ISCTE Business School
Instituto Universitário de Lisboa

Resource Dependence of China's Economic Growth and its Challenges

LI Lin

Thesis submitted as partial requirement for the conferral of

Doctor of Management

Supervisor:

Professor Álvaro Rosa, Senior Lecturer, ISCTE University Institute of Lisbon

Co-supervisor:

Professor LI Shiming, Full Professor, University of Electronic Science and Technology of China

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Abstract

Since reform and opening up, China economy grows rapidly and industrialization process boosts gradually. The fluctuation of China economic growth and high consumption of resources aggravate the contradiction between resource demand and supply, and make environmental pollution more seriously. Therefore, how to improve the protection ability of resource and coordinate resource consumption and economic growth has become a hot issue and catches the attention of government and academia.

Considering the resource constraints faced by economic growth, this essay studies the dependence of China economic growth on resource consumption, examines the relationship between economic growth and resource consumption empirically. And this essay suggests the government alleviates the contradiction of China economic development by improving resource support capabilities, economic growth transformation and other measures, and makes China economy into a virtuous cycle and sustainable development way.

Key words： Economic growth; Industrialization; Resource and environment; Econometric model

Resumo

Desde o início da reforma económica e da abertura ao mundo, a República Popular da China tem crescido rapidamente bem como os processos de industrialização têm avançado gradualmente. A flutuação do crescimento económico da China e o elevado consumo de recursos minerais têm agravado os efeitos da procura e oferta destes recursos e fez com que a poluição ambiental se transformasse numa questão séria. Deste modo, como melhorar a capacidade de protecção dos recursos naturais em coordenação com o consumo destes e promover o crescimento económico tornou-se uma questão importante e está na agenda tanto do governo como da academia.

Tendo em conta os constrangimentos existentes nos recursos minerais em face às necessidades geradas pelo desenvolvimento económico, este projecto investiga a dependência do crescimento económico da China em face ao consumo de recursos minerais, examinando empiricamente a relação entre crescimento económico e o consumo de minérios. Este estudo sugere ainda que o governo deva reduzir a pressão sentida no binómio de procura de recursos minerais e crescimento económico através de melhoria de capacidade de apoio à extracção ou, mudança de modelo de crescimento da indústria transformadora ou, adopção de outras medidas adequadas e tornar a economia da China um circulo virtuoso e sustentável.

Palavras chave：Crescimento económico; industrialização; Recursos e ambiente; modelo econométrico

Acknowledgments

I have studied for the doctor of business administration of UESTC-ISCTE for three years, and will accept the award of doctorate. All sorts of feelings well up in my mind. I am a farmer's son from Chongqing, experience the pain of learning and appreciate the harvest of sweet. In the work, I am fortunately to grow up to be a geologist. Either work or holidays I have never gave up learning. I understand I am born of low extraction, but know that a slow sparrow should make an early start.

In the three years study, I not only learned the wealthy management knowledge, but also accepted the enthusiastic help from schoolmates, the inculcation from teachers, and the careful counseling and cordial help from my advisor. More than I can say is thanks.

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List of Acronym

WSA - world steel association

MTPA - metric ton per annum

GDP – gross domestic product

Outline

Resource is the basis of economic growth. With the rapid economic development and population growth, economic growth in the world is facing resource constraint. China is in the fast lane of economic development, and the coordination of resource and economy has become the core issue of Chinese government in achieving strategic development objective. The sustainable development of China economy requires security resource and environment. Nowadays China economic growth is facing serious resource and environmental constraints, which is an inevitable stage in industrialization process.

This essay focuses on the resource dependence of China economic growth and its challenge in resource and environment. The first three chapters discuss research background, related literature and research design. Chapter 4 describes the 60 years economic growth history, selects the consumption data of raw coal, crude oil, iron ore and refined copper, adopts multiple linear regression, and examines the dependence of China economic growth on the consumption of various resources and the internal relationship among various resource. Chapter 5 adopts multiple linear regression to analyze the relationship between high energy consumption industries and GDP, and researches the economic structure and environmental pollution. Finally chapter 6 provides some policy suggestions from improving resource protection ability, economic growth transformation and economic structure adjustment.

Chapter 1: Introduction

1.1 Research Background and Topic

1.1.1 Research Background

1.1.1.1 China's Reform, Opening up and Economy Development

China Economy has grown rapidly and has obtained remarkable achievement with more than 30 years development since reform and opening up in 1978. Reform and opening up firstly establishes four special economic zones Shenzhen, Zhuhai, Shantou, Xiamen, then establishes the opening cities along the sea, river and border, finally realizes the comprehensive, multi-level and wide-ranging opening. The reform and opening up in China constantly groping forward, and create a great miracle. China GDP is from 364.5 billon Yuan in 1978 to 39798.3 billion Yuan in 2010, and annual growth rate is more than 9%[1]. From an international point of view, GDP of mainland China is 5745.133 billion US dollar in 2010 and exceeds GDP of Japan which is 5390.897 billion US dollar on the basis of IMF's data. China also becomes the world's second largest economy following USA. China economy still holds fast growth speed in 2010 and the growth rate is 10.3%. In future annual growth rate also keeps more than 9% though China is under pressure of inflation nowadays. This is the basis of future growth and is also helpful for macroeconomic regulation and control of Chinese government against inflation.

With the rapid development of economy, China gains solid economic power, reasonable industrial structure, increasing urbanization, and the better quality of life. In 2010 China's per capita disposable income of urban households is 19109 Yuan and Engel coefficient reduces to 35.7% from 57.5% in 1978. China's per capita net income of rural households is 5919 Yuan and Engel coefficient[2] reduces to 41.1% from 67.7% in 1978. The history from 1978 to nowadays suggest China economy growth accompanies with system transition from the traditional planned economy to the socialist market economy, and the industrialization and urbanization in the comprehensive construction well-off society. Therefore, system transition, industrialization and urbanization have become the basis of economy growth. At the same

[1] In 1978 the average exchange rate of RMB against U.S. dollar is 1.684, and in 2010 the average exchange rate is 6.7695.
[2] Engel coefficient refers to food expenditure proportion of total expenditure.

time the resource dependence of economy growth is increasing gradually. Resource excessive consumption and ecological environment destruction have become an increasingly important issue.

The process of China reform and opening up can be divided to 3 stages.

The first stage covering 1978 to 1992 is the exploration and establishment stage of reform. The fundamental path and basic line of socialism with Chinese characteristics are established after "putting wrongs to rights". The third plenary session of the Eleventh conference of Chinese Communist Party held in 1978 is a significant transition of Chinese society. Since then China starts to reform and open up. In 1978 the basic thought of reform and opening up is issued, which includes the principle of "planned economy primarily, market regulation for auxiliary" and the theory of socialism with Chinese characteristics. In 1979 Xiaoping Deng said "Why can't we develop a market economy under socialism? Developing a market economy does not mean practicing capitalism. We can make planned economy primarily and market regulation for auxiliary. But this is a socialist market economy." [3] This principle is summarized as "planned economy primarily, market regulation for auxiliary" in the report of the 12th conference of Chinese Communist Party held in September 1982. Allowing the production and trading of some commodity is adjusted by market and not by plan, is a breakthrough and progress for traditional planned economy which is characterized by single mandatory plan. From 1985 to 1992 China comes into force the commodity economy with plan. City economic system begins to reform along with the success of rural reform. The third plenary session of the 12th conference of Chinese Communist Party held in Oct 1984 summarizes the practice of reform and development, and issues "the decision of economic system reform by central committee of Chinese Communist Party". This indicates the overall reform starts. The decision points out "we should break through the traditional opinion of contrasting plan and market, understand socialist planned economy is commodity economy with plan based on public ownership, and apply law of value." From 1979 to 1992 China starts overall reform and establishes the fundamental path and basic line of socialism with Chinese characteristics. China economic growth is fast. This becomes the system basis of economic growth.

The second stage covering 1993 to 2001 is rapid development stage. Deng Xiaoping's south tour speeches in 1992 are the beginning of the second ideological emancipation.

[3] Deng Xiaoping anthology, Vol 2, People's Publishing House, 1994, 236

The14th conference of Chinese Communist Party makes the aim of socialist economic system reform. This is from planned economy to market economy and from extensive growth to intensive growth. The 15th conference of Chinese Communist Party in 1997 points out individual economy and private-owned economy are the important parts of socialist economy. China builds the basis of market economy in 1997. In 1998 China economy development changes to demand-restricted. SOE reform becomes a new beginning. In 2001 China joins WTO, and starts overall opening up. The opening up strategy changes to expert high additional value commodity. The opening up policy changes to support expert and export rebates, promoting the economy development.

The third stage covering 2002 to nowadays is the stage of comprehensive construction well-off society. China economy development focuses on scientific development, harmonious development and peaceful development. Economy, polity, culture and society are developed concertedly. The 16th conference of Chinese Communist Party in Nov 2002 issues the aim of comprehensive construction well-off society. The third plenary session of the 16th conference of Chinese Communist Party held in 2003 make sure the developed views of "people first" and 5 arranges. The 4th plenary session in 2004 ensures the idea of building a harmonious socialist society[4]. The 17th conference of Chinese Communist Party in Oct 2007 proposes we should adjust the development mode, alter the economic structure, promote the change of growth mode, achieve sustainable development, perfect modern market system, and enforce reform and opening up deeply.

1.1.1.2 China Industrialization and Mineral Resource Consumption

China economy development not only supports the rapid growth, but also adds the consumption of mineral resource. Mineral resource is nonrenewable and the important material of economy development. Along with the industrialization and urbanization, the demand of mineral resource increases quickly, and the demand growth rate is higher than the supply growth rate. Nowadays China has become the largest consumption state of coal, iron ore, alumina, copper and cement. The oil consumption is in the largest 2. Between 2000 and 2010 China demand induces the increase of some mineral resource prices all over the world. Since 2010 the comprehensive price index increases rapidly.

[4] Harmonious socialist society is a beautiful community of humankind, a social ideal of Marxist party relentless pursuit. The 16th conference of Chinese Communist Party, the third plenary session and the fourth plenary session start from building a moderately prosperous society and initiating a new situation in the socialist with Chinese characteristics, issue clearly the strategy of building a harmonious socialist society, which is the important content of strengthening the governance capability of party.

China has become the largest import country of iron ore. In the beginning of 2009 the data from IISI show China steel production is 38% of world steel production, keeping No. 1 in 12 years. In 2007 the export of steel is 54.88 million tons. The consumption of mineral resource is huge. China is the main country of copper consumption. ICSG shows in 1999 to 2008 China copper production increases 2.60 million tons and the copper consumption increases 3.70 million tons. The demands of coal, crude oil and natural gas of China in 2010 are 2.273 Billion Tons, 0.620 Billion Tons and 0.141 Billion Tons. The demand of coal is the 43% of world demand. In 2008 the growth of China energy consumption is 75% of world energy consumption. The consumption of aluminum is similar. China has become the main large country of aluminum consumption. In 2007 the aluminum production is 12.56 million tons, 34% of world production.

As a view of industrial structure, manufacture is the main industry to promote economy development. Since 2002 the consumption elasticity of energy is larger than 1 and increases continuously. Economic growth relies on resource consumption. According to economy development stage theory, China economy is in beginning stage, needs high investment rate, leading industry and economic system reform. So the resource dependence of economic growth will continue for a long time.

1.1.2 Research Topic

1.1.2.1 Mineral Resource Dependence

Along with the rapid increase of mineral resource consumption, the conflict of demand and supply of mineral resource appears and resource restriction has become the important problem in China economy development. For one side the resource consumption speed is more than the economic growth speed. China is the first large country of coal, steel and copper consumption in the world, the second large country of oil and power consumption. For another side China geological exploration has obtained some achievement and resource supply increases. But mineral resource reserves per capita are very low. The mineral resource supply is short. In order to achieve the aim of economy development, the shortage of mineral resource is large. How to solve the shortage of mineral resource effectively is the important problem in current China.

In recent years China geological exploration and mineral resource utilization have obtained some achievement, but there are remain some problems. The problems contain 4 aspects.

(1) Some important mineral reserves decline. Although reserve-production ratio of important mineral resource improves and supply increases, excessive consumption of reserves, the lack of geological investment and the difficult prospecting work make some important mineral reserve-production ratio reduces. The gap between demand and supply increases. Oil, iron, manganese, lead, potash and other mineral reserve have a serious shortage of reserves.

(2) The increasing mineral exploitation is incompatible with the national macro-control. Taking the period of the tenth five-year plan as an example, the production of China oil, coal, steel, iron ore and refined copper increased by 7.4%, 95.8% and 130.2%, 39.7% and 50.3% from 2000 to 2004, while the consumption increased by 29.5%, 50.2%, 141.8%, 94.2% and 69%. The speed of consumption growth is faster than the growth of production. In recent years the rapid growth of steel, cement, automobile, textile and other manufacturing industry leads to the high consumption and demand of coal, iron ore, bauxite, cement, limestone and other mineral resource. Tungsten, tin, antimony and other mineral resource can not play the maximum benefit because of production uncontrolled.

(3) The structure of mineral resource exploitation and utilization is not proper, and can not accord with the aim of industrial structure. The medium and large mines account for only 1.3% of the total number of mines. This induces more resource and environment problems. In addition, the upstream industries attenuate gradually. The downstream industries are overheating. Resource depletion and idle capacity appear.

(4) The uneven regional distribution of mineral resource exists. The utilization effectiveness is low. Nowadays the mineral reserves in the eastern and central regions dropped sharply and can not support the high-intensity exploitation. The potential resource exploitation of the western region is large, but the continuous exploitation is difficult. In addition, extensive mode, serious waste and low efficiency have not been solved. The energy utilization efficiency is 33%. The total recovery of mineral resources is 30%, and is lower than the foreign by 10% or 20%.

1.1.2.2 Mineral Resource Challenge

1 Mineral resource supply challenge

The demand of mineral resource increases along with the rapid development of China economy. The shortage of mineral resource supply enforces the large quantities import of mineral resource. According to WTO statistics, in 2008 the import value of mineral resources of China has risen to 8.48% of the world and is the third after the United States and Japan.

However, mineral resource has become the contention object of around the world. The developed countries have controlled the most trade and development rights of mineral resource all over the world. The resource restriction of China economy development includes the following.

(1) The resource price rises rapidly, production cost improves and the inflation pressures are large. Since 2000 China price index of commodities increased faster, the living costs of people increased significantly. Economic growth does not improve the welfare of people. Social conflicts intensified and economic development is affected.

(2) The restriction of resource stock enlarges. Economy development is related with resource input. The rapid expansion of China economy greatly increases the consumption of resource. The shortage of resource appears, and most of mineral resource can not meet the need of economy development.

(3) The increasing price of main imported goods leads to the profits transfer. After joining the WTO, the resource shortage can be supplied by the international market. Since 2003 the prices of energy, mineral resource and resource material increased. The cost of China manufacturing industries enlarges and the profits transfer to other countries. In 2009 China has 204 million tons of crude oil imports, 51.3% foreign dependence; 627 million tons of iron ore imports, 70% foreign dependence; 55.4 billion cubic meters of natural gas imports, 8.7% foreign dependence. In recent years the foreign dependence of chrome ore, manganese, nickel, potassium are 90%, 56%, 75% and 80%.

2 Environment pollution and ecological crisis

Resource exploitation and utilization refers to natural resource itself, the production and living of human society, ecological system, population and technology. They constitute natural resource exploitation and utilization system. The system consists of two parts: the ecological system and socio-economic system. Ecological system mainly makes the contact of natural resources and socio-economic system by many methods. The use of resource will produce some residues. Part of the residues is reprocessing to be used by human consumption. Part of the residues will release into the environment system. When the residues are more than the ability of ecological system, ecological environment problem appears. In addition, the exploitation of resource usually ignores the relationship between single resources. This will induce to the exploitation of the entire system. The use of natural resource can not break away from the complex of natural resource. The overall imbalance and collapse will threaten the survival of human beings, life and production.

China current ecological environment is not optimistic. Air pollution, water pollution and solid waste increase. Local environmental problems cause mass events. Environmental standards induce to trade disputes.

Firstly, air pollution is increasingly serious, including sulfur dioxide pollution, soot pollution, dust pollution and vehicle exhaust pollution. Coal is the main resource. Coal consumption increases will lead to a sharp increase in sulfur dioxide emissions. The scope of acid rain pollution also expands, and the results are grain, vegetables and fruit production reducing, tree mortality, soil and water acidification. In 2010 sulfur dioxide emissions are 21.851 million tons. According to acid rain monitoring there are 249 cities with acid rain in 494 cities and the proportion is 50.4%. There are 160 cities which acid rain frequency is above 25% and the proportion is 32.4%. There are 54 cities which acid rain frequency is above 75% and the proportion is 11.0%. The main source of dust emission is thermal power plants and industrial boilers. Many power plants use inefficient dust, so dust emissions is so high and is serious harm to the atmospheric environment. In 2010 China dust emissions is 8.291 million tons and industrial dust emissions is 4.487 million tons. According to World Development Indicators 2006, China has 13 cities in the most serious air pollution top 20 cities and in all 24 cities in China Dalian and Urumqi are the best, but still much higher than major countries in Europe, Africa and Latin America. In addition, driven by economic growth, China motor vehicles number has grown rapidly in recent years. Vehicle emissions of nitrogen oxides, carbon monoxide and hydrocarbon increases year by year.

Secondly, water pollution is prominent. Although Chinese government has taken various measures to strengthen pollution control, water pollution has not been effectively curbed in general, and water pollution problem is still serious. In 2005, the water quality of about 59% China seven major rivers is in Class IV and V. The data in 2010 is also 40.1%. The increasingly serious water pollution and frequently occurrence water pollution events has become a matter of China most prominent environmental issues. Green National Accounting Study by State Environmental Protection Administration points out in 2004 the economic losses caused by environmental pollution is 511.8 billion Yuan, accounting for 3.05% of GDP. 56% environmental losses in 2004 are caused by water pollution. In environmental accidents occurred in 2005, 97.1% is pollution incidents and water pollution accidents account for 50.6% in pollution accidents. Water pollution occurred every two days.

Thirdly, the utilization level of solid waste, industrial waste and hazardous waste is not high. Current solid waste emissions in China declines since 2002, but the comprehensive

utilization rate of most solid waste is not high and storage state is also relatively simple. Sound disposal of municipal solid waste is low, and rural solid waste pollution problems have become increasingly prominent. In 2010 industrial solid waste generation is 2,409,435,000 tons, the emissions is 4.982 million tons, the capacity utilization, storage capacity, disposal volume are 1,617,720,000 tons, 239,183,000 tons, 572,638,000 tons, and comprehensive utilization rate is 67.1% of total production. With the accelerated process of urbanization, urban construction waste generated each year accounts for more than 30% of the total municipal solid waste, of which the vast majority of construction waste is without any treatment. The data show that China construction waste recycling rate is of less than 5%, while the rate of the EU countries is more than 90%. In rural areas, the pollution caused by burning crop straw has become a thorny issue facing China. So that in 2008 China State Council issues Document No. 105, proposes to speed up the comprehensive utilization of crop straw views and put forward that until 2015 we set up straw collection system with rational layout and multi-use pattern of industrial utilization of straw. And the straw comprehensive utilization is more than 80%.

1.2 Research Content and Framework

1.2.1 Research Content

Mineral resources have become a major constraining factor of China economic growth. China economy development faces insufficient supply of resources, high resource dependence and weak resources support. These problems are related to whether the objectives of China future economic can be successfully achieved. To solve this problem, this essay attempts to analyze the relationship between economic growth and mineral resources, make sure the mineral resources dependence, and propose a different policy measures to reduce resource dependence and enhance the protection capacity of resources. Overall, this essay is as follows:

First of all, research content is China economic growth and development. After reform and opening up, China economy has developed rapidly. But resource constraints have been an important troubled issue for China economic stability and sustainable development, which requires us to recognize and take advantage of China's economic development, can not be blindly optimistic, establish the scientific development concept, and find a fundamental solution to China's sustainable economic development. This essay studies the relationship of

China's economic growth and mineral resources, and its aim is to analyze China's current economic growth mode, characteristics, the relationship of resources consumption and economic growth, reveal the status of resources consumption, understand the current nature of China's economic development and propose effective measures to ease resource supply pressure.

Secondly, research content is the relationship between supply-demand of mineral resources and China's economic growth. The coordinated development of economic growth and mineral resources is the key of China's modernization success. In order to achieve economic stability and sustainable development, we must solve the relationship of economic growth and mineral resources. Nowadays the gap between supply and demand of resources is very large. This increases the dependence on foreign. On the other hand, the waste of mineral resources is staggering, and the mining of mineral resources recovery, recovery of smelting and comprehensive recovery still lags behind developed countries. Therefore, how to handle the relationship between economic growth and mineral resources has become the key of sustainable economic development. This essay adopts quantitative method to analyze the relationship between mineral resources and economic growth. Current research focused primarily on theoretical research, and empirical research is rarely. This essay bases on the data of the supply and demand of mineral resources, analyzes the correlation between mineral resources and economic growth by compare analysis and regression, and measure the mineral resources dependence of economic growth to reflect the resource utilization and resource crisis in China.

Thirdly, research content is supply and protection of China mineral resources. The lack of mineral resource directly affects China's manufacturing industry and its overall economic development. How to meet the growing demand of mineral resources has become the important issue in 21st century. This essay analyzes the measures of economic growth from the views of increasing the effective supply of resources, reducing resource consumption and issuing innovation. Increasing the effective supply of mineral resources is the future strategic direction of exploration and development. We need to establish the view of “two resources and two markets”, to strengthen the investigation, exploration, development, planning and management, protection and rational utilization of mineral resources and to maximize economic, social and environmental benefits of mineral resources. The essay attributed the problem to increase the effective supply of resources, which is the fundamental way of increasing the need of resource. Only combining geological survey and resource economics can ease the pressure of resources supply, and keep the sustainable development of China's

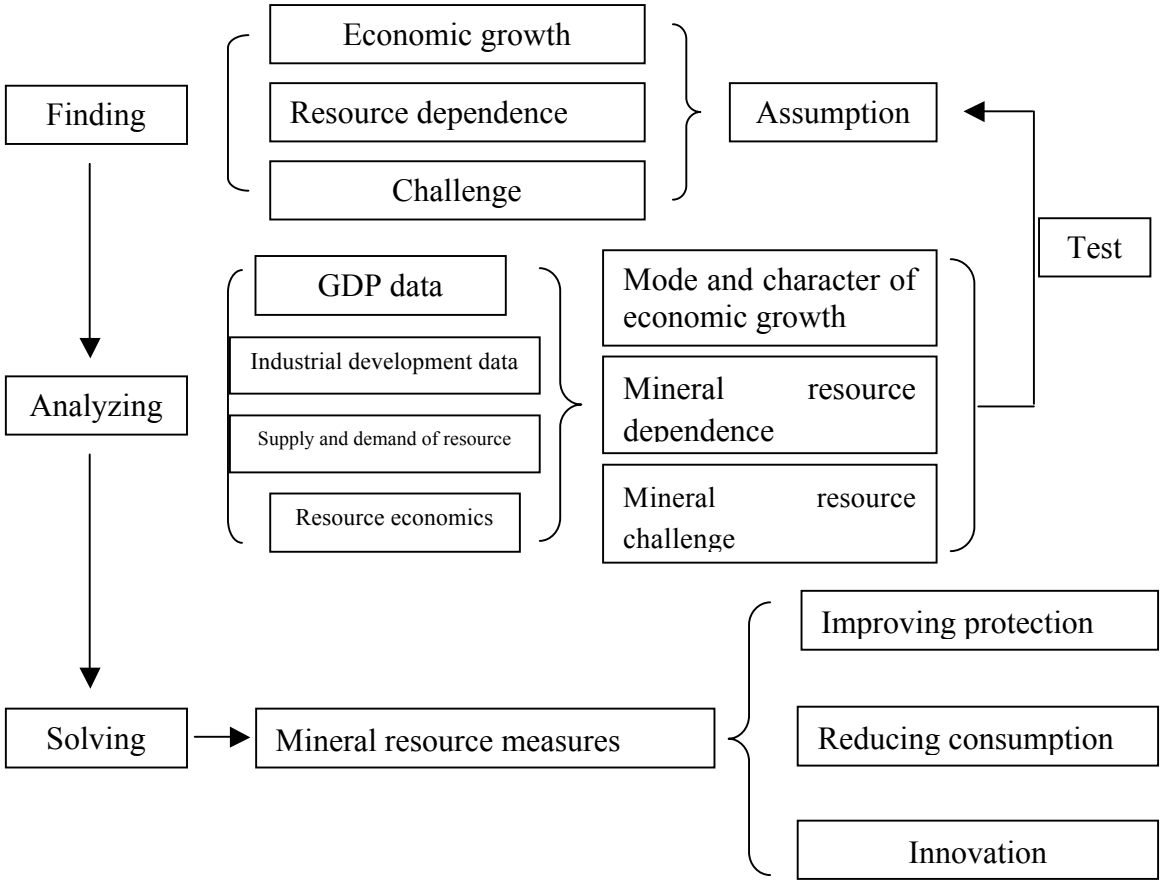
economy.

1.2.2 Framework

This essay follows the line of finding question, analyzing question and solving question. The essay focuses on the resource dependence and challenge of economic growth, analyzes the question by compare and regression, and provides policy suggesting. The structure and framework are shown as follows.

The structure is arranged as follows. Chapter 1 is introduction, including the background, topic, research framework, research importance and implications. Chapter 2 is literature review, including literature sort and comments. Chapter 3 is research design, introducing the data and methods. Chapter 4 is analyzing the resource dependence of economic growth, investigating the economic growth, economic structure and the consumption of mineral resource and revealing the economic growth mode, character and the resource dependence situation. Chapter 5 is analyzing the challenge of economic growth from the aspects of mineral resource constraint and ecological crisis. Chapter 6 is researching the policy measures to resource challenge from the aspects of adding supply, reducing consumption and developing innovation. Chapter 7 concludes the essay, points out the shortcomings and future study.

Figure 1-1 Structure and Framework



1.3 Research Meanings and Implications

1.3.1 To Pay Attention to Resource and Promote the Research of Resource Economics

The rapid development of China economy adds the consumption of resource. Due to the limitation of resource, resource constraints have become the important problem for economy development. Due to the lagged reflection, market system can not solve the resource problem in economic growth. This essay analyzes the mineral resource dependence of economic growth, indicates the direction of economic development and can promote the research of resource economics.

1.3.2 To Ease Resource Constraints and Realize Sustainable Development

Along with resource-intensive economic growth, the contradiction between economic growth and mineral resource appears. Economic growth faces resource constraints and resource shortage. How to ease the pressure of resource constraints and keep sustainable development is very important for China modernization. We should enhance the research of resource economics and follow the way of sustainment development, build mineral development strategy, promote structural adjustment, change the traditional industrial mode and focus on economic and social benefits.

1.3.3 To Enhance the Supply of Resource and Protect Resource Security

Resource security mainly refers to the protection of resources to economic development and living. The higher protection is, the greater security is. Resource security related to the supply of resources, supply steady and the price of resources. The resource per capita is seriously inadequate. But the consumption of resource will rise along with economic development. The demand and supply shortages will be serious. China's economic security faces the severe challenge. Research on the relationship between economic growth and mineral resource is the need of China economy security, and is the need of improving China's resource self-sufficiency, reducing external dependence and building an independent economic and resource security system.

Chapter 2: Literature Review

2.1 Literature Source and Introduction

In order to understand research status of the relationship between economic growth and mineral resource and follow research fronts, Data collection is from government website, academic literature database, land resources and mining BBS, book, journal, conference proceeding. The data are related to economic development, land policy, resource exploration and mineral business. Through literature review and analysis, this essay finds the shortage of existed researches, and issues the research aim. In literature review there are more than 20 monographs, such as “Resource and growth”, “Resource constraints, structural change and economic growth”, “The Limits to Growth”. There are 984 papers, where 556 papers in Chinese core journals, such as “Natural Resource Economics of China”, “Economic Research”, “Resource Science”; 312 papers in national journals, such as “China High Technology Enterprises”, “Tian Fu New Idea”, “Journal of Qiannan Normal College for Nationalities”; 65 papers in academic conference proceeding; 51 papers in other journals and newspapers. Besides, this essay collects exact data from The ministry of land and resources information center, General Administration of Customs of PRC, China statistic yearbook, China non-ferrous metal industry yearbook, supporting the research on the relationship between China economic growth and mineral resource.

2.2 Theory Review

2.2.1 Economic Growth Theory

2.2.1.1 Classic Economic Growth Theory

Classic economics is the main economics thought before Keynesianism. The major representatives are Adam Smith, David Ricardo, Thomas Malthus and John Mill. Classic economics takes labor theory of value as main theory, including production theory, capital theory, allocation theory, exchange theory and currency theory. In 1776 Adam Smith issues the labor theory of value in the book “An Inquiry into the Nature and Causes of the Wealth of Nations”. That is “National wealth is the total commodity, and labor is the source of wealth”. David Ricardo (1817) considers capital accumulation is the key of economic growth. Thomas

Malthus points out in “An essay on the principle of population” published in 1798 that the unrestrained population will increase geometrically and living material will increase arithmetically. The population expansion will lead to the shortage of resource. World economy will be destroyed due to the resource drain. John Mill (1848) inherits the tradition of Smith and Ricardo, and pay attention to economic growth. The economic development has 3 characteristics, such as adding the ability of controlling nature, adding security and adding cooperation ability.

In sum, classic economist has found the cause of economic growth, but ignored the relationship between natural resource and economic growth. Firstly classic economics focuses on economic growth analysis, takes natural resource as wealth source, such as land. Secondly classic economics focuses on the agricultural economics, and strengthens the factors of land and population. They suppose economic growth can not be happen persistently. Thirdly early research refers to the contribution of resource on economy, and latter research takes Malthus and Mill as the representatives, and analyzes resource value and the conflict between economic growth and resource. Malthus points out the growth of resource demand is higher than the one of resource supply. Mill discovers the relationship between human and resource.

2.2.1.2 New Classical Economic Growth Theory

New classic economic growth theory takes marginal analysis as character, uses marginal analysis to check pricing, resource allocation and income allocation. The theory ignores economic growth. The resource view bases on utility value. Demand law is explained by marginal utility, and supply law is explained by marginal production cost. Resource allocation bases on market adjustment. In 1874 Walras developed market equilibrium theory in “Elements of Pure Economics”. Equilibrium price exists when market equilibrium exists. Besides, In 1920 Arthur Cecil Pigou in “welfare economics” proposes individual welfare is related to total welfare and government regulation can achieve the optimal resource allocation.

New classic economics ignores resource. The economist thinks natural resource is not an important factor for economic growth. They focus on the resource allocation in economic activity. Major industrialized countries hold rapid economic growth until 1970s. This verifies the prospects of Marshall. Secondly, new classic economics developed a new way to analyze the relation between resource and economic growth, such as equilibrium analysis, and welfare economics can provide some suggestions to promote the society welfare.

2.2.1.3 Modern Economic Growth Theory

Modern economics root from effective demand issued by Keynes (1936). Modern economic growth theory mainly discusses the determinant, speed and way of economic growth, using model to analyze. Modern economic growth theory can be divided into exogenous and endogenous economic growth theory. The former considers economic growth is motivated by exogenous factors, and the latter thinks economic growth is motivated by endogenous factors. Therefore, exogenous economic growth theory takes R. M. Solow and T. W. Swan (1956) as the representatives. Endogenous economic growth theory takes P. Romer and Robert Lucas as the representatives. Solow and Swan issue Solow model in 1956, which attribute economic growth to exogenous technological advance. The following factor analysis contains capital, labor, ignores natural resource. Romer introduces knowledge into model, such as general knowledge and professional knowledge. Douglass North (1994) pays attention to system factor in economic growth.

Modern economic growth theory focuses on the determinant of economic growth, and emphasizes the economic relation. However, this theory takes resource as simple production material, and ignores the resource constraints.

2.2.1.4 Resource environment and sustainable development theory

Energy crisis in 1970s reduces the speed of economic growth. The economists start to pay attention to ecological environment and sustainable development. The main theories include neo-Malthusianism (Francis Place, Richard Carlile), growth limit theory (Dennis L. Meadows) and sustainable development theory, and so on. neo-Malthusianism focus on non-renewable resource depletion and environmental pollution, and develop Malthus Theory of Population. In 1972 The Limits to Growth analyzes the disaster of economic growth. Meadows calculates the effect of population on human survival. In 1962 the book “Silent Spring” written by Rachel Carson induces to sustainable development theory. In 1987 the United Nations world and environmental development committee issues the concept of sustainable development in the report “Our Common Future”. Sustainable development refers to sustainable economy, sustainable ecology and sustainable society.

Neo-Malthusianism, growth limit theory and sustainable development theory discuss the relation between resource and economy. Industry development will destroy environment. Resource dependence exists. Neo-Malthusianism claim population control. Growth limit theory thinks economic growth will stop. sustainable development theory adopts a feasible measure between economic growth and resource consumption.

2.2.2 Resources Endowment Theory and Resource Curse Theory

2.2.2.1 Resource Endowment Theory

Resource endowment theory is also said Factor Endowment Theory issued by ELI. Heckscher in 1919 and Bertil Ohlin in 1933. The theory origin is Theory of Absolute Advantage by Adam Smith and comparative advantage theory by David Ricardo. Resource endowment theory supposes the difference of same product price in different countries due to cost difference, and cost difference due to factor price difference, and factor price difference due to resource endowment. Factor endowment decides international division of labor.

Resource endowment theory is the basis of foreign trade study. Since 1990s economic globalization and integration have become the tendency of world economic development. Commodity flow can recover the shortage of factor flow. Resource endowment decides the product. But Resource endowment theory ignores the dynamics of economic factor.

2.2.2.2 Resource Curse Theory

In traditional resource-oriented economic growth mode, natural resource endowment largely determines economic development. But in the late 20th century, resource-oriented growth model fails. The economic performance of resource rich countries is weaker than the one of resources lack countries. This led some economists began to explore the reason. In 1993 Auty first proposed the concept of "resource curse". That is to say abundant resources are the restrictions of economic growth. Sachs and Warner (1997) study economic growth of 95 developing countries, find out in natural resource-based countries the negative relation between export and economic growth exists. This verified resource curse. a lot of researches analyze the transmission mechanism of natural resource constraints and economic growth., such as Sachs and Warner (1997), Zhao Fengjun (2006). The transmission mechanism studies explain the resource curse phenomenon.

Resource curse theory describes the relationship between mineral resource and economics, promoting resources research. Resource hinders economic growth through a transmission mechanism. So the study of the transmission mechanism has played a catalytic role in economic growth.

2.3 Domestic Literature Review

2.3.1 Economic Growth and Resource Constraint

The high consumption of resource and environment pollution have become the barriers of China's economic development. The contradiction between economic development and population, resources, environment appears. The resource constraint is the focus of study.

Li Gang et al.(2008) analyze the mineral resources constraints to China economic growth empirically using import and export data from 2001 to 2006. They find out the long period of resource price adjusting cause a lot of enterprise bankruptcy and social waste of resources. Meng Yao (2007) discovers resource supply gap is the cause of resource constraint. Fu YunSheng (2005) thinks natural resources shortage and abundant human resources are the main constraint of China's economic development. But Liu Xin (2006) considers resource constraints do not exist in China's economy and the effective demand constraints exist. The opinions of scholars give us a better sense of China's economic growth problems.

2.3.2 Economic Growth and Resource Curse

Natural resources are the basis of China’s economic growth, and are the fundamental of China's economic growth. Natural resources consumption is the precondition of economic growth. Natural resources are the material of economic growth. Natural resource endowments will improve economic growth speed.

Generally speaking, certain geographical conditions determine a country or region's natural resource endowments. Cao Shitu (1989) proposes geography is the decisive factor in social development, and geography promotes production mode, determines the mode of development and change. In China economic growth of natural resource-rich regions, such as Shanxi, Heilongjiang, Yunnan, is worse than resource-poor regions, such as Guangdong, Zhejiang, Jiangsu. Xu Kangning and Wang Jian (2005) test the hypothesis of resource curse using panel data. Many provinces in China have abundant natural resources, but restrict economic growth. They attributed to the exploitation of resources and systems caused by weakening of the manufacturing recession. Li Tianzi (2007) also tests the hypothesis of resource curse using panel data. The results show that the abundance of natural resources does not directly have a negative impact on economic growth, but impede economic growth by reducing foreign direct investment, education, level of innovation indirectly.

2.3.3 Regional Economic Growth and Natural Resource

China's regional economic growth is of importance for reducing regional economic disparities. And Reducing regional economic disparities need a long time.

Pan Shuang and Zou Hui (2009) point out the phenomenon of resource depletion is serious in China. Resource-saving paths are needed to take. Zhao Xia (2008) takes natural resource as an important factor in regional economic growth, analyzes the phenomenon of resource trap in regional economic growth, and proposes the importance of natural resources in regional economic development. Zhang Yan et al. (2001) point out the advantage of natural resources does not mean economic advantage, propose it should adjust the resource-based economic development, and build a resource-conserving mode of economic development.

2.3.4 Resource, Environment and Sustainable Development

Resource depletion, population growth, pollution and other issues have become the world's development challenges. Countries began to find a harmony sustainable development way without compromising the ecological environment. China's economy is also facing serious environmental pollution, shortage of resources, waste and a huge imbalance of economic development. In order to achieve sustainable development, we must deal with the relation between natural resources and the environment. Therefore, sustainable development has become the focus of research.

Chen Zhonghong and Sun qi (2005) analyze the China's economic development since reform and opening up. China's economy has achieved an average annual GDP growth rate of more than 8%, but resources are not used most efficiently and environmental conditions deteriorates. This restricts the further development of the Chinese economy. Ding renzhong (2005) points out ecological and environmental problems can not be ignored in economic development. Ecological carrying capacity is limited. The resource consumption is faster than economic growth and energy and resource crisis are always the challenge of human being. The traditional economic growth mode should be changed and sustainable development mode should support for economic growth.

2.4 Discussion and Comment

According to classic economics, modern economics, economic growth is studied deeply. The methods are from single factor model to multiple factor model, from exogenous to endogenous growth theory. Research on resource is also a deepening process from none to

most and from ignoring to attention. Economic growth theory and resource theory provide the view and basis of resource dependence of economic growth. Current literature mainly adopts macro view and compare-analysis method, discusses regional economic growth. The shortage is as follows.

(1) Research content appears theorization. General economic growth theory is used to discuss the function of resource. Current research ignores the character of mineral resource.

(2) Research scope is too narrow. Mineral resources are the important influence factors of economic development, referring to resources consumption, memory, import and export, exploration and manufacturing industry. We should consider geological exploration and manufacturing industry to analyze the resource dependence and challenge of economic growth.

(3) Research methods are simple, lack of theoretical model and empirical evidence.

In this essay, we should consider mineral resource is the important influence factor of economic development. We should analyze the topic using economic growth theory, resource endowment, and sustainable development theory.

Chapter 3: Research Topic and Design

3.1 Basic Theory and Research Topic

3.1.1 Basic Theory

3.1.1.1 Sustainable Endogenous Economic Growth Theory

Resource economics indicate resource exploitation and utilization are usually related to economic development. The resource exploitation and utilization in underdeveloped economy adopts extensive mode. Economic growth relies on the quantity of resource. This is a growth style of resource dependence. With economic growth the production and technology will improve. And the conflict between limited resource and economic growth becomes highlighted. Under the background this is very difficult if economic growth only rely on more resource. Only depending on technical progress and producing high-value effects can keep economic growth sequentially. So intensive mode of economic growth is necessary. Economic growth and resource dependence are supplied each other.

For theoretical research, the relationship of economic growth and resource problem has become the hot topic in resource and environment research following the issue of endogenous economic growth theory and sustainable development. Endogenous economic growth theory with resources and environment restriction is developed.

Economic growth theories contain exogenous growth theory and endogenous growth theory. The former points out that economic growth is driven by the exogenous technology progress. But the latter indicates economic growth is driven by internal economic factors, such as capital accumulation. Modern economic growth theory can be divided into 2 classes. One class is economic growth theory which makes technology as exogenous variable, and the representative is R. M. Solow. Another class is economic growth theory which makes technology as endogenous variable, and the representative is P. Romer.

This essay bases on endogenous economic growth theory and improves sustainable endogenous economic growth model. The growth models in 1970s make resource as endogenous variable (Solow, 1974; Stiglitz, 1974; Georgescu-Roegen, 1975). Sustainable endogenous economic growth model focuses on the scarce resources allocation under the condition of harmony of human and environment. Traditional economic growth model

considers income growth relies on the improvement of capital and productivity. Sustainable endogenous economic growth model is different from the traditional economic growth theory. It is worth noting that traditional market economy system is unsustainable development system, emphasizes the assumption of homoeconomicus and focuses on economic benefits. Sustainable development strategy and green reform will follow the assumption of ecological mankind and consider the benefits of environment, economy and society. Also they base on resource and environment system, make ecological benefits as adjustment aim, and consider resource and environment value.

3.1.1.2 Resource and Environment Theory

In 1960s and 1970s the economists have some shortage about resource and environment problem. So resource and environment economic theory is issued in 1980s. In 1960s and 1970s the economists only focus on the resource and environment problems in micro level, such as resource depletion, pollution control and environment protection. But resource and environment economic theory focuses on the macro level and points out economic activity depended on environment and will induce environmental cost.

Environment is a scarce asset and has 3 economic functions. (1) Environment can provide material and energy for economic activity. Resource can be priced in market economy. (2) Environment can absorb the waste of economic activity. However, this function will be destroyed when waste emissions exceed the absorptive capacity of environment. (3) Environment can supply services for economic activity.

Besides, resource scarcity includes long-term scarcity and short-term scarcity. If environment is overused and the quality reduces, short-term resource scarcity will appear. If environment quality reducing can be controlled, economic growth will be limited and long-term resource scarcity will appear. Also resource scarcity can not be eliminated through the innovation of inner economy system. Resource and environment theory proposes some innovation can weaken the involution of environment quality. In order to keep environment quality, system design and government policy supply is necessary.

3.1.2 Research Assumptions

3.1.2.1 Assumption of the Pattern and Character of China Economic Growth

Since reform and opening up China economy developed rapidly. But the extensive growth mode does not have the ability of sustainment development because of the conflict

with resource and environment.[5] Therefore, the study of economic growth should analyze the resource consumption in China economy development reveal the character and mode of China economic growth.

Assumption 1: China economic growth is industrialization-dominant, has extensive mode, and is motivated by investment demand.

(1) Since reform and opening up, China industry developed rapidly, such as steel, colored metallurgy, oil refining, chemical industry, cement and electricity. The development appears industrialization-dominant.

(2) For growth mode, the phenomenon of "three high and one low" is widespread, which is high input, high consume, high pollute, low output, low quality and low benefit. Economic growth relies on the expanding of production elemental and number, and has the character of extensive.

(3) It can be seen from proactive fiscal policy in 1998 to massive investment after financial crisis that investment demand can make economic growth.

3.1.2.2 Assumption of the Resource Dependence of China Economic Growth

In the middle and last of 1990s, industrialization process speeds up in China economy. The remarkable character is the consumption of energy, metal and mineral increases. This essay will analyze the relationship between economic growth and mineral resource empirically and reveal the resource dependence of economic growth. The resource dependence contains not only the contribution rate of resource consumption to economic growth, but also the consumption elasticity of mineral resource. The contribution rate and elasticity coefficient can reflect the relationship between economic growth and mineral resource consumption, and the resource dependence of economic growth. We will build linear regression model to describe the dependence.

Assumption 2: China economic growth depends on mineral resource obviously. That is to say the contribution of mineral resource consumption to economic growth is high, the change of mineral resource consumption is large, and the positive correlation between economic growth and mineral resource consumption exists.

(1) Mineral resource is the important production material. The consumption of mineral resource increases annually. The pricing power of mineral resource is the focus. The

[5] Song gui xia, Liu chun yan. Analysis of China economic growth, Introduction of Economic Research, 2006, (3), 17

contribution of resource consumption on economic growth is high.

(2) The high consumption of mineral resource is consistent with the high development of China industry. Resource consumption is quicker than economic growth. We assume the elasticity of mineral resource consumption is larger than one.

(3) China economic growth and mineral resource consumption keep in a high level since 2000. We assume the positive correlation between China economic growth and mineral resource consumption exists.

3.1.2.3 Assumption of the Challenge of China Economy Development

Resource supply is limited, but resource demand in economic growth is very huge. In order to keep sustainment development of China economy, the challenge includes resource supply, resource safety and environment. Resource supply ability is very important for China economy development due to the limited resource. Resource safety is also important due to the lack of resource security strategy. Owing to the restriction of law and technology, the situation of China resource and environment is very severe. Analyzing the challenge of economy development can explain current resource situation, and can be used as policy basis.

Assumption 3: The sustainable development of China economy will faces the challenge from resource supply, resource safety and environment. The challenge is very important for the well-to-do society.

China has large mineral resource reserves, but the resource per capita is low. Resource supply is very hard. The shortage of resource supply maybe induce resource safety problem. Also environment destroy is an assignable factor for economy development.

3.2 Data

3.2.1 Macroeconomic Data

The macroeconomic data include GDP, National total income, GDP index, GDP growth rate, GDP per capita, industrial enterprise gross output covering the period from 1978 to 2010. The data is from China statistical yearbook (1981-2010).

GDP, GDP growth rate, GDP per capita are used to analyze China economic growth, reflecting economy development. Industrial enterprise gross output is used to the industrial background, especially related to resource, reflecting the development of China mineral industry.

3.2.2 Resource and Its Consumption Data

The resource data include mineral resource reserves (2002-2010), mineral resource production (1978-2010), mineral resource consumption (1978-2010), and the geological exploration funds (1978-2010). The data is from China statistical yearbook (2003-2010), China industrial economy statistical yearbook (2009), China colored metal industry statistical yearbook (2009), China gold group and the notice of geological exploration industry.

China mineral resource reserves data are used to analyze the development of China mineral resource. China mineral resource production and mineral resource consumption data are used to analyze China mineral resource production and consumption. China geological exploration funds data are used to analyze China geological exploration investment.

3.2.3 Mineral Resource Trade Data

The mineral resource trade data include total export-import volume (1978-2010), trade volume of mineral resource (1990-2010), customs import and export classification volume and mineral resource trade volume. The data is from China foreign trade yearbook (1984-2009), China business yearbook (2003-2007) and China statistical yearbook (1981-2010). The data is used to analyze the demand and supply of China mineral resource.

The data of total export-import volume (1978-2010), trade volume of mineral resource (1990-2010), customs import and export classification volume and mineral resource trade volume are used to analyze China minerals trade situation, reflecting the demand and supply challenge of China minerals.

3.2.4 Emission and Environment Ecology Data

The emission and environment ecology data include the emission data of waste gas, waste water and industrial residue, total emission volume and the pollution regulation situation. The data is from China statistical yearbook (1981-2010). The data is used to check the environment pollution and ecological crisis in the process of China economic growth, find out the crisis and challenge of China economic growth and provide the policy suggestions.

The data of the emission of waste gas, waste water and industrial residue, total emission volume and the pollution regulation situation are used to analyze the resources and environment pollution and ecological crisis in China economic growth, discover the crisis and challenge, and offer the policy suggestion for mineral resource exploitation and utilization.

3.3 Research Methods

3.3.1 Research idea and Framework

3.3.1.1 Basic Idea

This essay will base on the current situation of China economic growth, the demand and supply of mineral resource, analyze China economic growth, the mineral resource consumption and the relationship between them. The relationship can reflect the restriction of mineral resource to economic growth, and the challenge of sustainable development of China economy. Also this essay offers the policy suggestions from the views of improving resource protection ability, economic growth transformation and economic structure adjustment.

3.3.1.2 Research Framework

The framework includes 4 parts. Part 1 is the situation of China economic growth and mineral resource consumption. Part 2 is the mineral resource dependence of China economic growth. The methods contain compare analysis, causal analysis and regression analysis. Part 3 is the challenge of China economic growth. Part 4 is policy suggestions.

3.3.2 Research Methods

3.3.2.1 Causal Analysis

Causal analysis focuses on the causal relationship between each other, including function relation and correlation. Causal analysis in this essay is mainly regression analysis. Regression mainly forecast the change of dependent variable according to independent variables. This essay adopts regression method, designs independent and dependent variables, sets up regression equation, estimates the equation, tests the results by F test and T test and analyzes research assumptions.

3.3.2.2 Compare Analysis

Compare analysis mainly compare some things by certain indicators, discover the nature and regular, and evaluate correctly. This essay adopts compare analysis to check the relationship between China economic growth and mineral resource consumption.

3.3.2.3 Literature Analysis

Literature analysis mainly check research topic through literature survey. This essay searches and reads book, newspaper, journal and yearbook, and so on, describes the mode and

character of China economic growth, and the position and effect of resource in economic growth. Literature analysis is basic research method, and offers research background.

3.3.2.4 Model Analysis

Model can describe the main relationship among the factors. This essay bases on the traditional model, accords to the conclusion of regression analysis, issues new economic growth model, adopts this model to examine the resource dependence of China economic growth and explains the results.

Chapter 4: Resource Dependence of China Economic Growth

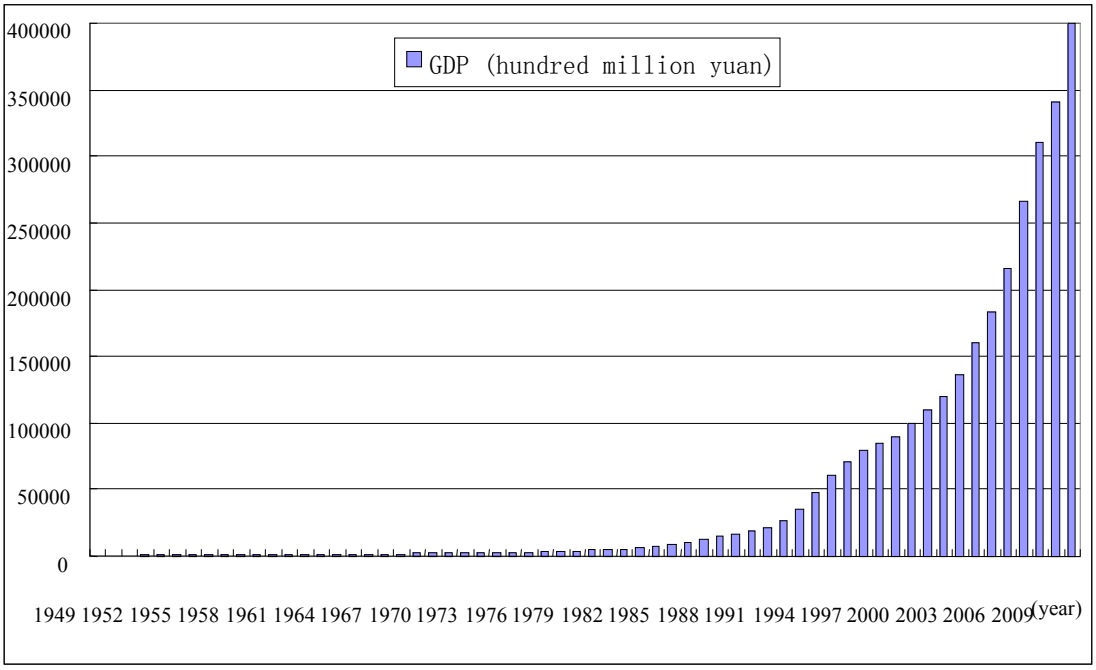
4.1 China Economic Growth

4.1.1 The Whole Scene of China Economic Growth

People's Republic of China established in 1949. Until 2010 the history of People's Republic of China is more than 60 years. China GDP in 2010 is 40 trillion Yuan, which is 1,000 times GDP in 1949. China economic growth is the most quick among global countries. China economic growth is shown in Figure 4-1.

China economic growth is quick, and has the characters of high volatility and high resource consumption.

Figure 4-1 China economic growth



Data source: China Statistical Yearbook.

4.1.2 High Volatility of China Economic Growth

The history of 60 years can be divided to 2 periods: 1949-1978 and 1978-2010. The average annual growth rates are 7.89% in 1949-1978 and 15.82%. The difference between 2 rates is very obvious, and the details are shown in Table 4-1.

Table 4-1 China economic growth rate

Period	GDP growth rate (%)	Period	GDP growth rate (%)
1949-1978	7.89	1978-2010	15.82
1949-1958	13.97	1978-1990	14.58
1958-1968	2.80	1990-2000	18.18
1968-1978	7.78	2001-2010	14.98
Period		GDP growth rate (%)	
1949-2010		11.98	

Data source: China Statistical Yearbook.

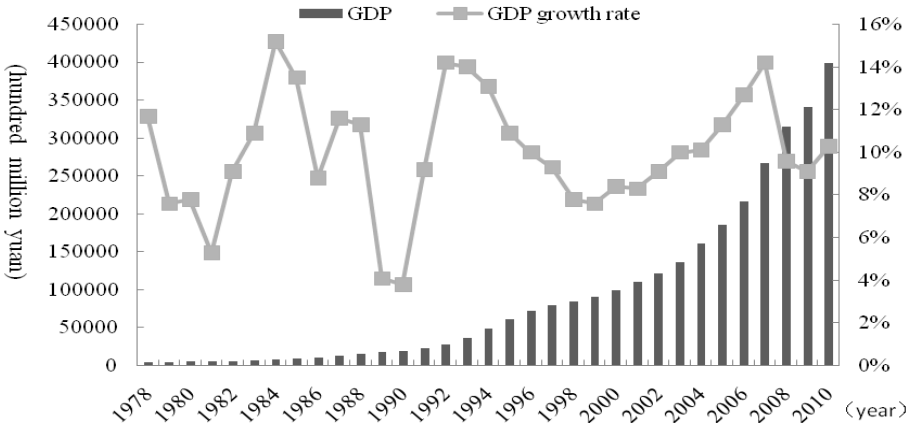
The table above shows the imbalance of China economic growth exists.

After People's Republic of China established in 1949, public ownership system makes the productivity improve largely. The average annual growth rate of GDP is 13.97% in 1949-1959. However, the political fights, especially the Great Cultural Revolution, make trouble to China economy. So the average annual growth rates of GDP are 2.80% in 1958-1968 and 7.78% in 1968-1978. China economic growth is very slowly. Since 1978 China's reform and opening up starts and the rapid economic growth appears. The average annual growth rate of GDP is 15.82% in 1978-2010. We discuss the details further as follows.

There are 3 periods. The first period is from 1978 to 1990 and the volatility of economic development is high. The average annual growth rate of GDP is 14.58%. The second period is from 1990 to 2000. During the period non state-owned economy develops quickly, the foreign investors come to China, and the export increase. China economic appears grow fast. The average annual growth rate of GDP is 18.18%. This becomes the basis of China economic development. The third period is from 2001 to 2010 and China economy appears stable growth. The average annual growth rate of GDP is 14.98%. China economic growth tendency is shown in Figure 4-2.

According to Figure 4-2, in 1978-1992 China economic growth rate shake violently, the maximum is 15.2% and the minimum is 3.8%. In 1992-2007 the economic growth rate has a U-like pattern. The rate in 1999 is 7.6% and in 1992 and 2007 is 14.2%. The volatility reduces. Since 2008 the economic growth slows down due to global financial crisis and keeps in 9% and more.

Figure 4-2 China econimic growth

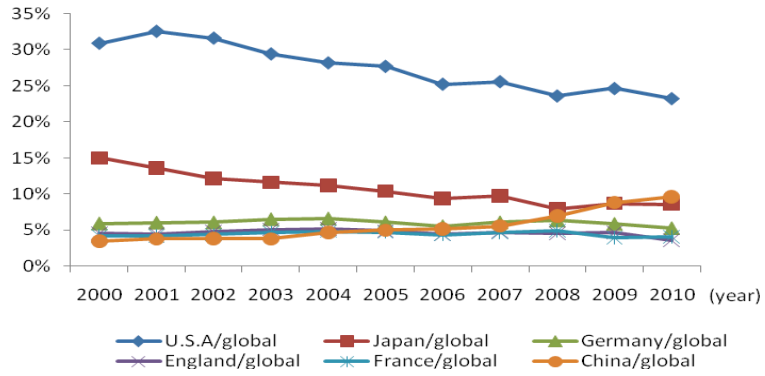


Data source: China Statistical Yearbook 2010.

4.1.3 The Role of China in Global Economy

The rapid growth of China economy makes the difference between China and the developed countries small. From 1978 to 2010 China economy exceeds Russia, Canada, Italy, France, UK, Germany and Japan early and late. The World Bank points out the rank of China GDP is the 11th in 1978, the 6th in 2000, the 4th in 2005, the 3rd in 2007, and the 2nd in 2010. China GDP is 40.11% of GDP of USA in 2010.

Figure 4-3 GDP Rank



Data source: World Bank Development Database.

4.2 Resource Consumption of China Economic Development

4.2.1 The High Resource Consumption

The high resource consumption is another obvious character of China economic growth except high volatility. Part of resource consumption is shown in Table 4-2.

The table shows the average annual growth rate of China GDP is 9.88% removing inflation in 1978-2010. The growth rates of asset investment, concrete consumption and steel consumption are 12.65%, 11.07% and 11.83%, which are larger than GDP growth rate. The high resource consumption is obvious.

Table 4-2 GDP growth and resource consumption

Year	GDP	Asset investment	Concrete	Steel
	0.1 billion Yuan	0.1 billion Yuan	0.1 billion ton	10 thousand ton
1978	3645	761	0.65	2208
1979	4063	830	0.74	2497
1980	4546	911	0.80	2716
1981	4892	961	0.83	2670
1982	5323	1230	0.95	2902
1983	5963	1430	1.08	3072
1984	7208	1833	1.23	3372
1985	9016	2543	1.46	3693
1986	10275	3121	1.66	4058
1987	12059	3792	1.86	4386
1988	15043	4754	2.10	4689
1989	16909	4410	2.10	4859
1990	18548	4517	2.10	5153
1991	21618	5595	2.53	5638
1992	26638	8080	3.08	6697
1993	35334	13072	3.68	7716
1994	48198	17042	4.21	8428
1995	60794	20019	4.76	8980
1996	71177	22913	4.91	9338
1997	78973	24941	5.12	9979
1998	84402	28458	5.36	10737
1999	89677	29855	5.73	12110
2000	99215	32918	5.97	13143
2002	120333	43500	7.25	19218
2003	135823	55567	8.62	24119
2004	159878	70477	9.70	29723
2005	182324	88604	10.60	39692
2006	209407	109870	12.40	47340
2007	265810	137239	13.60	56894
2008	314045	172291	13.88	58177
2009	340507	224846	16.50	69626
2010	400507	278140	18.80	79776
Average growth rate	9.88%	12.65%%	11.07%	11.86%

Data source: China Statistical Yearbook.

"Five year plan" is the main economic development plan in China. Nowadays China is in the twelve "five year plan". During the last three "five year plan" the average annual economic growth rate is 9.81%. The growth rate of fixed asset investment is 14.58%. The consumptions of concrete, steel, electrolytic copper and plastics grow rapidly. The high resource consumption is obvious, shown in Table 4-3.

Table 4-3 Main resource consumption

Five year plan	Steel	Electrolytic copper	Plastics	Concrete
	10 thousand ton	10 thousand ton	10 thousand ton	10 thousand ton
The ninth (1996-2000)	55311	1103.3	15710	270893
The tenth (2001-2005)	126283	1991	27871	422011
The tenth / The ninth	2.28	1.8	1.77	1.56
The eleventh (2006-2010)	181593	3094.6	43581	692903
The eleventh / The tenth	1.44	1.55	1.56	1.6
The eleventh / The ninth	3.28	2.8	2.77	2.56

Data source: China Statistical Yearbook.

Table 4-2 shows steel consumption has increased 2.28 times from the ninth "five year plan" to the tenth "five year plan", which is the largest among all resource consumption. And electrolytic copper consumption has increased 1.8 times and plastics consumption has increased 1.77 times. Concrete consumption has increased 1.26 times. Besides, from the tenth "five year plan" to the eleventh "five year plan" the resource consumption also increases rapidly and largely. The rank of resource consumption growth is steel, electrolytic copper, plastics and concrete.

4.2.2 Energy Consumption of China Economic Growth

Energy is the important resource and material in production and living, and is the key factor for building a well-off society. Energy consists of coal, crude oil, natural gas, hydropower, nuclear power and wind power. Table 4-4 shows the base number of China energy consumption is large, and major energy is coal. Coal consumption is 70.6% of energy consumption. Crude oil is the second largest energy and its consumption is 20.1% of energy consumption. The rate of natural gas consumption in energy consumption increases gradually and reaches to 4.3% in 2010. Power consumption rate keeps in 6.7%. Besides, China energy consumption has increasing trend and the average annual growth rate is 6.4%. The growth of China energy consumption is slow from 1995 to 2010, and is fast in 2003 and 2004. After 2004 the growth is also slow.

Table 4-4 China energy consumption structure

Year	Energy consumption		Coal		Crude oil		Natural gas		Power	
	sum	growth	rate	growth	rate	growth	rate	growth	rate	growth
	1,000 ton Coal	%	%	%	%	%	%	%	%	%
1995	131176	6.9	74.6	6.3	17.5	7.5	1.8	1.3	6.1	14.4
1996	135192	3.1	73.5	1.5	18.7	10.1	1.8	3.1	6	1.4
1997	135909	0.5	71.4	-2.3	20.4	9.7	1.8	0.5	6.4	7.2
1998	136184	0.2	70.9	-0.5	20.8	2.2	1.8	0.2	6.5	1.8
1999	140569	3.2	70.6	2.8	21.5	6.7	2.0	14.7	5.9	-6.3
2000	145531	3.5	69.2	1.5	22.2	6.9	2.2	13.9	6.4	12.3
2001	150406	3.3	68.3	2.0	21.8	1.5	2.4	12.7	7.5	21.1
2002	159431	6.0	68	5.5	22.3	8.4	2.4	6.0	7.3	3.2
2003	183792	15.3	69.8	18.3	21.2	9.6	2.5	20.1	6.5	2.6
2004	213456	16.1	69.5	15.6	21.3	16.7	2.5	16.1	6.7	19.7
2005	235997	10.6	70.8	12.6	19.8	2.8	2.6	15.0	6.8	12.2
2006	258676	9.6	71.1	10.1	19.3	6.8	2.9	22.3	6.7	8.0
2007	280508	8.4	71.1	8.4	18.8	5.6	3.3	23.4	6.8	10.1
2008	291448	3.9	70.3	2.7	18.3	1.1	3.7	16.5	7.7	17.7
2009	306647	5.2	70.4	5.4	17.9	2.9	3.9	10.9	7.8	6.6
2010	325000	6.0	69.9	5.3	19.1	12.9	4.3	18.2	6.6	-9.8
Average	201870	6.4	70.6	6.0	20.1	7.0	2.6	12.2	6.7	7.6

Data source: China Statistical Yearbook.

Table 4-5 Global primary energy consumption

Year	World	USA	China	UK	Japan	Germany	France
	Mtoe	%	%	%	%	%	%
2005	108001	21.8	15.7	2.1	4.9	3.1	2.4
2006	11088	21.0	16.8	2.0	4.8	3.1	2.3
2007	11398	20.8	17.5	1.9	4.8	2.8	2.3
2008	11536	20.1	18.0	1.9	4.5	2.8	2.2
2009	11363	19.4	19.3	1.8	4.2	2.7	2.1
2010	12002	19.0	20.3	1.7	4.2	2.7	2.1
Average	11365	20.4	17.9	1.9	4.5	2.9	2.2

Data source: World Bank Development Database.

In table 4-5 USA and China are the two largest countries in primary energy consumption. The percent of USA in the world is 20.4% and rank 1. And the percent of China is 12.9% and rank 2. Also China primary energy consumption increases, but other countries consumptions reduce. Until 2010 China exceeds USA and becomes the largest primary energy consumption country all over the world.

4.3 The Influence of Resource Dependence on China Economic Growth Using Regression Method

The high resource consumption of China economic growth has become a common view. However, we do not understand the resource dependence of China economic growth, resource and environment challenge of China economic growth very well. This section will analyze resource dependence of China economic growth by regression method.

China economic growth depends on adding investment and resource consumption. This is an extensive economic growth pattern. China resource consumptions include 46% steel of the global, 16% energy of the global and 52% concrete of the global. But China GDP is only 8% of the global GDP. Resource consumption exceeds other countries in the same GDP. So research on resource dependence of China economic growth is necessary and important.

4.3.1 Data and Variable

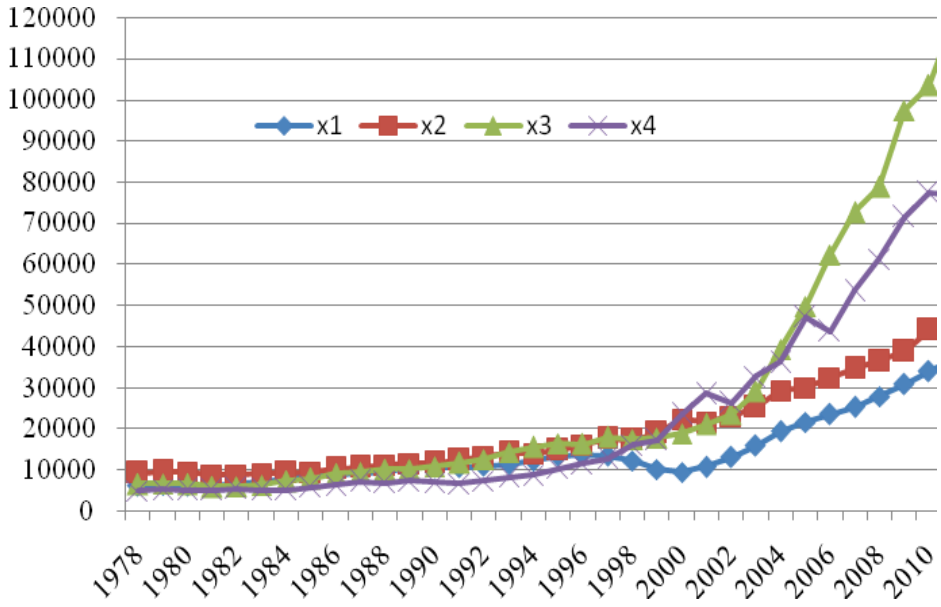
The data in this essay include China GDP and resource consumption, such as raw coal, crude oil, iron ore and refined copper. The data come from China Statistical Yearbook spanning from 1978 to 2011. We set GDP as dependent variable Y, and set the consumptions of raw coal, crude oil, iron ore and refined copper as the independent variables X1~X4.

4.3.2 Resource Dependence of China Economic Growth

The data show the tendency of China resource consumptions of raw coal, crude oil, iron ore and refined copper are increasing, showing in figure 4-4.

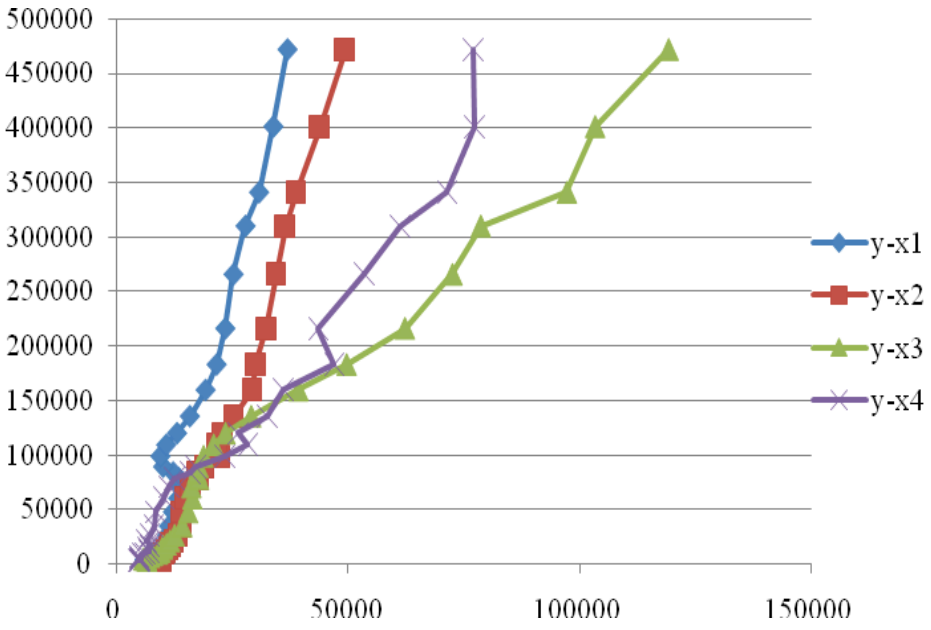
Figure 4-5 is scatter diagram of China economic growth and resource consumption, showing the linear relationship exists. We suppose the model is Y= F(Xi), where i=1,2,3,4.

Figure 4-4 China resource consumption tendency



Data source: China Statistical Yearbook.

Figure 4-5 Scatter diagram of China economic growth and resource consumption



4.3.2.1 Single-variable Regression Results

The single-variable regression results of economic growth and resource consumption are shown in table 4-6.

Table 4-6 The relationship between China economic growth and resource consumption

Y	Variable	Coefficient	Std. Error	t-Statistic	Prob.	R-squared	Test results
Eq1	x_1	1.466158	0.0568	25.81245	0	0.954173	Pass
	c	-105505.6	9268.519	-11.38322	0		
Eq2	x_2	10.89596	0.317562	34.31127	0	0.973538	Pass
	c	-108195.9	7058.282	-15.32892	0		
Eq3	x_3	3.953834	0.106335	37.1828	0	0.977378	Pass
	c	-9920.918	4432.472	-2.238236	0		
Eq4	x_4	5.398817	0.159404	33.86886	0	0.972861	Pass
	c	-18208.1	5028.82	-3.62075	0		

The results show the coefficients are positive and significant, indicating economic growth depends on resource consumption.

4.3.2.2 Multiple-variable Regression Results

According to the results above, the multiple regression equation is shown as follows.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \mu_t \quad t = 1, 2, \cdots, T$$

The estimation results by OLS are shown as follows.

$$y = -0.19x_1 + 6.05x_2 + 2.64x_3 - 0.42x_4 - 53130.49 + \hat{\mu}_t \qquad (4.1)$$

$$t = (-1.32) \quad (5.54) \quad (5.62) \quad (-0.65) \quad (-5.26)$$

$$R^2 = 0.99 \qquad D.W. = 0.97$$

where $\hat{\mu}_t$ is the residual.

In the model the consumptions of raw coal and refined copper do not have significant influences on economic development. This is against economic concept. So the model has specification bias. Besides, the small D.W. indicates the residuals have serial correlation. LM statistic is used to test autocorrelation of residuals. The autocorrelation coefficients, partial autocorrelation coefficients and Q statistics of residual series are shown in the following figure.

Figure 4-6 The residual series correlations in equation 4.1

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.490	0.490	8.9055	0.003
		2	0.216	-0.032	10.688	0.005
		3	0.065	-0.038	10.854	0.013
		4	-0.254	-0.350	13.489	0.009
		5	-0.271	-0.006	16.599	0.005
		6	-0.262	-0.097	19.601	0.003
		7	-0.270	-0.085	22.916	0.002
		8	-0.383	-0.408	29.838	0.000
		9	-0.272	-0.016	33.448	0.000
		10	-0.272	-0.320	37.212	0.000
		11	-0.166	-0.013	38.682	0.000
		12	0.153	-0.007	39.985	0.000
		13	0.295	0.139	45.070	0.000
		14	0.292	-0.239	50.275	0.000
		15	0.202	-0.145	52.891	0.000
		16	0.144	-0.125	54.302	0.000

The figure above shows the autocorrelation coefficient and partial autocorrelation coefficient of order 1 exceed the dotted lines, indicating 1 order serial correlation exists. So the estimation results are not effective, and the serial correlation should be amended. AR(1) model is used to correct the autocorrelation of residual series. The AR(1) model is shown as follows.

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \mu_t, \quad t = 1, 2, \cdots, T$$

$$\mu_t = \phi \mu_{t-1} + \varepsilon_t$$

The regression results are as follows.

$$y = 0.22x_1 + 5.53x_2 + 1.29x_3 - 0.42x_4 - 80952.89 + \hat{\mu}_t \quad (4.2)$$

t = (1.07) (4.27) (2.26) (0.84) (-3.93)

$$\hat{\mu}_t = 0.78\hat{\mu}_{t-1} + \hat{\varepsilon}_t$$

t = (4.92)

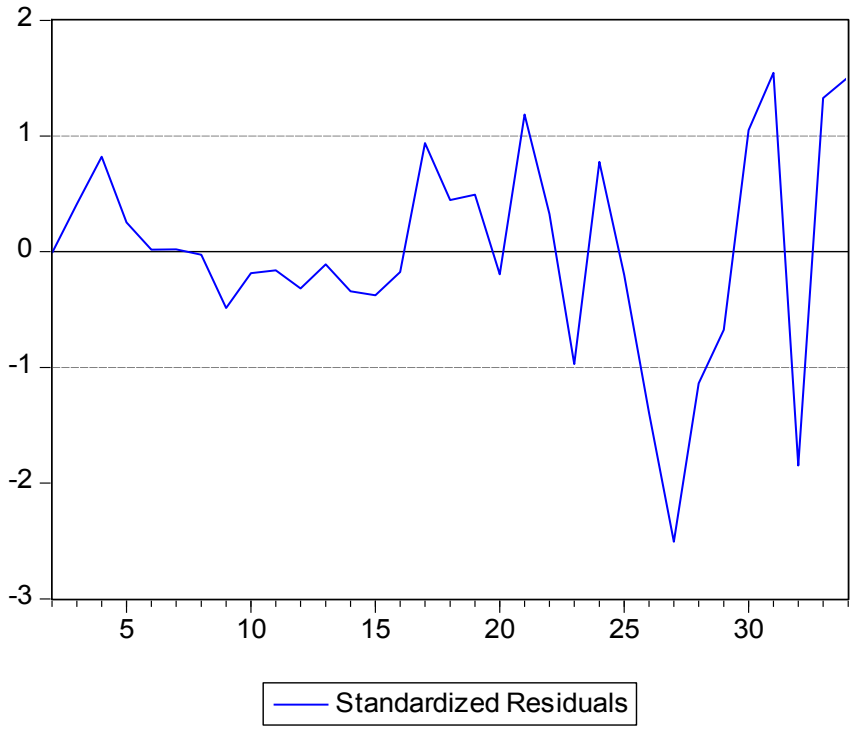
$R^2 = 0.996$ $D.W. = 1.52$ AIC =21.17 SC =21.44

Using LM test to new residual series $\hat{\varepsilon}_t$ (p=2), the results is shown as follows.

F-statistic	1.341720	Prob. F(2,25)	0.2796
Obs*R-squared	3.198790	Prob. Chi-Square(2)	0.2020

The test results can not reject null hypothesis, showing the serial correlation of new residual series does not exist. AR(1) model is effective. The new residuals are shown in the following figure. The volatility clustering exists. That is to say the large volatility follows the large volatility and the small volatility follows the small volatility. So the heteroscedasticity exists.

Figure 4-7 The residual series of GDP equation

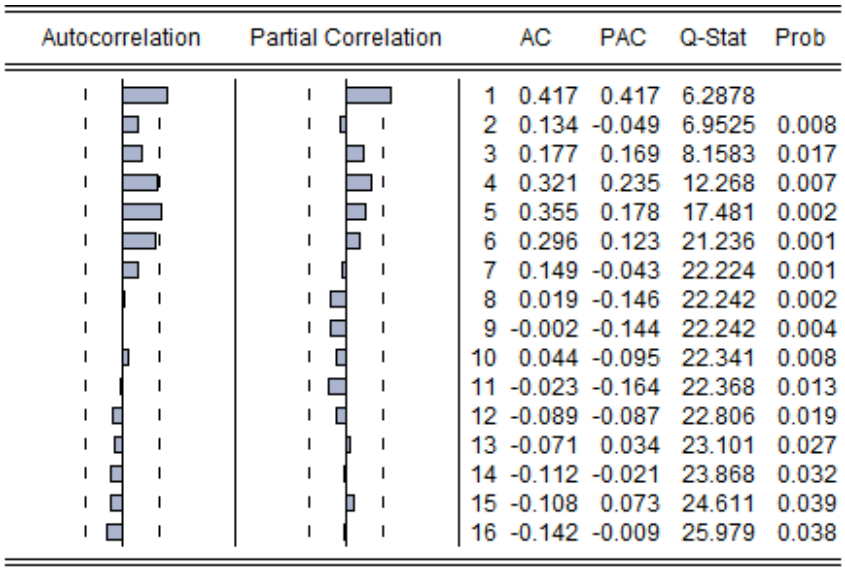


Using ARCH LM test for conditional heteroscedasticity and lag order 3, the results are shown in the following table.

F-statistic	3.101467	Prob. F(3,24)	0.0456
Obs*R-squared	9.219359	Prob. Chi-Square(3)	0.0265

The results reject null hypothesis, indicating the ARCH effect exists in equation 4.2. Also the autocorrelation coefficients and partial autocorrelation coefficients of residual squared are shown in the following figure.

Figure 4-8 The correlation of residual squared series in equation 4.2



Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.417	0.417	6.2878	
		2	0.134	-0.049	6.9525	0.008
		3	0.177	0.169	8.1583	0.017
		4	0.321	0.235	12.268	0.007
		5	0.355	0.178	17.481	0.002
		6	0.296	0.123	21.236	0.001
		7	0.149	-0.043	22.224	0.001
		8	0.019	-0.146	22.242	0.002
		9	-0.002	-0.144	22.242	0.004
		10	0.044	-0.095	22.341	0.008
		11	-0.023	-0.164	22.368	0.013
		12	-0.089	-0.087	22.806	0.019
		13	-0.071	0.034	23.101	0.027
		14	-0.112	-0.021	23.868	0.032
		15	-0.108	0.073	24.611	0.039
		16	-0.142	-0.009	25.979	0.038

The results show the autocorrelation coefficients and partial autocorrelation coefficients are not equal to zero, and Q statistics are significant. So the residual series have conditional heteroscedasticity. ARCH model or GARCH model is suitable.

Using GARCH(1,1) model to reestimate equation 4.2, the results are shown as follows.

Mean equation: $y = 0.15x_1 + 4.65x_2 + 1.38x_3 + 0.73x_4 - 52426.78 + [\mathrm{AR}(1)=0.91]$ (4.3)

z = (0.93) (2.27) (2.66) (2.69) (-1.13) (7.41)

Variance equation: $GARCH = 66724231.78 + 0.56RESID(-1)\wedge 2 - 0.61GARCH(-1)$ (4.4)

z = (1.66) (1.15) (-1.3)

$R^2 = 0.995$ $D.W. = 1.55$ AIC =20.95 SC =21.35

In GARCH(1,1) model, AIC and SC are smaller, indicating GARCH model fits the data more properly. Also Using ARCH LM test for conditional heteroscedasticity and lag order 1, the results of the residual series in equation 4.3 are shown in the following table.

F-statistic	0.470657	Prob. F(1,31)	0.4978
Obs*R-squared	0.493529	Prob. Chi-Square(1)	0.4824

The results can not reject null hypothesis, indicating the ARCH effect does not exist. So GARCH(1,1) model eliminates the conditional heteroscedasticity of residual series in equation 4.1 and 4.2.

4.3.3 Regression Results Analysis

The resource dependence of China economic growth is very high. With population growth, economic development and the improvement of life quality, the demand of non-renewable resources will grow largely. The non-renewable resources, such as raw coal, crude oil, iron ore and refined copper, will be consumed quickly and face the risk of dried up. Also environment pollution brought by resource production and usage will severe.

The regression results show the consumptions of crude oil, iron ore and refined copper have significant positive effects on China economic growth. And the lagged economic growth has positive influence on current economic growth. So economic growth is a accumulated process. We should solve the problem of sustainable utilization of non-renewable resources and environment pollution control. This is very important to China economic sustainable development.

Chapter 5: Resource and Environment Challenge of China Economic Growth

Resource crisis and ecological crisis are two serious consequences of China economic development with high resource consumption. The secondary industry is the main part in China economy. During more than 30 years since reform and opening up, China has become global manufacturing center. High energy consumption industry is the major in China industry. So resource constraint and environment constraint are very severe to China economic growth. During the eleventh "'five year plan" the average annual growth rates are 12.4% for steel output, 11.5% for concrete output and 17.1% for non-ferrous metal output. Energy consumption of industry is 70% of the whole energy consumption and the high energy consumption industry is the major.

This chapter focuses on analyzing the resource and environment challenge of China economic growth with high resource consumption. Firstly, the correlation between GDP and resource consumption is test and it can be used to forecast the resource demand of China economic growth. Secondly, resource challenge is analyzed based on the relationship between economic growth and resource demand. Finally, environment challenge of China economic growth is shown by analyzing the relationship between resource consumption and industrial waste.

5.1 Empirical Analysis of the Relationship between Resource Consumption and Economic Growth

The data in this essay include China GDP and resource consumption, such as raw coal, crude oil, iron ore and refined copper. The data come from China Statistical Yearbook spanning from 1978 to 2011. We set GDP as independent variable, and set the consumptions of raw coal, crude oil, iron ore and refined copper as the dependent variables Y1~Y4. The regression results are as follows using Eviews 6.0.

(1) Raw coal consumption and GDP

$$y_1 = 0.56GDP + 87952 + [AR(1) = 1.87, AR(2) = -1.39, AR(3) = 0.38]$$

se =(0.05)(11625)(0.19) (0.31) (0.18)

t=(10.55)(7.57)(10.07) (-4.50) (2.04) $R^2 = 0.996$ $D.W.$=1.86

In the line of "se" the number is standard error of regression coefficient. In the line of "t" the number is t statistic under the null hypothesis of regression parameter zero. Coefficient of determination R^2 measures goodness of fit. AR(p) p=1,2,3 indicates the lagged order is p in residual series.

The coefficient 0.56 indicates if GDP increases 0.1 billon Yuan, average raw coal consumption will increase 0.056 billion tons. The coefficient 87952 indicates the average influences of other factors on y. R^2=0.99 is to say GDP can explain 99.6% changes of raw coal consumption. $D.W.$=1.86 shows autocorrelation does not exist.

(2) Crude oil consumption and GDP

$y_2 = 0.074GDP + 14666 + [AR(1) = 0.94]$

se=(0.01) (8024) (0.09)

t=(7.27) (1.83) (10.15) $R^2 = 0.994$ $D.W.$=1.90

(3) Iron ore consumption and GDP

$y_3 = 0.24GDP + 3271 + [AR(1) = 0.78]$

se=(0.013)(3206) (0.11)

t=(18.34)(1.02) (6.88) $R^2 = 0.991$ $D.W.$=2.21

(4) Refined copper consumption and GDP

$y_4 = 7072 + 0.15GDP + [AR(1) = 0.79]$

se=(5206)(0.03) (0.21)

t=(1.36)(5.62) (3.85) $R^2 = 0.98$ $D.W.$=1.92

The positive relationship exists between economic growth and resource consumption. Economic growth leads to resource consumption increasing. The influence of GDP growth on raw coal consumption is the largest and the coefficient is 0.56. The following is iron ore consumption.

Resource demand depends on China economic growth, economic structure, energy policy and energy technology, and so on. In 1980 Deng Xiaoping designed the "three step" strategy and goal for China reform and opening up. Until 2000 the problem of food and clothing is solved in the countrywide and GDP reaches the four times of GDP in 1980. Until

2020 the well-to-do society is realized in China and GDP reaches the four times of GDP in 2000. Until 2050 the modernization is realized in China and China economy reaches moderately developed country.

According to the “three step” strategy and goal, China government designs the aim for the future ten years in 2010. GDP in 2020 reaches the two times of GDP in 2010. China economic development will adopt promoting industrialization with informationization and following the way of Chinese characteristics industrialization. Therefore we assume there are three states of 2020 China gross industrial production, named as low, middle and high. The three states are 1.5 times, 2 times and 3 times of 2010 China gross industrial production. The assumptions are as follows. (1) China economic structure and energy technology do not have significant change in the future ten years. (2) There are low, middle and high states of 2020 China GDP, which are 1.5 times, 2 times and 3 times of 2010 China GDP.

We forecast the resource demand in 2020 in table 5-1 as follows. Considering GDP in 2020 is two times of GDP in 2010, the resource demand of raw coal, crude oil, iron ore and refined copper are shown in table 5-2. When GDP reaches two times of 2010 GDP, capital and resource demand also reach two times of 2010 level.

Table 5-1 China resource demand forecast

State	GDP	Raw coal	Crude oil	Iron ore	Refined copper
	0.1 Billion Yuan	10 thousand ton	10 thousand ton	10 thousand ton	10 thousand ton
Low	596975	424018	57897	148630	973
Middle	795966	536048	72594	197082	1274
High	1193949	760102	101943	293987	1875

Table 5-2 China capital and resource demand

	GDP	capital	coal	crude oil	concrete	electric power	steel	electrolytic copper
	0.1 Billion Yuan	0.1 Billion Yuan	0.1 Billion Ton	10 thousand ton	10 thousand ton	0.1 Billion degree	10 thousand ton	10 thousand ton
1990	18548	4517	10.8	16400	2.10	6212	5153	79.4
2000	99215	32918	13.0	23200	5.97	13556	13143	276
2010	397983	278140	32.4	42900	18.80	42065	79776	908.5
2020	795966	650000	59.0	84892	35.59	83171	171017	1764
2020/2010	200%	233.7%	182.1%	197.9%	189.4%	197.7%	214.4%	194.2%

5.1.1 Constraint from Crude Oil

Crude oil consumption is 0.164 billion tons in 1990, 0.429 billion tons in 2010, and 8.49 billion tons in 2020 forecast. And China crude oil product increases 23.93% from 2000 to 2010. China has the fourth largest oil producing country following Saudi Arabia, Russia and USA. However, China crude oil consumption increases with higher speed than crude oil production increasing. So the gap is huge. China crude oil relies on global markets (see table 5-3).

Table 5-3 China crude oil dependence

	Output	consumption	Net import	Net import expend	dependence
	0.1 Billion Ton	0.1 Billion Ton	0.1 Billion Ton	0.1 Billion dollar	%
2000	1.63	2.32	0.60	148.6	35.19
2001	1.65	2.15	0.53	116.7	33.12
2002	1.67	2.36	0.63	127.6	34.92
2003	1.70	2.66	0.83	198.1	41.19
2004	1.75	3.00	1.17	339.1	47.86
2005	1.82	3.18	1.19	477.2	46.58
2006	1.84	3.47	1.39	664.1	49.71
2007	1.86	3.46	1.59	797.7	51.34
2008	1.90	3.9	1.75	1293.4	53.44
2009	1.89	4.00	1.99	892.6	56.04
2010	2.02	4.49	2.36	1351.5	57.64

Table 5-3 shows China crude oil import increases 4 times and import expend increases 9 times from 2000 to 2010. The dependence of China economic growth to import crude oil increases from 35.2% in 2000 to 56.7% in 2010. Until 2020 China will become the first largest country of crude oil import and exceeds USA. The dependence will be 76%. So China economic growth faces with the constraint of crude oil.

5.1.2 Constraint from Iron Ore

China is a big country in steel production. China steel product increases 2.55 times from 1990 to 2000, 6.09 times from 2000 to 2010, 2.14 times from 2010 to 2020 forecasting. China steel productions are from 0.126 billion tons in 2000 to 0.627 billion tons in 2010 and the growth rate is 397.62%. In the same time global steel productions are from 0.847 billion tons

in 2000 to 1.414 billion tons in 2010 and the growth rate is 66.94%. The ratios of China steel production in global steel production are from 14.88% in 2000 to 44.34% in 2010.

Besides, China is a big country in steel consumption. However, the iron ore is serious short in China. Therefore, China steel industry depends on iron ore import. In 2000 China iron ore import is less than 70 million tons. In 2010 China iron ore import is near 0.62 billion tons. The import expands are from 1.858 billion dollar in 2000 to 79.4 billion dollar in 2010 and the growth rate is 42.57 times. The dependences of China steel industry on global iron ore are from 31.38% in 2000 to 67.82% in 2010. The details are shown in table 5-4. If China steel demand reaches 1.7 billion tons in 2020, China steel industry and economic development will face the constraint from iron ore. The non-ferrous metal industry, such as copper industry, also faces the constraint from resource. The details are shown in table 5-5.

At the same time, steel industry is also the industry with high energy consumption and high pollution. Steel industry also fact energy and environment challenge.

Table 5-4 China steel industry dependence

Year	Global steel production	China steel production	China / Global	China rolled steel production	Iron ore import	Iron ore import expend	dependence
	0.1 billon tons	0.1 billion tons	%	0.1 billion tons	10 thousand tons	0.1 billion dollar	%
2000	8.47	1.26	14.88	1.31	6997	18.58	31.38
2001	8.24	1.41	17.11	1.57	9231	25.03	42.54
2002	9.02	1.82	20.18	1.92	11149	27.69	48.26
2003	9.45	2.22	23.49	2.41	14813	48.57	56.54
2004	10.55	2.72	25.78	2.97	20808	126.99	67.34
2005	11.29	3.49	30.91	3.97	27526	183.73	65.54
2006	12.39	4.18	33.74	4.73	32629	209.13	56.45
2007	13.44	4.89	36.38	5.69	38309	337.96	56.17
2008	13.30	5.00	37.59	5.82	44356	605	53.83
2009	12.20	5.68	46.56	6.96	63000	504.1	71.59
2010	14.14	6.27	44.34	7.98	61865	794.3	67.82

Table 5-5 China copper industry dependence

	Copper mine import		Copper import		China copper production	China copper consumption	Dependence
	amount	expend	amount	expend			
	10 thousand tons	0.1 billion dollar	10 thousand tons	0.1 billion dollar	10 thousand tons	10 thousand tons	%
2000	181	8.06	405	45.10	137	276	49.66
2001	226	8.98	503	47.50	152	298	51.07
2002	207	8.09	750	43.10	163	337	48.4
2003	267	12.89	645	98.72	184	385	47.75
2004	287	22.38	645	98.72	209	447	46.8
2005	406	37.07	736	125.07	253	507	49.99
2006	361	61.17	700	164.60	293	499	58.65
2007	452	88.16	836	260.61	344	622	55.33
2008	519	104.40	822	251.97	371	635	58.45
2009	613	88.11	828	287.61	425	854	49.78
2010	647	126.79	865	449.73	479	909	52.76

5.1.3 Constraint from Energy

China economic development is along with high energy consumption. Table 5-6 shows the ratios of China GDP and primary energy in the world. China GDP is 3.56% of global GDP in 1999 and the ratio reaches 9.65% in 2010. On the other hand, the ratios of China primary energy consumption in global primary energy consumption are from 8.1% in 1999 to 20.26% in 2010. Table 5-6 also suggest China primary energy consumption ratio is smaller than China GDP ratio, indicating China energy efficiency is low and should be improved.

Table 5-6 China GDP ration and primary energy consumption ratio in the world (%)

	1999	2000	2001	2002	2003	2004
GDP ratio	3.56	3.40	3.71	3.77	3.72	4.67
Primary energy consumption ratio	8.10	10.42	10.70	11.10	12.50	13.83
	2005	2006	2007	2008	2009	2010
GDP ratio	4.96	5.13	5.54	6.95	8.84	9.65
Primary energy consumption ratio	15.66	16.76	17.52	18.03	19.25	20.26

Taking electric power as an example, the average annual growth rate of China electric power consumption is 9.13% from 1978 to 2010. The electric power consumption elasticity is 0.92 with respect to 0.2 to 0.3 in developed country. High energy consumption character is obvious in China economic growth.

Table 5-7 Electric power consumption

	Global power industry		China power industry			
	installed capacity	generated energy	installed capacity	generated energy	installed capacity ratio	generated energy ratio
	10 thousand KW	10 thousand KWH	10 thousand KW	10 thousand KWH	%	%
2000	337281	165484	31932	13556	9.47	8.19
2001	353798	148326	33849	14706	9.57	9.91
2002	374867	157655	35300	16530	9.42	10.48
2003	387722	166931	38500	18844	9.93	11.29
2004	403141	175635	44280	21939	10.98	12.49
2005	370856	183388	50841	24747	13.71	13.49
2006	436867	190560	62200	28344	14.24	14.87
2007	459628	199432	72209	32777	15.71	16.44
2008	469802.2	203420	79295	34047	16.88	16.74
2009	489360.1	201355	87407	37147	17.86	18.45
2010	495467.6	213251	96219	42065	19.42	19.73

Until 2020 China electric power consumption will reach 8.32 trillion KWH and China installed capacity will exceed 1.9 billion KW.

In China power structure fire coal generator is 75.3% and fire coal generator installed capacity is 1.4 billion KW. The addition of fire coal generator increases coal consumption. Coal consumption is 1.556 billion tons in 2009, 1.7 billion tons in 2010. And we forecast coal consumption is 3.5 to 4 billion tons.

Therefore, resource and environment crisis forms due to electric power consumption increasing. Generated energy increasing affects installed capacity increasing and coal consumption increases rapidly. Resource crisis appears due to coal exploration and consumption. Also waste causes environment crisis.

The resource dependence of China economic development is more obvious in 2011. Table 5-8 shows China iron ore import, crude oil import and refined oil import increases

rapidly in first half year of 2011. The growing rates of import expand are 54.00%, 42.50% and 49.10%.

Table 5-8 China resource import

	Iron ore		Crude oil		Refined oil	
	amount	expand	amount	expand	amount	expand
	10 thousand tons	10 thousand dollar	10 thousand tons	10 thousand dollar	10 thousand tons	10 thousand dollar
2011.1~6	33425	5377660	12621	9513666	2102	1638785
2010.1~6	30920	3491987	11795	6676257	1854	1099118
Growth rate	8.10%	54.00%	7.00%	42.50%	13.38%	49.10%

5.2 Energy Challenge of China Economic Growth

5.2.1 China Economic Structure

In order to analyze China economic structure we firstly compare the GDP structure in global countries. The results are shown in table 5-9. The table shows China has the largest Secondary Industry as percentage of GDP and the smallest Tertiary Industry as percentage of GDP in 2000 to 2009.

Table 5-9 GDP structure

Country or Area	Primary Industry as Percentage of GDP		Secondary Industry as Percentage of GDP		Tertiary Industry as Percentage of GDP	
	2000	2009	2000	2009	2000	2009
World	3.6	2.9②	29.1	27.5②	67.2	69.4②
High Income	1.9	1.5②	27.9	25.6②	70	72.7②
OECD Countries	1.9	1.5②	27.7	25.3②	70.3	73.0②
High Income: nonOECD	2.1	1.5②	35.1	33.9②	62.8	64.7②
Middle Income	11.3	10	35.6	36.4	53.1	53.8
Upper Middle Income	6.5	6.4	32.2	33	61.3	61
Lower Middle Income	17.1	13.2	39.5	39.4	43.4	47.4
Low and Middle Income	12	10.5	35.1	36.1	52.9	53.6
Low Income	34.5	26.9①	21	26.2①	44.5	46.9①
Least Developed Countries	32.8	24.7①	23.9	29.4①	43.3	45.9①
China	15.1	10.4	45.9	46.3	39	43

Note: ①Data refer to 2008. ②Data refer to 2007.

The resource and environment challenge reflects China specific conditions. Table 2-10 shows China economic structure and power consumption. During 1980 to 2010 China gross industrial output is 40.01% of GDP and power consumption is 75.86% of total power consumption. High energy consumption of China economic growth is related to China economic structure. In China industrial structure heavy industry is the majority. The percents of heavy industry in total industry are 52.85% in 1978 and 70.00% in 2010. And the average is 58.96%. Heavy industry has high energy consumption and high pollute. The power consumption is 80% of industry power consumption.

Table 5-10 China economic structure and power consumption

	GDP	Total power	Industry rate		Industry structure		Industry power structure	
	0.1 billion Yuan	0.1 billion KWH	addition	power	light	heavy	light	heavy
1980	4546	3006	43.93%	82.23%	47.15%	52.85%	18.20%	81.80%
1985	7208	4118	38.25%	79.74%	47.08%	52.91%	19.97%	80.03%
1986	10275	4507	38.61%	80.96%	47.61%	52.39%	20.01%	80.00%
1987	12059	4985	38.03%	80.36%	48.19%	51.81%	20.47%	79.53%
1988	15043	5467	38.41%	79.84%	49.27%	50.73%	21.32%	78.68%
1989	16992	5865	38.16%	79.22%	48.88%	51.12%	20.48%	79.52%
1990	18668	6230	36.74%	78.22%	49.38%	50.62%	20.43%	79.57%
1991	21781	6804	37.13%	77.31%	48.40%	51.60%	20.90%	79.08%
1992	26923	7589	38.20%	76.82%	46.60%	53.40%	20.41%	79.58%
1993	35334	8300	40.15%	75.66%	46.50%	53.50%	20.06%	79.94%
1994	48198	9260	40.42%	75.41%	46.30%	53.70%	19.33%	80.67%
1995	60794	10023	41.04%	76.42%	42.75%	57.25%	18.93%	81.07%
1996	71177	10764	41.37%	74.74%	43.03%	54.21%	18.52%	81.48%
1997	78973	11284	41.69%	74.40%	42.74%	57.26%	18.58%	81.42%
1998	84402	11598	40.31%	72.47%	42.93%	57.07%	19.63%	80.37%
1999	89677	12092	39.99%	73.05%	41.97%	58.03%	19.65%	78.67%
2000	99215	13466	40.35%	74.30%	39.80%	60.20%	20.10%	76.39%
2001	109655	14683	39.74%	71.14%	39.43%	60.57%	21.17%	79.26%
2002	120333	16200	39.42%	72.80%	39.14%	60.86%	21.37%	77.59%
2003	135823	18894	40.45%	73.57%	35.49%	64.51%	20.74%	77.95%
2004	159878	21762	40.79%	74.69%	33.47%	66.53%	21.03%	77.64%
2005	183217	24849	41.76%	74.54%	32.63%	67.37%	19.92%	77.57%
2006	211924	28367	42.21%	74.90%	29.93%	70.07%	19.30%	80.47%
2007	257306	32458	41.58%	75.89%	29.53%	70.47%	18.28%	81.46%
2008	314045	34381	41.48%	73.84%	28.66%	71.34%	18.00%	82.73%
2009	340903	36430	39.72%	72.06%	29.45%	70.55%	17.59%	83.99%
2010	400507	42065	40.21%	73.68%	29.13%	71.00%	16.79%	83.20%

Data source: China Statistical Yearbook.

5.2.2 High Energy Consumption Industry

We select mining, ferrous metal smelt and processing industry, chemistry manufacturing industry, non-ferrous metal smelt and processing industry, oil refining industry, power-gas-water product and supply industry and nonmetallic mineral industry, named as seven largest high energy consumption industries, to analyze high energy consumption situation in China economic growth. Table 5-11 shows the gross industrial output rate and power consumption rate of the seven largest industries. The average industrial output rate to GDP is 13.82% during 1995 to 2010. And the power consumption rate is 53.29%.

Table 5-11 Industrial output rate and and power consumption rate of seven largest industries (%)

	1995	1996	1997	1998	1999	2000	2001	2002
Industrial output rate	9.83	10.55	10.35	9.31	9.79	10.7	10.57	10.87
power consumption rate	55.65	55.49	54.86	52.52	52.8	52.04	52.28	52.01
	2003	2004	2005	2006	2007	2008	2009	2010
Industrial output rate	12.42	16.27	17.16	18.73	19.89	18.84	18.34	17.44
power consumption rate	53.07	53.45	53.89	53.2	54.41	52.54	52.15	52.23

Data source: China Statistical Yearbook.

5.2.3 Economic Growth and Energy Consumption

5.2.3.1 Data and Variable

The data include China gross industrial output and the energy consumption of mining, ferrous metal smelt and processing industry, chemistry manufacturing industry, non-ferrous metal smelt and processing industry, oil refining industry, power-gas-water product and supply industry and nonmetallic mineral industry spanning 1995 to 2009. The data come from China Statistical Yearbook. We set gross industrial output as the dependent variable Y, and energy consumption of the seven largest industries as the independent variables X1 to X7.

5.2.3.2 Regression Analysis of China Industrial Economic Growth and Seven Largest Industries Energy Consumption

The energy consumption of seven largest industries appears the increasing tendency. And the energy consumption of ferrous metal smelt and processing industry is the most.

Figure 5-1 Energy consumption tendency of seven largest industries

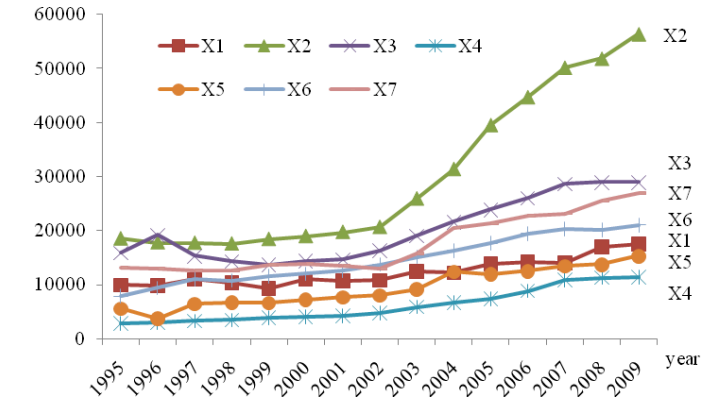


Figure 5-2 China industrial economic growth and energy consumption

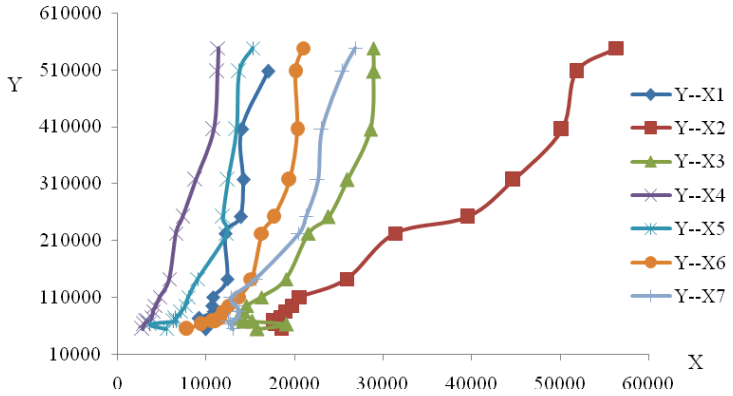


Figure 5-2 shows the positive relationship exists between China industrial economic growth and energy consumption.

Table 5-12 shows the correlation between China industrial economic growth and energy consumption. The correlation is more than 0.9266, positively and significantly.

Table 5-12 The correlation between China industrial economic growth and energy consumption

Correlation	Y	X1	X2	X3	X4	X5	X6	X7
Y	1							
X1	0.96914	1						
X2	0.983306	0.956071	1					
X3	0.945651	0.91669	0.970983	1				
X4	0.982903	0.949187	0.987176	0.950399	1			
X5	0.928192	0.916526	0.942674	0.879133	0.954063	1		
X6	0.926624	0.915203	0.948438	0.902808	0.97028	0.970762	1	
X7	0.970699	0.94809	0.985343	0.957938	0.968913	0.95691	0.941014	1

Considering the linear relationship between China industrial economic growth and energy consumption, we build the model Y=F(Xi). The results of single-variable regression are shown as follows.

Table 5-13 The relationship between China industrial economic growth and energy consumption

Y	Variable	Coefficient	Std. Error	t-Statistic	Prob.	R-squared	Results
eq1	X1	63.89468	4.507594	14.1749	0	0.939232	Pass
	C	-585171.8	56564.02	-10.3453	0		
eq2	X2	11.4739	0.588879	19.48432	0	0.966891	Pass
	C	-142967.6	19477.37	-7.34019	0		
eq3	X3	27.41392	2.614555	10.48512	0	0.894255	Pass
	C	-348213.7	54398.26	-6.401192	0		
eq4	X4	53.34978	2.771793	19.24739	0	0.966098	Pass
	C	-126690.5	18952.94	-6.684477	0		
eq5	X5	44.18702	4.912997	8.993904	0	0.861541	Pass
	C	-212319.8	48934.65	-4.338843	0.0008		
eq6	X6	36.34296	4.089966	8.885884	0	0.858633	Pass
	C	-330033.9	62124.74	-5.312438	0.0001		
eq7	X7	30.94712	2.124774	14.5649	0	0.942257	Pass
	C	-335759.4	38417.15	-8.739831	0		

The coefficients in the equations above are positive, indicating energy consumption growth promotes economic growth. The function rank is mining, non-ferrous metal smelt and processing industry, oil refining industry, power-gas-water product and supply industry, nonmetallic mineral industry, chemistry manufacturing industry and ferrous metal smelt and processing industry.

The energy consumption of ferrous metal smelt and processing industry is the highest, but the function is smallest. The energy consumption of chemistry manufacturing industry is rank 2, but the function is rank 6. The energy consumption of nonmetallic mineral industry is rank 3, but the function is rank 5. This indicates the energy utilization efficiency is low.

5.2.4 Energy Consumption and Economic Growth

In order to forecast the future energy consumption, we set China industrial energy consumption as dependent variable Y and the energy consumptions of mining, nonmetallic mineral industry, ferrous metal smelt and processing industry, power-gas-water product and

supply industry as Y1-Y4, and set gross industrial output as independent variable X and the industrial outputs of mining, nonmetallic mineral industry, ferrous metal smelt and processing industry, power-gas-water product and supply industry as X1-X4. The regression results are as follows.

(1) Industrial energy consumption and gross industrial output

y= 0.253339194774x + 86795.1957477

se=(0.01) (3940.130)

t=(18.92) (22.03) R^2=0.962

(2) mining energy consumption and its gross industrial output

y_1= 0.233623646151x_1 + 9507.63397433

se=(0.01) (283.8)

t=(17.56) (39.80) R^2=0.957

(3) nonmetallic mineral industry energy consumption and its gross industrial output

y_2= 0.656783128883x_2 + 11625.7623525

se=(0.56) (710.4)

t=(11.78) (16.37) R^2=0.908

(4) ferrous metal smelt and processing industry energy consumption and its gross industrial output

y_3= 0.9503100474x_3 + 15210.8933242

se=(0.04) (977.78)

t=(23.08) (15.57) R^2=0.974

(5) power-gas-water product and supply industry energy consumption and its gross industrial output

y_4= 0.116766519996x_4 + 1688.25638563

se=(0.03) (574.21)

t=(11.12) (17.83) R^2=0.898

The results above suggest the influence of economic growth on energy consumption is positive and significant. The more economic growth, the more energy consumption. According the results, the energy demand forecast is as follows.

Table 5-14 Energy demand forecast

situation	Industry		mining		nonmetallic mineral industry		ferrous metal smelt and processing industry		power-gas-water product and supply industry	
	output	Energy	output	Energy	output	Energy	output	Energy	output	Energy
2008	507448	209302	336610	17050	20944	25401	20949	51863	30061	20145
Low	925024	321140	57070	22841	43418	40143	73367	84932	55834	29815
Middle	1233366	399255	76093	27285	57891	49647	97823	108173	74445	36340
high	1850049	555458	114140	36173	86836	68658	146734	154654	111667	49390

Following the middle situation that is gross industrial output in 2020 is double gross industrial output in 2010, China energy consumption in 2020 is double energy consumption in 2008. Under the energy constraint the energy demand can not be reached. So energy challenge of China economic growth is huge and serious.

5.3 Environment Challenge of China Economic Growth

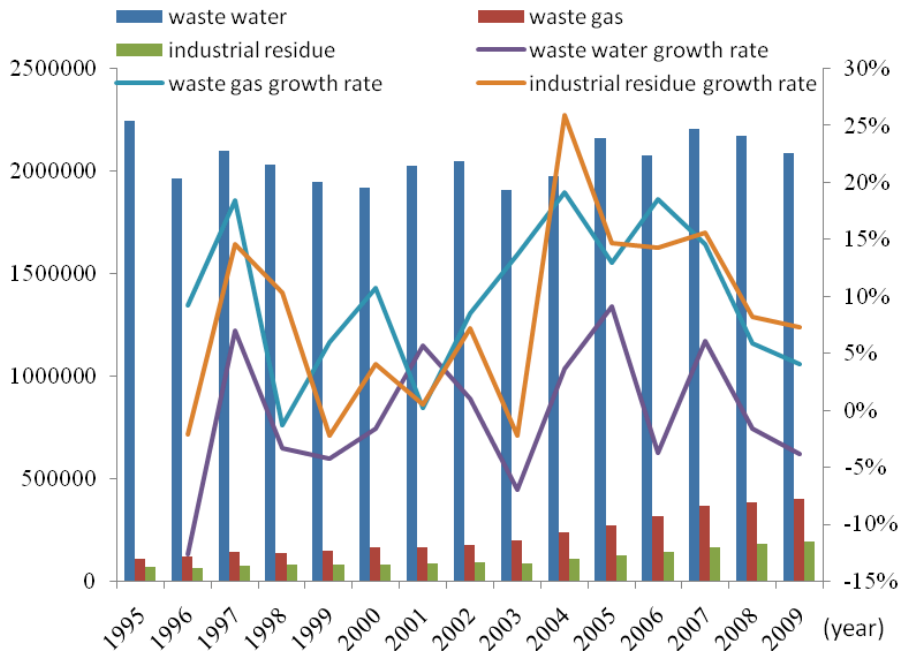
5.3.1 Environmental Pollution with China Economic Growth

Environmental pollution goes along with industrialization. Before 1950s China industrialization does not start and environmental pollution is little. After 1950s heavy industries develop rapidly and environmental pollution increases. The polluted scope is city and the damage is limited. Until 1980s China environmental pollution aggravates and expands to rural area along with reform and opening up. Nowadays environmental pollution is serious in China.

The resource and environment problems are highlighted and sustainable development faces serious challenge. During the ninth “five year plan” the waste water emissions are 37.3 billion tons in 1995, 41.52 billion tons in 2000. The sulfur dioxide emission in 2000 is 19.951 million tons and more 1.041 million tons than 1995. Industrial sulfur dioxide emission in 2000 is 16.125 million tons and is 11.48 times of the one in 1995. Industrial smoke emission, dust emission and solid waste in 2000 are 9.553, 10.92, 816.077 million tons and are 113.8%, 170.9%, 126.6% of the ones in 1995.

In 2005 the waste water emission is 52.45 billion tons and is 126.3% of the one in 2000. Industrial waste water emission in 2005 is 125.2% of the one in 2000. Living waste water emission is 127.4% of the one in 2000. The sulfur dioxide emission in 2005 reaches 25.493 million tons. And industrial solid waste emission is 1.34 billion tons and is 164.2% of the one in 2000.

Figure 5-3 Industrial pollution from 1995 to 2009



Data source: China Statistical Yearbook.

Considering industrial pollution is serious, we select the three wastes (waste gas, waste water and industrial residue) data to analyze industrial pollution. Figure 5-3 shows gross industrial waste water emission is about 20 billion tons, and waste gas and industrial residue increases every year.

5.3.2 China Environmental Pollution Control

Controlling serious environmental pollution needs lots of investment. The industrial pollution control investment in 2005 is 45.82 billion Yuan, and is 191.4% of the one in 2000. Gross environment pollution control investment is 238.8 billion Yuan in 2005 and this is 1.31% of GDP. Gross environment pollution control investment is 338.76 billion Yuan in 2007 and this is 1.36% of GDP. In 2009 gross environment pollution control investment is 452.5 billion Yuan and is 189.5% of the one in 2005. The rates of environmental pollution control investment in GDP are 1.30% in 2005, 1.33% in 2009. Until the end of 2009, there are

77,018 waste water control facilities, 176,489 waste gas control facilities and 26,995 desulfuration facilities. Gross industrial sulfur dioxide removal is 28.9 million tons and is 1.7 times of the one in 2005. Industrial smoke removal is 328.48 million tons and is 159.6% of the one in 2005. In 2009 gross industrial waste water emission qualification rate is 94.2% and is 3% more than the one in 2005. Ammonia Nitrogen removal in industrial waste water is 0.641 million tons and is 132.6% of the one in 2005. Industrial sulfur dioxide emission qualification rate is 91.0% and is 11.6% more than the one in 2005. Industrial smoke emission qualification rate is 90.3% and dust emission qualification rate is 89.9%. The three wastes comprehensive utilization production value is 160.82 billion Yuan and is 2.1 times of the one in 2005.

Table 5-15 Industrial environmental pollution control

year	industrial added value (0.1 billion Yuan)	GDP (0.1 billion Yuan)	Industrial added value/ GDP (%)	Industrial pollution control investment (0.1 billion Yuan)	Environmental pollution control investment (0.1 billion Yuan)	Industrial / Environmental (%)
1995	24950.6	60793.7	41	--	98.7	--
1996	29447.6	71176.6	41.4	--	--	--
1997	32921.4	78973	41.7	--	502.4	--
1998	34018.4	84402.3	40.3	--	--	--
1999	35861.5	89677.1	40	--	152.7	--
2000	40033.6	99214.6	40.4	--	1015	--
2001	43580.6	109655.2	39.7	174.5	1106.6	15.8
2002	47431.3	120332.7	39.4	188.4	1367.2	13.8
2003	54945.5	135822.8	40.5	221.8	1627.7	13.6
2004	65210	159878.3	40.8	308.1	1909.8	16.1
2005	77230.8	184937.4	42.2	458.2	2388	19.2
2006	91310.9	216314.4	43.1	483.9	2566	18.9
2007	110534.9	265810.3	43	552.4	3387.3	16.3
2008	130260.2	314045.4	42.9	542.6	4490.3	12.1
2009	135239.9	340506.9	39.7	442.6	4525.3	9.8
2010	160029.6	397983	40.2	--	--	--
Average	69562.9	170595.2	41.02	374.7	1933.6	15.06

Data source: China Statistical Yearbook.

5.3.3 Economic Growth and Pollution Emission

The industrial three wastes data suggest the pollution is related to industrial character. Mining has the most solid waste emission, and the rate is 42%. Next is power-gas-water product and supply industry, and the rate is 19.9%. The rate of ferrous metal smelt and processing industry is around 16.7%. In industrial waste water emission the rate of power-gas-water product and supply industry is the first and is 1/3. Next are nonmetallic mineral industry and ferrous metal smelt and processing industry. The addition rate is 1/3. However, the emission of ferrous metal smelt and processing industry is reducing. Power-gas-water product and supply industry emission rate is around 10%. Therefore, we focus on the four industries, including Mining, ferrous metal smelt and processing industry, power-gas-water product and supply industry and nonmetallic mineral industry.

Table 5-16 Pollution emission ratio of China power sector

Power sector	1995	1996	1997	1998	1999	2000	2001	2002
Industrial value added	7.91	7.31	8.20	9.66	10.02	9.17	9.52	9.59
solid waste emission	18.82	19.94	21.57	14.87	15.44	16.27	18.19	19.29
Industrial waste gas emission	35.52	38.49	34.77	34.6	34.33	35.12	33.27	33.32
sulfur dioxide emission	51.09	56.43	56.55	43.67	44.17	42.41	53.89	55.01
Industrial dust emission	53.03	59.24	49.81	28.63	31.67	31.21	43.67	45.32
Industrial waste water emission	9.32	12.51	10.55	10.62	10.68	9.73	11.00	10.21
	2003	2004	2005	2006	2007	2008	2009	average
Industrial value added	8.59	8.96	7.92	7.59	7.54	7.26	6.93	7.90
solid waste emission	22.11	21.01	20.62	20.51	22.88	23.48	23.67	19.91
Industrial waste gas emission	34.17	33.62	32.96	33.51	31.25	30.08	30.95	33.73
sulfur dioxide emission	57.97	56.97	58.93	58.14	56.6	56.48	56.01	53.62
Industrial dust emission	46.89	43.8	47.4	44.74	42.65	41.42	40.79	43.35
Industrial waste water emission	13.66	12.72	11.63	10.44	7.92	8.36	7.13	10.43

Data source: China Statistical Yearbook.

Power sector is the basic industry in economy. Power sector supports the quick development of China economy, and also brings huge environmental problem, showing in table 5-16.

Power sector ratio of industrial value added is 7.9% averagely. But the pollution emission ratio is larger than this number. Sulfur dioxide emission ratio is 53.62%, and industrial dust emission ratio is 43.35%. Industrial waste gas emission ratio is 33.73%. So power sector is high pollution industry.

Table 5-17 shows mining, ferrous metal smelt and processing industry, power-gas-water product and supply industry, nonmetallic mineral industry have serious pollution. China pollution control is severe.

Table 5-17 Four industries pollution emission

year	Waste gas (%)				Waste water (%)				Solid waste (%)			
	M	N	F	P	M	N	F	P	M	N	F	P
1995	6.4	2.7	13.6	9.3	3.1	13.9	15.4	35.5	41.1	1.8	17.3	18.8
1996	6.3	2.4	13.9	12.5	3.0	11.9	14.5	32.9	41.2	1.5	17.1	19.9
1997	6.3	2.6	13.2	10.5	2.8	15.0	14.2	29.8	48.1	2.3	17.2	21.6
1998	6.2	2.4	12.7	10.6	3.2	15.3	13.1	30.1	50.9	1.8	13.7	14.9
1999	6.3	2.4	11.7	10.7	2.4	16.3	13.0	29.9	48.8	2.0	13.8	15.4
2000	6.7	2.2	11.5	9.7	2.2	17.0	13.3	29.8	48.0	1.8	14.8	16.3
2001	6.2	2.3	9.5	11.0	2.5	21.1	15.5	33.3	43.8	2.4	14.5	18.2
2002	5.3	2.2	9.3	10.2	2.4	20.7	16.6	33.3	42.6	2.2	16.2	19.3
2003	5.7	2.5	9.3	13.7	2.2	19.9	17.0	34.2	41.3	1.7	15.6	22.1
2004	5.7	2.4	9.4	12.7	2.2	19.7	19.3	33.6	38.6	3.0	17.2	21.0
2005	5.4	2.2	7.9	11.6	2.1	18.6	21.0	33.0	39.2	2.6	18.9	20.6
2006	6.4	2.1	7.5	10.4	2.0	17.6	19.3	31.5	37.1	3.0	20.5	20.5
2007	6.9	1.8	7.1	7.9	2.1	18.5	21.5	32.5	38.5	2.5	18.1	22.9
2008	7.1	1.6	6.6	8.4	2.0	19.5	20.5	32.1	37.8	2.2	17.7	23.5
2009	7.3	1.6	6.0	7.1	2.2	19.2	22.5	33.1	39.2	2.3	17.8	23.7
average	6.3	2.2	10	10.4	2.4	17.6	17.1	32.3	42.4	2.2	16.7	19.9

Data source: China Statistical Yearbook. M indicates Mining. F indicates ferrous metal smelt and processing industry. P indicates power-gas-water product and supply industry. N indicates nonmetallic mineral industry.

Economic growth will cause a series of environmental problems. The conflict between economic growth and environmental pollution is a hot topic. Economic activities bring resource consumption and waste emission. Environmental problems will appear when waste emission exceeds environmental carrying capacity and restrict economic growth.

China economic growth adopts extensive growth pattern and depends on high resource consumption and large waste emission. So environmental pollution is serious. With the rapid economic growth, environmental pressure and resource pressure increase continually. When environmental pressure is above environmental carrying capacity, environment deterioration will be irreversible. And then, economic growth will stagnate and environmental disaster will appear.

Nowadays China economic growth is mainly promoted by the input of material capital and human capital. Natural environment plays an important role in accepting waste. Especially, the influence of industrial activities on environment is very serious. Therefore, research on the relationship between environment and economic or industrial growth has the important implications in theory and practice. Pollution control is good for both short-run and long-run economic growth.

5.3.3.1 Data and Variable

The data of this essay include China gross industrial output and industrial three wastes emissions spanning from 1995 to 2009. The data come from China Statistical Yearbook. We set gross industrial output as the dependent variable Y, and set industrial waste water emission, industrial waste gas emission, and industrial solid waste emission as the independent variables X1, X2, X3.

5.3.3.2 The Correlation between Industrial Economic Growth and Industrial Waste Emission

The correlation between gross industrial output and the three wastes emissions is positive. Industrial economic growth is along with the increasing of the three wastes emissions.

Table 5-18 The correlation results

Correlation	Y	X1	X2	X3
Y	1			
X1	0.482602	1		
X2	0.985757	0.442233	1	
X3	0.992183	0.49434	0.992296	1

5.3.3.3 The Impact of Industrial Waste Emission on China Industrial Economic Growth

Figure 5-4 shows the trend of China industrial three wastes emission. China industrial waste water emission does not have the obvious trend. Industrial waste gas emission and solid waste emission have the growth tendency, and the latter is larger.

Figure 5-4 China industrial three wastes emission

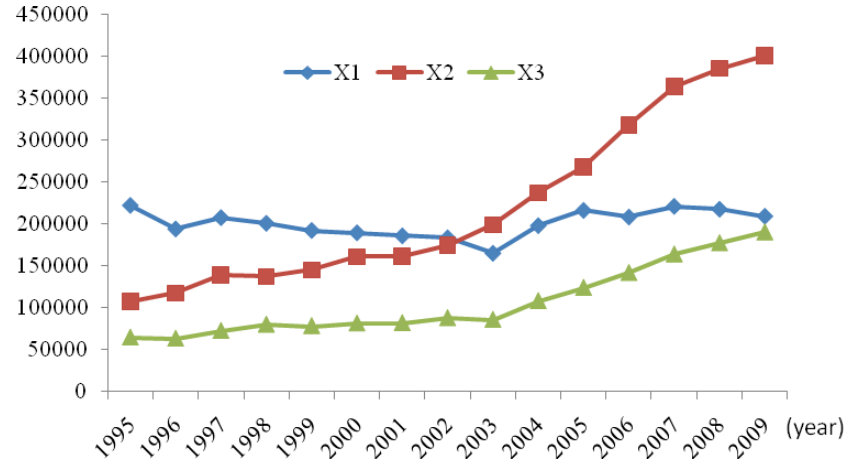
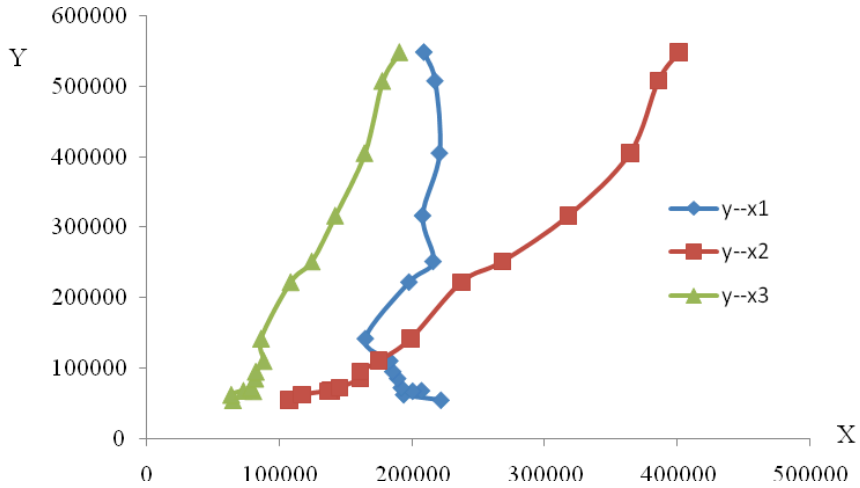


Figure 5-5 shows the scatter of industrial economic growth and industrial waste emission. The positive correlation exists.

Figure 5-5 Scatter of industrial economic growth and industrial waste emission



We build the model Y= F(Xi). The linear regression results are as table 5-19.

5.3.3.4 Results Analysis

China industrial waste water emission reduces until 2003 and increases from 2004. The industrial solid waste emission increases. And the industrial waste gas emission also increases. Considering economic significance and statistical significance, the results suggest the industrial solid waste emission has the largest impact on China industrial economic growth.

In regression results in table 5-19, the goodness of fit in industrial waste water emission and industrial output value is low. Maybe the cause is the sample size is smallest, or data collection has some problems.

Table 5-19 The regression results of China industrial economic development and industrial pollution emission

eq	Y	C	X1	X2	X3	R-squared	F-value
1	Coefficient	-823342.5	5.106474			0.232905	3.947043
	p-value	0.1353	0.0684				
2	Coefficient	-162089.9		1.641384		0.971716	446.6234
	p-value	0		0			
3	Coefficient	-221894.9			3.951612	0.984427	821.8003
	p-value	0			0		
4	Coefficient	-275757.2	0.613844	1.598666		0.974423	228.5885
	p-value	0.0197	0.2818	0			
5	Coefficient	-201976.9	-0.110254		3.972127	0.984509	381.333
	p-value	0.0278	0.8052		0		
6	Coefficient	-217563.7		0.132063	3.638165	0.984524	381.6962
	p-value	0		0.789	0.0084		
7	Coefficient	-205912.1	-0.070867	0.096972	3.734639	0.984551	233.674
	p-value	0.0378	0.8921	0.8665	0.0212		

5.3.4 Industrial Waste Emission and Industrial Economic Growth

The data of this essay include China gross industrial output and the wastes emissions of mining, nonmetallic mineral industry, ferrous metal smelt and processing industry, power-gas-water product and supply industry spanning from 1995 to 2010. We set gross waste water emission, the four industrial waste water emissions as the dependent variables W, W1, W2, W3, W4, set gross waste gas emission, the four industrial waste gas emissions as the dependent variables G, G1, G2, G3, G4, and set gross solid waste emission, the four industrial solid waste emissions as the dependent variables S, S1, S2, S3, S4. Also we set gross industrial output and the four industrial outputs as the independent variables X, X1, X2, X3 and X4.

The optimal regression equations and results are as follows.

(1) Industry

$W = 0.178589284508X + 2017105.41265$

se=(0.13) (39142)

t=(2.34) (4.49) R^2=0.8056

$G = 0.558861741202X + 106738.392403$

se=(0.026) (7858)

t=(20.93) (13.58) R^2=0.969

$S = 0.245675039923X + 57414.7817364$

se=(0.007) (2122.9)

t=(34.06) (27.04) R^2=0.988

(2) mining

$W_1 = 0.895792000696X_1 + 118558.810986$

se=(0.25) (4511.9)

t=(3.56) (26.27) R^2=0.8759

$G_1 = 0.164981182864X_1 + 3132.96995372$

se=(0.008) (146.21)

t=(20.266) (21.428) R^2=0.967

$S_1 = 1.33637182253X_1 + 28422.7982099$

se=(0.009) (1588)

t=(15.11) (17.89) R^2=0.942

(3) nonmetallic mineral industry

$W_2 = -7209.48714097\log(X_2) + 109048.637644$

se=(1537.49) (1368.84)

t=(-4.689) (7.966) R^2=0.81098

$G_2 = 28610.7266525\log(X_2) - 210781.928961$

se=(1440.35) (1282.4)

t=(19.86) (-16.64) R^2=0.9657

S_2 = 1602.35341047log(X_2) - 11619.9105789

se=(126.4) (1125.435)

t=(12.676) (10.32) R^2==0.9198

(4) Ferrous metal smelt and processing industry

W_3 = -50167.0746636log(X_3) + 665744.985328

se=(6381.6) (59699.39)

t=(-7.86) (11.15) R^2=0.815

G_3 = 1.72424704082X_3 + 14067.1119491

se=(0.072) (1706.91)

t=(23.98) (8.24) R^2=0.976

S_3 = 0.563634822974X_3 + 9537.80426932

se=(0.03) (722. 26)

t=(18.53) (13.21) R^2=0.9608

(5) power-gas-water product and supply industry

W_4 = -1.74230747818X_4 + 233868.455032

se=(0.568) (1033.03)

t=(-3.067) (22.64) R^2=0.8019

G_4 = 2.9733307097X_4 + 35121.2875556

se=(0.101) (1844.25)

t=(29.32) (19.04) R^2=0.984

S_4 = 1.04892082697X_4 + 9356.83442101

se=(0.037) (668.33)

t=(28.55) (14.00) R^2=0.981

According to the results above, we forecast the three wastes emissions considering the low, middle and high situations of gross industrial output. The results are as follows, indicating the environmental pollution is serious.

Table 5-20 The three wastes emissions forecast (10 thousand tons)

	The whole industry				Mining				nonmetallic	
	Gross industrial output	Waste water emission	Waste gas emission	Solid waste emission	Gross industrial output	Waste water emission	Waste gas emission	Solid waste emission	Gross industrial output	Waste water emission
2009	548311	2090300	468500	190674	32855	151579	66500	74834	24844	32777
Low	57070	2182305	623699	284670	43418	169682	12548	104689	733677	32061
Middle	76093	2237371	796019	360422	57891	186722	15687	130112	97823	29987
High	114140	2347504	1140660	5119256	86836	220804	21964	180956	146734	27064

Table 5-21 The three wastes emissions forecast (10 thousand tons)

	nonmetallic		Ferrous				power			
	Waste gas emission	Solid waste emission	Gross industrial output	Waste water emission	Waste gas emission	Solid waste emission	Gross industrial output	Waste water emission	Waste gas emission	Solid waste emission
2009	68500	4359	42636	125978	73500	33894	33435	149010	145000	45131
Low	94741	5491	55834	103712	140570	50890	925024	136589	201133	67922
Middle	102972	5952	74445	89279	182738	64674	1233366	104163	256470	87444
High	114573	6602	111667	68938	267073	92242	1850049	39310	367145	126487

5.4 Suggestion for Replying Resource and Environment Challenge

5.4.1 Strategy Analysis of China Economic Development

China resource consumption is positively related to economic growth. The correlations between economic growth and the consumptions of steel, power, concrete are more than 0.99. And the correlation between economic growth and the consumptions of electrolytic copper, coal, crude oil, plastic are more than 0.95. In the four largest high energy consumption industries, the increasing of gross industrial output depends on the excessive energy consumption. The cost of ferrous metal smelt and processing industry development is the largest. Also the base energy consumption of China industry is large, indicating the resource dependence of China economic growth is strong. According to energy demand forecast above, coal will be the major of energy consumption and the crude oil and natural gas consumptions will increase until 2022. Nowadays coal pollution leads to acid rain and the land area covered by acid rain has exceeded 1/3 land area. China CO_2 emission increases every year and has become the second in the world. With the rapid industrial development, environmental pollution is serious, especially in high energy consumption industry. Under the background of industrial economic growth, industrial three wastes emission increasing and environmental

pollution worsening, the scale effect in industrial development is the most important factor in emission.

There are two ways in industrial development: extensive development and intensive development. The former depends on resource input and has the cost of environmental pollution. The latter depends on technology improvement and efficiency improvement, and focuses on resource saving and environmental protection. So intensive development fits the requirement of sustainable development. Considering the constraint of resource and environment, industrial economic development need emphasize resource saving and sustainable development. The resource and environment dependence of China economic development is highlighting and the potential threat increases. So the extensive industrial development can not be lasting. In order to fit the situation of China energy shortage, China industry should follow sustainable development way.

In a word, China economic development strategy for replying resource and environment challenge should contain the following three points. The first one is how to face the resource demand of economic development and allocate the resource supply. This is the need of China economic growth and the common puzzle of world energy shortage. Supporting energy demand need increasing energy supply and reducing energy consumption. Increasing energy supply need China strengths resource exploration and searches the effective method in technology and trading. Reducing energy consumption should alter China economic growth mode and economic structure. The second one is altering China economic development mode. China economic development since reform and opening up has the characters of resource-driven and element-driven and has the cost of resource consumption and environmental pollution. The future economic development should have the character of innovation-driven and depends on education development, science development and technology innovation. The third one is adjusting economic structure. China economic structure should transform to modern service economic structure. China manufacture should transform to China creation and China service. And the fundamental change of China economic structure will realize.

5.4.2 Strategy Suggestion of China Economic Development

5.4.2.1 Improving Resource Support

Firstly, we should add resource exploration and improve effective resource supply. Under planned economy China mineral exploration is financed by China government,

executed by national exploration section, and used by mine free. This mechanism prevents mineral exploration development. Under socialist market economy, mineral exploration market opens up and the investment structure changes and has the diversification tendency. Generally speaking, China mineral exploration is falling behind and commercial mineral exploration market is small. The high risk mineral exploration is lacking for investment. Mineral exploration need guide from the views of policy and investment. On one hand, mineral exploration company should be the majority and has high market core competitiveness due to specialization. On the other hand, national investment should attract social capital to commercial mineral exploration, perfect national investment structure and strength the pertinence of national investment. The participation of various investors in commercial mineral exploration meets the demand of building and supplies funds for mineral exploration.

Secondly, we should take advantage of "two resources and two markets" and use foreign mineral resources in diversification, multi-channel and multimode. We should use the resource that is domestic shortage and important for economic development (such as oil, copper) and the resource that has high economic value (such as gold, platinum, diamond). We should pay attention to geopolitical relations, keep Asia-Pacific countries markets, extend Africa and Latin American developing countries market, and allocate mineral resources in the world. We should put unified minerals import and export policies into practice and carry out international trade actively. We should adjust the mineral trade structure planned and step by step considering comparative advantage. We should import the mineral resource that is domestic shortage and necessary for domestic economy, control and adjust the superiority mineral exports in order to obtain maximum economic benefits. General speaking, the two strategies are as follows.

(1) "Going out" strategy. We should explore and develop foreign mine alone or joint with multinational mining companies, purchase mineral futures, and explore the "going out" strategy and way. Nowadays China foreign exploration and development share for crude oil and non-ferrous metal ores is not high. We should make sure the mine import share considering different minerals, and establish foreign mineral resources supply base. The principal part of "going out" is enterprise. The role of government is to create conditions for enterprises to "going out", provide financial support and reduce the risk of foreign exploration. We should combine country's foreign economic aid and "going out" strategy, enhance the competitiveness of mineral enterprise in international market and the influence of China on

global mineral resources, and build a stable, economic, polybasic system of mineral supply.

(2) "Bringing in" strategy. Mining development strategy should adapt to economic globalization, catch the chance of joining WTO and the international mining situation improved, carry out the policy of active, rational and effective foreign capital usage, adjust and plan "bringing in" region-oriented and mine kind-oriented, and promote the rapid development of "bringing in". China western resource development is the key in "bringing in" strategy. Western region mineral resources are rich, high concentrated and have large potential. We should select the necessary minerals as "bringing in" minerals, utilizes foreign capital in commercial mineral exploration. We should strengthen Northeast Asia mineral resources cooperation, fully open sea mineral exploration and development, resist the world mineral market risk and promote the upgrading of China mineral and structure adjustment further.

5.4.2.2 Altering China Economic Growth Mode

Firstly, the key of economic development transformation is economic growth concept transformation and development concept innovation. An important factor of China economic development behind is economic growth concept behind. The economic growth concept of some local governments is "only GDP consciousness". GDP pursuit is fanatical and blind. And the projects and industries that need more resource consumption is the precise way of GDP growth. Therefore, economic development transformation should dilute "only GDP consciousness", make improving the quality of economic growth as the core of economic development, put "reducing energy consumption, improving economic growth efficiency, improving people living substantially" in the first. This can ease the pressure of mineral resource demand.

Secondly, we should insist on taking a new way of industrialization and realize the fundamental transformation of China economic development. The new way of industrialization is different from western countries industrial development way with 200 years history and China traditional industrialization way. The sixteenth congress report points out we should take a new way to industrialization that is use information technology to stimulate industrialization and use industrialization to promote information technology. The so-called new way to industrialization requires high technological content, good economic returns, low resources consumption, little environmental pollution, and human resources playing fully. If we can truly use information industry and advanced technology to lead industrialization, use high and new technology to transform and upgrade traditional industries

and use the optimization and upgrading of traditional industries to upgrade industrialization, we may reduce the predatory exploitation and low utilization of mineral resources, and greatly promote China sustainable economic development. This naturally alleviates the plight of China mineral resources.

Thirdly, we should develop “circular economy” and “low-carbon economy”. The drawback of extensive economic growth is not only one-sided pursuit of extension and expansion, but also the one-time usage of resources. Circular economy refers to during the process of resource allocation, production and consumption improve resource utilization efficiency, transform traditional, resource-dependent development to ecological cycle development. Ma Kai (2004) pointed out that circular economy makes the efficient and recycling usage of resources as the core, makes “reducing, reusing and recycling” as the principle, and makes low consumption, low emission, high efficiency as the basic features. Circular economy accords with sustainable development concept, and is the fundamental change of the traditional growth pattern with “mass production, mass consumption and mass waste”. Low-carbon economy refers to the ecological economy with low power consumption and low pollution, involving electric power, transportation, construction, metallurgy, chemical, petrochemical and other departments, and relating to the efficient usage of renewable energy and new energy, the exploration and development of oil and gas resources and coal bed methane, carbon capture and sequestration, and the effective control of greenhouse gas emissions. Actually both low-carbon economy and circular economy is the same thing, mentioning the rational usage of energy. Besides, energy is the biggest problem facing human development. Low-carbon economy implementation should follow the three points. The first is industrial structure adjustment and eliminating backward production technology. The second is to change the energy structure, and giving priority to nuclear energy, hydropower, wind and bio-energy. The third is energy saving, reducing carbon dioxide emission by optimizing the process line.

5.4.2.3 Adjusting China Economic Growth Structure

Economic structure considers the position and the relative proportions of various components in national economy, including aggregate demand structure, ownership structure, allocation structure, industrial structure and regional economic structure from a macro perspective, and including organizational structure and product structure from the micro view. Economic restructuring refers to meet and promote the productivity development through the rationalization and upgrading of economic structure. Economic structure is related to

economic growth speed and quality. Economic restructuring includes two main aspects, structural optimization and upgrading. Structural optimization refers to the coordination and ration of national economy structure. Structural upgrading refers to using scientific and technological breakthroughs and innovation to realize economic structure advancement. China economic restructuring focuses on domestic industrial structure adjustment and industrial planning incorporating mineral resources characteristics.

Firstly, China must continue to adjust the industrial structure from relying mainly on secondary industry to relying on first, second and third industries jointly driving economic development. We should promote the optimization and upgrading of industrial structure, form the new structure using a high-tech industries as the leader, supporting by basic industries and manufacturing and the comprehensive development of service industry. This is the direction of China industrial structure adjustment. From the general economic development perspective, the larger the third industry proportion in GDP, the higher economic development. For example, the third industry proportion in 2006 GDP is 76.5% in USA, 69.5% in Japan, 39.4% in China. The third industry proportion in 2007 GDP is 72.1% in Beijing, 52.6% in Shanghai. Therefore, the third industry development is the main content of China economic restructuring. To this end, we should earnestly implement the favorable policies and measures for the third industry development, including the relaxation of service market access, promoting and supporting high-tech services and cultural industries, developing new services actively, developing the traditional service steadily, and rising market competitiveness and brand influence. At the same time we should continue to adjust the intra-industry structure, support the key industries development, speed up industrial upgrading and realize the transformation from increasing material consumption to relying on scientific and technological progress, and improving the quality of workers and management innovation. The lacking of innovation and low-level industries are the main factors of restricting China economic structure optimization and upgrading. We should consider the influence of financial crisis, implement the restructuring and revitalization of key industries, promote corporate mergers and acquisitions, eliminate backward production capacity, and reduce excess production capacity. We should focus on the future development and the next round of international competition, select emerging strategic industries, encourage and support the industries of energy-saving environmental protection, new energy, new materials, new medicine, biology, information and other industries, and form new economic growth point.

Secondly, we should coordinate regional industrial development and mineral resources

exploitation. There are some problems in China regional industrial development. The processing and manufacturing industries concentrate in eastern and mineral resources reserves concentrate in central and western. For example, iron ore is mainly in Liaoning, Hebei, Shanxi, Xinjiang and Sichuan, and the iron ore reserves in Hebei, Liaoning and Sichuan is 64% of total reserves. Phosphorite is mainly concentrated in Yunnan, Guizhou, Hubei, Hunan and Sichuan and the reserves is 81% of total reserves. 1/3 zinc ore reserves is in Yunnan. Bauxite is concentrated in Shanxi, Henan, Guangxi and Guizhou, and the reserve is 90% of total reserves. The distribution patterns of mineral resources and manufacturing industries are not coordinated. According to 2007 statistics, 11 eastern provinces contributed 60% of the country GDP, 64% of local revenue, 70% of gross industrial output and 91% of exports. Since 1999 eastern region energy consumption doubled in 10 years. Nearly 50% of energy consumption is in eastern region. In 2007 eleven eastern provinces are the net coal call-in provinces and the net crude oil call-in provinces except Tianjin. The gasoline consumption of Jiangsu reaches 4.82 million tons and is the double of the sum of Yunnan and Guizhou. The kerosene consumption of Shanghai is 2.95 million tons and is more than western twelve provinces consumption. As a result, eastern region will transfer mineral resources from middle and western region. Therefore, the nation should strengthen the coordination of regional industrial layout and resources development layout from the strategic level. Firstly, governments should strengthen the concept. Secondly, the central government investment authorities should prepare a unified regional industrial layout and resources development layout, guide the industrial development and resources development strategy, guide major project investment plans of enterprises, and regulate the project approval procedures of the central government investment authorities. Thirdly, this plan should consider regional industrial development, mineral resources development and environmental protection. Further regional industrial development and mineral resources development are related to urban construction. We should consider regional industrial development, mineral resources development, urban construction development and regional environmental protection, prepare the unified plan of industry, resources, environment and land resources. Fourthly, the plan should be incorporated into the legal track, is approved by the NPC session promulgation and implementation. This can enhance the constraints of the blind investment and development of local government.

Chapter 6: Conclusion and Outlook

6.1 Conclusion

Industrialization is the process from natural resources to social wealth by human labor, and is an insurmountable development stage in human historical process. Economic growth depends on mineral resources consumption, which is the basic characteristic of industrialization. The industrialization process of major developed countries starts from the 18th century, and completes with over 200 years. Until the third industrial revolution in 1970s and 1980s, China industrialization starts, China industrialization takes 30 years relative to 200 years of other developed countries, which is unprecedented in human history. Under the background of world energy and raw material supply and consumption patterns, China industrialization will face the dual constraints of resources and environment.

This essay uses economic growth data, gross industrial output data, industrial data, mineral resources and raw materials production and consumption data since PRC establishment, adopts linear regression method and the horizontal and vertical comparative analysis of time series, sets up the charts and models, researches the dependence of China economic growth on mineral resources, such as coal, crude oil, concrete, power, steel, copper and plastic, analyzes the relationships between China economic growth and mining, ferrous metal smelting and rolling processing industry and other major energy-intensive industries. This essay also examines the relationship between China economic growth and industrial pollution emission in order to reveal the dependence of China economic growth on resources and environment. The conclusions are as follows.

1. China economic growth has the high volatility and obvious high resources consumption, which is consistent with China industrialization development and issues the requests for steady economic growth in industrialization process. The volatility is affected by macro-economic control, market mechanism and external factors. During PRC establishment to reform and opening up, the industrial system is in the recovery period, and economic growth is mainly affected by national economic policy. After reform and opening up, China industrialization gradually starts, and the volatility of economic growth is due to the imperfections of market system and monitoring system. Since 1990s with the advance of industrialization, China economic growth depends on foreign trade and the relevance between

China economy and global economy strengthens. Manufacturing industry is at the bottom of industrial chain, has the weak risk taking ability, and is easily affected by international speculation and bubble. The financial crisis in 1998 and 2008 affect China economic growth seriously. The resource dependence of China economic growth mainly shows resource and major raw material serious consumption. The regression results shows the correlations between China economic growth and mineral resources consumption are large. The interaction of non-ferrous mineral resources consumption and energy promotes China economic growth. Besides, mineral resources are the basis of industrialization. Therefore, the short-term and stage characteristics of China industrialization determine the high volatility and energy consumption of China economic growth. Maintaining steady economic growth need strengthen macroeconomic policies and market regulation, solve the problems in industrialization process, and reasonable guide industrial development direction.

2. China economic growth depends on resource consumption strongly and faces the dual constraints of resources and environment. The positive correlations exist between China economic growth and resources consumption, waste emission. Economic growth leads to the increasing of resource consumption and waste emission. This essay analyzes the representative four highest energy consumption industries, finds out economic growth depends on adding resource consumption, especially ferrous metal industry. This indicates China economy has a strong dependence on resource, matching the China current situation in industrialization. Major industrialized countries experience shows the resource dependence of economic growth has an inverted “U” shape. When one state is into the stage of industrialization, the rapid industrialization growth is along with mineral resources consumption increasing. In the initial stage of industrialization, the proportion of agriculture in GDP declines and the proportion of industry in GDP increase. Manufacturing development need more mineral resources and raw materials consumption. But in the middle stage of industrialization, due to technological advances and economic structure changes the extensive application of new materials leads to the declining consumption of traditional raw materials, and makes the consumption elasticity of energy and raw materials decrease. From the beginning of the 21st century, China enters the middle stage of industrialization. From the views of gross industrial output, industrial production, foreign direct investment, industrial imports and exports, China has become a real major industrial country. This situation will last until 2020. During this period, China economic growth in general is a high input, high consumption and high pollution growth. We need achieve economic stable and healthy

development and break the dual constraints of resources and environment to beyond this stage.

3. The sustainable development of China economy fundamentally depends on the effective protection of resources and economic restructuring. Sustainable development of China economy depends on the adequate supply of mineral resources. However, the reserves of quality energy and minerals, especially oil and gas, iron ore, bauxite, copper and other key strategic resource, is short and the grade is low. The lack of strategic resources is the hard constraints of China economic growth. China resources demand expands rapidly and its dependence on external markets increases. China has become the major consumer and importer of global energy and mineral resources. This will be the weakness of China economic development. Meanwhile, China current economic structure is imbalanced and industrial structure is unreasonable. This essay suggests the proportion of heavy industry is 52.85% in 1978, and 71.00% in 2010. The heavy industry has the typical high-resource, high energy consumption and high environmental pollution. Its resources consumption proportion is much higher than the proportion of heavy industry added value. Hence, the sustainable development of China economy need strengthen effective resource support and promote economic restructuring.

The innovations of this essay include the following aspects.

Firstly, the researches on the resource dependence of China economic growth are little and focus on theoretical studies. The empirical studies are little, and only discuss the relationship between regional economic growth and region mineral resource. This essay bases on the domestic consumption of mineral resources and raw materials, adopts regression method to discuss the correlation between economic growth and resource consumption, the resource demand forecast, and explains the resource dependence of China economic growth.

Secondly, this essay uses comparative analysis of time series and multiple linear regression to analyze the relationship between economic growth and mineral resource consumption. Also the data include major mineral resources consumption, raw material resources consumption. The analysis is more representative. This essay not only makes targeted policy measures for different types of mineral, but also provides guidance suggestions for the development of energy-intensive industries.

Thirdly, this essay analyzes the issue from two views of resources and economy and provides the effective method to solve China resource problems. Also this essay combines supply channels and exploration strategy, and proposes the ways to improve resource

protection capability. Mineral exploration should consider “two resources and two markets”. This is the tasks and future development direction. Only combining mineral exploration and resource economy and increasing exploration investment can ease the pressure of resource supply, reduce foreign resources dependence and realize the sustainable development of China economy. From the economic view, this essay captures the high resource consumption features of China economic growth, analyzes economic growth transformation and economic restructuring. This essay considers the concepts of “low-carbon economy” and “regional economic development” and the suggestions are practical.

6.2 Outlook

This essay obtains some conclusions about the resource dependence of economic growth, reveals the resource constraints faced China economy and provides useful suggestions for the sustainable development of China economy. Due to the limitation of view and method, this essay does not analyze the mineral resources problem deeply, only exploratory study economic growth pattern change and economic restructuring. China resources protection, economic growth, economic restructuring are the important issue for the sustainable development of China economy. The further studies include resource supply analysis, resources reserve system analysis, industrial structure upgrading and resources and environment protection. The details are shown as follows.

1. Resource availability analysis.

Resource effective supply need analyze resource availability deeply. Resource availability analysis is very important for national stable, sustainable and secure supply and economic macro-control. Establishing resource availability is the core of the analysis. Mineral resource is a resource with global market allocation. China resource availability analysis need consider the relationship with neighboring countries and third world countries search the related data, and measure resource exploration and development abilities.

2. Strategic reserve of resources

As the largest developing country, China is in the middle stage of industrial development. No strategic reserve of resources will lead to low capacity of risk control. The event of resources supplies interruption or international market price fluctuations will have serious impact on Chinese society, especially crude oil. We must attach importance to resource reserves, especially oil strategic reserve. Strategic reserve of resources is related to the

national resources strategic reserve system, strategy, and so on. Only the macro-level analysis can establish suitable China resources reserve system.

3. Economic growth transformation

Economic growth transformation is system engineering, meaning the reform of original economic development mode. On one hand, the change process depends on the original mode of economic development. On the other hand, the change should be thorough from the original to the new mode of economic development. Therefore, this is a long-term, systemic problem, relating to ideas, institutions, and mechanisms. Besides, economic growth transformation should take into account globalization, information technology and the rise of emerging economies comprehensively.

4. Environmental protection mechanism

The deterioration of ecological environment in China attributes to many reasons, both natural causes and human factors. The long-term extensive economic growth and the irrational exploitation of resources is the main reason. Meanwhile, some local has weak environment regulatory and resources protection, focuses on construction and development and ignore management and protection. Therefore, we must take effective measures to solve environmental problems, and safeguard the national ecological security. Solving environmental problems not only need regulate resource development order, environmental early warning, monitoring, governance, but also need establish laws and regulations for ecological protection.

Bibliography

Arrow K J (1962), The economic implications of learning by doing, Review of Economic Studies 29(3). 155-173

Baland J M and Francois P (2000), Rent-seeking and resource booms, Journal of Development Economics 61.

Barro R J (2004), Determinants of economic growth, Beijing: China Renmin University Publishing.

Cai Yiming (2009), Resource, technology, system and economic growth, Journal of Hubei University of Economics (Humanities and Social Sciences) (3). 36-39

Carson R (1962), Silent spring, New York: Fawcett Crest Books.

Case K E and Fair R C (1994), Principles of economics, Beijing: China Renmin University Press.

Chang Yugang (2005), Comprehensive utilization and circular development: some opinions about mining circular economy and mineral resource comprehensive utilization, Southern Land Resource (7).25-26

Chao Xiaojing and Ren Baoping (2008), Economic transition and quality of economic growth in China: Accounting for contribution ratio of Total Factor Productivity, Modern Economic Science (4).23-29

Chen Cai (2001), Regional economic geography, Beijing: Science Publishing House.

Chen Jin (2007), Economic growth compare between Rresource-based provinces and processing provinces, Enterprise Economy (12).88-91

Chen Linsheng and Li Gang (2004), Resources endowment, comparative advantage and regional economic growth, Research on Financial and Economic Issues (4).63-66

Chen Lixin and Li Guoping (2006), Oil resources prospecting, using and economic development: Discuss 2004 oil resource tax rises, Research on Development (4).69-72

Chen Yaoming and Zhong Denghua (2008), The analysis of the internal causal for technology progress in resources-based city, Science & Technology Progress and Policy (6).87-90

Chen Zhongchang, Zhang Xiang and Chen Xikun (2008), A research on the relationship between the regional conditions of energy and economic growth from two perspectives: An empirical analysis based on interprovincial panel data, Economic Survey (3).

Chen Zhonghong and Sun Qie (2005), China economic growth, resource and environment protection and sustainable development, Journal of Ocean University of China (6).35-38

Cheng Hongwen and Zhang Yonghai (2007), Rural economic development mechanism research based on labor economy and resource economy, Issues in Agricultural Economy (3).

Cheng Yeqing (2004), On exploitation of mineral resources and regional economic sustainable development in mineral areas, Resources Science (6).

Cheng Zhe and Wang Mengting (2007), Dutch disease, low division of labor and the development direction of China's international trade, Market modernization (1).

China's modernization strategy research group and The research center of China's modernization of Chinese academy of sciences (2003), Chinese modernization reports, Beijing: Peking University Press

Coadse R, Alchain A and North D (1994), Property rights and institutional change: Property School and the new system of school Translations, Shanghai: Shanghai People's Publising House.

Cole H L, Mailath G J and Postlewaite A (1992), Social norms, savings behavior and growth, Journal of Political Economy 100(6), 1092-1125.

Collier P and Hoeffler A (2000), Greed and governance in civil war, Policy Research Working Paper 2355, Development Research Group, World Bank, Washington DC.

Cui Wei (2008), Economic growth, resource function and China allocation performance and strategy, Energy and Environment (2).

Davis J, Ossowski R, Daniel J and Barnett S (2001), Stabilization and savings funds for non-renewable resources, Occasional paper 205, International Monetary Fund, Washington DC.

Deng Kebin and Ding Juhong (2007), Government intervene, natural Resource and economy development: Based on regional panel data study of China, Nankai Economic Studies (3).56-64

Deng shande and Tang Zhengguo (2002), Mineral resources development and regional economic development theories and patterns (1), Land & Resources (3).16-19

Devlin J and Lewin M (2002), Issues in oil revenue management, Paper to the World Bank/ESMAP Workshop in Petroleum Revenue Management, Washington DC.

Ding Renzhong (2005), Economic growth: The theoretical debate on the issue of resource, environment and growth limit and the choice faced by human being, Economist (4).11-19

Dong Chunshi (2008), Oil and gas resources endowment and regional economic development path selection, Commercial Times (25).69-72

Dong Xuewang, Zhi Ruizhi and Jiang Bo (2007), On image-building in regional economic development: A case study of Shanxi Province, Economic Geography (3).353-356

Dorn J A (2000), The revolution of development economics, Shanghai: Shanghai People's Publishing House.

Du Fenglian and Sun Jingfang (2009), A study on the relationship between industrial structure and employment in resource abundant areas: The case of Inner Mongolia, Economic Theory and Business Management (4).36-42

Duan Limin (2009), The study of resource curse and regional economic growth, PhD Thesis, Northwestern University.

Fan Gang, Wang Xiaolu, Zhang Liwen and Zhu Hengpeng (2003), Marketization index for China’s provinces, Economic Research Journal (3).9-18

Fang Lin and Zou Weixing (2008), Natural resource, social status and economic growth: A growth model in resource constriction frame, Journal of Shanxi Finance and Economics University (11).1-5

Faucheux S (1998), Sustainable development: Concepts, rationalities and strategies, Dordrecht: Kluwer.

Feng Bangyan and Zhou Mengliang (2005), Regional cooperation and resources optimum allocation: The economic analysis of the pan-pearl river delta strategy, Journal of Jinan University (4).

Feng Peizhong, Qu Xuanhui and Wu Xiaofei (2004), Study on the strategy of exploitation and utilization status of China's mineral resources, China Mining Magazine (6).12-16

Feng Yao and Zhang Jinghua (2008), Analysis on the relations between economic growth, Natural Resources and Institution, China Soft Science (7).38-46

Feng Yuenuan (2002), The study of natural-resource utilization in Chinese economic Sustainable development, PhD Thesis, Heilongjiang University.

Fu Yunsheng (2005), Resource constraints, profit transfers, and diseconomy growth -resources in China's high economic growth, Economic Theory and Business Management (9).14-20

Glyfason T, Herbertsson T T and Zoega G (1999), A mixed blessing: Natural resources and economic growth, Macroeconomic Dynamics 3.

Gong Liutang (2002), Dynamic economic methods, Beijing: Peking University Press.

Gong Xiuguo (2008), China's "Dutch Disease" and its exchange rate policy, Journal of Sichuan University(Humanities & Social Sciences) (4).88-93

Gong Xiuguo and Deng Juqiu (2009), China's Dutch Disease and its regional economic development, Journal of Finance and Economics (4).131-141

Gu Zhenbin (2007), Study on the relationship between amount change of forest resources and economic growth in China, Beijing: Beijing Forestry University.

Guo Liancheng (2005), Resource-dependent economy and Russia economic growth and development, Social Sciences Abroad (6).24-33

Guo Min, Hu Sichun and Liu Xinhai (2007), Improving multipurpose utilization of mineral resources by developing mining recycling economy, Conservation and Utilization of Mineral Resources (3).1-5

Gylfason T, Herbertson T T and Zoega G (1999), A mixed blessing: natural resources and economic growth, Macroeconomic Dynamic.3.

He Yuan (2007) The study of resource-based industries development in Northwest, PhD Thesis, Lanzhou University.

Hu Jian and Jiao Bing (2007), Stimulating effect of oil and gas resources development on the regional economy in Western China: A case study of Shaanxi Province, Resources Science (1).45-52

Hu Jian and Jiao Bing (2008), The research on the problem of the endowment of oil and gas resources and "Resources Curses" of the regional economic growth, Statistics & Information Forum (2).42-46

Hu Liang and Pan Li (2007), Economic growth, international trade, FDI and resource environment: empirical research using Zhejiang data, Economic Consulting, (4).18-25

Huang Minghui (2007), Research on the relation among property right, resource allocation, and economic growth, Journal of Qiannan Normal College for Nationalities (2).56-60

Huang Rongbing (2008), Resource economy breaks resource curse and financial regulatory mechanism, Modern Economic Research (11).15-18

Huang Rongbing and Wang Yuetang (2009), How to break resource curse: evidence from China, Jianghai Academic Journal (Bimonthly) (2).

Huang Yi (2009), Resource based economic transition and Resource Curse solution, Social Sciences in Yunnan (2).87-91

Ji Zhiying (2006), Market opening, resource allocation and economic growth: empirical test of China economy, International Business Research (6).

Jiang Dan (2004), A study of the restrictions of natural resources and sustainable development of the economy, PhD Thesis, Hebei University.

Jiang Xiaojuan (2004), Entering a new stage: China's challenges and strategies for economic development, Economic Research Journal (10).

Jin Bei (2009), Resource and growth, Beijing: Economy & Management Publishing House.

Jun Feng (2004), Western resources endowment and economic growth, Inner Mongolia Social Sciences 25(4).

Keynes J M (1986), A treatise on money. Beijing: The Commercial Press.

Kong Shanyou and Tang Decai (2008), An empirical study on capacity for sustainable development of Jiangsu's manufacturing, China Soft Science (9).

Lei Yapping and Li Caifeng (2006), Influence of the change of the human resources and the industrial structure in Xi'an on the economic growth, Science & Technology Review (9).

Lewis A (1996), The theory of economic growth, Beijing: The Commercial Press.

Li Gang, Chen Zhi, Jin Bei and Cui Yun (2008), Estimation of mineral constraints to China's economic growth, Finance & Trade Economics (7).18-23

Li Haibo and Lu Caiwu (2000), The development of mineral resources and sustainable development, Gold Science & Technology (2).

Li Jian, Ren Likui, Wang Lijie (2008), Research development on the relation between natural resources and economic growth, China Mining Magazine (17)5-8

Li Mingli and Chu Peixin (2008), Natural resource abundance and economic growth relations review, Ecological Economy (9).82-84

Li Shantong (2000), Rapid growth do not have ending: Domestic and overseas experts analyzes China economic growth, Beijing: China Financial and Economic Publishing House.

Li Shaoxing and Yan Peixia (2007), A multi-scale review on the relationship between natural resource endowment and urbanization level, China Population Resources and Environment (6).44-49

Li Tianzi (2007), The impact of natural resource abundance on China regional economic growth and its transmission mechanism, Economic Science (6).66-76

Li Wenguang (2002), General situation of mineral resources in the western part of China, Jilin Geolgy (3).106-112

Li Yan (2009), Discussion on the feasible path to sustainable development of poor and resource concentration areas, Journal of Anhui Agricultural Sciences (2).870-873

Li Yue and Wang Peng (2008), Using resource advantage and building strategy resource development base, China Market (31).

Liang Kai and Lan Jingzhi (2004), The present condition of the comprehensive utilization of China's mineral resources and its countermeasures, China Mining Magazine (12).

Lin Fuqing (2006), Discussion on the harmonious development between mineral resources exploitation and economy: Taking Anxi, Fujian as an example, Resources & Industries (1).

Liu Bin and Ai Guanghua (2005), Research on problem of comprehensive utilization of mineral resources, Express Information of Mining Industry (11).8-9

Liu Bin and Ai Guanghua (2006), Comprehensive utilization of mineral resources in China, Mining Engineering (2).1-3

Liu haiyang (2008), Resource endowment, effect of learning in doing and economic growth, Economic Survey (1).36-39

Liu Huiling and Yan Hong (2007), The relationship between western science and technology input and economic growth, Special Zone Economy (6).194-195

Liu Jinping, Li Wanheng, Hua Jianwei and Ju Zhili (2008), Number of issues of thinking of mineral resources economic, China Mining Magazine (5).26-28

Liu Jinsong (2005), Study of China mineral resource compensating mechanism, Coal Economic Research (2).10-15

Liu Jun and Xu Kangning (2008), Determinants of industrial agglomeration in China, Science of Science and Management of S.& T. (10).127-133

Liu Mingxing, Tao Ran and Zhang Qi (2003), System, technology and endogenous economic growth, World Economic Forum (6).64-80

Liu Shan (2008), The analysis of the optimal economic growth with constraints of natural resources, Master Thesis, Xiangtan University.

Liu Wenxin ans Lu Yunhang (2007), Institutional change and provincial economic growth: A positive research based on endogeneity perspective, Journal of Shanxi Finance and Economics University (11).27-33

Liu Xin (2005), Getting rid of the natural resource comparative superiority pitfall of the economy development in the west of China, Jilin Geology (1).12-14

Liu Xin (2005), Reconstituting the outlook of superiority of China's natural resources, Natural Resource Economics of China (8).

Liu Xiuhai (2005), The research about sustainable development of energy-based economy, PhD Thesis, Huazhong Agricultural University.

Liu Zhen, Cheng Yongjun, Yang Wu and Ren Liyun (2009), Analysis of system resource curse phenomenon from an evolutionary point of economic, Energy Research & Utilization, (1).

Liu Zhibiao and Zhang Shaojun (2008), Regional disparity and rectification analysis in China: Based on GVC and NVC's perspective, Academic Monthly (5).49-55

Long Baolin (2006). Strategic research on the present situation and sustainable supply of important mineral resources of the northeast old industry base, Master Thesis, China University of Geosciences.

Lu Jinping (2009), Generalized "Resource Curse" theory and empirical test, China Population Resources and Environment (1).133-138

Lu Yeshou and Guo Min (2008), The study of evaluating index system of recycling economy

in the realm of the mineral resources, China Mining Magazine (1).

Luo Renhui and Feng Jie (2003), The source of economic growth and development selection, Reform of Economic System (1).164-166

Lv Guo (2006), Analysis of natural resources and economic development in western Gansu Province, Master Thesis, China University of Geosciences.

Lv Ning, Mai Fu (2005), A comparison between factor endowment theory and new trade theory, Journal of Changchun Communist Party Institute (3).41-42

Ma Jinping (2007), Simple analysis of sustainable development strategy of mineral resource in China, China Mining Magazine (12).8-11

Ma Qin (2007), China border trade zone conditional difference and zone advantage cultivating, Northern Economy and Trade (12).

Ma Zhisheng and Hua Ming (2005), Thinking about mineral resource comprehensive utilization and circular economy, Enterprise Economy (8).10-11

Ma Zihong and Hu Hongbin (2006), Natural resources and economic growth: Theory review, Economic Tribune (7).45-48

Maloney W F (2002), Innovation and growth in resource rich countries, Central Bank of Chile Working Papers No 148, February.

Malthus T R (1992), An essay on the principles of population, Beijing: The Commercial Press.7

Marshall A (1981). Principles of economics, Beijing: The Commercial Press.

Meadows D L (1984), The limits to growth. Beijing: Economic Science Press.

Meadows D L (1997), The limits to growth, Changchun: Jilin People's Press

Mel G M (2004), The forefront issues of economic development, Shanghai: Shanghai People's Publising House.

Meng Xiaojun (2008), Water resources constraint force on economic growth of single oasis city in arid area of west China, Master Thesis, Xinjiang University.

Mill J S (1991), Principles of political economy with some of their applications to social philosophy, Beijing: The Commercial Press.

Ming Yu (2007), The research of association between natural resource and economic growth of Sichuan Province, Master Thesis, Sichuan University.

Niu Jianying (2007), Study on strategy mineral resources application security, Ph.D. Thesis, China University of Geosciences (Beijing).

Niu Panqiang and Xie Fuji (2008), Empirical study on relationship between regional economic development environment and economic development, Technology Economics (1).

North D C (1994), Structure and change in economic history, Shanghai: Shanghai People's Publishing House.

North D C and Thomas R P (1998), The rise of the western world: A new economic history, Beijing: Hua Xia Publishing House.

North D C, Williamson J (2003), System, contracts and organizations: The perspectives from new institutional economics, Beijing: Economic Science Press.

Papyrakis E and Gerlagh R (2006), Resource abundance and economic growth in Unite States,

European Economic Review 4, 253-282.

Pigou A C (2007).The economics of welfare, Beijing: Huaxia Publishing House.

Qiu Dingfan (2002), Resources recycling, Engineering Science (10).

Qu Shiyou and Wang Ling (2008), Different types of regional innovation policy selection study, Forum on Science and Technology in China (8).

Qu Xiaoe (2009), An analysis on Chinese inter-provincial differences in energy efficiency and their determinants, Economic Theory and Business Management (2).

Rao Wenjun (2007), Review of the relationship between economic growth and natural resources, Market Modernization (10Z).

Ren Ge and Li Zhi (2009), Resource curse and industrial restructuring of the resources-rich regions, Collected Essays on Finance and Economics (3).

Ren Wei, Gao Fan and Wang Dianru (2005), Shortage of mineral resources and establishment of mineral resource strategy system in China, Naturnal Resource Economics of China (5).

Ricardo D (1962), On the principles of political economy and taxation. Beijing: Economic Science Press.

Ross M (1999), The political economy of the resource curse, World Politics 51(2).

Sachs J and Warner A (1995), Natural resource abundance and economic growth, NBER Working Paper No.5398.

Sachs J and Warner A (2001), The curse of natural resources, European Economic Review 45, 827-838.

Sachs J D and Warner A M (1997), Natural resource abundance and economic growth, Center for International Development and Harvard Institute for International Development, Harvard University, Cambridge MA.

Sachs J D and Warner A M (1998), The big push, natural resource booms and growth, Journal of Development Economics 59, 43-76.

Samuelson P A and NuoDeHaoSi W D (1999), Economics, Beijing: Hua Xia Publishing House.

Shan Haiping (2005), The industry of mineral resources and its sustainable development, Naturnal Resource Economics of China (12).16-18

Shao Shuai and Qi Zhongying (2008), Energy development and economic growth in Western China: An empirical analysis based on the resource curse hypothesis, Economic Research Journal (4).

Shen Ling (2003), China mineral resource's features and sustainable development strategy, Science & Technology Progress and Policy (13).45-46

Sheng Jian (2009), Natural resource and middle region economic growth, Journal of Henan Business College (1).38-42

Smith A (1997), An inquiry into the nature and causes of the wealth of nations, Beijing: The Commercial Press.

Solow M R (1999), Growth theory: An exposition, Beijing: Economic Science Press.

Song Shouzhi, Zhong Yong and Xing Jun (2006), Situation and development of comprehensive utilization of mineral resource, Metal Mine (11).1-4

Sun Jingyu (2007), The interest groups and the institutional change: An analysis on the mystery during transformation, Jiangsu Social Sciences (4).82-89

Sun Zhaorong (2007), Scientific concept of development, the transformation of economic growth and building a resource-saving and environment-friendly society, China High Technology Enterprises (5).209-210

Torvik R (2001), Learning by doing and the Dutch disease, European Economic Review 45.

Torvik R (2002), Natural resources, rent seeking and welfare, Journal of Development Economics 67.

Walras L (1997), The mere Economics to justice, Beijing: The Commercial Press.

Wang Haijian (2000), Exhaustible resources, environment pollution and endogenous economic growth, Fudan Journal(Social Sciences Edition) (1).

Wang Hao (2007), Regional leading industry selection: comparative advantage method, Journal of Changsha University (6).28-29

Wang Huahua (2006), Research on the natural economic resources price, Cheng Du: Sichuan University.

Wang Juanzhi (1996), Western economic think tanks, Beijing: Economic Science Press.

Wang Meihong, Sun Gennian and Kang Guodong (2009), A spatial dislocation analysis of natural capital, human capital and economic capital in the mainland China, Studies in Science of Science (1).59-65

Wang Shaoguang and Hu angang (1999), China: The political economy of uneven development, Beijing: China Plan Publishing Company.

Wang Yongsheng (2004), Land and resources' sustainable utilizing by developing recycling economy, China Mining Magazine (6).

Wang Yongxue and Chen Sanxia (2007), Mineral resource, environment and China economic development, China High Technology Enterprises (8).41

Wang Zhihui (2008), The research on the Paradox of natural resources endowment and economic growth, PhD Thesis, Jilin University.

Wei Houkai (1997), China regional development: Economic growth, institutional change and regional differences, Beijing: Economy & Management Publishing House.

World Commission on Environment and Development (1997), Our common future, Jilin: Jilin People's Publishing House.

Wright G and Czelutsa J (2002), Resource-based economic growth, past and present, Stanford University.

Wu Fuke, Hu Shigeng and Zeng Xianchu (2007), The dynamic effect of the social status on macroeconomic variables, Journal of Quantitative & Technical Economics (8).109-118

Wu Meifang (2007), Resource course and economic development: Using Shanxi data, On Economic Problems (10).

Wu Qiang (2008), Environmental cost and demonstration of mineral resources exploitation, PhD Thesis, China University of Geosciences.

Wu Wenjie, Li Meiyu and Li Meiying (2008), Improving the system of land use for mining

development: An important way for elimination of the “Resource Curse” of China’s oil and gas resources area, Natural Resource Economics of China (1).

Wu Xinwen (2008), The role and relationship study of natural resources in the economic growth, China Economist (10).7-9

Xie Chen, Li Zhou and Zhang Xiaohui (2007), Forest resources, forest reform and rural forestry development in China, Forestry Economics (1).132-135

Xie Sanming (2001), China's economic growth potential and economic cycle research, Beijing: China Plan Publishing Company.

Xu Kangning and Han Jian (2005), “Resource Curse” effect on regional economy in China: Another explanation to regional discrepancy, Economist (6).127-133

Xu Kangning and Wang Jian (2005), Course of Chinese industrialization: International comparison and complex development strategy, Jianghai Academic Journal (Bimonthly) (3).63-69

Xu Kangning and Wang Jian (2006), An empirical study of a linkage between natural resource abundance and economic development, Economic Research Journal (1).69-102

Xu Shaoshi (2008), Speed up development and reform, improve the ability of mineral resources protection, Journal of China National School of Administration (2).4-7

Xu Zhaoyang and Shen Bin (2007), Strategic mergers, resource-reallocation & economic growth, Commercial Research (11).

Xue Yazhou and Hu Dewen (2005), Developing circular economy, strengthen the comprehensive utilization of mineral resources, China Economic and Trade Herald (10).24

Xue Yazhou and Liang Zhenjie (2005), China mineral resource economic situation and outlook, China Economic and Trade Herald (8).18-19

Yan Junyin and Zhao Guojie (2006), Analysis on the resources requirement for regional sustainable development of social economy, Journal of Shijiazhuang University of Economics (4).

Yang Duogui, Zhou Zhitian, Chen Shaofeng and Wang Haiyan (2004), China future economic growth trend and strategy choice, Shanghai Economic Review (6).5-12

Yang Fenglin, Chen Jinxin, Yang Jingyu (1996), A development of economic growth theory, Economic Science (1).

Yang Lei, Guan Xiangyong and Liu Yu (2008), Resource endowment, path reliance and economic growth-empirical analysis of Shaanxi, Journal of Xi’an University of Post and Telecommunications (2).62-64

Yang Yang (2008). A research of Chinese economic growth drag c39-53aused by land, PhD Thesis, Zhejiang University.

Yang Yong (2008), Research on relationship between tourism resources and tourism development, Research on Economics and Management (7).22-27

Yao Congli (2008), Economic development mode change in reconstruction of the western ecological environment, Research on Development (4).45-49

Yao Fang, Sun Linyan and Zhou Mi (2008), Comparative analysis on regional manufacturing industries in China, Journal of Xi’an Jiaotong University (Social Sciences) (1).19-24

Ye Yumin (2000), China's regional development, Beijing: China Light Industry Press.

Yin Bibo and Fan Fangzhi (2004), The source of economic growth: Resources endowment, technology or institution? Journal of Guizhou College of Finance and Economics (5).5-8

Yu Jiang (2008), Resource constraints, structural change and economic growth, Beijing: People Publishing House.

Yuan Fuhua (2008), Development of labor resources and economic growth: Theory, history and rerspective, China Opening Herald (2)11-18

Yue Liping (2007), A study of natural resources restriction and economic growth mechanism, Xi An: Northwestern University.

Zhang Feigei, Liu Gang and Shen Lei (2007), Research on relationship between resource abundance and regional economy development in China: Based on resource curse theory, China Population Resources and Environment (4).

Zhang Fuming and Jing Puqiu (2006), Resource-based economy and its transition review, Social Sciences in China (6).78-87

Zhang Gongsheng (2008), Resource curse: A debatable proposition, Finance and Trade Research (6).88-91

Zhang Hongwei and Cheng Lin (2009), Discussing resource, environment, economic growth and scientific outlook on development, Tian Fu New Idea (3).

Zhang Huixin (2009), The dynamic mechanism study of China's resource-based industry cluster, Xi An: Northwestern University.

Zhang Jinghua (2008), Is natural resource gospel or curse: Analysis based on natural resource function, Social Science Research (6).

Zhang Jiying (2009), Thinking about the theory of industrial restructuring in Gansu-based on the angle of main functional region, Journal of Lanzhou Jiaotong University (2).

Zhang Jun, Shi Shaohua and Chen Shiyi (2003), The industry reform and efficiency change in China: Methodology, data, literatures and conclusions, China Economic Quarterly (4).

Zhang Liangliang (2008), Mineral resource enrichment, natural bonus and resource curse: problem and measure of economic growth in Inner Mongolia, World Economic Outlook (6).

Zhang Qian (2008), Resource, environment constraint and economic growth, Economic Tribune (14).

Zhang Xiaofeng (2009), The primary study of nonferrous metals industry recycling economy development, Environmental Protection and Circular Economy (6).

Zhang Yan, Zhang Hong and Peng Buzhuo (2001), Natural resources and economic development in a region, resources and environment, The Yangtza Basin (2).

Zhang Yuyan (1992), Economic development and system choice, Beijing: China Renmin University Publishing.

Zhang Zhanren (2008), Research on correlation mechanism among education, natural resource and economic development in Karst-geographical counties of Guangxi, Master Thesis, Guangxi Normal University.

Zhao Fengjun (2006), Resource curse: A literature review, Journal of Chongqing Technology and Business University (West Forum) 16(1).

Zhao Guoyou (2006), Study on the relations between the comparative advantage of labor resources and the energy safety in China-based on future perspective, but non-current benefit,

Finance and Trade Research (5).

Zhao Hongtu (2007), Energy crisis: Myth and reality, Contempo Rary International Relations (9).

Zhao Pengda and Chen Jianping (2000), Prospect of mineral resources economics in the 21st century, Journal of Natural Resources (3).

Zhao Pengda and Chen Jianping (2000), System of nontraditional mineral resources and its key problem, Advance in Earth Sciences (3).

Zhao Xia (2008), Natural resource and regional economic growth: A summary, Technoeconomics & Management Research (2).

Zhao Xianzhou (2007), From limited growth & end-of-pipe-treatment to circular economy: A summary of economic growth theories in restriction of resources and environment, Journal of Zhengzhou Economics & Management Institute (2).

Zhong Bing and Fu Lei (2007), China mineral resource comprehensive utilization situation analysis, Enterprise Reform and Management (11).

Zhou Hongchun, Wang Ruijiang and Chen Renyi (2004), China mineral resource situation and development strategy after join in WTO, Review of Economic Research (52).

Zhou Peng (2005), A contrastive study of economic development between the China's resource-oriented and processing-oriented areas: A case study between Shanxi and Zhejiang Province, Economic Geography (3).

Zhou Qiye (1989), Regional economics, Beijing: China Renmin University Publishing.

Zhou Shaobo and Hu Shigeng (2003), Dynamic analysis to natural Rresources and economic growth model, Wuhan University Journal(Natural Science Edition) (5).

Zhou Xinqin (2003), The sustainable development in undeveloped area, Chong Qin: Southwest China Normal University.

Zhu Xun (2001), China mining task and development strategy in new century, China Mining Magazine (1).

Zou H (1994), The spirit of capitalism and long-run growth, European Journal of Political Economy (11). 279-293

Zou H (1998), The spirit of capitalism, social status, money, and accumulation, Journal of Economics (68). 219-233