comes. While GNP (or GVIAO: Gross Value of Industrial and Agricultural Output, an economic indicator, like GNP) has been applied for predicting the productive consumption in SD-FRED, the per capita personal income has also been employed as one of the determinant variables for simulating household consumption of wood products (such as furniture, housing, etc.). This is because, in a given society, personal income per capita may be an ideal indication of living standard, as it already excludes government's saving and population effects.

It is very difficult to do a world-wide comparative study of China's per capita income, simply because of the difference between the distorted nominal exchange rates and the actual purchasing power of its currency. However, a cautious analysis of China's past economic development would still be useful to help foresee its pattern of growth in the near future.

While some western economists doubted its target growth rate -- 5% per year for the next decade, China's past record is quite encouraging. From 1952 to 1982, despite relatively rapid population growth and a period of acute political disturbances (such as the Great Leap Forward, and the Cultural Revolution), per capita national income grew at an average annual rate of 4.0%, with phases of significantly faster growth. Of particular relevance is China's performance during the past few years of policy and system reforms: from 1978 to 1990, per capita national income grew at 6.3% per year.

- The growth of national income in the model depends mainly on the level and efficiency of investment. It also depends on the ratio of net output (that is, contribution to national income) to gross output in each sector, which in turn depends on efficiency in the use of materials, energy, and other intermediate inputs.

6.2.3 Price

Price is a critical element in the analysis of demand and supply. Determining the prices of wood products for the modelling projection in China's case is particularly problematical. This is not only because of the distorted price system (see 4.2.2) which is still playing a considerable role, but also because of the infancy of the market mechanism within a mixed economic system (see 2.4). While the relative prices of wood products, compared with the prices of competing materials, were and still are lower, the "real" prices of most wood products which remained constant from 1952 to 1972, and did not rise appreciably until 1979 have risen markedly over the last decade: two-three times for market prices, and two times for planned prices. As these price hikes occurred in the reform period and the economic system has been transferring from the planned to a mixed economy, it would be irrational to use statistics of this sort to calculate the price elasticities of both supply and demand for the Chinese situation, although prices have become increasingly important.

The complexity of wood product prices has also been aggravated by import prices, by considerably increased proportions of wood products available in the free market supplied by collective and private foresters, and by the biased reform which tried to avoid systematic adjustment of prices. Nevertheless, there is a clear tendency for import price and domestic market prices to influence planned prices, and for wood prices to increase dramatically.

The trends of further price change in China mainly depend on the direction of the reforms (both economic reform and institutional reform). The conflict between the short supply of wood products and the increasing demand for forest resources requires for, and puts pressure on, the reforms to establish a rational pricing system. The government has recognized that this must be accomplished by changing the price-setting system to allow market forces to play a greater role, not by administered changes in prices set by the state, which tend to lack the flexibility, complexity, and precision needed in a modern economy. In fact, as stated in chapters 2 and 4, the prices of many minor items, and of some transactions in more major items, have already been successfully decontrolled.

In this study, the influence of price on wood demand is taken into account in the following way: it is assumed that monetary (price, cost, etc.) variables appear as separate terms and are explicitly deflated by some all-commodity general price index leading to price variables of the form P_{it}/REP_i (where P_{it} is a price variable and REP_i is a reference price). It should be noted that in this case, the "deflated" prices are not directly comparable across countries, since the reference price is specific to the individual country.

$$D_{it}=D_{it-1}\left(\frac{P_{it}}{REP_{it}}\right)^{\alpha_i} \qquad (6.1)$$

$$\propto_i = 0 \text{ when } P_{it} < REP_{it}$$

$$\propto_i \neq 0 \text{ when } P_{it} > REP_{it}$$

where,

D_{it}:	the demand of wood product i by end-users in year t;
D_{it-1}:	the demand of wood product i by end-users in year t-1;
P_{it}:	the price of wood product i in year t;
REP_i:	the reference price of wood product i in year t;
$\propto_i$:	the price elasticity parameter for product i.

It is assumed that the reference price is a price level at which the domestic price reflects the world market, and the market mechanism is strong enough to influence the demand and supply. Below this level, the potential demand has not been met, and is decided by supply; when the ratio of wood product price to the reference price is greater than 1 ($P_{it}/REP_i > 1$) the price elasticity starts to affect the demand either because of the competition of the world market or because of the competition of different substitution materials. The estimate of the reference prices in the study depends upon import cost, insurance, and freight (CIF) prices, and also the negotiated domestic market prices during the last few years.

The question here is how far the price reform in China will go ahead and what sort of prices should be used to drive the dynamic simulation model forward. The following points should be considered for the modelling process:

Future price levels for wood products in China remain uncertain but are likely to depend largely, as they have done in the past, on the rate of economic growth of China, and are likely to be identified with the world market price; the higher the rate of growth and the rate of openness, the greater the demand for wood and the closer the real price in China to the world market price. The fact that a rising demand for wood products has to be met from the world market would eventually push up prices unless these trends were reversed by halting the reform or by slowing down the speed of economic development. Another trend, which is certain, is that the prices of wood products will be a determinative influence on investment in forestry in the future, since the stumpage price, from which the reinvestment in forestry is formed and the producer's revenues are gained, is the residual of market timber price after subtracting the transport fees and manufacture fees.

In sum, the trend of wood products price seems likely to be:

-- The price of wood products in China will keep an increasing tendency. The price differential among the three systems will be reduced.

-- The marketed proportion of wood products including those purchased at floating price and those purchased at market price will increase and the market will begin to respond more sensitively.

6.2.4 The Availability of Wood (WA)

In China's statistical classification, there is a difference between the total forest area and the quantity of forested land. The former is the land which is classified for forestry use, but may still be wasted; and the latter is the land which is the part of the former and has been forested. Obviously, the availability of wood depends not only upon the quantity of forested land, but also upon the total forest stock, and more precisely depends upon the quantity of the timber production forest and the accessibility of forest resource with the current technical and economic capabilities in the country. The availability of resource, therefore, is a more relevant factor than the total amount of resource, in determining wood supply.

The availability of resource also influences consumption. Gregory (1966) constructed his "Wood Availability Index (WAI)" as an indicator of resource availability; Madas (1974) applied Gregory's WAI formula in considering the importing/exporting factors, and concluded that: 'on comparable GNP levels, exporting countries consume about twice as much as the importers, but the ratio varies for different products. A rise in the forest area significantly affects wood consumption'.

Moreover, importation is another critical factor determining the availability of wood products. Madas compared Great Britain's situation with Zaire: with a per capita forest area 333 times less than that of Zaire, Great Britain consumed 26 times as much industrial wood. This corresponds to the fact that Great Britain had a large import of wood.

Availability is a concept related to timing (t). The availability of domestically produced round wood depends entirely upon the availability of forest resource in the country, hence, it relies on:

(1) total stock (S^T),

(2) technical possibility of harvesting (H^L),

(3) environmental protection requirement (E^L),

(4) the sustainable level of stock (S^S),

(5) the average mature rate of stock (M^T),

(6) the loss of stock from diseases and forest fire (DISE),

(7) economic considerations, etc.

It may be formed as the following:

$$WA_t(\%) = \frac{S^T_t\, M^T_t\, H^L_t - E^L_t - S^S_t - DISE_t}{S^T_t} \tag{6.2}$$

If all requirement remains unchangeable, then,

$$\begin{aligned} WA_{t+1}(\%) &= \frac{WA_t + INC^s_{t+1} - DEC^s_{t+1}}{S^T_{t+1}} \\ &\cdots \\ &\cdots \\ &\cdots \\ WA_{t+n}(\%) &= \frac{WA_{t+n-1} + INC^s_{t+n} - DEC^s_{t+n}}{S^T_{t+n}} \end{aligned} \tag{6.3}$$

where,

INC^s: increase in stock,

DEC^s: decrease in stock.

Of course, all variables themselves in RHS are the functions of time. The effects of these variables on availability vary from time to time and from place to place. For example, given a certain amount of resources, to raise the level of sustainable requirement of stock probably reduces the availability of resource for the current period, but will increase the availability for the long-term future. From one period WA is a level variable which shows the quantity of resource accessible during that period; but from the long term view point, WA is a rate variable which indicates a dynamic movement of resource.

It may be derived from the above argument that other significant factors influencing the availability of forest resource are the age-structures, the general quality of the forest in use, and annual growth, hence the intensity of management. A given stock with a higher proportion of the mature forests means a higher availability of resource nowadays; a certain stock with a higher proportion of the young stock probably means a potentially higher availability for the future. Only a sustained level of stock with a sustainable quality and with a reasonably high annual growth means a sustainable availability of resources.

Thus, for modelling China's demand and supply of wood products, the following points relevant to wood availability in the country must be taken into account:

1. the limited land classified for forestry use at 261.0 million ha, of which 110.1 million ha has been forested. (Richardson, 1987, Table 2, p.25).

2. the considerably low annual growth rates of growing stocks: (Gu *et al*, 1986) 9.897% for young forests, 4.066% for middle-aged forests, and 1.07% for mature/over-mature forests.

3. the geographical location which sets restraints on a considerable amount of resource being accessible due to either the environmental functions, or the high extraction and/or transportation costs.

4. the inappropriate proportions of the age class structure. It is reported (MOF, 1987) that the proportions of area and growing stock in young, middle-aged, and mature/over-mature classes are 1:1.04:0.82, and 1:3.84:6.56, respectively.

5. the poor transportation capacities which result in a huge waste of forest resources in forest areas, especially in the northeast and southwest forest districts.

6. the low success rate of plantations (including afforestation and reforestation) which was only about 25%--30% (Yong, 1985).

7. the sustainable level of stock. The principle of sustainable development should be applied in such a modelling process (like SD-FRED), but the theory is rather ambiguous as it has not yet been defined both practically and theoretically. Its ambiguity rests not only on the time horizon (as this generation must meet the needs of the present without compromising the ability of future generations to meet their own needs (the Brundtland

Report, 1987)), but also on the spatial concept which implies that the correct amount of wood should be harvested from the right locations. Instead of following the trail of a theoretical debate, such as what the sustainable level of forest stock in China should be at present, this study takes into account two practical points in the modelling process. They are:

(a) Chinese Forest Law (1987) states that annual growth must be greater than annual cutting;

(b) as soon as the mature stock drops to the level less than 1.7 billion m^3, there will be hardly any mature resource which can be harvested, due to the accessibility of the resource under the current technological level and the limits of the environmental protection requirement.

8. the limitation of land for forestry use. Land is ultimately the most fundamental factor for forestry development. Theoretically speaking, the maximum percentage of forested land will never be over 27.8% (this is derived from the ratio of land classified for forestry use to the total territory: 2.6749/9.6), if the current land use policy is not changed. Thus, the goal of 30% forest cover rate, proposed by some foresters and forest economists, cannot be realistic, even if all lands presently classified for forest use are forested.

6.2.5 Investment

Growth of forestry development depends mainly on the level and efficiency of investment. Investment is of vital importance in two main ways. First, it is important at the individual producers' level in relation to credit availability to refinance plantation activities and support producers themselves and their families. Second, investment must also be looked at in the national context where there is often a need for government-sponsored development or improvement schemes in the forestry sector.

The availability of government finance is important in the development of forestry in any kind of economic system, because of forestry's long production cycles and externality. This is particularly true in the case of developing countries where farmers are poor and unable to afford to invest in forestry, or they view forests as a barrier to development (Mcgaughey and Gregersen, 1988).

In China, the dominant finance source for forestry is directly from or tightly controlled by the national investment. There is no trajectory to follow for estimating forest investments from other industrial enterprises, joint-venture companies, or foreign investors, since those events happen randomly, although there is a growing trend of this kind of investment in recent years. But statistics are available for the aggregated forest investments from the state government, the local governments, and the private sectors, and these provide a basis for a basic-run of the model. The level of investment in the state-owned forest is determined by the share of forest investment in the total national productive investment which is allocated among all production sectors. The availability of the total national productive investment is decided by two factors: the national income saving rate and the amount of foreign borrowing. Both of those are treated as exogenous variables in this model, since they depend on government policy decisions.

The state forest investment in China was kept at only two million yuan annually from 1950-1980, well below necessary levels for proper maintenance practices. The agricultural population was expected to invest in forest privately, with virtually no financial support from the state. Lack of proper investment was, and still is, a major reason for excessive exploitation of accessible resources, and for the fact that few new areas were brought into production. In recent years, the availability of total financial resource to forestry in China has risen markedly from RMB¥851.75 million in 1978 to RMB¥1380.53 million in 1986, while the governmental investment has increased slowly with fluctuation in terms of absolute monetary measure (Table 6.2).

Table 6.2 Investment in Forestry 1978-1986

Unit: million RMB¥.

	1978	1979	1980	1981	1982	1983	1984	1985	1986
Total	815.75	1166.53	1385.73	1188.46	1196.44	1321.63	1321.63	1385.98	1380.53
Govern.	653.68	907.58	684.80	610.25	648.32	735.67	817.82	787.32	817.53

Source: Forestry Statistics 1949-1986.

Within the low national investment in forestry, around only 29-30% goes to forest silviculture (Table 6.3).

Table 6.3 Investment in Forestry

Unit: billion RMB¥; % = of national total.

	1983		1984	
	Amount	% of total	Amount	% of total
1. Forest (silviculture sector)	0.269 (29%)	0.5	0.308 (30%)	0.4
2. Forest industry of which	0.642 (71%)	1.1	0.705 (70%)	0.9
Felling & transport	0.493	0.8	0.505	0.7
Timber processing	0.106	0.2	0.136	0.2
Wood products	0.019	–	0.003	–
Daily production	0.007	–	0.002	–
Forest chemicals	0.017	–	0.58	–

Source: NFPA Report (1986).

The Ministry of Forestry planned an annual budget of RMB¥1.0 billion by 1990 to be increased annually by RMB¥100-700 million by the end of the century. Fifty percent of this budget would be allocated to the exploitation of new forest areas, the other half to build fast-growth, light-yield stands, and to harvest young and middle growth stands.

The investment level in the collective farms and the private-owned forests, however, is mainly decided by the silvicultural fee (a surrogate of stumpage prices), as well as personal income, and subsidies from governments. The silvicultural fee is the only source of reforestation funds, and must go back to forestry for regeneration, according to the Forest Law. One institutional factor is the clarification and stabilisation of the forest ownership, which implicitly, but determinatively influences private investment in forestry, as discussed previously in Chapter 4, section 4.3.2 and 4.3.3.

For estimating private investment in afforestation, a multiplier parameter (ψ) is used in the model. It can be shown as follows:

$$\varphi = \frac{C_{pt}}{Z_{gt}} - 1 \tag{6.4}$$

where,

C_{pt}: average planting cost per ha;

Z_{gt}: governmental subsidy per ha.

The parameter indicates a ratio of private producers' investment to the governmental subsidy in the private plantation sector and is estimated from statistical data, with a consideration of the plantation costs. Therefore, the forestry investment from private sources(I_{pt}) is calculated by the following:

$$\sum I_{pt} = \varphi_t Z_{gt} \sum a_{it} \tag{6.5}$$

where, a_{it}: annual planted area by individual investor (i).

6.2.6 Labour, Employment and Population

To increase the supply of forest resource requires not only more capital and more materials, but also more labour. Labour supply relates not only to the amount of population, but also to the age-structure, and the ratio of skilled/unskilled labour. As in most developing countries, in China the problem of labour is twofold. On the one hand, managerial and professional skills as well as skilled labour tend to be scarce, while unskilled or semi-skilled labour tends to be abundant; on the other, the family planning policy undoubtedly makes the age-structure unbalanced. Hence, there will be some possibility that labour shortage may occur in the future. It is, however, assumed in this study that the overall forestry development in China is not curtailed by the availability of labour. This is because:

(a) forestry requires relatively less skilled labour than most other sectors;

(b) much of the manual work in forestry is not tied to a strict time schedule, so that it is possible to use seasonal surplus labour from other sectors, or unemployed labour;

(c) it is always difficult, especially in forestry, to distinguish skilled labour from unskilled;

(d) the possible labour shortage caused by unbalanced age structure will not occur during the period covered by this study.

6.2.7 Technological Progress

The general progress of technology affects both consumption and production. On the production side, the progress of technology leads to increased productivity over all forestry sections, such as to expand the availability of resources to increase the success rate of plantation and the growth rate of trees, to improve the quality of resource, and to decrease the loss of forest resources through controlling diseases and improving management, reducing transportation and fire loss, etc. On the consumption side, the effects of technological progress are rather complex. On the one hand, the technological progress leads to substitution of wood by other materials. For instance, there is evidence that the consumption of wood for pit-props in mines and for railway sleepers and building poles has fallen considerably because of the increasing substitution for these purposes of steel, reinforced concrete and light metals. It leads to consuming less wood to achieve a given utility. For example, packaging material, wood-based panels, paper and paper board are being increasingly substituted for sawnwood which leads to a substantial saving of wood. It also leads to the new wood-based products becoming relatively less expensive than competing non-wood products. On the other hand, improved technologies may expand existing uses or create new uses for wood. The above examples imply that the cheap uses of wood-based products are likely to stimulate the total demand for wood products; and the extensive use of computers may lead to an increase of paper consumption.

Many economists have tried to estimate the effects of technical progress on resource use, but a quantitative measure of this is still problematic and challengeable. In this study, the effects of technological progress are treated differently in accordance with different products and different sectors. While planned substitute rates have been employed for some products (such as pit-props, railway sleepers), statistical parameters have also been applied in some sectors (such as paper and paper-based products, furniture, etc), and the simulated values are used in the analysis of the impacts of technological progress on the availability of resources.

6.2.8 Other Assumptions

In addition to the general assumptions outlined above, the projections of demands and supplies for wood products included in this study rest on a variety of other specified and implied assumptions. The most important are described in the appropriate places within the sections that follow. Such assumptions include management intensities, the continuation of past relationships between variables, constraints on the use and management of commercial timber land associated with multiple-use, and so on.

6.3 Data and Parameter Estimation

6.3.1 Data Sources and Collection

A major consideration in deciding the approach to modelling and computing is the availability and quality of data. The difficulties involved in information gathering and developing accurate statistical reporting in China has been recognized by researchers both inside China and abroad (NFPA, 1986; Richardson, 1986; Gu, 1987; etc.). The main difficulties in China's case are:

(1) There is a lack of consistent reporting procedures among and within ministries, bureaus, and factories.

(2) The methods of data collection and the definition of statistical concepts have been changed from year to year, as has the data base. Therefore, it has seemed pointless at the present time to develop or use time series data for the whole modelling.

(3) Statistics have often been altered to be politically correct, and to conform to the policy and plan. The policy targets have often been quoted as a statistical fact.

In spite of the difficulties listed above and the inappropriateness of using time series method, there are several independent data sources available. These include "The Market for Softwood Lumber and Plywood in P.R.C." (NFPA, 1986); "The Cotchell Report" (Richardson, 1987); "Forests and Forestry in China" (Richardson, 1990); "China: Long-term Development Issues and Options" (World Bank, 1985). Apart from those, there are two volumes of "China's Economy Looks Toward the Year 2000 (CELT 2000)" published by Chinese authorities, in 1986. It can be used as an independent source, since most of papers in CELT were commissioned from academic and professional Chinese researchers; and there is also a report entitled "The Present and Future States of Forest Resources in China" (Gu *et al*, 1987) in which valuable data have been gathered from different sources in various ways. Moreover, the presently modified and renewed versions of official statistics, such as 'A Statistical Survey of China' (by MOF, 1986), 'Statistical Year-book of China' (by State Statistical Bureau, 1987), and some reports released by New China News Agency are also becoming more realistic to the facts.

More importantly, some comprehensive interviews and specific data collection were carried out by the author early in the year of 1989. Some detailed or specific data required by this study were not available in general statistics and in the publications available in the U.K., therefore, specific sources had to be exploited in China. During a two-month visit to China, a great deal of information was obtained from the following sources:

(1) China Forestry Statistical Information: 1979-85, MOF;
(2) China Trade Report. Issue of November, 1985;
(3) Report of National Forest Resources Survey: 1977-81. Statistical Division, MOF;

(4) China Statistical Information of National Income and National Expenditure: 1950-83;
(5) Forestry Statistics Digest: 1949-81. Planning Division, MOF;
(6) China Technical Regulations for Forest Resources Survey. Forest Resources Division, MOF. 1985;
(7) Many discussion papers, articles, and bulletins closely relevant to the subjects of this study.

While those sources obviously are very valuable, no amount of reading and statistics takes the place of observation and questioning in China. Statistical data may be incorrect for a variety of seasons. Some data are wrong because of poor recording or for political reasons, some are simple errors perpetuated through uncritical reporting; and the data for some periods (such as the Great Leap Forward, the Cultural Revolution) are not reliable because they were made as supplementary after the events had happened, and based simply on guess work. In this case, there was a need for experience and commonsense in the interpretation, calibration and confirmation of those data, and interviewing Chinese professional and practioners became necessary and important. Interviews were conducted at both the national level and the provincial level. By this grass roots approach in the field, coupled with a great help from the author's friends and former classmates who were working either in Chinese government or in the academic institutes in China, fairly accurate and specific information, estimates and knowledge were obtained. The data used in this study comprise all of those sources, and are carefully chosen through comparing and/or compiling those sources.

In addition, data difficulties also relates to the type of the model chosen. As discussed in 5.4.4.2, the SD model provides a more flexible way to facilitate the use of quantitative data and qualitative information, and helps to alleviate modellers' data requirements.

6.3.2 Base Year Data and Parameter Estimation

Inevitably, most data sets in economic statistics contain various amounts of measurement error due to factors such as observer variability, interviewer bias and response hedging, and the amount of this error is never exactly known. Furthermore, the experts' assumptions are included more or less in almost all the sources listed above. In the case of obvious errors in these statistics, or inconsistency between different sources, the data are calibrated on the basis of logical inference or up-date publications.

The projections all start from 1980, the latest year for which a complete set of the necessary data could be compiled. The major source of the base year data is China's forestry statistical data and forest resources survey.

There are many parameters employed in the model. Some of them are estimated using traditional statistical methods, some are collected from the existing literature, some have to be guessed since there is no detailed information available. All parameters, however, have been calibrated in order to be consistent with existing trends over the past several years. For those reasons, numerical accuracy between the model output and the real world in the future is not expected. Instead, the study does expect the model output to be close to the real data for corresponding years in the near future, and demand similar trends between the two time series. That is, a simulation is successful if it can provide a fairly accurate picture of the relative consequence of the various policies tested, even if the absolute levels may be less certain.

The bases of parameter estimations are discussed in Chapter 7.3 (End-user Demand Sub-section) and Chapter 7.4 (Supply Sub-section). The values and variations of some estimated important parameters can be found in the corresponding sections of the coming chapters (i.e, Chapter 8 for individual policy simulations and Chapter 9 for scenario simulations). Table 6.4 in the next page shows the initial values of some selected level variables. These values as the start levels of SD-FRED provide a base for the modelling simulation, especially for the base-run.

It must be stressed at this stage that since SD-FRED is a simulating model, like most models of this type, it represents a sequence of the solutions of a dynamic model under a set of conditions in which the exogenous variables are taken as given and the endogenous variables are generated sequentially by the model (Labys, 1973). Solutions do not necessarily (and do not usually) incorporate intertemporally optimal strategies in the optimal control or dynamic programming manner (Day, 1973). If the model's assumptions are relatively close to the reality, the model would be able to explore some prevailing problems. Change of the assumptions will, of course, lead to the change of the consequences.

Table 6.4 The Intial Value of Some Seleced Importment Variable

Resource Supply Side		Product Demand Side	
Variable	Value	Variable	Value
1 Growing stock (mil. m^3)	9027.950	1 End-users' Demand (mil. m^3)	152.21
Young forest	791.750	Capital construction	29.94
Mid-aged forest	3039.700	Railway	1.51
Mature or over-mature	5196.490	Fuel & agriculture	63.60
Others	0.130	Mining	6.71
2 Growing Rates (%)		Paper & Paperboard	3.74
Young forest	9.897	Furniture	2.30
Mid-aged forest	4.066	Others	42.10
Mature or over-mature	1.070	2 Population	
Others	2.660	Population (mil.)	987.05
3 Forest Structure (%)		Birth rate (%)	1.82
(1) Area Structure		Death rate (%)	0.66
Young forest	34.980	3 National Saving Rate	28.00
Mid-aged forest	36.330	4 Share of investment in plantation to National Total Saving (%)	0.39
Mature or over-mature	28.690		
(1) Age Structure		5 Gross National Income (GNI)	
Young forest	8.770	Value (RMB bil.)	368.8
Mid-aged forest	33.670	Growth rate (%)	9.5
Mature or over-mature	57.560		
4 Forest Cover Rate (%)	11.895		
5 Plantation Servive Rate (%)	29.000		
6 Total Land (mil. km^2)	96027.000		
7 Total forest land	11422.412		

CHAPTER 7

THE STRUCTURE OF SD-FRED

The following issues are discussed in this chapter:

The model is a type of dynamic input-output model designed to analyze long-term patterns of growth and structural change of forestry in China. The model is large in scope and size because it attempts to contain as many behavioural elements of wood product demand and supply as possible, but technically speaking it is quite simple, as the model is based on the general behaviour relationships which can be obtained either from statistics or from observations. No attempt is made to show in this study that any specific event will happen exactly at a specific time in a particular place, but the aggregate model only tries to indicate the trend of the future as has been explained in Chapter 5. Therefore the model emphasizes the cumulative effects in the whole system, rather than the accuracy of a few influential variables.

7.1 Relationship Consideration

SD-FRED is made up of about 210 variables, some of which are lagged. They are related by 230 equations, some of these are non-linear and valid only within a specified range of values for the variables. The total model has 35 phases, and 3 development schemes are formulated based on the sensitivity analysis of 8 sets of selected policies. Within the model the variables are categorised into three types:

1. *policy variables* which represent the government intervention in the system;

2. *endogenous variables* which measure the effect of changes in policies. The values of these variables are derived in the simulation process; and

3. *exogenous variables* whose value is not determined within the model, but plays a role in the determination of the value of endogenous variables. These variables include world prices, the economic and population growth rates, etc.

Some simplified general relationships between major sectors in the model are shown in Fig. 7.1.

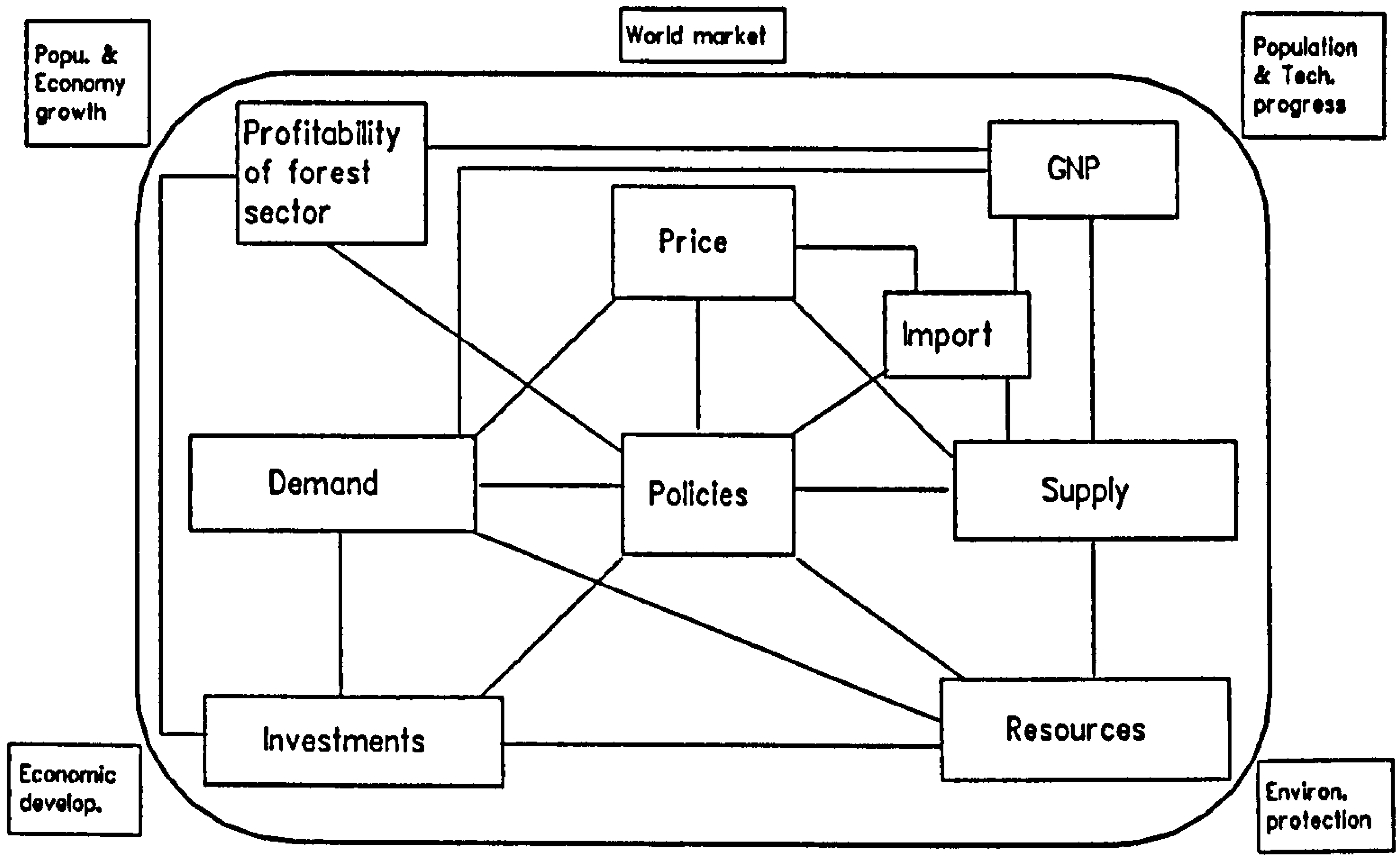


Fig. 7.1 A Simplified Relationship Chart of SD-FRED

The main relationships considered in the model are discussed in the following.

7.1.1 Demand

Demand includes intermediate demands and final demands for forest products from different sectors of the economy. Almost all studies in the field up-date grouped consumption into two types: planned and out-plan (including market and self-sufficient without any legal allowance) consumption. Because of the difficulties of quantifying the percentage of these two consumption groups, this study does not follow this classification. Instead, demands are estimated according to end-use groups, excepting the illegal cutting for agricultural domestic use, which is extremely difficult or even impossible to distinguish from fuelwood consumption and other agricultural use. Several planned wood substitution rates for different end-use groups have been adopted in the model. Since those rates generally illustrate planners' expectations, therefore, the estimates made by this study are certainly somewhat optimistic as past experience shows, but it is plausible from the viewpoint of this study, which believes that the efficiency of wood uses in China will, to some extent, be improved in line with the country's economic reform and technological progress.

7.1.2 Supply

Supply includes all imports and the domestic supply from all available sources including the commercial forest resource, fast-growing forests, and possibly available resources from other forests (such as environmental protection forest, four-sides plantations, and special-use forest). Since wood supply depends decisively on the forest resource available, the focus of the supply side in this model is on the dynamics of the resource, that is, the production possibility of wood products from a long term viewpoint.

7.1.3 Resource

This comprises all forest resources including young, middle-aged, mature, over-mature, fast-growing, and miscellaneous forests from all ownerships. This sector of the model aims to give a rather detailed picture about the forest resource in China in the next twenty years. The simulated results of the dynamic movement of forest resources will offer a basis for the analysis of the future supply of wood products and for the planning of multiple-use of forest resources in terms of sustainable forest development.

7.1.4 Market and Distribution Sector

The sector plays a role of linkage between the demand sector and the supply sector, either through the market channel or through the planned distribution system. The importance of this sector is that different channels affect the efficiency of allocation and distribution of resources via changing consumers' and producers' behaviour, via stimulating efficient use of resources. For both planned and market channels, obviously, the key factor within this sector is the levels of prices, since prices decisively influence the distribution of benefit, hence influence the incentive for investing in forestry as well as consumption patterns and substitution possibilities, as mentioned previously.

7.1.5 Investment and Profit Sector

For developing countries, capital investment may be the most important factor among other inputs such as land, labour, and technology. In terms of the sustainable production cycle of forest resources, this sector is critical, as it links forestry development with the policy of national macro-economic growth.

Investment is either treated as an exogenous variable of the system, or handled endogenously in the system, depending upon the types of investment. For example, given the ratio of the government's investment in forestry and the ratio of silvicultural fees, the government's investment and the producers' investment in replantation are modelled as an endogenous variable. But investment from other sectors, from foreign countries and from domestic private sources are treated as exogenous variables in the model. Investment links consumption and production: in fact, it links many policies as can be seen from Fig. 7.2.

Given the national macroeconomic policies, producers' net profit may be influenced by three main factors:

(1) quantity of products,

(2) costs,

(3) prices of the products, and

(4) tax or subsidies.

Producers' decisions among the alternative investment and land use are based upon their perceptions of the relative profitability of the available alternatives. In principle, profitability in this model is defined as the maximum average annual net return over the whole investment period discounted at bank interest rates. The causal mechanism for forest investment in this model, however, is quite different from the causes of investment in logging and wood processing. The former is more complicated

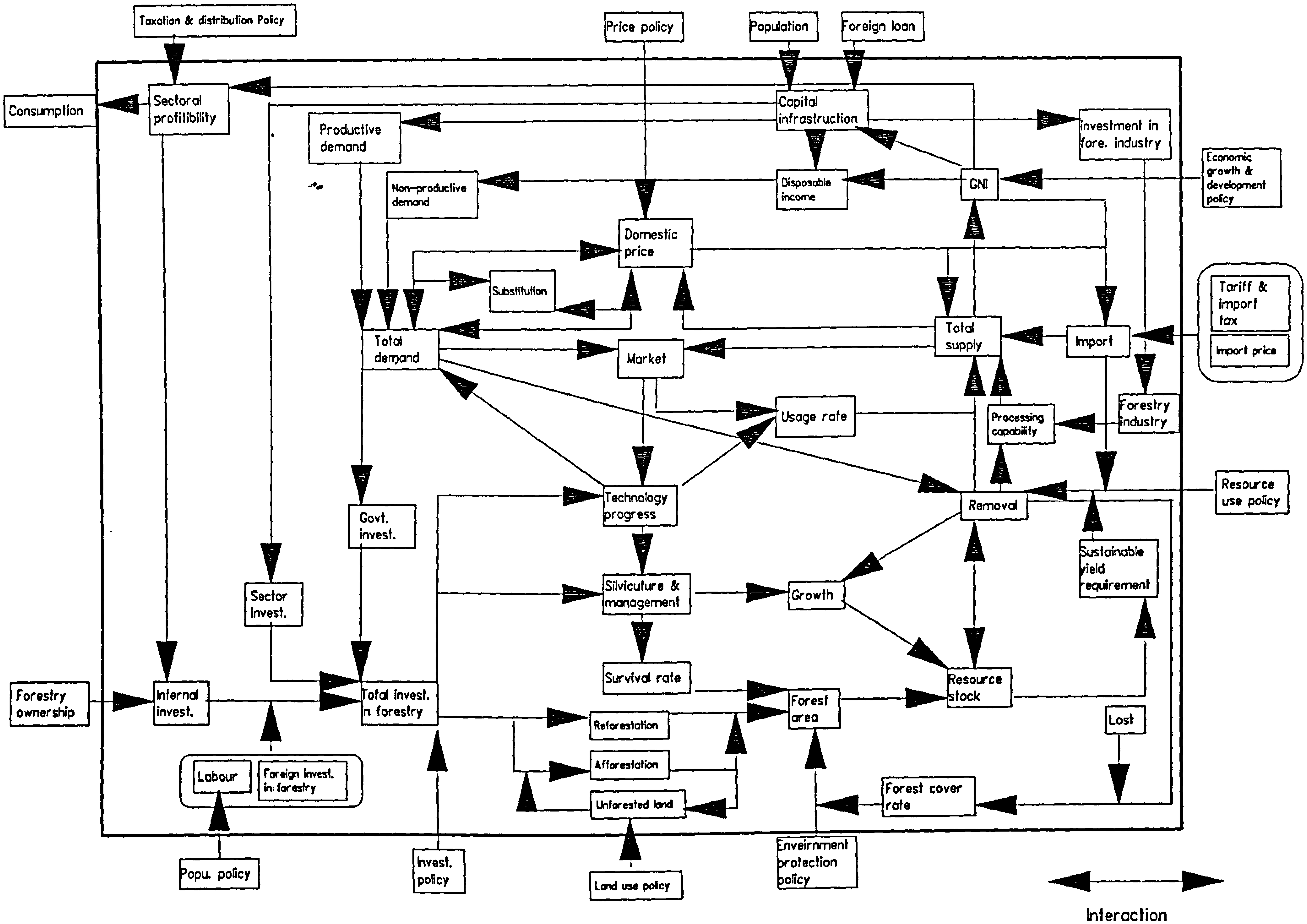


Fig. 7.2 SD–FRED Causal Structure

than latter. As discussed in Chapter 4, the government's policies in taxation, subsidies and the ownership of forest resources strongly influence the producers' determination of investment in forests in China, thus, these policies, together with the profit maximisation mechanism, play roles in forest investment.

7.1.6 Economic Growth

Growth of national income in the model depends mainly on the level and efficiency of investment, and it in turn determines the growth of per capita income. Since economic growth is determined outside the system, it is treated as an exogenous variable.

7.1.7 Labour Force and Population

Population influences wood consumption through the final demands (e.g. furniture, paper) and through the derived demand (e.g. building construction); it influences production through labour supply and land re-allocation. Obviously, the demand is determined by total population, but the supply is influenced mainly by the rural population. Also, the wood consumption pattern and the population growth rate of urban residents are significantly different from those of the rural population.

With regard to these differences, the simulation of agricultural population in the model is fulfilled separately from the simulation of urban population. Growth rates of both urban and rural population are treated as exogenous variables.

Besides the labour supply, the importance of further considering demographic influence is in its impact on the demand for wood products, on the availability of land for forestry use in future, and on the availability of capital for investment. The rate of population increase is an important ingredient of China's relatively favourable economic growth prospects. Given the existing population, clearly, the net increase rate is the determinant factor.

7.1.8 Policies

Policies are the key issues in the development of forestry. Policies in this model include forestry policy and other policies which influence forestry development or are influenced by forestry, such as policies in price, subsidy, investment, land-use, resource, substitution, import and technological progress. Forest policy is important because its major task is to settle the priorities and the proper balance between long term and short term objectives, between measures to satisfy local rural needs of wood for fuel and other domestic use on the one hand, and processed wood for industry and urban use and/or export on the other hand, and also between wood production and environmental conservation and protection. Due to the fact that forest policy influences almost all aspects of forest development, it infiltrates all the individual sectors in the model. However, in the flow-diagram (Fig. 7.1), policy appears as a separate section from the import, technological progress and price section: this separation is only for the convenience of illustration. The detailed relationships are shown in the next section -- total model structure.

7.2 Total Model Structure

To gain further insights about possible demand-supply-resources movement and determinants, considerations about structure and parameters of some relationships mentioned above have been formalized in quantitative equations forming a computer simulation model. It is worthwhile here to stress again that the ambition of this model is not to predict what will actually take place in the future, but to describe possible development paths in an internally consistent way. Although quantitative tools were used, the conclusions are qualitative.

7.2.1 Influence Feedback Loops

A simplified influence diagram for the model is demonstrated as in Fig. 7.3. The diagram provides detailed information about the relationships considered and the structure contained within the model, although it omits some detailed relationships (such as those with the forest industry, and forest recreation, which, in fact, are closely connected with forestry) and only comprises some simplification for the sake of clarity. For the purpose of this study, the analysis is mainly focused on demand for and supply of the forest resource, and on two of the closely relevant aspects: market (allocation) and resource stock. Therefore, the principal influence feedback loops are those in Fig. 7.3:

Fig. 7.3 Influence Feedback Loops

(1)	Demand $\xrightarrow{+}$ removal $\xrightarrow{-}$ resources $\xrightarrow{-}$ sustainable yield requirement $\xrightarrow{-}$ removal $\xrightarrow{+}$ supply $\xrightarrow{-}$ prices $\xrightarrow{-}$ demand;
(2)	Demand $\xrightarrow{+}$ removal $\xrightarrow{+}$ supply $\xrightarrow{+}$ GNI $\xrightarrow{+}$ profit $\xrightarrow{+}$ demand;
(3)	Demand $\xrightarrow{+}$ price $\xrightarrow{+}$ supply $\xrightarrow{-}$ price $\xrightarrow{+}$ demand;
(4)	Supply $\xrightarrow{+}$ GNI $\xrightarrow{+}$ profit $\xrightarrow{+}$ investment $\xrightarrow{+}$ forest area $\xrightarrow{+}$ resource $\xrightarrow{+}$ supply;
(5)	Supply $\xrightarrow{-}$ prices $\xrightarrow{+}$ import/removal $\xrightarrow{+}$ supply;
(6)	Supply $\xrightarrow{-}$ prices $\xrightarrow{-}$ demand $\xrightarrow{+}$ prices $\xrightarrow{+}$ supply;
(7)	Resource $\xrightarrow{+}$ removal $\xrightarrow{-}$ growth $\xrightarrow{+}$ resource;
(8)	Resource $\xrightarrow{+}$removal $\xrightarrow{+}$ profit $\xrightarrow{+}$ invest $\xrightarrow{+}$ resource;
(9)	Resource $\xrightarrow{+}$ removal $\xrightarrow{-}$ forest area $\xrightarrow{+}$ resource;
(10)	Domestic price $\xrightarrow{+}$ import $\xrightarrow{-}$ removal $\xrightarrow{-}$ resource $\xrightarrow{+}$ supply $\xrightarrow{-}$ domestic price;
(11)	Domestic price $\xrightarrow{+}$ supply $\xrightarrow{+}$ GNI $\xrightarrow{+}$ demand $\xrightarrow{+}$ domestic price;
(12)	Domesticprice $\xrightarrow{-}$demand $\xrightarrow{+}$shortage $\xrightarrow{+}$utilityrate $\xrightarrow{+}$supply $\xrightarrow{-}$domestic price.

These 12 influence loops (including 6 positive and 6 negative) represent the consequences or influences arising from the flows. A positive (+) sign on a link indicates that an increase in the variable at the tail of a link will cause the variable at the head of a link to change in the same direction, whereas a negative (-) sign indicates that an increase in the variable at the tail of a link will cause the variable at the head of a link to change in the opposite direction. If the number of negative signs within a loop is an odd number, the loop is defined as a negative loop; or vice versa. Fig. 7.3 can be interpreted in this way: If a variable at the tail of a link increases, what the effect (either positive or negative) on the variable at the head of the link will be depends upon the relation between those two variables. For example, loop (12) presents that an increase in domestic price will result a decrease of demand; given supply unchanged, an increase in demand will cause a shortage of supply; the shortage will stimulate an increase in the utility rates of wood; and so on. The coupling of positive and negative influence loops forms the system's behaviour and produces a time sequence of accumulated effects. In order to construct a tenable model, this process must be articulated in terms of quantitative interloop and intraloop relationships representing other variables of interest that exist within or related to the system studied.

7.2.2 Externality of the Model Structure

One critically important aspect shown by Fig. 7.2 is the so-called positive 'externality', a set of policies which are modelled exogenously, such as price policy, environment protection policy, investment policy, and so forth. Forest policy is derived from these macro-policies. All of them together play a determinative role in forestry development.

A major task of forestry policy is to settle the priorities and obtain the right balance between various objectives. A rational forest policy should function:

(1) to ensure the economic use of forest resource including forest land, and

(2) to provide and balance the demand and supply of forest products and services.

For modelling purposes, a set of policies can be grouped into target variables which constitute the objectives of society (or governments) such as forest cover rate, the net increase of total forest resources, and control variables which are instruments affected by the objectives, such as the price policy, the investment policy, etc. By varying the levels of control variables, the impact of policies on the target variables can be observed. In addition to specifying the economic relationship between variables, the model also attempts to incorporate technological, institutional and political relationships.

The relationships between the control variables, the target variables and the model structure applied are described in Fig. 7.4.

The control variables, which constitute a subset of the exogenous variables, are generated independently outside the model. The target variables, which normally

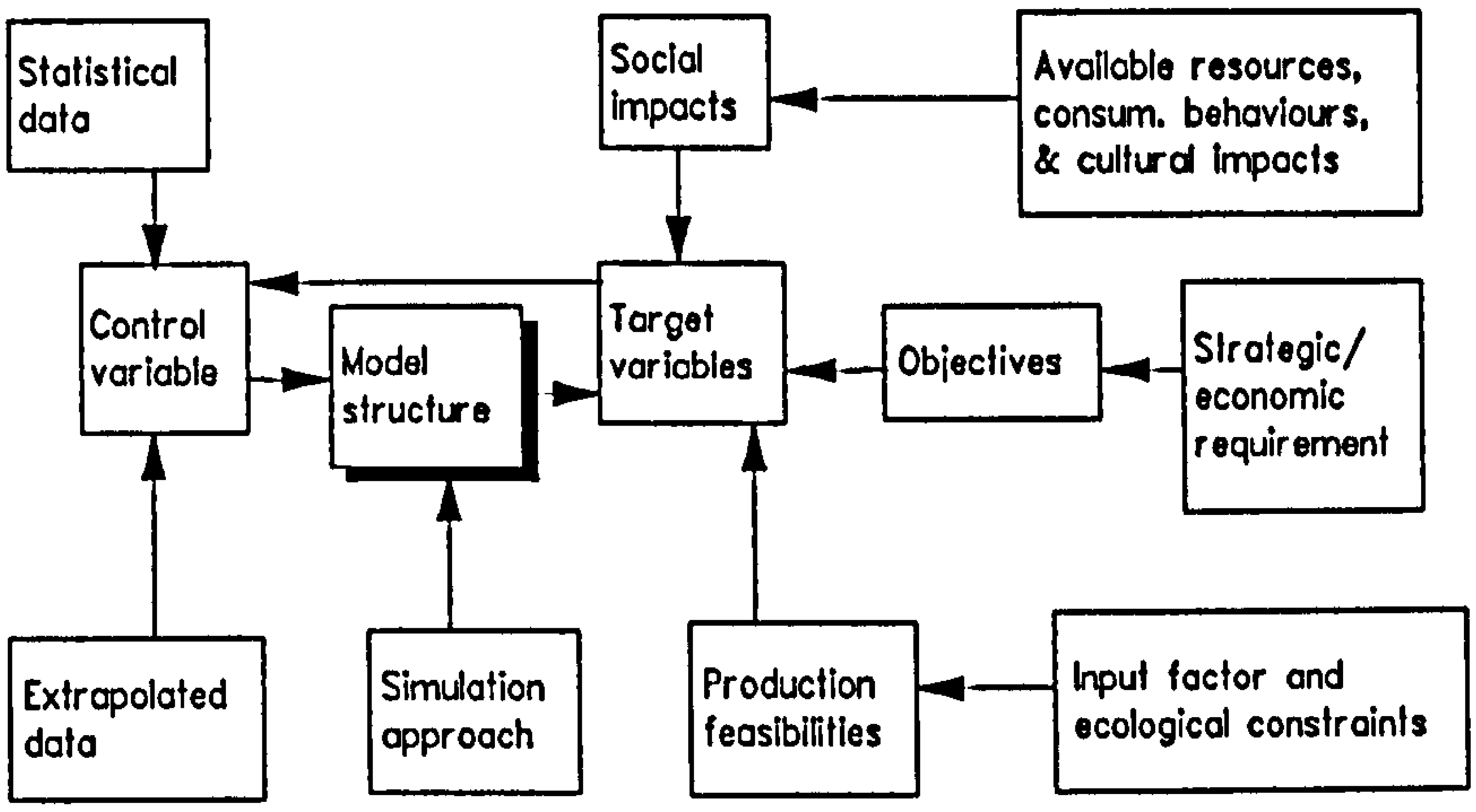


Fig. 7.4 Relationship Between Policy Variables and Model Structure

represent a set of the endogenous variables, are solved by the model itself, but affected by the control variables. Both sets of variables are linked by a specified and estimated model structure.

Since SD-FRED is a policy-oriented model, there are a number of places in which policy makers can enter the simulated system to perform experiments. Two primary classes of experiments may be conducted. One involves changing system parameters and technological coefficients which may be different from the current

policies to see the effect on the model's performance. The other class includes changing control variables (some policies) which should play a role in future policy planning decisions.

Fig. 7.4 and the 12 influence loops displayed above indicate a general relation of supply, demand, resources, investment, price, economic growth and sector profitability. For the purpose of this study, it is necessary to carry out the analysis of demand for and supply of the resource in detail. This analysis will be implemented in the following two sections.

7.3 End-user Demand Subsection

Total demand of wood products is the sum of the demand from different sectors and end-use groups. Generally, demand can be divided into two groups: the productive demand and the non-productive demand.

As has been said previously, the demand for wood products is influenced by many factors, such as GNP, population, prices, the availability of wood, investment, and so on, but the effects of these factors on the demand are different in different sectors. Most of the productive demand is met through the planned distribution channel, and non-productive demands are satisfied via marketing and illegal cutting. While GNP, the availability of wood, and investment are the most determinative factors of the production demand, population, prices and personal income are more important for the determination of non-productive demands than the others. Therefore, demands for different wood products from different users are treated separately in this model.

This subsection highlights some specific features of individual end-users. Those features form an important base for the detailed modelling, especially for specifying the structure of those subsectors. Because of the complexity of the links between those subsectoral models and the total model, the equations for all sub-sectors are left in the computer programme of SD-FRED, interested readers can refer to Appendix II of this thesis.

7.3.1 Construction Demand for Wood

1. The distinctive features of construction demand for wood are listed as follows:

(1) Capital construction, which includes building construction as well as fixed assets, is the single largest expense item in China's national budget. It consumes about 20% of total planned domestic consumption, 40% of total wood consumption, and 45% of all imported wood consumption, in the early 1980s.

(2) The demand of capital construction can be divided into two major groups: urban demand and rural demand. The former comprises demands of common factory buildings, hospitals, theatres, stadiums, hotels, schools, urban residential housing, etc. These demands, generally, are met through the state planned distribution channel. The latter consists of rural housing and township enterprises housing. These demands are satisfied via the market, even via illegal cutting.

(3) The annual investment in capital construction has increased sharply during the last decade, according to statistics. It has risen from RMB¥ 55.9 billion in 1980, to RMB¥ 106.0 billion in 1985, to RMB¥ 120.0 billion in 1990, correspondingly (NFPA, 1986). The increase of the investment in capital construction has led to an increasing consumption of wood products, with the planned consumption being RMB¥ 20.8 million in 1990 (People's Daily Overseas Edition, 1, April 1991) and the outside plan consumption taking an ever bigger share. This trend seems to continue until year 2000 as the government's target is to increase the average per capita living space from 4 m^2 to 8 m^2 (Table 7.1) by then.

Table 7.1 Construction in the Planned Sector

(State urban industrial and residential projects only)

Year	1981	1982	1983	1984	1985
Investment in construction (RMB¥ billion)	44.3	55.6	59.4	74.3	106.0
Planned construction (m^3 million)	220	251	273	333	361
Wood consumption rate in construction (m^3/100 m^2)	4.966	4.514	4.596	4.482	3.401
Planned wood consumption in construction (m^3 million)	10.80	12.30	13.4	16.6	17.7

Source: NFPA Report (1986).

(4) According to the existing literature (Wang and Hou, 1984; Richardson, 1986; NFPA, 1985), the construction area in rural regions is roughly 1.7 times as much as that in urban areas.

(5) The average consumption of wood per unit construction area (m^2) now is the

amount 0.04 m^3 for urban, and 0.042 m^3 for rural areas. As the consumption is affected by living standard, it will slightly increase as personal income rises.

(6) Low income elasticity of demand for housing may reflect the severe constraints of the housing construction, the current housing-allocation system, and the high urban housing subsidies to residents (not to constructors). It may severely under-estimate the real demand for housing in the country. The precedents set by rural developments, and the heavy burden of housing subsidies from governments, have already forced a housing system reform. The reform started in a few cities in 1986, but from 1991, it has spread throughout most cities in the country. The basic idea of this reform is to increase rent and reduce subsidies sharply, hence, to encourage the housing privatisation and construction of more residential houses.

(7) Use of wood as building materials is limited not only by the short supply, but also by its high expense (compared with some substitute materials, such as bricks, stone, concrete), by the substitution policies (which discourage extensive use of wood), and by traditional preference (as brick, stone and cement structures are perceived to be longer lasting).

(8) Residential housing construction is also influenced by land use policies. The extension of constructional use of land is tightly controlled by the government's policy and the land law.

(9) The increase of wood price is another important factor which influences the wood demand in construction, especially in residential housing construction.

2. The causal diagram of construction demand sector is given in Fig. 7.5

Based on a causal diagram, a flow diagram can be developed. A flow diagram shows the relationships among variables in a system. it is more specific than a causal diagram, and indicates the types of variables as well as the interconnection. The

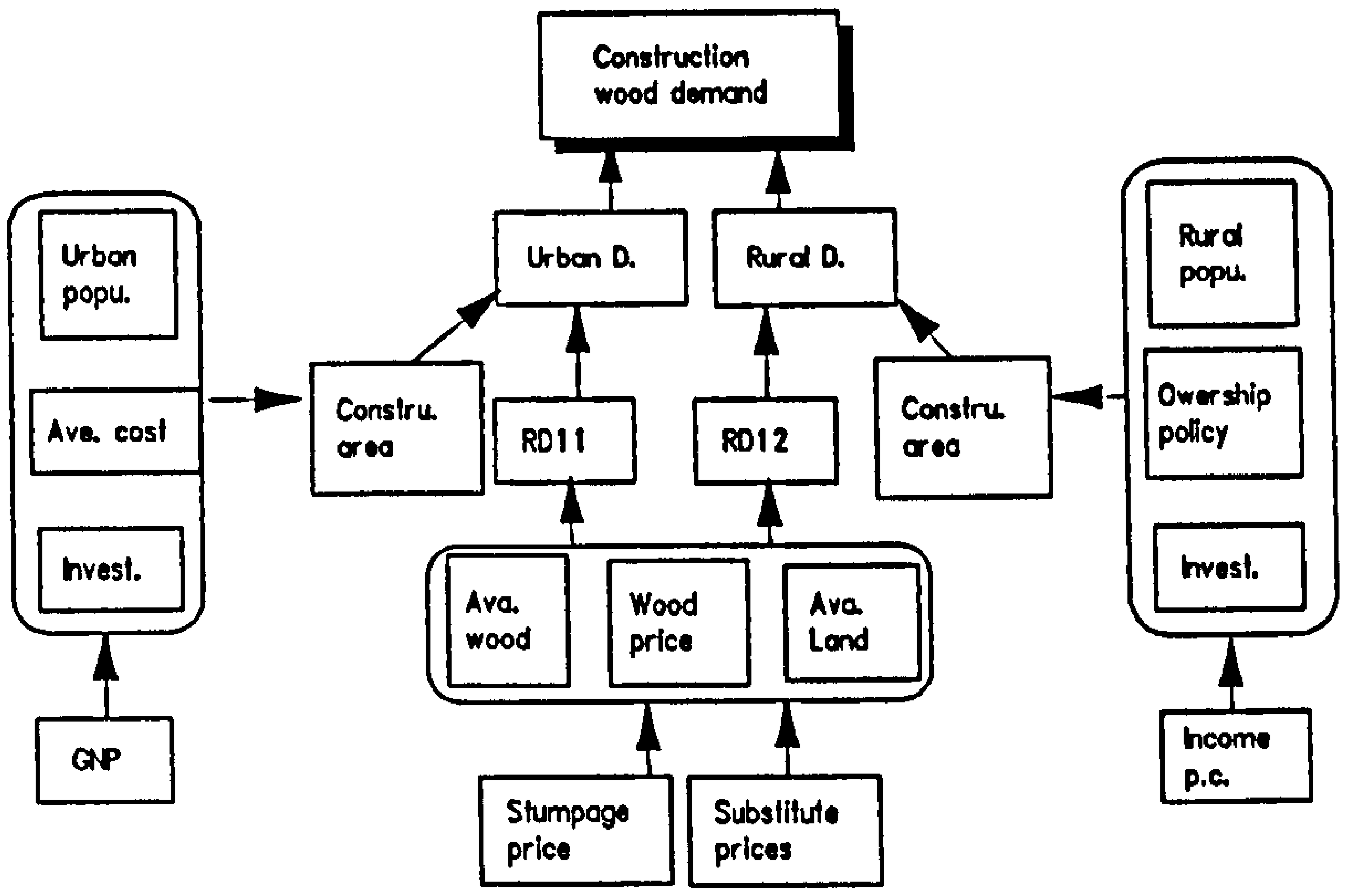


Fig. 7.5 The Causal Diagram of Construction Wood Demand

corresponding flow diagram of Fig. 7.5 is presented in the following and serves as an example (Fig. 7.5A).

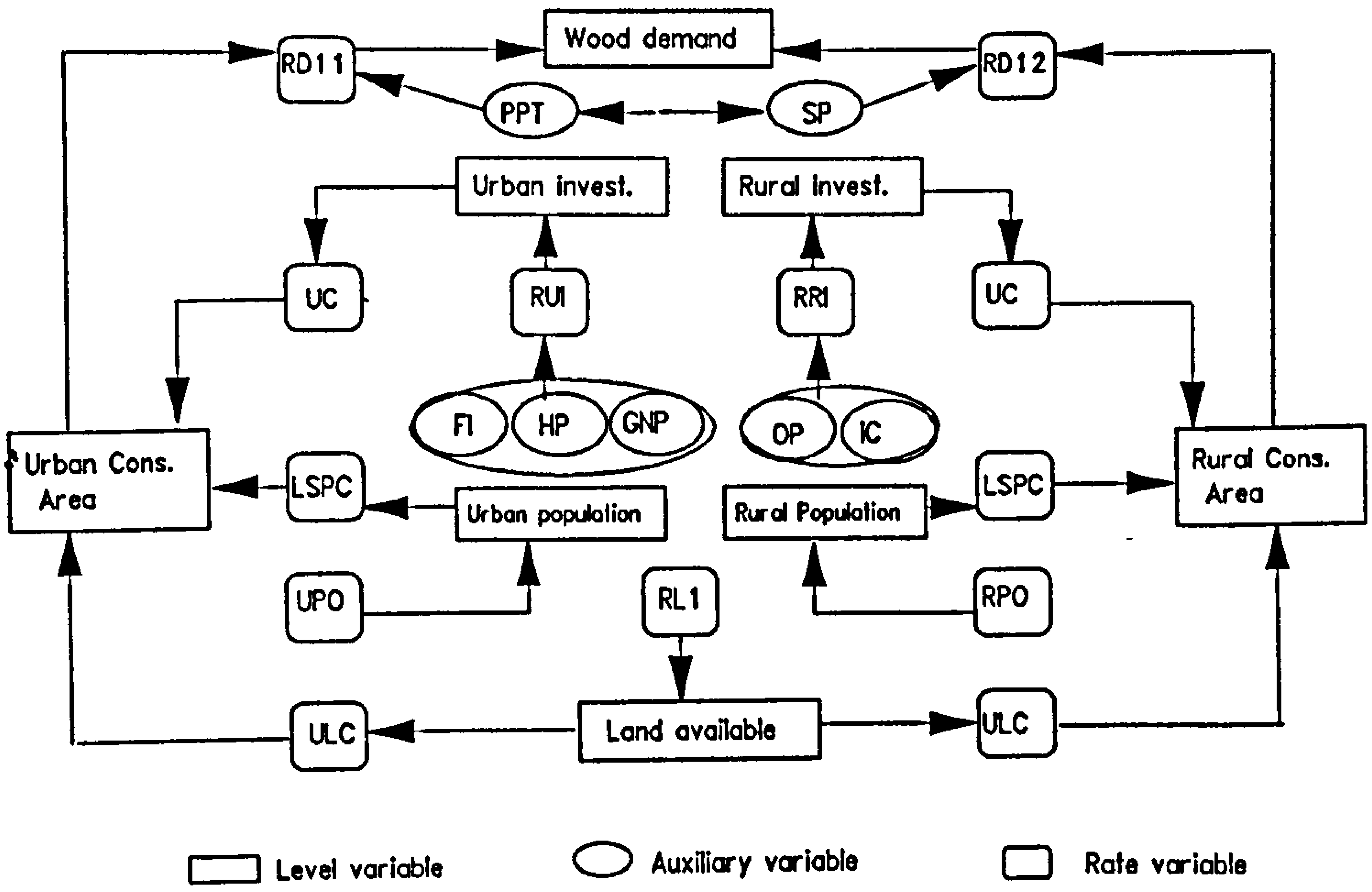


Fig. 7.5A The Flow Diagram of Construction Wood Demand

List of variables:

RD11:	Change of wood demand in urban (%)	RD12:	Change of wood demand in rural (%)
PPT:	Wood Prices (RMB¥)	SP:	Price level of substitutes (RMB¥)
RRI:	Rural investment rate (%)	RUI:	Urban investment rate (%)
FI:	Foreign investment in construction (RMB¥)	HP:	Housing policy in urban (index)
OP:	Ownership policy (index)	IC:	Per capita income in rural (RMB¥)
UPO:	Urban population (million)	RPO:	Rural population (million)
UC:	Cost per unit space (RMB¥/m^3)	LSPC:	Living space per capita (m^3)
ULC:	Land consumption per unit space (m^3)	RL1:	Change of land availability (ha)

3. For the sub-model of construction demand sector, see appendix II, demand section 1 -- Demand for Constructional Wood.

7.3.2 Railway Demand for Wood.

1. The distinctive features of railway demand for wood are listed as follows:

(1) The railway demand must be met with a priority, as railways have long been recognised as a weak point in the economy.

(2) Most of this demand may be expected to grow more or less in accord with the investment in transportation infrastructure which comes from two sources: one is domestic investment, another the foreign loans. The ratio of reinvestment in railway transport to total railway revenue, according to the statistics during the last 30 year, is 0.0008. The reinvestment is used for increasing the existing capacity by replacement of steam locomotives, and by diesel and electric power, combined with some double-tracking.

In addition, the NFPA report (1986) points out that in southern China, US$577.5 million would be invested to increase railway capacity from 1985 to 1995, including $160 million World Bank loan, and a credit of about $70 million from the International Development Association. China would provide $374.5 million.

(3) Wood consumed by the railway ministry can be generally broken down into two parts: railway sleepers, and building materials (including the uses for bridge

construction, rail cars, and the railway ministry construction projects).

(4) Government policy is strongly against using wood for sleepers and bridges, but encourages using pre-stressed concrete sleepers to substitute for wood. In spite of the policy, the rapid expansion of the railway system which began during the sixth Five-Year Plan (FYP) and which will continue in the next FYP has required a consistent amount of wood for development. Wood sleepers are used for stations, junctions areas where there is switch gear, and for routes with special requirements, and bridge construction still consumes a considerable amount of lumber.

(5) It is believed that the substitution of wood sleepers by pre-stressed concrete sleepers was not economical in the long run because the latter do not have enough spring and require more repair and replacement, and also because the cost of the former is cheaper. Therefore, substitution will not be developed quickly until the relative prices of wood increase to a rational level, and/or until the technical limitation of the concrete sleepers has been reduced by new technologies.

(6) The consumption of wood in the manufacture of passenger and freight rolling stock (floors and walls), bridges and other construction was 0.4 million m^3 per year at minimum in the early 1980s. The production figures for the manufacture of rolling stock is as follows (Table 7.2):

Table 7.2 Manufacture of Railway Rolling Stock

Year	Passenger cars	Freight cars	Locomotives
1980	1230	15785	589
1983	1200	19108	658

Source: Ministry of Railway, PRC .

However, in March of 1991, the State Statistics Bureau (SSB) announced that freight volume had reached 2632 billion ton.km annually from 1202 billion ton.km in 1980, which is up 120%, and increasing at an annual average rate of 143 million tons.km, and that passenger volume had increased to 561.2 billion head.km from 228.1 billion head.km in 1980. Meanwhile, the proportion of railway transport to the total transportation volumes had also gone up from 40.2% in 1980 to 47.5% in 1990. This actual development exceeded the expectations of many studies (NFPA, 1986; Hou, 1983; etc.).

2. The causal diagram for railway demand sector is in Fig. 7.6.

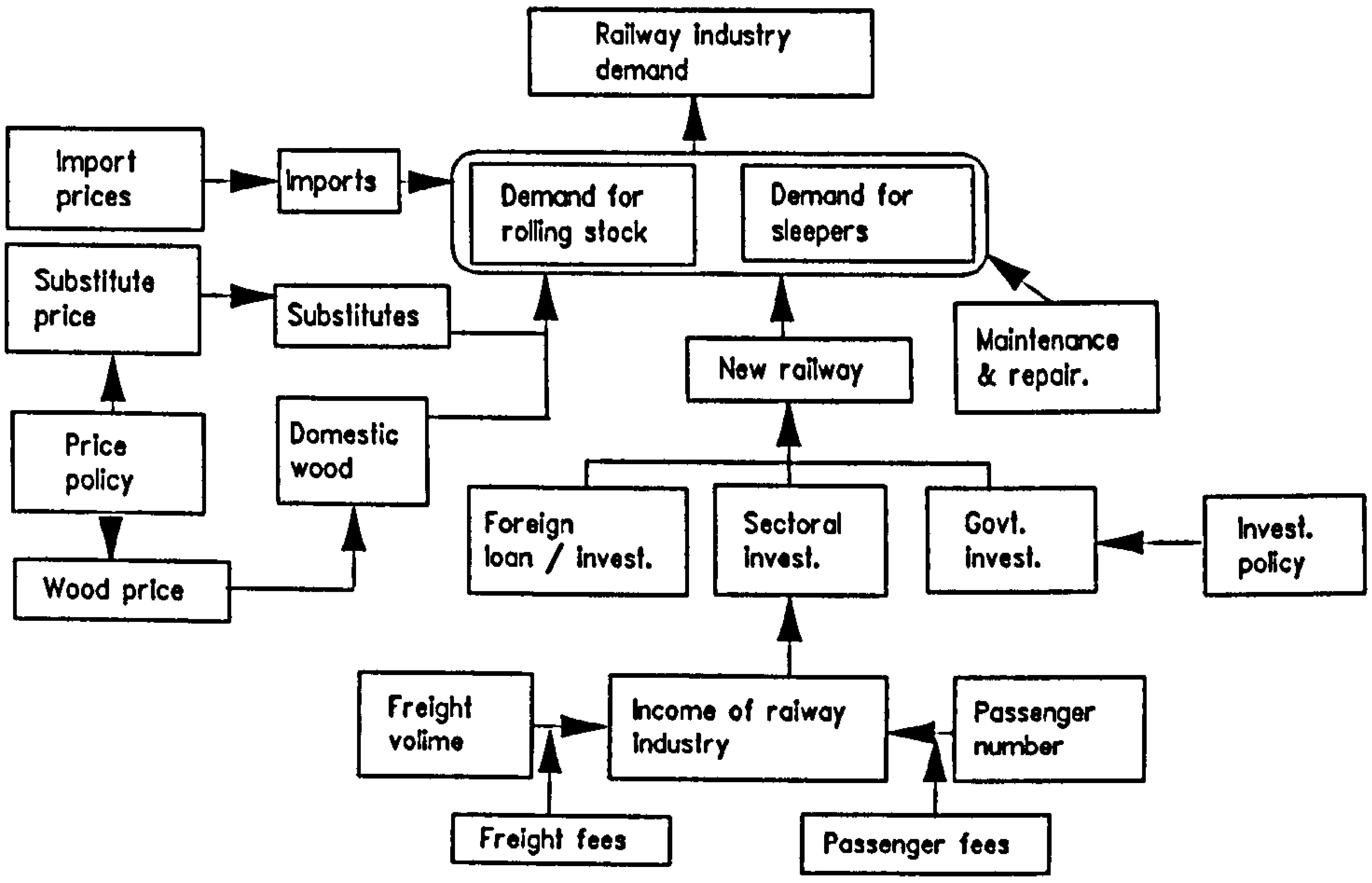


Fig. 7-6 The Causal Diagram of Wood Demand In Railway

3. For sub-model of railway demand see Appendix II, Demand Section 2.

7.3.3 Fuelwood, Agricultural Demand and Illegal Cutting (FAI)

1. An analysis of FAI

The consumption of fuelwood makes up a big proportion of the total consumption of forest resources, and plays a important role in providing rural household energy in most developing countries. The need for fuelwood may be the main reason behind illegal cutting of forests in China, since the fuelwood and agricultural demand was, and still is, excluded from the state plan, and it was not possible to purchase it from a market which did not exist.

Despite increased production of coal and oil, the demand for firewood throughout China is growing (Richardson, 1990), though the estimate of fuelwood consumption differs in different studies. Some selected results are shown in Table 7.3.

Table 7.3 Estimate of Fuelwood Consumption in China

Unit: m^3 million.

	FAO	USDA	Shiraishi	Zhong	NFPA
Fuel consumption	154	70-90	134	50	50
Estimate year	1984	1985	1983	1985	1986

Among the above figures, FAO's estimate is based on surveys of household consumption carried out in other countries; Shiraishi's data is based on statistics published in the Chinese official newspaper, People's Daily of 13 November 1982, which assumed per capita demand of 500 kg annually in rural areas; others lack evidence to support their estimates.

To model the fuelwood demand is difficult. As has been pointed out (Laarman and Wohlgenaut, 1984; Foley, 1986; Laarman, 1987), the difficulty is due to the following:

(1) much of fuelwood production and consumption is of non-market origin. It can be highly misleading if analyses based upon commercial fuelwood are applied to non-commercial consumption;

(2) most studies of fuelwood to date are small-area surveys and guesswork;

(3) inadequate data and limited knowledge of fuelwood study are available;

(4) neither organised markets, nor monetary prices exist for the bulk of household consumption.

Nevertheless, Laarman and Wohlgenaut (1984) specified and estimated an economic model for fuelwood consumption studies at the international level, with emphasis on fuelwood consumption in developing countries. They used real income and an index of commercial energy prices as demand shifters, and forest area as the supply shifters. Estimated coefficients in their model indicated that fuelwood consumption adjusted very slowly; increased income led to increased consumption in the low-income developing countries, but the income relationship was not significantly different from zero in the middle-income developing countries.

Smil (1980) studied China's energy consumption. His finding shows that economic growth and energy consumption in China are closely related: GNP-energy linear regression for the years 1949 - 1976 has a correlation coefficient 0.973 and explains 94.77 per cent of the variability.

The present study finds that:

(1) Fuelwood consumption in China is closely related to the agricultural population, the availability of resources, and fuelwood's own price.

(2) Fuelwood consumption varies in accordance with its own price but very little when changes occur in the price of other fuel materials.

(3) At the current relative prices of fuel-materials, the substitution of fuelwood depends partly on the availability of other fuel materials, such as coal and electricity; and partly on the patterns of forest landholding in agricultural areas. The evidence from China, in line with that from other developing countries, shows that those with their own farms are enthusiastic to save their forest resource by using harvesting residues or may be able to obtain most of their fuel requirements from live hedges, trimmings of fruit and shade trees, and other sources of burnable biomass from their farms. Beginning in 1979 and extending through the end of 1985 in China, 50 million households were involved in managing 30 million hectares of private hills which were

promised to and assigned to households for a few decades or even permanently, without requiring payment of a share of income back to the collective, and 40 million hectares of forest land was under the contract responsibility system (so-called responsibility hill). Regarding this fact, therefore, it is reasonable to assume that the shift of landholder pattern, from collective to private, will encourage agricultural households to save forest resources consumed as fuelwood by using other energy sources.

(4) In suburban areas and small cities, where the alternatives exist, the choice of fuels appears to be strongly related to the income level of the consumer. The hierarchy of cooking fuels ranges from straw to fuelwood to coal to kerosene to gas, in line with the average income per capita.

(5) In most rural areas, it is difficult to split resource consumption into fuelwood, agricultural use and illegal cutting. In this study, these three are simply aggregated as one consumption group.

2. The causal diagram of FAI is in Fig. 7.7.

3. The sub-model of FAI is provided in Appendix II, Demand Section 3.

7.3.4 Mining Demand for Wood

1. The Features of Mining Demand for Wood

Like the railway industry, the mining industry is a major user of timber, both for pit-props and for sawnwood. Its supply mainly comes from the allocation channel, as the most important mining enterprises are owned by the state. Because of its scale and relatively primitive technology, the coal industry is a particularly significant wood demander.

Demand for wood products in the mining industry depends largely upon its

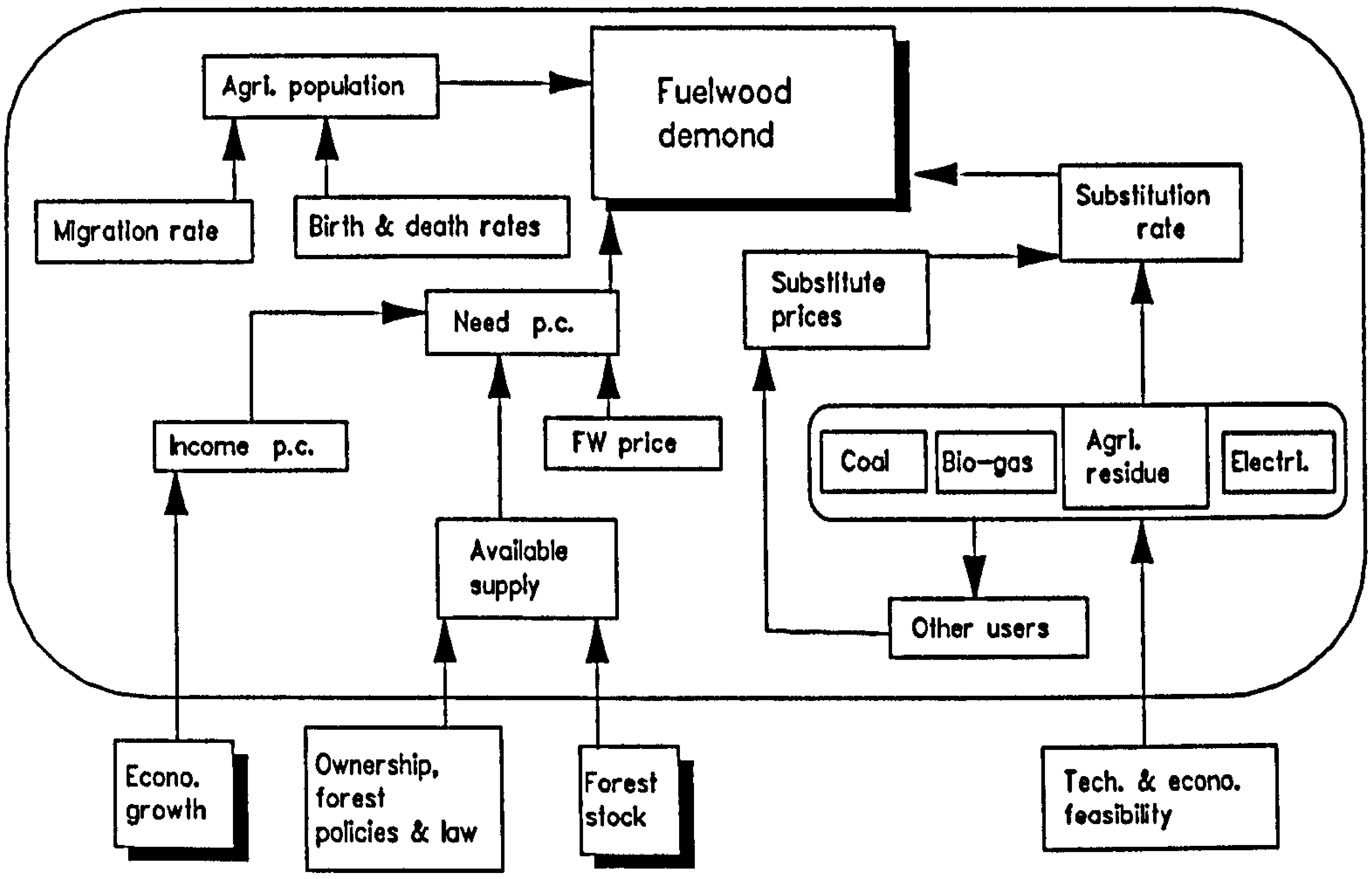


Fig. 7.7 The Causal Diagram of Fuel & Agri.-use Wood Demand

production target, the technically substitute possibilities and the substitute policy. The price influence plays a relatively small role.

Coal production has risen from some 30 million tons in 1950 to over 600 million tons in 1980, and to 1.08 billion in 1990 when the industry faced an investment and 'capacity to deliver' crisis. The production target for the year 2000 is 1.2 billion tons (raw coal), and is obviously a conservative estimate, if one considers the increasing trend of the production during the last 10 years.

The roundwood allocation to mining was about 7.5 - 8.5 million m^3 in the early 1980s (for producing about 900 million tons of coal). The unit consumption of wood was 8.37 m^3/1000 tons. The state government requires the mining industry to have a high priority for wood savings through preservation, and the target unit consumption is 6.0 - 7.0 m^3/1000 tons. However, Richardson (1987) pointed out that it is not impossible that the increased use of preservative-treated timber could extend rather than reduce the use of wood. This is based on the following consideration.

Apart from 6000 mines in the state sector, China has more than 120,000 collective mines. Most of the wood demand of those mines with small scale and primitive technology is met through the market. Because of technical and economical reasons, wooden props are preferred to steel by these locally owned (county or village) mines, which are expected to increase production at a higher rate than state mines (Keidel, 1986).

2. The causal diagram of mining demand sector is shown in Fig. 7.8.

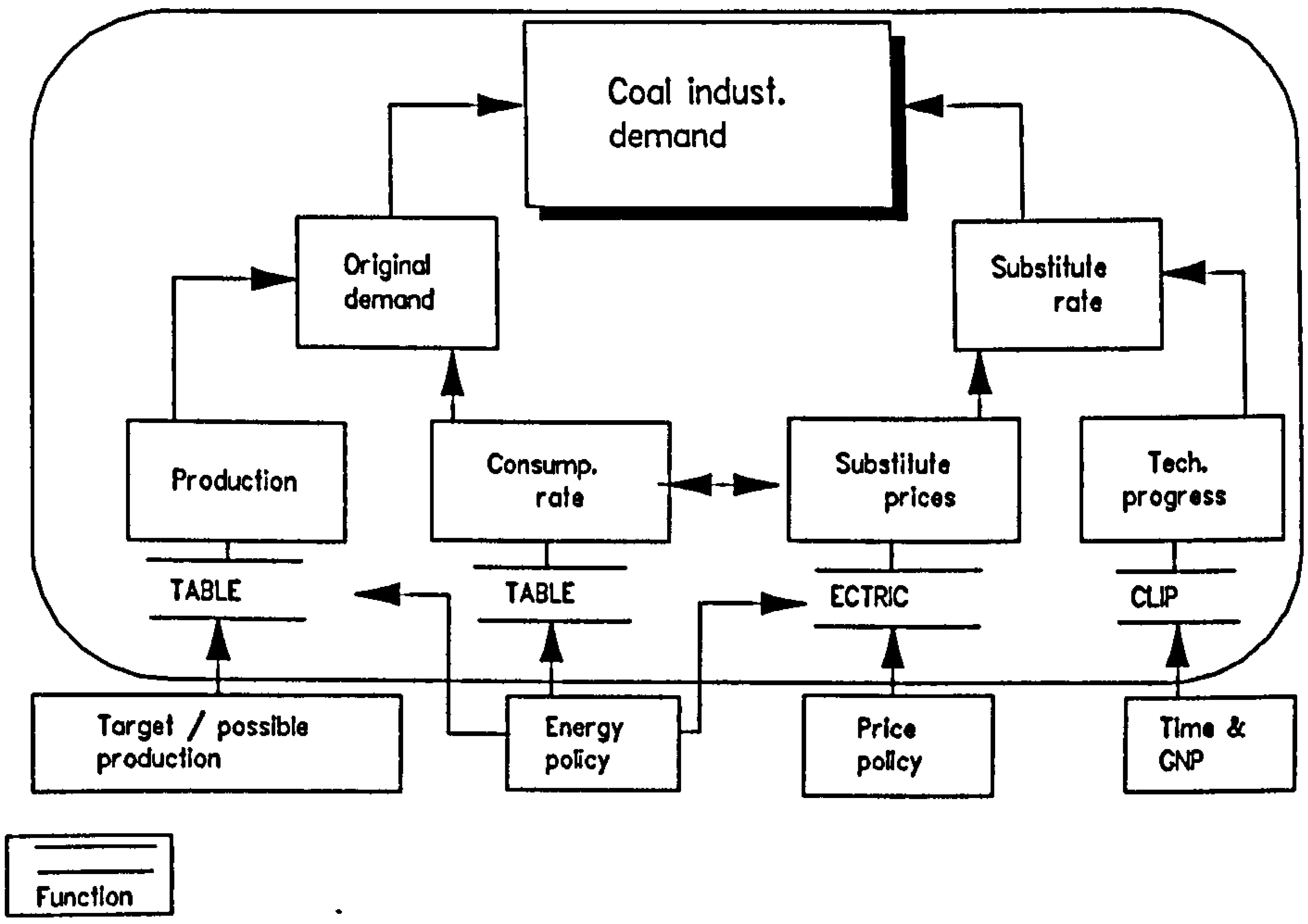


Fig. 7.8 The Causal Diagram of Mining Prop Demand

3. For the sub-model of mining demand sector see Appendix II, Demand Section 4.

7.3.5 Pulp and Paper

1. It is reported that in China wood accounts for 25% of the raw materials used in

paper manufacturing. The majority of pulp materials are non-wood fibres, such as bagasse and grain stalks. Because of the product quality and environmental problem, as well as the lack of other types of fertilizer required by farmers, there is an increasing trend of using those raw materials for agriculture, and the proportion of non-wood fibre materials in paper manufacturing has been and seems to be continually reduced.

In 1986, the domestic production of paper and paper products was 10 million tons (Lin Lin, 1986), but the domestic pulp production was only 16% of total pulp required, and consumed 3.74 million m^3 wood. An analysis of the Ministry of Light Industry, based on nearly 100 years of statistics about international development of the paper industry, found that, in nearly all cases, the paper industry developed simultaneously with the nation's economy, especially in countries with large populations and independent economic systems. Table 7.4 states some historical trends of the relationship between GNP increase and the paper industry development in some selected nations:

Table 7.4 Relationship Between GNP and Paper Industry

Country	Year	Increase rate of GNP	Increase rate of paper industry
U.S.A.	1947 - 73	1.72	1.72
USSR	1959 - 74	2.64	2.64
INDIA	1959 - 74	2.07	2.42
CHINA	1957 - 79	3.90	4.30

Source: Hou *et al.* (1985).

The FAO's study (1986) indicates that the paper industry world-wide will continue as a growing industry, and the growth is generally expected to be faster in developing countries than in developed countries. Consumption relates to the development of the world's economies and their infrastructure, the preference of consumers in the areas of communication and packaging, the effect of technological progress on the industry and its products, and the availability of basic raw materials. Based on China's current case, paper demand, in these studies, relates closely to price, and time. Compared with income elasticity, price elasticity is small, therefore the estimate of price change is not critical in projecting consumption. In general, income elasticity tends to decrease over time and with increasing GNP per capita. But when GNP per capita is greater than US$ 3000, the situation of estimating consumption will be more complex than the situation where GNP per capita is less than US$ 3000, there seems no correlation between per capita income and per capita consumption of paper and paper products above this level. The typical example is the comparison of the situation between U.S.A. and Scandinavian countries, it shows that the former has achieved lower GNP per capita, but higher per capita consumption than latter has.

This study finds that the situation of demand for paper and paperboard in China is more or less subject to the above conclusions, but the exception is that price can not be directly employed in the simulation models. Instead, the study treats price as a conditional variable in the model, as mentioned previously, and the elasticities of income and price also vary in line with development levels.

The influence of changes of technology, substitution, and consumption preferences is very complex and this has been represented by a relationship to time in this study.

2. For the causal diagram of pulp and paper sector, see Fig. 7.9.
3. The sub-model of pulp and paper sector can be found in Appendix II, Demand Section 5.

7.3.6 Demand of Furniture

1. The furniture industry has consistently been one of China's important consumers of wood. It is reported (NFPA, 1986) that the furniture output was 63.83 million pieces in 1982, 84 million pieces in 1984, 126 million pieces in 1985 (which was only 80% of total furniture output, another 20% was self-produced furniture), and 183 million pieces in 1986 (Hou, 1985) of which wooden furniture accounted for 61.8% and wood consumption per piece is 0.04 m^3.

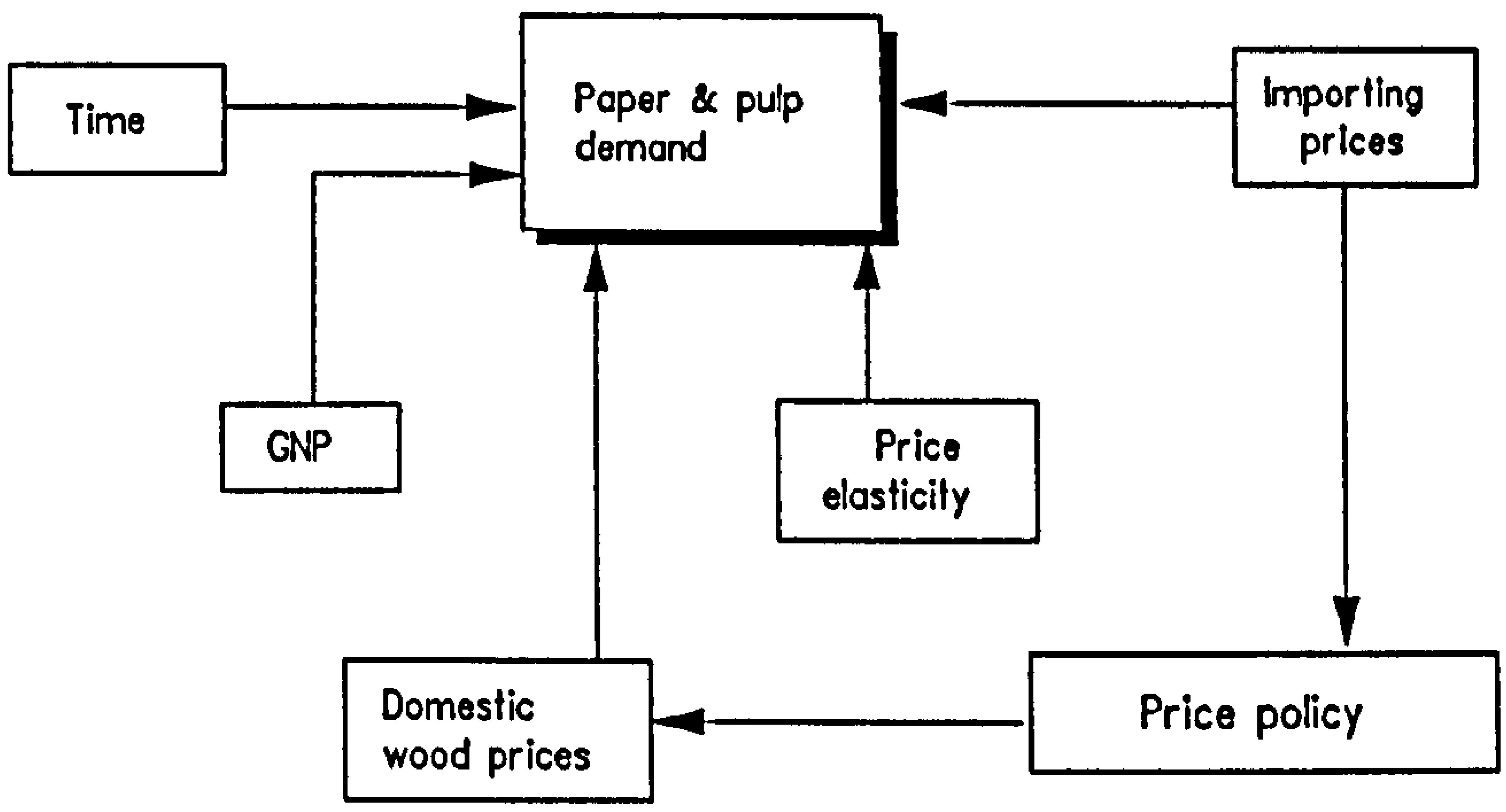


Fig. 7.9 The Flow Diagram of Paper and Pulp Demand Sector

The furniture demand can be divided into two groups: one is public demand (including products demanded by schools, universities, theatres, hotels, institutes, companies, governmental offices, etc.) which is about 30% of total furniture consumption. The other group is private demand, about 70% of total, which can be further divided into household demand and newly married couple demand.

This study finds that the public demand and private demand for furniture must be treated separately. While the former is correlated with non-productive investment and furniture price, the latter depends mainly upon the availability of personal consumption income, furniture price, the population, and the number of newly married young couples, which entirely depends on the dynamic movement of the age structure of population.

2. The model's structure for furniture sector is shown in the following causal diagram (Fig. 7.10).

3. The sub-model of furniture sector can be found in Demand Section 6 of Appendix II.

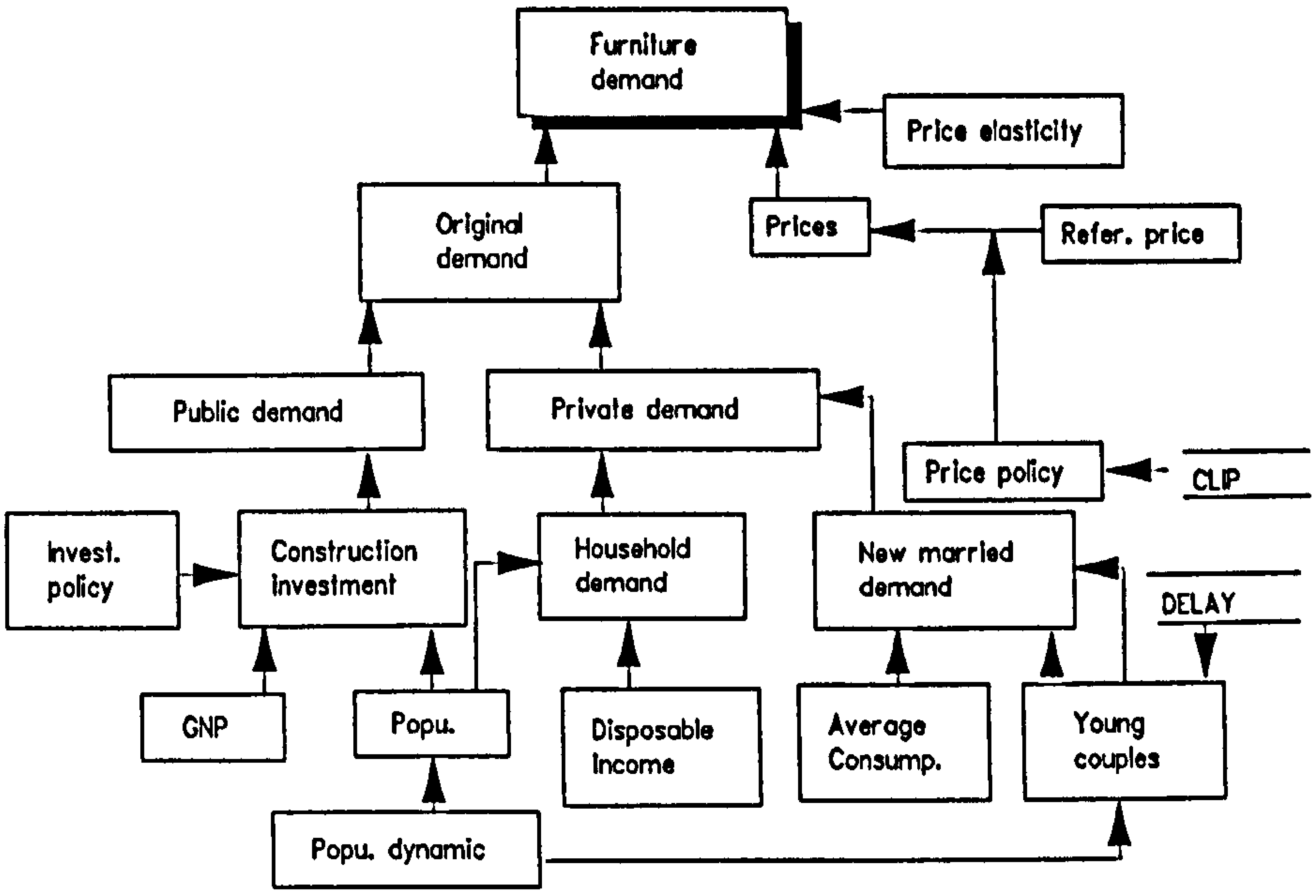


Fig. 7.10 The Causal Structure of Furniture Demand

7.4 Supply Sub-Section

As discussed in Chapters 2 to 3, timber supply is derived from harvesting the forest resource. Without resource inventory, there would be no supply of wood products and services at all. However, under a given amount of resources, the quantity of supply can vary under different strategies, which may result in 'sustainable development', or 'resource depletion'.

Long-term wood supply is determined by the interaction of the sequence of short-term harvests, forest management decisions, and forest growth relationships. The concept of sustainable supply is a dynamic process, rather than a static result. It depends on the initial state, and the external and internal relationships of influential factors, so does sustainable forest development. Therefore, the study of future forest inventories should be concerned with the following aspects:

(1) initial state,

(2) forest growth relationships,

(3) forest succession dynamics,

(4) internal management activities (such as harvest, thinning, rotation),

(5) external factors affecting the forest system (such as investment policy, prices, population growth, land-use policy, substitution policy, environmental protection requirement, etc.).

This can be shown as in Fig. 7.11:

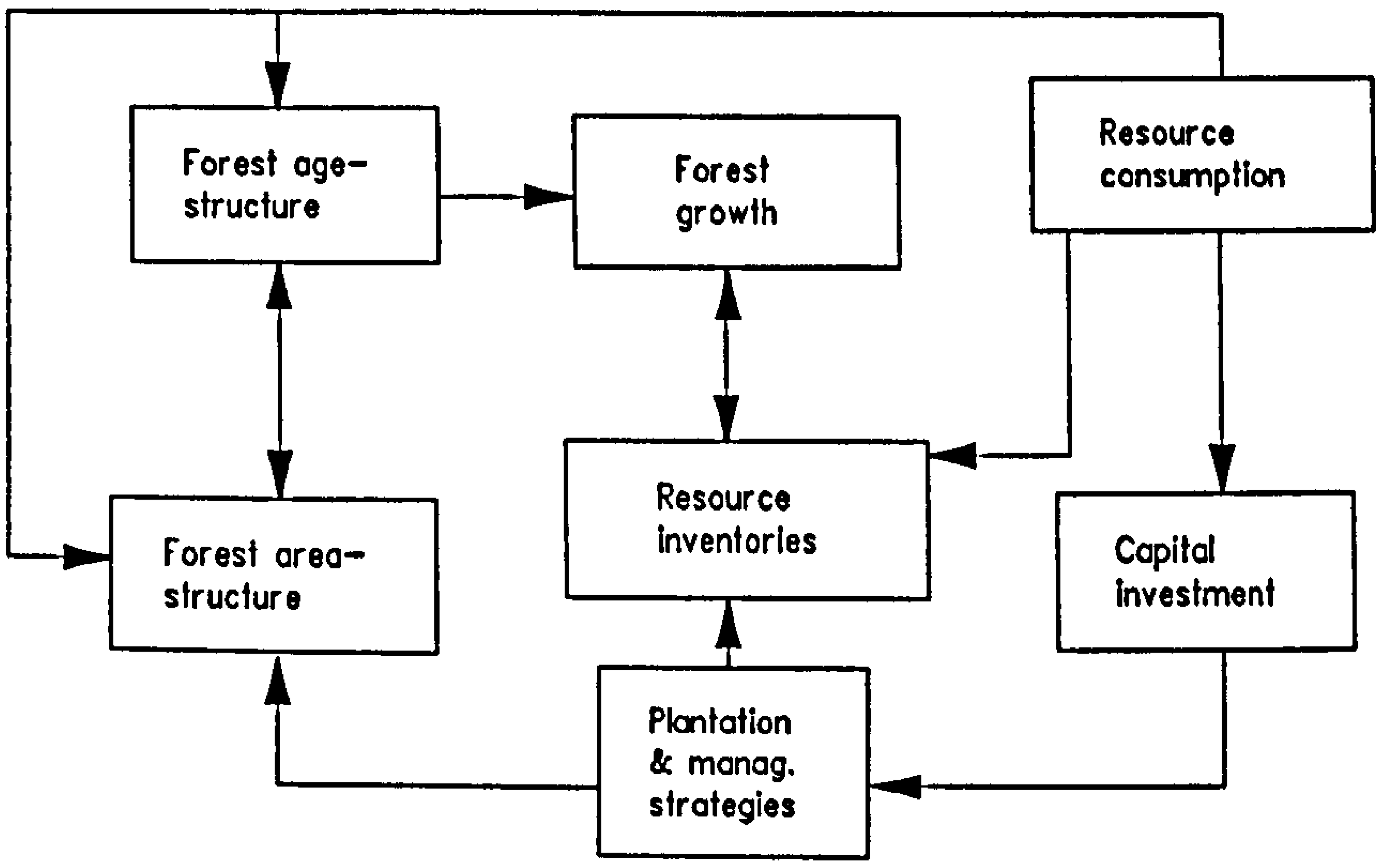


Fig. 7.11 The Causal Structure of Forest Inventory Dynamics

As shown in Fig. 7.11, the emphasis in the supply sector is focused on the movement of resource inventories. The change of resource inventories depends on the consumption rate, growth rate of existing forest, and the increase rate of new plantation.

For convenience of modelling the resource movement, this study classifies all forest resources into five categories, i.e., three commercial forests, which are the dominant part of the forest resource in the country, namely young forests, middle-aged forests, and mature (including over-mature) forest; and two other groups, which are respectively fast-growing forests and other forests (including special-use forests, bamboo forests, and non-timber tree crops). The dynamic characteristics of all these two categories are represented by the DELAY function of DYNAMO. This broad classification and simplification, based on a combination of age, growth and management characteristics, is believed to be reasonable for a study of this sort.

7.4.1 The Structure of Resource-Growth

The above classification and dynamic movement can be shown as in Fig. 7.12.

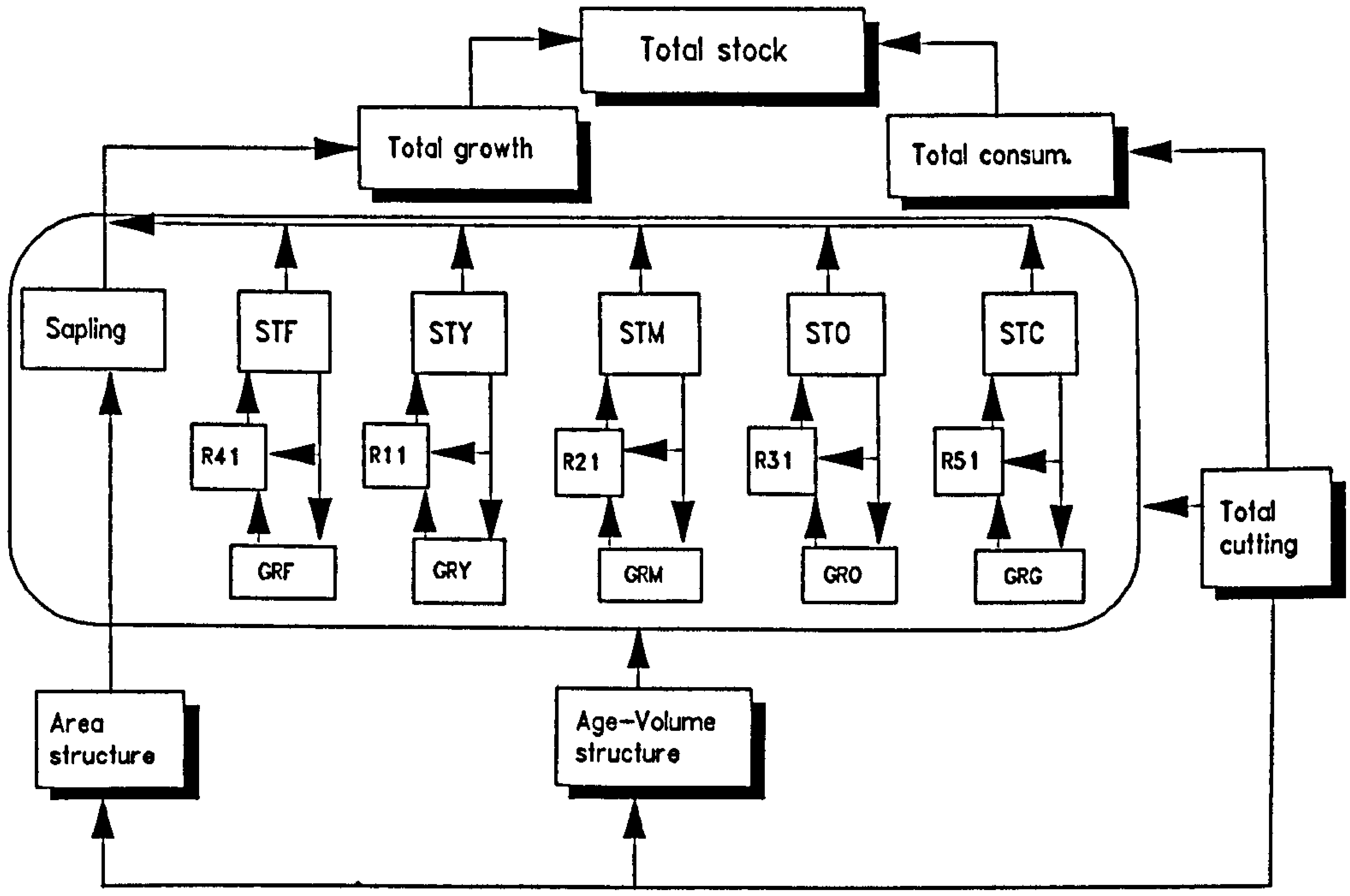


Fig. 7.12 The Causal Structure of Resource Growth

In the above diagram, as well as in the rest of the diagrams in this chapter, STY, STM, STO, STF and STC stand for the stock of young forests, the stock of mid-aged forests, the stock of mature forests, the stock of fast-growing forest, and the stock of other forests including that for special use and 'four-side plantations', respectively. GRY, GRM, GRO, GRF and GRC stand for the average growth rates of young forests, mid-aged forests, mature forests, fast-growing forests and other forests, respectively. R11, R21, R31, R41 and R51 stand for the net increase rates of young forests, mid-aged forests, mature forests, fast-growing forests and other forests, respectively.

Fig. 7.12 depicts the effects of total cutting on the total consumption and total growth of forest resources, hence on the total stock, through the changes in the volume structure and area structure of the resources.

7.4.2 Age-stock Structure and Area Structure

The function of this sector is to indicate the age-stock- and area- structural changes of the forest resource, since optimal harvest is based on a sustainable yield production, which requires a normal structure in volume and in area.

This sector comprising all forests from sapling to mature, and from man-made to natural stock, deals with the transitional problem, this is, in different age, the average stock per ha differs even within one age-group (say young forest). The increase (decrease) of amount of forest area does not necessarily bring about the increase (decrease) of amount of forest stock proportionally. Therefore, age-structure and area-structure of different forest groups must be treated separately.

The growth time-span has been divided into four stages: sapling, young forests, middle-aged forest, and mature and over-mature forest. The transition of resources from sapling to mature stock is a time-delay process: it is represented in Fig. 7.13.

Fig. 7.14 shows the dynamic movements of the age-structure and area-structure of forest stocks. One point which must be stressed here is that the movement is not simply described by the use of delay functions only, the difference of transfer rate between the entry and the exit within one group has also been considered for each group.

The detailed equations can be found from SD-FRED in Appendix II.

7.4.3 Total Resource Consumption Sector

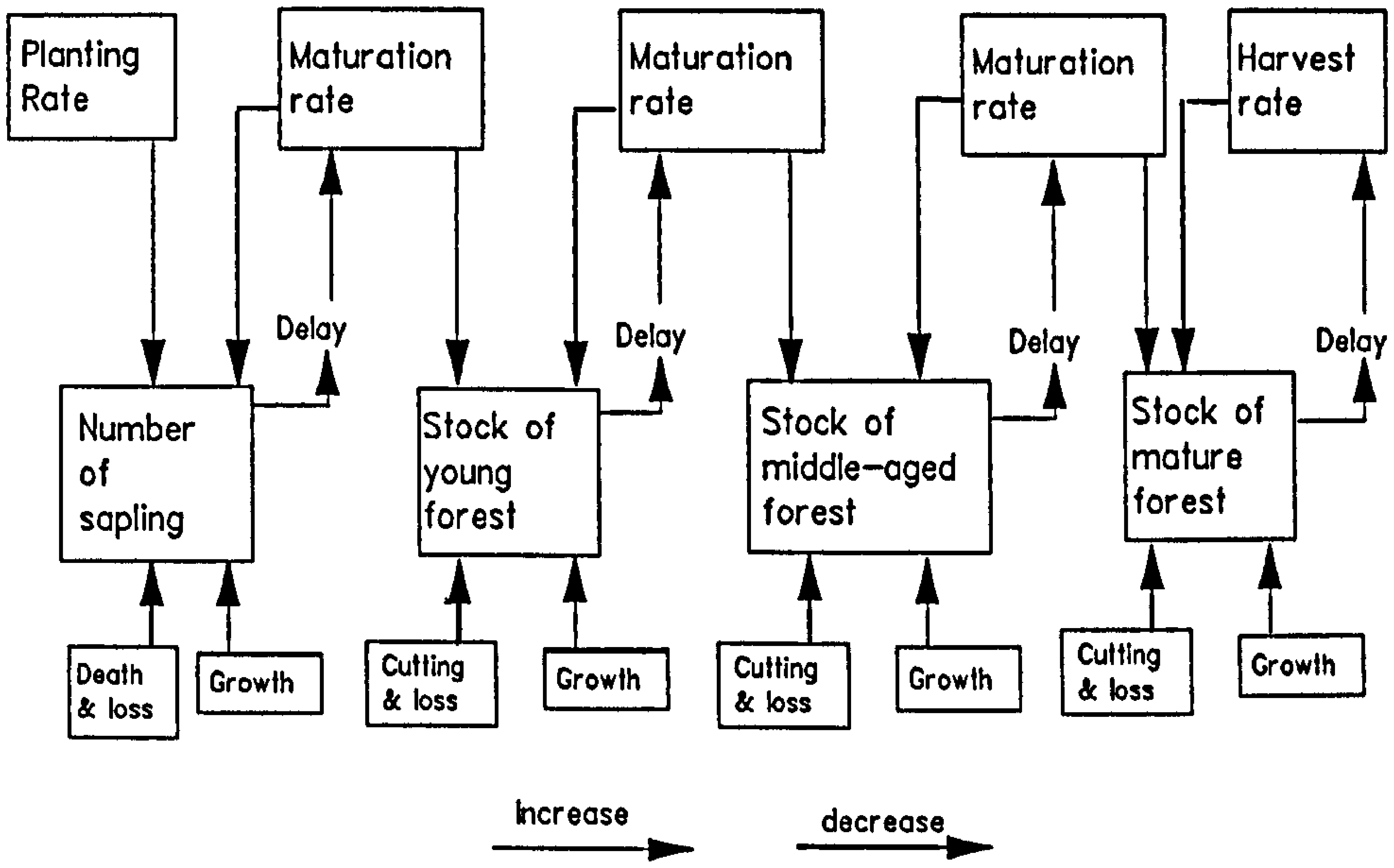


Fig. 7.13 Transition process of forest resources

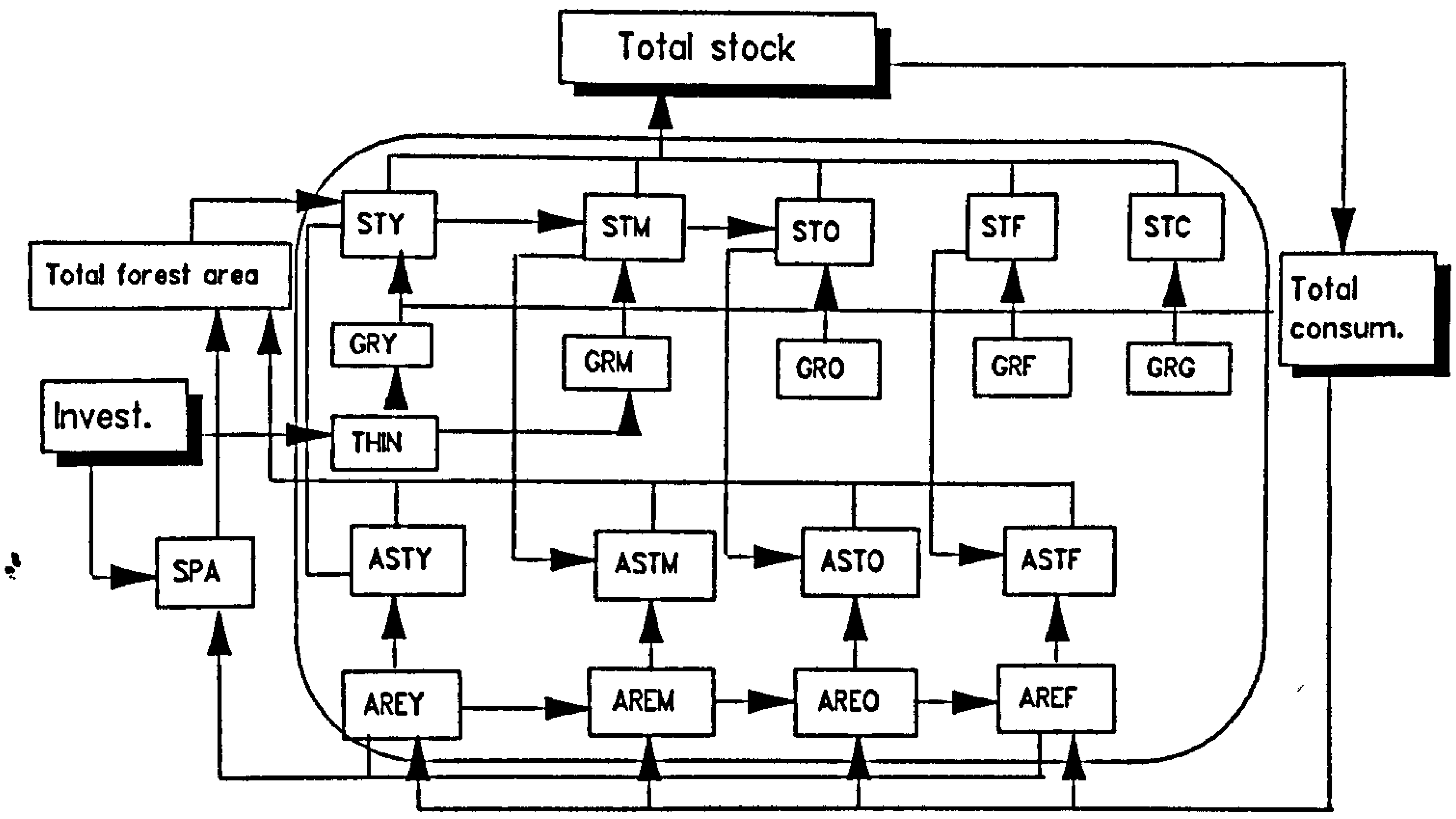


Fig. 7.14 The Flow Diagram of Resource Dynamics: Area- and Age-volume structures

This sector links total demand and total inventory of resources. This linkage can be shown as follows (Fig. 7.15):

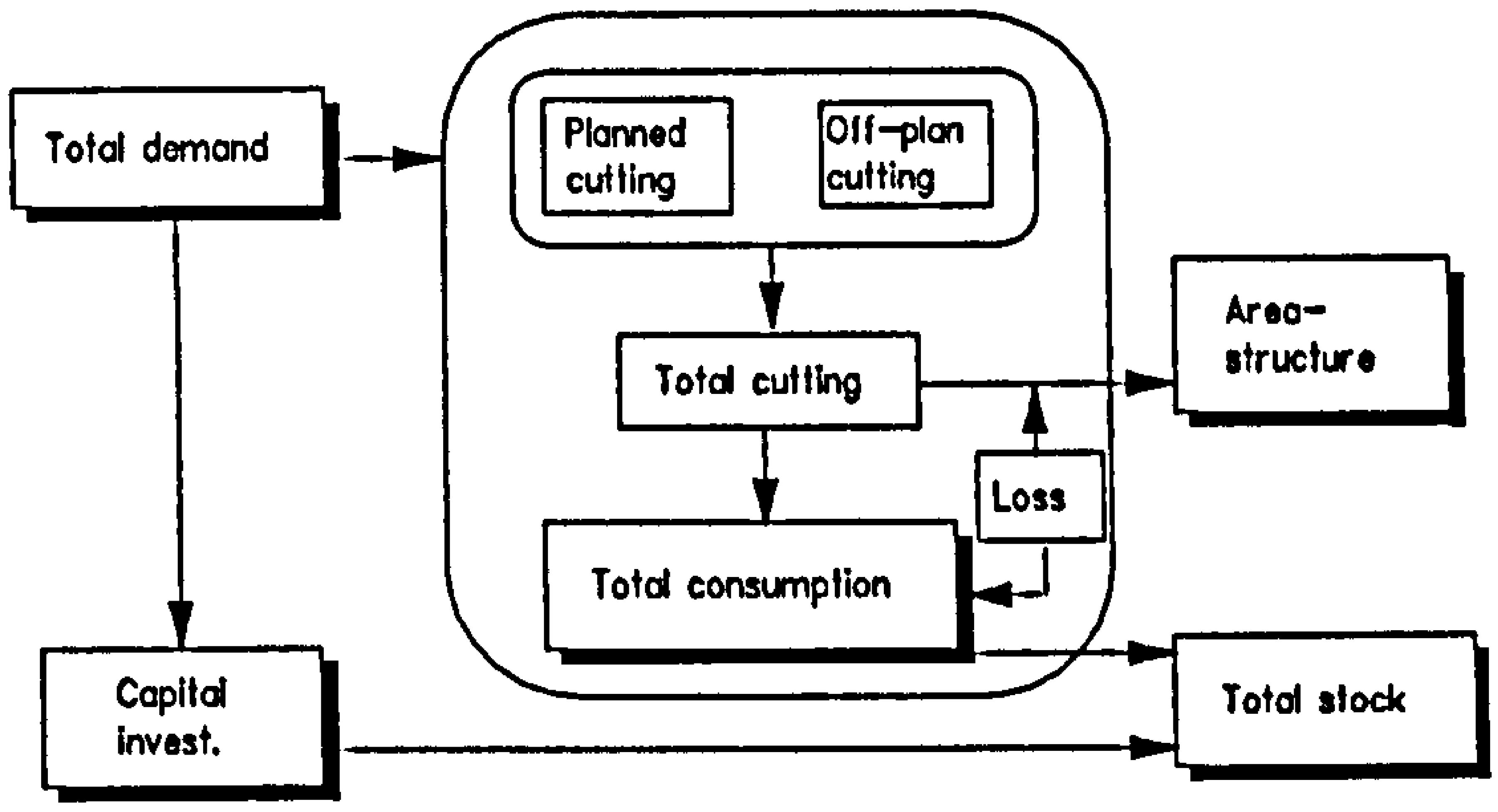


Fig. 7.15 Structure of Consumption Sector

As Fig. 7.15 shows, in this study, total consumption is determined by total demand. In turn, the present consumption level determines total forest stock and area structure in the future. The investment from forest producers is determined by the amount of silvicultural fees, which is a proportional charge on harvesting income and must be used for forest regeneration. Therefore, with given wood price levels, and given government reinvestment ratio, wood consumption, to some extent, influences the total investment in the forestry sector. Total resource loss, including fire-loss, disease loss, natural decay and transportation loss, and others, has a negative relationship with management level.

7.4.4 Capital Investment

Investment in forestry is formed from three parts:

(1) the state budget (including government investment, government credit);

(2) foreign loan and joint venture, and

(3) silvicultural fee (stumpage price, which is deducted from producer's revenue of selling wood products, at a certain ratio, and must return back, as regeneration fee to forest reproduction).

This can be indicated as Fig. 7.16.

Moreover, for simulating different strategies and policies, total investment in this

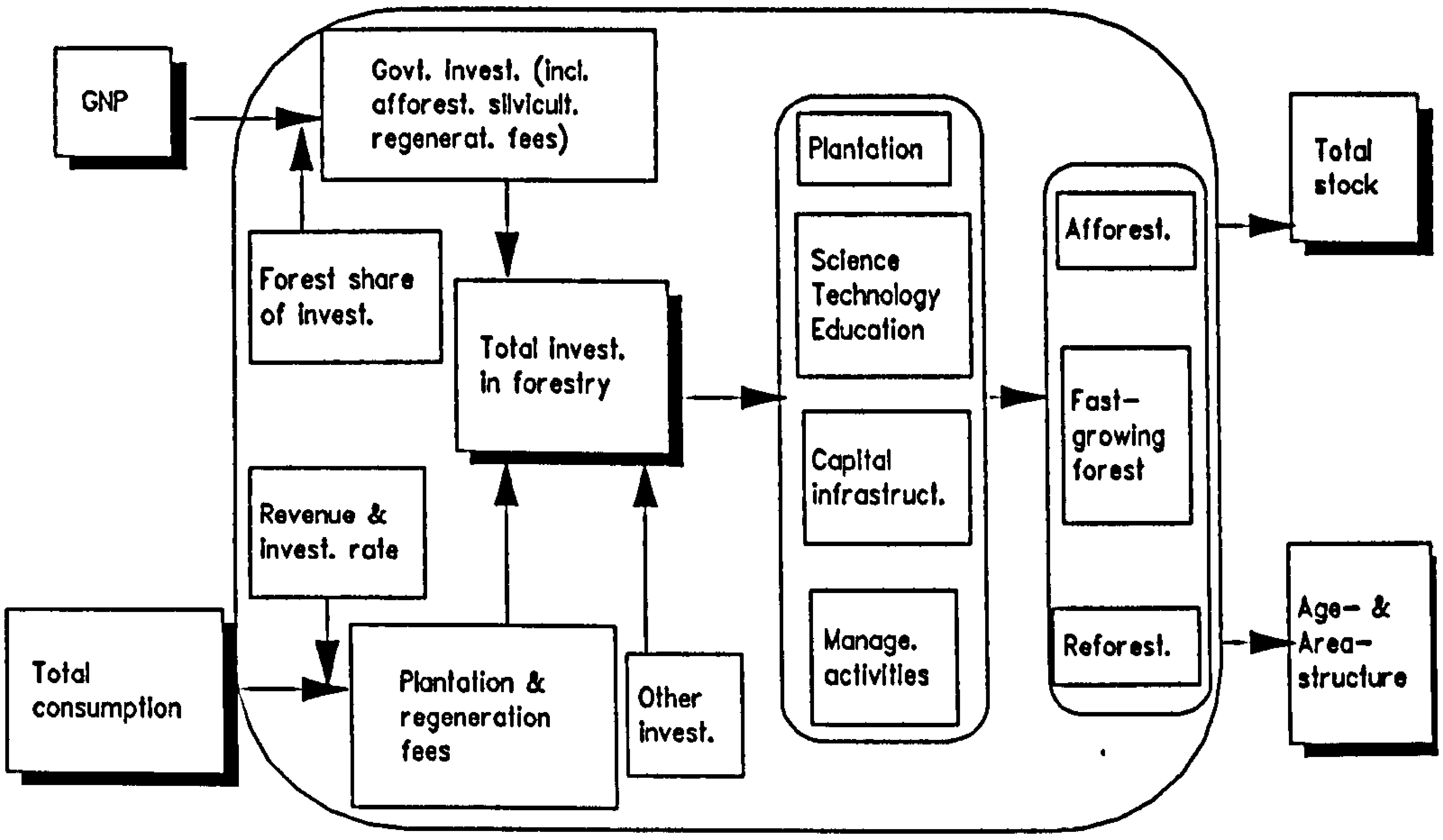


Fig. 7.16 The Flow Diagram of Investment in Forest

model also includes the transferring investment (TRASV) which is an investment transferred from wood import to domestic forestry development. The simulation of transferred investment starts from 1990, and is to be zero in the basic run of the model.

7.4.5 Cutting

As assumed previously, the removal of forest stock depends on the minimized demand estimate. That is, the essential demand must be met anyway, either by planned cutting, or by illegal cutting, or by importing.

Theoretically, under a centrally planned system, the amount of removal should be controlled by the authorities, and subject to the production plan, or the government's desired goal.

According to the current forestry production policy, total annual consumption should not exceed total annual growth. But, as analyzed in Chapter 4, the long ignored essential wood demands of the agricultural population have to be met one way or the other. The demands of other sectors and users are to be satisfied by the increasing openness of domestic markets, and by wood import from the world market in line with the decentralized control of foreign exchange earning and foreign trade. This will most likely lead to further increase of wood products prices, hence improving wood utilisation rate on the one hand; and this will also probably stimulate more cutting on the other, regardless of the shortage of forest resources.

Therefore, the cutting in the future simulated in this model is affected less by harvesting policy control, but rather by product prices, by the possibility of substitution, and by efficiency of resource management. That is, the price policy, the financial policy, and the ownership policy play a determinative role in the consumption of the resource. The detailed cause and effect relationship between cutting and policies is presented in Fig. 7.3, and the corresponding equations is in the Total Model section of Appendix II.

CHAPTER 8

BASELINE SIMULATION AND SENSITIVITY ANALYSIS

This chapter addresses the following issues:

8.1 Simulation Scenarios

Since a number of assumptions are required for making a simulation, theoretically, there is a large number of possible alternative sets of results, even if an individual assumption is varied only within a limited, plausible range. Those assumptions are about both the future values of exogenous variables and the specific causal linkage between variables. Among all variables in the model, however, some are more influential on the system behaviour than others. Through a number of policy experiments, those more influential variables have been selected for simulation and discussion while others are fixed. This chapter presents some of the results from sensitivity tests and deterministic policy experiments with a discussion. The discussion will be focused on the use of SD-FRED to evaluate the effects of current and alternative public policies in China's forest sector.

The original statements in the model represent a simulation of the 'baseline' projection of the system for the period 1980 through 2010. The baseline simulation then serves as the datum against which the outcomes of other simulations are measured. It tries to describe what will possibly happen if the current trends continue, and to provide a base for discussing what policy change needs to be done for the forest development in China.

Then, some alternative policies or behaviourial assumptions are simulated by changing the value of variables in the model to examine the model's sensitivity. The choice of variables for the simulation not only depends upon their sensitivity to the system simulated, but also closely relates to the current debate about forest policies in China. These changes include:

(1) Wood prices (PPT) (in terms of 1980 constant price per unit of forest resources);
(2) Utilisation rates of raw materials (RTPT);
(3) The investment rate in forestry from the total national investment (RINVFT);
(4) The survival rate of plantations (PSRT);
(5) Increase of wood import (IMPORT);
(6) A shift from wood import to home development (HOME);
(7) Wood consumption of construction industry.

The type of alternative simulation contemplated here is the comparison of more theoretical explanations for the phenomenon discussed previously within the system being modelled. The theoretical explanations, based on the considerations of the current situations and a range of probable policy changes, are quantified and then inserted separately into the scenario formulation. Successive computer runs are made, one for each theoretical explanation being considered, and their respective outputs are compared to the time series of real data. Random variation of results with given parameters and variables is dealt with by the RANDOM NOISE function of DYNAMO as mentioned in Chapter 5.5.

8.2 Baseline Simulation and Results

Baseline here indicates a scenario that provides the basis for comparison and discussion of policy experiments. It means that if the trends and the policies set currently for the future go continually, it illustrates what the most probable results will be under assumptions which are considered to be reasonable. All the relationships and assumptions within the system modelled at the baseline level are shown in the Run-base model (Appendix II), but some variables, which have been considered as more important than others, are listed in Table 8.1.

Table 8.1 Estimates of Some Parameters for Baseline Scenario

	1980	1985	1990	1995	2000	2005	2010
PPT (RMB¥)	70.46	94.17	110	120	130	130	130
RINVFT (%)(E-3)	1.97	1.27	1.27	1.24	1.22	1.22	1.22
PSRT	0.29	0.33	0.34	0.34	0.34	0.34	0.34
INVCT (RMB¥)(E9)	55.9	106	130	150	165	170	180
CA2T (m^2)(E6)	586	748	750	725	754	756	756
IMCOST (RMB¥)(E6)	748.8	3860	3860	3860	3860	3860	3860
F26T (ton)(E6)	61.5	--	83.3	--	85.0	--	88.0

	1980-1990	1995	2000-2010
TRASVT (RMB¥)(E8)	0	0	0
GRYT (E-3)	98.97	98.97	98.97
GRMT (E-3)	40.66	40.66	40.66
GROT (E-3)	10.7	10.7	10.7
R16T (E-3)	1	1	1
R26T (E-3)	1	1	1

	1980-1990	1992	1994-2010
RTPT	0.60	0.60	0.60
DARET (ha)(E3)	887.26	880	880
FARET (ha)(E3)	392.57	390	390

Note (the following abbreviations are applicable to the rest of this thesis):

PPT	= price of wood products (RMB¥/m^3)
RINVFT	= share of total saving for investment in forest (%)
PSRT	= survival rate of plantation
INVCT	= investment in construction sector per year (RMB¥)
CA2T	= construction area in countryside per year (m^2)
IMCOST	= import cost (RMB¥)
F26T	= annual coal production (ton)
TRASVT	= value transferred from import to home production (RMB¥)
GRY	= growth rate of young forest (%)
GRM	= growth rate of mid-aged forest (%)
GRO	= growth rate of mature forest (%)
R16	= tending density of young forest (%)
R26	= tending density of mid-aged forest (%)
RTPT	= wood utilisation rate (%)
DARE	= area suffered from forest diseases and insects (ha)
FARE	= area suffered from forest fire (ha)

Baseline scenario assumes a continuation of the present trends. The outcomes of Baseline simulation are briefly shown in Table 8.2 and Fig. 8.1.

Note: the following abbreviations are applicable to the rest of this thesis:

TFS	= total forest stock
FCOV	= forest cover rate
TGV	= total growth volume
TCONS	= total annual consumption of forest resources
WC	= annual consumption of wood products
WP	= annual wood production
ASTARE	= per ha average stock
SPA	= area of successful afforestation
TCSUM	= annual timber consumption per capita
TINVSF	= total annual investment in forest

Table 8.2 Result of RUN-BASE

TIME	TFS	FCOV	TGV	TCONS	WC	WP	ASTARE	SPA	TCSUM	TINVSF
	(m^3)	(%)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3/ha)	(ha)	(m^3/p.c.)	(RMB¥)
E00	E06	E00	E06	E06	E06	E06	E00	E03	E00	E06
1980	9028	11.895	257.58	377.67	294.41	291.21	79.058	1156.6	0.1785	519.5
1985	8411	12.322	266.39	390.92	320.52	303.85	71.073	1225.1	0.18246	654.6
1990	7804	12.952	279.97	396.64	327.22	310.55	62.703	1378.3	0.17441	847.3
1995	7228	13.767	299.41	410.43	339.84	323.28	54.612	1451.9	0.17042	1052.4
2000	6696	14.122	324.92	422.46	351.37	334.28	49.311	1382.6	0.16588	1249.6
2005	6303	14.298	357.47	466.38	334.64	318.08	45.824	1285.4	0.14935	1327.5
2010	6122	14.549	391.58	411.78	339.29	332.73	43.719	1224.4	0.14358	1503.9

Fig. 8.1 Results of RUN-BASE

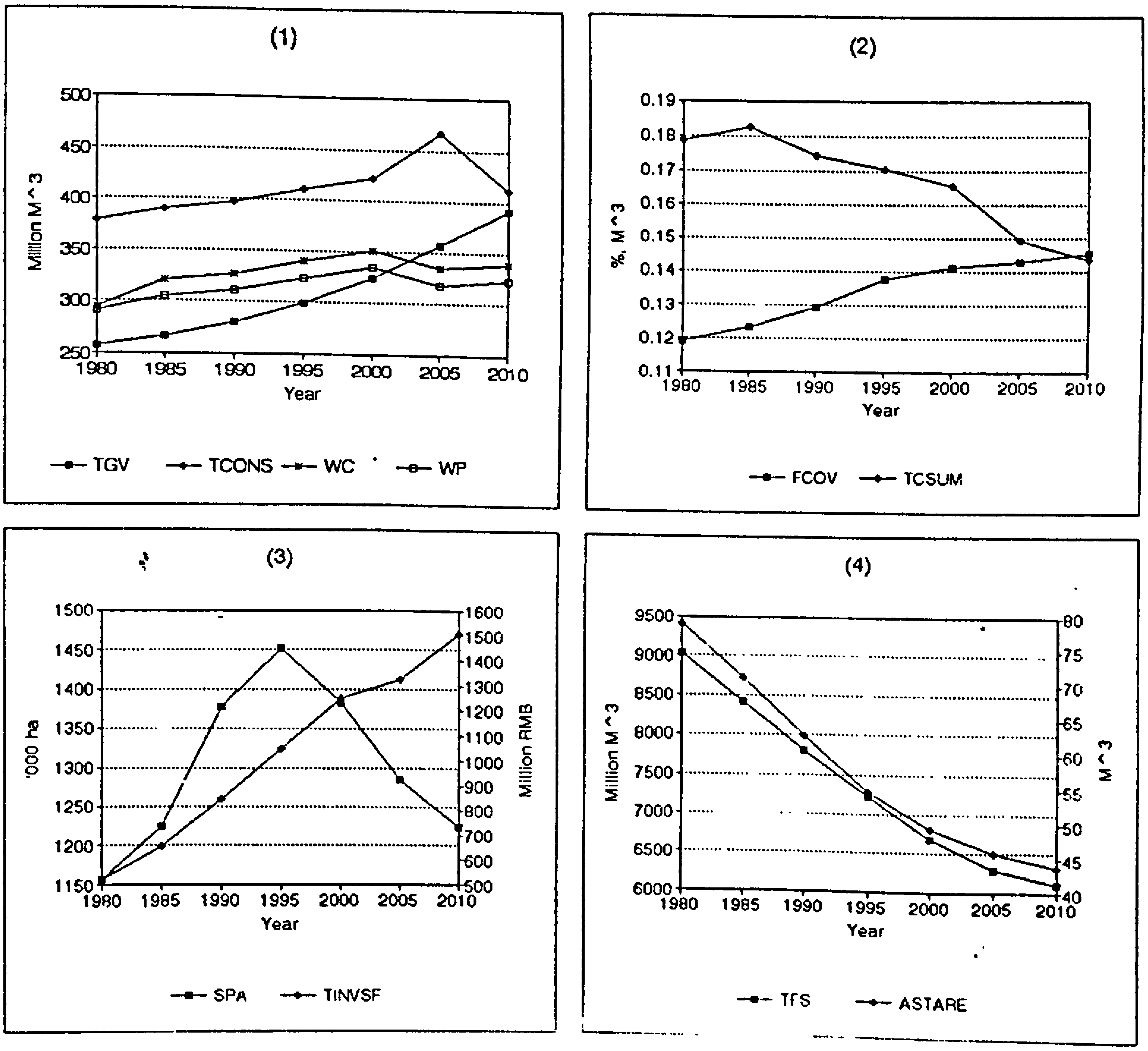


Table 8.2 and Fig. 8.1 together indicate that, even under a low-level equilibrium of demand and supply (i.e. the demand is minimized), the total growth volume of forest stock (TGV) will still continually be less than the total consumption. Consequently, the annual deficit will be about 50 million m^3, the total forest stock will keep on decreasing dramatically, from 9028 million m^3 in 1980 to 6122 million m^3 in 2010. If the mass campaign of plantation continues, as a result, the forest's cover rate (FCOV) will slowly rise; however, because of over-cutting mature forest, the average stock per unit land will also fall rapidly from 79.105 m^3 per ha in 1980 to 42.171 m^3 per ha in 2010. In fact, there are two points which make the results seem very conservative:

(1) the demand for fuelwood, agricultural use and illegal cutting has been assumed to be reduced to 50% of the 1980s level by 2010;

(2) the timber consumption per capita 0.16 m^3, which is very low compared with the world average level 0.65 m^3 in 1980 (UN, 1984), is assumed to fall steadily.

The detailed results provide an informative insight for future policy-making.

8.3 Policy Variation: Sensitivity Analysis

Policy changes, such as price policy, ownership, import/home development, investment, etc. have been at the centre of the current national debate over demand and supply of forest products. In order to answer the questions stated previously, (Where should China place top priority -- on demand-reducing policies or on policies designed to increase supply? Which policy options are most effective over the long term?), it is important to observe the sensitivity of model solutions to the policy changes, variations in the parameters of the model from the Baseline run.

Sensitivity analysis of the model in this study is defined as the study of model responses to the changes of the policies. It has several useful functions in the overall process of model building. First and foremost for a model of this magnitude and complexity, sensitivity analysis is necessary for understanding the behaviour of the model and checking its logical consistency. Furthermore, sensitivity analysis is a useful device for exploring in detail the complexity of interactive and feedback effects. Only through a comprehensive understanding of these processes can the policy results of the model be conveyed to policy makers.

Second, sensitivity analysis helps in exploring the various implications of the model. By varying parameters of policies included in the model, tentative policy conclusions can be reached. Some of these parameters, such as wood product prices, can be explicitly treated in policy runs of the model where various current evidence shows an increasing trend. Other parameters, such as the ratio of the national total investment to forestry, are not explicitly linked with policy instruments but are treated exogenously in the model. However, if the model proved to be sensitive to these variables, attentions would be drawn to these variables from either policy makers or further researchers.

Finally, the sensitivity runs are useful in pinpointing the data requirements of the model. Because much uncertainty is associated with many parameters of the model, it is of interest to know whether this is of consequence in policy formulation.

In the sensitivity analysis, all changes, with the exception of perturbation in exogenous variables (including noise functions), can be viewed as being either a structural change (e.g. reformulating parts of model), or a parameter (initial values and delay times) change (e.g. changing the initial value of a level), or a combination of both.

The dividing line between these two types of changes is not always clear however, because:

(1) parameters are in a way reduced structures, and

(2) a parameter change may induce structural changes, e.g. supposing wood supply to the domestic users are currently from both home production (say, 80%) and

import (say 20%). Now, the government decides to cut down foreign currency allocated to wood import gradually to zero in five years. This, reflecting to modelling process, will be a parameter change during first four years, but a structural change in year five since there will be no 'wood import' as a component in the model structure by then.

Altering the use of a parameter reflects a change in the implicit structure generating the parameter. In fact, throughout the process of model construction and refinement in this study, structural sensitivity analysis has been taken into account (see Chapter 7). As soon as the basic model has been established, the analysis concentrates on parameter values, and may give the first indication of the model's sensitivity to parameter changes.

The effects on forest development of alternative policies within the forest system and of alternative assumptions outside the system are simulated and analyzed in this section. The sensitivity analysis was carried out extensively during the computer experimental stage; however, the discussion here focuses only on the effects of a few selected variables. It is hoped that by highlighting these few, some idea of the complexity and sensitivity of the whole model will be borne out.

8.3.1 Variation of Prices (PPT)

Prices of wood products are always important influential factors on both demand and supply of wood products in a market economy, they are going to be more and more influential on China's economy as a result of the increasing proportion of transactions occurring through the market. The variation of price for this run set exogenously, compared with the base-run, is listed in Table 8.3.

Table 8.3 Changes of Aggregated Prices

Unit: RMB¥/m^3.

	1980	1985	1990	1995	2000	2005	2010
Variant	70.46	94.17	140	144	148	152	156
Original	70.46	94.17	110	120	130	132	134

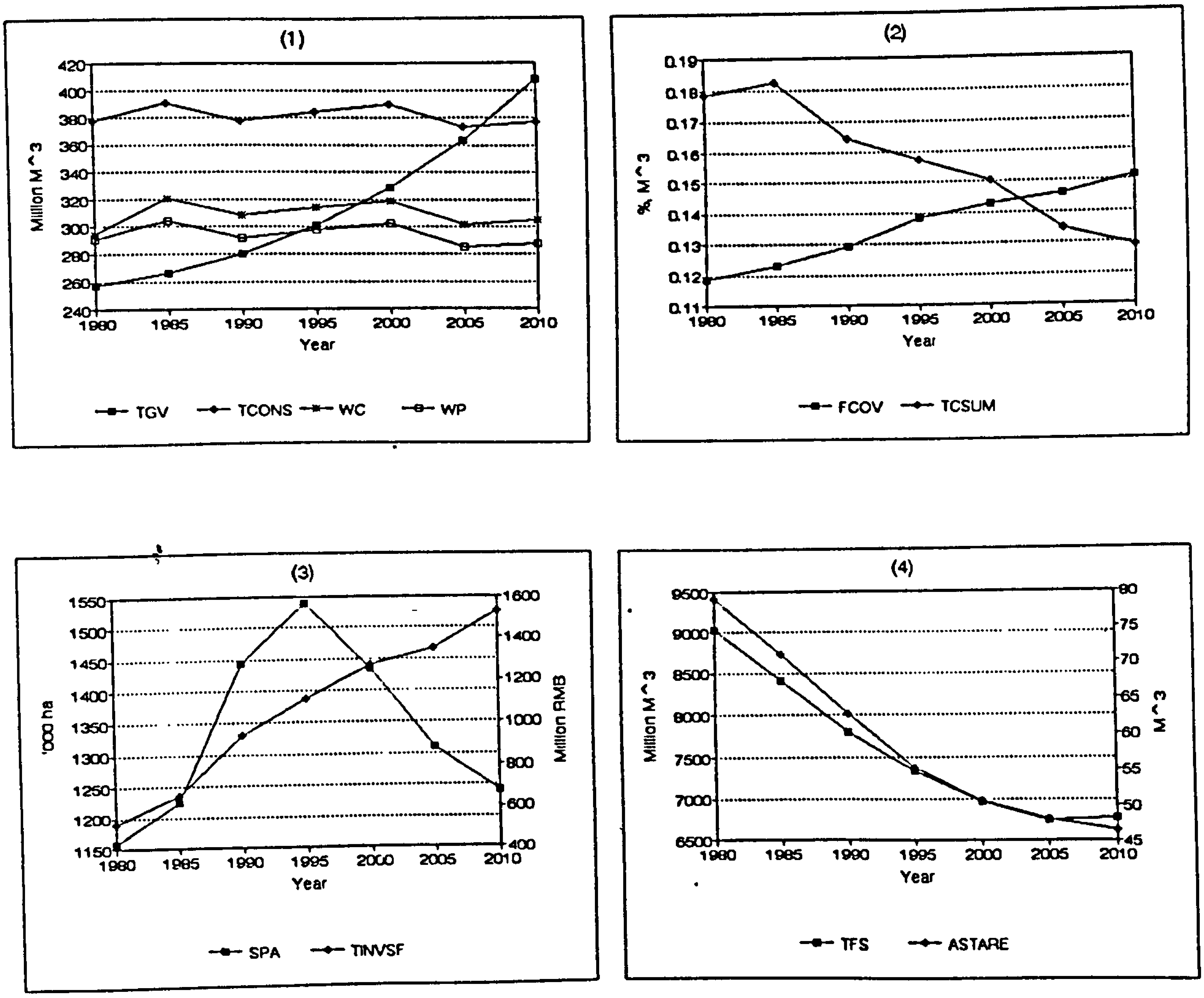
The results of the price simulation (see Table 8.4 and Fig. 8.2 in the following) show significant effects of price change on forest development. If prices increase sooner (in 1990) rather than 10 years later, the result will be different from that shown in the base-run.

Table 8.4 also shows that under this variation, total forest stock will not increase very much, but a turning of the change will happen around year 2006, in which the total growth volume of stock will begin to exceed the total consumption, and the rate of land covered by forest will go up by 2.2% during the period from 1990 to 2010. This may be because of two causes. Firstly, the increase of wood product prices will reduce the consumption by stimulating the substitution of wood products by other materials or by simply changing consumption behaviour, or by both; consequently, the total consumption of resource will remain steady with some small fluctuation. Secondly, at a given investment policy, the increase of price will result in the rise of the investment in forestry (INVSF), and increase the survival rate of plantations (PSRT). Accordingly, the average stock per unit land (ASTARE) will be higher (46.448 m^3/ha) than it is in the Baseline (43.719 m^3/ha), while the average timber consumption per capita (TCSUM) will keep on a declining trend due to the steadily increasing population.

Table 8.4 Result of RUN-PPT

TIME E00	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.c.) E00	TINVSF (RMB¥) E06
1980	9028	11.895	257.58	377.67	294.41	281.21	79.028	1156.6	0.1785	519.5
1985	8411	12.322	266.36	390.92	320.52	303.85	71.073	1225.1	0.1825	654.6
1990	7806	12.956	280.05	377.83	308.41	291.74	62.696	1444.3	0.1644	942.1
1995	7340	13.827	300.59	384.74	314.15	297.59	55.219	1539.4	0.1575	1110.1
2000	6960	14.288	328.35	390.13	319.04	302.49	50.662	1434.3	0.1506	1267.2
2005	6752	14.601	363.87	373.78	302.04	385.49	48.081	1310.7	0.1348	1347.5
2010	6782	15.175	407.84	377.24	304.75	288.19	46.448	1241.1	0.1291	1528.2

Fig. 8.2 Results of RUN-PPT



8.3.2 Variation of Resource Utilisation Rate (RTPT)

It is widely believed that there is an unnecessary waste of forest resources in areas where there are forests (Richardson, 1987). Wood production is at an enormous expenditure of waste. It is reported that the present average utilization rate of logs in wood production is around 60%. There is a big potential to raise the wood utilization rate by effectively and efficiently using wood and through conservation measures (NFPA, 1987).

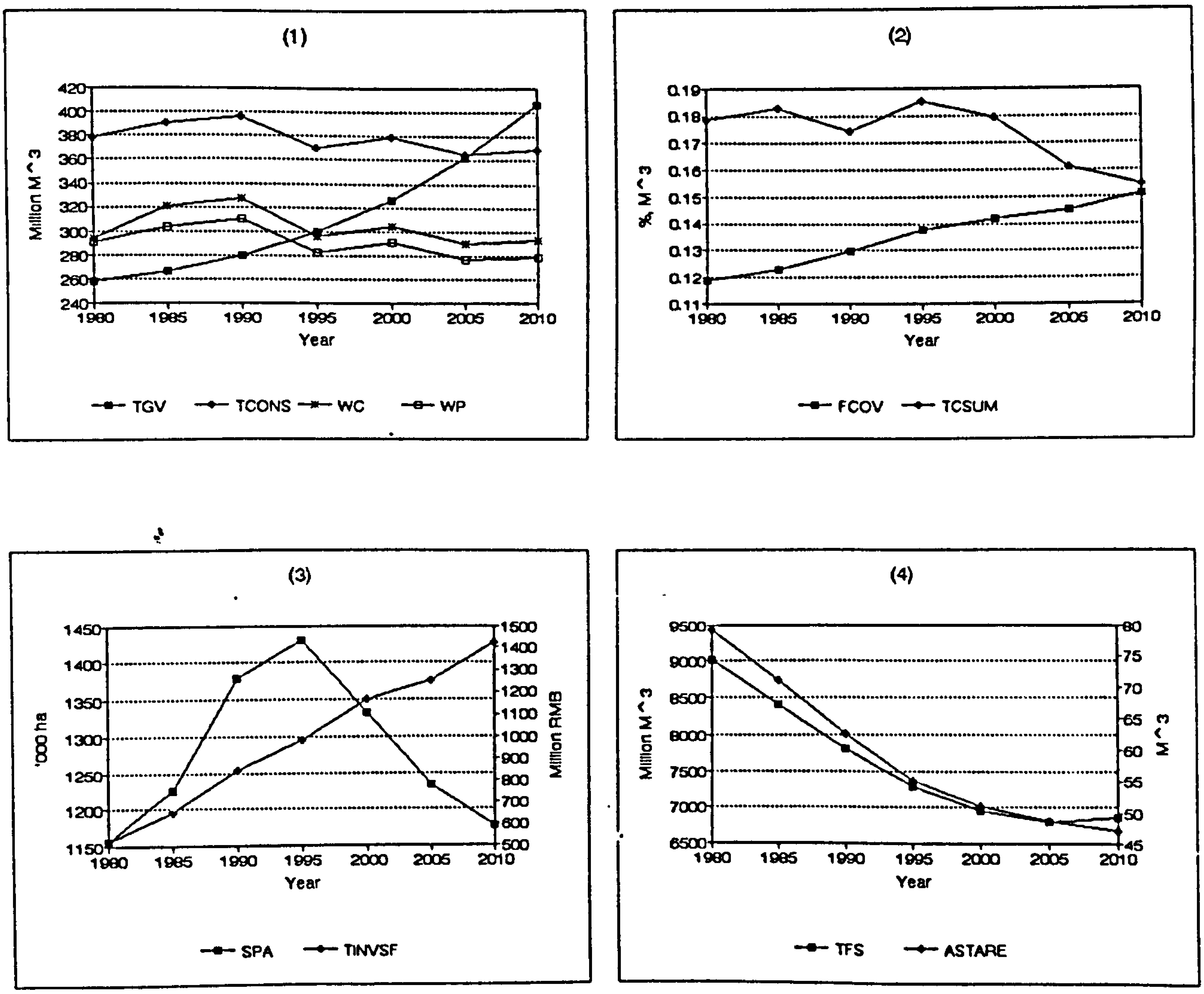
This run foresees what the outcome will be, if the utilisation rate (RTPT) increases from present figure 60% to 75%. This assumption is believed to be feasible, referring to the utilization rate in all industrialized countries, and even in some urban areas of China. The result of the run is presented in Table 8.5.

From Table 8.5 and Fig. 8.3, it can be inferred that the rise of the utilization rate of resource yields strong and positive effects on forest development in China. While the forest cover rate (FCOV) will be slightly lower than that from price simulation scheme, all other indicators show an improvement, and the most important point is that this scheme will lessen the total consumption of resource, with a lesser reduction of per capita consumption of timber products, and with improved forest area-structure of forest age-groups.

Table 8.5 Result of RUN-RTPT

TIME E00	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.c.) E00	TINVSF (RMB¥) E06
1980	9028.1	11.895	257.58	377.58	294.32	291.12	79.058	1156.4	0.17955	519.5
1985	8411.5	12.322	266.39	689.92	320.41	303.75	71.075	1225.1	0.18251	654.4
1990	7805.1	12.953	279.98	396.53	327.11	310.44	61.709	1378.1	0.17444	847.1
1995	7288.9	13.771	299.49	370.01	296.13	282.86	55.056	1430.8	0.18535	983.6
2000	6968.6	14.202	326.54	378.91	304.52	291.25	51.028	1332.4	0.17943	1169.2
2005	6802.1	14.517	361.81	364.91	289.88	276.61	48.714	1233.8	0.16148	1249.8
2010	6865.5	15.133	406.79	368.47	292.69	279.42	47.147	1177.3	0.15459	1421.6

Fig. 8.3 Results of RUN-RTPT



8.3.3 Increasing Investment in Forest Plantation

Many Chinese foresters and forest economists generally accept this view that insufficient investment in forestry from the government is the long-standing reason for forest depletion (Liu, 1984; Chen, 1988, Jin-yan,1988). There is no doubt about this argument, but the question is what the possible increase rate of government investment in forest will be, and how important the increase of the government's investment in forestry is at the present, compared with other policies, such as the increase of wood product prices.

In China's current financial situation, investment resources are in short supply, and the budget for investment is not made by foresters. Moreover, forest investment is not attractive in terms of financial cost-benefit ratio. It has been seen that the share of investment in silviculture to total national investment decreased sharply from 0.1966% in 1980 to 0.127% in 1985. Thus, forest investment will not be expected to increase very much.

In this simulation, the average proportion of the investment in silviculture to total national investment rises from 0.127% in the last 5 years to 0.167% in the next 20 years. This increased level is still below that in 1980, and is believed achievable. The result of the simulation is shown in Table 8.6 and Fig. 8.4.

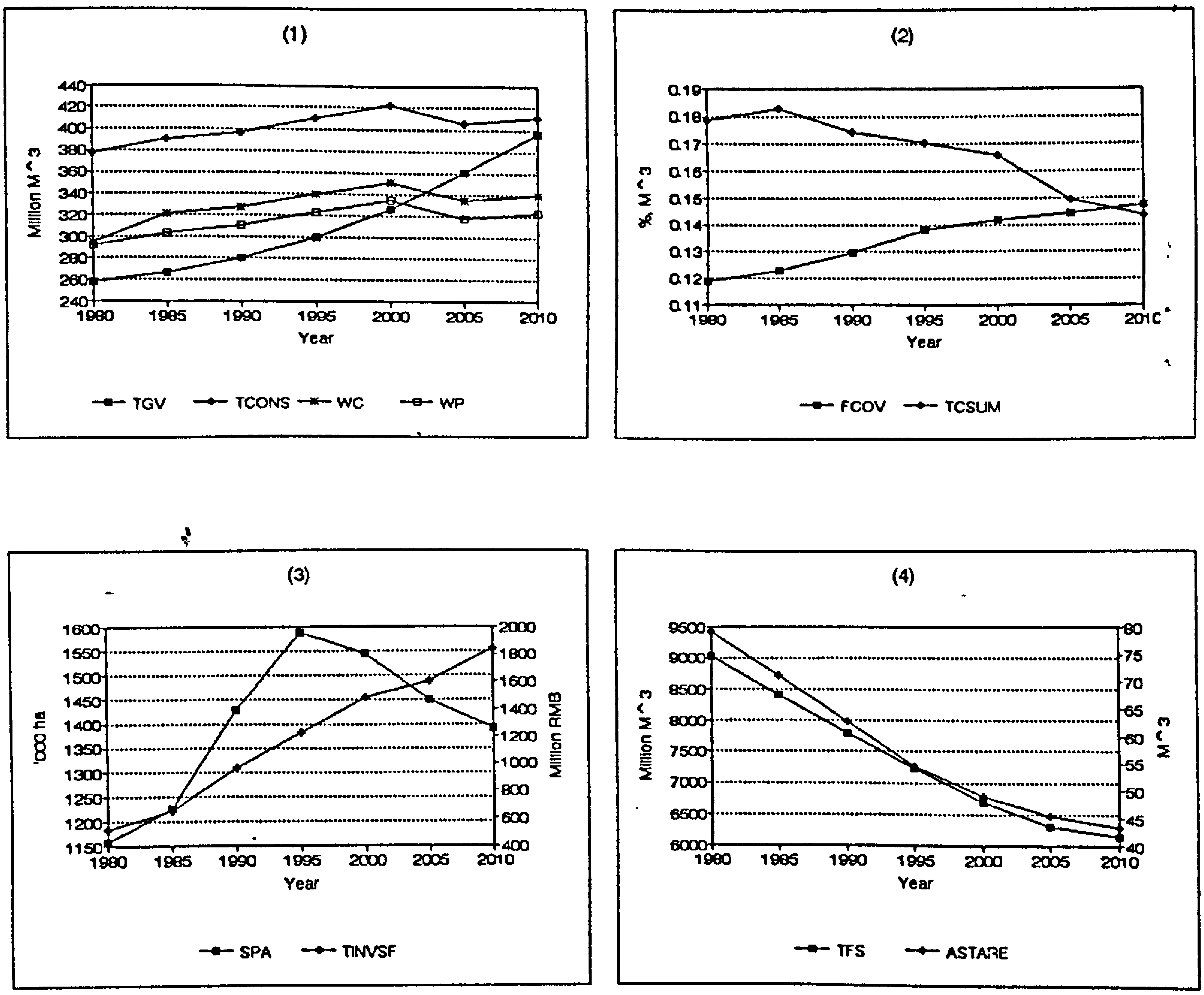
Table 8.6 (also Fig. 8.4) shows that 31% increase of the absolute amount of government investment in forest will make some difference to forest development from the baseline simulation: TFS will increase 6.3 million m^3 by year 2000 and 36.6 million m^3 by year 2010; FCOV will increase 0.08% by year 2000 and 0.19% by year 2010. The effects of the investment on forest development are positive, but not as significant as some economists believed (Chen, 1988; Li, 1988). There are two reasons which may explain the result:

(1) the current investment from the government in silviculture is too little to alleviate the financial thirst of China's forestry;

Table 8.6 Result of RUN-RINVFT

TIME E00	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.c.) E00	TINVSF (RMB¥) E06
1980	9028.1	11.895	257.58	377.67	291.10	291.21	79.058	1156.6	0.17851	519.5
1985	8411.1	12.322	266.39	390.02	320.52	303.85	71.073	1225.1	0.18246	654.6
1990	7804.1	12.955	280.03	396.64	327.22	310.55	62.689	1429.9	0.17441	961.5
1995	7229.4	13.799	300.02	410.43	339.84	323.28	54.496	1587.7	0.17042	1226.4
2000	6702.9	14.201	326.61	422.46	351.37	334.82	49.084	1544.5	0.16588	1482.7
2005	6320.6	14.427	360.61	406.38	334.64	318.08	45.539	1449.7	0.14935	1597.4
2010	6158.9	14.735	396.55	411.78	339.29	322.73	43.427	1390.4	0.14358	1832.2

Fig. 8.4 Results of RUN-RINVFT



(2) the effect of increasing investment in forest will be eroded by the increase of the plantation cost per ha, due to the dramatic increase of the factor prices in the recent years.

By contrast, some factors, such as increase of stumpage price and demarcation of forest ownership, will have a significant positive effect on forest development through the increase of non-government investment, with various legal and institutional constraints and incentives, that affect the way different owners manage and use their resources; even though increase of plantation cost will not be easily offset.

This does not mean that the government investment is not important in China's forest development. On the contrary, it implies:

a. in the current circumstance, the lack of investment in silviculture is one of several critical factors which bring about the overall stagnancy or failure of forest development in China;

b. the current investment policy of the government discriminates against forestry. The share of investment in silviculture should reach at least to its 1980s level (0.1966%), or higher;

c. with the present budget constraints, the increase of government investment is limited, and government investment alone can not meet the financial need of forestry. The most important thing the government can do is to redesign its policies relating to the investment in forestry, which should be able to generate incentives for non-forest sectors, companies and individuals to invest in forest (like Swedish case).

8.3.4 Rising Survival Rate of Plantations (PSRT)

The survival rate of plantations was very low, around 25-30%. The individual responsibility system, (including the individual hill and the private hill regimes) has already made progress in raising the survival rate of plantations. This study assumes that the survival rate will keep on improving in line with the enforcement of the responsibility system. The assumption of this simulation is as in Table 8.7.

Table 8.7 Assumed PSRT 1990 - 2010

Unit: %.

	1990	1995	2000	2005	2010
Variation	0.44	0.52	0.58	0.63	0.65
Original	0.335	0.34	0.34	0.34	0.34

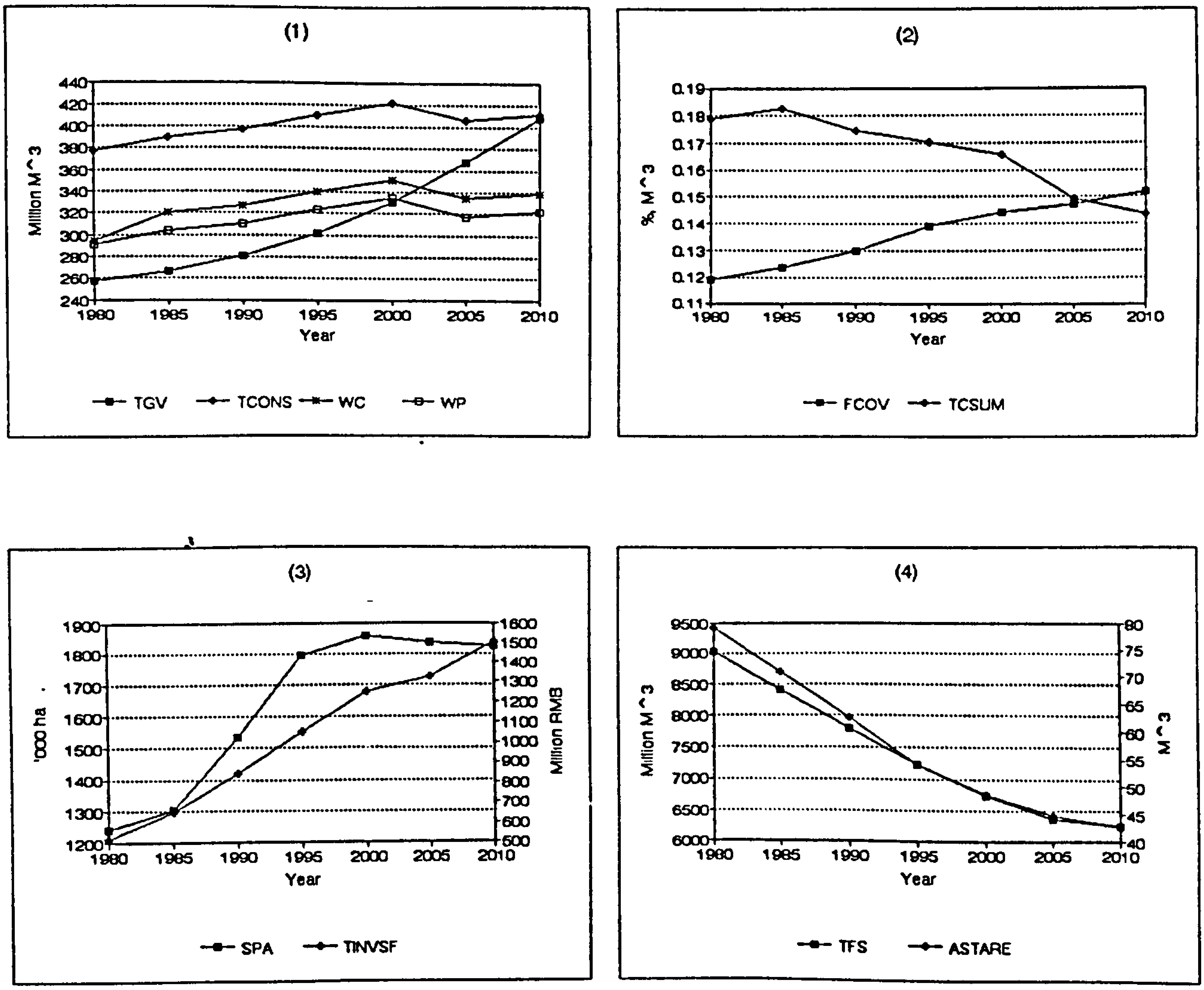
Running the model with this assumption, the result is presented in Table 8.8:

As shown in Table 8.8, the effect of rising PSRT on resource development will not be obvious during the short period, because of the long rotation of forest production, but the forest cover rate (FCOV) will increase considerably (the net increase of FCOV will be 0.022 from 1990 to 2010). This indicates good potential for increasing forest stock in the future. The general trends of this run is shown by Fig. 8.5.

Table 8.8 Result of RUN-PSRT

TIME E00	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.c.) E00	TINVSF (RMB¥) E06
1980	9028.1	11.895	257.58	377.67	294.41	291.21	79.058	1243.6	0.17851	519.5
1985	8411.9	12.348	266.91	390.02	320.52	303.85	70.928	1303.1	0.18246	654.6
1990	7808.8	13.013	281.17	396.64	327.22	310.55	62.446	1535.5	0.17441	847.3
1995	7241.8	13.914	302.32	410.43	339.84	323.28	54.138	1797.4	0.17042	1052.4
2000	6730.5	14.404	331.03	422.46	351.37	334.82	48.592	1858.3	0.16588	1249.6
2005	6376.5	14.741	368.25	406.38	334.64	318.08	44.964	1635.1	0.14935	1327.5
2010	6261.3	15.187	408.62	411.78	339.29	322.73	42.838	1825.6	0.14358	1503.9

Fig. 8.5 Results of RUN-PSRT



8.3.5 Variation of Thinning Ratio

Thinning ratio in this study is defined as the ratio of the area on which thinning is actually taking place to the area on which thinning should be carried out. The effect of thinning varies from region to region and from forest to forest. While the wisdom of thinning was rarely questioned, 'the disadvantages are rather more subtle' (Price, 1989). In China's present circumstances, it is generally believed that thinning is beneficial not only to increase the quality and quantity of forest resource, but also to shorten the technical rotations of forests, hence to improve the forest productivity and to raise the rate of capital return (Zhang, 1986; Lin Lin, 1987; Gu *et al*, 1987). If the thinning intensity is lower than 20%, and the proportion of annual thinning area is not over 5% of the area of young and middle-aged forests, the thinning will increase resource growth rate at 7% (Gu *et al*, 1987). There are more than 42 million ha of young and mid-aged forests (Sha, 1985), and it would not be realistic to consider thinning over all those areas within a short period because of the limits of both labour force and capital. This study has adopted the estimate made by Gu as an analytical assumption, and chosen two sets of alternative thinning ratios listed in Table 8.9 for simulation. The simulation effects of alternative II are shown in Table 8.10 and Fig. 8.6.

Table 8.9 Two Alternative Annual Thinning Ratios

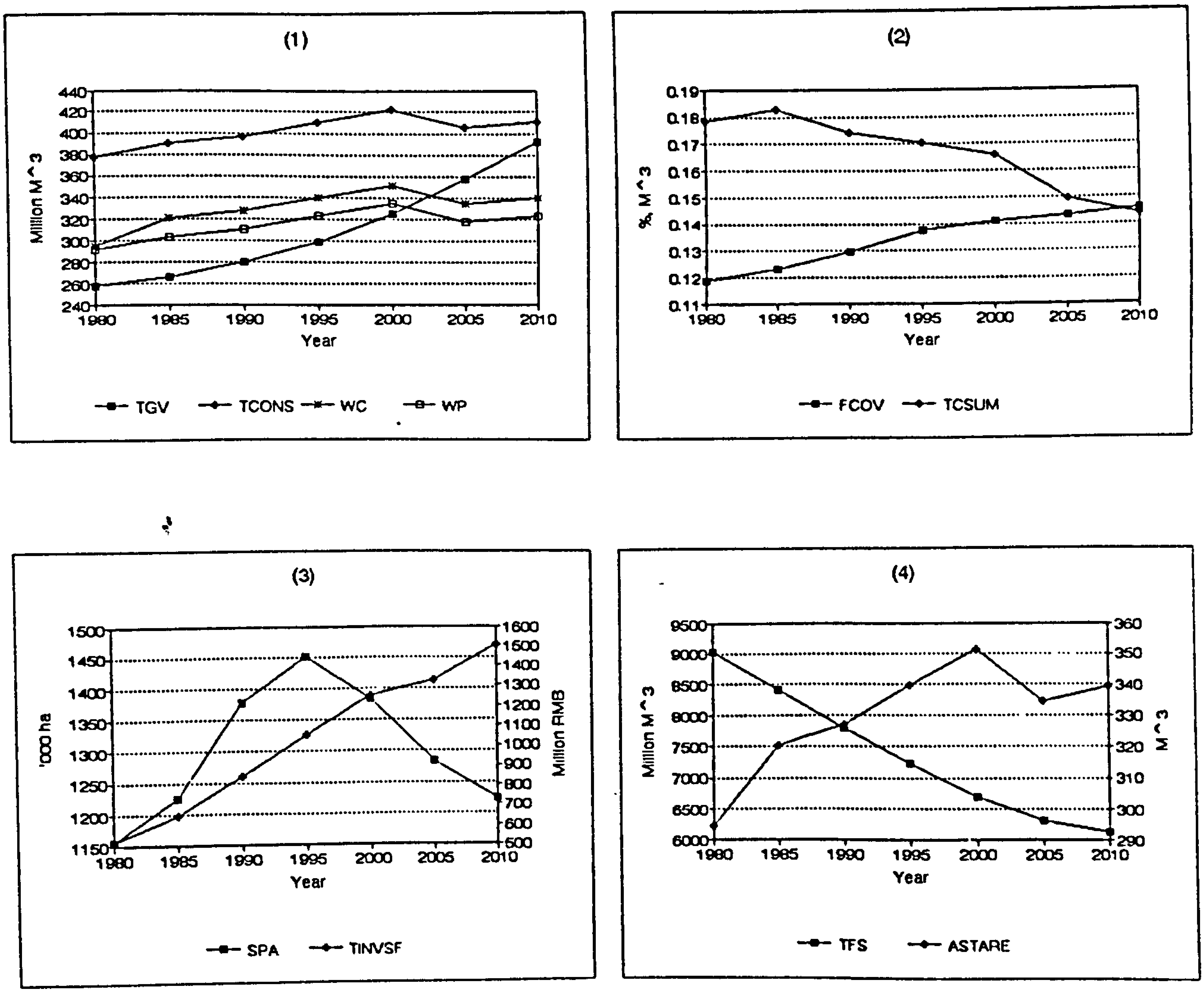
	1980-1990	1995	2000-2010
Original	0.001	0.010	0.010
Alternative I	0.001	0.015	0.020
Alternative II	0.001	0.020	0.030

Comparing the outcomes from this run with that of base-run, the result indicates that increase of thinning rate will lead to a slight rise of total forest resource (the difference between 6122.3 of base-line scenario and 6130 of this run in 2010) and the forest cover rate (the difference is 0.03% between base-line scenario and this run in 2010), but will reduce the average stock per unit land slightly. However, the results show that the effect of thinning is positive to increase forest resources. Proper thinning may improve the quality of resource; and by providing some intermediate products to reduce the high pressure of wood consumption on pre-mature resources, it may

Table 8.10 Result of RUN-THINNI (II)

TIME E00	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.c.) E00	TINVSF (RMB¥) E06
1980	9018.1	11.895	257.58	377.67	294.41	291.21	79.058	1156.6	0.17851	519.5
1985	8411.1	12.324	266.43	390.02	320.52	303.85	71.063	1225.1	0.18246	654.3
1990	7804.5	12.956	280.07	396.64	327.22	310.55	62.689	1378.3	0.17441	847.3
1995	7229.3	13.774	299.58	410.43	339.84	323.28	54.594	1451.9	0.17042	1052.4
2000	6698.8	14.135	325.24	422.46	351.37	334.82	49.284	1382.6	0.16588	1249.6
2005	6307.5	14.321	358.03	406.38	334.64	318.08	45.783	1285.4	0.14935	1327.5
2010	6130.1	14.586	392.48	411.78	339.29	322.73	43.665	1224.4	0.14358	1503.9

Fig. 8.6 Results of RUN-THINNI



improve the age-structure of forest. For the complexity of this issue and the limitation of data availability, this study is not able to answer the question that what the cost-benefit effect of thinning in China's present circumstances is.

8.3.6 Transferring Import Expenditure to Home Plantation Investment

Referring to the argument concerning whether China should take the "import saving" strategy or "home development" strategy as introduced in Chapter 1 and Chapter 4, this run intends to give some insight about this debate.

The standing point in this section is that if expenditure on importing wood products is transferred to home development by 5% and 10% of the current level respectively, what consequences each change may bring about. The results of these two simulations are shown in Table 8.11.

After comparison and marginal analysis of the outcome of two alternative transfers, some results have been summed up in Table 8.12. In this simulation, it is assumed that the transfers occur from 1990 onwards, and the percentage of transfers is based on the average figure for the last five years (1985-1989). Table 8.12 shows the marginal results of every 1% of transfer rate.

Table 8.11 Comparison of Home Development with Import

Year	Alter.	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	TCUT (m^3) E06	ASTARE (m^3/ha) E00
	Base	6696.6	14.122	324.92	422.46	334.82	49.31
2000	I	6690.9	14.124	324.95	423.29	335.65	49.26
	II	6685.1	14.125	324.98	424.12	336.48	49.22
	Base	6122.3	14.549	391.58	411.78	322.73	43.72
2010	I	6109.2	14.554	391.75	412.61	323.56	43.61
	II	6096.1	14.558	391.92	413.44	324.39	43.51
	Base	6099.1	16.726	445.55	424.69	334.14	37.82
2020	I	6079.9	16.735	445.87	425.52	334.97	37.71
	II	6060.7	16.745	446.18	426.35	335.81	37.57

Note: Base: baseline scenario – 0% transfer rate of import cost to home development;
I: alternative 1 – 5% transfer rate of import cost to home development;
II: alternative 2 – 10% transfer rate of import cost to home development.

Table 8.12 Comparison of the Marginal Results of Two Alternative Transfer Rates

Alter.	Year	TFS (m^3) E03	FCOV (%)	TGV (m^3) E03	TCUT (m^3) E03	ASTARE (m^3/ha)
	2000	-1140	0.0004	6.0	166	-0.010
I	2010	-2620	0.0010	34.0	166	-0.022
	2020	-3840	0.0018	64.0	166	-0.022
	2000	-1150	0.0003	6.0	166	-0.009
II	2010	-2640	0.0009	34.0	166	-0.021
	2020	-3810	0.0019	62.0	166	-0.025

Table 8.11 and Table 8.12 together provide some interesting findings and a further insight about the 'import/home development' debate.

(1) The transfer of financial resources from import to home development will help to increase the domestic forestation, hence, to increase forest cover rate, but will reduce the total forest stock because of increasing pressure on domestic supply.

(2) By the year 2010, alternative I, (which transfers less from import), may bring better results than alternative II probably would do, in terms of increasing forest area and average forest stock per ha. However, it can be seen from Table 8.11 that alternative II will result in a slightly higher TGV increase (0.17 million m^3 per year by 2010, and 0.31 million m^3 per year by 2020) and a slightly higher FCOV (0.004% by 2010, and 0.01% by 2020) than alternative I will do. This can be explained as a consequence of more capital input in domestic plantation.

This simulation implies that, in China's present situation, the transferring of financial resources from wood import to home development may not be a good policy. The higher the transfer rate, the earlier the depletion of forest resource occurs. Around the year 2020, the speed of the resource consumption will be more or less the same as its present level (about 3.8 million m^3 per year), but the total forest stock under alternative II will be nearly 20 million m^3 less than that under alternative I. However, because the transfer will increase forest area and forest cover rate, therefore, there will probably be a potential of increasing forest productivity in the future if those young plantations can survive the threat of pre-mature harvesting.

(3) Table 8.12 also shows that intensive removal of home resources will lower the average stock, hence lower the quality of the resource. Fig 8.7 (4) also shows the change of average stock per ha.

Some forest economists (Liu, 1988) defended the comparative advantage of home development policy. The approach they followed includes three steps:

(1) dividing total importation cost by average plantation cost per ha;
(2) multiplying the result from step 1 by average stock per unit land (ha);
(3) comparing the result from step 2 with the amount of total importation. If the former is greater than the latter, it means the comparative advantage of home development exists; or vice versa.

By applying this approach in China's case, they concluded that the home development could bring 16-20 times comparative benefit as much as import did (Liu, 1988). The approach is straightforward, but naive because of two reasons:

a. it neglects the importance of time in forest resource development,

b. the money for import and money for investment in forest are from different sources. The former is from demand, the latter from producer. Both could be transferable, but only under the conditions that there is ample supply of resources and that the price mechanism works efficiently.

There is not, perhaps never, a clear answer about the 'import/home development' question. For a further understanding of the question, it is necessary to carry out a detailed financial and social cost-benefit analysis, which is beyond the scope of this study. However, this simulation at least provides a base for a further analysis.

8.3.7 Importation

Transferring money from import to home plantation is not an effective means to develop China's forestry. By contrast, importation can play a very important role in wood supply in China. In fact, it is doing so. There are several reasons to assume that the import of wood will keep an increasing pace:

(1) The mature forest resource has been becoming critically short, with the majority of forest stands still in the young age group, the currently unbalanced age-structure will be aggravated. Therefore, the capacity of domestic supply will decrease dramatically over the next few decades.

(2) The demand for wood will maintain a rapid and substantial expansion as the prerequisite to economic development, the result of population increase and the improvement of living standard. It has been widely reported that the "economic need" for wood import can potentially grow to as much as 50 million m^3 per year from 10 million m^3 in 1985 towards the end of this century (Waggener, 1989).

(3) The increase of market proportion in the wood product distribution system, the decentralisation of financial power, the increase of the planned commodity prices, all of these factors together will actively narrow the gap between domestic and import prices. It has also been reported that in the coastal provinces, the imported wood has strong competitive advantage, because of its high quality (Li *et al*, 1987).

(4) Chinese tariffs have more to do with controlling the use of foreign exchange and promoting economic efficiency than with protecting domestic industry, because there is hardly any rivalry between import and domestic supply for the same timber demand. In some cases, the tariffs are rather political. For example, early in 1991, the U.S.A, which had declared a trade deficit with China (together with other reasons), even debated a bill to cancel MFN (Most Favoured Nation) treatment as a retaliatory measure against China. By facing that trade situation, China had to adopt some measures for a more positive opening of markets or expansion of imports, in which timber shared a big proportion. It is reasonable to assume that if the imbalance of demand-supply gets worse in the near future, Chinese tariffs must be lowered resulting in a further increase of wood products.

(5) With the domestic supply shortage and the worsening environment, foreign exchange, which is critical to China's drive for development, has already been allocated for the wood necessary for China's modernisation. The allocation of foreign exchange to wood import will increase in order to meet increased demand.

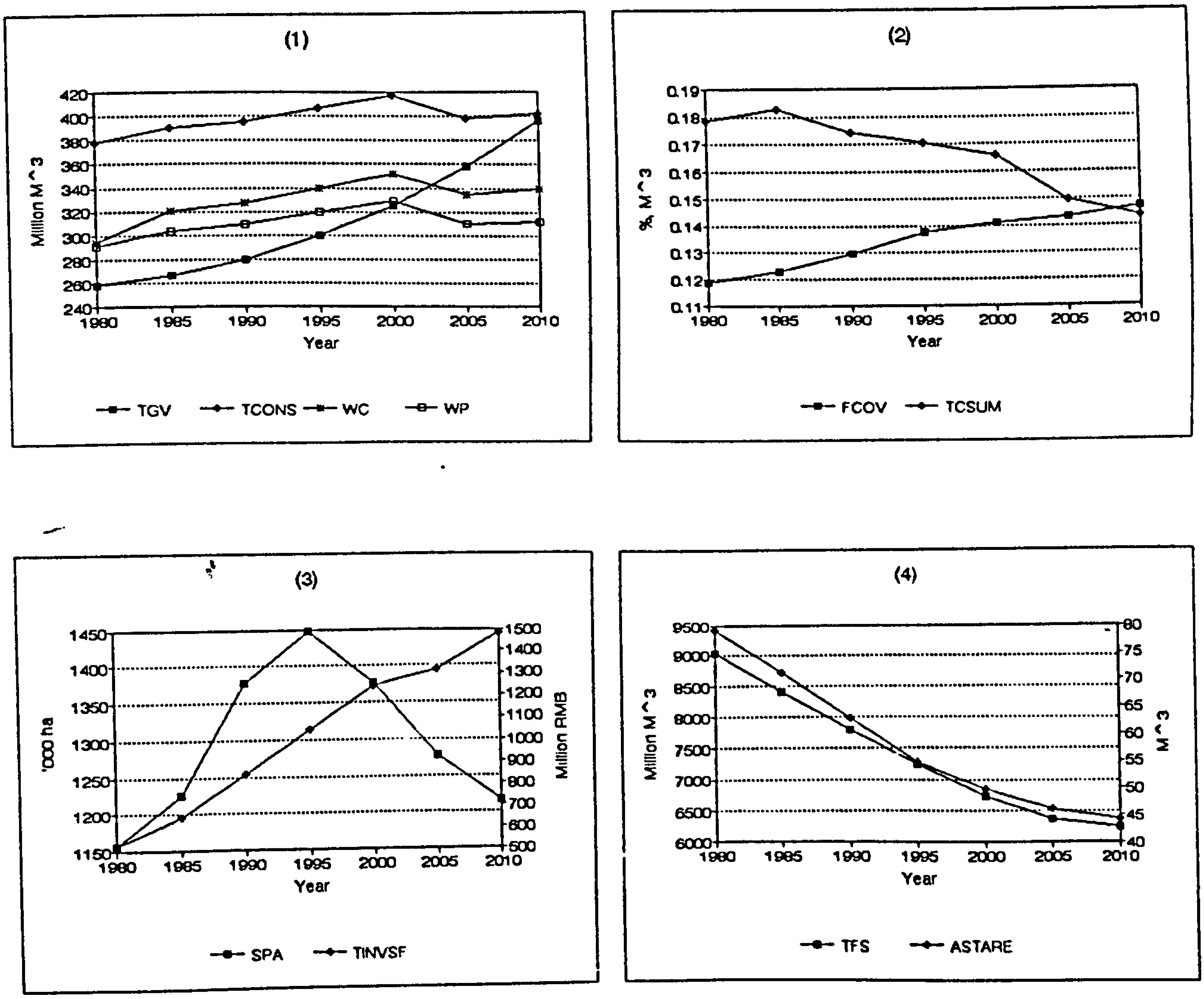
(6) The demand for some specific species and grades of products may only be met by import. The demand for big timber falls in this category as there will be no mature forest to be harvested.

A simulating run has also been based on the above considerations. It is assumed that import increases by 10% during each 5-year period. The simulation results are shown in Table 8.13, and illustrated by Fig. 8.7.

Table 8.13 Result of RUN-IMPORT

TIME E00	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.a.) E00	TINVSF (RMB¥) E06
1980	9028.1	11.895	257.58	377.67	294.41	291.21	79.058	1156.6	0.17851	5519.5
1985	8411.1	12.322	266.39	390.02	320.52	303.85	71.073	1225.1	0.18246	654.6
1990	7807.5	12.952	279.98	394.91	327.22	308.81	62.729	1377.1	0.17441	844.6
1995	7244.4	13.772	299.51	406.81	339.84	319.65	54.717	1447.8	0.17042	1046.2
2000	6735.9	14.136	325.21	416.72	351.37	329.08	49.551	1376.5	0.16588	1239.1
2005	6377.9	14.331	358.11	398.31	334.64	310.01	46.264	1277.8	0.14935	1312.4
2010	6250.8	14.706	396.47	401.14	339.29	312.09	44.163	1216.2	0.14358	1483.7

Fig. 8.7 Results of RUN-IMPORT



Comparing the result of import-run with the results of home-run (refer to Table 8.11), import will obviously save the home resource (see also Fig. 8.7). In the short term, the effect is not very significant, but if the simulation is expanded further, the outcome of this run is rather encouraging: around year 2012, the total growth will be greater than the total consumption of resource; by the year 2013, the total reserve will start to rise (6250.8 million m^3 in year 2012), and then will keep an increasing trend. But this strategy also faces some challenges:

(1) the availability of foreign exchange for timber import;

(2) the increase of average import cost per unit of wood products as the result of the producer countries' preference policy for exporting timber in the form of sawn lumber rather than logs;

(3) the stability of social and political environment, affecting the wood trade.

In short, from a long-term viewpoint, forest development must be based on home production, but for China's present situation, the reduction of current quantity of import means no less than pushing forest development from a possible solution into a vicious cycle.

8.3.8 Variation of Construction Demand for Wood Products

The consumption of wood products in all simulations so far has been minimized. This is to say, wood consumption (including both productive consumption and non-productive consumption) is assumed to keep the current low level, as planers of the government expected. It may be wise at this stage to ask the question -- "what will happen if something goes beyond one's expectation". The future demand for wood products in construction is probably a typical question of this kind, due to the present rapidly increasing trend of personal income, a huge housing demand, and the nation-wide reform of housing privatisation started from 1990.

There are two aspects concerned in this simulation:

(1) construction investment in urban areas;

(2) rapidly expanded housing in the countryside.

Table 8.14 presents assumed changes in construction in the next 20 years.

Table 8.14 Variation of Construction Demand

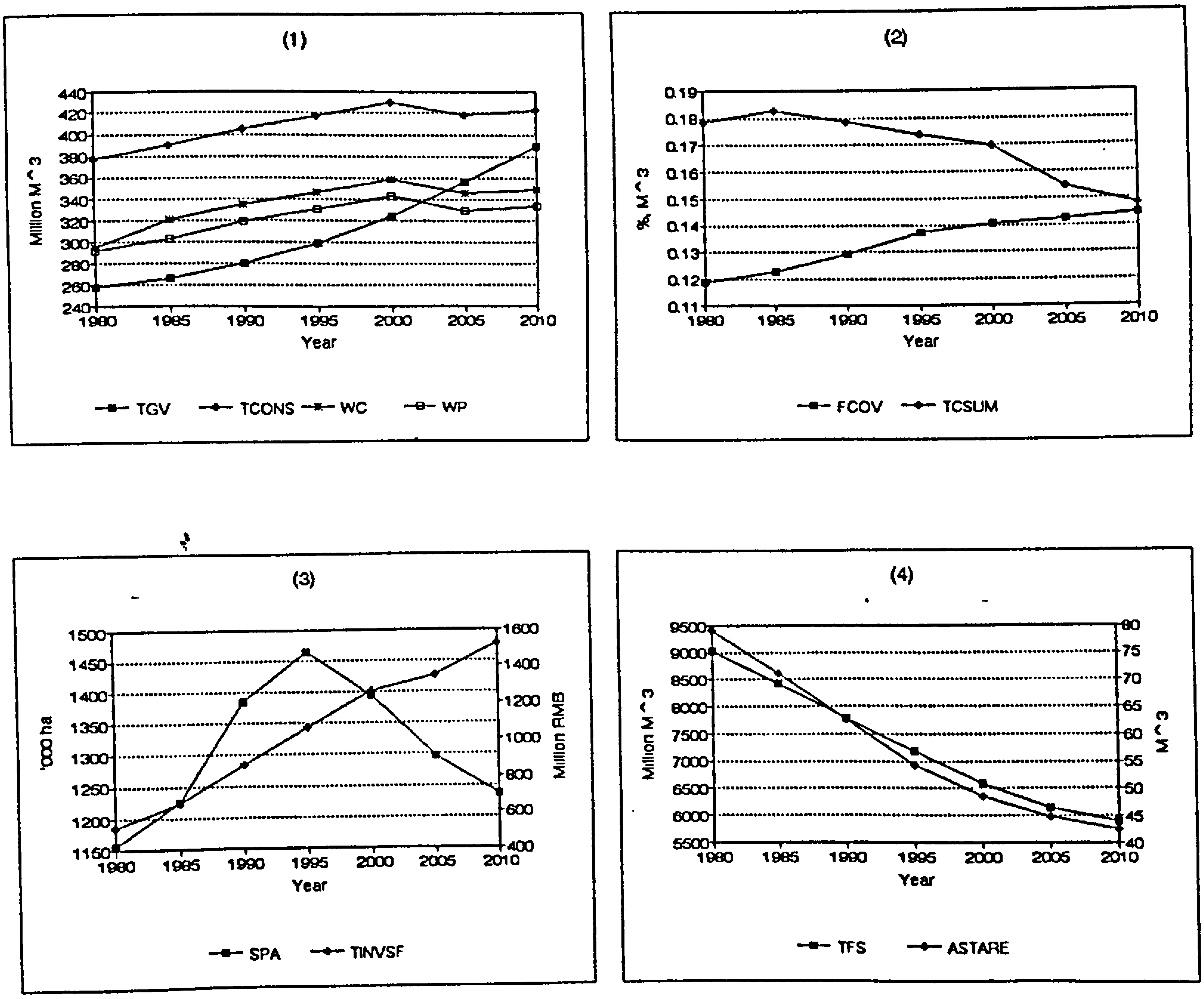
		1980	1985	1990	1995	2000	2005	2010
INVCT	Present	56	106	130	160	180	190	200
(RMB¥ bill.)	Original	56	106	120	150	165	170	180
CA2T	Present	586	730	780	820	830	840	850
(m^2 mill.)	Original	586	730	740	750	752	754	756

The outcome of this run is rather pessimistic (see Table 8.15 below and Fig. 8.8). Table 8.14 shows that if the current rapid expansion of housing construction, especially in the countryside, can not be controlled, the consumption of wood materials by the construction industry will increase steadily. This will lead to a destructive effect on the forest resource in the near future.

Table 8.15 Results of RUN-CONSTR

TIME E00	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.c.) E00	TINVSF (RMB¥) E06
1980	9028.1	11.895	257.58	377.67	294.41	291.21	79.058	1156.6	0.17851	519.5
1985	8411.1	12.322	266.39	390.02	320.52	303.85	71.073	1225.1	0.18246	654.6
1990	7787.5	12.951	279.93	404.72	335.31	318.63	62.581	1384.5	0.17871	859.9
1995	7173.1	13.751	299.06	417.33	346.74	330.18	54.261	1464.2	0.17388	1064.1
2000	6602.6	14.082	324.11	430.19	359.11	342.54	48.757	1394.1	0.16953	1263.8
2005	6156.7	14.227	356.08	417.99	346.25	329.69	44.979	1297.3	0.15454	1349.6
2010	5911.1	14.431	389.16	422.49	350.01	333.44	42.544	1236.2	0.14811	1524.3

Fig. 8.8 Results of RUN-CONSTR



8.4 Sensitivity Test: Theil Coefficient of Individual Policies

It is the purpose of this section to report a series of sensitivity tests on the policy variables, which are judged to be of most importance to the system and have been simulated individually in the last section. The sensitivity analysis in this study refers to the study of model responses to the change of the policies.

The Theil coefficient has been employed in the sensitivity analysis (Thiel, 1971). The formula of Thiel coefficient is as the following:

$$(Theil)\varphi = \frac{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y^*_i - Y_i)^2}}{\sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y^{*2}_i)} + \sqrt{\frac{1}{n}\sum_{i=1}^{n}(Y_i^2)}} \qquad (10.1)$$

where, (Theil)ϕ: Theil coefficient of parameter i (Y_i),

Y_i: value of variable Y in time period i (i = 1, 2,...n);

Y^*_i: value of variable Y in time period i with an alternative parameter.

In the present sensitivity analysis, each parameter is varied from the most likely value by ±10% to reflect the uncertainty associated with a given parameter. The results of Theil coefficients of the sensitivity analysis are presented in Table 8.16.

Table 8.16 Theil Coefficient of Sensitivity Analysis

	TFS		FCOV		TGV		TCONS	
	Coefficient	Order	Coefficient	Order	Coefficient	Order	Coefficient	Order
RTPT (Y7)	0.023502	1	0.008791	3	0.009501	3	0.059965	1
PPT (Y3)	0.02127	2	0.01002	2	0.01065	2	0.05181	2
IMPORT (Y4)	0.00392	5	0.00226	5	0.00297	5	0.03232	3
RINVFT (Y5)	0.00104	6	0.00339	4	0.00368	4	0.02746	5
HOME (Y6)	0.00044	7	0.00009	7	0.00012	7	0.02746	5
CONSTR (Y2)	0.00714	3	0.00203	6	0.00176	6	0.02362	6
PSRT (Y8)	0.00409	4	0.01172	1	0.01268	1	0.02786	4

Seven key policy variables and four endogenous variables (outcomes) have been selected. The results of this analysis presented in Table 8.16 show the sensitivity of each outcome to these policies. According to Theil, the greater the Theil coefficient, the more sensitive the variable is. Obviously, among these policies, wood product prices (PPT), resource utilization rate (RTPT) and plantation survival rate (PSRT) are the most influential variables. Increasing plantation survival rate has a very strong positive influence on forest cover rate (FCOV) and total growth volume (TGV) rather than on total forest stock (TFS) and total consumption of forest resources (TCONS). By contrast, improving resource utilization rate will improve both TFS and TCONS, but with less effect on FCOV and TGV compared with the effect of PSRT. Table 8.16 also shows that PPT are very important on all these four aspects. As discussed previously, problems in these three (RTPT, PPT and PSRT) aspects, to a large extent, result from the country's economic system. Therefore, RTPT, PPT and PSRT should be placed in first priority of forest policy reform agenda in China. Some intermediate measures have already been taken, for example, in price reform. But because of the overall hampering of the country's system, further measures are needed. Wood prices should be adjusted to the level reflecting wood production costs, wood demand and supply, the plantation survival rate and the wood utilization rate should be improved through the improvement of resource management system. In fact, some measures for reform in these aspects can be undertaken immediately, since they do not need financial inputs. Only reasonable and consistent policies are needed.

Concerning the debate about wood import saving/home development, the results of the model simulation clearly indicate that given the nation's foreign exchange constraint, wood import has some better effects on the country's long-term forestry development than home development strategy does. Wood import at the present situation can save the domestic resource from overcutting. It can play an important role to establish a healthy marketing setting which is fundamentally necessary and critical for all aspects of the forestry policy reform, including the adjustment of demand and supply of wood products.

Needless to say, investment in forestry is always important in China's case, where there is a chronic "investment hunger" in forestry, especially in silvicultural activity. However, the simulations show that the increase of investment is less important than policies mentioned above. The conclusion may indicate that the current shortage of investment in forestry can not be an adequate excuse for pessimism about forestry development in China. Much can be done to improve the current situation without a sharp increase of forest investment.

One point may also be worth making. Although the Theil coefficient of CONSTR is not large, compared with others, considering the construction industry as one of many wood consumers, it is very significant to the balance of demand and supply of wood products in China now. For the future reduction of wood consumption, the current rapid expansion of construction must be put under control. The increasing use of wood material in construction must be, to some extent, substituted by other materials. This also applies in the case of the railway industry.

CHAPTER 9

SCENARIO VARIATIONS

This chapter presents a simulation and feasibility analysis of three scenarios under the following headings:

SD-FRED provides an efficient approach to test changes in the overall economic conditions within the model. Along the lines described in the last chapter, much can be done to improve the current forest situation in China, even if no single means can entirely reverse the trend. In this chapter, the discussion on the baseline scenario will be brought further by presenting a feasibility study of three scenarios to see how the forest situation will fare under three different policy packages or assumption bundles.

A scenario may be treated as a model solution comprising a set of conditional projections, because the results are conditional on the values of the exogenous parameters; it is varied only within a limited, plausible range. To generate scenarios, a number of assumptions, both about the future values of exogenous variables and about specific causal linkages among variables are required. After a series of experiments and analysis of the base-line scenario with variations in key areas, three scenarios have been combined with selected policies for discussion. They are expected to serve as an acceptable abstraction of three possible policy packages' performance.

These three scenarios - named LOW, MODERATE, and HIGH - have no monopoly of merit, but are useful for illustrative purposes, and span quite a wide range of possibilities, both for policies and for factors beyond government control.

Considering the fact that the base-line scenario is based on the current trends and the current policies affect forest development in the near future, these three scenarios try to answer the question of what the prospects will be if the current situation is improved at low, moderate and high speeds, respectively.

In these three scenario simulations, the selection of variables depends mainly upon the results of sensitivity analysis, i.e, it depends on the influence of variables on the whole system. It also considers the most probable future trends derived from the theoretical analysis in Chapter 3 and 4, such as:

(1) increasing the role of the market mechanism through price reform affecting PPT;
(2) increasing private investment in forest affecting RRIVT and forest management intensity affecting DARET, FARET, R16T, R26T, PSRT etc. through the extension of the so-called production responsibility system and the demarcation of forest ownership;
(3) increasing the forest growth rates affecting GRYT, GRMT, GROT and the resources utilization rate affecting RTPT through technological progress and more intensive management;
(4) increasing government investment affecting RINVFT through government and non-government sources, through private and public sources, and through producers and consumers of wood products;
(5) increasing import affecting IMCOST through open-door policy and narrowing the gap between domestic product prices and imported prices;
(6) increasing the demand due to the increase of population and personal income, etc.

In short, these scenarios are formed by the consideration of two aspects:
(1) developing new forest resources;
(2) efficient use of existing resources.

They also reveal a number of specific questions and problems, which will be addressed later in the next chapter.

9.1. Low Scenario

9.1.1 Main Changes from the Baseline

Parallel with the base-line assumption, the low scenario assumption is made. Table 9.1 shows the changes of parameters from the base-line scenario.

Table 9.1 Estimates of Some Parameters for Low Scenario

	1980	1985	1990	1995	2000	2005	2010
PPT (RMB¥)	70.46	94.17	120.00	122.00	124.00	126.00	128.00
RINVFT (%)(E-3)	1.97	1.27	1.27	1.27	1.27	1.27	1.27
PSRT	0.35	0.35	0.38	0.40	0.42	0.45	0.48
INVCT (RMB¥)(E9)	55.90	106.00	125.00	155.00	165.00	170.00	180.00
CA2T (m^2) (E6)	586	730	750	770	790	810	820
IMCOST (RMB¥)(E6)	749	3860	4057	4264	4481	4709	4950
F26T (ton)(E6)	61.50	–	83.30	–	84.00	–	85.0
RRIVT (E-3)	14.19	–	15.00	–	15.00	–	15.00

	1980-1990	1995	2000-2010
TRASVT (RMB¥)(E8)	0.00	0.00	19.30
GRYT (E-3)	98.97	98.97	100.00
GRMT (E-3)	40.66	40.66	40.88
GROT (E-3)	10.70	10.70	10.80
R16T (E-3)	1.00	5.00	10.00
R26T (E-3)	1.00	5.00	10.00

	1980-1990	1992	1994-2010
RTPT	0.60	0.60	0.65
DARET (ha)(E3)	887.26	700.00	700.00
FARET (ha)(E3)	392.57	300.00	300.00

In this scenario, the variations for most variables are changed slightly. For example, from 1985 to 2010, wood price (PPT) increases from RMB¥94.17 to RMB¥128, the survival rate of plantation (PSRT) from 36% to 48%, the utilisation rate of forest resources (RTPT) from 60% to 65%, so are the cases of forest growth rates (GRYT, GRMT, and GROT) and others; the areas suffering annually from forest diseases and insects and from forest fire (DARET and FARET) decrease slightly from 887,260 ha in the 1980s to 700,000 ha during the rest of the period studied. Some of them keep a constant trend from the 1985 level, e.g., the share of investment in silviculture to the national total capital investment (RINFT) is 0.127%, and the rate of re-investment in forest silviculture from the forest farms and companies (RRIVT) is 1.6%, through the whole period under study. The changes in some parameters, however, are relatively higher than those mentioned above, this is based on the assumption that, given a constant wood consumption per capita, the total consumption increases proportionally in line with the increase of population. Therefore, the importation cost of wood products (IMCOST) rises from RMB¥3860 million in 1985 to RMB¥4950 million in 2010, and the same trend is assumed for the consumptions in housing construction and coal production sectors.

9.1.2 Outcome of the Low Scenario

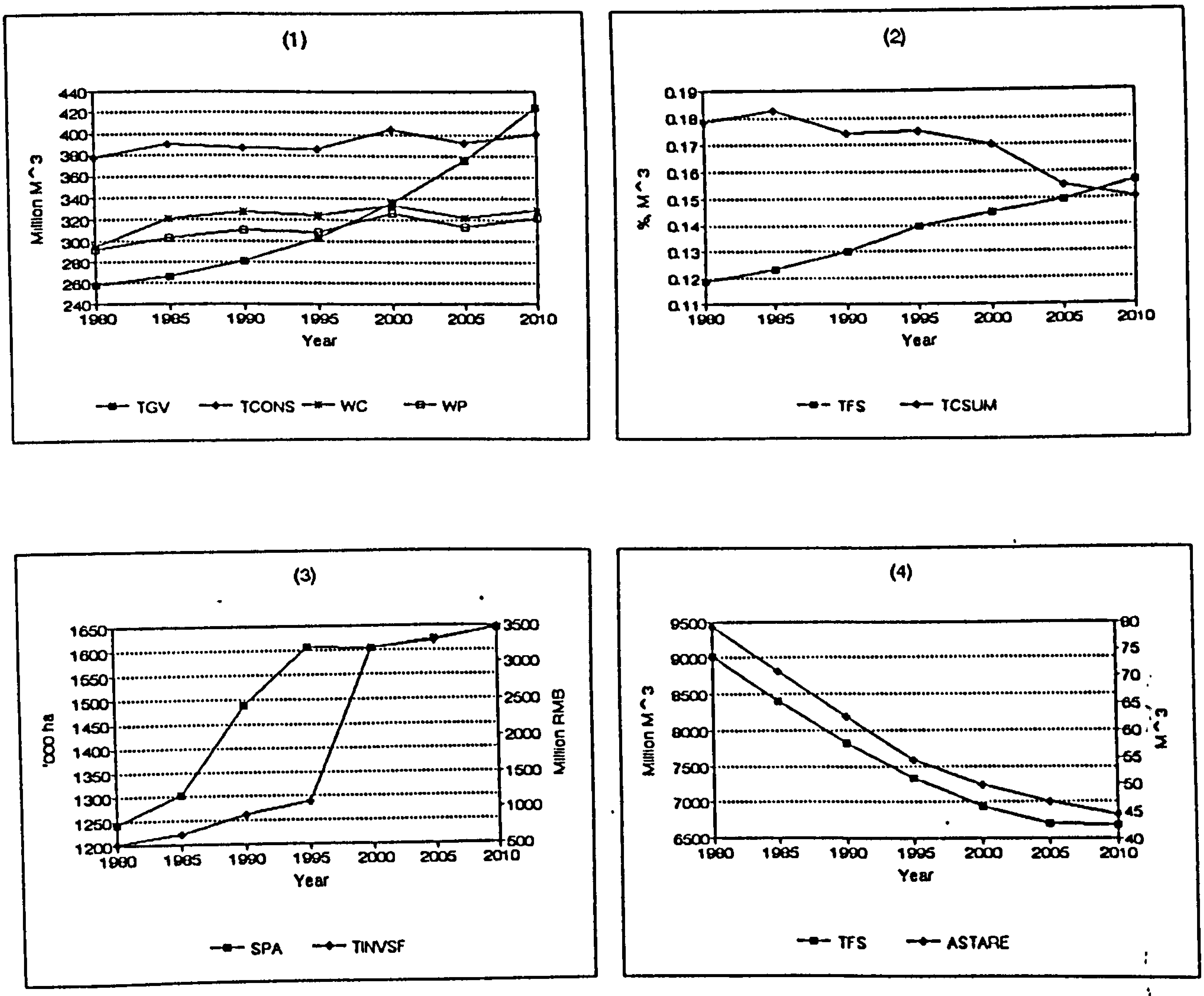
Under the above assumptions, the outcome of the RUN-LOW scenario is summarised and presented in Table 9.2 and Fig. 9.1 in the following page.

Table 9.2, together with Fig. 9.1, shows that the trend of resource decrease will continue until year 2007, in which total forest stock will fall to a minimum of 6620 million m^3, the annual total growing volume will be equal to the annual total consumption of resource, about 396 million m^3 per year, and the average stock per ha forest land will be 45.68 m^3 dropping from 79.058 m^3 per ha in 1980, with an increase of forest cover rate from 11.895% in 1980 to 15.207%. Then, the annual growth will be greater than annual consumption, hence, the total stock will possibly increase. But the problem will, at that stage, be that there will be no mature resource for harvesting due to the abnormal age-structure of forests, and due to the low average stock per unit of forest land (see Fig. 9.1).

Table 9.2 Simulation Result of RUN-LOW

TIME	TFS	FCOV	TGV	TCONS	WC	WP	ASTARE	SPA	TCSUM	TINVSF
	(m^3)	(%)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3/ha)	(ha)	(m^3/p.c.)	(RMB¥)
E00	E06	E00	E06	E06	E06	E06	E00	E03	E00	E06
1980	9028.1	11.89	257.58	377.58	294.32	291.12	79.058	1243.5	0.1786	519.5
1985	8411.9	12.34	266.89	390.18	320.41	303.72	90.931	1302.8	0.1825	654.4
1990	7828.2	13.03	281.63	386.88	327.11	320.44	62.504	1490.1	0.1744	921.3
1995	7335.8	13.97	303.69	385.91	323.75	328.41	54.616	1605.6	0.1752	1078.4
2000	6948.1	14.50	336.22	404.47	334.12	326.47	49.803	1603.4	0.1702	3195.1
2005	6705.3	14.94	375.73	392.82	321.82	314.16	46.655	1623.7	0.1550	3285.5
2010	6700.2	15.65	425.01	401.09	329.35	321.69	44.478	1644.2	0.1504	3474.4

Fig. 9.1 Results of RUN-LOW



In the initial stage of the depletion, the retrogression of both resource quality and age-structure is usually ignored. As soon as the mature resource will be used up, the forestry situation in China will be like that in Great Britain in the early part of this century. That is, the wood supply will rely mainly on import, if there will be enough wood products exported in the world market and if China's economic power will be strong enough to import them. In any case, this scenario suggests that the current policies or the slight improvement of the current policies can not rescue the forestry crisis in China, as the decreasing trend of resource will continue until around 2007. Then it will be difficult to restore the forest stock even to the present level by 2030.

9.2. Moderate Scenario

9.2.1 The Main Changes

As shown in Table 9.3, the growth rates in this scenario are higher than those in the base-line scenario and the low scenario. Compared with the low scenario, this scenario assumes that while other factors increase slightly, two notable changes in this run are made. The aggregate price of forest resource and the investment rate in forestry will increase considerably from the 1990s level. It also assumes that, from 1995, China will spend more money to balance the demand and supply of wood products. Instead of just increasing imports, about 50% of the increased expenditure for wood import will be transferred to home development while the absolute figure of import keeps to the current level (about 10 million m^3 per year).

Table 9.3 Estimates of Some Parameters for Moderate Scenario

	1980	1985	1990	1995	2000	2005	2010
PPT (RMB¥)	70.46	94.17	140.00	142.00	144.00	146.00	148.00
RINVFT (%)(E-3)	1.97	1.27	1.34	1.34	1.34	1.34	1.34
PSRT	0.32	0.35	0.40	0.43	0.45	0.50	0.55
INVCT (RMB¥)(E9)	55.90	106.00	130.00	150.00	165.00	180.00	185.00
CA2T (m^2)(E6)	586	730	760	800	810	820	830
IMCOST (RMB¥)(E6)	749	3860	4261	4705	5195	5736	6333
F26T (ton)(E6)	61.50	–	83.50	–	88.00	–	90.00
RRIVT (E-3)	14.19	–	16.00	–	16.00	–	16.00
		1980-1990		1995		2000-2010	
TRASVT (RMB¥)(E8)		0.00		19.30		19.30	
GRYT (E-3)		98.97		98.97		110.00	
GRMT (E-3)		40.66		40.66		41.00	
GROT (E-3)		10.70		10.70		11.00	
R16T (E-3)		1.00		8.00		15.00	
R26T (E-3)		1.00		8.00		15.00	
		1980-1990		1992		1994-2010	
RTPT		0.60		0.60		0.70	
DARET (ha)(E3)		887.26		621.00		621.00	
FARET (ha)(E3)		392.57		274.80		274.80	

Apart from two notable changes remarked above, the variations for most other parameters in this scenario are also rather considerable, except for the increase of construction area (CA2T) and the rate of re-investment in forest from forest farms and companies (RRIVT) whose changes are relatively small. For example, it is assumed that, from 1985 to 2010, wood price (PPT) increases from RMB¥94.17 to RMB¥148 (57% increase), the survival rate of plantation (PSRT) from 35% to 55%, the utilisation rate of forest resources (RTPT) from 60% to 70%. The same is true in the cases of forest growth rates (GRYT, GRMT, and GROT) and many others; the areas suffered annually from forest diseases and insects and from forest fire (DARET and FARET) decrease from 887,260 ha in the 1980s to 621,000, and from 392,570 to 274,80, respectively, during the rest part of the period studied. The share of investment in silviculture to the national total capital investment (RINFT) increases from 0.127% in baseline to 0.134%, and the rate of re-investment in forest silviculture from forest farms and enterprises (RRIVT) is 1.6%, through the whole period under this study. While the importation cost of wood products (IMCOST) rises gradually from RMB¥3860 million in 1985 to RMB¥4950 million in 2010, the home development of forestry, to some extent, is enhanced through transferring some money from wood import to joint-venture investment in forest between end-users and producers, from 1995 onwards.

9.2.2 Outcome of the Moderate Scenario

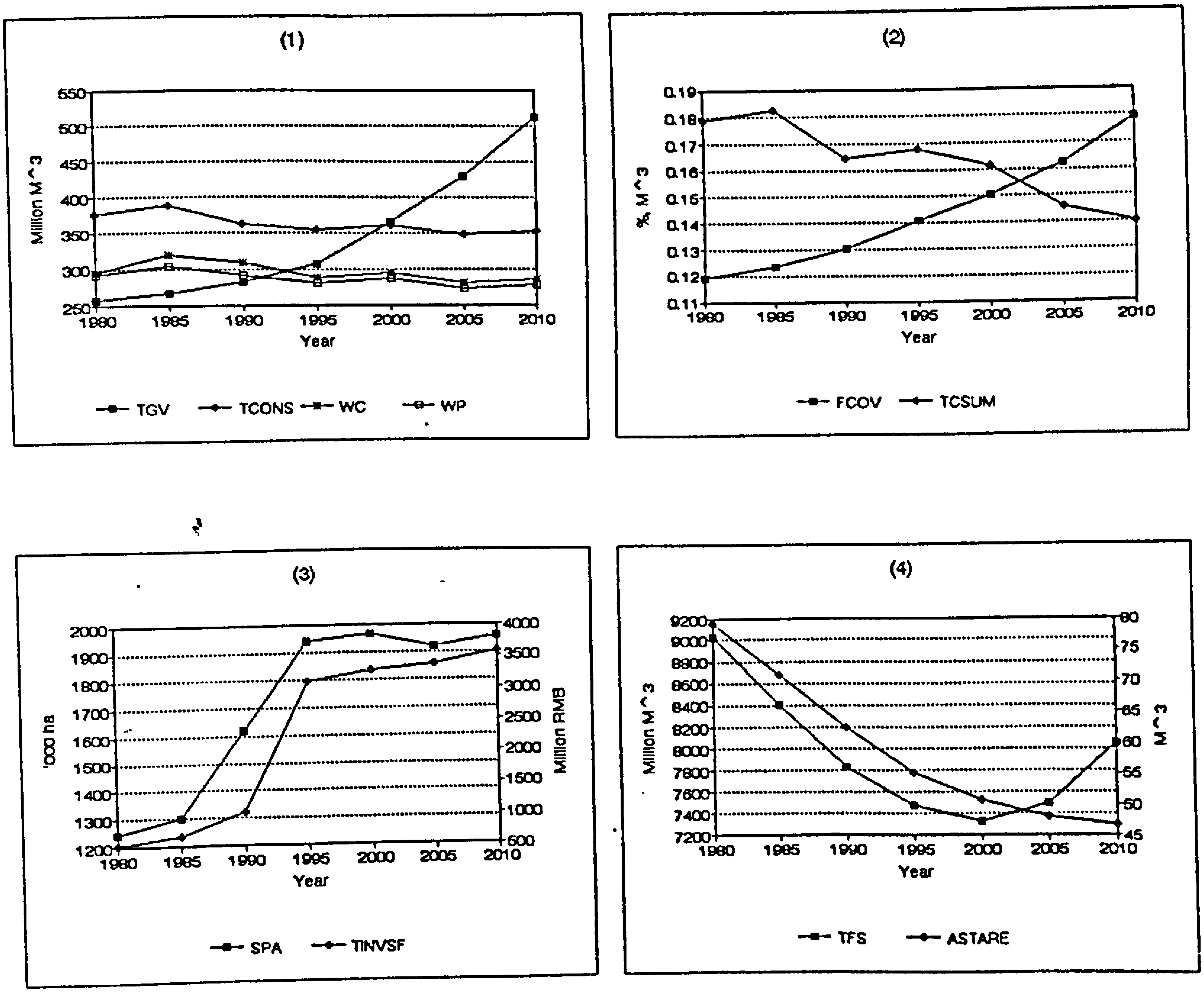
The results of this run of SD-FRED are illustrated in Table 9.4 and Fig. 9.2.

Table 9.4 suggests that, in this scenario, total consumption of the resource must be controlled tightly. The gap of increased demand with slightly decreased supply will be met by both increase of resource utilization rate and by the encouragement of substitution of wood by other materials. If that can be done at the rates assumed in this scenario, the depletion will be stopped around the year 2000, in which, the total forest stock will drop to the lowest level, 7327 billion m^3. Then, it will start to increase and will have arrived at the current level in the year 2015. Compared with the previous two scenarios, this one seems fairly promising. However, the average stock per unit of forest land will still be low due to the abnormal age-distribution. This scenario indicates a better prospect, but the imbalance of demand and supply will last for a long period.

Table 9.4 RUN-MODERATE

TIME E00	TFS (m^3) E06	FCOV (m^3) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.c.) E00	TINVSF (RMB¥) E06
1980	9028.1	11.895	257.58	377.58	294.32	291.12	79.058	1243.5	0.1786	519.5
1985	8411.9	12.348	266.89	390.18	320.41	303.75	70.931	1302.8	0.1825	654.4
1990	7838.1	13.051	282.01	364.16	308.31	291.64	62.497	1619.4	0.1644	1035.8
1995	7474.4	14.109	306.49	354.77	288.31	281.19	55.106	1939.3	0.1680	3111.3
2000	7327.5	15.041	366.46	361.41	294.44	287.33	50.671	1966.3	0.1615	3286.1
2005	7497.6	16.231	429.62	348.72	281.11	273.99	48.033	1919.7	0.1458	3373.7
2010	8050.6	17.927	512.88	353.44	285.07	277.96	46.686	1955.9	0.1402	3566.1

Fig. 9.2 RUN-MODERA



9.3. High Scenario

9.3.1 The Main Changes

The high scenario describes a future that is based on two assumptions: (1) a rapid increase of the nation's comprehensive economic capacity; (2) desirable effects of a set of economic policy changes on forest development (including the positive effects of prices on utilisation of resource, a higher investment rate in the development of forest, a higher survival rate of plantation, etc.) and maximum reduction of resource wastes (including the high utilisation rate of resource, low man-made and natural disasters etc). The major changes of the assumptions are shown in Table 9.5.

Table 9.5 Estimates of Some Parameters for High Scenario

	1980	1985	1990	1995	2000	2005	2010
PPT (RMB¥)	70.46	94.17	140.00	144.00	148.00	152.00	154.00
RINVFT (%)(E-3)	1.97	1.27	1.66	1.66	1.66	1.66	1.66
PSRT	0.32	0.35	0.44	0.52	0.56	0.63	0.65
INVCT (RMB¥) (E9)	55.90	136.00	135.00	155.00	170.00	185.00	200.00
CA2T (m^2)(E6)	586.00	730.00	780.00	820.00	830.00	840.00	850.00
IMCOST (RMB¥)(E6)	749.00	3860.00	4475.00	5187.00	6014.00	6972.00	8082.00
F26T (ton)(E6)	61.50	–	83.30	–	90.00	–	100.00
RRIVT (E-3)	14.19	–	17.00	–	17.00	–	17.00

	1980-1990	1995	2000-2010
TRASVT (RMB¥)(E8)	0.00	19.30	38.60
GRYT (E-3)	98.97	98.97	111.00
GRMT (E-3)	40.66	40.66	42.00
GROT (E-3)	10.70	10.70	11.50
R16T (E-3)	1.00	15.00	20.00
R26T (E-3)	1.00	10.00	20.00

	1980-1990	1992	1994-2010
RTPT	0.60	0.65	0.70
DARET (ha)(E3)	887.26	500.00	500.00
FARET (ha)(E3)	392.57	220.00	220.00

As can be seen from Table 9.5, the changes of parameters made in this scenario are remarkable, compared with the previous two scenarios.

One feature of the assumptions in this scenario is the high rate of government investment in forestry silviculture which is 0.166% of national savings. Given the total amount of the national capital investment, the share of governmental investment in forestry is entirely decided by the investment policy. The assumption of the annual investment rate (0.166%) for the future is higher than the present level (0.127%), but is lower than the 1980-1985 level (0.2614%) and the level from 1952 to 1986 (0.2426%).

With a fixed share of the central government investment in forestry in the scenario, the investment from small producers and from forest enterprises will increase significantly from RMB¥473.9 million in 1990 to RMB¥1211.3 million in 2010. Meanwhile, the additional investment transferred from the importation expenditure of other end-use sectors to afforestation will increase sharply from 1992 to 2000, and will reach 3860 million RMB¥, then will remain steady while the import continues at the current year's level, 10 million m^3 annually. Obviously, these investment policies have the following characteristics:

(1) encouraging the producers toward investment in forestry through proper income distribution policies (such as price policy and taxation policies), through the government subsidy policy and through laws and regulations;

(2) increasing home forest resources, to meet the future demand for wood products and forest site-services.

The increased amount of money either transferred from import or arising from other industrial sectors to home plantations is based partly on the government's intervention (administrative means) and partly on the degree of openness (economic means). Import is critical presently and in the near future as it not only supplies some specific products (i.e., some particular species or some large-size timber) for today's demand, but also rescues the home resource from depletion for future reproduction. However, as said previously, home development must be considered as the first long term priority both for economic reasons and environmental reasons, hence, it is assumed that the annual increase rate of timber import for the next 10 years will be about 6.5%, which will be in line with the planned national economic growth, but much lower than the average annual increase rate of the country's import during the 1973 -1983 period, which was 23.2%. It is also assumed that the increase of money for importing timber will be transferred to home development by 20% of the current level from 1992 and 100% of the current level from the year 2000, while the net import still keeps at 10 million m^3 annually.

The second notable feature of the assumption is a high resource utilization rate and a high plantation survival rate. The former is based on the two considerations:

a. the increasing price of wood products, and the increasing consumption will stimulate and encourage the improvement of the forest utilization rate, and
b. technological progress will provide the technical possibility for improvement.

The latter is based on the fact that the production responsibility system and the privatisation of collective forest resources make the success of plantations closely linked to the farmers' final benefit. These changes together will positively affect the forest growth rate and resource management, hence they will probably improve forest resource utilization rate and plantation survival rate.

It is also assumed that, from 1985 to 2010, wood price (PPT) increases from RMB¥94.17 to RMB¥154 (about 63% increase), reflecting closely world market prices; the survival rate of plantation (PSRT) from 35% to 65%; the utilisation rate of forest resources (RTPT) from 60% to 75% (still much below the level of industrialised countries). Improvement also takes place in other aspects of forest management, such as increasing forest growth rates (GRYT, GRMT, and GROT) and reducing resource loss from forest diseases, insects, and forest fire (DARET and FARET) during the rest part of the period studied.

9.3.2 Outcome of the High Scenario

Some results of the simulation are shown in Table 9.6 (also see Fig. 9.3).

Table 9.6 RUN-HIGH

TIME E00	TFS (m^3) E06	FCOV (%) E00	TGV (m^3) E06	TCONS (m^3) E06	WC (m^3) E06	WP (m^3) E06	ASTARE (m^3/ha) E00	SPA (ha) E03	TCSUM (m^3/p.a.) E00	TINVSF (RMB¥) E06
1980	9028.1	11.895	257.58	377.58	294.32	291.12	79.058	1243.5	0.1786	519.5
1985	8411.9	12.348	266.89	390.18	320.41	303.75	70.931	1302.8	0.1825	654.4
1990	7851.2	13.075	282.51	357.79	308.31	291.64	62.491	1744.4	0.1644	1168.1
1995	7549.8	14.251	309.42	342.08	272.79	266.17	55.107	2318.7	0.1747	3253.5
2000	7541.9	15.435	382.44	356.37	275.31	275.33	50.821	2573.1	0.1701	5412.6
2005	7909.1	17.033	457.61	347.22	260.37	260.41	48.289	2739.4	0.1525	5528.5
2010	8734.4	19.249	557.88	349.81	264.01	264.03	47.181	2853.7	0.1465	5762.6

Fig. 9.3 Results of RUN-HIGH

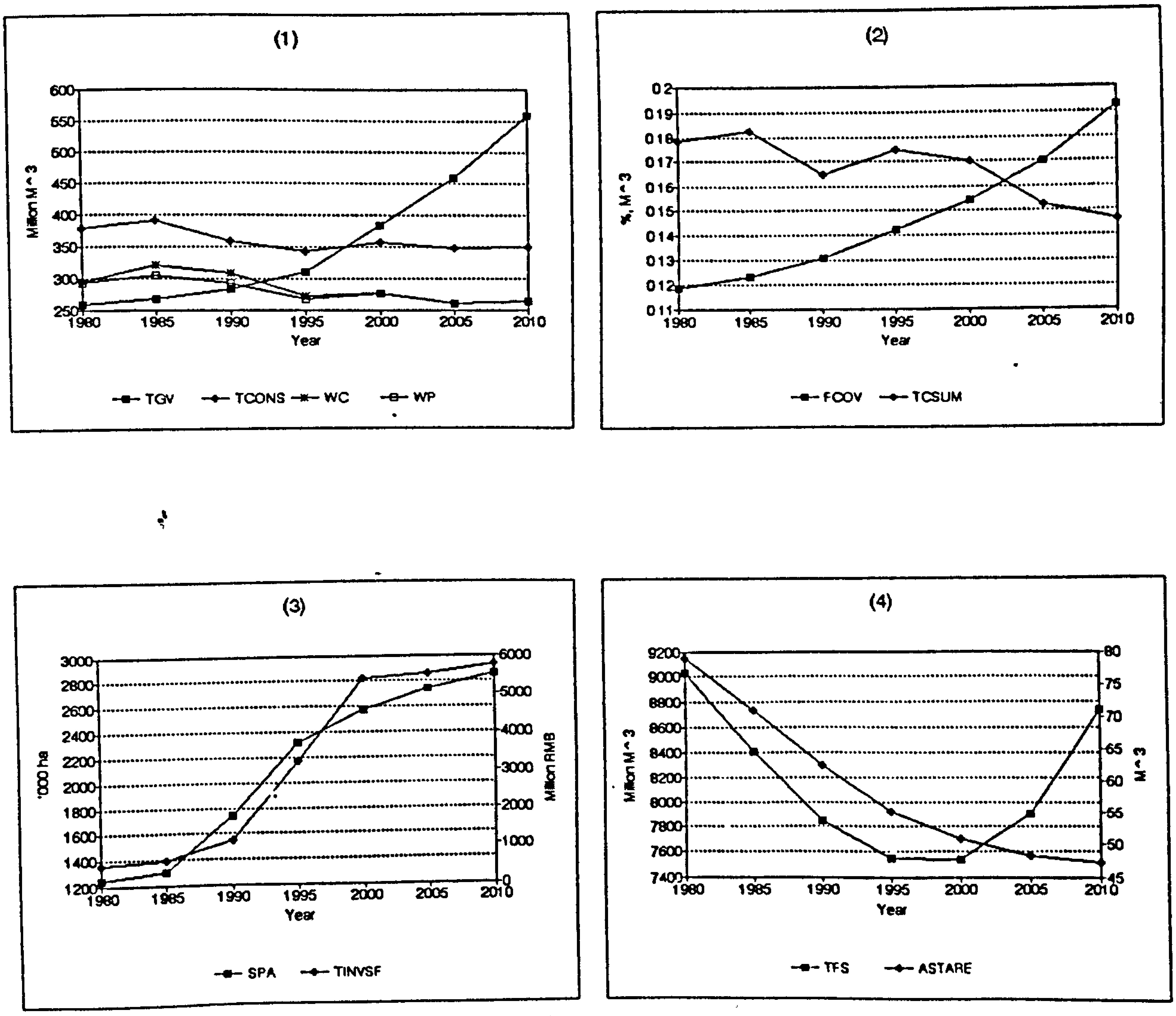


Table 9.6 indicates that if forest development will follow the path of the assumptions described in this scenario, resource depletion will be stopped, and forest stock will drop to a minimum of 7500 million m^3 by the year 1997, and will regain the level seen in 1985 (8411.9 million m^3) by the year 2009. Then, the total stock will keep an increasing trend. There will be a significant effect on the forest cover rate. Thus, the forest development in China will pass a turning-point and start to escape from the current vicious circle. Even if this stage is reached, however, China's forestry development will still have a long way to go to establish a sustainable structure of resource and to attain enough inventories for a sustainable growth.

It must be pointed out that the rather optimistic results produced from this scenario are based on substantially reduced total consumption of forest resource effected by all means. Despite the increase of population and the increase of construction considered in this run, the total annual consumption of the domestic forest resource will fall from 357.79 million m^3 in 1990 to 349.81 million m^3 in 2010, and the wood consumption per capita will fall from the 1990s level. However, these two figures are still higher than the corresponding indicators from other scenarios described previously. The reduction of total consumption will be mainly due to the substitution of fuelwood by other fuel materials and the economical use of raw resources. Consequently, this will change the consumption patterns. That is, instead of the reduction of fuelwood consumption per capita, the householder's other consumption of some end-use products (e.g. paper consumption) will increase and other uses will be steady (e.g. furniture consumption, building consumption). Obviously, if wood consumption can not be controlled and wood utilization can not be improved at the level described above, the outcome of China's forestry programme will vary from the picture portrayed in this scenario.

9.4. Feasibility Analysis of the Scenarios

If there was no scarcity of resources, there would be no need for any economist in the world; similarly, if the assumptions made for those scenarios are one's pure wishes, the results from the scenario simulation will barely provide society with any practical value. Therefore, one critical question to be addressed is how realistic and achievable those scenarios are, with a consideration of the country's current situations and its development trends toward the near future. Obviously, the feasibility analysis here needs to be focused only on the high scenario which stands for desirable policy changes.

The factors affecting China's development of forest resources are many, but the driving forces, as found by this simulation study, are a few, namely, investment in forest, pricing policies, the utilisation rates and the incentive of efficiently managing the forest resource. These issues have been argued in the relevant sections of previous chapters, and the bases of the assumptions made for the simulation have been provided in Chapter 6 and Chapter 7. Much improvement of those driving forces, to a large extent, relates to the policy or institutional changes. Three points regarding the high scenario particularly are emphasised below.

1. INVESTMENT

As stated above, the share of government investment in forest assumed in the high scenario (0.166%) is much lower than the 1980-85 level (0.2614%) and the average level of 1952-86 (0.2426%), thus, this assumption is entirely feasible. Increasing the investment in forest silviculture is a critical and necessary means in China's forest development. This is based on the belief that the current investment policy is not appropriate as it inclines towards the view of short-term economic growth and ignores long-term development, and that China should avoid the failures occurred in the early stage of the industrialization process in many industrialized nations, especially in Great Britain. Therefore, it is desirable to raise the forest share of national investment.

The assumption of the investment from other sources seems fairly optimistic, but not entirely impossible. As argued in Chapter 6 of this study, the availability of total financial resource to forestry has risen markedly during the last few years. In the south and coastal area of China, there have been an increasing number of family forest farms established during the last ten years, there have also been an increasing amount of money invested in forestry in those areas from some international organisations (such as World Bank, FAO), foreign companies and overseas Chinese. Moreover, joint-venture between wood-users (such as timber factories, paper manufacturing companies, city's construction bureaus, railway companies etc.) and forest producers has become an effective way of increasing investment in forestry. The evidence shows that the potential investment from those sources is enormous.

2. Success Rate of Plantation and the Utilisation Rate of Forest Resources

There is no doubt that it is possible to raise the success rate of plantation from 30-35% (the current level) to about 60%, from a technical viewpoint. By most international standards, 60% utilisation rate is very low. In many industrialised countries, the rate is over 95%. Therefore, 20-30% increase of the rate as assumed in this scenario is achievable.

3. The Cost of Alternative Policies Adopted in the Scenarios

No extra requirement has been made for increasing the total land for forestry use, the increase in plantation will take place on the land allocated to forest use but currently wasted. There is no constraint of labour force to the forest development in China either, as unskilled and unemployed labour is abundant and always available. Those labourers need to be supported by the society one way or the other, thus the opportunity cost for employing those may be zero, even negative.

The cost of capital investment is not a simple issue to be tackled, a conceivable analysis of the aspect links to many serious economic debates which is beyond the scope of this study. Given the fact that forest must be developed and the demand and supply of wood products in China has to be balanced (as stated in the Seventh Five-year Plan of the PRC for Economic and Social Development) by some means or other, then the crux question is not whether China should invest in her forestry, but what the affordable share of investment in forestry should be, by which way (import/home development) the wood demand should be met without depleting the home forest resources, and at what speed (how much at the present/in the future) the investment should occur. In this sense, the study focuses on these questions, and has already given some answers.

9.5. Summary of the Scenario Simulation

Results produced from the above scenarios are intended to be indicative of the broad range of policy problems which can be addressed with small or larger changes from the base-line scenario. These scenarios are combined with the consideration of the sensitivity analysis of single policy change carried out in the last chapter.

Under the different scenarios, the trends of China's forest system will differ. RUN-LOW is not acceptable in every sense. If the policy package as illustrated in RUN-MODERATE is adopted, the situation will be improved somewhat, but the problems will last for a considerably long period. With the HIGH-RUN assumption, the system will be substantially improved by 2010, i.e., the depletion of resources will be stopped early, but the mature stock for wood production will still be in short supply, and the forest will still not emerge from a transitional stage. This is because of the long time lags in implementing any major reform policies and in the reproduction of the forest resource in the wood supply-and-demand systems. The scenario analysis shows that no single policy change alone and no combined policies in the short-term can reverse the current forest crisis in China; immediate "independent and self-sufficient" goals as suggested by some economists (Liu, 1988) are unacceptable.

CHAPTER 10

CONCLUSION AND DISCUSSION

This chapter ends up with the following points:

This study starts with a brief introduction to and analysis of China's economic system, its reform and the forestry sector, and highlights the main features and problems. Then an analysis is focused on the exploration of some deep-rooted causes of the unbalanced demand and supply of the forest resource in the context of the national economic system and policy variations during the last 40 years. Based on a broad review of several modelling methods in general, and a close examination of the system dynamics (SD) method in particular, this study identifies some key questions, problems and pitfalls in those methods. This is undertaken with an explicit recognition of the critical difference between the Chinese central planning system, and a market economic system, and of the difficulties for modelling forest economic problems in China's case.

The study chooses SD as a tentative approach to tackle these problems, and discusses the possibility of improving SD in two areas: parameter estimation and formula identification. The application of the SD approach is also combined with the statistics method. SD-FRED has been designed to describe the real system and to simulate the long-term trends of forest resource production and consumption. Enormous efforts have also been made in gathering a variety of statistical data from various sources, in calibrating and processing those data, and in establishing relationships between many variables employed in the model. Consequently, the model has some outstanding features, such as dynamics, the reflection of a mixed economic system, the linkage between economic and biological systems, aggregation, and scenario analysis. The author believes that the simulation of SD-FRED not only contributes a logical and consistent framework for studying China's forest issues in an experimental setting, but also generates some interesting points for policy-makers' consideration and for further research.

10.1. Conclusions

The baseline run and three scenario simulations as well as the theoretical discussions lead to some interesting results. The main conclusions can be drawn as follows:

1. THE RESULTS FROM THIS STUDY VERIFY A PREVIOUS STATEMENT THAT CHINA'S FORESTRY IS FACING A CRISIS

The current forest resource crisis is the result of the long-standing overlogging during the last few decades, but inappropriate policies have aggravated forest resource depletion (refer to 9.1.2). The critical shortage of forest reserves will probably not be resolved in the next twenty years. Even with the most optimistic scenario (High-run scenario), there is a sign of better prospects in terms of growth/drain by 2010, but the mature stock will still be in short supply (9.3.2). It will take 20 years from now to recover the forest stock to the level held in 1985, and several decades to re-establish a sustainable structure of forest-age groups. If the current trends continue, while forest cover rate will keep on an increasing trend for some time, the depletion of forest will be accelerated. Around the year 2000, the mature stock will be used up, except for two million ha of inaccessible resource. As soon as the main harvest is focused on the immature stock, a dangerous situation will befall the whole forest system. At that stage, the forest resource in China will not be restored in a short period even at a higher price. The results generated from this study disagree with some prevalent opinions:

(1) It may be naive to cheer the slight increase of forest cover rate. There is no doubt about the achievement of the "four-side plantations", shelter-belt forest, and agroforestry in the rural areas, but compared with the rapid depletion of the commercial forest's resource, these achievements can only contribute very little help in terms of supply of wood products. As soon as the natural forest is used up, there will rarely be any sizeable forest to be harvested. It would be dangerous if the forest development strategy is overwhelmingly focused on forest cover rate. The forest cover rate is an important indicator only if it stands for a rational age-structure and area-structure of forests. It would also be blind optimism if one believes the opinion of 'after harvesting the mature, then the middle-aged will be mature, and then the young'.

(2) Although other forests (including agroforestry, shelter-belt forestry, etc.) are playing a role in agricultural use of wood products, not too much can be expected in the balance of demand and supply, because of their small share of land use (as shown in Table 2.2), and because of their ultimate function which, after all, is to protect agriculture and environment rather than to provide for wood production.

(3) If the current crisis of demand and supply of forest products is the result of depletion which occurred during the past few decades, then the continuing over-cutting will lead to future crisis. Even if the assumed transitional forest policies are implemented from now on, a considerable long-rotation will be needed (at least 40 years according to this study) for regulating the forest system. Some temporary means, such as planting fast-growing forests with short-rotation, increasing import substitutions, will certainly be helpful, but only to a limited degree. Hence, the crisis will continue for quite a long period in the future. This study finds that, given the total forest stock in the early 1950s which was not as low as what the official statistics states, the failure of forest development in China during the last four decades was attributable to the low growth rates of forests and the low success rates of plantations. Thus, one insight can be inferred from this finding that the productivity of a renewable resource (like forest) may

be more important, in terms of sustainable development, than the resource stock itself.

(4) The average aggregated growth rate (%) is another mis-informative indicator. The decrease of total forest resource may lead to the increase of average aggregated growth rate due to the change of the age-structure, but it also results in the fall of the average stock per unit forest land, and hence degrades the quality of forest resource and decreases the total reserves.

(5) Referring to the 'import/home development' debate, the result of simulation reveals that, at least with the current situation, any reduction of import of logs will accelerate the depletion of domestic resources, before the young (even fast-growing) plantations become harvestable (refer to 8.3.6).

(6) Some measures, such as the increase of investment, of the plantation survival rate, of the utilization rate of raw wood, and the increase of wood products prices, will bring some positive effects to forest development, but the increases of those factors themselves have limitations. Realistically, as the sensitivity analysis (see 8.3) shows, there are not too many choices left, and no one single policy change alone can solve the resource crisis in China's forestry.

2. THE ESTIMATED DEMAND OF THIS STUDY APPEARS SIGNIFICANTLY GREATER THAN THE FIGURE FOR PLANNED DEMAND

This study believes that the figures from the so-called "central plan" only provide the public a pseudo-safeguard, if it does anything, since it underestimates, or even ignores the huge proportion of necessary consumption outside the government's integrated plan, such as agricultural use, fuelwood and various wastes. The estimated demand in the model is conservative rather than exaggerative as the model has already taken into account some possible substitution and higher utilization rate of raw material. Moreover, it will be difficult to reduce demand further, considering the steady population increase and economic growth. In fact, the average consumption per capita in China is only about 40% of the world average. Within this low level per capita consumption, 67% is productive (intermediate) consumption, only 33% is consumed by householders.

The result of this study indicates that, in any case (scenario) (refer to 8.1.2; 2.2.2; 8.3.2), in order to keep pace with a booming economy, the net overlogging may continue at least until year 2000. By then, overlogging is expected to be doubled from the 1980s figure.

3. CHINA'S DEMAND WILL HAVE TO BE MET MAINLY BY ITS OWN SUPPLY AT LEAST FOR THE NEXT FEW DECADES

Unlike Japan or Great Britain whose wood supply mainly relies on imports, China's poor economy and huge total demand, and especially the shortage of foreign exchange make it impossible to rely on importation for wood supply. In the current circumstances, however, increasing wood import is one of the few choices for China to save the domestic forest resource for future development, unless the balance of total resource growth/removal is achieved and a certain amount of mature resource required by sustainable forest development is available. To meet the demand without depleting the domestic forest resource, international trade in forest products becomes an increasingly critical issue for the government policy agenda, both to narrow the current gap between wood demand and wood supply, and to aid the forest sector's success in rebuilding China's forest resources within a relatively short period of time. Some economists have argued for the comparative advantage of home development. Yet the results from this study show that under the current resource and technical circumstances, the reduction of import may only accelerate the destruction of the immature resource base, and damage long term efficiency, even though it is absolutely true that forestry and its efficiency must begin at home. Consequently, China's comparative advantage in home forestry development, if there is such a thing, will be eliminated by the country's currently low resource reproductivity. Thus, given limited foreign exchange, China should increase its wood import as much as her economic power allows to do so.

4. INVESTMENT POLICIES NEED READJUSTMENT

Financial resources are always short in all developing countries and foresters have not convinced the national policy-makers of the sector's importance: this is the case in China. Therefore it is not realistic to require the central government to increase investment as much as desired by foresters. The result of this study shows that, in China's present circumstance, the total forest investment can be increased considerably by increasing producers' profits through increasing wood price and governments' subsidies for private forester's afforestation. In this way, the investment in the future will mainly come from producers or other industrial enterprises. By the year 2010, the total investment in forests will rise about eleven times as much as the 1980 level, while the investment from the central government will only increase 2.37 times under the high scenario.

5. PRICE AND PROFIT MECHANISMS SHOULD BE ENHANCED

This study has simulated the effects of the increase in wood prices at three different levels occurring at different points in time. The results show that, under China's present circumstances, the earlier and sooner the price increase occurs, the more economic the forest resource use and the smaller the inertia of the resource depletion will be. If domestic prices of wood reach world price level (which is about 48.67% higher than domestic level in 1990), the total consumption of the forest resource will stay approximately at the current level.

With a growing market proportion of the national economy, prices will have to play an increasingly important role, and the increase of wood product prices up to the world market level will bring positive effects on China's forestry. However, this does not mean that capitalism is kind to trees and that solely increasing price will be the panacea for curing China's forest problems. As discussed in Chapter 4, a high market price may also stimulate over-logging, but may not necessarily encourage the producers to extend forest stock. Increasing the forestry profit rate through the market mechanism is an essential means to stimulate producers' incentive; however, it must be implemented in conjunction with other institutional means, such as clarifying forest ownership and enhancing the legal system in order to protect the existing resources.

From the general economic point of view, the greatest losses from rising relative prices will be sustained by consumers, but this is not the case in China's forestry today. On the contrary, the price increase brings an opportunity to those consumers who desperately need and are willing and able to pay for wood, and it also makes those who used to obtain wood supply through the unified allocation system at incredibly cheap prices reduce wood wastes. Politicians and some economists, anxious about the increase of prices, are mainly so from political concerns rather than economic misgivings. In comparison with some social diseases, such as corruption, illegal cutting, huge wastes, and unequal income distribution, the outcome of increased wood price will be more positive to forest development.

6. FOREST RESOURCE UTILISATION HAS AN ENORMOUS POTENTIAL TO BE TAPPED FOR BRIDGING THE DEMAND-SUPPLY GAP, HENCE, FOR FORESTRY DEVELOPMENT

The utilisation rate is very low, although the estimates vary from 40% (MOF, 1985) to 60% (Hou, 1985), and resource waste is a serious problem (Richardson, 1990). There are a variety of economic, technological and environmental obstacles to increased use of logging residues, rough and rotten trees, and other kinds of unused wood resources. It is believed that the major reason for the low utilisation rate, in most cases, is that current market prices for such materials are lower than the cost of harvesting, collecting, and transporting logs to sawmills, so both technological progress and price increases will improve the use of forest resources. Technically, as MOF's report argued, there is big potential for doing so, such as improving the existing processing, expanding the substitution of raw materials with artificial materials, improving wood protection, developing the production of laminated wood products, using bamboo as a substitute for wood, etc. The only prerequisite for doing these is reasonable policies for motivating economical use of resources. If the utilisation rate rises from the current level (60% has been adopted in this study) to 75%, the annual saving of resources will be 40-52 million m^3 without reducing the current consumption, and forest resource depletion will be stopped around the year 2005 according to this study.

In sum, developing forestry is a sophisticated social activity. It is closely related to many macro-economic and institutional aspects, such as the growth of GNP, the increase of population, the change of legal system, the transition of the national economic system, etc. The simulation of a set of individual policies shows that there is no single solution which will be able to solve the current problems facing China's forestry, but there are some policy changes which bring more efficient results than others (see Chapter 8). The critical consideration of forest policy reform should be in line with the creation of producers' motivation to develop and utilise the forest resource efficiently and economically. Therefore, it seems clear that the institutional changes (such as clarifying the ownership, improving the market environment) are required with a first priority to create an efficient mechanism to dredge the demand-supply channel. Of course, the reformed policies do not exclude the government's interventions or valid plans.

10.2 Discussions

The study, dealing with China's forestry as a whole, links the supply of forest stocks, the demand for wood products, import, management activities, and price, with the development of the nation's economy system. Based on the discussion about specific features and the description of the behaviour of a planned economy, the study explains the behaviour and its conclusions as a logical consequence of the underlying assumptions and formulates the conditions necessary to obtain a particular sort of behaviour. Most important is the realisation that the simulation modelling has made considerable strides in clarifying the apathy and reducing the uncertainty surrounding decision making in forest development and policy applications. Nonetheless, further research is needed to bridge the gap between the complexities of forest development and the simplistic nature of the model used to describe them.

10.2.1 Discussion on SD-FRED

Main Features

Compared with the forest sector models built by others, SD-FRED has the following features:

(1) DYNAMICS One of the remarkable features of the model is its dynamic effects with a given policy. It explicitly recognizes that the solution taken in a given period affects what happens in the next. For example, the volume imported affects the domestic supply, the volume harvested domestically in this period will affect forest growth rates and forest inventories in different age-groups, in the next period -- different solutions result in different resource movements.

(2) MIXED ECONOMY The model does not simply consider China's economy as one with non-competitive behaviour, even if it was the so-called centrally planned economy and has been recently renamed a socialist market economy. Instead different demand-supply relationships are treated individually, according to the different channels through which the products exchange hands. Therefore, some variables, such as real income and prices, which are considered as solely important by econometricians, are critically important to some demand-supply relationships, or to all the relationships in some periods, but may not be to others; also the importance may change as time passes. For example, prices play a more important role for the products through the market channel than those through planned allocation, and prices will play an increasingly important role in wood market in the future, as the market mechanism is enforced.

Of course, there are many distinctive aspects and relationships within the mixed economy, such as the impacts of ownership on the resource utilisation; the increase of wood prices on sustainable forest development, the increase of governments' subsidy on plantation survival rates, and so on. While SD-FRED may not have been fully successful in quantifying these complex interactions, it has managed to achieve such broad coverage while maintaining a logical consistency. At a minimum, experience with SD-FRED has heightened awareness of the importance of these interactions, and provided examples of their effects in the context of a mixed economic system.

(3) ECONOMIC-BIOLOGICAL LINKAEG Another feature of the model is that it links the domestic supply closely with the bio-productivity of the forest resource. It can be easy for decision-makers to misunderstand the issues of resource economics by separating these two aspects, hence, development strategies can be inappropriately formulated. For example, there is a close relationship between resource inventory and forest cover rate, but they are different. An increase of forest cover rate may not necessarily bring a total increase of resource inventory. Adopting forest cover rate as the only indicator of forest development may only cover up the problems of resource depletion temporarily, and hence, lead to a misunderstanding of real problems. In addition, a high average growth rate does not necessarily indicate either a high increase of stock volume, or a positive move toward sustainable development.

(4) AGGREGATION This model is an aggregated one. In this model, demand has been classified according to the end-use groups, and supply divided into young, middle-aged, old forests, fast-growing forest and other forests from a management point of view. The emphasis of this study is laid upon the dynamic analysis of wood demand and supply under different policy changes in the national context.

(5) SCENARIO ANALYSIS SD-FRED is based on the statistics and realities of China's forestry setting, analyses a considerable number of variables and embodies their linkages into a comprehensive model, and portrays the impacts of many forest sector policies on China's forest development in the future through a set of scenario analyses. To generate a set of scenarios, instead of a pin-point forecast, may be useful and acceptable, because the results from the scenarios are conditional on the values of endogenous parameters and the estimate of exogenous parameters. If the analysis of the basic model structure is plausible, the results of the study can be judged on the basis of assumptions. With a reasonable range of assumptions of future events, three alternative scenarios derived from the baseline scenario will be valuable for decision making, either avoiding

unexpected consequences, or by adopting certain means to achieve some desired goals. At minimum, these scenarios help users formulate appropriate questions and facilitate intelligent dialogue concerning prospects for China's forest sector.

It is interesting to note here that since the construction of SD-FRED in 1990, some of the policy changes such as investment and import simulated in the model have actually been adopted and implemented in China's forestry development (CSB, 1993). The outcome has to a large extent validated SD-FRED in practice. In the case of forest cover rate, for example, what has been reported in the last few years corresponds accurately to this simulation.

Shortcomings

There is no hiding the fact that, like most models, this model inevitably has some shortcomings. These shortcomings may be summarised under three broad categories:

(1) those that come from the high level of generalisation;
(2) those reflected by the changes of the system behaviour due to the transition of the macro-economy system; and
(3) those linked to data use.

(1) **GENERALISATION** Since the model is built to address a variety of questions in the national context concerning long-term forest sector changes, the model does not make any distinction between geographic locations, well aware as the model builder is of the fact that the regional differences are critically important from the management viewpoint. In addition, because of a lack (or non-existence) of disaggregated data (such as costs, prices, and transportation fees in different regions for different products), it is not possible to carry out an optimal analysis in regional and/or product detail in the normative sense. Therefore, SD-FRED provides less useful information for any specific region of China.

(2) **SIMULATION** The scenario analysis technique is a rational and plausible

approach for decision-making. With some amount of uncertainty, it may provide a base or framework for a further and detailed analysis (such as cost-benefit analysis, optimal analysis), and for developing durable long-term plans. Nevertheless, it is generally assumed that the range of scenarios provided in the simulation covers most possible changes in the future. Therefore, the question arises from the specific application as to how wide the range should be. In this modelling process, some assumptions about technical or economic changes may be comparatively easy to estimate, but some, such as unexpected disasters (fire, diseases) or dramatic social change, can never be foreseen. Even if the model is designed as a general framework of forest resource movement for discussion and as a source of ideas for further analysis, improvement may still be necessary and possible in two ways:

a. Generalization If much of what has been found in the model remains useful and only a few additional aspects have to be considered, the understanding could be extended slightly towards different conditions or modification of model parameters. Otherwise, the specific aspects of interest have to be examined separately.

b. Detailed Analysis Generally, the detailed analysis of a model, like SD-FRED in this study, will be possible only after decomposition of the model into sufficiently small or simple parts. The possibility and the necessity of detailed analysis depends on several factors, notably the peculiar natures (such as boundary, scope, aggregation, and time) of the (sub) systems studied, the data available for the detailed study, and the main objectives of the study. It would be useful for simulation analysts to formalize the approach to problem definition with the given objective of the study, i.e., to develop a well-defined procedure for deciding upon scope, boundary, level of aggregation, and time horizon. Formalities of the problem definition process should give impetus toward the development of general principles and, consequently, improve system dynamics accessibility to a greater number of simulation analyses. In China's case, it would be a wise idea to carry out any sort of specifically detailed (regional) analysis within the general framework of the broad national context.

(3) **DATA** Many modelling problems arise because of poor or non-existent data.

There are never enough data with as high a quality as that on econometricians' "wish list", but any economic study must be based on data of some sort, with a reasonable informative and reliable nature, and so does this study. In any behaviourial model based on simulation techniques, like system dynamics, it is not expected that statistical techniques will ever attain the same prominent role they play in econometric models, but statistical data are still very important in the whole process of model construction. For example, distorted price signals make it difficult to estimate the price elasticities of demand and supply, and hence to accurately describe the behaviour of consumers and producers. A great number of parameters and correlation coefficients have to be estimated one way or the other.

In fact, as stated in Chapter 6, this study has carried out an exhaustive data collection from many sources for the model construction. Accordingly, the collected and identified data can themselves serve a useful purpose for any future studies of China's forestry. Nevertheless, there is no hiding the poor quality of Chinese data. Although much effort has been put into the data collection, identification and parameterisation, obviously, there may still be statistical errors. Thus, the results of SD-FRED should not be interpreted as quantitative forecasts, but rather as an informative indication of changes in key indicators by alternative policies and external conditions in the near future.

The increase of the market trade proportion of wood products and the re-establishment of a new economic order will certainly provide and improve some information required for economic modelling in quality and quantity. It therefore would seem reasonable to re-estimate some parameters and to re-portray the model's behaviour whenever the economic system changes distinctively, and the information is available.

(4) FURTHER RESEARCH One area which is the toughest task and needs further research is wood substitution with technological progress, though it has been generally considered in the model by dealing with it in separate end-use groups. The adopted parameters of substitution in the model are based on numerous preliminary projections by knowledgeable persons in academic institutions, enterprises and governments. The

complexity and difficulty of modelling wood substitution is due to a great deal of uncertainty of technological progress and its influence on wood product substitutions, as well as the unknown or changeable aspect of the price of wood products and the prices of substitution materials.

As Price (1989) pointed out, the possibility of substitution can be easily mis-identified, and its power can be overestimated by using price elasticities of supply and demand which implicitly incorporate these effects. All of those make forest economists "find themselves adrift in a wider context than they either expect or wish". There is no doubt about the importance of substitution in the study of demand and supply of wood products; therefore, it is worth stressing that there is an urgent need for detailed research on the substitution process and the sensitivity of wood demand and supply to the change in the prices of competing products.

10.2.2 Discussion on Modelling

Modelling is a process of trying to analyze complicated realities. A model should be considered just as a model, and nothing more or less than that. On the one hand, it can be dangerous to consider it as if it were the real world; on the other hand, it may be less useful only to duplicate past realities without providing some useful information/knowledge about future. A simulation model may offer much wider possibilities and reduce more analytic uncertainties than the regression or linear programming model can do. 'Unrealistic' experiments may teach us many things especially in the socio-economic research fields which can not be replicated.

The validation of a model depends upon many factors, such as the understanding of the realities studied, the information available, and the approach chosen. Among these, the understanding of the realities studied is a vital one. Misinterpretation can lead to erroneous and costly consequences. In a theoretical framework, the acquisition of understanding a model is a fairly straight-forward procedure, but, in practice, the insight or understanding may be acquired by applying many strategies and techniques, many times. Model analysis is essentially iterative and ought to be performed during the model construction phase in order to know better on what to focus attention. Only thus can it be determined which model parts and what circumstances deserve close attention and what can be ignored in the light of the goals set to the study as a whole, and the model and the understanding of the realities may be benefited and improved mutually.

The experience of this study suggests that various approaches can be adopted for different analytical purposes within one modelling process. What is acquired from the output of one sub-model can be very useful for the analysis or design of another sub-model and total model. Each way of tackling a model yields a different type of insight. Conversely, each insight may be attained along different paths. There is no single, superior approach, but a variety of methods which can be used for different purposes to deal with different problems, and, in some cases, can be integrated into one model.

The study shows that the simulation model by using the system dynamics method can be based closely on empirical and theoretical information, as well as the rules/goals the decision makers use in their planning process. While the latter presents the government's intervention which will possibly change the system's behaviour in the future, the former is useful for describing the trends and modes of the past, and for some parameter estimation and statement validation. In any complex system, such as national forestry, not all relationships are described in correlative forms, nor in causal forms, and nor in probability forms. Thus different methods, as they become appropriate, can be employed for serving different purposes, such as parameter estimation, consistency tests, and confidence bounds. They may efficiently indicate areas of sensitivity or inconsistency which might otherwise be found only with difficulty, and may not only reveal the presence of trouble, but also suggest an appropriate remedy in model structure, data validation and performance monitoring. In fact, statistical and probability analysis within a system dynamics framework, has played some important roles in the study, at least in the formulating of base-run scenario and sensitivity analysis.

Economic analysis and economic modelling must face future development, but the future is always uncertain. This is not only because of exogenous parameters which are outside a system studied, and which are always changeable with time, but also because of a system's behaviour which is influenced by these exogenous parameters, hence, change in line with the external changes.

Nevertheless, for the purpose of this study, SD-FRED has proven to be valid so far as modelling is concerned, and, under the given condition, it has produced some alternative scenarios which would provide some insights for policy makers in their effort to balance the long term demand and supply of forest resources in China.

Appendix I

GLOSSARY OF SYMBOLS IN SD-FRED

A_1: Animal waste

A_{11}: Increase rate of young forest area

A_{12}: Decrease rate of young forest area

ACC: Average consumption per capita (RMB)

ACOST: Average plantation cost of fast-growing forest per ha

ACUTFG Cutting area of fast-growing forest

ADF: Area of deforestation (ha)

AEST: Average stock of fast-growing forest per ha

AEST: Average Expected stock of old-forests (M^3/ha)

AFF: Total plantation area (ha)

AFR: Available forest resource

AFVP: Average transportation distance of FV

AGV: Average growth volume of forests

AID: Agricultural use and illegal cutting

APC: Average cost of plantation per ha

APCT: Table parameters of APC

APLFG: Planted area of fast-growing forest

APLO: Planted area of old-forests

APVP: Average transportation distance of PV

AREC: Area converted from 'four-side' plantation by the average stock of total forest

ARECC: Inaccessible area

AREFG: Fast-growing forest areas

AREM: Middle - aged forest areas

AREO: Mature forest areas

ARERF: Reforested area

AREY: Young forest areas

ASTC: Average volume of the forests converted from 'four-side' plantation

ASTF: Average volume of fast-growing forest

ASTY: Average stock of young forests in the beginning of transformation per ha (15.0246/10000)

ATENM: Tending area of mid-aged forests

ATENY: Tending area of young forests

ATHIN: Are of total thinning

AURT: Multiplier of silviculture cost (Gu p97)

AVRTT: Table parameters of AURT

AVSTM: Average volume of middle-aged forest per ha

AVSTO: Average volume of mature forest

AVSTY: Average volume of young forest per ha

BIR: Birth rate

CA_1: Construction area in urban (M^3)

CA_2: Construction area in countryside (M^3)

CAR: Number of carriages

CFW: Consumption of fuelwood per capita (M^3/head)

CM: Consumption of props per unit coal product

CS_1: Average wood consumption per kilometre new road (M^3/km)

CS_2: Substitute rate of railway ties demand by concrete

CS_3: Freight transportation fees (RMB/ton. km)

CS_4: Passenger transportation fees (RMB/capita. km)

CS_5: Increase rate of INVRW

CS_6: Cost of increasing a kilometre railway

CSUMPC Average consumption of forest resource per capita

CUTM: Removal of mid-aged forests stock

CUTO: Cutting of mature forests

D_1: Growth period of young forest

D_3: Growth period of mid-aged forests

D_4: Initial period of fast-growing forest

D_6: Growth period of old-forests

DCW: Demand for construction wood (M^3)

DCW_1: DCW in urban (M^3)

DCW_2: DCW in countryside (M^3)

DCWO: Original wood demand of construction

DEA: Death rate

DEMM1: Construction demand elasticity of Price

DEMM2: Railway demand elasticity of price

DEMM4: Price elasticity of mining wood demand

DEMM5: Price elasticity of Paper and paperboard demand

DEMM6: Price elasticity of furniture wood demand

DEO: Planned consumption of other sectors

DEPO: Original demand of mining props

DFAI: Demand for fuelwood, agricultural use, and illegal cutting

DFLOSM Lost of middle-aged forests due todeforestation

DFLOST Lost volume of young forest from deforestation

DLOST: Disease lost

DPP: Demand for paper and paperboard

DPPO: Original demand of paper and paperboard

DRR: Total wood demand of railway industry
DRS: Demand for railway rolling stock
DS: Demand for sleeper
DT: Accounting interval
E_{26}: Coal for agricultural household use
EST: Expected stock of fast-growing forest per ha
EXCH: Foreign exchange rate
EXPOR: Wood exports
EXST: Expected stock of old-forests
F_{26}: Total coal product
FCINV: Capital construction investment
FCOV: Forest cover rate
FDT: Ratio of forest area suffered from diseases to total forest area
FIV: Investment for silvicultural operations
FLOST: Lost stock of young forest from forest fire
FLOSTM Fire lost from mid-aged forests
FLOSTO: Fire lost from mature forests
FV: Freight volume
FWD: Fuelwood demand
FWDO: Original fuelwood demand
GNI: Gross national income
GNP: Gross national production
GRG: Growth rate of general forest
GRM: Growth rate of mid-aged forests
GRO: Growth rate of mature forests (0.0107, Gu)
GRY: Growth rate of young forests
GVIAO: Gross value of industrial and agricultural output
I_{12}: Number of marsh gas ponds
I_{14}: Total production of marsh gas
I_{15}: Straws for fuel
I_{151}: Quantity of total straw at the beginning of each periods
I_{152}: Ratio of straw used to fuel stuff
ICRW: Income of railway industry
ILLR: Illegal cutting rate
IMCOST Import cost
IMPOR: Wood imports
INACCO Inaccessible stock
INCOST: Increasing average cost of plantation per ha
INDVF: Private demand for furniture
$INDVF_1$: Household furniture demand
$INDVF_2$: Furniture demand by youth married couple
INV: Investment in railway
INVC: Investment in construction (RMB 10E9)
INVESF: Investmant in forestry
INVFG: Investment in fast-growing forests
INVFG: Investment to fast-growing forest (¥10000)
INVRW: Income of railway industry
LOANF: Foreign loan
LOSTM: Lost from mid-aged forests due to disease and insects
LOSTY: Lost volume of young forest from diseases and insects (m^3)
MCUT: Main cutting
Mk: Demand for mining props
MP: Annual coal production
NCUT: Other cutting
NIAP: Net increasing of agricultural population
NIMCOS Net import cost
NLOST: Other lost
NRFF: Natural reforestation area
NRW: Increasing railway
OGV: Growth volume of existing forests
OGVT: Table parameters of growth volume of existing forests
OGY: Growth of original young forests
OSTO: Original stock of mature forests
PIFA: fuelwood demand elasticity of price
POP: Total population
PP: Price of wood products
PPIM: Average import price
PSR: Ratio of success area to total plantation
PSRT: Table parameters of PSR
PUBF: Public demand for furniture
PV: Passenger volume
R_{11}: Increase rate of young forest stock
R_{12}: Decrease rate of young forest stock
R_{13}: Survival rate of plantation
R_{18}: Tending removal rate of young forests (M^3/ha)
R_{16}: Tending density of young forest (%)
R_{21} Increase rate of mid-aged forest stock
R_{22} Decrease rate of mid-aged forest stock
R_{25}: Ratio of tending removal from mid-aged forests to STM
R_{26}: Tending density of mid-aged forests
R_{31}: Increase rate of mature forests
R_{32}: Decrease rate of mature forests
R_{41}: Increase rate of fast-growing forest stock
R_{42}: Decrease rate of fast-growing forest stock
R_{51}: Increase rate of other forest

R_{62}: Decrease rate of other forest

R_{63}: Successful rate of plantation

RAM: Ratio of mid-aged forest area to total forest area

RAY: Ratio of young forest area to total forest area (34.98%)

RB: Increase rate of demand for DRS

RCUTM: Cutting rate of mid-aged stock

RCUTM: Ratio of CUTM to STM

RCUTO: Ratio of cutting from mature forests to total cutting

RD_1: Increase rate of demand for railway ties

RD_{11}: Average consumption of construction in urban (M^3)

RD_{12}: Average consumption of construction countryside (M^3/M^2)

RD_2: Decrease rate of demand for railway ties (i.e., substitute for wood ties)

RD_{32}: Production of marsh gas per ponds

RD_{61}: Consumption rate of wood item (M^3/item)

RD_{62}: Share of wood furniture to total furniture market

RD_{63}: Fixed capital construction investment rate

RDFM: Deforestation rate of mid-aged forests

RDFY: Ratio of deforestation of young forests to total deforestation

RDFY: Ratio of deforestation in young forest to STY

RE_{26}: Share of coal allocation to agricultural households

REFP: Reference price

REFRO: Reforestation (including artificial and natural)

RFRC: Parameter of forest resources consumption

RFRCT: Table parameters of RFRC

RFW_1: Increasing rate of fuelwood demand

RFW_2: Decreasing rate of fuelwood demand

RFW_3: Substitution of fuelwood

RGNI: Increasing rate of GNI

RGNIT: Table parameters of RGNI

RGVIA: Increasing/decreasing rate of GVIAO

RINVC: Rate of investment in construction (%)

RINVF: Share of total saving for investment in forest

RIV: Investment for plantation

RLOSM: Ratio of lost from mid-aged forests to STM

RLOSY: Ratio of lost stock of young forests to total lost

RNRFF: Survival rate of natural reforestation

RO_{61}: Random function

ROC_1: Ratio of available resource to total forest resource

ROC_2: Rate of annual cutting

ROS: Saving rate

RP_1: Increasing rate of agricultural population

RP_2: Decreasing rate of agricultural population

RPLAN: Ratio of the planned afforestation fees to total investment in silviculture

RPO1: Increase rate of total (urban & rural) population

RPOP2: Decrease rate of total (urban & rural) population

RPPO: Seccessful rate of voluntary afforestation

RRGNI: Annual increase rate of GNI

RRIV: Ratio of the reinvestment

RSR: Survival rate of plantation

RTF_1: Increasing rate of total forest resources

RTF_2: Decreasing rate of total forest resources

RTP: Recovery rate

RTPT: Table parameters of RTP

RTREE: Voluntary afforestation per capita

RVOL: Rate of voluntariness

S_1: Substitute rate of coal for fuelwood

S_2: Substitute rate of straw for fuelwood

S_3: Substitute rate of marsh gas for fuelwood

S_4: Substitute rate of animal waste for fuelwood

SPA: Area of successful new-plantation

STC: Stock of other forest

STF: Stock of fast-growing forest

STM: Mid-aged forest stock

STO: Stock of mature forests

STY: Stock of young forest (64110)

TARE: Total territory area

TCONS: Total consumption

TCSUM: Average consumption of wood products per capita

TCUT: Total cutting of resources

TENY: Tending stock of young forest

TFARE: Total forest areas

TFG: Transferred area form scrub to fast-growing forest

TFS: Total forest stock

TFV: Total FV

TGV: Total growth volume of forests

THIM: Volume from thinning mid-aged forests

THIY: Volume from thinning young forests
TINVSF: Total investment in forestry (=INVEST+TRASV)
TPLA: Total plantation (annual afforestation and reforestion)
TPV: Total PV
TRANS: Transfer rate of population from countryside to city
TRASV: Transfered value
TSTC: Transferred stock from scrub forest to young forest per ha
TSTM: Transferred forest stock from mid-aged forests to mature forests
TSTY: Transferred stock from young forest to mid-aged forest per ha (4.5/10000)
TV: Annual thinning volume
UPOP: Urban population
VOLAF: Urban voluntary (mass movement) afforestation
WC: Total wood consumption
WC_1: Planned wood consumption
WDF: Demand for wood for furniture manufacturing
WDFO: Original wood demand of furniture manufacturing
WP: Wood production
WS: Wood stock
YCOUP: Youth married couples
Z_{5i}: Parameters of Paper Demand Sector (i=1,2,3,4)

Appendix II

COMPUTER SIMULATION PROGRAMME FOR SD-MODEL[1]

TOTAL MODEL

```
A    EQUI.K=SMOOTH(WS.K,5)
A    WS.K=WP.K.+IMPOR.K*RTP.K-WC.K-
     EXPOR.K*RTP.K

L    GVIAD.K=GVIAD.J+DT*(RRGVIA.K)
R    RRGVIA.KL=GVIAD.K*RGVIA.K
N    GVIAD=7066E11
A    RGVIA.K=TABHL(RGVIAT,TIME.K,1980,
     2010,5)
T    RGVIAT=0.106/0.11/0.082/0.062/0.0435/
     0.043/0.043/.04/.035

A    WC.K=WC1.K+DMO.K
A    DMO..K=WD1.K*0.32
A    WC1.K=(DCW.K+DRR.K+DMP.K+DPP.K
     +DFU.K)*RTP.K+DFAI.K
A    DFAI.K=FWD.K+AID.K
A    AID.K=FWD.K*ILLR.K
A    RTP.K=TABHL(RTPT,TIME.K,1990,1994,
     2)
T    RTPT=1.671/1.67/1.66
A    ILLR.K=TABHL(ILLRT,TIME.K,1980,2020
     ,5)
T    ILLRT=.9/.8/.7/.65/.6/.55/.52/.5/.46

A    WP.K=TCUT.K

L    TFS.K=TFS.J+DT*(RTF1.JK-RTF2.JK)
N    TFS=9.0279533E9
R    RTF1.KL=TGV.K
R    RTF2.KL=TCONS.K

A    TFSPC.K=TFS.K/POP.K
S    ASTARE.K=(TFS.K-STF.K)TFARE.K

A    TCUT.K=MCUT.K+NCUT.K.
A    MCUT.K=WC.K-IMPOR.K*RTP.K
     +EXPOR.K*RTPK-NCUT.K
A    NCUT.K=TV.K+R42.K
A    TV.K=THIY.K+THIM.K
A    IMPOR.K=NIMCOS.K/PPIM
A    NIMCOS.K=IMCOS.K-TRASV.K
A    IMCOS.K=TABHL(IMCOST,TIME.R,1980,
     2010,5)*1E6
T    IMCOST=748.84/3860/3860/3860/3860/3
     860/3860
A    EXPOR.K=TABHL(EXPORT.TIME.K,198
     0,2010,5)
T    EXPORT=28.55E3/25.34E3/25E3/25E3.2
     6E3
C    PPIM=386

A    TCONS.K=TCUT.K+FLOST.K+DLOST.K+
     NLOST.K+R42.K

A    SPA.K=DELAY1(SPA1,D9)
A    SPA1.K=AFF.JK*PSR.K+ARERF.K*RSR+
     NRFF.K*RNRFF+VOLAF.K*PSR.K
N    RNRFF=.4
A    PSR.K=TABHL(RSRT,TIME.K,1980,2020,
     5)
T    PSRT=0.29/0.33/0.335/0.34/0.34/0.34/0.3
     4/0.34/0.34
C    RSR=.6
N    D9=5
A    NRFF.K=NOISE()+85E3
A    VOLAF.K=UPOP.K*RTREE*RPPO/ATREE
A    UPOP.K=POP.K-APOP.K
C    RTREE=3 (3/PER CAPITA)
C    RPPO=.3
C    ATREE=3000 (TREE/HA)

R    AFF.KL=(INVSF.K-INVFG.K)/(APC.K
     *AURT.K)-ARERF.K/2+TRASV.K/ACOST
X              *CLIP(0,1,,FCOV.K,0.2646)
A    INVSF.K=RIV.K+TRASV.K
A    TINVSF.K=INVSF.K+TRASV.K
A    TRASV.K=TABHL(TRASVT,TIME.K,1990.
     2010,5)
T    TRASVT=0/0/0
A    THIF.K=(ATHIY.K+ATHIM.K)*NTHIC
C    NTHIC=244.5

A    AAFF.K=AFFJK+ARER.K+APLFG1.K*NR
     FF.K+VOLAF.K*RVOL.K
A    RVOL.K=TABHL(RVOLT,TIME.K,1980,20
     10,5)
T    RVOLT=1/.95/.92/.85/.80/.75/.60

A    TFARE.K=AREY.K+AREM.K+AREO.K

A    FCOV.K=MIN(TFARE.K/TARE,0.2645)
N    TARE=960E6 (ha,1Km=100Ha)

L    AREY.K=STY.K/AVSTY.K
A    AVSTY.K=TABHL(AVSTYT,TIMGK,1990,
     2010,5)
T    AVSTYT=19.8/20/22/25/28

L    AREM.K=STM.K/AVSTM.1
C    AVSTM=73.31
```

[1] The basic form of the equations in this programme is as follows:

TYPE   Quantity = Expression

"Type" is single letter designating the type of an equation. L indicates a level equation; A, an auxiliary equation; R, a rate equation; N, an initial value equation; C indicates a constant, T shows a Table function, and X works as the continuation card.

```
L    AREO.K=STO.K/AVSTO
C    AVSTO=158.72

L    AREFG.K=AREFG.J+DT*(A41.JK-A42.JK)
N    AREFG=2.541E4
A    A41.K=APLFG.K
A    A42.K=ACUTFG.K

A    ARER.K=DELAY1(ARERF,D1)
A    ARERF.K=TABHL(ARERFT,TIME.K,1980
     ,2010,5)
T    ARERFT=468.098E3/601.755E3/650E3/7
     00E3/750E3

A    ATHIN.K=ATHIY.K+ATHIM.K

A    RIV.K=WP.K*PP.K*RRIV.K
A    RRIV.K=TABHL(RRIVT,TIME.K,1980,199
     0,5)
T    RRIVT=.01419/.01419/.01419

A    FIV.K=GNI.K*ROS.K*RINVF.K
A    ROS.K=TABHL(ROST,TIME.K,1980,1990
     ,5)
T    ROST=0.315/0.328/0.2982/0.2962/0.2942
     /0.28/0.28  (Wibe,GFN)
A    RINVF.K=TABHL(RINVFT,TIME.K,1980,2
     010.5)
T    RINVFT=.001966./.00127/.00127/.00124/.
     00122

L    GNI.K=GNI.J+DT*(RRGNI.K)
R    RRGNI.KL=GNI.K*RGNI.K
N    GNI=3.688E11
A    RGNI.K=TABHL(RGNIT,TIME.K,1980,20
     10,5)
T    RGNIT=0.095/0.11/0.083/0.06/0.04

L    APC.K=APC.J+DT*INCOST
N    APC=135.29
C    INCOST=3.564

L    POP.K=POP.J+DT*(RPO1.JK-RPO2.JK)
N    POP=9.8705E8
R    RPO1.KL=POP.K*BIR.K
R    RPO2.KL=POP.K*DEA.K

A    CSUMPC.K=WC.K/POP.K
A    TCSUM.K=CSUMPC.K/RTP.K

A    TGV.K=STY.K*GRY.K+STM.K*GRM.K+S
     TO.K*GRO.K+STF.K*GRY.K

A    AURT.K=TABHL(AURTT,TIME.K,1990,20
     10,5)
T    AURTT=1.3/1.73/2.29/2.5/2.7

A    PP.K=TABHL(PPT,TIME.K,1980,2020,5)
T    PPT=70.458/94.17/110/120/130/132/134/
     147/139
```

RESOURCE-SUPPLY SUBMODEL

1. STOCK OF YOUNG FOREST (STY)

```
L    STY.K=STY.J+DT*(R11.JK-R12.JK)
N    STY=7.9175E8  (M3)
```

INPUT OF YOUNG FOREST STOCK (R11)

```
R    R11.KL=(OGY.K+SPA.K*TSTC*(1+GRY.
     K))*(1+RTHIY*R16.K)
N    TIME=1980
N    TSTC=9.8
A    OGY.K=STY.K*GRY.K
N    D1=5
A    GRY.K=TABHL(GRYT,TIME.K,1990,2010
     ,5)
T    GRYT=0.09897/0.09897/0.09897
N    RTHIY=0.07
```

OUTPUT OF YOUNG FOREST STOCK (R12)

```
R    R12.KL=TSTY.K+THIY.K+LOSTY.K+FLO
     STY.K
A    FLOSTY.K=FLOST.K*RLOSY
A    FLOST.K=(NOISE()+FST.K)
A    FST.K=FARE.K*21.6
A    FARE.K=TABHL(FARET,TIME.K,1980,19
     90,5)*1E3
T    FARET=392.568/392/390
A    TSTY.K=(STY.K-THIY.K-LOSTY.K-
     FLOSTY.K)/D2
A    THIY.K=ATHIY.K*R15
A    ATHIY.K=AREY.K*R16.K/D2
N    R15=8.4/3
A    R16.K=TABHL(R16T,TIME.K,1990,2010,5)
T    R16T=.001/.001/.001
N    D2=14
A    LOSTY.K=DLOST.K*RLOSY.K
A    DLOST.K=(NPOSE()+DST.K)
A    DST.K=DARE.K*42.8
A    DARE.K=TABHL(DARET,TIME.K,1980,19
     90,5)*1E3
T    DARET=887.256/881/880
C    RLOSY=0.0677
```

2. STOCK OF MIDDLE-AGED FIREST (STM)

```
L    STM.K=STM.J+DT*(R21.JK-R22.JK)
N    STM=3.0397E9
```

INPUT RATE OF M-A FOREST STOCK (R21)

```
R    R21.KL=(TSTY.K*(1+GRM.K)+OGM.K)*(1
     +RTHIN*R26.K)
A    OGM.K=STM.K*GRM.K
A    GRM.K=TABHL(GRMT,TIME.K,1990,201
     0,5)
T    GRMT=0.04066/.04066/.04066/.04066
N    RTHIM=0.18
```

OUTPUT RATE OF M-A FOREST STOCK (R22)

```
R    R22.KL=(TSTM.K+THIM.K+LOSTM.K+C
     UTM.K+FLOST/3)
A    TSTM.K=(STM.K-THIM.K-LOSTM.K-
     CUTM.K-FLOSTM.K)/D3
A    THIM.K=ATHIM.K*R25
A    ATHIM.K=AREM.K*R26.K/D3
N    R25=8.4
```

A R26.K=TABHL(R26T ,TIME.K,1990,2010,5)
T R26T=.001/.001/.001
N D3=25
A LOSTM=0.4033
A FLOSTM.K=FLOST.K*RLOSM
A CUTM.K=SMOOTH(CUTM1.K,CUTMAT)
C CUTMAT=5
A CUTM1.K=MCUT.K*RCUTM.K
A RCUTM.K=CLIP(0.2,1.0,STO.K,INACCO.K)
A INACCO.K=ASTO*ARECC
C ARECC=11E6
C ASTO=139.0144

3. STOCK OF MATURE FOREST (STO)

L STO.K=STO.J+DT*(R31.JK-R32.JK)
N STO=5.19649E9

INPUT RATE OF MATURAL FOREST (R31)

R R31.KL=TSTM.K*(1=GRO.K)+OSTO.K
A OSTO.K=STO.K*GRO.K
A GRO.K=TABHL(GROT,TIME.K,1990,201 0,5)
T GROT=0.0107/.0107/.0107

OUPUT RATE OF MATURE FOREST (R32)

R R32.KL=(DLOST.K+FLOST)*(1-RLOSY-RLOSM)+CUTO.K+NLOSTO.K
A CUTO.K=SMOOTH(CUTO1.K,CUTOAT)
C CUTOAT=5
A CUTO1.K=MCUT.K*RCUTO.JK
R RCUTO.KL=1-RCUTM
A NLOST.K=(NOISE()+40E6)
A NLOSTO.K=NLOST.K*.82

4. STOCK OF FAST-GROWING FOREST (STF)

L SFT.K=STF.J+DT*(R41.JK-R42.JK)
N STF=254E3

INPUT RATE OF F-G FOREST (R41)

R R41.KL=DLINF3(EST.K,3*D4.K)
A EST.K=APLFG,JK*AEST.K
C D4=5
N AEST=150
A. APLFG.K=DELAY1(APLFG1.K,D4)
A APLFG1.K=INVFG.K/ACOST.K*FGSR
A INVFG.K=TABHL(INVFGT,TIME.K,1980, 2020,5)
T INVFGT=2.0E7/8E7/10E7/12E7/15E7/16 E7/18E7/18E7/18E7
A ACOST=3530
C FGSR=0.85

OUTPUT RATE OF F-G FOREST (R42)

R R42.KL=ACUTFG.K*AEST.K
R ACUTFG.KL=DELAY3(APLFG.K,4*D4)*CLIP(1,0,TIME.K,Y+3*D4)
C Y=1977

5. STOCK OF OTHER FOREST (STC)

L STC.K=STC.J+DT*(R51.JK-R52.JK)
N STC=1.23203E9

R R51.KL=DLINF3(EXST.K,3*D5)+STC.K*GRR.K
A GRG.K=TABHL(GRGT,TIME.K,1990,200 0,5)
T GRGT=0.023/0.021/0.02
A EXST.K=APLO.JK*AEST2.K*R63.K
A APLO.K=TABHL(APLOT,TIME.K,1980,20 00,5)
T APLOT=1.55737E5/1.80384E5/2E5/2E5/2 E5
C R63=0.6
N AEST2=5.221

N D5=5
R R52/KL=NLOSTC.K+CUTC.K
A NLOSTC.K=NLOST.K*0.18
A CUTC.K=(NOISE()+18.8E6)

DEMAND SECTION

1. DEMAND FOR CONSTRUCTURAL WOOD (D1)

A DCW.K=DCWO.K*DEMM1.K
A DEMM1.K=EXP(ELASP1.K*LOGN(PP.K/REFT))
C REFT=130
A ELASP1.K=CLIP(-.7,0,PP.K,REFT)

A DCWO.K=DCW1.K+DEW2.K

A DCW1.K=CA1.K*RD11.JK
A DCW2.K=CA2.K*RD12.JK
A RD11.K=TABHL(RD11T,TIME.K,1980,20 10,5)
T RD11T=.0392/.041/.042/.042/.043/.043/.0 435
A RD12.K=TABH(RD12T,TIME.K,1980,201 0,5)
T RD12T=.058/.0523/.0483/.045/.0452/.045 3/.0455

A CA1.K=INVC.K*RINVC.JK
A INVC.K=TABHL(INVCT,TIME.K,1980,202 0,5)*1E9
T INVCT=55.9/106.0/120/150/165/170/180/ 185/190
A RINVC,K=TABHL(RINVCT,TIME.K,1980, 2010,5)
T RINVCT=72.642E-4/53.062E-4/50.45E-4/47.2E-4/45.2E-4/34E-4/33E/4

A CA2.K=TABHL(CA2T,TIME.K,1980,2010, 5)*1E8
T CA2T=5.86/7.48/7.5/7.52/7.54/7.56

2. DEMAND OF RAILROADS (D2)

A DRR.K=DRRO.K*DEMM2.K
A DEMM2.K=EXP(ELASP2.K*LOGN(PP.K/REFT))
A ELASP2.K=CLIP(-.2,PP.K,REFT)

```
A   DRRO.K=DS.K=DRS.K

R   DRS.KL=CAR.K*RB.K
A   CAR.K=TABHL(CART,TIME.K,1980,2010
    ,5)*1E3
T   CART=22/23/24/24/25/25/25.5
C   RB=20

L   DS.K=DS.J+DT*(RD1.JK-RD2.JK)
N   DS=59.94E4 (M3)
R   RD2.KL=NRW.K*RD21*CS2.K
A   CS2.K=TABHL(CS2T,TIME.K1980,2000,5)
T   CS2T=0.75/0.8/0.85/0.87/0.90

R   RD1.KL=NRW.K*RD21
C   RD21=200 (M3)

R   NRW.KL=(INVRW,J+LOANF.K*CLIP(1,0,
    TIME.K,1985)+LOANF.K*CLIP(0,1,TIME.
    K,1995))/CS6
A   LOANF=LOAN*EXCH
N   LOAN=57.75E6
C   EXCH=4.7
C   CS6=50E4

A   INVRW.K=ICRW.K*CS5
C   CS5=0.8E-3

A   ICRW.K=FV.K*CS3.K+PV.K*CS4.K
A   CS3.K=TABHL(CS3T,TIME.K,1980,2000,5)
T   CS3T=0.08/0.15/0.16/0.17/0.17
A   CS4.K=TABHL(CS4T,TIME.K,1980,2000,5)
T   CS4T=0.02/0.05/0.06/0.08/0.08

A   FV.K=AFVD.K*TFV.K
A   PV.K=APVD.K*TPV.K

A   AFV.K=457.428+14.738*(TIME.K-1977)
A   APVD.K=126.714+7.071*(TIME.K-1977)
A   TFV.K=3688+3866*T1
A   TPV.K=11996+2991*T1
A   T1.K+TABHL(T1T,TIME.K,1980,2020,5)
T   T1T=26/31/36/41/46/51/58/60
```

3. DEMAND FOR FUELWOOD & FOR AGRI. USE (D3)

```
A   FWD.K=FWDO.K*PIFA.K
A   PIFA.K=EXP(ELASP3.K*LOGN(PP.K/RE
    FP))
A   ELASP3.K=CLIP(-1.2,0,PP.K,REFP)
L   FWDO.K=FWDO.J+DT*(RFW1.JK-
    RFW2.JK)
N   FWD0=56E6
```

INCREASING RATE OF DEMAND FOR FW

```
R   RFW1.KL=NIAP.K*CFW.K
A   CFW.K=TABHL(CFWT,TIME.K1990,2000
    ,5)
T   CFWT=0.197323/.21/.215
A   NIAP.K=APOP.K*(RP1.JK-RP2.JK)

L   APOP.K=APOP.J+DT*(RP1.JK-RP2.JK)
N   APOP=819.054
R   RP1.KL=APOP.K*BIR.K
R   RP2.KL=APOP.K*(DEA.JK+TRAS.JK)
A   BIR.K=TABHL(BIRT,TIME.K,1980,2020,5)
T   BIRT=20.78E-3 /19.54E-3/20.83E-3/19.01E-
    3/18.2E-3/ 17.34E-3/17.0E-3/16.2E-3/15.2E-
    3
A   DEA.K=TABHL(DEAT,TIME.K,1980,2020,
    5)*1E-3
T   DEAT=8/7/6.5/6.5/6.6/6.5/6.5/6.6/6.8
A   TRAS.K=TABHL(TRAST,TIME.K,1980,20
    20,5)*1E-3
T   TRAST=12/12.5/13/13.5/13.5/13.5/13.5/1
    3.5/13.5
```

DECREASING RATE OF DEMAND FOR FW

```
R   RFW2.KL=RFW3.K/791.41
R   RFW3.KL=I15.K*S3+I14.K*S2+E26.K*S1
    +A1*0.5
C   S1=1.2501
C   S2=1.2501
C   S3=0.85
C   S4=1.0626
C   A1=2.13176E7

A   I15.K=I15.K*I152.K*10E6
A   I151.K=(-432.54+0.2212*
    TIME.K0*(1+RF22.K)
A   RF22.K=NOISE()/10
A   I152.K=TABHL(T152T,TIME.K,1980,2020
    ,5)
T   I152T=0.650/0.60/0.50/0.45/0.30/0.30/0.3
    0/0.30/0.29

A   I14.K=I12.K*RD32.K
A   RD32.K=TABHL(RD32T,TIME.K,1980,20
    20,10)
T   RD32T=200/205/208/210/212
L   I12.K=I12.J+DT*(R091.K)
N   I12=346
A   R091.K=TABHL(R091T,TIME.K,1980,200
    0,5)
T   R019T=5/7/5/3/2

A   E26.K=F26.K*RE26*10E6
C   RE26=0.05
A   F26.K=TABHL(F26T,TIME.K,1980,2020,10)
T   F26T=6.15/8.325/8.5/8.8/9.1
```

4. DEMAND OF MINING PROPS (D4)

```
A   DMP.K=DMPO.K*DEMM4.K
A   DEMM4.K=EXP(DLASP4.K*LOGN(PP.K/
    REFP))
A   ELASP4.K=CLIP(-0.4,0,PP.K/REFP))
A   DMPO.K=CM.K*MP.K
A   MP.K=TABHL(MPT,TIME.K,1980,2000,5)
    *1E8
T   MPT=6.20/8.72/10.87/13.54/15
A   CM.K=TABHL(CMT,TIME.K,1980,2010,5)
    *1E-2
T   CMT=1.129/0.83/0.75/0.72/0.70/0.65/.62
```

5. DEMAND FOR PAPER AND PAPERBOARD (D5)

```
A      DPP.K-DPPO.K*DEMM5.K
A      DEMM5.K=EXP(ELASP5.K*LOGN(PP.K/
       REFP))
A      ELASP5.K=CLIP(-.2,0,PP.K,REFP)
A      DPPO.K=EXP(DPP1.K)
A      DPP1.K=LOGN(Z51)+Z52*LOGN(GNI.K)
       +Z53*LOGN(TIME.K)+Z54
N      Z51=0.5284
N      Z52=0.62 0.61
N      Z53=0.041
N      Z54=-0.046
```

6. DEMAND OF WOOD FOR FURNITURE MANUFACTURING (D6)

```
A      DFU.K=WDFO.K*DEMM6.K
A      DEMM6.K=EXP(ELASP6.K*LOGN(PP.K/
       REFP))
A      ELASP6.K=CLIP(-.5,0,PP.K,REFP)
A      WDFO.K=(PUBF.K+INDVF.K)*RD61*RD62
C      RD61=0.04 (M3.ITEM)
C      RD62=0.618 (%)
A      PUBF.K=RD63+RD64*FCINV.K
N      RD63=3331156*0.4
N      RD64=0.000648*0.4
A      FCINV.K=GNI.K*RD65.K
A      RD65.K=TABHL(RD65T,TIME.K,1980,20
       00,5)
T      RD65T=0.049/0.0548/0.0494/0.05/0.05
A      INDVF.K=INDV1.K+INDV2.K
A      INDV1.K=RD66+RD67*ACC.K+RD68*PO
       P.K
N      RD66=-23460884*0.4
N      RD67=46650*0.4
N      RD68=0.0233*0.4
A      ACC.K=GNI.K/POP.K
A      INDV2.K=YCOUP.K*RD60
N      RD60=5.12 (RIECE/COUPLE)
A      YCOUP.K=TABHL(YCOUPT,TIME.K,198
       0,2010,5)*1E6
T      YCOUPT=10.22/10.5335/12.948/11.586/8
       .66/8.8/8.8
```

MODEL OUTPUT

```
SPEC   DT=1/LENGTH=2010/PRTPER=5/PLTPE
       R=5
OPT    PR
PRINT  TFS,FCOV,TGV,TCONS,WC,WP,ASTARE,
       SPA,TCSUM,TINVSF
PRINT  EQUI,WC,WP,FCOV,IMPOR,EXPOR
PRINT  TGV,TCONS,TCUT,MCUT,NCUT,TV,TFS
       ,TFSPC
PRINT  AAFF,AFF,SPA,ATHIN,ARER
PRINT  DCW,DRR,DFAI,DMP,DPP,DFU,DMO
PRINT  POP,GVIAO,GNI,WC,CSUMPC,TCSUM
PRINT  STY,STM,STO,STF,S TC,TFS,TV,ASTARE
PRINT  AAFF,AFF,FCOV,AREY,AREM,AREO,AR
       EFG
PRINT  RIV,FIV,TRASV,INVSF,COSTIM,THIF,AP
       C,PP
PLOT   WC=C(250E6,*),WP=P(250E6,*),
       IMPOR=I(190E4,*)
PLOT   TCUT=U(230E6,*),TGV=G(230E6,*),TCO
       NS=C(230E6,*)
PLOT   RIV=2,FIV=3,COSTIM=1
PLOT   POP=P(10E6,*)/GVIAO=V(10E9,*)/GNI=G
       (10E9,*)
PLOT   STY=Y,STM=M,STO=O, STC=C
PLOT   STF=F, AFF=A, SPA=S,TV=T
PLOT   TFARE=0,AREY, AREM,AREO
PLOT   ARERF,APLFG,ATH
PLOT   CSUMPC,TCSUM,FCOV,ASTARE
RUN

T      PPT=70.458/94.17/140/144/148/152/156/
       160/164
RUN PPT

T      RTPT=1.67/1.67/1.33
RUN RTPT

T      RINVFT=.001966/.00127/.00167/.00167/.
       00167
RUN RINVFT

T      PSRT=.32/.35/.44/.52/.58/.63/.65/.68/.69
RUN PSRT

T      CA2T=5.86/7.3/7.8/8.2/8.3/8.4/8.5
T      INVCT=55.9/106/130/160/180/190/200
RUN CONSTR

T      R16T=.0001/.02/.03
T      R26T=.0001/.02/.03
RUN THINNIG

T      TRASVT=0/193E6/193E6
RUN HOME1

T      TRASVT=0/386E6/386E6
RUN HOME2

T      IMCOST=748.84/3860/4261/4705/5195/5
       736/6333
RUN IMPORT
```

SCENARIO 1 (MODERATE)

```
T      RTPT=1.67/1.67/1.4286
T      RRIVT=14.19E-3/14.19E-3/16E-3
T      RINVFT=.001966/.00127/.00134/.00134/.
       00134
T      PSRT=.32/.35/.4/.43/.45/.50/.55/.58/.59
T      TRSVT=0/386E6/386E6
T      FARET=392.568/392/274.8
T      DARET=887.256/887/621.08
T      GRYT=.09897/.09897/.11
T      GRMT=0.04066/.04066/.041
T      GROT=.0107/0.107/.011
T      PPT=70.458/94.17/140/142/144/146/148/
       150/152
T      F26T=6.15/8.325/8.8/9.0/9.1
T      R16T=.001/0.018/0.015
T      R26T=.001/0.018/0.015
RUN MODERA
```

SCENARIO 2 (LOW)

```
T       RTPT=1.67/1.67/1.5385
T       RRIVT=14.19E-3/14.19E-3/15E-3
T       RINVFT=.001966/.00127/.00127/.00127/.
        00127
T       PSRT=.32/.35/.36/.38/.40/.42/.45/.48/.49
T       TRASVT=0/193E6/193E6
T       FARET=392.568/392/300
T       DARET=887.256/887/700
T       GRYT=.09897/.09897/.1
T       GRMT=0.4066/.04066/.04088
T       GROT=.0107/.0107/.0108
T       PPT=70.456/94.17/120/122/124/126/128/
        130/132
T       F26T=6.15/8.325/8.4/8.5/8.8
T       R16T=0.001/0.005/0.01
T       R26T=0.001/0.005/0.01
RUN LOW
```

SCENARIO 3 (HIGH)

```
T       RTPT=1.67/1.67/1.33
T       RRIVT=14.19E-3/14.19E-3/17.E-3
T       RINVFT=.001966/.00127/.00166/.00166/.
        00166
T       PSRT=.32/.35/.44/.52/.56/.63/.65/.68/.69
T       TRASVT=0/772E6/772E6  (10E6 M3)
T       FARET=329.568/392/220
T       DARET=887.256/887/550
T       GRYT=.09897/.09897/.111
T       GRMT=.04066/.04066/.042
T       GROT=.0107/.0107/.0115
T       PPT=70.458/94.17/140/144/148/152/154/
        156/158
T       F26T=6.15/8.235/9/10/11
T       R16T=.001/.01/.02
T       R26T=.001/.01/.02
RUN HIGH
```

Appendix III

A Note on the Technique of Cross-impact Analysis

Suppose there are two choices for increasing supply of wood products: choice A, to develop wood products domestically, and choice B, to import from overseas. Let us temporarily ignore other factors in the decision-making, and only consider the foreign exchange value of the cost for both of them at time t: P_A^t, foreign exchange value of cost of domestic production at time t, and P_B^t, foreign exchange value of cost of import at time t. Further, suppose at the initial point, P_B^0 is a δ-distribution, i.e., import price at t = 0 is known with certainty, and there are only two periods: t = 0 and t = 1.

At t = 0, $P_A^t = P_A^0$ and $P_B^t = P_B^0$, known with certainty,
At t = 1, $P_A^t = P_A^1 =$, say, P_A^0, but

$$P_B^1 = \begin{cases} P_B^0 & Prob.=\alpha_1 \\ \beta P_B^0 & Prob.=\alpha_2 \quad when\ \beta>1 \\ \gamma P_B^0 & Prob.=1-\alpha_1-\alpha_2 \quad when\ \gamma<1 \end{cases} \tag{A3.1}$$

where, β_t and Γ_t are the simulating variables and are the function of many factors. If r_A and r_B are the social discount rates for domestic production and import, respectively, then cost can be calculated for both A and B:
for A,

$$E^1(A) = P_A^0 + \frac{P_A^0}{(1+r_A)} \tag{A3.2}$$

for B,

$$E^1(B) = \begin{cases} P_B^0 + \dfrac{P_B^0}{(1+r_B)} & Prob.=\alpha_1=1 \\ P_B^0 + \dfrac{\beta P_B^0}{(1+r_B)} & Prob.=\alpha_2 \\ P_B^0 + \dfrac{\Gamma P_B^0}{(1+r_B)} & Prob.=1-\alpha_1-\alpha_2 \end{cases} \tag{A3.3}$$

then,

$$E^1(B) = P_B^0 + \frac{[\alpha_1+\alpha_2\beta+(1-\alpha_1-\alpha_2)\Gamma]\,P_B^0}{(1+r_B)} \qquad (A3.4)$$

therefore,

$$E^1(B-A) = P_B^0[1+\frac{(\alpha_1+\alpha_2\beta+(1-\alpha_1-\alpha_2)\Gamma)}{(1+r_B)}] - P_A^0[1+\frac{1}{(1+r_A)}] \qquad (A3.5)$$

If $r_A = r_B = r$, then (A3.5) becomes:

$$E^1(B-A) = (P_B^0-P_A^0) + \frac{[\alpha_1+\alpha_2\beta+(1-\alpha_1-\alpha_2)\Gamma]P_B^0-P_A^0}{(1+r)} \qquad (A3.6)$$

Extending periods from t = 2 to t = n, and supposing the annual demand is increased/decreased proportionally at rate β or Γ, then the formula (A3.6) will have the following form:

$$E^n(B-A) = (P_B^0-P_A^0) + \frac{[\alpha_1+\alpha_2\beta+(1-\alpha_1-\alpha_2)\Gamma]P_B^0-P_A^0}{(1+r)^1} + \ldots + \frac{[\alpha_1+\alpha_2\beta+(1-\alpha_1-\alpha_2)\Gamma]P_B^0-P_A^0}{(1+r)^n} \qquad (A3.7)$$

(A3.7) can be summarised and generalised as the following form:

$$E^n(A-B) = \sum_{t=0}^{n} \frac{P_B^t}{(1+r)^t}[\alpha_1+\alpha_2\beta_t+(1-\alpha_1-\alpha_2)\Gamma_t] - \sum_{t=0}^{n} \frac{P_A^t}{(1+r)^t} \qquad (A3.8)$$

The social discount rate is a complex topic which has been discussed by many forestry economists (Price, 1989; 1993) and this study does not attempt to involve the theoretical discussion of the topic, rather to apply the technique to its practical analysis. Thus, the question here is how to decide the probabilities (α_i) of each event.

REFERENCES

A.A.A.S. *Bulletin,* (1973). XXV (7):9.

Adams, D.M. (1974). Forest Product Prices and National Forest Supply in the Douglas-fir Region. *Forest Science,* 20:243-60.

Adams, D.M. and Haynes, R.W. (1987). The 1980 Softwood Timber Assessment Market Model: Structure, Projections, and Policy Simulations. *Forest Science,* Monogragh 22.

Adams, G.F. and Blackwell J. (1973). An Econometric Model of the United States Forest Products Industry. *Forest Science,* 19: 82-96.

Allen, G.M. and Gould, E.M. (1984). Complexity, Wickedness and Public Forests. *Journal of Forestry,* 84(4): 20-23.

Amidon, E.L. and Akin, G.S. (1968). Dynamic Programming to Determine Optimum Levels of Growing Stock. *Forest Science,* 14:287-91.

Andersson, A.E. and Brannlund, R. (1987). The Demand for Forest Sector Products. In M. Kallio *et al.,* (eds.), *The Global Forest Sector: An Analytical Perspective,* IIASA, John Wiley & Sons.

Ballance, R.H. (1988). Trade Performance as an Indicator of Comparative Advantage. In D. Greenaway (ed.), *Economic Development and International Trade,* Macmillian Education Ltd.

Barnett, A.D. (1981). *China's Economy in Global Perspective,* Washington, DC; Brookings.

Barnett, A.D. (1986). China's Modernization: Development and Reform in the 1980's. In Selected Papers: *China's Economy Looks Toward the Year 2000,* 1:160-83. U.S. Government Printing Office, U.S. Wash.

Batten, D.F. and Johansson,B. (1987). Substitution and Technological Change, In Kallio *et al.* (eds), *The Global Forest Sector: An Analytical Perspective,* IIASA, John Wiley and Sons.

Binkley, C.S. (1987). Economic Models of Timber Supply, In Kallio *et al.* (eds), *The Global Forest Sector: An Analytical Perspective,* IIASA, John Wiley and Sons.

Brodie, J.D. Adams, D.M. Chiang, K. (1978). Analysis of Economic Impacts on Thinning and Rotation for Douglas-fir, Using Dynamic Programming. *Forest Science,* 24:513-22.

Boyce, S.G. (1983). Examine Forestry Policies with System Dynamics Methods. *Dynamics,* 1983. 9 (2):54-59.

Brat, J.D., Adams, D.M. and Kayo, C. (1978). Analysis of Economic Impacts on Thinning and Rotation for Douglas-fir, Using Dynamic Programming. *Forest Science,* 26: 217-227.

Bronson, R. and Jacobson C. (1986). Simulation and Social Theory, *Simulation,* 1986 (8).

Brooks, D.J. (1987). Modelling forest dynamics. In M. Kallio *et al.* (eds), *The Global Forest Sector: An Analytical Perspective,* IIASA, John Wiley and Sons.

Brown, J. (1985). *Project China 2000,* WFP. Beijing.

Buongiorno, J. (1977). Long-term Forecasting of major Forests Consumption in Developed and

Developing Economies. *Forest Science*, 23: 13-25.

Cannon, T. and Jenkins A. (eds) (1990). *The Geography of Contemporary China.* Routledge, London.

Cardellichio, P.A. and Adams, D.M. (1990). An Appraisal of IIASA Model of the Global Forest Sector: Advances, Shortcomings, and Implications for Future Research. *Forest Science*, 36(2):343-57.

Cavana, R.Y. and Coyle, R.G. (1984). A Policy Analysis Model for New Zealand's Plantation Forestry System. *New Zealand Journal of Forestry*, 29:(1).

----- (1986). *CELT 2000 (China's Economy Looks Towards the Year 2000). Vol. 1: The Four Modernisations; Vol. 2: Economic Openness in Modernising China.* Washington D.C.

Chappelle, D.E. (1966). Economic Model Building and Computers in Forestry Research. *Journal of Forestry*, 64 (5):329-33.

Chen, C.G. (1988). The Motive Force of Forestry Development in China, *Forestry Problems*, 1988 No.2. pp.17-37.

Chen, C.M. Rose, D.W. and Leavy, R.A. (1980). Derivation of Optimal Stand Density Over Time--a Discrete Stage, Continuous State Dynamic Programming Solution. *Forest Sciences*, 26:217-27.

Chenery, H.B. (1980). Interactions Between Industrialization and Exports. *American Economic Review*, 70:281-7.

Chenery, H.B. and Bruno, M. (1962). Development Alternatives in an Open Economy: The Case of Israel. *Economic Journal*, 72:79-103.

China Statistics Bureau (1988). *A Statistical Survey of China*, China Statistics Publishing House.

Clawson, M. (1975). *Forests for Whom and for What?* John Hopkins Univ. Press. Washington D.C.

Clawson, M. (1976). *The Economics of National Forest Management*, John Hopkins Univ. Press. Wash.

Clower R.W. and Leijohufvud, A.1 (1975). The Coordination of Economic Activities: A Keynesian Perspective. *American Economic Review*, 65:182-8

Coyle, R.G. (1977). *Management System Dynamics*, Wiley, New York.

Coyle, R.G. (1980). *Equations for Systems*, Univ. of Bradford Printer, Bradford.

Day R.H, (1973). Recursive Programming Model: A Brief Introduction, in G.Judge and T.Takayama (eds). *Studies in Economic Planning Over Space and Time*, Amsterdam, North Holland.

Dent, J.B. and Black, M.J. (1979). *Systems Simulation in Agriculture*, Applied Science Publishers Ltd.

Diab, M.A. (1956). *The United States Capital Position and the Structure of its Foreign Trade*, Amsterdam, North-Holland.

Duerr, W.A. (1976). Planning as Escape From Our Forest Production-Goal Muddle. In Convery F.G. (ed.), *Long-range Planning in Forestry*, Duke Univ. School of For. Durham, NC.

Edelman, D.J., Byron, R.N., and Manson, D.M. (1985) The Bangladesh Forestry Sector Simulation, *International Journal for Development Technology*, Vol.3 pp5-18.

FAO (1976). *A Model for the Evaluation of Forest Sector Development Strategies in Peninsular Malaysia: A Description of the Method of Analysis with Selected Commants.* FAO Rome. FO: MISC/77/21.

FAO (1977). *A Model for the Evaluation of Forest Sector Development Strategies in Peninsular Malaysia: A Supplementary Note on Analytical Procedures.* FAO Rome. FO: MISC/77/21.

FAO (1982). *Forestry in China,* FAO, Rome.

FAO (1986). *Forest Products: World Outlook Projections.* Forestry Paper No.73, Rome.

Fedorov, V., Kallio, M., Reteium, A. and Smyshlayev A. (1987). Planned Economies in the Global Forest Sector Model. In M Kallio, at el. (eds) *The Global Forest Sector: An Analytical Perspective, IIASA,* John Wiley and Sons.

Flick, W.A. (1985). Economics of Timber sale Decisions. *Southern Journal of Applied Forestry,* 9:3, 146-150.

Forestry Commission Bulletin: *Forestry Facts and Figures, 1985-89,* Forestry Commission, U.K.

Forrester, J.W.(1961). *Industry Dynamics,* MIT Press, Cambridge, Mass.

Forrester, J.W. (1968). *Principles of Systems,* MIT Press, Inc. Cambridge, Mass.

Forrester, J.W. (1973). *World Dynamics,* MIT Press. Inc. Cambridge, Mass.

Forrester, J.W. and Senge, P.M. (1980) Tests for Building Confidence in System Dynamics Models, In Machol, R.E. (ed.), *TIMS Studies in the Management Sciences (System Dynamics).* North-Holland Publishing Company.

Fowler, K.S. (1978). Toward a More Integrated Regional Timber Model. *Forest Science,* 24: 434-43.

Gabor, D. (1972) World Modelling. *Science* (176):109.

Gane, M. (1986) TIMPLAN: A Planning System for Industrial Timber-based Development. *Commonwealth Forestry Review,* 65(1), pp4.1-49.

Gane, M. (1995) Modelling Growth with TIMPLAN, *Lesnictvi-Forestry,* Vol.41, 1995(4), pp163-172.

Gong, B.L.(1988) *China's Timber Circulation and Management.* China's Forestry Publishing House, Beijing.

Gorden, H.S. (1954) The Economic Theory of a Common Property Resource: The Fishery. *Journal of Political Economy,* 62:124-42.

Graham, A.K. (1980). Parameter Estimation in System Dynamics Modelling, In Randers, J. (eds), *Elements of the System Dynamics Method,* MIT Press, Cambridge, Mass and London.

Greber, B.J. and Wisdom, H.W. (1985). A Timber Market Model for Analysing Roundwood Product Interdependencies. *Forest Science,* 31:164-79.

Gregory, G.R. (1966) Estimating Wood Consumption With Particular Reference to the Effects of Income and Wood Availability. *Forest Science,* 12:230-46.

Gregory, G.R. (1987). *Resource Economics for Foresters,* New York; Wiley. 477p.

Gu, K.P. *et al.* (1987) The Present and Future States of Forest Resources in China, *Forestry*

Problems, 1987, No.4.

Hall, O.F. (1967) New Tolls for Planning and Decision Making. *Journal of Forestry*, 65 (7):467-72.

Hardin, G. and Baden, J. (1977). *Managing the Commons*, W.H. Freeman, San Francisco.

Haynes, R.W. (1977). A Derived Demand Approach to Estimating the Linkage Between stumpage and Lumber markets. *Forest Science*, 23: 281-8.

Haynes, R.W. (1975). *A Dynamic, Spatial Equilibrium Model of the Softwood Timber Economy With Demand Equations Specified. Ph.D Dissertation*, School of Forest Resource, North Carolina State Univ., Raleigh, NC. 102p.

Haynes, R., Harou, P. and Mikowski, J.(1992). *Forestry Sector Analysis for Developing Countries*. Proceedings of IUFRO Conference - the 10th Forestry World Congress, Paris in 1991. Distributed by College of Forest resources, University of Washington, Seattle, WA 98195, USA.

He, N.W. (1978) *Is Yangtze Going to be Another Yellow River?* An Article on Renmin Ribao (People's Daily) 24/5/1978.

Hicks, J.R. (1946). *Value and Capital: an Inquiry into Some Fundamental Principles of Economic Theory*. Clarendon Press, England.

Hoganson, H.M. and Rose D.W. (1984). *A Simulation Approach for Optimal Management Scheduling*. Forest Science, 30(1):220-38.

Holdgate, M.W. (1979). *A Perspective of Environmental Pollution*, Cambridge, Cambridge University Press.

Holley, D.L., Haynes, R.W. and Kaiser, H.F.J. (1975). *An Interregional Timber Model for Simulating Change in Softwood Forest Economy*, North Carolina State Univ., School of For. Res. Raleign, NC. Tech. Rep. 54. 70p.

Hool, J.N. (1966). Dynamic Programming-Markoff Chain Approach to Forest Production Control. *Forest Science*, Mono. 12. 26p.

Hou, Z.Z. (*et al.*). (1985). *Supply and Demand for Timber in China*, Beijing.

Howe, C,W. (1979). *Natural Resources Economics*, John Wiley & Sons, Inc.

Huang, D. Y. (*et al.*). (1985). *Study of Development Trend of Forest Resources in 2000 in China*, Chinese Association of Forestry. Beijing, China.

Hyde and Newman (1991). *Forest Economics and Policy Analysis: An Overview*. World Bank Discussion Papers No. 134, World Bank

Jin-Yan, (1986). Import, Supply and Demand for Timber and Forestry Development. *Forest Economics*, (*Lin Ye Jin Ji*) 1986 3:21-24. China, Beijing.

Johansson, P.O. Lofgren, K.G. (1985). *The Economics of Forestry and Natural Resources*, Basil Blackwell.

Johnston, Grayson and Bradley, (1967). *Forest Planning*, Faber and Faber Ltd, London.

Kallio, M., Dykstra, D.P. and Binkley, C.S. (1987). *The Global Forest Sector: An Analytical*

Perspective, IIASA, John Wiley & Sons.

Kaplan, A. (1964). *The Conduct of Inquiry, Methodology for Behavioral Science,* San Francisco: Chandler Publishing Co. 428p.

Kendrick, D.A. (1988). *Feedback: A New Framework for Macroeconomic Policy,* Kluwer Academic Publishers, Boston. 147p.

Keynes, J. M. (1936). *The General Theory of Employment, Interest and Money,* Macmillan and Co., ltd.

Kirby M. (1975). Land-use Planning, Transportation Planning, and Integer Programming. In Meadows, *et al.*, (ed), *Systems Analysis and Forest Resource Management,* Soc. Amer., Washington, DC p.271-84.

Klein, L. R. (1956). *A Textbook of Econometrics,* New York: Row, Peterson and Company.

Kumar, R. (1985). Supply and Demand Medols in Forestry -- A Survey and a Suggested Model. *Journal of World Forest Resource Management,* Vol.1(2), pp133-150.

Laarman, J.G. & Wohlgenant, M.K. (1984). Fuelwood Consumption: A Cross-country Comparison, *Forest Science,* 30 (2):383-392.

Labys, W.C. (1973). *Dynamic Commodity Models: Specification, Estimation and Simulation,* Health Lexington Books, Lexington.

Lang, J.M. and Fish, D.L. (eds) (1975). *Resources and Decisions.* Duxbyry Press, A Division of Wadsworth Publishing Company, Inc.

Lange, O. (1970). *Papers in Economics and Sociology,* Oxford Pergamon, 600p.

Lange, O. and Taylor, F.M. (1976). *On the Economic Theory of Socialism,* In B.E. Lippincott (ed.). Tata Mcgraw-Hill, New Delhi. 143p.

Leamer, E. (1974). *The Commodity Composition of International Trade in Manufactures: An Empirical Analysis.* Oxford Economic Papers 26:351-74.

Leontief, W.W. (1956). Factor Proportions and the Structure of American Trade Future Theoretical and Empirical Analysis, Review of Economics and Statistics, 38: 386-407.

Lewis, A. (1972). *The New York Times,* January 14, 1972.

Li, J.C. Kong, F.W. He, N.H. and Ross, L. (1988). Price and Policy: The Keys to Revamping China's Forestry Resources. In Repetto, R. and Gillis, M. (ed). *Public Policies and the Misuse of Forest Resources,* Cambridge University Press.

Li, Z. and He, N.W. (1988). A Critique of "Forestry is in the Turning-point in China". *Forestry Problems,* 6:106-139. Beijing.

Licobman, (1976). *A Critique of Methods of Adjusting, Updating and Projecting Matrices Coefficients,* Input-output Publishing Company, London.

Lim, E. (1985). *China: Long-Term Development Issues and Options* (main Report). John Hopkins, Baltimore, World Bank.1985.

Lin, Lin. (1986). China's Forestry in a Turning Point. *Forestry Problems,* Beijing

Linnemann, H. (1966). *An Econometric Study of International Trade Flows*. North-Holland, Amsterdam.

Lipsey, R.G. (1977). *An Introduction to Positive Economics*, 4th Edition. Weidenfeld and Nicolson.

Liu, A. (1984). Study on Economic and Social Analysis of Regeneration of Plantations in Beijing Area. *Journal of Beijing Forestry*, 1984 No.2. pp.10-8.

Liu, A. and Jin, H. (1989) *Primary Study of Wood Product Market in China*, Unpub. Paper.

Liu, D.S. (1991) *Reform in Collective Forest Sector*, Unpublished Discussion Paper, Institute of Forest Research, China Academy of Forest Sciences, Beijing.

Liu, P.(1991). *A Global Comparason of the Relation Between Planning and Market*. Jiangxi People's Publishing House, China.

Liu, X.L. (1988). China's Timber Import Policies and Forest Development, *Forestry Problems*, 1988, No.4.

Lofgren, K.G. (1983). The Faustmann-Ohlin Theorem: A Historical Note. *History of Political Economy*, pp.261-264.

Loomba, N.P. (1978). *Management - A Quantitative Perspective*. Macmillan Publishing Co. Inc., New York. 594p.

Luenberger, P. (1979). *Introduction to Dynamic System; Theory Models and Applications*. John Wiley and Son, New York. 446p.

Madas, A. (1974). *World Consumption of Wood: Trends and Prognoses*. Hungary.

Maren, (1984) Forest Policy?

Marx, K. (1885). *Capital a Critique of Political Economy*.

Mckillop, W. (1967). *Supply and Demand for Forest Products: An Econometric Study*, Univ. Calif. Agr. Exp. Stn. Hilgardia. 38(1): 132p.

Mckillop, W. and Wibe, S. (1987). Demand for Sawnwood and Panels. In M. Kallio, al et. (eds.). *The Global Forest Sector: An Analytical Perspective*, IIASA, John Wiley and Sons.

McGaughey, S.E. and Gregersen, H.M. (1988). *Investment Policies and Financing Mechanisms for Sustainable Forestry Development*. Inter-American Development Bank, Washington D.C.

Mclean, D.W. (1984) Planning for Forest Resource Management: Some Thoughts on Method. *N.Z. Journal of Forest*, Vol.29, No 3.

Meadows, D.H. Meadows, D.L. Randers, J. and Behrens, W.W. (1972). *The Limits to Growth*, Universe Books, New York.

Meadows, D.L. Behrous, W.W. Meadows D.H. Naill, R.F. Randers, J. and Zahn E.K.O. (1974). *Dynamics of Growth in a Finite World*, Wright-Allen Press, Cambridge, Mass.

Mendoza, G.A. & Sprouse, W. (1989). Forest Planning and Decision Making Under Fuzzy Environments: An Overview and Illustration, *Forest Science*, 35:481-502.

Mikram, G.A. (1972). *Simulation: Statistical Foundations and Methodology*, New York, Academic Press.

Ministry of Finance (1985). *China Statistical Information of National Income and Expenditure: 1950-83*. Ministry of Finance, Beijing.

Ministry of Forestry (MOF) (1982). *Forest Statistical Digest: 1949-81.* Planning Division, MOF. Beijing.

MOF (1985). *China Technical Regulation for Forest Resource Survey,* Forest Redources Division, MOF. Beijing.

MOF (1986). *A Statistical Survey of Forest Resources in China,* MOF, 1986. Beijing.

MOF (1986). *China's Forestry Statistical Information: 1979-85.* MOF, Beijing.

MOF (1986). *Report on National Resources Survey: 1977-81.* Statistical Division, MOF. Beijing.

MOF (1987). *Outline of Forest Statistics: 1949-1986,* Beijing.

Molean, D.W. ((1984).) Planning For Forest Resource Management: Some Thoughts on Method, *New Zealand Journal of Forestry,* Vol.29

Nagy, A and Andersson A. (1988) Introduction, in Nagy, A. (ed.) *International Trade in Forest Products.* A B Academic Publishers.

National Statistical Bureau (NSB) (1987). *Statistical Year-Book of China.* China Statistical Publishing House, Beijing.

Navon, D. (1975). Short-run and Long-run Models for Planning forest Transportation. In Meadows, *et al.* (ed.). *Systems Analysis and Forest Resource Management,* Soc. Amer., Washington, DC 300-312pp.

Naylor, T.H. and Finger, J.M. (1967). Verification of Computer Simulation Models. *Management Science,* 14: 92-101.

Naylor, T.H. Balintfy, J.L. Burdick, D.S. and Chu,K. 1966. *Computer Simulation Techniques,* New York: Wiley.

Neary J. and Wijnbergen S.V. (eds) (1986). *Natural Resources and the Macroeconomy.* Basil Blackwell Ltd.

NFPA, (1986). *The Market for Softwood, Lumber and Plywood in the People's Republic of China,* 2 Vols. Washington, D.C. 1/09/1986.

Nolar P. and Dong F.R. (1990) *The Chinese Economy and Its Future,* Basil Blackwell Ltd

Nordhous, W.D. (1973). World Dynamics: Measurement Without Data. *Economic Journal,* 83:1156-83.

Olechowski, A. (1987). Barriers to Trade in Wood and Wood Products. In M. Kallio *et al.* (eds), *The Global Forest Sector: An Analytical Perspective,* IIASA, John-Wiley and Sons.

Palo, M. (1987). Deforestation Perspectives for the Tropics: A Provision Theory with Pilot Applications. In M. Kallio *et al.* (eds), *The Global Forest Sector: An Analytical Perspective,* IIASA, John Wiley and Sons.

Papps, I. and Henderson, W. (1977). *Models and Economic Theory,* London. 131p.

Pearse, P.H. (1990). *Introduction of Forestry Economics,* UBC Press.

Porterfield, R.L. (1976). A Goal Programming Model to Guide and Evaluation Tree Improvement Programs. *Forest Science,* 22: 417-30.

Price, C. (1979). Terms of Trade and Forest Products. *Commonwealth Forest Review,* 58(4):235-42

Price, C. (1987). *Does Shadow Price Go on for Ever?* Dept. of For. and Wood Sci., UCNW, Bangor.

Price, C. (1989). *The Theory and Application of Forest Economics,* Basil Blackwell Inc.

Price, C. (1993). *Time, Value and Discounting,* Basil Blackwell Inc.

Prybla, J.S. (1986). *Contribution to "Economic and Political Development in China",* A Heritage Round Table, 27. 27-46.

Pugh, A.L. (1973), *Dynamo II User's Manual,* MIT Press, Cambridge, Mass.

Randers, J. (1976). *A System Dynamics Study of the Transition From Ample to Scarce Wood Resources,* Proceedings 4-6, XVIth Intern. Union. of For. Res. Organ. World Congress. Oslo, Norway, P.302-22.

Rees, J. (1985). *Natural Resources: Allocation, Economics and Policy.* Methuen and Co. Ltd.

Ricardo, D. (1817). *The Principles of Political Economy and Taxation,* Reprint: Everyman, London, 1926.

Richardson, S.D. (1987). *The Cotchell Report,* Cotchell Pacific Ltd. Hong Kong.

Richardson, S.D. (1990). *Forests and Forestry in China: Changing Patterns of Resource Development,* Washington D.C.: Island Press.

Robbins, L. (1938). *An Essay on the Nature and Significance of Economic Science,* Macmillan and Co., Limited, London.

Roberts, N. Anderson, D.F. (1983). *Introduction to Computer Simulation: the System Dynamics Approach,* Addison-Wesley Publishing Company. Mass. 562p.

Robinson, V.L. (1974). An Econometric Model of Softwood Lumber and Stumpage Markets, 1947--1967. *Forest Science,* 20:171-9.

Robinson, V.L. and Willard, R.F. (1983). Use of System Dynamics Approaches to Regional Forest Sector Models. In R. Seppala, *et al.* (ed.) *Forest Sector Models,* 93-104. A B Academic Publishers.

Roise, J.P.A. (1986). A Nonlinear Programming Approach to Stand Optimization. *Forest Science,* 32:735-48.

Samuelson, P.A. (1948). *Economics,* McGraw-Hill, New York. 622p.

Schrank, W.E. Holt, C.C. (1967). Critique of Verification of Computer Simulation Models. *Management Science,* 14:104-6.

Sedjo, R. and Lyons, K. (1983). An Optimal Control Theory Model to Estimate the Regional Long-term Supply of Timber. *Forest Science,* 29:798-812.

Sergeyev, V.P. (1964). Economic Principles of the Foreign Trade of Socialist States. In Harrod, R. and Hague, D. (eds), *International Trade Theory in A Developing World,* Macmillan, London.

Sha, Z. (1985) Analysis of Forest Tending Effects, *China's Forestry in 2000.* China Forestry Association, Beijing. 1:219-32.

Shubik, M. (1971). Modelling on a Grand Scale. *Science,* (174):1014.

Sik, O. (1976). *The Third Way: Marxist-Leninist Theory and Modern Industrial Society,* International Arts and Sciences Press. London.

Slutsky, E.E. (1952). On the Budget of the Consumer. Reprinted in *Readings in Price Theory.* American

Economic Association. Irving, TX.

Smil, V. (1980). China's Energetics: A System Analysis, in V. Smil and W.E. Knowland (eds.), *Energy in the Developing World: the real energy Crisis,* Oxford University Press, Oxford.

Smil, V. (1992) *China's Environmental Crisis: An Inquiry Into the Limits of National Development.* M.E. Sharpe, New York.

Smith, A. (1776). *Inquiry into the Nature and Causes of the Wealth of Nations.*

Stover, J.G. (1980). Including Future Events in System Dynamics Model. In R.E. Machol (ed.), *TIMS Studies in the Management Sciences 14.* North-Holland Publishing Company.

Tharakan, P.K.M. (1984). *Intra-Industry Trade: Empirical and Methodological Insures,* Amsterdam, North-Holland.

Tharakan, P.K.M. and Vandoorne, M. (1979)., *Structure of Belgium's Comparative Advantage vis-a-vis the Developing World: A tentative Classification of Industries,* Cahiers Economiques de Bruxelles, 213-34.

Theil, H. (1960). *Economic Forecast and Policy.* Amsterdam, North-Holland Publishing.

Theil, H. (1971). *Principles of Econometrics,* John Wiley and Son Inc.

Todaro, M.P. (1977). *Economics for a Developing World: An Introduction to Principles, Problems and Policies for Development.* Longman.

United Nation, (1984). *Statistical Yearbook: 1983 & 1984.* United Nation.

Vanek, J.F. (1959). The Natural Resource Content of Foreign Trade 1870-1955 and the Relative Abundance of Natural Resources in the United States, *Review of Economics and Statistics,* 41:146-53.

Waggener, T.R. (1989). *Forest Products and the People's Republic of China.* CINTRAFOR Working Paper, No.23.

Wang, C. and Lin, W. (1981). .*The Economic Problems of Forestry in Land Use.* Zhan-Wang Press, Beijing.

Weeks, J. and Wisdom, H.W. (1987). Ocean Shipping of Forest Products. In M. kallio *et al.* (eds), *The Global Forest Sector: An Analytical Perspective,* IIASA. John Wiley and Sons.

Westoby, J.C. (1975). Forestry in China, *Unasylva,* 108(27): 20-28.

Westoby, J.C. (1987). *The Purpose of Forests,* Basil Blackwill Inc.

World Bank, (1985). *China: Long Term Issues and Options,* Baltimore, The Johns Hopkins University Press.

Wright, R.P. (1971). *Industrial Dynamics Implementation: Growth Strategies for a Trucking Firm,* Sloan. Manag. Rev. 13.

Yue Pine, (1980). *Afforestation and Protection of Forests in the National Economy,* Hongqi (Red Flag), 1981 (23):40-45.

Yong, W.T. (1981). Article in *Agricultural Economic Problems (Nongye Jingji Wenti)* No.9.

Yong, W.T. (1987). The Fundamental Way Out for China's Forestry lies in the Development of

Productivity. *Forestry Problems*. Chinese Forestry Association. 1987, No. 4. Beijing.

Zadeh, L. (1965). Fuzzy sets, *Information Control,* 8: 338-353.

Zhai, Z. & Yin, J. (1981). *Ways in Which to Raise the Economic Benefits of Land in Forestry*, Zhangwang Press, Beijing.

Zhang, M.X. (*et al.*) (1988) Cooperative Forestry Development in Plain Regions of China, *Forestry Problems,* Chinese Forestry Association, No. 3. Beijing.

Zhong, M.G.(*et al.*), (1985). Synthetical Study of Forestry Development in China. *Forestry Academic Science of China*, Beijing.