The Energy Structure and Economic Growth in China

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I. This report is designed to provide a better understanding of energy supply and demand situation of China and the relationship between the energy structure and economic growth.

II. China has a very high economic growth rate since the launch of economic reform and opening, and the high growth momentum will be continued to the 21st Century. The consumption of its primary energy will grow continuously pushed by its further growth of economy. China is also an economy in transition. The demand and supply of energy will be effected by its economic growth, structural change of the economic sectors, spatial location of its production activities and their linkages to the regional and global economy, the energy policies, the reform of current system of enterprise, etc. All these will have their impacts on the demand and supply of energy. Because there are many factors and uncertainty of them, our projection of future energy demand will be based mainly upon the official document "China: Outlines of the Ninth Five-Year Plan and Long-term Target towards to 2010" authorized by the People's National Congress (PNC) on March, 5th 1996. Projection in this report is based upon pragmatic method - the energy intensity method, it is convenient to adapt to structural changes. But results done by using our sophisticated model - CGE model and projections done by various other resources are also collected in the appendices to provide cross reference.

III. The report of this study consists of a main report and appendices. The main report is composed of three parts: the role of energy in the national economy; change of energy structure and its impact on national economic growth and the environment; and national energy demand projection and energy policy and investment demand. China uses coal as a dominant energy sources and Standard Coal Equivalent (SCE)[1] is used for the measurement of various forms of energy in official statistics, a conversion table to other energy forms is also provided in the appendix B.

IV. Major findings of this report are:

[1] Standard coal equivalent is defined to be coal with 7000 KC of heat content.

1. China's energy demand and supply are effected greatly by its economic system. The former central planning system in the fields of the allocation of resources, the distorted energy pricing system, inward looking self-sufficient energy production system, insufficient allocation of financial resources on geological survey and exploration of energy sources, compartmentalization of organizations (for example, the exploration and production of crude oil refining and processing are belonging to different line ministries or corporations); the division of coal mining industry into state mine, local mine (including town and village mine etc.) had been a serious constraint to the growth of the energy industry. Energy had been a bottleneck of the economy for a long time in China. The launch of the economic system reform and opening to the outside world have improved the situation greatly. But issues are there because the change of the structure and production of energy industry take a long time and period of gestation, it also requires large amount of financial resources.

2. The major energy policies implemented since 1979 are as follows:
(1) To reform the energy management system, and encourage the development of energy sector by the collaborative efforts of the central and local government, enterprises, individuals and foreign investors.
(2) To gradually reform the energy pricing system, "dual track" pricing system had been adopted in transition.
(3) To raise investment through financing from various channels.
(4) To implement opening policy of the energy sector gradually, and actively use foreign direct investment, technology and management experiences.

3. Major achievements since reform
(1) There is a change of structure of investment, the share of state budget is declined greatly, and the share of domestic loans, local financing, sectoral and enterprise self financing and others increase rapidly. For example, foreign direct investment in the power sector was 2.24 billion Yuan in 1988, and increased to 9.5 billion Yuan in 1995.
(2) There is a moderate growth of primary energy to meet the high growth of economy. Although the average growth rate of primary energy is lower than previous 26 years (average annual growth rate of primary energy is 10.1% from 1952-1978), industrial restructuring and national priority on energy saving have solved this problem to a large extent. Generally, primary energy has the highest growth rate (6.1%) in the Sixth-Five Year Planning period (1981-1985); town and village coal mine contributed the most of it in this growth process (a net increase of

150 million tons of coal produced by town and village coal mine among the total increase of 250 million tons of coal in this period). Power sector has high growth rate in the Seventh-Five (1986-1990) and Eighth-Five Year (1991-1996) planning period. In the former period, there is an annual increase of 10.2 million Kw capacity installed each year; in the later period, the annual increase of installed generating capacity is 15.9 million Kw each year. The production of the crude oil is maintained stable inspire of the on-shore oil fields in the later stage (past peak) of production, the increase of production of oil off-shore has complemented the stagnation of oil production on-shore. There is also increase of production of natural gas through more investment. All above achievements are results mainly from policies of reform and opening.

4. Major issues or challenges to be met

(1) The growth rate of energy industry cannot cope with the growth of the national economy. The average annual growth rate of GDP is around 9.8% from 1978 to 1995 and the growth rate of primary energy is only 4.9%.

(2) It is difficult for energy sector to develop by itself. Energy industry is a high capital intensive sector. The fixed asset of the energy sector ranks the first of all sectors, a share of 25% of the total national fixed assets. But its share of value of output is very low due to low energy price, distorted price system and imperfect market mechanism. The value-added of the energy sector was no more than 10% of industrial sector of GDP in 1994, and it had only a share of no more than 4.4 percent of GDP in 1994, i.e. high input and low output. Therefore, it has no capability to accumulate financial resource to develop by itself.

(3) There is still a large room for energy saving although the Government emphasizes energy saving as a priority of energy policy throughout all consecutive Five-Year plans. This study shows that there is certain false vision among the Chinese scholars and officials that China's energy intensity per unit of GDP is several times of those of the developed economies. This false vision comes from the unit used to measure the overall economic strength of a nation. China has not undertaken an official study on purchasing power parity. If GDP per capita measured by PPP of 2510 USD estimated by the World Bank is used (1996 World Development Report of the World Bank), China's energy intensity will be around 1.86 times of those of the OECD countries. This checks with current operation of production.

(4) The large energy production enterprises are low competitive due to high social burden, low energy price, central control of administration etc. There is the need of further reform of the energy sector.

(5) The current structure of primary energy consumption and production has some

irrationality due to lack of long term energy policy and insufficient coordination. There is dominant share of coal consumption and production around 75% share of total primary energy which results in serious environmental issues, SO_2 discharged was 18.3 million tons, whereas its removal was only around 12% in 1994, CO_2 discharged will also result greenhouse effect. These have raised concern from international community. The high share of coal in primary energy production also brings along serious pressure to transportation.

(6) There is insufficient proven reserve of petroleum. It is reported officially that the proven reserve of crude oil is 15.98 billion tons. The proven reserve of the natural gas is 860 billion cubic meters. Due to many oil fields have passed their peak production stage, there is decrease of R/P ratio. More financial, technological and management input should be input to geological exploration.

(7) Coordinated study is needed in China on the major energy and material sectors using primary energy, the power sector, the transportation sector and the chemical engineering sector etc. For example, it is necessary to have a comparative study of the priority in development of hydro/ thermal power with factors of transmission line cost, coal mine and railway line construction cost, environmental protection equipment cost taken into the consideration. Similar study should also be undertaken for alternative energy sources. A sound energy policy (inward or outward looking) should be established in the basis of the coordinated study of various aspects in a changing regional and global environment.

5. Energy demand projection

(1) The energy demand projection is done with three Scenarios. The base Scenario (medium Scenario) is based upon the targets set up by the official document "China: Outlines of the Ninth Five-Year Plan and Long Term Target towards 2010" authorized by the PNC (People's National Congress) on March 5th, 1996. The high Scenario is based on empirical trend of past planning implementation, the low Scenario is based upon assumption of possible natural disaster affecting the agricultural sector. Generally, the planning target of China can be achieved because it is determed on conservative basis. The result of projection is shown below.

Table 1 Energy Demand Projection 2000-2010

Year	Low Scenario		Medium Scenario (base Scenario)		High Scenario	
	Annual GDP Growth Rate %	Aggregate Energy Demand 10^8 tSCE	Annual GDP Growth Rate % (GDP in 10^8 USD 1995)	Aggregate Energy Demand 10^8 tSCE	Annual GDP Growth Rate %	Aggregate Energy Demand 10^8 tSCE
2000	7.5	14.57	8.1 (9909.6)	14.99	9.5	15.98

2005	7	17.03	7.5 (14226.6)	17.94	8.3	19.85
2010	6.5	18.78	6.9 (19860.5)	20.14	7.4	22.82

Source: DRC staff estimation.

Table 2 Component Energy Demand in 2000

	Total	Coal	Petroleum	Natural Gas	Electricity		
					Total	Within:	
	10^8 tSCE	10^8 tSCE (ton Real)	10^8 tSCE (ton Real)	10^8 tSCE (10^8 M^3 real)	Billion Kwh	Hydro 10^8 tSCE (Billion Kwh)	Nuclear (billion Kwh)
Low Scenario	14.57	10.93 (15.3)	2.52 (1.76)	0.26 (195)	1283.8	0.86 (212.8)	
Medium Scenario	14.99	11.24 (15.73)	2.59 (1.81)	0.27 (203)	1400.2	0.88 (217.8)	(13)
High Scenario	15.98	11.99 (16.78)	2.76 (1.93)	0.29 (218)	1783.6	0.94 (232.6)	

Source: DRC staff estimation.

Table 3 Component Energy Demand in 2010

	Total	**Coal**	**Petroleum**	**Natural Gas**	**Electricity**		
					Total	Within:	
	10^8 tSCE	10^8 tSCE (10^8 ton Real)	10^8 tSCE (10^8 t Real)	10^8 tSCE (10^8 M^3 Real)	Billion Kwh	Hydro 10^8 tSCE (Billion Kwh)	Nuclear (billion Kwh)
Low Scenario	18.78	13.14 (18.40)	3.53 (2.47)	0.60 (451.8)	2786.0	1.48 (367.2)	61
Medium Scenario	20.14	14.10 (19.74)	3.79 (2.65)	0.64 (484.6)	2806.2	1.59 (393.8)	67.8
High Scenario	22.82	15.97 (22.36)	4.29 (3.00)	0.73 (549.1)	2923.2	1.80 (446.2)	74.7

Note: The following conversion factors are used to convert SCE into real terms

Raw coal 0.7143 Kg SCE/Kg

Crude oil 1.4286 Kg SCE/Kg

Natural gas 1.3300 Kg SCE/M^3

Hydro power 4.04 tSCE 10000 Kwh

Source: DRC staff estimation.

(2) Supplementary projection of demand of crude oil is done based upon detail calculation of the major consumption sectors. The crude oil demand will be 197.5 million tons in the year 2000. Based upon the official target, China will produce 155 million tons of crude oil in the year 2000. Therefore, the import of the crude oil will be around 38[2]-42.5 million tons in 2000. The import of the crude oil will be around

[2] Note: The value of high Scenario of petroleum is used from table 2.

100 million tons in 2010 according to the estimation of the Chinese experts.
(3) The demand of LPG is done separately. It will be 6.19 million tons in the year 2000 and 10.514 million tons in the year 2010. This may be on the higher side.
(4) The generation and growth of nuclear energy is not done through projection in the report, because it is a new sub-sector of the power industry. The figures listed in table 2 is based upon the existed two nuclear power stations, Qinshan and Dayawan assuming there will be no new units been put into operation in the year 2000. The figure listed in table 3 is based upon the available information that new units of nuclear power will be installed in Guangdong, Zhejiang, Fujian, Shandong and Liaoning provinces through utilization of foreign direct investment. The planned new installed capacity is around 10 million Kw capacity from 1996-2010. It is assumed that a part of capacity will be put into operation in 2010. Different Scenario has different assumption of capacity been put into operation and in full capacity of operation.

6. Energy industry investment projection
The result of energy industry investment projection is shown in table 4.

Table 4 Investment Demand Projection of Energy Industry (10^8 Yuan)

Year	Sector		
	Coal	Petroleum and Gas	Electricity
2000	2635.54	4680.96	7668.14
2010	5377	21939	45841.73

Source: DRC staff estimation.

V. Role of energy in the national economy

1. Overview of Chinese Economy and Energy in 1997
China's GDP in 1997 was 7477.24 billion Yuan (around 900 billion USD, exchange rate 8.3 Yuan : 1 USD). The share of primary, secondary and tertiary sector is 18.7% : 49.2% : 32.1%. Total investment of fixed assets was 2494.1 billion Yuan. The total retail sales was 2729.9 billion Yuan. The total external trade was 325.06 billion USD with import equals to 142.3 USD and export equal to 182.7 billion USD. China produced 1.37 billion tons of coal, 160.74 million tons of crude oil and 1135.6 billion Kwh of electricity in 1997. The sum of energy production was 1319.89 million tons of standard coal equivalent. One USD GDP per unit of energy use is 1.46 Kg of SCE. The average growth rate of GDP from 1991-1997 is 11.2%, the

growth of primary energy is 3.5%. The elasticity of energy (production) is around 0.31 in this period.

2. Structure of China's energy production and consumption is dominated by coal. The share of raw coal, crude oil, natural gas and hydro-power in the primary energy is around 75%:17.3%:1.8%:5.9% in consumption. The shares in the production of primary energy are nearly the same.

3. Coal. China is rich in coal reserve. The prospective reserve is 986.3 Gt, the proved amount in place (defined by the World Energy Commission) is around 259.89 Gt, and the recoverable reserve is 114.5 Gt. The reserve used in design is 46 Gt. The reserve is very unevenly distributed geographically. The reserve in Northern, Northwestern and Southwestern regions has 84% of total coal reserve, within which the Shanxi province has the largest share of 27%, the Inner Mongolia 21% and Shaanxi province 16%. This distribution of energy reserve affects greatly the network of transportation of China in relying upon coal as the major domestic energy source. Coal accounts for 29% of total railway freight by ton-km (42% of total tons). It is also the dominant commodity handled at seaports, of the 678 million tons of goods handled through sea ports in 1993, coal accounted for 211 million tons (31%).

4. Petroleum and Natural Gas

The petroleum industry had substantial success between 1952 and 1978. This industry now faces new challenge to meet the demand in the coming future since China's largest oil fields have passed their peak productivity. The future prospect of this industry will be largely determined by the extent of new discoveries and the speed and the economic feasibility which they can be developed. Formerly, the exploration of natural gas was administrated by the petroleum sector, this had a negative effect in exploration activity because petroleum received the major focus while exploration of natural gas had received minor concern. The establishment of the China National Petroleum Corporation (in Chinese term, it is called Chinese Petroleum and Natural Gas Corporation) has improved the situation. Therefore, Chinese economic activity is effected greatly by its institutional arrangement in administration. The prospective petroleum reserves are 94 billion tons and those of natural gas are 43000 billion M^3. The proved reserves of petroleum and natural gas are 15.98 billion tons and 946 billion M^3. There are around 292 oil fields and 79 gas fields in operation. China produced 149.2 million tons of petroleum and 17.7 billion M^3 of natural gas in 1995.

5. The Electricity Sector

China has established a large electric power sector since 1949. By the end of 1996, the total installed capacity is 236.54 million Kw. The per capita installed capacity is only 0.19 Kw, the electricity generation per capita is 901 Kwh. The structure of the

power sector is dominated by thermal power with coal as the major primary energy. Therefore, it has important impact on environmental issue. SO_2 discharged by the power plants covers 1/3 of the national total. The hydro-power has a share of 23.5%. The nuclear power is in the beginning stage of development, the total installed capacity is only 2.1 million Kw, a share of 0.9 % only.

China has a large potential of hydro-power resources, its exploitable capacity is 379 Gw. But its potential has not been fully developed. There are now 12 principal hydro-power bases under development. For a long term, it is reasonable to have restructuring the primary energy source of the power sector through adjustment of shares of coal, hydro-energy, oil, nuclear energy and alternatives.

6. Overview of sectoral consumption of energy.

The agricultural sector has 18.7 % share of GDP in 1997, the energy intensity is around 0.33 Kg SCE/ USD of GDP output. The industrial sector has 40.8% share of GDP. It is the major consumer of various forms of primary energy, the energy intensity is 2.6 Kg SCE/ USD of GDP output.

VI. Change of energy structure and its impact on economic growth at national level

1. There is change of structure of primary energy production from 1978 to 1997. The share of raw coal, crude oil, natural gas and hydro-electricity in primary energy is 70.3:23.7:2.9:3.1 in 1978, and it becomes 74.3:17.4:2.3:6.0 in 1997. There is a decrease of share of production and consumption of crude oil and natural gas. Both are due to the constraints of discovery of new reserve, and geological survey and exploration cannot cope with the demand. The energy gap due to decline of share of crude oil and natural gas is met through increase of share of coal and hydro-electricity.

2. The high growth rate of the Chinese economy from 1978 to 1997 is met by moderate growth of energy through adjustment of industrial structure and energy. The ratio of heavy to light industry was 56.3:43.7 in 1978, and it was 48.5:51.5 in 1980. This high growth of economy is accompanied with low elasticity of energy production and consumption, the mean values of them from 1978 to 1985 were 0.40 and 0.45 respectively. The mean of elasticity of electricity is 1.4 from our calculation, the result calculated by Ministry of Electricity is 0.89 from 1979-1994. Because electricity is a high class form of energy due to its convenient use in production and consumption. Therefore, it is reasonable to have a higher value of elasticity.

3. The change of energy is analyzed. Due to the change of price and change of exchange rate, no exact trend can be derived for the change of energy intensity over time. For the energy intensity of the overall economy, there is decrease of energy intensity per Yuan, but there is a increase of energy intensity per US dollar if comparison is made between 1980 and 1994, due to a large devaluation of RMB suddenly from 1 USD: 5.9 RMB down to 1 USD: 8.7 RMB in Jan. 1994. China has done a lot of works for energy saving. Therefore, there must be decrease of energy intensity through analysis from various aspects. The value of energy intensity per USD in 1994 may not reflect the reality. This fact illustrates the complexity in judging economic reality. Similarly, a fact is derived from this study that in contrast of the prevailing opinion nearly in all academic papers that China has a large waste of energy, the energy intensity per unit of output is several times of those of developed countries. Analysis done in this paper shows that the potential of scope of saving averaged 1.8 times at most under current conditions of production and technology.

4. Analysis of products of crude oil and energy consumption of petrochemical products is also done. The share of structure of consumption of crude oil shows the current condition of production. This data is also used for the supplementary demand projection of crude oil in the study. It should be emphasized that this structure of crude oil consumption is subjected to change. It will differ greatly with other countries. It will also be subjected to change through changing process of production.

VII. Energy Demand Projection

1. Methodology

There are many ways in doing energy projections, projection by sophisticated mathematical models, projection by elasticity of energy production or consumption to GDP, projection by energy intensity per unit output etc. The result of energy output and the growth of other sectors based our CGE model is shown in the appendix A. In the report, two pragmatic methods are both used for cross check purpose, the energy intensity method and the per capita energy consumption method. Supplementary detailed calculation is also done for petroleum, natural gas and LPG. Because projection is done based upon many economic assumptions, but analysis of conflict results among two different methods will provide a guideline to identify the results which approaches closer to the reality.

2. Recommended results of projection

(1) The result of projection is shown in Table 1, 2, 3, and 5 of this report.

(2) For demand of crude oil in the year 2000, the value of high Scenario (1.93×10^8 tons in table 2) is recommended in the year 2000. The value of low to medium Scenarios ($2.47\times2.65\times10^8$ tons in table 3) will be recommended for 2010.

(3) For demand of coal in the year 2000 and 2010, the value of low Scenario (15.3×10^8 tons in table 2 and 18.4×10^8 ton in table 3) is recommended.

(4) For demand of electricity in the year 2000, the value of the medium Scenario (1400.2 billion Kwh in table 2) is recommended, the value of low Scenario (2786.0 billion Kwh in table 3) is recommended for the year 2010.

(5) Our projection on the demand of natural gas is relatively on the lower side.

The above recommendation is given through our consultation with related field of experts.

3. The energy demand projection of regions (2000-2010)

The result is shown in table 6, low Scenario of projection of table 6 is recommended.

VIII. Energy Policy and Investment Projection

1. The evolution of energy policy of China is shown in various sources of documents. The related part of official statement of energy policy in the Sixth (1981-1985), Seventh (1986-1990), Eighth (1991-1995) and Ninth (1996-2000) Five-Year will be abstracted, background of these policies are explained. The detailed sectoral energy policy is also quoted from the Energy Technology Policy issued by the State Council on May 24 1986. The major energy policies implemented since 1979 had been described in the item 2 of IV in this report.

2. Investment Projection

(1) Historical data of investment on fixed assets of energy is collected for coal, petroleum and natural gas and electricity to provide a framework of reference. The accumulated investment on fixed assets for coal mining industry is 169.94 billion Yuan (1981-1994), petroleum and natural gas is 2027.6 billion Yuan, and it is 422.52 billion Yuan for electricity.

(2) Methodology of investment projection

The basic method used for investment projection is based on unit investment method, i.e. the cost of addition of unit capacity is estimated. This estimation is derived from several considerations:

(i) A base cost of unit cost per ton of coal mine or petroleum developed, or cost per

Kw electric capacity installed is estimated, based upon the record of implementation of the Sixth Five-Year Plan;

(ii) Unit cost per unit capacity of coal and petroleum in 1995 is derived from the base cost of the implementation of the Sixth Five-Year Plan with correction of appreciation factor in consideration with factors of price change. Consultation from experts of related energy sector is also done to have appropriate unit cost per unit capacity in 1995. The following cost per unit are used:

Coal: 660 Yuan/ton and Electricity: 6000 Yuan/Kw

This is a comprehensive index including transmission and distribution network and all auxiliary facilities.

Derivation of the unit cost for petroleum and natural gas is more or less complicated because the new capacity added is not large, but in order to develop the new capacity, there is a part of exploration cost, the cost of exploration off-shore and also to maintain the capacity of production is also included, 8890 Yuan/ton is used through consultation.

The unit cost of investment in 2000 and 2010 is derived with the above 1995 unit cost multiplied with a factor of compounding of price changes.

(3) The result of investment demand projection in the year 2000 and 2010 is summed up in table 5.

Table 5 Investment Projection Unit: 10^8 Yuan

Year	Coal	Petroleum & Gas	Electricity	Total
2000	2635	4681	7668	14984
2010	5377	21939	45842	73158

Source: DRC staff estimation.

3. Financing Resource

The investment system of China changes greatly in recent decade, there is a rapid decline of share of state appropriation and increasing share of loans, foreign investment, fund raising (self financing of local government, enterprise, through issue of bonds and stocks)and others. Basic information of change of source of investment financing is collected and the share of various financing resource is derived based upon the assumption that the trend is declining share of state appropriation and domestic loan, increasing share of foreign investment, self-financing will be normalized (more bonds or stocks etc.).

Table 6 Financing Resource of Investment Projection

	2000		2010	
	Percentage	Investment	Percentage	Investment

	(%)	10^8 Yuan	(%)	10^8 Yuan
State Appropriation	4.55	681.12	2.17	1587.52
Domestic Loan	22.73	3405.60	17.39	12722.12
Foreign Investment	12.73	1907.14	18.12	13256.18
Fund Raising	49.09	7356.10	47.83	34991.33
Others	10.91	1634.69	14.49	10600.55
Total	**100.00**	**14984.64**	**100.00**	**73157.70**

Source: DRC staff estimation.

IX. Conclusion

This report has given an overview of the economic development and the role of energy in China's growth process. A review of the past and a prospective study of the future of energy economic relationship are done at national level. Due to constraints of time and the objective of the study, the three major elements of contemporary energy policy have not been paid the especial attention, i.e. the energy security, economic growth and the environmental protection. Economic growth has received the priority of consideration in this report. China is an economy in transition, the past practice and data system give some false vision from the international context, the low share of value added in the contribution of GDP is a typical example, because of the distorted price system, both the commodity price and factor price. In 1994, the GDP of China was 4500.8 billion Yuan, industry was 1835.9 billion Yuan, whereas the value added of energy sector such as coal mining, petroleum and natural gas extraction, petroleum processing and coking products, electric power, steam and hot water production and supply are 54.72, 93.81, 54.22 and 102.24 billion Yuan respectively, their contribution to GDP was 1.2%, 2.1%, 1.2%, and 2.3% respectively. These added together was only 6.8%. There's no way to correct them, although the coal price is liberalized, but the coal price at the spot of sales may be five times of that at the place of production, and there are many different tariff rates of electricity throughout the whole country. The current available statistics cannot disclose these facts. Anyhow, this study has covered a broad scope of energy and economic relationship of China, some useful results have been derived. And new problem emerged through this study. For example, production of fertilizer by coal or oil or natural gas or LPG differ greatly in production cost and cost of project. What is appropriate industrial policy in an increasing open economy in the globalization process? The rich materials in this study will provide a good foundation for continuos rolling study of energy-economic relationship of China.

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Appendix A Energy Data Sheet

Table A-1 Production and Consumption of Primary Energy (10^4 tsce)

Year	Production	Consumption	Import	Export
1978	62770.0	57144.0		
1979	64562.0	58588.0		
1980	63735.0	60275.0	261.0	3058.0
1981	63227.0	59447.0	252.0	3178.0
1982	66778.0	62067.0	395.0	3485.0
1983	71270.0	66040.0	363.0	3482.0
1984	778555.0	70904.0	371.0	4621.0
1985	85546.0	76682.0	340.0	5774.0
1986	88124.0	80850.0	741.0	5745.0
1987	91266.0	86632.0	661.0	5795.0
1988	95801.0	92997.0	912.0	5767.0
1989	101636.0	96934.0	1765.0	5746.0
1990	103922.0	98703.0	1310.0	5875.0
1991	104844.0	103783.0	2022.0	5819.0
1992	107256.0	109170.0	3334.0	5633.0
1993	106995.0 *111263	107373.0 *111768		
1994	114009.0 *118729	118095.0 *122737	4342.0	5772.0
1995	129034.0	131176.0	5456.0	6776.0
1996	132616.0	138948.0	6837	7529.0

*From 1993, the coefficient for electric power convert into sce adopt equivalent for 10 Kwh convert into 1.229 in sce Figures led by star and,
before 1992 adopt average electric power using up coal in the same year.

Table A-2 production and Consumption of Coals (10^4 Ton)

Year	Production	Consumption	Import	Export
1980	62015.0	61009.5	199.0	632.0

1981	62164.0	60583.8	193.0	657.0
1982	66633.0	64125.8	219.0	644.0
1983	71453.0	68713.0	214.0	656.0
1984	78923.0	74968.3	249.0	695.5
1985	87228.4	81603.0	230.7	777.0
1986	89403.9	86012.1	247.1	981.7
1987	92796.5	92799.0	194.1	1353.0
1988	97987.6	99353.9	169.3	1564.6
1989	105414.3	103427.0	229.0	1533.8
1990	107988.3	105523.0	200.3	1729.0
1991	108740.6	110432.0	136.8	2000.1
1992	111638.0	114084.8	123.0	1966.3
1993	114970.0			
1994	123990.1	128532.2	120.9	2419.4
1995	136100	137676.5	163.5	2861.7
1996	139700	144473.44	321.7	3648.4

Table A-3 Production and consumption of Petroleum (10^4 Ton)

Year	Production	Consumption	Import	Export
1980	10594.6	8757.4	82.7	1806.2
1981	10122.1	8305.8	71.0	1884.2
1982	10212.3	8210.4	157.2	2089.7
1983	10606.8	8382.6	134.9	2092.6
1984	11461.3	8655.0	112.5	2868.7
1985	12489.5	9168.8	90.0	3630.4
1986	13068.8	9728.0	350.1	3462.0
1987	13414.0	10312.2	323.4	3293.8
1988	13704.6	11092.5	508.4	3142.3
1989	13764.1	11583.7	1065.1	3106.4
1990	13830.6	11485.6	755.6	3110.4
1991	14099.1	12383.6	1249.5	2930.7
1992	14209.7	13353.7	2124.7	2859.6
1993	14523.7			
1994	14608.2	14956.0	2903.3	2380.2

1995	15005.0	16064.9	3673.2	2454.5
1996	15733.4	17436.2	4536.9	2696.0

Table A-4 Production and Consumption of Natural Gas (10^8 cu. m^3)

Year	Production	Consumption
1980	142.7	140.6
1981	127.4	124.5
1982	119.3	119.0
1983	122.1	121.3
1984	124.3	126.3
1985	129.3	129.3
1986	137.6	127.6
1987	138.9	138.9
1988	142.6	143.6
1989	150.5	150.3
1990	153.0	152.5
1991	153.6	158.9
1992	157.0	158.8
1993	167.5	
1994	175.6	173.4
1995	179.5	
1996	201.1	

Table A-5 Production and Consumption of Electricity (10^8 Kwh)

Year	Production				Consumption	Import	Export
	Hydro power	Thermal	Nuclear	Total			
1980	582.1	2424.2		3006.3	3006.3		
1981	655.5	2437.2		3092.7	3095.7	3.0	
1982	744.0	2532.8		3276.8	3280.1	3.3	
1983	863.6	2650.8		3514.4	3518.7	4.3	
1984	867.8	2902.1		3769.9	3777.6	8.0	0.3
1985	923.7	3183.2		4106.9	4117.6	11.1	0.4
1986	945.3	3550.0		4495.3	4507.0	12.1	0.4
1987	1000.1	3972.6		4972.7	4985.2	12.9	0.4
1988	1091.5	4360.6		5452.1	5466.8	15.1	0.4
1989	1183.9	4664.2		5848.1	5865.3	17.7	0.5
1990	1267.2	4944.8		6212.0	6230.4	19.3	0.9
1991	1250.9	5524.6		6775.5	6804.0	31.1	2.6
1992	1324.7	6214.7	5.2	7539.4	7589.2	49.8	
1993	1518.2	6838.8	16.0	9394.5			
1994	1821.6	7459.2		9280.8	9260.4	18.5	38.9
1995	1905.6	8043.2	128.3	10070.3	10023.4	6.4	60.3
1996	1879.7	8777.1	143.4	10813.1	10764.3	1.2	37.1

Table A-6 Energy Consumption of Primary Sector

Year	Total 10^4 tsce	Coal 10^4 t	Petroleum 10^4 t	Natural Gas 10^8 cu. m^3	Electricity 10^8 Kwh
1980	4692.0	2905.0	814.9		331.4
1981	4773.0	2975.0	776.2		346.8
1982	4888.0	3097.0	725.09		375.2
1983	5037.0	3233.0	742.01		383.8
1984	5467.0	3703.0	799.5		389.9
1985	4045.0	2209.0	759.0		317.0
1986	4238.0	2297.0	818.0		322.0

1987	4471.0	2287.0	884.0		360.0
1988	4709.0	2378.0	929.0		379.0
1989	4724.0	2181.0	969.0		411.0
1990	4852.0	2095.0	1034.0		427.0
1991	5099.0	2124.7	1038.2		478.9
1992	5020.0	1768.3	1072.5		522.4
1993					
1994	5105.0	1783.0	1089.1	0.4	530.6
1995	5505.1	1856.7	1193.0	0.02	582.4
1996	5717.1	1917.3	1212.7	0.23	618.3

Table A-7 Energy Consumption of Secondary Sector

Year	Total 10^4 tsce	Coal 10^4 t	Petroleum 10^4 t	Natural Gas 10^8 cu. m^3	Electricity 10^8 Kwh
1980	39943.0	41976.0	6380.2	137.4	2457.6
1981	38263.0	40440.0	6038.2	121.0	2508.9
1982	40108.0	43097.0	5943.6	115.0	2652.6
1983	42285.0	47591.0	5953.1	119.5	2848.4
1984	45023.0	49815.0	6123.0	120.9	3058.0
1985	52370.0	59145.0	6464.0	123.7	3355.0
1986	55664.0	63150.0	6705.0	129.6	3702.0
1987	60052.0	69228.0	7064.0	129.4	4064.0
1988	64199.0	74352.0	7557.0	126.6	4427.0
1989	675562.0	79017.0	7802.0	131.8	4712.0
1990	68791.0	81529.0	7649.0	130.8	4938.0
1991	72691.0	86791.0	7991.9	138.6	5334.4
1992	77671.0	92716.9	8550.4	130.8	5912.9
1993					
1994	89204.0	108274.4	9423.5	149.9	7132.7
1995	96191.3	117570.7	14716.3	154.4	7659.8
1996	100322.3	123885.9	15690.9	157.2	8044.7

Table A-8 Energy Consumption of Tertiary Sector

Year	Total 10^4 tsce	Coal 10^4 t	Petroleum 10^4 t	Natural Gas 10^8 cu. m^3	Electricity 10^8 Kwh
1980	4625.0	2637.0	1422.2	1.2	112.1
1981	4700.0	2876.0	1330.4	1.3	122.0
1982	4927.0	3020.0	1391.6	0.9	131.8
1983	5265.0	3150.0	1502.4	0.5	149.2
1984	5597.0	3378.0	1553.4	0.6	170.6
1985	6949.0	4625.0	1721.0	0.8	223.0
1986	7365.0	4747.0	1941.0	1.5	235.0

1987	7786.0	4789.0	2092.0	1.8	275.0
1988	8555.0	5099.0	2330.0	1.7	317.0
1989	9047.0	5186.0	2517.0	1.7	348.0
1990	9261.0	5200.0	2519.0	3.1	385.0
1991	10000.0	5063.9	2921.4	2.2	446.2
1992	10843.0	4818.09	3392.4	3.1	513.9
1993					
1994	13015.0	5427.8	4098.8	3.2	730.1
1995	13734.2	4719.0	-	3.6	775.6
1996	13895.0	4532.0	-	7.8	968.3

Table A-9 Energy Consumption of Petroleum Processing and Coking

Year	Total 10^4 tsce	Coal 10^4 t	Crude Oil 10^4 t	Fuel Oil 10^4 t	Natural Gas 10^8 m^3	Electricity 10^8 Kwh
1985	1651.7	3258.7	7019.6	312.5	5.3	48.8
1986	1953.0	3597.0	7741.5	350.0	10.7	61.0
1987	2138.0	3993.0	7996.0	373.3	11.1	64.3
1988	2259.2	4171.1	8458.8	352.6	9.8	70.1
1989	2480.0	4797.6	8761.6	487.7	8.8	78.3
1990	2507.05	4801.7	8603.8	467.6	10.0	87.4
1991	2748.3	4254.9	8775.2	509.2	8.6	98.1
1992	2508.0	5253.4	9727.3	321.0	6.9	124.3
1993						
1994	3590.9	5477.6	10585.9	610.0	9.3	188.2
1995	5567.3	8025.1	11338.4	611.9	15.14	156.1
1996	3665.2	7757.3	11897.9	546.2	8.1	165.8

Table A-10 energy Consumption of Chemical Raw Material and Product Manufacturing

Year	Total 10^4 tsce	Coal 10^4 t	Coke 10^4 t	Crude Oil 10^4 t	Fuel Oil 10^4 t	Natural Gas 10^8 m^3	Electricity 10^8 Kwh
1980	9394.0	4886.0	934.6	1082.9	460.1	43.1	528.0
1981	8074.0	4609.0	851.1	945.1	4444.4	12.1	528.6
1982	9375.0	4910.0	841.0	959.2	429.0	39.8	560.3
1983	8778.0	5316.0	788.7	1057.9	423.4	39.9	593.2
1984	9193.0	5656.0	799.6	1126.7	420.3	41.9	622.4
1985	8094.04	5189.5	721.9	988.6	402.7	41.4	513.5
1986	8556.0	5621.0	690.3	1057.6	435.3	42.8	554.9
1987	9635.0	6489.0	765.3	1158.0	465.5	44.3	631.6
1988	10194.0	6973.6	812.8	1159.1	500.9	45.6	678.6
1989	10945.5	7392.8	892.6	1242.1	544.9	47.3	707.1
1990	10985.8	7241.1	946.2	1445.3	547.6	48.5	735.1
1991	11530.9	7674.0	951.2	1491.4	566.0	55.5	776.6
1992	12019.0	8081.7	1019.	1493.5	481.4	54.7	814.2

			2				
1993							
1994	16196.3	9644.0	1035.9	942.1	496.8	65.9	933.0
1995	15821.6	10803.5	1298.7	1078.8	388.6	63.4	1028.1
1996	20118.4	11172.6	1441.4	1336.1	514.3	78.2	1250.5

Table A-11 Energy Consumption of Metallurgical and Processing of Ferrous Metal

Year	Total (10^4 tsce)	Coal (10^4 t)	Coke (10^4 t)	Electricity (10^8 Kwh)
1985	7638.6	6547.8	3237.2	363.2
1986	8527.0	7053.0	3681.6	392.4
1987	8890.0	7404.0	3982.8	425.2
1988	9445.1	7727.8	4137.8	460.0
1989	9980.0	7792.7	4340.6	515.8
1990	10554.6	8089.9	4809.7	555.7
1991	11154.4	8768.5	5007.1	585.7
1992	11922.0	9315.4	5398.0	657.4
1993				
1994	15338.6	11549.0	6536.8	884.6
1995	16196.3	12920.7	7810.8	905.4
1996	18213.6	13130.1	7465.8	919.2

Table A-12 Energy Consumption of Metallurgical Processing of Non-ferrous Metal

Year	**Total 10^4 tsce**	**Coal 10^4t**	**Electricity 10^8 kwh**
1985	1370.5	641.4	173.9
1986	1498	681	190.6
1987	1552	660	207.3
1988	1686.5	740.1	235.9
1989	1797.2	755.9	255.1
1990	1890.9	814.5	269.9
1991	2047.2	876.3	290.6
1992	2297	1076.3	318.7
1993			
1994	2555.1	1509.6	373.4
1995	2841.7	1348.6	425.6
1996	3040.2	1377.4	454.2

Table A-13 Energy Consumption of Non-metallic Mineral Manufacturing

Year	Total 10^4 tsce	Coal 10^4t	Electricity 10^8 kwh
1985	8019.9	8613.7	221.6
1986	8575	9172	256.8
1987	9248	9883	293.4
1988	9925.1	10499.9	319
1989	10205.7	10669.8	327
1990	9721.6	9962.8	330.8
1991	10197.6	10320	362.2
1992	10904	10777.8	417.2
1993			
1994	12556.1	12218.9	574
1995	13058	13424.2	599.6
1996	13747.3	13588.5	592.5

Table A-14 Energy Consumption of Textile Industry

Year	Total 10^4 tsce	Coal 10^4t	Electricity 10^8 kwh
1980	1992	1433	121.7
1981	2157	1513	142.8
1982	2249	1575	155.2
1983	2386	1665	166.8
1984	2480	1751	172.4
1985	2381.2	1867.6	185.7
1986	2515	1968	199.3
1987	2656	2096	212.4
1988	2875.3	2276.7	234.9
1989	3014.7	2370.3	243.4
1990	3033.7	2359.4	246.6
1991	3113.3	2376.1	260.3
1992	3325	2470.1	280.1
1993			
1994	3439.3	2532.5	308.3
1995	7531.3	2536.9	335.2
1996	3332.3	2171.8	323.6

Table A-15 Energy Consumption of Thermal Power Generation

Year	Coal 10^4t
1980	12648.4
1981	12699
1982	13427.3
1983	14310.8
1984	15935.1
1985	16440.7
1986	18012.4

1987	20289.1
1988	22833.9
1989	25150.7
1990	27204.3
1991	30119.1
1992	33459.4
1993	
1994	40053.1
1995	43799.6
1996	49596.5

Table A-16 Energy Consumption of Construction Industry

Year	Total 10^4 tsce	Coal 10^4t	Gasoline 10^4 t	Kerosene 10^4 t	Diesel Oil 10^4 t	Electricity 10^8 kwh
1980	956		54.1	0.8	76.5	47.1
1981	787	259	49.3	0.6	72.6	46.6
1982	857	414	54.9	0.8	79.4	50
1983	956	467	61.6	0.7	94.7	52.7
1984	1021	471	64.2	0.9	107.1	57.7
1985	1301	531	73	1.3	125	71.2
1986	1223	498	79.3	1.8	150.1	53.5

1987	1260	453	88.2	1.7	154.9	58.4
1988	1158.7	445.2	87.1	1.2	142.4	62.7
1989	1270.8	452.5	95.5	1.5	146.9	65.2
1990	1213.3	437.6	89.5	1.3	133	65
1991	1278	432.3	96	1.1	151.3	74.2
1992	1393	466.4	108	1.3	169.9	82.5
1993						
1994	1349.3	504.5	105	2	112.4	149.7
1995	1334.5	439.8	103.6	3.5	118.2	159.6
1996	1448.6	446.4	106.2	5	129.6	181.8

Table A-17 Energy Consumption of Transportation, Storage,

Postal and Communication Services

Year	Total 10^4 tsce	Coal 10^4t	Gasoline 10^4 t	Kerosene 10^4 t	Diesel Oil 10^4 t	Electricity 10^8 kwh
1980	2902		404.9	31.4	316.1	26.5
1981	2942	2085.9	360.9	35.6	303.3	29.1
1982	3108	2173.2	385.2	39.1	330.8	19.9
1983	3261	2191.8	421	41	365.6	35.8
1984	3436	2279.6	440.2	51.7	390.7	41.4
1985	3713.5	2307.1	477.4	56.2	454.4	63.4
1986	3996	2295	508.5	53	580.8	66.9
1987	4126	2242	532.5	67.7	650	76.7
1988	4328.6	2259.4	565.4	68.6	690	89.5
1989	4499.2	2284.1	591.9	72.2	721	98.7
1990	4541.1	2160.9	620.1	93.4	709.4	105.9
1991	4755.7	2024.8	703.8	132.2	759.7	117.2
1992	5058	1875.9	807.6	165	827.7	136.1
1993						
1994	5625.6	1873.4	900.2	200	997.9	164
1995	5862.9	1315.1	982.3	250	1246.6	182.3
1996	5994.5	1175.9	991.3	298.9	1261.1	197.9

Table A-18 National Economic Indicator

Year	Gross Value of Industrial and Agriculture Output (GVIAO) 10^8Yuan	GNP 10^8 Yuan	Gross Value of Energy Industry Output 10^8 Yuan Current Price	Gross Value of Industrial Output (GVIAO) 10^8 Yuan
1978	5634	3624.1		4237
1979	6379	4038.2		4681
1980	7077	4517.8	635.4	5154.3
1981	7581	4860.3		5400
1982	8294	5301.8		5811
1983	9211	5957.4		6461
1984	10831	7206.7		7617.3
1985	13335	8989.4	1014.9	9716.5
1986	15207	10201.4	1113	11194.3
1987	18489	11954.5	1301.2	13813
1988	24089	14922.3	1520.2	18224
1989	28552	16917.8	1895.4	22017.1
1990	31586	18598.	2215.3	23924.4

		4		
1991	26405	21662.5		28248
1992	46151	26651.9		37065.7
1993		34560.5		52692
1994		46495.8		76909.5
1995		57650		98520

Note: China use MPS system since the establishment of PRC, GVIAO and GVIO are indicator including all intermediate consumption. Approximately, the Value-added of Industrial sector or energy industry is around 40-45% of the Gross value of output. Therefore, the contribution of energy to GNP is very small.

Table A-19 The Structure of Energy Production

Year	Total	Structure (percent)			
	10^4 tsce	Coal	Oil	Gas	Others
1978	62770	70.3	23.7	2.9	3.1
1980	63735	69.4	23.8	3	3.8
1981	63227	70.2	22.9	2.7	4.2
1982	66778	71.3	21.8	2.4	4.5
1983	71270	71.6	21.3	2.3	4.8
1984	77855	72.4	21	2.1	4.4
1985	85546	72.8	20.9	2	4.3
1986	88124	72.4	21.2	2.1	4.3
1987	91266	72.6	21	2	4.4
1988	95701	73.1	20.4	2	4.5
1989	101639	74.1	19.3	2	4.6
1990	103922	74.2	19	2	4.8
1991	104844	74.1	19.2	2	4.7
1992	107256	74.3	18.9	2	4.8
1993	111263	73.8	18.6	2	5.3
1994	118729	74.6	17.6	2	5.9
1995	129034	75.3	16.6	1.9	6.2
1996	132616	75.2	17	2	5.8
1997	131989	74.3	17.4	2.3	6

Table A-20 The Structure of energy Consumption

Year	Total	Structure (percent)			
	10^4 tsce	Coal	Oil	Gas	Others
1978	57144	70.7	22.7	3.2	3.4
1980	60275	72.2	20.7	3.1	4
1981	59447	72.7	20	2.8	4.5
1982	62067	73.7	18.9	2.5	4.9
1983	66040	74.2	18.1	2.4	5.3

1984	70904	75.3	17.4	2.4	4.9
1985	76682	75.8	17.1	2.2	4.9
1986	80850	75.8	17.2	2.3	4.7
1987	86632	76.2	17	2.1	4.7
1988	92997	76.2	17	2.1	4.7
1989	96934	76	17.1	2	4.9
1990	98703	76.2	16.6	2.1	5.1
1991	103783	76.1	17.1	2	4.8
1992	109170	75.7	17.5	1.9	4.9
1993	115993	74.6	18.2	2	5.2
1994	122737	75	17.4	1.9	5.7
1995	131176	74.6	17.5	1.8	6.1
1996	138948	74.7	18	1.8	5.5
1997	142000	73.5	18.6	2.2	5.7

Appendix B Conversion Table

Coefficients of Conversion of Various Form of Energy into Standard Coal Equivalent

Type of Energy	Average Low Calorific Value	Coefficients of Conversion
	(kj/kg)	(kg sce/kg)
Coal	20934	0.7143
Washed Fine Coal	26377	0.9
Coke	28470	0.9714
Crude Oil	41868	1.4286
Fuel Oil	41868	1.4286
Gasoline	43124	1.4714
Kerosene	43124	1.4714
Diesel Oil	42705	1.4571
Liquefied Petroleum Gas	50241	1.7143
Dry Gas	46055	1.5714
	(kj/m^3)	($kg\ sce/m^3$)
Natural Gas	38979	1.33
Coke Oven Gas	16474-18003	0.5714-0.6143
		(kg sce/million Joule)
Thermal Power(equivalence)		0.0341
	(kj/kwh)	(kg sce/kwh)
Electricity(equivalence	3601	0.1229

Appendix C Comparative Study of Projection of Relationship of Energy and Economy

Summary of Projection Results from Four Sources

	Method 1 DRC (middle case)		Method 2 SPC		Method 3 Tsinghua (high case)		M
Year	2000	2010	2000	2010	2000	2010	2000
Population (100 million)	12. 18	13. 79	n.a	n.a	12. 94	14. 5	13. 04
GDP (100 million yuan, 1995 price)	85000	170000	n.a	n.a	700013. 1	239780. 8	77764
Total Energy Demand (million ton of SCE)	1499	2432	1340	1800	1530. 4	2684. 3	n.a
Coal(million ton)	1573	2382	1450	1850	1628. 9	2425. 1	n.a
Oil (million ton of sce)	259	379	221. 4	285. 7	161. 4	360. 4	n.a
Natural Gas (100 million M^3)	203	484.6	250	800	296. 5	945. 7	n.a
Electricity(100 million kwh)	14002	28062	14000	n.a	13053	29606	14418. 8
Hydro-power(100 million kwh)	2178	3938	n.a	n.a	2500	6840	n.a

Note: DRC Development Research Center
SPC State Planning Commission
Tsinghua Institute of Nuclear Energy Technology, Tsinghua University
CASS Institute of Quantitative & Technical Economics, Chinese Academy of Social Sciences

Table C.2 Medium Growth Scenario(1995-2020) - Macro Results

	1995 *	2000	2010	2020
GDP (1995 price, billion 1995 yuan)	6016.3	9062.6	19379.9	36851.2

With which (at current price):				
Share of Primary industry %	20.4	20.0	22.7	23.7
Share of Secondary %	50.9	48.9	44.8	41.6
Share of Tertiary %	28.7	31.1	32.5	34.7
Households Consumption/ GDP %	47.1	45.7	49.4	54.1
Investment /GDP %	38.7	42.0	39.5	34.9
Export / GDP %	22.7	20.6	17.6	15.9
Import / GDP %	20.1	19.5	17.3	15.9
Growth rate(annual %)		1996-2000	2001-10	2011-20
GDP		8.5	7.9	6.6
TFP		2.7	2.6	2.9
Capital Stock		10.8	9.5	7.3

*The year of 1995 is the base year of the model.

Table C.3 Medium Growth Scenario (1995-2020) – Structural Change

Share (%)	Gross Output		Employment		Export		Import	
	1995	2020	1995	2020	1995	2020	1995	2020
Grain	4.2	1.4	26.9	11.4	0.3	0.0	1.3	2.1
Non-grain Crops	2.9	1.2	18.8	10.9	1.5	0.1	0.9	2.0
Other Agri.	5.9	3.1	7.2	3.6	1.3	0.1	0.8	4.5
Coal Mining	0.9	0.4	0.8	1.3	0.7	0.1	0.1	0.1
Crude Oil & Natrual Gas	1.0	0.7	0.2	0.9	1.5	0.8	2.2	3.1
Metal Mining	0.5	0.3	0.2	0.2	0.3	0.2	1.3	1.2
Non-metal Mining	1.2	1.0	0.5	0.6	0.6	0.5	0.5	0.3
Food	6.8	6.4	1.3	1.5	5.5	3.9	3.2	4.1
Textiles	5.1	3.4	1.7	1.8	12.3	5.9	7.5	7.7

Apparel	3.6	4.4	1.1	1.6	13.8	15.9	1.6	1.9
Lumber, wood & Furnoture	1.0	1.4	0.4	0.8	2.0	2.2	1.0	1.5
Paper & Social Articles	2.8	3.1	0.9	1.4	6.9	6.9	3.0	3.5
Electricity	1.9	2.4	0.3	0.9	0.2	0.4	0.0	0.0
Petroleum refining	1.4	1.7	0.2	0.6	0.6	0.9	1.8	1.3
COKING	0.3	0.2	0.0	0.1	0.5	0.4	0.0	0.0
Chemical	7.7	7.4	1.9	2.8	9.4	10.0	14.2	10.7
Stone Clay & Glass	4.0	3.5	2.3	2.7	2.6	2.9	1.2	0.7
Metal	5.1	4.4	1.0	1.1	4.1	4.4	7.4	4.6
Metal Products	2.2	2.7	0.7	1.2	3.0	4.1	1.4	1.0
Machinery	4.9	4.9	1.7	2.3	8.6	9.1	20.5	16.2
Motor vehicles	1.5	1.4	0.4	0.5	0.4	0.5	2.2	1.3
Transport equipment	1.1	1.1	0.4	0.5	1.6	1.8	1.9	1.5
Electrical machinery	2.5	2.7	0.7	1.6	4.3	4.6	3.8	3.2
Electronics	2.4	3.3	0.4	1.0	8.5	13.1	9.8	9.2
Instruments	0.2	0.3	0.2	0.3	0.4	0.4	1.4	1.7
Other Industries	0.6	0.4	0.8	0.8	0.2	0.2	0.3	0.2
Construction	8.6	9.7	5.3	9.0	0.5	0.5	0.5	0.5
Infrastructure	3.4	4.0	4.3	6.4	4.0	4.6	2.4	2.7
Commerce	7.0	8.5	9.5	11.9	1.2	1.7	3.0	2.8
Services	9.3	14.5	10.2	20.3	3.4	4.0	4.7	10.0
Primary	13.0	5.8	52.9	26.0	3.1	0.2	3.0	8.6
Secondary	67.3	67.3	23.1	35.4	88.4	89.5	86.9	75.8
Tertiary	19.7	26.9	23.9	38.6	8.6	10.2	10.1	15.6

Appendix Algebraic Specification of the Model

This Appendix provides a detailed description of the algebraic specification of the CGE model for China. The set definition is given first, followed by definition of variables and parameters, as well as a complete equation list.

1 Sets Definition

i Production sectors. ***j*** is an alias for ***i***. (including *e, nf, tex* and *ag* as a subset)

- ***nf*** Represents the non-fuel commodities.
- ***e*** Represents fuel commodities.
- ***tex*** Represents textile and clothing commodities.
- ***ag*** Represents food and agricultural commodities subjected to import quota.
- ***comm*** Represents commerce sectors

l Represents the labour types.

- ***aglb*** Represents agricultural labour forces
- ***uslb*** Represents production workers
- ***slb*** Represents professionals

h Represents the households.

f Represents the final demand expenditure categories. (including *s, zp* as a subset)

- ***s*** Represents the social consumption category.
- ***zp*** Represents the fixed asset investment category.

c Represents the firm types (including *O, P* as a subset).

- ***O*** Represents the ordinary enterprises
- ***P*** Represents the processing export enterprises.

m Represents the import types (including *n, P* as a subset).

- ***n*** Represents the import of non-intermediate of processing export.
- ***P*** Represents the import of processing trade.

v Represents the capital vintages.

t Time index.

I=41, NF+E=I, L=3, H=10, F=2, c=2, m=4, v=2

2 Definition of Variables

VARIABLE	DEFINITION	No. of Variables
Production variables		
Xp_{ic}	Output	I×C×V
Xpv_{vic}	Output by vintage	I×C×V
ND_{vic}	Demand for ND bundle	I×C×V
KEL_{vic}	Demand for KEL bundle	I×C×V
PXA_{ijc}	Price for intermediate demand	I×I×C
PX_{ic}	Producer price exclusive of taxes	I×C
PXv_{vic}	Producer price exclusive of taxes	I×C×V
PP_i	Producer price inclusive of taxes	I
$PKEL_{vic}$	Price of KEL bundle	I×C×V
PN_{ic}	Price of ND bundle	I×C
XAp_{ijc}	Intermediate consumption	I×I×C
AL_{jc}	Aggregate demand for labour	I×C
KE_{vjc}	Demand for KE bundle	I×C×V
AW_i	Average sectoral wage rate	I
PKE_{vjc}	Price of KE bundle	I×C×V
Ev_{vic}	Demand for energy bundle	I×C×V
KT_{vjc}	Demand for capital land bundle by vintage	I×C×V
PEv_{vic}	Aggregate price of energy bundle	I×C×V
PKT_{vjc}	Price of capital land bundle	I×C×V
Kv_{vjc}	Capital demand by vintage	I×C×V
K_j^d	Aggregate capital demand	I
Tv_{vjc}	Land demand by vintage	I×C×V
T_j^d	Aggregate land demand	I
L_{ljc}^d	Demand for labour by sector and skill	L×I×C
W_l	Wage by skill	L
Capital income distribution variables		
CY	Retained capital income	1
Tax^c	Business direct tax	1
Sav_c^p	Business retained earnings	1
Fee^c	Value of enterprise fee	1

Household income variables

YL_l	Net labour income by type of labour	L
$YMIG$	Labour income of migration of agricultural labour	1
YH_h	Household income by type of household	H
RMQ	NTBs rent of Import	1
REQ	MFA quota rent	1
Tax_h^h	Household direct taxes	H
Fee_h^h	Household fee by household types	H
YD_h	Household disposable income	H

Consumer variables

PC_{ih}	Consumer prices inclusive of taxes and subsidies	I×H
Y_h^*	Supernumerary income	H
XAc_{ih}	Household consumption	I×H
$HSav_h$	Household saving	H
S_h	Total household saving	1
cpi_h	Consumer price index	H

Final demand variables

$XAFD_{if}$	Armington final demand	I ×F
$TFDV_f$	Value of final demand expenditures	F
TFD_{zp}	Volume of fixed assets investment	1
PFD_{if}	Final demand price incl of taxes	I×F

Government revenue and expenditure variables

$GExp$	Government Expenditure	1
VA_{ic}	Sectoral value-added	I×C
$VATx$	Value of value-added tax	1
$IMDITx$	Value of intermediate demand indirect taxes	1
$PITx$	Value of production indirect taxes	1
$HITx$	Value of household indirect taxes	1
$FDITx_f$	Value of final demand indirect taxes	F
$TIndTax$	Total value of indirect taxes	1
$ExVAT$	Value of VAT rebate for export	1
$YTrade$	Revenue from tariffs	1
$GRev$	Total government revenues	1
S^g	Nominal government saving	1
$ExBRev$	Extra-budget revenues	1
$ExBC$	Extra-budget Consumption	1

S^{ExB}	Extra-budget saving	1

Armington prices and volumes

PA_i	Economy wide Armington price	I
PMo_i	Domestic price of aggregated ordinary imports	I
PM_{im}	Domestic price of imports	I×M
XD_i	Aggregate domestic sales of domestic production	I
XMo_i	Aggregated ordinary imports	I
XM_{im}	Imports	I×M
XA_i	Economy wide Armington demand	I
$XAPpd_{ij}$	Intermediate Armington demand of processing export	I×J
$XAPpm_{ij}$	Intermediate demand for processing import of processing export	I×J

CET variables

PD_i	Producer price of domestic sales	I
WPE_i	Export price at the border	I
PE_{ic}	Export price before the border	I×C
ESW_i	Aggregated Exports supply	I
ES_{ic}	Exports supply	I×C
ED_i	Export demand	I
FTC	FTC export margin	1

Factor market variables

$MigAg$	Migration of agricultural labour to production worker	1
$Pland$	Aggregate price of land	1
PT_i	Sector specific land price	I
TR	Aggregate rental rate	1
R_j^v	Sectoral rental rate by vintage	I×V
χ_{ic}^{Old}	Old capital output ratio	I×C
$RR_{i,t}$	Relative rental rate of old capital	I
$K_{ic,0}^s$	Initial capital supply by sector	I×C
K_t	Aggregated capital stock	1
K_t^s	Aggregated capital supply	1
γ^i	Annual growth rate of investment	1

Macro aggregates

$GDPVA$	GDP value at market price	1
$RGDP$	Real GDP at market price	1
ER	Exchange rate	1

Exogenous variables

P	GDP price deflator	1
L_l^s	Labour supply by type of labour	L
TK^s	Aggregate capital supply	1
$Tland$	Aggregate quantity of land	1
Pop_h	Population	H
S_f	Foreign saving	1
$TR_{g,h}^h$	Government transfers to households	H
$Subs_{g,h}^h$	Government subsidies to households	H
$TR_{f,h}^h$	ROW transfers to households	H
StB	Aggregate volume of stock building	1
RGc	Government real spending	1
WPM_{im}	World import price	I×M
$WPINDEX_i$	Price index of world exports	I
λ_j^t	Land efficiency factor	I
λ_j^k	Capital efficiency factor	I
λ_{lj}	Labour efficiency factor	L×I
λ_{vj}^e	Energy efficiency factor	I×V
λ_j	Hicks productivity factor	I
δ^H	Household direct tax shifter	1
δ^{Tar}	Tariff adjustment shifter	1
δ_i^{ntb}	Tariff equivalent of NTBs adjustment factor	I
δ^c	Corporate tax adjustment shifter	1
δ^x	Intermediate demand indirect tax adjustment shifter	1
δ^v	VAT adjustment shifter	1
δ^{vm}	VAT for import adjustment shifter	1
δ^{ve}	VAT rebate for export adjustment shifter	1
δ^p	Production tax adjustment shifter	1
δ^{HTr}	Government to households transfers adjustment factor	1
δ^E	Export tax adjustment shifter	1
$AgQuota_{ag}$	Import quota of food and agricultural products	AG
$TexQuota_{tex}$	Export quota of textiles and clothing	TEX

3 Definition of Parameters

σ_{vj}^{p}	Top level CES elasticity between non-energy intermediate input and capital- energy-labor bundl
σ_{vj}^{v}	CES substitution elasticities between labor and capital-land-energy bundle
σ_{vj}^{k}	CES substitution elasticities between capital-land bundle and energy bundle
σ_{vj}^{s}	CES substitution elasticities between capital and land
σ_{vj}^{f}	CES substitution elasticities between different types of energy
σ_{j}^{l}	CES substitution elasticities between different types of labor
σ_{j}^{x}	CES substitution elasticities of intermediate input of processing export
α_{vjc}^{nd}	CES share parameter for ND bundle
α_{vjc}^{kel}	CES share parameter for KEL bundle
α_{vjc}^{l}	CES labour share parameter
α_{vjc}^{k}	CES capital share parameter
α_{vjc}^{e}	CES energy share parameter
α_{vjc}^{kt}	CES capital land share parameter
α_{vjc}^{t}	CES land share parameter
α_{vjc}^{k}	CES capital share parameter
$\alpha_{e,vjc}^{f}$	CES share parameters in energy bundle
α_{ljc}^{l}	CES share parameters for different types of labor
α_{ij}^{m}	CES share parameters for intermediate input of processing import
α_{ij}^{d}	CES share parameters for intermediate input of Armington goods
Φ_{ljc}	Relative wages across sectors for same skill labor
$a_{i,j,c}$	Leontief coefficients
χ^{k}	Retained capital earnings
Ξ_{hl}	Wage income distribution matrix
ϕ_{h}^{k}	Distribution shares for land income
ϕ_{h}^{t}	Distribution shares for capital income
ϕ_{h}^{c}	Distribution shares for corporate earnings
ϕ_{h}^{r}	Distribution shares for quota rent
μ_{ih}	Marginal propensity to consume
θ_{ih}	Subsistence minima
afd_{i}^{f}	Final demand share parameters
α_{i}^{st}	Change in stock share parameters
κ^{c}	Corporate tax rate
κ_{h}^{h}	Household direct tax rate

η_c	Enterprise fee rate
η_h^h	Households fee rate
τ_{ic}^p	Indirect taxation of production
τ_{ih}^h	Consumer indirect tax rate
τ_i^f	Final demand indirect tax rates
τ_i^x	Intermediate demand indirect tax rates
τ_{ic}^{ftc}	FTC export margin rate
τ_{ic}^E	Export tax rate (export tax equivalent of VER)
τ_{ic}^v	VAT rate
τ_{ic}^{ve}	VAT rebate rate for export
$\tau_{i,m}^{vm}$	VAT rate for import
$\tau_{i,m}^m$	Import tariffs
$\tau_{i,m}^{ntb}$	Tariff equivalent of NTBs
φ_{ic}^p	Production subsidies
σ_i^m	Armington elasticity
σ_i^r	Second level Armington elasticity
σ_i^t	CET elasticity
σ_i^{e2}	CES elasticity between processing export and ordinary export
σ_i^e	Export demand elasticity
α_i^e	Initial export demand shifter
$\alpha_{d,i}^t$	CET domestic share parameter
$\alpha_{e,i}^t$	CET export share parameter
$\beta_{i,c}^e$	CES export share parameter
β_i^d	Economy wide Armington domestic share parameter
β_i^m	Economy wide Armington import share parameter
$\beta_{i,n}^s$	Second level Armington import share parameter
σ^{agl}	Transformation elasticity of agricultural labour
$w^0{}_l$	Initial wage shifter
η_i^k	Dis-investment elasticity of old capital
δ	Depreciation rate of capital

Production

Top-level Production Equations

(1.1) $$ND_{vjc} = \alpha_{vjc}^{nd}\left[\frac{PXv_{vjc}}{PN_{jc}}\right]^{\sigma_{vj}^{p}} XPv_{vjc}$$

(1.2) $$KEL_{vjc} = \alpha_{vjc}^{kel}\left[\frac{PXv_{vjc}}{PKEL_{vjc}}\right]^{\sigma_{vj}^{p}} XPv_{vjc}$$

(1.3) $$PXv_{vjc} = \left[\alpha_{vjc}^{nd}(PN_{jc})^{1-\sigma_{vj}^{p}} + \alpha_{vjc}^{kel}(PKEL_{vjc})^{1-\sigma_{vj}^{p}}\right]^{1/(1-\sigma_{vj}^{p})}$$

(1.4) $$PX_{jc}XP_{jc} = \sum_{v} PXv_{vjc}XPv_{vjc}$$

(1.5) $$PP_{jc} = PX_{jc}(1+\delta^{p}\tau_{jc}^{p} - \varphi_{jc}^{p})$$

Second-level CES Production Equations

(1.6) $$XAp_{nf,jc} = \sum_{v} a_{nf,jc}ND_{vjc}$$

(1.7) $$PN_{jc} = \sum_{nf} a_{nf,jc}PXA_{nf,jc}$$

(1.8) $$PXA_{ij,O} = (1+\delta^{x}\tau_{i}^{x})PA_{i}$$

(1.9) $$PXA_{ij,P} = \left[\alpha_{ij}^{m}(PM_{i,P})^{1-\sigma_{j}^{x}} + \alpha_{ij}^{d}(PXA_{ij,O})^{1-\sigma_{j}^{x}}\right]^{1/(1-\sigma_{j}^{x})}$$

(1.10) $$AL_{jc} = \sum_{v} \alpha_{vjc}^{l}\left[\frac{PKEL_{vjc}}{AW_{jc}}\right]^{\sigma_{vj}^{v}} KEL_{vjc}$$

(1.11) $$KE_{vjc} = \alpha_{vjc}^{k}\left[\frac{PKEL_{vjc}}{PKE_{vjc}}\right]^{\sigma_{vj}^{v}} KEL_{vjc}$$

(1.12) $$PKEL_{vjc} = \left[\alpha_{vjc}^{l}(AW_{jc})^{1-\sigma_{vj}^{v}} + \alpha_{vjc}^{k}(PKE_{vjc})^{1-\sigma_{vj}^{v}}\right]^{1/(1-\sigma_{vj}^{v})}$$

Labour Demand

(1.13) $$L_{ljc}^{d} = \frac{\alpha_{ljc}^{l}}{\lambda_{j}\lambda_{lj}}\left[\frac{\lambda_{j}\lambda_{lj}AW_{jt}}{(1+\tau_{jc}^{v})\Phi_{ljc}W_{l}}\right]^{\sigma_{j}^{l}} AL_{jc}$$

(1.14) $$AW_{jc} = \left[\sum_{l} \alpha_{ljc}^{l}\left(\frac{(1+\tau_{c}^{v})\Phi_{ljc}W_{l}}{\lambda_{lj}}\right)^{1-\sigma_{j}^{l}}\right]^{1/(1-\sigma_{j}^{l})}$$

Capital-Land Bundle and Energy Bundle Demand

(1.15) $$Ev_{vjc} = \alpha^{e}_{vjc}\left[\frac{PKE_{vjc}}{PEv_{vjc}}\right]^{\sigma^{k}_{vj}} KE_{vjc}$$

(1.16) $$KT_{vjc} = \alpha^{kt}_{vjc}\left[\frac{PKE_{vjc}}{PKT_{vjc}}\right]^{\sigma^{k}_{vj}} KE_{vjc}$$

(1.17) $$PKE_{vjc} = \left[\alpha^{e}_{vjc}(PEv_{vjc})^{1-\sigma^{k}_{vj}} + \alpha^{kt}_{vjc}(PKT_{vjc})^{1-\sigma^{k}_{vj}}\right]^{1/(1-\sigma^{k}_{vj})}$$

Capital and Land Demand

(1.18) $$Tv_{vjc} = \frac{\alpha^{t}_{vjc}}{(\lambda_j\lambda^{t}_{j})^{1-\sigma^{s}_{vj}}}\left[\frac{PKT_{vjc}}{(1+\tau^{v}_{jc})PT_j}\right]^{\sigma^{s}_{vj}} KT_{vjc}$$

(1.19) $$Kv_{vjc} = \frac{\alpha^{k}_{vjc}}{(\lambda_j\lambda^{k}_{j})^{1-\sigma^{s}_{vj}}}\left[\frac{PKT_{vjt}}{(1+\tau^{v}_{jc})R^{v}_{j}}\right]^{\sigma^{s}_{vj}} KT_{vjc}$$

(1.20) $$PKT_{vjc} = \left[\alpha^{t}_{vjc}\left(\frac{PT_j}{\lambda_j\lambda^{t}_{j}}\right)^{1-\sigma^{s}_{vj}} + \alpha^{k}_{vjt}\left(\frac{R^{v}_{j}}{\lambda_j\lambda^{k}_{j}}\right)^{1-\sigma^{s}_{vj}}\right]^{1/(1-\sigma^{s}_{vj})}$$

(1.21) $$T^{d}_{j} = \sum_{v}\sum_{c} Tv_{vjc}$$

(1.22) $$K^{d}_{j} = \sum_{v}\sum_{c} Kv_{vjc}$$

Decomposition of the Energy Bundle

(1.23) $$XAP_{e,jc} = \sum_{v}\frac{\alpha^{f}_{e,vjc}}{\lambda^{e}_{vj}}\left[\frac{\lambda^{e}_{vj}PEv_{vjc}}{PXA_{e,jc}}\right]^{\sigma^{f}_{vj}} Ev_{vjc}$$

(1.24) $$PEv_{vjc} = \left[\sum_{e}\alpha^{f}_{e,vjc}\left(\frac{PXA_{ejc}}{\lambda^{e}_{vj}}\right)\right]^{1/(1-\sigma^{f}_{vj})}$$

Income Distribution

Corporate Earnings Equations

(2.1) $$CY = \chi^{k}\sum_{i}\sum_{v}\sum_{c} R^{v}_{i}Kv_{vic}$$

(2.2) $$Tax^{c} = \delta^{c}\kappa^{c}CY$$

(2.3) $$Fee^{c} = \eta^{c}CY$$

(2.4) $$Sav_c^p = (1 - \sum_h \phi_h^c)(1 - \delta^c \kappa^c) CY - Fee^c$$

Household Income Equations

(2.5) $$YL_l = \sum_i \sum_c \Phi_{lic} W_l L_{lic}^d$$

(2.6) $$YMIG = W_{aglb} \min(MigAg, 0) + W_{uslb} \max(MigAg, 0)$$

(2.7)
$$\begin{aligned} YH_h &= \sum_l \Xi_{hl} YL_l + (\Xi_{h,aglb} - \Xi_{h,uslb}) YMIG + \phi_h^l \sum_i \sum_v \sum_c PT_i Tv_{vic} + \phi_h^k (1 - \chi^k) KY \\ &+ \phi_h^c (1 - \chi^c) CY + \phi_h^r (RMQ + REQ) + P\delta^{HTr} TR_h^{gh} + P Subs_h^{gh} + ER TR_h^{fh} \end{aligned}$$

(2.8) $$RMQ = ER \sum_i \sum_m \delta_i^{ntb} \tau_{i,m}^{ntb} WPM_{i,m} XM_{i,m}$$

(2.9) $$REQ = \sum_c \sum_{tex} PE_{tex,c} \tau_{tex,c}^E (1 + \tau_{tex,c}^{ftc}) ES_{tex,c}$$

(2.10) $$Tax_h^h = \delta^h \kappa_h^h YH_h$$

(2.11) $$Fee_h^h = \eta_h^h YH_h$$

(2.12) $$YD_h = YH_h - Tax_h^h - Fee_h^h$$

Household Consumption and Savings

Household Consumption and Savings Equations

(3.1) $$PC_{ih} = PA_i (1 + \tau_{ih}^h)$$

(3.2) $$Y_h^* = YD_h - Pop_h \sum_i PC_{ih} \theta_{ih}$$

(3.3) $$XAc_{ih} = Pop_h \, \theta_{ih} + \mu_{ih} Y_h^* / PC_{ih}$$

(3.4) $$HSav_h = YD_h - \sum_i PC_{ih} XAc_{ih}$$

(3.5) $$cpi_h = \frac{\sum_i PC_{ih} XAc_{ih}}{\sum_i PC_{ih,0} XAc_{ih}}$$

Other Final Demands

Final Demand Expenditure Equations

(4.1) $$PA_i XAFD_{if} = afd_i^f TFDV_f$$

(4.2) $$TFD_f = \sum_i XAFD_i^f$$

(4.3) $$PFD_{if} = PA_i\left(1+\tau_i^f\right)$$

(4.4) $$GExp = P\,RGc + P\sum_h \left(\delta^{HTr} TR_h^{gh} + HSubs_h^{gh}\right)$$

(4.5) $$TFDV_s = P{\cdot}RGc + ExBC$$

Government Revenues and Saving

Indirect Tax Equations

(5.1) $$VA_{ic} = \sum_l \Phi_{lic} W_l L_{lic}^d + PT_i \sum_v Tv_{vic}^d + R_i \sum_v K_{vic}^d$$

(5.2) $$VATx = \sum_i \sum_c \tau_{ic}^v VA_{ic} + \sum_i \tau_{i,O}^{vm} PM_{i,O} XM_{i,O}$$

(5.3) $$PITx = \sum_i \sum_c (\delta^p \tau_{ic}^p - \varphi_{ic}^p) PX_{ic} XP_{ic}$$

(5.4) $$IMDITx = \sum_i PA_i \delta_i^x \tau_i^x XAp_{i,O}$$

(5.5) $$HITx = \sum_h \sum_i PA_i \tau_{ih}^h XAc_{ih}$$

(5.6) $$FDITx_f = \sum_i PA_i \tau_i^f XAFD_i^f$$

(5.7) $$TIndTax = PITx + IMDITx + HITx + \sum_f FDITx_f + +VATx$$

(5.8) $$ExVAT = \sum_i \sum_c \tau_{ic}^{ve} PE_{ic} ES_{ic}$$

Government Revenues and Closure Equations

(5.9) $$YTrade = ER\delta^{Tar} \sum_m \sum_i \tau_{i,m}^m WPM_{i,m} XM_{i,m}$$

(5.10) $$GRev = Tax^c + TIndTax + YTrade + \sum_h Tax_h^h - ExVAT$$

(5.11) $$S^g = GRev - GExp$$

(5.12) $$ExBRev = Fee^c + \sum_h Fee_h^h$$

(5.13) $$S^{ExB} = ExBRev - ExBC$$

(5.14) $$S^{ExB} = \xi^{ExB} ExBRev$$

Trade, Domestic Supply and Demand

Armington Equations

(6.1) $$XA_i = \sum_j XAp_{i,j,O} + \sum_j XAPpd_{ij} + \sum_h XAc_{ih} + \sum_f XAFD_{if}$$

(6.2) $$XD_i = \beta_i^d \left(\frac{PA_i}{PD_i} \right)^{\sigma_i^m} XA_i$$

(6.3) $$XMo_i = \beta_i^m \left(\frac{PA_i}{PMo_i} \right)^{\sigma_i^m} XA_i$$

(6.4) $$PA_j = \left[\beta_i^d PD_i^{1-\sigma_i^m} + \beta_i^m (PMo_i)^{1-\sigma_i^m} \right]^{1/(1-\sigma_i^m)}$$

(6.5) $$XM_{i,n} = \beta_{i,n}^s \left(\frac{PMo_i}{PM_{i,n}} \right)^{\sigma_i^r} XMo_i$$

(6.6) $$PMo_i = \left[\sum_n \beta_{i,n}^s ((1+\delta^{vm}\tau_i^{vm})PM_{i,n})^{1-\sigma_i^r} \right]^{1/(1-\sigma_i^r)}$$

(6.7) $$PM_{i,m} = ER\,WPM_{i,m}(1+\delta^{Tar}\tau_{i,m}^m + \delta_i^{ntb}\tau_{i,m}^{ntb})$$

(6.8) $$XAPpd_{ij} = \alpha_{ij}^d \left[\frac{PXA_{ij,P}}{PM_{i,P}} \right]^{\sigma_j^x} XAP_{ij,P}$$

(6.9) $$XAPpm_{ij} = \alpha_{ij}^m \left[\frac{PXA_{ij,P}}{PXA_{ij,O}} \right]^{\sigma_j^x} XAP_{ij,P}$$

(6.10) $$XM_{i,P} = \sum_j XAPpm_{ij}$$

(6.11) $$\sum_m XM_{ag,m} \le AgQouta_{ag}$$

CET Equations

(6.12) $$XD_i = \alpha_{d,i}^t \left(\frac{PD_i}{PP_{i,O}} \right)^{\sigma_i^t} (XP_{i,O} - \alpha_i^{st} StB - bool_i \frac{FTC}{PP_{comm,O}})$$

$$if\ i = comm \quad bool_i = 1 \quad else \quad bool_i = 0$$

(6.13) $$ES_{i,O} = \alpha_{e,i}^t \left(\frac{(1+\delta^{ve}\tau_{i,O}^{ve})PE_{i,O}}{PP_{i,O}} \right)^{\sigma_i^t} (XP_{i,O} - \alpha_i^{st} StB - bool_i \frac{FTC}{PP_{comm,O}})$$

$$if\ i = comm \quad bool_i = 1 \quad else \quad bool_i = 0$$

(6.14) $$PP_{i,O} = \left[\alpha_{d,i}^t PD_i^{1+\sigma_i^t} + \alpha_{d,i}^t ((1+\delta^{ve}\tau_{i,O}^{ve})PE_{i,O})^{1+\sigma_i^t} \right]^{1/(1+\sigma_i^t)}$$

(6.15) $$ES_{i,P} = XP_{i,P}$$

(6.16) $$PP_{i,P} = (1+\delta^{ve}\tau_{i,P}^{ve})PE_{i,P}$$

(6.17) $$WPE_i = \left[\sum_c \beta_{ic}^{e} ((1+\delta^E \tau_{ic}^E)(1+\tau_{ic}^{ftc}) PE_{ic})^{1-\sigma_i^{e2}} \right]^{1/(1-\sigma_i^{e2})}$$

(6.18) $$ES_{ic} = \beta_{ic}^{e} \left(\frac{WPE_i}{(1+\delta^E \tau_{ic}^E)(1+\tau_{ic}^{ftc}) PE_{ic}} \right)^{\sigma_i^{e2}} ESW_i$$

(6.19) $$FTC = \sum_c \sum_i \tau_{i,c}^{ftc} PE_{i,c} ES_{i,c}$$

Export Demand and Market Equilibrium

(6.20) $$ED_i = \alpha_i^{e} \left(\frac{ER\overline{WPINDEX}_i}{WPE_i} \right)^{\sigma_i^{e}}$$

(6.21) $$ED_{tex} \le TexQouta_{tex}$$

(6.22) $$ESW_i = ED_i$$

Equilibrium Conditions

Labor, Land Supply and Market Equilibrium

(7.1) $$\sum_i \sum_c L_{ic,slb}^{d} = L_{slb}^{s}$$

(7.2) $$\frac{\sum_i \sum_c L_{ic,aglb}^{d}}{\sum_i \sum_c L_{ic,uslb}^{d}} = \frac{L_{aglb}^{s}}{L_{uslb}^{s}} \left(\frac{W_{aglb}}{W_{uslb}} \frac{w_{aglb}^{0}}{w_{uslb}^{0}} \right)^{\sigma^{agl}}$$

(7.3) $$\sum_i \sum_c L_{ic,aglb}^{d} + \sum_i \sum_c L_{ic,uslb}^{d} = L_{aglb}^{s} + L_{uslb}^{s}$$

(7.4) $$MigAg = L_{aglb}^{s} - \sum_i \sum_c L_{ic,aglb}^{d}$$

(7.5) $$TLand = \sum_i T_i^{d}$$

(7.6) $$PT_i = PLand$$

Output by vintage

(7.7) $$\chi_{ic}^{Old} = \frac{Kv_{ic,Old}}{XPv_{ic}^{Old}}$$

(7.8) $$XPv_{ic}^{Old} = \min\left(K_{ic,0}^{s} / \chi_{ic}^{Old}, XP_{ic} \right)$$

(7.9) $$XPv_{ic}^{New} = XP_{ic} - XPv_{ic}^{Old}$$

Capital Market Equilibrium

(7.10) $$RR_{i,t} = \min\left(1, RR_{i,t-1}\left(\frac{\sum_c Kv_{ic,Old}}{\sum_c K^s_{ic,0}}\right)^{1/\eta^k_i}\right)$$

(7.11) $$\sum_i K^d_i = K^s$$

(7.12) $$R^{New}_i = TR$$

(7.13) $$R^{Old}_i = TR\ RR_i$$

(7.14) $$K^s_{ic,0,t} = (1-\delta)^n K^d_{ic,t-n}$$

Aggregated Capital Stock

(7.15) $$K_t = (1-\delta)^n K_{t-n} + \frac{(1+\gamma^i)^n - (1-\delta)^n}{\gamma^i + \delta} TFD_{zp,t-n}$$

(7.16) $$\gamma^i = \left(\frac{TFD_{zp}}{TFD_{zp,t-n}}\right)^{1/n} - 1$$

(7.17) $$K^s_t = \frac{K^s_{t-n}}{K_{t-n}} K_t$$

Macro Closure

(8.1) $$TFDV_{zp} = Sav^p_c + \sum_h HSav_h + ERS_f + S^g + S^{ExB} - \sum_i \alpha^{st}_i PP_{i,O} StB$$

(8.2) $$\begin{aligned} GDPVA &= \sum_l W_l \sum_i \Phi_{li} L^d_{li} + \sum_i PT_i T^d_i + \sum_i R_i K^d_i \\ &\quad + PITx + VATx + YTrade + REQ + RMQ - ExVAT \end{aligned}$$

(8.3) $$\begin{aligned} RGDP &= \sum_i \sum_h XAC_{ih} + \sum_i \sum_f XAFD_{if} + StB \\ &\quad + \sum_i ED_i WPE_{i,0} - \sum_i XM_i WPM_{i,0} ER_0 \end{aligned}$$

(8.4) $$P = \frac{GDPVA}{RGDP}$$