LUND UNIVERSITY
School of Economics and Management

Master programme in Economic Growth,
Innovation and Spatial Dynamics

An Empirical Study of Shanxi's Coal Resource-dependent Economic Development

Yue Wu

egi12ywu@student.lu.se

Abstract: China's economic development has made a remarkable achievement over the past three decades. However, compared with other developed economies, it still mainly relies on coal resources as its primary energy. As country's leading coal resources producer, Shanxi is now in an awkward position. A possible explanation is this region suffering "Resource Curse": that the abundant resources did not bring rapid and comprehensive development, but instead, it generated a series of severe constraints. This paper attempts to provide evidence for resource curse theory through comparing Resource Abundance Index with economic growth among China's 27 regions; and then to analyse Shanxi's plight from several particular aspects. It is relevant to show a picture that these constraints, as explanations to resource curse, based on Circular Cumulative Causation theory, has formed a backwash effects, which in turn exacerbated the resource curse on regional economic development.

Key words: Regional economic development; Resource curse; Circular cumulative causation (CCC) effects.

EKHR 71:

Master Thesis, first year (15 credits ECTS)
June 2013
Supervisor: Martin Andersson
Examiner: Astrid Kander

Contents

1. Introduction

Natural endowment, physical capital, technical progress, public order, law and values have been revealed and placed in an outstanding position successively in studying the economic growth. Among them, natural resources, as the essential inputs for material production activities, once were fully affirmed to be especially significant. North (1955) and Innis (1956) claimed that the abundance of natural resources has a positive impact on developing countries' economic growth, for it is the premise and source to capital accumulation. The rapid industrialization in Scandinavian and the U.S. indeed set a good example. For those less developed countries that lacking capital investment and technological innovation, exporting resources and resource-intensive products tend to be an important means to acquire foreign exchange earnings; and furthermore be an effective way to provide necessary financial support for the expansion of domestic investment and the process of industrialization.

However, since 1980s, it is becoming increasingly difficult to ignore the phenomenon that a growing number of resource abundant economies fell into the growth trap. Countries such as Nigeria and Venezuela are rich in oil but experienced severe economic crisis. Their very different situation becomes the evidence of an opposite view. By contrast, Japan, South Korea, Taiwan, Hong Kong and Singapore are all resource-poor but had remarkable achievements in their own development. In fact the discussion about the negative correlation between natural resources and economic growth became frequent since 1950s. The Core-periphery theory (Prebisch, 1950) and the Deteriorating Trade Terms Theory (Singer, 1950) both argued that the dependence on primary exports leads to the terms of trade deterioration, which in further widen the gap between less-developed and industrialized countries. In addition, the New Growth Theory (Romer, 1986; Lucas, 1988) reseals the paradox between natural resources and economic development by analysing the increasing return to scale and endogenous technological progress. Auty first named this "Resource Curse" in 1994. He found that abundant natural resource became restriction to those countries' economic growth.

Currently, most of theoretical interpretation and empirical study for resources rich regions' curse phenomenon still concentrate at national level. Whether there is a similar paradox in regional level within a country? As one of the coal richest province in China, Shanxi produced about 10 billion metric tons of raw coal during the period from 1979 to 2011, accounting for around 28% of the country's total output. Considering China is a country with coal dominant energy structure, Shanxi's development has strategic significance for national energy security, which means even a small action of its industries may have impact on China's energy structure.

1.1 Research questions

By choosing quantitative case study of one single province, this paper analyzes Shanxi Province's coal resource-based economic development with its constraints and then put forward to path choice of new energy base establishment.

It first attempts to investigate the hypothesis that resource is becoming a curse for Shanxi Province's development. It begins at introducing Shanxi's coal dependence through the employment situation and mining industry prosperity. After calculating economic growth (GDP per capita) and Resource Abundance Index (RAI) within 27 province-level regions, Shanxi's general development situation could be revealed.

The second hypothesis is that the resource curse in fact triggered the Circular Cumulative Causation effects (CCC). Theoretically, a change of one factor will lead to successive changes in other factors; and these changes will continue in a cycle. Paper will try to combine several prominent problems as factors in analysing Shanxi's development difficulties. It first will investigate the structural change of Shanxi over period of 1992 and 2011; then will analyse indicators related to crowding-out effects on human resources, such as the changes of government appropriation in aspects of education and R&D, the number of patents application accepted and granted per 10,000 populations. Income inequity will be another main aspect. Based on Kuznets Curve theory, as the economy develops, the inequity should be first enlarged and then be narrowed. What the paper wants to find is that whether there is a turning point in this region. It will be supportive that over dependence on natural resources also led to the occurrence of rent-seeking, corruption, and environment deterioration problem. Furthermore, it is more important to put weight on explaining the backwash effects but not spread effects existing in region now.

Then the question would be how to get rid of dilemma, which in other words, path choice of transition. It targets to form a new energy base through the establishment of regional innovation system. The paper offers several aspects of recommendation, which specifically includes system innovation; technological innovation; human capital accumulation; and industrial diversification.

1.2 Research justification

It is expected that these findings of the study could have implications for further policy formulation and implementation. Being a typical and representative case of resources-based region, Shanxi' path choice of economic transition will provide both experience and lessons to other regions which are attempting to break the resource advantages dilemma. In addition, the country now is under increasing severe pressure of energy issues – the high speed of economic growth relying on high level of energy input and coal resource is still the key components of current energy structure. Hence, the energy transition is expected to get a clue from the case of Shanxi, which may improve Shanxi's status throughout country as well. Furthermore, it is hopeful to call for regional cooperation. Theoretically, the resource curse may generate crowding-out effect to technological and human capital development, thus, balancing the allocation of human capital is vital to deal the urgent situation of widening regional disparity in China. At last, the current studies more focus on exacerbating imbalance between regions, rather than within regions. It is hope to arouse the attention on enlarging imbalance especially in resources regions.

1.3 Basic frame of paper

The paper is divided as follows: section 2 takes a glimpse at the previous research of existence and explanation on resource curse; section 3 provides the basic context of current economic development and energy structure in both China and Shanxi Provinces; section 4 is the analysis of Shanxi's economic development, first it introduces region's heavy dependence on coal industry, then it investigates Shanxi's existence of resource curse; this is followed by of section 5: analysing the constraints of region's economic development due to resources dependence; section 6 is the conclusion and also the explanation for circular cumulative causation effects; section 7 is the last part that offers possibilities for structural transition.

1.4 Limitation

The data of GDP per capita and income per capita are chosen directly from *Statistical Yearbook*, obviously it used registered population when calculating. As is known, China has being a large amount of unregistered floating population since "Reform and Openness" in 1978. It is very common that higher degree of labour forces who register in one region choose to work in another more developed region. However, this situation could not be reflected in the statistics, which may lead to deviation of results. Those core regions and cities absorb much more capital than the periphery, basically enlarging the regional imbalance. But if the paper could get the result that resources dependence led to the inequality by existing data, this kind of deviation will not have much influence for analysis. Historical factor should be taken into consideration as well. The geographer Baron Richthofen introduced Shanxi "one of the most remarkable coal and iron regions in the world" in 1870 (cited by Thompson, 2011). Learning history could be helpful to have a better understanding of region's development; however, the paper will not involve it this time.

2. Literature review

2.1 Resource curse

The concept of "Resource Curse" was first proposed by Auty in 1994. After studying the development in mine production countries, he found that resource-abundance became restriction to those countries' economic growth. In fact, a large number of attempts have been made to prove the existence of resource curse. Through investigating 95 developing countries' GDP growth rate from 1970 to 1989, Sachs and Warner (1995, 1997, and 1999) found that only two resource-abundant countries had a growth rate faster than 2 percent; in addition, the economic growth will decline by 1 percent as every 16 percent increase in the proportion of resource-intensive exports to GNP. Furthermore, although taking into consideration of other factors such as price fluctuation and regional effects, the negative correlation of resource and economic growth still existed. More recently studies by Isham (2002), and Musrshed and Perala (2001) reveal that point resources (such as mineral resources) economies are more vulnerable to suffer the resource curse, for the reason that government could get access to largely income directly through centralized mining, which in turn breeds a corrupt and predatory government. However, resource curse is still not an iron law. Brunnschweiler (2007) took institutional factor into examining the resource effect and found a positive correlation between resources abundance and economic development. Davis (1995) demonstrated a similar result after analysing the Resource Abundance Index (RAI) according to the ratio of resources production and total production of 91 resource-wealth countries from 1970 to 1991. In addition, Stijns (2001) argued that it has no clear evidence to prove the negative correlation due to that various measurements and understanding of RAI may lead to different conclusions.

Meanwhile, numerous studies have attempted to explain the resource curse. These studies support the hypothesis that natural resource produces the crowding-out effect on some other essential factors which crucial economic growth. Gylfason

(2001) called this the Transmission Mechanisms of resource curse. Basically it has following several kinds of transmission mechanisms.

i. Countries and regions with single resource-intensive industrial structure tend to be trapped into the “Dutch Disease”. In the theoretical model, there exists three sectors: traded manufacturing sector; traded resource-export sector; and non-traded good sectors (domestic construction sector, retail trade sector, and the tertiary sector). The sudden discovery of natural resources or an unexpected rise of resource price will cause two consequences. Firstly, as a large amount of labour and capital input turn to resource-export sector, the traded manufacturing sector forces to spend more on attracting labour force; meanwhile, the increase in foreign exchange earnings due to the natural resources export makes the currency appreciation. Hence, the competitiveness of traded-manufacturing sector would be hugely shocked. This is so called “resource movement effect”. Secondly, the growing income from exporting resources will increase the demand for the products in manufacturing and non-traded sectors. However, by this time satisfying the demand is through importing relatively cheaper manufactured goods, which causes the “spending effect” (Corden and Nerary, 1982; Corden 1984).

ii. Another explanation is the crowding-out effect on human capital. Gylfason’s study (2001) revealed that countries with an abundance of resource tend to underestimate the long-term value of education and human capital investment. Resource exploitation sector in resource-abundant countries has a serious shortage of highly skilled labour force. The relative low return on investment forces the human capital outflow to other sectors. In addition, being a capital-intensive sector, its technology diffusion is severely constrained. As a result, over-reliance on natural resources will neglect the accumulation of foreign capital, human capital and social capital.

iii. Rent-seeking becomes one reason of resource curse as well. Torvik (2002) built a model to investigate the rent-seeking transmission mechanisms. The result showed that the inefficiency allocation of productive resources triggered by resource abundance can lead to the generation of unproductive rent-seeking, finally giving birth to corruption. Because most developing countries lack of sound legal system and property rights arrangements, the operators tends to obtain the entry permits through rent seeking. What worse, the capital outflows caused by the corruption seriously distorted country's economic activity. Bardhen found that "corruption has its adverse effects not just on static efficiency but also on investment and growth" (1997). A payment for bribes in order to get license obviously reduces the incentive of long term investment and economic development.

iv. Quite a few studies attempted to explain the transmission mechanisms from institutional perspective. After estimating different countries' development path, Auty (2001) concluded that institutional system in resource-dependent countries lagged relatively, especially in countries with abundant point resources. The studies of Sala-I-Martin & Subramanian (2003) and Isham et al.(2003, cited by Sala-I-Martin & Subramanian, 2003) found similar result that the democratization process is always fall behind in one country with heavy reliance on resource exports. Resource advantage of those abundance countries tends to hinder the intensive for government's system innovation, thus delaying the process of industrialization and market diversification. As is well known, innovation mechanisms is the driving force to the whole society, the lack of institutional innovation will force the country to face the recession eventually.

Chinese scholars value the hypothesis of resource curse as well in recent years. Xu and Wang (2006) did a comparative analysis based on relevant penal data during the years 1978 and 2003 to verify the existence of resource curse in provincial level of China. The findings showed that the economic development was restricted by the recession of manufacturing and the weakness of institution. The crowding-out effect on the human capital and technological innovation could be found in China, too. The study of Shao and Qi (2009) focused on development in the west of China and indicated that under the "West Development Strategy", resource curse appeared more seriously. There are several other reasons may trigger the resource curse: resource-based industries fluctuated dramatically as the policy changes; resource-based industries have characteristic as diminishing marginal returns; it tends to form the local protectionism in resource-rich regions; the loose spatial structure of resource-dependent economy may cause the lag-behind of infrastructure construction (Zhang, 2002; Luo & Shang, 2008; Ding & Zuo, 2008).

2.2 Circular cumulative causation effects

Circular cumulative causation (CCC) is a multi-causal approach where delineated according to the core variable and its linkages. A change of one social-economic factor will bring about successive changes in other factors; and these changes, in turn, will strengthen the initial core factor's impact to the whole social and economic system. Hence, the relationships between these variables not tend towards equilibrium, but the movement in a circular manner. Myrdal formulated the CCC for the first time in his book of *An American Dilemma – the Negro Problem and Modern Democracy* (1944) in testing hypothesis of circular causation between prejudice and poverty. He uncovered that the prejudice and discrimination the white against the black led to the black's low level of material and cultural aspects; and the black's poverty and poor education, which in turn increased the discrimination from the white. In this way, this movement is not a simple circular flow but along with a cumulative effect.

In the book of *Economic Theory and Underdeveloped Regions* (1957), Myrdal divided the circular cumulative process into two opposite directions: upward and downward, in explaining the problem of the increasing inequality observed between industrialized and developing countries. He criticized that adjusting allocation of resources spontaneously through market mechanism is impossible for undeveloped countries' balanced development. Thus, a dynamic non-equilibrium and structuralism analysis method should be adopted. Theoretically, factors in the social and economic systems tend to cumulate within a positive or negative cycle. Once certain areas develop ahead due to initial comparative advantage, this advantage will be maintained. The cumulative circle further strengthens the uneven situations, thus causing two distinct effects. One is the Backwash Effects, which means under the influence of the income differences, production elements such as labour force, capital and technology tend to flow into central areas from periphery. As a result, the declining cumulative circle will widen the regional gap. The other one is the Spread Effects. When one economy develops to a certain extent, the external economic benefits become smaller gradually and thus weaken the momentum of growth. Further expanding the scale of production in developed areas will be uneconomical, so those inputs will begin to spread back to periphery. As a result, the Spread Effects will bring a rising cumulative circle and finally narrow the regional gap.

He also pointed out that the market mechanism allows the backwash effects to precede and also have greater influence than the spread effects. Once one region's pace of development faster than the average, it will achieve the continuous accumulation competitive advantage. The developed regions continue to absorb those advantage factors while the backward areas only can accept those unfavourable factors. Hence, the market forces generally tend to enlarge rather than narrow the imbalance: that the coexistence of economically developed and underdeveloped regions often becomes a consequence of such process of circular cumulative causation. Therefore, in order to fill the gap due to the circular cumulative causation, it stresses governments intervene to take proactive policies to stimulate backward areas' economic development, rather than waiting passively for the spread effects come from developed areas.

Kaldor (1966, 1970) made a great contribution to the CCC theory's development as well. He attributed different economic performance to the efficiency wage, which is, the relative low level of efficiency wage induces high economic growth. Theoretically, the increasing return to scale improves the productivity and thus reduces the efficiency wage. He stated that productivity growth in manufacturing sector due to increasing returns to scale will cause labour force inflow from other non-manufacturing sectors. Consequently, the export competitiveness will be enhanced and in turn the increased export will promote the production of manufacturing sector. Therefore it forms a rising and positive cumulative circle.

2.3 The Kuznets curve

The Kuznets curve, which was proposed by Simon Kuznets in 1955, is used to describe that the income distribution changes with the process of economic development. Kuznets (1955) analyzed this change happens based on the transition process from traditional agricultural to modern industry. If the horizontal axis represents some of the indicators of economic development (usually the output value per capita) while the vertical axis represents the degree of income inequality, so the relationship of this hypothesis is revealed in an inverted U-shape. Theoretically, three factors affect the change of income distribution: the ratios of individuals divided by sectors; the income difference between the sectors; and the income inequality within the sector. During the underdevelopment stage, the income inequality which driven by increasing ratio of non-agricultural sector (high degree of inequality) becomes wider; then after experiencing a temporary period without obvious changes and entering into the fully developed stage, the non-agricultural sector becomes dominant and the income differences among sectors will be narrowed. Thus, the internal income distribution tends to be balanced.

However, quite a few studies questioned its validity. Take the East Asian Miracle (EAM) as an example. Relied on export-oriented pattern and remarkable reforms on education, industry, etc., the East Asian countries' success along with an immediate decrease in inequality, which was not match to the Kuznets curve theory. In addition, as the process of economic development, the inequality in third-world countries is widening and still has no sign of change.

2.4 Innovation policy

Innovation is ranking on the top of policy agendas today both in national and regional perspectives. The Lundvall & Borras's report in 1997 provides a definition of innovation policy which "refers to elements of science, technology and industrial policy that explicitly aim at promoting the development, spread and efficient use of new products, services and processes in markets or inside private and public organizations; the main focus is on the impact on economic performance and social cohesion" (p.37). For there is no "ideal model", two main kinds of approaches, regional innovation systems (RIS) approach and knowledge bases approach, are recognised in studying regional innovation policy through investigating different innovation preconditions and innovation activities among peripheral, old industrial and metropolitan regions.

2.4.1 RIS approach

The RIS approach studies the regional level differences based on their own strengths and weaknesses. Tödding & Trippl (2005, pp. 1203-1219) developed this approach to regional policy dimension thus RIS includes three subsystems: knowledge generation and diffusion; knowledge application and exploitation; policy making and implementation. It is worth notice that the active interaction among subsystems enhances regional R&D competencies and quality of human resource. However, there are also three types of system failures limit the functioning of regional innovation policy. First is organizational thinness which due to an underdeveloped organisational and institutional setting up (Tödding & Trippl, 2005, pp. 1203-1219); second is lock-in occurs in regional old industries; the last, opposite to the second one is called fragmentation, which is the situation of lacking linkage and cooperation between institutions in RIS.

Tödding & Trippl detailed problematic regions into three types based on failures mentioned above. Peripheral regions are regions mainly poor in building knowledge base. Clusters or networks and innovation activities are far more sufficient in periphery that knowledge application and exploitation is much rely on the participation of SMEs (Small and Medium-sized Enterprises). Similarly, knowledge generation and diffusion subsystem is inefficiency with the low level of R&D inputs and patenting. Combined with undeveloped institutional structure, this district could not be an attractor of high-skilled labour. The barrier of 'lock-in' most distinguished in old industrial regions. Old industrial regions often have high level of specialization thus the problem becomes the over strong clustering. Clearly, knowledge generation and diffusion develop quite well in these old industries while the lock-in limits the interaction among various actors. Metropolitan regions could also meet barriers in the innovation process when knowledge clustering and innovation networking are both week. Fragmentation is their main challenge. These districts gain abundant support for R&D development in both public and private sectors but have little links between the first two subsystems.

For peripheral regions, catch-up learning should be put into priority. It is essential to encourage more firms into innovation process and connect subsystems both inner and outside regions. Those old industrial regions ought to break lock-in and focus on new and renew industries' upgrading comprehensively. The core thinking to metropolitan regions should be improving RIS in the perspective of global knowledge economy. Building close linkage of university-industry is an effective way to turn the situation of separation of knowledge generation and application.

2.4.2 Knowledge bases approach

Asheim and Gertler (2005) argued that the innovation process of firms and industries is particularly dependent on their specific knowledge base. There are three types of knowledge base for different industrial sector – "analytical" "synthetic" and "symbolic".

Analytical knowledge base deeply relies on scientific knowledge within industrial settings. It calls for knowledge creation which based on cognitive and rational process. In spite of their own R&D departments, firms high value the significance of universities and other research participants in RIS. In 'analytical' type of knowledge base, codified knowledge is more frequent than tacit due to the pattern of knowledge generation and application. Hence, there are numbers of documents and patent descriptions about scientific achievement. In addition, knowledge is more acquired in deductive processes. Analytical knowledge base is more often seen in the high technological sectors, such as genetics, biotechnology and information technology.

Synthetic knowledge base often within industrial settings where innovation process occurs through exist knowledge applications and combinations to meet the needs of solving specific problems. During this process, innovation actors keep interacting among each other. Here R&D inputs are less important than that in analytical knowledge base. The university-industry linkage is often limited into applied research aspect while industry-industry network is more dynamic. Tacit knowledge could be seen more frequently that much knowledge is acquired through an inductive process of "learning by doing". This means the spatial proximity is important relatively. This type of knowledge base is usually seen in industrial sectors such as machinery.

Symbolic knowledge base is similar to synthetic knowledge base while one obvious difference is that industrial products driven by symbolic knowledge base are generally intangible. The development and application of knowledge is in the creative process based on aesthetics, imagination, designing ability rather than natural cognitive process. As the products shift from "use-value" to "sign-value" (Lash & Urry, 1994, pp. 175-180), tacit knowledge plays significant role in innovation process and the requirement of face-to face communication calls for strong sensitivity toward spatial proximity among innovation actors. Typical examples of this knowledge base are film, music and design industries.

3. The context of economic development

3.1 China's current economic development

Being the economy with the world largest population, China has experienced a rapid growth for decades since 1978: the GDP per capita rose from 381 yuan to 35181 yuan in the end of 2011. However, it has been realized that the economic boom was at the price of excessive energy consumption and serious environmental pollution. It already has become the world's largest consumer for coal since 1986 and the second largest consumer for oil since 2002 (BP, 2009). Along with China's total GDP accounting for around 9.5% of the global total amount in 2010, the energy consumption took for 20% of the world primary energy consumption. The energy consumption growth has accelerated during the new century, from 1455 million tons of standard of coal equivalent (tce) in 2000 to 3249 million tons of tce in 2010 (CESY, 2011). Due to the rapid expansion of industries such as steel industry whose production rely on a large amount of energy inputs, China's industrial sector is extremely energy intensive and took around 70% of total energy consumption, compared 40% of global average. Moreover, China's energy utilization rate is only 34%, which is 10% lower than that of world advanced level. Hence, China's per capita energy consumption with the world average of roughly the same per capita GDP is only 50% of the world average; the total GDP are roughly the same, but the total energy consumption is 4.7 times that of Japan.

As an economy that consumes it as its main energy, coal resources is playing a vital role in securing China's rapid economic growth. Coal resources not only are the primary source of fuel for industrial sector, but also the main chemical raw materials and civilian energy. The rising price of oil and natural gas further stimulated the demand for coal. The 17th Party Congress (2007) submitted the goal of comprehensive establishing an affluent society of a higher standard in an all-round way for the benefit over 1.3 billion Chinese people: it is expected to quadruple country's 2000 GDP by 2020 to approximately 4 trillion US dollars with a per capita level of some 3,000 US dollars and basically accomplish industrialization. Although the proportion of coal energy consumption will decline slowly for a long time to come, the coal-dominated energy structure coult not be changed fundamentally. According to the national *Medium and Long-term Energy Development Plan for 2004-2020,* China's energy strategy will adhere to coal-based energy structure in the long term. Hence, it will continue to push the rapid growth in energy consumption, which will at least be doubled the current total consumption. It is expected that coal consumption will grow constantly and in 2020 it is estimated to reach to 2.4 billion tons.

China's heavy reliance on coal stands out in international comparison. In 2010, coal took up 68% of primary energy consumption, while the world average was around 29%. The energy structure is clearly unreasonable: as high quality of liquid and gas energy taking more than 60% of total energy consumption in present world, in China it is less than 23%. The situation of coal dependence undoubtedly caused huge pressure for social and economic sustainable development. On one side, taking coal as power fuel and chemical raw materials resulted in a waste of energy. On the other side, environmental contamination caused by coal-dominated energy consumption structure would increase the pollution treatment costs, leading to economic losses. According to the evaluating, 70% of soot and CO_2; 90% of SO_2; and 67% of nitrogen oxides come from coal, considering that China's atmospheric pollution SO_2 and CO_2 rank the world's first and second place, respectively.

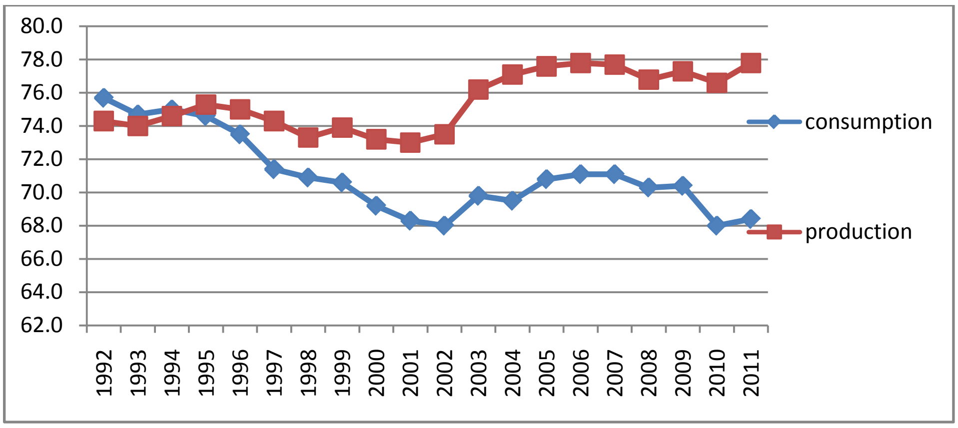


Figure 3.1 Coal as percentage of total energy production and consumption, 1992-2011. *Source: China Statistical Yearbook 2012.*

3.2 Shanxi’s context of coal resources and economic development

3.2.1 Coal resource endowments

The distribution of coal resources in China is uneven from region to region, with over 80 percent of coal reserves situated in north and northwest China. Possessing more than 260 billion metric tons of known coal deposits, Shanxi comes to about one third of China's total amount. It has coal storage area of 57,000 square kilometres, accounting for nearly 40 percent of total land area. According to the 1986 China’s national standards of coal classification, Shanxi owns 14 grades. Especially steam coal reserves in Datong City, the anthracite in Yangquan City and Jincheng City, and the rare coking coal reserves in Xiangning County are largely and widely distributed. The current exploitation maintains in the average depth of 300 to 500 meters, with relatively simple geological structure and good mining conditions. Holding the advantages on excellent quality with high calorific but low sulphur and low ash, Shanxi becomes a leading coal producer in China constantly. In the year of 2011, the production was more than 740 million metric tonnes, accounting for around 27.7% of country’s total amount. Taking two-thirds of volume in country’s coal market trade activity, over 500 million metric tonnes of total primary energy supply are sent out to other provinces annually. Furthermore, more than half of country’s coal exports come from Shanxi Province.

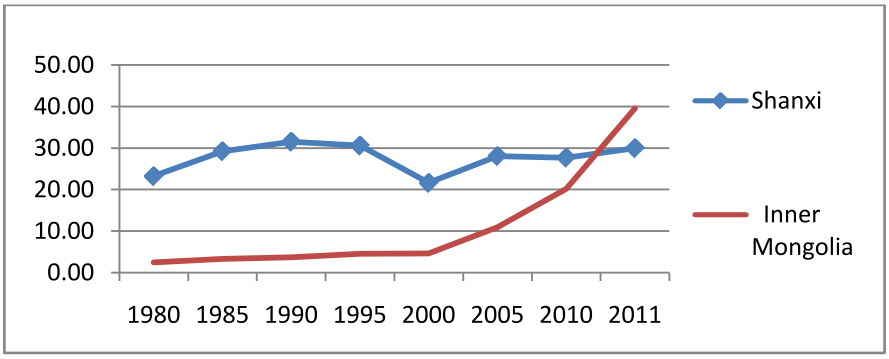


Figure 3.2.1 The proportion of Shanxi’s and Inner Mongolia’s coal production, 1980-2011.
Source: Shanxi Statistical Yearbook 2012; Inner Mongolia Statistical Yearbook 2012.

3.2.2 Shanxi's economic development

Since 1980s, the national coal exploitation strategy of "Strengthening the Eastern and Strategic Shift westward" established Shanxi's position as country's energy base. Relying on unique coal resources advantages and favourable geographic location, its coal industry has made rapid progress. Industry in Shanxi is concentrating around heavy industries such as coal and chemical production, power generation and metallurgy. The province's GDP rose from 42.93 billion yuan in 1990 to 1123.7 billion yuan in 2011; and GDP per capita increased from 1528 yuan to 31274 yuan. As the pillar industry of the province, coal industry contributes to 36% of industrial added value; over 37 percentage of Shanxi's tax revenue; and about half of Shanxi's GDP. Hence, the accumulated huge capital provides powerful driving force for regional economic development.

It is undeniable that Shanxi's development of coal industry chose an extensive mode that characterized as low level of utilization but high level of exploitation, consumption, emission and pollution, arousing a serious challenge for regional sustainable development. The energy intensity of Shanxi stays in high level over time. Meanwhile, coal industry lives with a certain impact of the international financial crisis since 2008. The dropping domestic demand for coal resulted in the decline of coal price and production. Overall, the traditional economic growth pattern is a great challenge for Shanxi Province, how to turn "Black GDP" to "Green GDP" becomes a key issue.

Such severe challenge could also become a golden opportunity. In order to guarantee the safe production, to reduce the energy consumption and to optimize the industrial structure, the government has made efforts to change the old "many, small and scattered" pattern through the implementation of coal resources integration. It aims at pursuing coal-mining scale extraction, mechanization, informatization and modernization (Leadership Office of Coal Mine Corporation Merger and Coal-Resource Integration of Shanxi, 2009). That the State Council approved Shanxi Province the establishment of "*National Resource-based Economy Comprehensive Reform Pilot Area*" in 2010 and the "*the Central Economic Zone Plan"* in the end of 2012 both marked Shanxi's further deepening reform. Basically, the government started from three aspects: the closure of small-scale mines, the improvement of mining productivity and the merger and acquisition of mining groups. Specifically, the mines with annual production below 30,000 tons, which accounted for over 80% of total production, must be closed. Meanwhile, large mining groups were established, calling for more comprehensive plans in terms of sustainable production and ecological restoration. Guo measured that after integration, large mining groups could raise the mining percentage extraction up to 87.13% (2009), which means four or five times of coal loss can be avoided (Wang and Liu, 2009).

4. Empirical analysis of resource curse in Shanxi Province

4.1 Resource dependence

4.1.1 Employment

Shanxi Province is a typical region that its economy heavily relies on mineral resources exploitation and coal production of Shanxi represents over 99 percent of total mineral resources production. This could be confirmed firstly through the indicator of employment. According to the proportion of employed persons of mining industry by registration status within country's 27 provincial level regions, there were 15 provinces with figure that higher than country's average in the end of 2011. Shanxi Province ranked the first place, around 20 persons in every 100 engaged in mining sector (calculated through data of Appendix 8). This situation is not accidental. Figure 4.1.1 shows mining's sustained and even greater contribution for Shanxi's employment in the last two decades. Although experiencing fluctuations during 1992 and 2011, the gap between Shanxi and country average became larger, rising from less than 10 percentages at the very beginning to more than 15 percentages in the end. Under the circumstance that in developed regions more employment opportunities are generated from the tertiary industry, Shanxi's dependence on the mining industry has deepened, on the contrary.

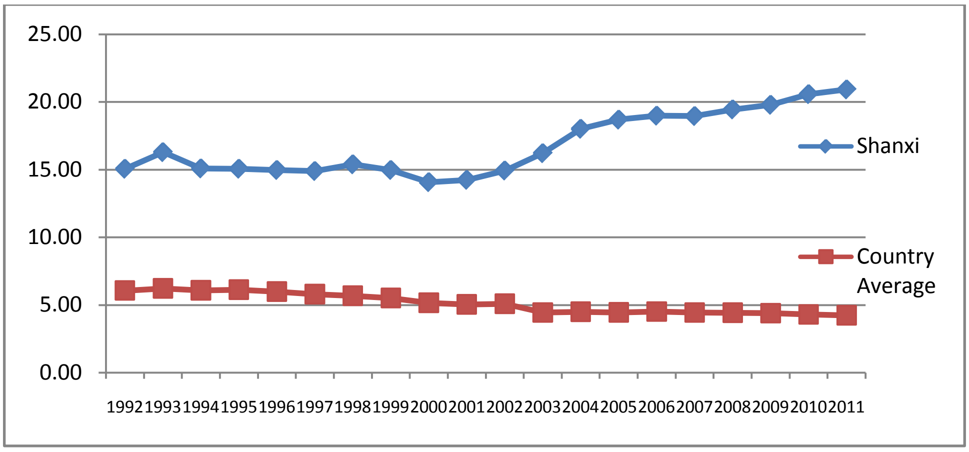


Figure 4.1.1 Proportion of Employed Persons of Mining Industry at Year-end Urban Units by Registration Status, 1992 -2011.
Source: China Statistical Database. Available online: http://www.stats.gov.cn/.

4.1.2 Mining industry development

Although had shrunk in a couple years, mining industry has generally been the dominance in regions industrial structure. Figure 4.1.2 below illustrates a U-shaped curve in terms contribution of mining industry added-value for region's GDP. During the stage from early 1980s to 1998 Shanxi coal industry had been fully developed; hence, it had a significant leap in aspects such as the scale of production, the size as well as the strength of firm, and the improvement of technical equipment. The coal production in 1993 exceeded 300 million tons, rising by nearly 200 million tons from 1979. As a result, the cumulative production of coal in this stage was around 4.75 billion tons, whose added-value brought more than 10 percent of region's GDP.

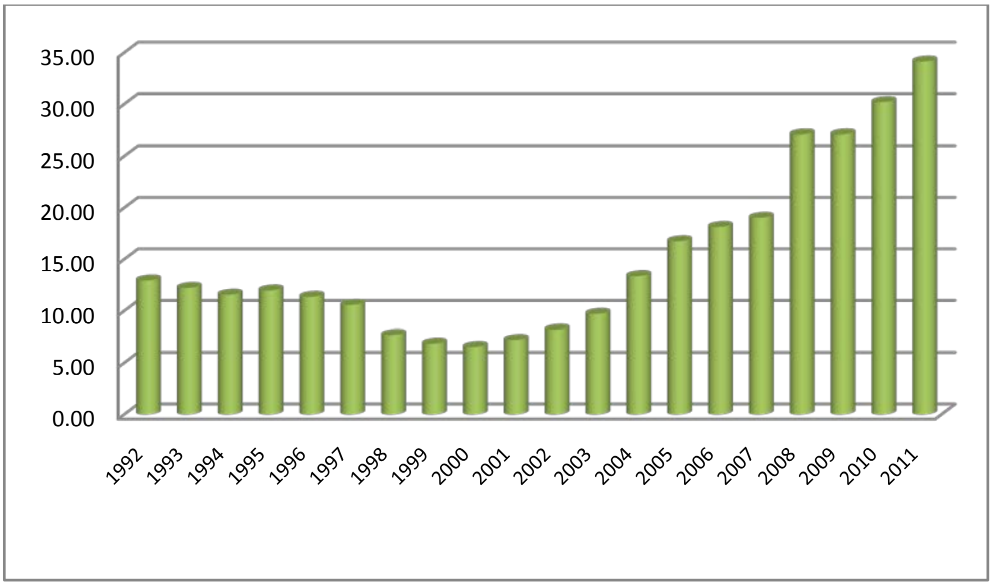


Figure 4.1.2. Proportion of mining industry added-value for Shanxi's GDP, 1992 – 2011.
Source: Shanxi Statistical Yearbook 2012.

However, in the mid-1990s, the structural contradiction appeared and gradually became more and more obvious. Since 1997, it formed the buyer's market at national scale: the serious surplus of coal production increasingly severed the economic situation. Continued falling of coal price led to serious loss for coal related industrial enterprises. In order to get out of the woods, a new structural adjustment had been implemented in the new century. Through eliminating a number of illegal and irrational coal mines with backward production capacity; and a serious of coal-based industrial upgrading projects such as Coal and Power Pool Project (CPPP), it made a significant progress in terms of coal comprehensive utilization. Thus, it showed an upward proportion of Shanxi's GDP that could attribute to mining industry added-value. In the end of 2011, the proportion reached to a new point with over 34 percent.

4.2 Investigation on Resource curse

Several attempts have been made to estimate resource abundance. Gylfason (2001) used the share of natural capital for national wealth to represent country's resources enrichment degree. National wealth here is the combination of natural capital, physical capital and human capital. The World Bank defines natural capital as the present value of rent flow generated by all expected green and mineral resources. Stijns (2006) adopted the ratio of natural capital and physical capital to avoid problems caused by human capital variable, which is namely, a potential misunderstanding that the more affluent resources, the less investment on education. Moreover, Sachs and Warner (1995) introduced the primary products exports intensity, which however, was criticized as more inclines to measure the trade simplification degree, but not resource abundance (Stijns, 2005). A similar indicator is the ratio of mineral products to total products exports (Davis, 1995). Nevertheless, because the shortage of statistics on cost as well as resources product value into and out of one province, it is problematic in measuring China's resource abundance through calculating rent or other indicators that using resource exports as numerator. In addition considering the significance of coal energy to China's industrialization, this paper constructed the Resource Abundance Index (RAI) mainly represented by coal resources.

RAI is constructed by scholars to illustrate China's inter-provincial level enrichment of energy resources. As is known, the three main primary energy production and consumption in China are coal, oil and natural gas.

$$\mathrm{RAI_i} = \frac{\mathrm{coal_i}}{\mathrm{coal}} * 75 + \frac{\mathrm{oil_i}}{\mathrm{oil}} * 17 + \frac{\mathrm{gas_i}}{\mathrm{gas}} * 2$$

Where i denotes one specific province; $\frac{\mathrm{coal}_{\mathrm{i}}}{\mathrm{coal}}$, $\frac{\mathrm{oil}_{\mathrm{i}}}{\mathrm{oil}}$, and $\frac{\mathrm{gas}_{\mathrm{i}}}{\mathrm{gas}}$ represent proportion of province i's reserves of coal, oil and natural gas to the country's total reserves of coal, oil and natural gas respectively. 75, 17, 2 are the three energy's proportions in China's primary energy production and consumption roughly. This paper choose same formula to estimate RAI, only adjusting the weight of three main energy about

75%, 15% and 3%, after averaging all forms of country's energy production from 1992 to 2011. Thus, the Resource Abundance Index (RAI) can be calculated as:

$$\mathrm{RAI_i} = \frac{\mathrm{coal_i}}{\mathrm{coal}} * 75 + \frac{\mathrm{oil_i}}{\mathrm{oil}} * 15 + \frac{\mathrm{gas_i}}{\mathrm{gas}} * 3$$

The provincial energy reserves are the average from 2003 to 2011 (China Statistical yearbook 2004-2012), in order to minimize the sample statistical error. The period chosen is due to there is no data about the provincial energy reserves before 2003.

The paper chooses GDP per capita as well as its growth rate in the period of 1992 and 2011 to indicate provincial economic performance. To eliminate the effects of inflation, the appropriate type of estimator is thus a "real growth rate" of GDP per capita in the following manner:

$$GR^i = \frac{1}{T} \cdot Ln \frac{PCGDP_T^i / P_T}{PCGDP_0^i / P_0}$$

where $\mathrm{GR^i}$ represents province i's average annual growth rate of GDP per capita; T denotes time period (T=19 in this paper); $\mathrm{PCGDP_0^i}$ and $\mathrm{PCGDP_T^i}$ are province i's GDP per capita at the beginning and the end of this period, here 0 and T represent two separate years of 1992 and 2011; $\mathrm{P_0}$ and $\mathrm{P_T}$ are province i's price level at the beginning and the end of the period, the paper chooses the Consumer Price Indices in two individual years of 1992 and 2011 *(China Statistical Database, available online: http://www.stats.gov.cn/)*.

The selected period from 1992 is mainly for two reasons. First of all, during that time previous economic reform was basically in the pilot phase that the control of government on strategic resources such as energy and mineral was still vigorous. Therefore, the statistical data before 1992 could not reflect the real market rules. The early stages of the "Dual System" reform damaged economic benefit of the central and western part of China where being the major suppliers of raw materials across the time. Part of their benefit was transferred to the coastal mainland manufacturers until the 1990-1991 when the "Dual system" was cancelled. Secondly, after 1992, the inter-provincial differences began to expand, arousing the necessary for studying regional inequality. The curve below represents the dispersion degree change of provinces' GDP per capita (Demurger et al, 2002). Obviously, there was a narrowing trend of inter-provincial differences until 1992 since "Reform and Openness". Considering the special circumstances of economic development, the sample excludes four municipalities of Beijing, Shanghai, Tianjin and Chongqing.

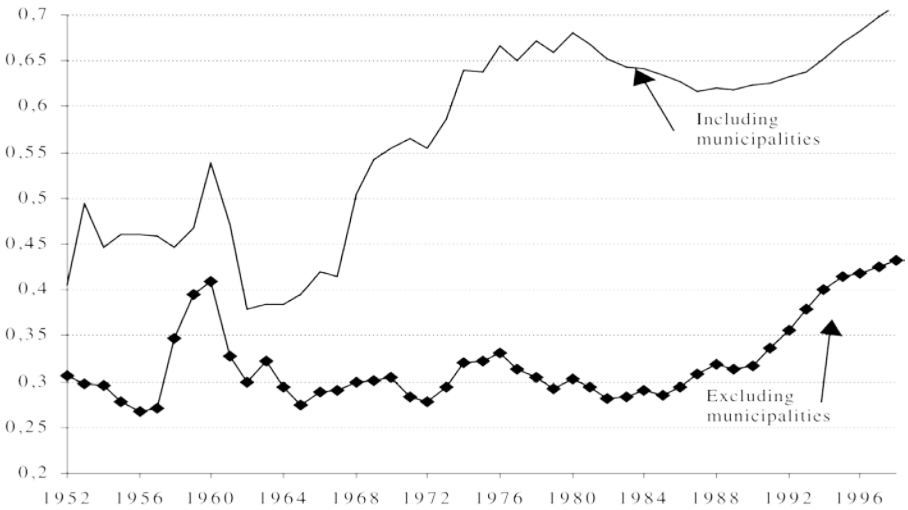


Figure 4.2.1 σ-Convergence across Chinese provinces, 1952 – 1998.
Source: Demurger et al (2002)
Note:

i. The vertical axis represents the degree of dispersion of provincial GDP per capita.
ii. Three metropolises here are Beijing, Shanghai, and Tianjin; the study by Demurger et al did not exclude city of Chongqing because it became municipality directly under the central government since 1997.

Table 4.2.1 provides the result of 27 provinces resource abundance (RAI), GDP per capita in 2011, annual growth rate of GDP per capita and their respective ranks. Inner Mongolia and Shaanxi are regions which had rapid economic growth along with abundant resources. They ranked first two places of GDP per capita growth rate and the second and the third in RAI ranks. Benefited from its relative less population, Inner Mongolia also ranked the third in the comparison of GDP per capita level, with 57974 yuan in 2011. Also being a resources rich region, Shandong's success relied on its coastal geographic location and higher degree of openness.

On the contrary, although lacking natural resource endowments, provinces like Jiangsu, Fujian and Zhejiang did pretty well performance in economic development with the help of their institutional advantages. More than three decades of development since the “Reform and Openness” generated significant differences of ownership structure among regions. As it shown in the table, in 2011, Jiangsu and Zhejiang became the two biggest regional economies in China with relative high level of growth rate.

Table 4.2.1 China's 27 provinces resource abundance, the GDP per capita, and the annual growth rate of GDP per capita with their rankings

	RAI	Rank	G (yuan)	Rank	GRi (%)	Rank
Shanxi	24.1888	1	31357	14	15.02	17
Inner Mongolia	18.3071	2	57974	3	18.18	1
Shaanxi	7.5042	3	33464	11	16.41	2
Xinjiang	6.2058	4	30087	15	13.35	25
Heilongjiang	4.9660	5	32819	13	13.40	24
Shandong	3.9947	6	47335	7	15.50	9
Guizhou	3.2038	7	16413	27	14.77	18
Henan	3.1484	8	28661	19	15.86	4
Hebei	2.6844	9	33969	10	15.21	14
Anhui	2.5460	10	25659	22	15.56	8
Yunnan	2.1938	11	19265	26	13.23	26
Liaoning	2.0295	12	50760	5	14.01	23
Gansu	1.8394	13	19595	25	14.10	21
Sichuan	1.7210	14	26133	21	15.33	11
Ningxia	1.4370	15	33043	12	15.77	5
Jilin	1.2748	16	38460	8	15.10	16
Qinghai	0.8171	17	29522	17	14.54	19
Jiangsu	0.5716	18	62290	1	16.09	3
Hunan	0.4578	19	29880	16	15.74	6
Guangxi	0.1899	20	25326	23	15.13	15
Jiangxi	0.1760	21	26150	20	15.29	12
Hubei	0.1386	22	34197	9	15.29	13
Fujian	0.1058	23	47377	6	15.61	7
Guangdong	0.0415	24	50807	4	14.16	20
Hainan	0.0242	25	28898	18	12.49	27
Zhejiang	0.0117	26	59249	2	15.48	10
Tibet	0.0028	27	20077	24	14.10	22
Average	3.3253		34769		14.99	

Source: China Statistical Database. Available online: http://www.stats.gov.cn/.

However, several resources-abundant regions such as Shanxi, Guizhou and Yunnan fell behind. Among them, Shanxi Province had highest RAI with 24.1888, which was more than 7 times the country's average. On the contrary of its outstanding resource abundance, from 1992 to 2011, the annual growth rate of GDP per capita was around 15.02%, which was almost equal to the same of country's average 14.99% but ranked only 17th among the country. Hence, in the end of 2011 the GDP per capita rose to 31357 yuan from 1862 yuan of 1992, comparing country's average of 34769 yuan. Briefly, the level of economic development in Shanxi did not match its abundant resources, supporting the hypothesis that Shanxi now is facing "resource curse".

5. The constraints of natural resource endowment for Shanxi's economic development

Shanxi Province has already formed a resource-oriented economy taking that resources exploitation as the core, and that a series of industries of resource processing, trade, services and other industries as the mainstay. From the perspective of regional economic development, resource-based economy shows significantly particularity in terms of economic growth, structural evolution, and income distribution. However, these peculiarities have brought quite a few problems in Shanxi's development process, causing a decline trend of its capacity for sustainable development.

5.1 The singular character of industrial structure

Thanks to large-scale exploitation of coal resources, the coal related industry dominance has been established in a short time and the level of urbanization has improved rapidly. However, over dependence on coal led to region's serious deviation during the economic structural evolution process. In fact, the singular character of the industrial structure resulted in "Dutch Disease" effects.

Firstly, it restricted the development of tertiary industry. Theoretically, it is the trend that the gravity centre of economic structure shifts periodically from primary industry to secondary and then to tertiary industry. China's development is the case. The share of secondary industry in China had a modest increase, from 43.5% in 1992 to 46.6% in 2011; and the tertiary industry rose at a higher speed, reached 47% from 34.8% during the period. On the contrary, Shanxi's structural shift was towards another direction. In those twenty years, the share of primary dropped 9.3%; with the secondary industry rose about 10%, the tertiary industry declined from year 2004. In year 2011, the percentage for total GDP contribution was only 35.2%.

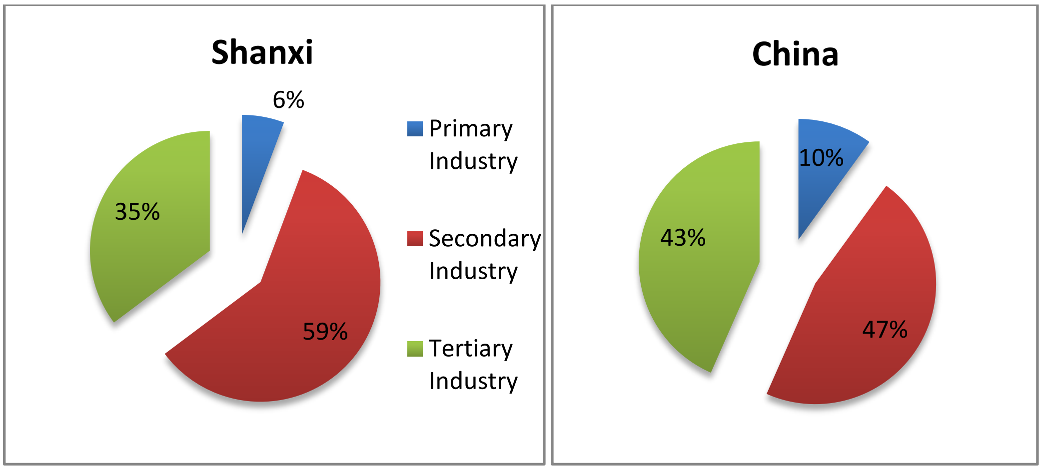


Figure 5.1.1 The comparison of Shanxi and country on GDP composition in 2011.
Source: China Statistical Yearbook 2012.

Secondly, although the share of second industry in Shanxi was becoming larger, the structure itself was imbalanced. The ratio of light and heavy industries in Shanxi's industrial output value was 35.2 : 64.8 in 1952 and dropped to 23.5 : 76.7 in 1978. In the end of 2011, it became only 4.9 : 95.1 (Appendix 10). Compared with country's average ratio of 28.1 : 71.9, Shanxi has to deal with a much more severe single industrial structure issue.

Of particular note is manufacturing sector was taking less share of the whole industry. Figure 5.1.2 illustrates Shanxi's industrial structure change from 1992 to 2011. Mining industry and manufacturing industry, the two leading components for province's industrial sector, had different experience within the period. Especially from the beginning of 2000s, mining industry had a continuous rising proportion for region’s total industrial added-value. It was over 50 percent since 2008 and even reached to 64 percent by the end of 2011.

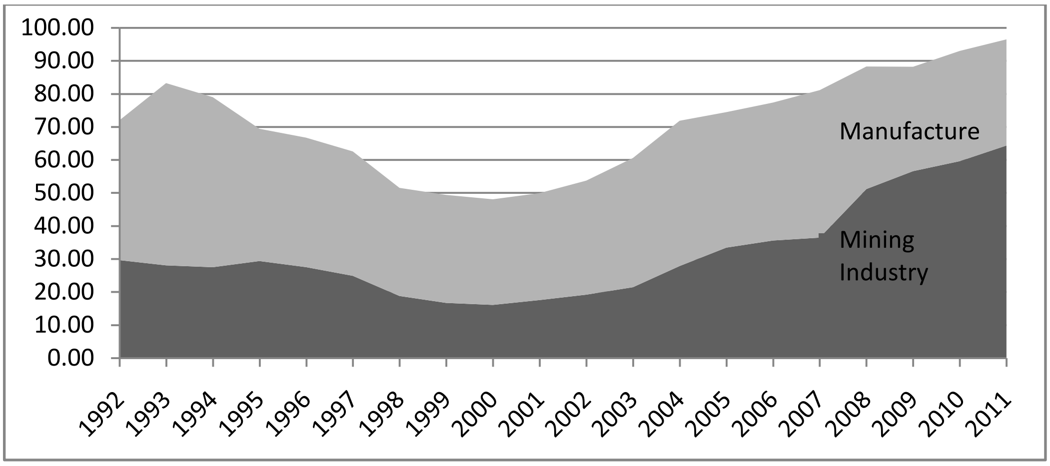


Figure 5.1.2 Shanxi’s industrial structure change, 1992 – 2011.
Source: Calculated through data from Shanxi Statistical Yearbook 2012.

However, situation in manufacture was more complicated. Until 2004 it showed a similar trend but with higher proportion compares with that of mining industry. Nevertheless, after a modest increase in 2006 and 2007, the proportion declined dramatically to only 37% in 2008 from last year’s 45%. What worse, it fell constantly since then: only accounted for nearly one third of whole industrial added value in recent years. During this period, annual growth rate of total industrial added value was 19%. However, in particular, the annual grow rate of mining industry’s added value was 26% while the figure was only 18% for manufacture. Hence, that the manufacture was crowded out by mining sector aroused the irrational phenomenon of “de-industrialization”. Shanxi’s rank of manufacture among the country fell from no. 6 in 1950s to no. 26 in 2000s. Being the recognized cradle of technological innovation in industrialization process, manufacturing sector’s decline is bound to be a mortal blow to the regional economic growth. Because losing powerful support from traditional and lacking energy from new manufacturing sectors, Shanxi is lagging behind the country.

For resource industry as the pillar of a single industrial structure, in addition its forward or backward linkages with other industries such as machinery, chemicals, iron and steel, electricity and heat, resource price volatility caused more severe instability for Shanxi's economic development. Taking the last year's price index as the base of 100, Figure 5.1.3 is the comparison between coal products price index and total industrial products price index. In general, the three indexes experienced similar process among the years and all reached highest in 1993, but clearly influenced by coal price, total industrial products price index of Shanxi experienced more fluctuations than that of country. From 1993 to 1999 was a period of price declining, Shanxi's coal products price index down to 91.9 in the end of 1999, while total industrial products price index of both Shanxi and country were 95.3 and 97.6 respectively. Since then price index again achieved a higher level periodically. Unfortunately, the surge decrease of coal price in 2008 global financial crisis shocked Shanxi's economy dramatically. In fact, Shanxi Province became the only province with negative GDP growth in first quarter of 2009.

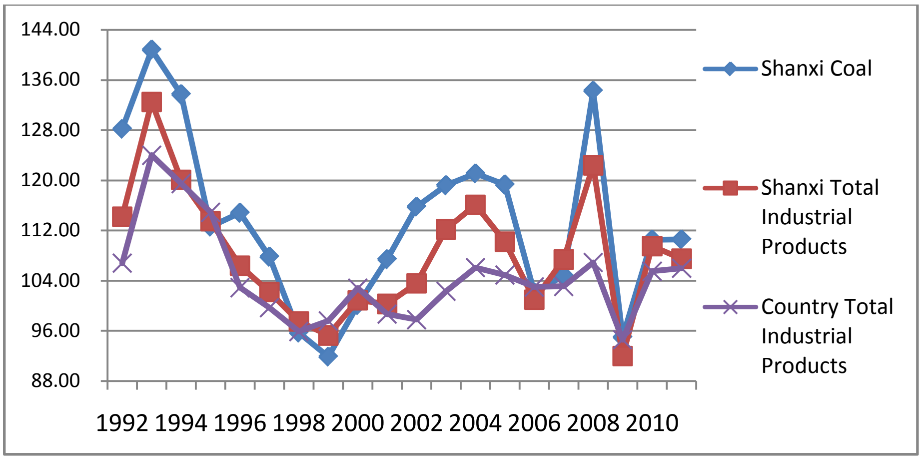


Figure 5.1.3 Comparison between coal products price index and total industrial products price index, 1992-2011.
Source: Calculated through data from China Statistical Database (available online: http://www.stats.gov.cn/) and Shanxi Statistical Yearbook 2012.

The decline of coal price damaged the coal industry's income directly. During this stage, capital investment was difficult to quit due to sunk costs (Jing, Zhao and Jia 2011, p141-152). In order to maintain production, employment demand could not reduce in a short time; in addition that coal industry is poor in human capital accumulation, so it became difficult for employment transition to non-resource industry sectors. Hence, employed persons were stuck in the coal industry, forming the "lock-in" effects. The level of manufacturing sector could not be raised because capital and labour remained in the coal industry. At this point, the double downturn of coal industry and manufacturing led to region's economy getting into an inevitable difficult position.

In short, the structure deviation in industrialization process of Shanxi Province characterized as high proportion of the industry along with low level of industrialization: that the high proportion of second industry but low proportion of tertiary industry and the low level of GDP growth; and high proportion of resources industry but low proportion of manufacturing sector, which is considered as owning high technological content and increasing returns of scale, within the industry sector.

5.2 Crowding-out effect on human capital and technological innovation

Human capital and technological capability are important indicators in measuring modern economic development. Only the up-to-date manufacturing and high-tech industry dominant structure, human capital can play full role and technological capabilities can be maintained into a high level.

After analysing the elements' contribution to economic growth, it is concluded that the main driving force of economic development in Shanxi Province is capital investment; while the contribution from TFP is far below the national average (Jing, 2011, pp. 5-6). The considerable income derived from resources was not used for human capital and technological innovation investment, resulting in the current situation that investment and fiscal expenditure on education and technology are lower than national level. According to government appropriation for education in the percentage of GDP during 1998 and 2011 (Figure 5.2.1), although it was over 3 percent in 2010 and 2011, the percentage of education funding was smaller than that of country's average all the time. Comparing that the country spent around 1.4% more on education, Shanxi had a 0.5% increase only in those years, from 2.64% in 1998 to 3.14% in 2011. It is explicitly stated in the *Outline of China's Education Reform and Development of 1993* that raising the government appropriation for education to 4% of gross domestic product as a strategic target. When country's average figure finally achieved this goal in 2012 through a period of continuous increase, Shanxi had to struggle with the more dramatic fluctuations, and even worse, the recent downward movement. Taking short period from 2003 to 2008 as an example, the percentage of government appropriation for education to GDP did not rise with the expansion of mining industry; instead, it down to the lowest point of 2.01% in 2004 and again 2.09% in 2008.

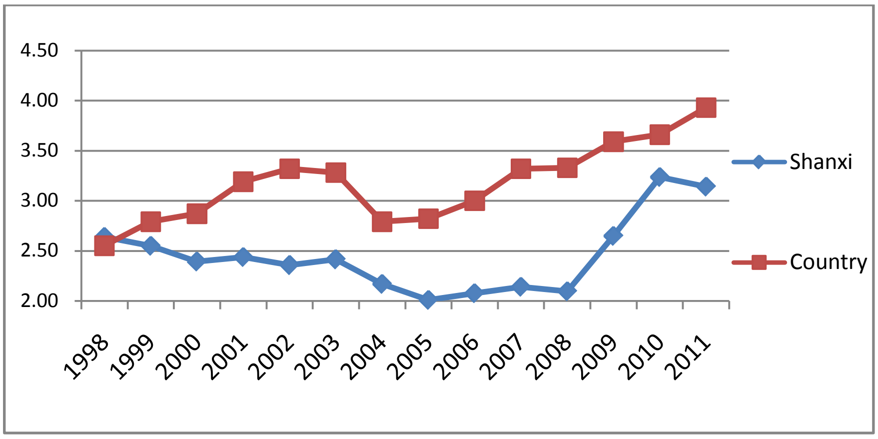


Figure 5.2.1 Government appropriation for education in the percentage of GDP, 1998 -2011.
Source: Calculated through data from Shanxi Statistical Yearbook 2012 and China Statistical Database (Available online: http://www.stats.gov.cn/).

As a result, it became problematic that Shanxi's extensive development pattern made it difficult for human capital accumulation. What such low end of mining industry's expansion needs is large numbers of cheap primary labour force, rather than the high-tech talent. The de-industrialization actually caused a serious brain drain in manufacturing sector. According to the statistics, in 1999 the number of scientific and technical personnel in manufacturing industry was about 135,000. Until 2006, it declined 24,000 to 111,000 in total. Moreover, the average wage of employed persons in Shanxi's manufacturing sector was 30,182 yuan in 2011 (Shanxi Statistical Yearbook 2012). This was only ranked no.29 among 31 provincial level regions in China; and was lower than the national average level of 36185 yuan (calculated by the data from *China Statistical Yearbook 2012*). The low income of manufacturing sector is not conductive for talent inflow, affecting its formation of human resources advantage.

As we know, the cumulated experience that learns from the practice is also a kind of input for production process. Lucas (1988) built an endogenous growth model by using human capital as the core factor. This model investigated that the specialized human capital expands with the increasing number of products. This is on the basis of the existing level of human capital. Basically, the higher the average levels of human capital, the faster its accumulation it would be (Lucas, 1988). Thus, the lagged manufacturing sector as well as its consequence of the brain drain resulted in the "leaning by doing" pattern could not become an effective way for Shanxi's human capital accumulation.

Shanxi not only performed poorly in cumulating human capital through learning-by-doing to achieve the "external effect", but also in aspect of schooling. Schooling is considered as a basic internal means to acquire human capital. As one of earliest provinces that set up modern educational institutions, Shanxi Province has more than one hundred years' history in higher education. However, it now is stating backward due to slow development. Until 2009, the Eastern developed part of China has 748 colleges and universities, taking around 40.1% of country's total number. By contrast, Shanxi owns only 71 (*China Statistical Yearbook 2010*), not mention that it barely has top-level universities. With not enough disciplines on engineering and machinery to meet its economic development demand, Shanxi higher education layout structure is irrational.

The region has already recognized the significance of technological innovation and established numbers of nation labelled Industry Parks and Hi-tech Development Zones. Nevertheless, in 2011 R&D intensity in Shanxi was 1.01%, even much lower than national average ratio of 1.84%. The ratio of R&D to GDP is an important indicator in reflecting economic competitiveness. Basically, R&D intensity of developed countries reaches 3% level, and Finland already reached 4%. According to the knowledge bases approach, the knowledge base in Shanxi is more often synthetic than analytical. Most of researches focus within enterprises that accounting for 82.5% of total region's R&D expenditure in 2011. By contrast, R&D expenditure in colleges and universities only took about 6.3%. Hence, the innovation network now is more tend to be industry-industry pattern; it still has weak linkage between university and industry.

The government expenditure on science and technology in 2011 was 2.7 billion yuan, accounting for 1.15% of Shanxi's general budgetary expenditure. But this was still lower than country's average level 2.03%. It can be seen that the proportion of government expenditure on science and technology declined with a substantial increase of province's fiscal revenue at the same time. Currently, due to the relative lack of inputs, the number of scientific and technological achievements correspondingly is less than those developed regions. Based on Table 5.2.1, Shanxi's number of patent application accepted and granted as a percentage of country's total is still small, and has no clear upward trend yet.

Table 5.2.1 Patents application accepted and granted per 10,000 population by region, 1998 -2011

	Patents Application Accepted				Patents Application Granted			
	National Total	Jiangsu	Shandong	Shanxi	National Total	Jiangsu	Shandong	Shanxi
1998	0.77	0.81	0.86	0.34	0.49	0.53	0.47	0.20
1999	0.87	0.98	0.97	0.36	0.73	0.85	0.74	0.29
2000	1.11	1.12	1.11	0.45	0.75	0.88	0.77	0.30
2001	1.30	1.41	1.24	0.45	0.78	0.84	0.74	0.32
2002	1.60	1.77	1.42	0.49	0.87	1.03	0.80	0.28
2003	1.94	2.48	1.73	0.53	1.16	1.33	0.99	0.35
2004	2.15	3.17	2.00	0.58	1.16	1.52	1.06	0.36
2005	2.93	4.66	3.12	0.59	1.31	1.82	1.16	0.36
2006	3.58	7.06	4.11	0.84	1.70	2.56	1.71	0.42
2007	4.44	17.58	5.00	0.98	2.28	6.28	2.44	0.59
2008	5.40	16.67	6.40	1.58	2.65	5.79	2.83	0.67
2009	6.58	22.57	7.06	1.99	3.76	11.30	3.64	0.94
2010	8.27	29.98	8.43	2.22	5.52	17.59	5.37	1.33
2011	11.17	44.10	11.37	3.55	6.56	25.30	6.11	3.09

Source: China Statistical Database (available online: http://www.stats.gov.cn/).

Note:

1. This table shows the number of three kinds of patent applications accepted and granted per 10,000 population in terms invention, utility model and design;
2. According to Figure 4.2.2, Jiangsu Province is the region with fastest economic growth but lacking natural resources, and Shandong Province is the region with relative rapid economic growth along with abundant resources.

It is not surprised that, the pillar industry, mining industry was not one of ten industries with more than 1% of R&D expenditure intensity. The absence of forming a virtuous circle mechanism between scientific research and production process had a negative impact on province's innovation capability enhancement. Meanwhile, the high wages because of the prosperity of coal industry restrains the development of other industries which rely heavily on the talents. Hence, the long-term neglect of investment on education and technological innovation led to the instability and inherent unsustainability of Shanxi's economy, which were concealed by its short-term prosperity. The current financial crisis has only exacerbated this development bottleneck.

5.3 Rent-seeking and corruption

For a long time, the property right system of natural resources has serious drawbacks due to the imperfect market system as well as legal system. Although the state ownership for mineral resources is stipulated by constitution clearly, such right has not been fully guaranteed. Local governments and other resources related management departments at all levels exercise the facto ownership right. Hence, the ownership right, the operation right and the usufruct were confused in resources extraction process.

On one hand, for personal political and economic interests, some of local government officials take advantages of their power into political rent-seeking. Driven by high profits, they have taken a variety of hidden ways in forming a community of interests with mine owners, such as openly or secretly harbouring miners' illegal operation; and ignoring the safety hazards in coal mining production and their behaviour of environment destruction; etc. These caused a huge loss of life and property. On the other hand, in order to get a lot of excess profits, operators ensure their exclusive possession of resources through bribery. The extensive ways of exploitation for compensating the loss in rent-seeking process led to a serious waste of resources. Ultimately, the large amount of benefit belongs to a small number of persons while the costs due to resources extraction are borne by the state and the society.

From 1980 to 2010, Shanxi Province had 19349 persons died in coal safety incidents. The death rate per million tons of coal production was 0.077 in 2010, much higher than that in developed countries (between 0.01 and 0.05). In two years of 2008 and 2009, there were 2353 government officials and 30.3 billion yuan in total involved in corruption. As a result, the rent-seeking and corruption delayed the reform process, greatly reducing the quality of economic development.

5.4 Widening income inequality

During the period of 1992 and 2011, the disposable income per capita increased more than ten times, reaching to 18124 yuan from 1163 yuan. Since 2000, although had once a downward trend in 2002 and 2003, the disposable income per capita maintains a growth momentum. It exceeded 10,000 yuan in 2006 and with a high growth rate of 15.3% in 2007. Nevertheless, influenced by the financial the annual growth rate of the disposable income per capita was only 6.7% in year 2009. This situation improved in 2011 and the growth rate backed to 2007 level (Appendix 15).

However, resource exploitation did not drive the increase of the disposable income synchronized with GDP growth. The per capita disposable income's annual average growth rate of 13.7% (urban area) was lower than GDP per capita's 15% throughout this period. Considering the gap between region and country's average, it was becoming wider than that of GDP per capita: in 2011 the disposable income in Shanxi was only equivalents to 0.83 of the national level. Hence, the capability of household consumption in promoting economy is relatively weak. Shanxi's positions in terms of per capita annual consumption expenditure in urban and rural areas respectively were no.27 and no.16, with 11354 yuan and 4356 yuan in the end of 2011. By contrast, country's average figures were 15161 and 4733 respectively (Appendix 16).

During this time, the total retail sales of consumer goods' average growth rate had a 0.3% lower than that of country's level, with 15.9% annually.

Table 5.4.1 Different levels of per capita disposable income in urban area of Shanxi, 2000 - 2009

	10% of the lowest level	10% of low level	20% of lower middle level	20% of middle level	20% of higher middle level	10% of high level	10% of the highest hevel	The ratio of the highest and the lowest
2000	1724	2509	3351	4471	5813	7456	10828	6.3
2001	1902	2793	3789	5083	6608	8541	12351	6.5
2002	1526	2791	3933	5850	7550	9550	14500	9.5
2003	2435	3650	4882	6453	8395	10596	16085	6.6
2004	2717	4077	5484	7245	9348	11981	18544	6.8
2005	2977	4517	6086	8204	10800	13914	20230	6.8
2006	3281	5184	6946	9217	12064	15598	22428	6.8
2007	4005	6094	8137	10792	13843	18391	28160	7.0
2008	4575	6832	9286	12501	16439	21187	33011	7.2
2009	5050	7483	9926	13240	17466	22697	35410	7.0

Source: Shanxi Statistical Yearbook 2004-2010.

Along with the general substantial increase of residents' income, the increase rate among high-income bracket was much higher than that of low-income bracket. From 2000 to 2009, the per capita disposable income within highest-income class rose by 3.3 times, while the lowest-income class grew by only 2.9 times. Other income groups remained at the 3.0 times level. As can be seen from the table above (Table 5.4.1), the gap between the high and the low became even lager. In 2000 the ratio of the highest and the lowest class groups of disposable income was 6.3 and in 2003 reached the maximum of 9.5. Although having a short period of alleviation during 2004-2006, in 2008 income gap contradictions began to highlight again with ratio of 7.2: the income distribution still has not showed the inverted U-shape yet in the region.

The increasing difference between sectors could be one main reason to explain income inequality. The high coal price brought the prosperity of coal related industries. Hence, the average wage of mining industry was higher than that of manufacturing factor and that of all sectors average level. From 1998 to 2011, the ratio of average wage in mining industry to manufacturing rose constantly to 2.14 (Table 5.4.2). This ratio was not only much bigger than that of developed regions like Zhejiang (0.99) and Jiangsu (1.27), but even much higher in comparison with another well-known coal abundant province Inner Mongolia with 1.41 (Appendix 17).

Table 5.4.2 Shanxi's income difference between the sectors, 1998-2011

	Manufacturing (yuan)	Mining (yuan)	Average (yuan)	Mining/Manufacturing	Mining/Average
1998	5014	7057	5641	1.41	1.25
1999	5519	6426	6065	1.16	1.06
2000	6244	7496	6918	1.20	1.08
2001	6947	8825	8122	1.27	1.09
2002	8030	10499	9357	1.31	1.12
2003	8944	12871	10729	1.44	1.20
2004	10612	17220	12943	1.62	1.33
2005	12820	22403	15645	1.75	1.43
2006	14852	26924	18300	1.81	1.47
2007	17078	30943	21525	1.81	1.44
2008	20345	38013	25828	1.87	1.47
2009	21872	42332	28469	1.94	1.49
2010	25436	52403	33544	2.06	1.56
2011	30182	64539	39230	2.14	1.65

Source: Calculated through data from China Statistical Database. Available online: http://www.stats.gov.cn/.

In addition, the increased inequality could also be found especially within mining sector. For one thing, this is due to the low-income employment rate remains in the doldrums. As the leading industry, such simple one-way flow pattern of "natural resources – resource products – waste" made coal industry chain relative short. It can provide employment mainly mining and transport workers, and part of coal washing workers. The rapid development of the coal industry could not promote employment effectively, thus income level had no chance to get improved. According to the statistics, unemployment rate of Shanxi Province is higher than that of country average. Lower employment has already been an important reason restricting Shanxi resident income increase.

For another, the property right problem brought about the growing concentration of wealth into small number miners and some unscrupulous officials, thereby enlarging the income gap. By virtue of coal resources to form a monopoly position, mine operators received considerable economic benefits. The existence of rent-seeking behaviour in mining right transfer process led to a large amount of non-wage income and the "grey income". It should be noticed that the "grey income" of both officials and the employees in monopoly enterprise stems from the encroachment to the disadvantaged group: that ordinary people are ultimately undertaker for the loss. It actually is a wealth transfer from low-income to high-income class. For low- and middle-income class, their income did not get a rapid growth, which exacerbated the degree of inequities.

5.5 Environment deterioration

The high pollution from industries such as coal, coking and thermal power, as well as the long-term extensive growth mode made Shanxi become one of provinces with the most serious environmental pollution and ecological destruction. The report of "*China's regional differences on ecological civilization*" reveals that Shanxi performed the worst in terms of ecological development. Due to over exploitation, 16 cities in Shanxi Province have higher level than the National Secondary Standard in terms the concentration of main pollutants; and 13 cities belong to 30 Cities with Serious Air Pollution. In addition, more than 75% of rivers do not meet the requirement of National Five-kind Standards of Water Environmental Quality". The groundwater pollution ranks the top of country, with around 35% of groundwater quality worse than the Class III Water Quality Standard, higher than 30% of national average level.

The ground subsidence, the groundwater recession, and water pollution caused by coal mining heavily damaged water resources. According to the *Research of Shanxi*

Coal mining's Effects on Water Resources Destruction, every ton of coal exploitation will damage 1.41 m^3 dynamic and 1.07 m^3 static of groundwater reserves (Niu, 2003). Nevertheless, Shanxi extremely is scarce at water resources, that water supply is equal to 41% of national average, with only 170 m^3 per capita. This ranks last among the country (China Statistical Database). From 1993 to 2003, the coal mining also led to more than 400 thousands of paddy land disappeared, causing a 30 billion yuan lost each year (Wu, 2007).

6. Conclusion：Circular cumulative causation effects

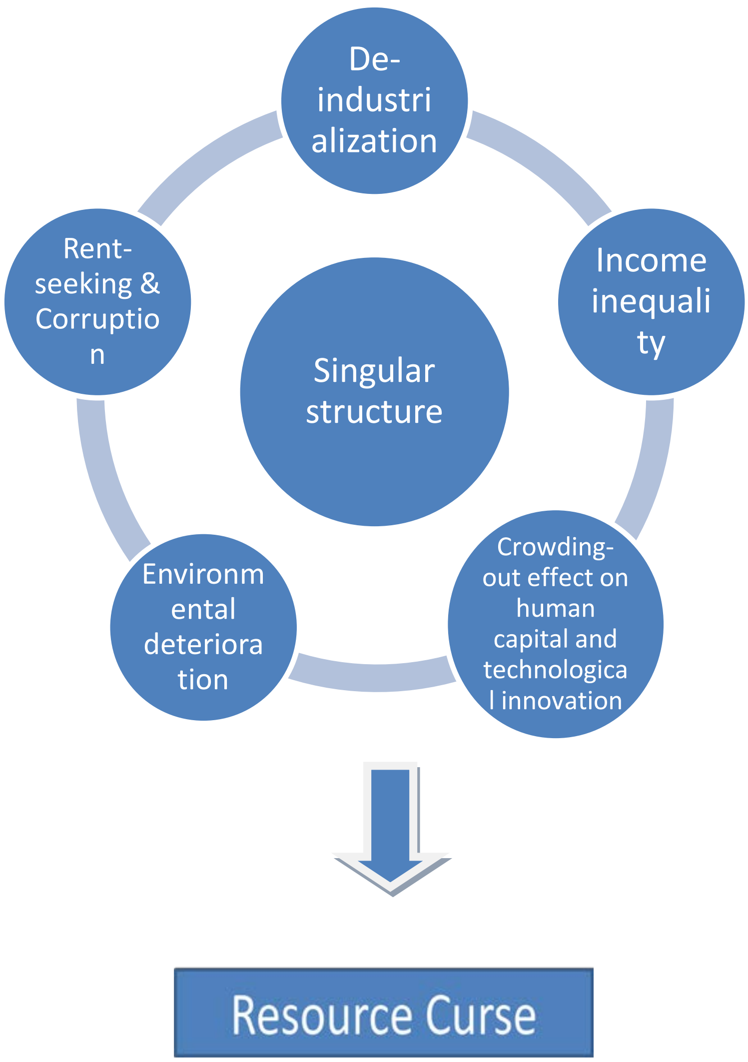
Under the circumstance that China's economy is now relying on coal resources as major primary energy and Shanxi Province is the leader of coal production, the paper first attempted to support the hypothesis about the existence of resource curse in Shanxi Province through calculating its rank disparity with respect to RAI and GDP per capita among regional level of China. As a result, the relative poor economic performance with the highest RAI provides evidence that natural resources in Shanxi Province are more a curse than blessing at present.

Several constraints generated in the economic development process could be used to explain resource curse. According to Myrdal's circular cumulative causation theory, the uneven situation will toward two distinct directions. In the case of Shanxi, unfortunately, it generated backwash effects rather than spread effects. Region's long-term development has witnessed more and more severe issues in all problems mentioned above: it actually is a downward cumulative process.

On one hand, over dependence on resource formed region's singular character of industrial structure, which becomes the core variable of CCC process in explaining resource curse: the analysis in section 5 shows that the dominant mining industry actually aggravated other variables' deterioration. We know Shanxi's unique coal resources advantages allow the investment returns in mining industry rapidly and lucratively. Hence, that over concentration of labour and physical capital within mining industry restricted development of manufacturing and tertiary industry, and thus led to the de-industrialization. Compared with the manufacturing sector, resource-based industries lack the inherent power for human capital accumulation due to its relative low demand and low return in human capital investment. Once this kind of investment can hardly get extra compensation, people's willingness to receive education declined and a large number of labour forces with high quality knowledge and skills flowed out of the region.

Increasing income gap is accompanied by Shanxi's development. In spite of admitting coal industry already has created huge wealth for region as well as quite a few of millionaires, it also exacerbated regional inequality. This could be seen in the comparison of the average disposable income between Shanxi and country average level; the widening gap of different levels of income within regions; and the rising significant differences between mining industry and manufacturing industry. In addition, singular structure with weak institutional system generated rent-seeking and corruption; and the severe waste of resources due to simple one way production process deteriorated ecological environment.

On the other hand, these unfolding events connected with a change in the economy. Not only these variables were the consequences for singular industrial structure, but their changes were also applied to a whole set of variables as a consequence of the multiplier effects of resources curse. It is easy understand that manufacturing and tertiary industries could not get a chance for development when lacking human and physical capital, which in other words, it is not possible to change current singular structural situation. Driven by economic benefits, mining industry will continue attracting large amount of labour force and investment. The operation pattern of low-cost but high-return was unable to generate motives for innovation. Moreover, people are satisfying with current mining industry's higher income, thus they do not have incentives for education and job training. Thereby, the lock-in situation forced Shanxi could not get rid of over reliance on natural resources. Besides, the super-profit caused by rent-seeking and corruption forced those operators and officials to take a risk. The existence of irrational and illegal mines exacerbated the dominance of mining industry as well. Hence, the momentum of downward circulation is self-perpetuating, which will continue to deepen resource curse and widen regional imbalance inevitably. Shanxi Province is becoming more and more backward and economic transition now is pretty urgent.



7. Path choice for economic growth transformation – RIS

The 17th Party Congress Report pointed out that the key to further economic development is to accelerate the transformation of its growth pattern and to focus on improving the innovation capability. Innovation is an inexhaustible motive force for economic development. In order to getting out of resource advantage trap and turning “backwash” to “spread”, it calls for creating a regional innovation-driven system (RIS). Through a series of targeted innovation policies to improve the rational flow and the optimal allocation of various components within the system, it is expected to achieve the goal of regional long-term competitiveness. Specifically, the following suggestions are provided in promoting the wealth conversion from natural resource to physical capital, human capital and social capital.

7.1 Improve government role of guidance and supervisory in resource exploitation

Myrdal highlighted the role of government in the formation of spread effects from backwash effects. Therefore, system innovation is particularly important to avoid the resource curse fundamentally. Firstly, the government in developed countries such as the United States mainly relies on legal means in participating their energy base’s construction and transformation process, which provides valuable experience for Shanxi’s new energy base construction. Considering China’s unperfected legal system, it is proposed to accelerate the legislative process of Energy Law to clarify the legal status of country’s energy strategy. Meanwhile, it also is mentioned to take resource accounting into consideration of national economic accounting system to promote resource’s rational development and its protection (Li, 2007; Jia, 2011). Secondly, the government should also strengthen administration. For example, it is recommended to organize a panel of experts to evaluate new mining enterprises before issuing them the access permits and to supervise production process. A transparent monitoring mechanism and public participation mechanism are both necessary to avoid potential corruption.

7.2 Reinforce technological innovation capacity

Pushing forward the technological progress in resource sector firstly is to reduce resources loss and achieve resources' sustainable utilization; secondly is to raise labour's skill and the proportion of capital investment, at the same time weaken the crowding-out effect on both physical and human capital; thirdly is to increase the allocation of technical elements in rental return derived from mineral resources exploitation, which thus prevent a variety of economic and social problems due to high rent. Thus, the resource sector steps from a primary one with low-tech into a modern industrial sector with high-tech that can bring increasing scale returns.

Therefore, it will be encouraged for large-scale of coal related enterprises to put more rental income into the technological innovation development and application of. Besides, Shanxi's RIS construction needs to form a group of competitive public organizations and institutions. Through promoting application-oriented research development (the proportions of fundamental, application-oriented and experimental research in terms of R&D expenditure in 2011 were 2.42%, 15.14% and 82.44%), it will form a linkage between enterprises and universities. The combination of research and commercial operation will apply research results into practice rapidly.

Furthermore, government should also provide policy support for SMEs innovation activities. Most of large-sized enterprises in Shanxi are state-owned enterprises (SOEs). The number of Private enterprises and SMEs is relative small and many of their owners are nouveau riche who relies on coal mining, rather than innovative entrepreneurs. Under this circumstance, the government should encourage them to shift funds from the free state to high-tech industries of manufacturing and service sectors. In turn, these new entrepreneurs generate endogenous demand for innovation, thus promoting industrial innovation progress.

7.3 Enhance human resources advantages

Human capital accumulation calls for rising education investment at the very beginning. The regional government should take education as the emphasis of public expenditure and pay more attention to broaden the sources of education funding. In addition, to release government pressure, it is encouraged that enterprises as well as individuals participate in school running by means of donation and investment. Moreover, under the premise of risk control, it is reasonable to provide financial support on expanding and perfecting student education loan system.

As a resources-based region, Shanxi should also attaches importance on professional education and vocational education. By using the full range of education and training resources, multi-channel of job and entrepreneurship training could be offered to adapt the needs of modern intensive mining. By the mining pre-job training, the mining efficiency and workers' safety awareness could be enhanced. Moreover, the retaining of miners in resources depleted region is a way to weaken mining industry's lock-in effect in human capital.

It is significant to build a competitive environment to attract and retain the talent. On one hand, this requires the establishment of an open and fair talent selection mechanism and incentive mechanism. On the other hand, it calls for the improvement of industrial diversification. The widespread application of advanced technology and new equipment is wise to increase the demand for R&D personnel.

7.4 Promote industrial diversification

The United States is a success case in industrial diversification without question. Being a country with abundant resources, its GDP in 2002 largely came from the service industry. In the long run, the growth of wealth in the United States since the

Second World War mainly relied on technological innovation and financial innovation, rather than resource industries.

The market operation based on the comparative advantage will firstly strengthen the single industrial structure. In addition, with the extension and expansion of the industrial chain, the region would not most dependant on primary resource products any longer and the structure will be upgraded from single and heavy to complex. Combining resources exploitation with high value-added manufacturing development will be a key step for encouraging the development of manufacturing and service industries, which is vital for human capital accumulation. The regional government already regarded tourism industry, ecological agriculture industry and environmental protection industry as significant strategic industries in region's latest five-year plan, which in order to increase economic vitality and potential.

References

Asheim, B. and Gertler. M. S. (2005). The Geography of Innovation: Regional Innovation Systems. *The Oxford Handbook of Innovation*. Oxford University Press, Oxford, pp. 291-317.

Auty, R. M. (1994). Industrial policy reform in six large newly industrializing countries: The resource curse thesis. World development, vol. 22, no. 1, pp. 11-26.

Auty, R. M. (2001). Resources Abundance and Economic Development. Oxford University Press.

Bardhan, P. (1997). Corruption and development: a review of issues. *Journal of Economic Literature*, vol. XXXV, pp. 1320-1346.

Brunnschweiler, C.N. (2007). Cursing the Blessings? Natural Resource Abundance, Insititution, and Economic Growth. *World Development*, vol. 36, no. 3, pp. 399-419.

BP (2009). Statistical Reviews of World Energy. Available online: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2009_downloads/statistical_review_of_world_energy_full_report_2009.pdf

CESY (2011). China Energy Statistical Yearbook 2011

Corden, W. M. and Neary, J. P. (1982). Booming Sector and De-industrialisation in a Small Open Economy. *The economic journal*, vol. 92, no. 368, pp. 825-848.

Corden, W. M. (1984). Booming Sector and Dutch Disease Economics: Survey and Consolidation. *Oxford economic Papers*, vol. 36, no. 3, pp. 359-380.

Davis, G.A. (1995). Learning to Love the Dutch Disease: Evidence from the Mineral Economies. *World Development*, vol. 2, no. 10, pp. 1765-1779.

Demurger, S. , Sachs, J. D., Woo, W. T., Bao, S. and Chang, G. (2002). The Relative Contributions of Location and Preferential Policies in China's Regional Development: Being in the Right Place and Having the Right Incentives. *The Journal of China Economic Review*, vol. 13, pp. 444- 465.

Ding, X. C. and Zuo, T. (2008). Natural Resource-dependent economy's Sustainable Development. *The Journal of Ecological Economy*, vol. 1, pp. 37.

Guo, L.F. (2009). Percentage Extraction of China National Coal Group Corp. in the Nation's leading status. *China Energy News Online*, 26th October.

Gylfason, T. (2001). Natural Resources, Education and Economic Development. *European Economic Review*, vol.45, pp. 847-859.

Innis, H. A. (1962). Essays in Canadian Economic History. Edited by Mary Quayle Innis. University of Toronto Press.

Isham, J. (2002). The effect of social capital on fertiliser adoption: Evidence from rural Tanzania. *Journal of African Economies*, vol.11, no. 1, pp. 39-60.

Jia, N. (2011). The Analysis of Resources Curse in Shanxi Province. Available online: http://www.cnki.net/

Jing, P. Q. (2011). The Path Choice of Coal Resource-based Regional Economic Development Transition. *The Journal of Coal Economic Research*, vol. 31, no. 9, pp. 4-10.

Jing, P. Q., Zhao, K. J. and Jia, L. (2011). Coal Price Fluctuations and Their Impact on Regional Economic Development. *The journal of Industrial Economy Review*, vol. 7, no. 4, pp. 141-152.

Kaldor, N. (1966). Causes of the Slow Rate of Economic Growth of the United Kingdom: an inaugural lecture. *Cambridge University Press*.

Kaldor, N. (1970). The Case for Regional Policies. *Scottish Journal of Political Economy*, vol. 17, no. 3, pp. 337-348.

Kuznets, S. (1955). Economic growth and income inequality. *American Economic Review*, vol. 65, pp. 1-28.

Lash, S. and Urry, J. (1994). Economies of Sings and Space. *Published in association with Theory, Culture & Society. Department of Administrative and Social Studies, Teesside Polytechnic*, vol. 26.

Leadership Office of Coal Mine Corporation Merger and Coal-Resource Integration of Shanxi (2009). *Coal Mine Corporation Merger and Coal-Resource Integration of Shanxi. Brief Report (1)*, 12th June.

Li, T. Z (2007). The Study on the Regional Economic Policies. Available online: http://www.cnki.net/

Lucas, R. E (1988). On the Mechanisms of Economic Development. *The Monetary Economics, vol. 22, pp. 3-42.*

Lundvall, B.-A. and Borras, S. (1997). The Globalising Learning Economy: Implications for Innovation Policy*. European Commission, Luxembourg*.

Luo, P and Shang, X. H. (2008). Resource-based Economy and the Thinking of Innovative Society. *The Journal of Ecological Economy*, vol. 2, pp. 4.

Murshed, S. M., & Perälä, M. (2001). Does the Type of Natural Resource Endowment Influence Growth?. *Manuscript, UNU/WIDER.*

Myrdal, G. (1944). An American Dilemma: The Negro Problem and Modern Democracy (2 vols.).

1944 Myrdal, G. (1957). Economic Theory and Under-developed Regions. London: University Paperbacks, Methuen.

Niu, R. L. (2003). The Research of Shanxi Coal Mining's Effects on Water Resources Destruction. *Beijing, China Science and Technology Press*.

North, D.C. (1995). Location theory and regional economic growth. *The Political Economy*, vol. 63, no.3, pp. 243-258.

Prebisch, R. (1950). 1950 The Economic Development of Latin America and Its Principal Problems. New York: United Nations.

Romer, P. M. (1986). Increasing Returns and Long-run Growth. *The Political Economy*, vol. 5, pp. 1002-1037.

Sachs, J. D. and Warner, A. M. (1995). Natural Resource Abundance and Economic Growth. *National Bureau of Economic Research working paper series*, 1995, No. w 5398.

Sachs, J. D. and Warner, A. M. (1997). Sources of slow growth in African economies. *Journal of African economies*, vol.6, no.3, pp.335-376.

Sachs, J. D. and Warner, A. M. (1999). The Big Push, Natural Resource Booms and Growth. *Journal of development economics*, vol. 59, no. 1, pp. 43-76.

Sala-i-Martin, X. and Subramanian, A. (2003). Addressing the Natural Resource Curse: An illustration from Nigeria (No. w9804). *National Bureau of Economic Research.*

Shao.S and Qi. Z.Y. (2008). Empirical Analysis of Energy development and Economic Development in Western of China-Based on the Hypothesis of the Resource Curse. *Journal of Economic Study*, vol. 11, pp. 147-160.

Singer, H. W. (1950). The Distribution of Gains between Investing and Borrowing Countries. *The American Economic Review*, vol. 40, no.2, pp. 473-485.

Stijns, J. P. C. (2005). Natural resource abundance and economic growth revisited. *The Journal of Resources Policy*, vol.30, no. 2, pp. 107-130.

Stijns, J. P. (2006). Natural Resource Abundance and Human Capital Accumulation. *World Development*, vol. 34, no. 6, pp. 1060-1083.

Thompson, R. R. (2011). If Shanxi's Coal is Lost, then Shanxi is Lost: Shanxi's Coal and an Emerging National Movement in Provincial China, 1898–1908. *Modern Asian Studies*, vol. 45, no. 05, pp. 1261-1288.

Tödtling, F. and Trippl, M. (2005). One Size Fits All? Towards a Differentiated Regional Innovation Policy Approach. *Research Policy,* vol. 34, pp. 1203-1219.

Torvik, R. (2002). Natural resources, rent seeking and welfare. Journal of *Development Economics*, vol. 67, pp. 455-470.

Wang, Z.K. and Liu, X.X. (2009). China's Largest Energy Province's Coal Mine Corporation Merger and Coal-resource Integration Progress, 1st November.

Wu, F. M. (2007). "Resource Curse" and economic development. *China Academic Journal Electronic Publishing House.* Available online: http://www.cnki.net/

Xu, K. N and Wang, J. (2006). Relationship between Natural Resource Abundance and the Level of Economic Development. *Journal of Economic Study*, vol. 41, no. 1, pp. 78-89.

Zhang, F. M. (2002). Resources Advantages Traps and Path Choice for Resource-based Economic Transition. *The Journal of China's Population*, vol. 12, no. 4, pp. 8-13.

Appendix

Table 1. China's total energy production, 1992-2011

Year	Total Energy Consumption (10 000 tons of SCE)	As Percentage of Total Energy Production (%)			
		Coal	Crude Oil	Natural Gas	Hydro-power, Nuclear, Power, Wind Power
1992	107256	74.3	18.9	2.0	4.8
1993	111059	74.0	18.7	2.0	5.3
1994	118729	74.6	17.6	1.9	5.9
1995	129034	75.3	16.6	1.9	6.2
1996	133032	75.0	16.9	2.0	6.1
1997	133460	74.3	17.2	2.1	6.5
1998	129834	73.3	17.7	2.2	6.8
1999	131935	73.9	17.3	2.5	6.3
2000	135048	73.2	17.2	2.7	6.9
2001	143875	73.0	16.3	2.8	7.9
2002	150656	73.5	15.8	2.9	7.8
2003	171906	76.2	14.1	2.7	7.0
2004	196648	77.1	12.8	2.8	7.3
2005	216219	77.6	12.0	3.0	7.4
2006	232167	77.8	11.3	3.4	7.5
2007	247279	77.7	10.8	3.7	7.8
2008	260552	76.8	10.5	4.1	8.6
2009	274619	77.3	9.9	4.1	8.7
2010	296916	76.6	9.8	4.2	9.4
2011	317987	77.8	9.1	4.3	8.8

Source: China Statistical Yearbook 2012.

Table 2. China's total energy consumption, 1992-2011

Year	Total Energy Consumption (10 000 tons of SCE)	As Percentage of Total Energy Consumption (%)			
		Coal	Crude Oil	Natural Gas	Hydro-power, Nuclear, Power, Wind Power
1992	109170	75.7	17.5	1.9	4.9
1993	115993	74.7	18.2	1.9	5.2
1994	122737	75.0	17.4	1.9	5.7
1995	131176	74.6	17.5	1.8	6.1
1996	135192	73.5	18.7	1.8	6.0
1997	135909	71.4	20.4	1.8	6.4
1998	136184	70.9	20.8	1.8	6.5
1999	140569	70.6	21.5	2.0	5.9
2000	145531	69.2	22.2	2.2	6.4
2001	150406	68.3	21.8	2.4	7.5
2002	159431	68.0	22.3	2.4	7.3
2003	183792	69.8	21.2	2.5	6.5
2004	213456	69.5	21.3	2.5	6.7
2005	235997	70.8	19.8	2.6	6.8
2006	258676	71.1	19.3	2.9	6.7
2007	280508	71.1	18.8	3.3	6.8
2008	291448	70.3	18.3	3.7	7.7
2009	306647	70.4	17.9	3.9	7.8
2010	324939	68.0	19.0	4.4	8.6
2011	348002	68.4	18.6	5.0	8.0

Source: China Statistical Yearbook 2012.

Table 3. Coal production in Shanxi and Inner Mongolia, 1980-2011

	Production			As Percentage of Country's Total Production (%)	
	Shanxi	Inner Mongolia	Country	Shanxi	Inner Mongolia
1980	10280.42	1076.89	44232.09	23.24	2.43
1985	18204.62	2027.55	62277.49	29.23	3.26
1990	24307.11	2816.25	77110.12	31.52	3.65
1995	29725.23	4389.03	97162.60	30.59	4.52
2000	21378.21	4508.48	98855.14	21.63	4.56
2005	47110.71	18292.32	167785.94	28.08	10.90
2010	62978.44	45935.06	227437.66	27.69	20.20
2011	74146.60	97943.53	247393.89	29.97	39.59

Source: Shanxi Statistical Yearbook 2012; Inner Mongolia Statistical Yearbook 2012.

Table 4. China's Ensured Reserves of coal, 2003-2011 (100 million tons).

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total	3342	3373.4	3326.4	3334.8	3261.3	3261.4	3189.6	2793.9	2157.9
Hebei	88.95	73.16	71.77	68.15	63.46	60.59	56.3	60.59	38.41
Shanxi	1045.3	1040.1	1054.8	1051.7	1056.1	1061.5	1055.5	844.01	834.59
Inner Mongolia	734.44	740.19	757.87	802.33	808.4	789.07	772.7	769.86	368.89
Liaoning	48.18	44.9	54.45	49.75	43.36	44.64	43.8	46.63	30.97
Jilin	15.34	15.58	16.4	17.11	12.53	12.48	12.8	12.4	9.52
Heilongjiang	95.88	90.17	77.33	77.67	74.15	72.44	69	68.17	61.75
Jiangsu	25.75	24.19	22.09	18.3	17.58	14.73	14.5	14.23	10.81
Zhejiang	0.5	0.49	0.5	0.49	0.49	0.49	0.5	0.49	0.44
Anhui	131.9	140.39	145.48	118.74	80.88	85.91	83.7	81.93	79.91
Fujian	4.42	4.64	4.31	4.79	4.44	4.42	4.2	4.06	4.29
Jiangxi	8.06	8.01	7.78	8.18	7.92	7.67	7.2	6.74	4.26
Shandong	91.11	107.19	108.18	103.25	96.25	84.11	82.1	77.56	74.1
Henan	121.67	132.57	127.1	123.3	117.8	115.87	114.7	113.49	97.46
Hubei	2.4	2.366	3.25	3.26	3.32	3.3	3.3	3.3	3.25
Hunan	20.06	20.26	20.37	20.12	19.83	19.57	18.9	18.76	13.29
Guangdong	1.89	1.87	1.89	1.89	1.89	1.89	1.9	1.89	0.23
Guangxi	8.31	8.15	8.54	8.46	8.51	8.24	7.7	7.74	2.02
Hainan	0.9	0.89	0.9	0.9	0.9	0.9	0.9	0.9	1.19
Sichuan	45.15	46.06	49.17	50.26	49.31	49.76	52.3	54.37	51.82
Guizhou	149.21	149.05	148.92	148.26	146.76	150.06	128.1	118.46	58.74
Yunnan	157	157.17	74.03	73.57	79.68	78.65	77.5	62.47	59.67
Tibet	0.12	0.12	0.12	0.12	0.12	0.12	0.1	0.12	0.12
Shaanxi	285.64	284.86	284.05	277.57	276.24	278.46	268.7	119.89	107.59
Gansu	48.93	48.77	49.37	61.7	58.42	60.48	58.4	58.05	23.51
Qinghai	17.44	17.47	19.93	20.66	20.53	20.2	20	16.22	16.12
Ningxia	68.39	68.11	68.52	70.06	59.17	58.15	55.5	54.03	31.28
Xinjiang	100.04	120.67	122.39	127.28	123.24	147.41	148	148.31	148.36

Source: China Statistical Database. Available online: http://www.stats.gov.cn/

Table 5. China's Ensured Reserves of crude oil, 2003-2011 (10 000 tons).

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total	243194	249098	248972	275857	283254	289043	294920	317435	323968
Hebei	12763	12262	12952	16339	25077	24707	26381	27781	27736
Shanxi									
Inner Mongolia	3950.8	4975.1	5670.9	5526.3	5763.4	7751	7618.3	7643.8	8520.4
Liaoning	18414	17598	17015	17010	16915	15734	14938	18799	17881
Jilin	14480	15169	15758	16530	16646	17778	18224	18862	17789
Heilongjiang	59882	56531	53418	62197	60072	57474	54520	54516	51273
Jiangsu	2305.2	2396.2	2402.5	2503.8	2521	2522	2568.1	2689.4	2933.4
Zhejiang									
Anhui	109.7	103.3	136.4	137.88	142.6	161	180.9	186.73	208.8
Fujian									
Jiangxi									
Shandong	31853	31005	29849	34748	34107	33496	32636	34311	34329
Henan	6105.1	5986.2	5876.8	5370.7	5219.2	5183	5051.9	5051.2	5190.3
Hubei	1053.1	1062.1	1033.4	1187.2	1199.8	1210	1224.1	1308	1302.6
Hunan									
Guangdong	9	9	9	9	8.84	8	8.3	8.16	8.05
Guangxi	135.7	128.8	122.46	175.16	191.73	187	181.7	146.41	142.88
Hainan	64	55	45.1	40.8	28.95	17	2.7	-17.27	-34.44
Sichuan	215.9	243.8	288.98	345.05	330.52	338	105.1	514.74	818.74
Guizhou									
Yunnan	10.5	10.5	10.5	12.4	12.21	12	12.2	12.21	12.21
Tibet									
Shaanxi	15104	16245	16973	19885	19917	23047	22490	24948	29844
Gansu	6716.1	8328.6	9465.2	8727.6	9395.2	9114	13799	16085	15529
Qinghai	3579.2	3833	3824.9	4377.2	4157.2	3959	4361.7	5635.2	5529.4
Ningxia	91.6	103.6	95.47	139.91	46.06	211	190.9	202.77	709.96
Xinjiang	36363	39783	41378	41883	41386	43643	46664	51163	56299

Source: China Statistical Database. Available online: http://www.stats.gov.cn/

Table 6. China's Ensured Reserves of natural gas in 2003-2011 (100 million cu.m).

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Total	22289	25293	28185	30009	32124	34050	37074	37793	40206
Hebei	182.11	176.42	179.45	240.59	302.66	303.9	294	359.32	333.1
Shanxi									
Inner Mongolia	3967.2	3969.4	3970.5	1643	3266.4	5635.4	6721.3	7149.4	8040.5
Liaoning	228.17	498.88	500.35	202.91	209.21	197.41	187.1	209.43	194.82
Jilin	171.33	181.34	199.88	167.84	670.18	690.33	677	681.26	827.29
Heilongjiang	467.83	449.99	903.8	935.83	1391.4	1366.3	1338	1455	1407.5
Jiangsu	24.48	24.55	24.47	22.71	22.85	22.47	22.6	23.66	24.04
Zhejiang									
Anhui	0.01		0.01	0.02	0.04	0.04		0.06	0.15
Fujian									
Jiangxi									
Shandong	285.54	283.25	277.08	348.36	348.18	349.43	353.8	366.99	379.2
Henan	173.71	172	161.25	110.42	97.22	98.83	84.1	99.21	98.51
Hubei	40.94	40.44	39.2	3.85	3.76	4.19	4.4	4.68	4.57
Hunan									
Guangdong	0.31	0.31	0.31	0.31	0.31	0.31	0.3	0.31	0.3
Guangxi	8.62	8.49	8.45	3.48	3.43	3.41	3.4	3.39	3.38
Hainan	13.84	12.57	10.95	8.9	6.87	4.4	2.5	0.7	-4.24
Sichuan	2032.8	3147.8	4295.1	5462.8	5915.7	6061.6	6487	6763.1	7973.1
Guizhou	11.05	10.41	9.87	4.61	4.54	4.53	4.5	10.61	10.5
Yunnan	14.96	14.72	14.5	2.86	2.79	2.63	2.5	2.41	2.32
Tibet									
Shaanxi	3611.7	4692.1	5450	8587.7	7435.4	5709.2	5658.7	5628.1	5478
Gansu	67.25	83.81	97.48	98.91	106.51	106.13	163.6	191.8	191.63
Qinghai	1260.2	1544.4	1525.3	1496.1	1462.1	1418.5	1377.3	1321.9	1329.1
Ningxia	0.74	0.83	0.47	1.67	1.68	2.18	2.2	2.75	2.54
Xinjiang	5554.8	5675.4	6023.6	6598.2	6676.3	7543.7	8354.1	8616.4	8809.9

Source: China Statistical Database. Available online: http://www.stats.gov.cn/

Table 7. The Real GDP per capita, 1992-2011

	Consumer Price Indices by Region (preceding year=100)		GDP per capita (yuan)		Gi (%)
	1992	2011	1992	2011	
Hebei	111.4	103.1	2040	33969	15.21
Shanxi	106.1	103.0	1862	31357	15.02
Inner Mongolia	107.3	103.2	1906	57974	18.18
Liaoning	107.4	103.0	3693	50760	14.01
Jilin	106.7	103.7	2246	38460	15.10
Heilongjiang	108	103.9	2672	32819	13.40
Jiangsu	110	103.8	3106	62290	16.09
Zhejiang	106.6	103.8	3212	59249	15.48
Anhui	107.5	103.1	1390	25659	15.56
Fujian	108.2	103.2	2557	47377	15.61
Jiangxi	105.9	103.0	1472	26150	15.29
Shandong	105.7	102.9	2556	47335	15.50
Henan	106.8	103.5	1452	28661	15.86
Hubei	107.8	102.9	1962	34197	15.29
Hunan	109.6	103.1	1595	29880	15.74
Guangdong	110.7	103.1	3699	50807	14.16
Guangxi	107.3	103.0	1490	25326	15.13
Hainan	105.9	104.8	2719	28898	12.49
Sichuan	107.4	103.2	1477	26133	15.33
Guizhou	107.4	102.9	1034	16413	14.77
Yunnan	107.8	103.7	1622	19265	13.23
Tibet	108.9	102.2	1468	20077	14.10
Shaanxi	110.3	104.0	1571	33464	16.41
Gansu	107.2	104.1	1384	19595	14.10
Qinghai	108	105.4	1912	29522	14.54
Ningxia	108.3	104.1	1718	33043	15.77
Xinjiang	108.6	104.3	2477	30087	13.35

Source: China Statistical Database. Available online: http://www.stats.gov.cn/

Table 8. Employed Persons of Mining Industry at Year-end Urban Units by Registration Status, 1992-2011.

	Shanxi (10,000 persons)		Country Average (10,000 persons)		Proportion (%)	
	Mining	Total	Mining	Total	Shanxi	Country Average
1992	69.7	462.8	898	14792	15.06	6.07
1993	75.3	462.3	925	14849	16.29	6.23
1994	70.3	466	904.2	14848.7	15.09	6.09
1995	69.8	463.4	914.3	14908	15.06	6.13
1996	69.6	464.9	888.5	14845	14.97	5.99
1997	67.9	455.9	850.8	14668	14.89	5.80
1998	60.3	391.8	701.6	12337	15.39	5.69
1999	56.8	379.4	649.5	11773.4	14.97	5.52
2000	52.1	370.2	580.9	11259	14.07	5.16
2001	51.7	363	544.2	10791.8	14.24	5.04
2002	52.5	351.6	537.3	10558	14.93	5.09
2003	56.4	347.9	488.3	10969.7	16.21	4.45
2004	63.4	352	500.7	11098.9	18.01	4.51
2005	65.8	352.1	509.2	11404.0	18.69	4.47
2006	67.8	357.2	529.7	11713.2	18.98	4.52
2007	69.5	366.7	535.0	12024.4	18.95	4.45
2008	71.1	365.7	540.4	12192.5	19.44	4.43
2009	74.4	376.1	553.7	12573.0	19.78	4.40
2010	79.1	384.5	562.0	13051.5	20.57	4.31
2011	85.7	409.7	611.6	14413.3	20.92	4.24

Source: China Statistical Database. Available online: http://www.stats.gov.cn/

Table 9. The mining industry added-value of Shanxi Province, 1992-2011

	GDP	Mining Industry	Proportion of Mining Industry added-value for Shanxi's GDP
1992	5511200	713170	12.94
1993	6804100	831115	12.21
1994	8266600	955542	11.56
1995	10760300	1288516	11.97
1996	12921100	1467062	11.35
1997	14760000	1560209	10.57
1998	16110800	1238399	7.69
1999	16671000	1143607	6.86
2000	18457200	1205839	6.53
2001	20295300	1462753	7.21
2002	23248000	1904025	8.19
2003	28552200	2772688	9.71
2004	35713700	4770259	13.36
2005	42305300	7083723	16.74
2006	48786100	8846927	18.13
2007	60244500	11459989	19.02
2008	73154000	19799299	27.07
2009	73583100	19918633	27.07
2010	92008600	27775082	30.19
2011	112375500	38357445	34.13

Source: China Statistical Database. Available online: http://www.stats.gov.cn/

Table 10. Composition of gross domestic product, 1992-2011

	Primary Industry	Secondary Industry	Tertiary Industry
1992	15.0	49.0	35.9
1993	14.3	49.2	36.5
1994	15.0	48.0	37.0
1995	15.7	46.0	38.4
1996	15.3	46.5	38.2
1997	13.0	47.9	39.1
1998	12.9	47.3	39.9
1999	9.6	47.1	43.3
2000	9.7	46.5	43.8
2001	8.4	47.1	44.5
2002	8.5	48.8	42.7
2003	7.5	51.3	41.2
2004	7.7	53.7	38.5
2005	6.2	55.7	38.1
2006	5.7	56.5	37.8
2007	5.2	57.3	37.5
2008	4.3	58.0	37.7
2009	6.5	54.3	39.2
2010	6.0	56.9	37.1
2011	5.7	59.0	35.2

Source: China Statistical Database. Available online: http://www.stats.gov.cn/

Table 11. Shanxi's industrial structure change, 1992 – 2011

	Industry (10,000 yuan)	Mining Industry (10,000 yuan)	Manufacture (10,000 yuan)	Proportion (%)	
				Mining Industry	Manufacture
1992	2404400	713170	1017584	29.66	42.32
1993	2960100	831115	1633494	28.08	55.18
1994	3471800	955542	1787604	27.52	51.49
1995	4385000	1288516	1756005	29.38	40.05
1996	5327300	1467062	2088547	27.54	39.20
1997	6263600	1560209	2359271	24.91	37.67
1998	6585500	1238399	2155771	18.80	32.74
1999	6845500	1143607	2238446	16.71	32.70
2000	7486500	1205839	2394032	16.11	31.98
2001	8324500	1462753	2695994	17.57	32.39
2002	9914400	1904025	3423513	19.20	34.53
2003	12919400	2772688	5055868	21.46	39.13
2004	17113000	4770259	7528278	27.88	43.99
2005	21176800	7083723	8687043	33.45	41.02
2006	24850600	8846927	10379706	35.60	41.77
2007	31418900	11459989	14031256	36.47	44.66
2008	38685400	19799299	14356338	51.18	37.11
2009	35188800	19918633	11122218	56.61	31.61
2010	46579700	27775082	15546903	59.63	33.38
2011	59599600	38357445.2	19158319	64.36	32.15

Source: China Statistical Yearbook 2012.

Table 13. Coal products price index and total industrial products price index of Shanxi Province and China, 1992-2011

	Shanxi		Country	
	Coal	Total Industrial Products	Coal	Total Industrial Products
1992	128.20	114.2	116.1	106.8
1993	140.80	132.5	139.7	124.0
1994	133.7	120.1	122.2	119.5
1995	112.6	113.5	111.3	114.9
1996	114.8	106.4	113.7	102.9
1997	107.8	102.2	108	99.7
1998	95.7	97.5	96.6	95.9
1999	91.9	95.3	94.8	97.6
2000	100.1	100.9	98.1	102.8
2001	107.4	100.3	106.5	98.7
2002	115.8	103.6	111.6	97.8
2003	119.2	112.2	107	102.3
2004	121.1	116.1	116	106.1
2005	119.3	110.2	118.2	104.9
2006	102.1	101	105.8	103.0
2007	104.80	107.4	105.4	103.1
2008	134.3	122.4	131.4	106.9
2009	95.03	92	98.5	94.6
2010	110.52	109.51	110.9	105.5
2011	110.6	107.5	109.6	106.0

Source: China Statistical Yearbook 2012; Shanxi Statistical Yearbook 2012; China Statistical Database. Available online: http://www.stats.gov.cn/

Table 14. The comparison between Shanxi Province and the country on education funding, 1998-2011

	Government appropriation for education in the percentage of GDP (%)		The Proportion of Fiscal expenditure in Education Funding (%)	
	Shanxi	Country	Shanxi	Country
1998	2.64	2.55	70.85	68.92
1999	2.55	2.79	71.22	68.29
2000	2.39	2.87	72.07	66.58
2001	2.44	3.19	71.22	65.92
2002	2.36	3.32	68.93	63.71
2003	2.41	3.28	70.39	62.02
2004	2.17	2.79	65.82	61.66
2005	2.01	2.82	65.14	61.3
2006	2.08	3.00	65.40	64.68
2007	2.14	3.32	68.16	68.16
2008	2.09	3.33	69.71	72.06
2009	2.65	3.59	73.53	74.11
2010	3.24	3.66	78.16	74.99
2011	3.14	3.93	78.29	77.87

Source: Calculated through data from Shanxi Statistical Yearbook 2012 and China Statistical Database (Available online: http://www.stats.gov.cn/).

Table 15. The change of Shanxi's disposable income, 1992-2011

	Disposable income (yuan)	Increase Value over Last Year (yuan)	Growth rate over Last Year (%)
1992	1622.8		
1993	1957.5	334.6	20.6
1994	2565.7	608.2	31.1
1995	3306.0	740.3	28.9
1996	3702.7	396.7	12.0
1997	3989.9	287.2	7.8
1998	4098.7	108.8	2.7
1999	4342.6	243.9	6.0
2000	4724.1	381.5	8.8
2001	5391.1	666.9	14.1
2002	6234.4	843.3	15.6
2003	7005.0	770.7	12.4
2004	7902.9	897.8	12.8
2005	8913.9	1011.1	12.8
2006	10027.7	1113.8	12.5
2007	11565.0	1537.2	15.3
2008	13119.1	1554.1	13.4
2009	13996.6	877.5	6.7
2010	15647.7	1651.1	11.8
2011	18123.9	2476.2	15.8

Source: Calculated through data from Shanxi Statistical Yearbook 2012 and China Statistical Database (Available online: http://www.stats.gov.cn/).

Table 16. Per capita annual consumption expenditure in urban and rural areas in Shanxi Province in year 2011

	Disposable Total Income (yuan)	Per Capita Annual Consumption Expenditure in Urban Area (yuan)	Per Capita Annual Consumption Expenditure in Rural Area (yuan)
Average	**21809.78**	**15160.89**	**4733.35**
Beijing	32903.03	21984.37	11021.24
Tianjin	26920.86	18424.09	6673.27
Hebei	18292.23	11609.29	4514.19
Shanxi	18123.87	11354.30	4355.78
Inner Mongolia	20407.57	15878.07	4827.99
Liaoning	20466.84	14789.61	5081.40
Jilin	17796.57	13010.63	4891.64
Heilongjiang	15696.18	12054.19	5024.72
Shanghai	36230.48	25102.14	10834.10
Jiangsu	26340.73	16781.74	7709.07
Zhejiang	30970.68	20437.45	9792.50
Anhui	18606.13	13181.46	4499.35
Fujian	24907.40	16661.05	6112.99
Jiangxi	17494.87	11747.21	4029.49
Shandong	22791.84	14560.67	5623.58
Henan	18194.80	12336.47	4047.87
Hubei	18373.87	13163.77	4382.95
Hunan	18844.05	13402.87	4355.70
Guangdong	26897.48	20251.82	6149.94
Guangxi	18854.06	12848.37	3522.59
Hainan	18368.95	12642.75	3781.63
Chongqing	20249.70	14974.49	3734.59
Sichuan	17899.12	13696.30	3924.27
Guizhou	16495.01	11352.88	2670.73
Yunnan	18575.62	12248.03	3205.35
Tibet	16195.56	10398.91	2235.62
Shaanxi	18245.23	13782.75	4254.92
Gansu	14988.68	11188.57	3151.10
Qinghai	15603.31	10955.46	3920.15
Ningxia	17578.92	12896.04	4209.55
Xinjiang	15513.62	11839.40	3889.69

Source: Calculated through data from Shanxi Statistical Yearbook 2012 and China Statistical Database (Available online: http://www.stats.gov.cn/).

Table 17. Average wage of mining industry and manufacturing industry in 2011

	Mining (yuan)	Manufacturing (yuan)	Mining/Manufacturing
Hunan	31827	35652	0.89
Zhejiang	35070	35363	0.99
Hubei	35715	35824	1.00
Fujian	33539	33341	1.01
Jilin	35981	35704	1.01
Yunnan	33926	32923	1.03
Guangxi	33527	30206	1.11
Guizhou	40914	35200	1.16
Jiangxi	36496	31158	1.17
Jiangsu	47936	37720	1.27
Sichuan	42399	33210	1.28
Hainan	39104	30601	1.28
Qinghai	45311	35208	1.29
Liaoning	49014	36417	1.35
Inner Mongolia	51159	36330	1.41
Heilongjiang	44726	31197	1.43
Tibet	43848	29796	1.47
Gansu	54103	36312	1.49
Guangdong	53944	35772	1.51
Shaanxi	52368	33385	1.57
Xinjiang	63085	39883	1.58
Shandong	53767	32069	1.68
Henan	52619	30012	1.75
Hebei	57900	32695	1.77
Anhui	65805	36355	1.81
Shanxi	64539	30182	2.14
Ningxia	78338	35503	2.21
Average	47295	34001	1.39

Source: Calculated data from China Statistical Database (Available online: http://www.stats.gov.cn/).

Table 16. The number of three kinds of application for patents accepted and granted, 1998-2011

	Patents Application Accepted				Patents Application Granted			
	National Total	Jiangsu	Shandong	Shanxi	National Total	Jiangsu	Shandong	Shanxi
1998	96233	5829	7597	1070	61378	3787	4127	644
1999	109958	7091	8589	1140	92101	6143	6536	920
2000	140339	8211	10019	1475	95236	6432	6962	968
2001	165773	10352	11170	1473	99278	6158	6725	1047
2002	205544	13075	12856	1630	112103	7595	7293	934
2003	251238	18393	15794	1743	149588	9840	9067	1175
2004	278943	23532	18388	1949	151328	11330	9733	1189
2005	383157	34811	28835	1985	171619	13580	10743	1220
2006	470342	53267	38284	2824	223860	19352	15937	1421
2007	586498	88950	46849	3333	301632	31770	22821	1992
2008	717144	128002	60247	5386	352406	44438	26688	2279
2009	877611	174329	66857	6822	501786	87286	34513	3227
2010	1109428	235878	80856	7927	740620	138382	51490	4752
2011	1504670	348381	109599	12769	883861	199814	58844	11119

Source: China Statistical Database (Available online: http://www.stats.gov.cn/).

Table 17 Population year-end by region, 1998-2011

	Population			
	National Total	Jiangsu	Shandong	Shanxi
1998	124671	7182	8838	3172
1999	125786	7213	8883	3204
2000	126743	7327	8998	3248
2001	127627	7355	9041	3272
2002	128453	7381	9082	3294
2003	129227	7406	9125	3314
2004	129988	7433	9180	3335
2005	130756	7475	9248	3355
2006	131488	7550	9309	3375
2007	132129	5060	9367	3393
2008	132802	7677	9417	3411
2009	133474	7725	9470	3427
2010	134091	7869	9588	3574
2011	134735	7899	9637	3593

Source: China Statistical Database (Available online: http://www.stats.gov.cn/).