Study on two layer planning decision model of carbon emission reduction under carbon trading system and carbon tax

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Abstract

While carbon emission reduction decision is a popular topic in the literature, many questions about the optimal decision of the government and enterprises under the compound policy (carbon trading system and carbon tax) remain unanswered. The present study aims to determine how the government and enterprises make decisions to keep the balance between emission reduction and benefit in China. To achieve this, we build a two layer planning decision model for carbon emission reduction under compound policy, apply Layer Particle Swarm Optimization (LPSO) to solve the model and use the Chinese actual data to simulate. The research results show that the model is effective to optimize carbon emission reduction between government and enterprises. The enterprise has a higher decision flexibility under the compound policy system of carbon trading system and carbon tax. With the increase of carbon tax, the carbon trading activities increase after an initial decrease in the carbon market. When the carbon tax is less than 10 yuan, as the carbon tax increases, social welfare and enterprise profit will also increase. This study contributes to raise the scientific level and effect of the emission reduction decision for government and enterprises.

Keywords: Carbon emission reduction; Carbon trading system; Carbon tax; Layer planning decision

Research on the Theoretical Basis and Evaluation of Inclusive Green Growth in China

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Abstract

This paper explains the theoretical connotation and basis of inclusive green growth, and constructs the indicator system from the dimensions of economic growth, social equity, livelihood welfare, green production consumption and ecological environment protection. Based on China's provincial panel data from 2001 to 2014, this paper calculated the inclusive green growth index by applying entropy weight method. The result shows that the inclusive green growth level in the Eastern region is significantly ahead and there is a ladder shape distribution (East>Northeast>West>Central) among regions. Overall, the inclusive green growth level of developed provinces is in the lead, while the provinces with weak economic traditionally lag behind. A few Western underdeveloped provinces stand out abruptly, in the meanwhile, a minority of economically strong provinces rank at the bottom. The unbalanced development problem among provinces is prominent. In most of provinces from Central and Western regions, the inclusive green growth takes on increasing trend. Part of the provinces come to the standstill, and few developed provinces even present the signs of retrogression.

Key words: Inclusive Green Growth; Theoretical Connotation; Theoretical Basis; Indicator System.

1 Introduction

The choice of the mode which promotes the national economic development varies from different periods and stages of development. The growth oriented development mode which has formed in China since the Reform and Opening-up, is rooted in the specific historical period and the background of survival development stage. This development mode, whose purpose focuses on getting rid of the survival dilemma remained in the early years of reform and opening up, such as the backward productivity, the shortage of product supply and the poverty of people, has specific characteristics of the age. There is no doubt that the growth oriented development mode has liberated the social productive forces greatly, improved the living standards of Chinese people significantly, and promoted the development of the national economy effectively. For example, during the period of 1978-2015, Chinese rural poverty population has decreased from 250 million to 55.75 million, and the impoverishment rate has reduced from 5.7% to 30.7%; GDP has increased from 365 billion yuan to 67670.8 billion yuan, which implies that the total economy has expanded 184 times and the average annual growth rate is up to 9.7%. Nevertheless, we must realize that the growth oriented development mode dominated by the extensive style has gradually unfolded its inherent shortcomings and drawbacks with the reform deepening. The problems of educational and medical inequity, irrational income distribution, unbalanced regional development and uncoordinated urban and rural development are increasingly prominent; the expanded gap between the rich and the poor, the interest differentiation of social groups, the energy resources waste and the ecological environmental pollution trend is overwhelmingly negative. This series of problems are stemming from the deficiency of inclusiveness and the lack of green. For instance, although China's Gini Coefficient falls from 0.479 in 2003 to 0.462 in 2015, which still exceed 0.4, the international warning line of the gap between rich and poor, and belongs to the "large income gap" level. In 2010, China became the world's largest energy consumer and in 2013, the energy consumption per unit output in China is 0.62 kg oe/USD, much higher than the national average value $0.15 in OECD countries. According to estimates, the cost of environmental pollution in China has accounted for more than 8% of GDP, and as much as 10% in China's developed areas（Yang, Xu & Wu, 2013）. The development mode, which ignores the inclusiveness and green, has become a bottleneck factor restricting the further development of China's economy and society. Obviously, the economic mode which devotes to material economy instead of humanistic economy is hard to sustain, and will be reflected in the unsustainable economic development as well as the incongruous relationship between "human and human, human and society, human and nature".

We pursuit economic growth at all costs, which causes the natural and social send out "retaliatory warnings" constantly. The problem of disharmony among economy, society and nature is imminent. Only by changing the mode of economic development can we solve this problem fundamentally. As

early as 1978, China began to explore the theory of economic development mode transformation. In 1987, the report of the 18th National Party Congress points out that the economic development mode should be changed from extensive management to intensive management. In 1996, the Ninth Five-Year Plan puts forward explicitly to change the mode of economic growth from extensive to intensive and change economic system from the traditional planned economy to socialist market economy. These two change are essentially the transformation of economic development mode. In 2007, the report of the 17th National Party Congress indicates that transforming the economic development mode is the crux of realizing the sound and fast development of the national economy. Besides, the transformation of economic growth mode is replaced by the transformation of the economic development mode formally, and Scientific Outlook on Development is put into the Party Constitution as the guiding ideology. inclusive green growth, which focus on livelihood and welfare of people, ecological civilization and fair share, can be thoroughly regarded as the inherent meaning and significance connotation of Scientific Outlook on Development. Although China began to change the economic development mode since the beginning of reform and opening up, we still have not fulfilled it completely (Jian & Li, 2010). Since the eighteenth National Party Congress in 2012, the Party Central Committee with Comrade Xi Jinping as general secretary keep on emphasizing the fundamental way to transform development mode, promote sustainable and healthy economic development and achieve qualify, effective and sustainable development which respects the economic rule. On the other hand, new governance ideas and strategies including “new normal”, “five concepts for development” and “Supply-side reform” are proposed creatively. These ideas and strategies are in response to the theory of economic development mode transformation and aim at the significant decreasing trend of economic development power, caused by the characteristics “superimposition of the three phases” of national economy, as well as the “three drop” of capital output rate, population increment and total factor productivity.

The concept of inclusive green growth is designed to rectify the growth oriented development mode. It’s an important stratagem which promotes the new normal development and a comprehensive embodiment of “harmony”, “green” and “share” of “five concepts” for development. In order to fulfill the human-oriented “five concepts for development” and “lead new normal” instead of “recognizing and adapting new normal”, we ought to drive our country toward the way to inclusive green growth. Therefore, this paper combine some research relating to inclusive growth and green growth, and explain the theoretical connotation and basis of inclusive green growth. Subsequently, we set up the indicator system in order to evaluate regional and provincial inclusive green growth level. And then we conclude some realistic inspirations about accomplishing the goal of inclusive green growth.

2 Inclusive Green Growth: a New Economic Development Mode

At present, research achievements on green growth and inclusive growth are continuously enriched. However, there are few research which propose inclusive green growth formally and define its connotation precisely. In this paper, we review from two aspects, one is green growth and another is inclusive growth. On this basis, we completely explain the theoretical connotation of inclusive green growth

2.1 Research on formation process and measurement of green growth

The proposition of green growth originates from Spaceship economic theory which presented by American scholar Bolding in 1960s, following by relevant theory like steady-state economy, green economy and ecological economy. Pearce et al.(1989) is the first to put forward the concept of green economy, a sustainable development mode which is acceptable for natural environment and human, and develop without environment deterioration, resource exhaustion and social division. Thereafter, Western developed countries reach a consensus on the proposition of green economy and advocate insisting on weak sustainable economic development mode which can reduce environmental pollution and social loss. In 2012, the United Nations Conference on Sustainable Development puts forward the proposal of "developing green economy" and defines green transformation as the future direction of the global economy development. At this point, green economy and green growth have become the consensus of the world. Chinese government has been committed to promoting the process of green economic development for many years. In 1988, Development Research Center of the State Council launches the topic research of bringing natural resources environment accounting into national economic accounting system. Based on that, the Sustainable Development Gtrategy Group of the Chinese Academy of Sciences carries out a more comprehensive supplementary accounting research in 2001. In 2005, the State Council releases Some Opinions about Accelerating the Development of

Circular Economy, which make it clear that circular economy will be an opportunity to accelerate the pace of green growth. In 2012, the report of the 18th National Party Congress points out that we should make great efforts to promote green growth, cycle development and low-carbon development, and form the resource-conserving and environment-protecting spatial pattern, industrial structure, production mode and life style. In 2015, The 5th Plenary Session of the 18th Central Committee proposes the implementation of the five development ideas of "innovation, coordination, green, opening and sharing".

There are three aspects of research focus on discussing the theoretical connotation about green growth. First, some research emphasize economic growth must consider resources and environment protection as well as climate change mitigation. For example, ESCAP(2005) defines green growth as sustainable economic growth for the first time. OECD(2009) points out that green growth is a kind of economic growth mode, which can ease climate change, environmental pollution and biodiversity loss as well as make sustainable use of natural resources Wang Jinnan et al (2006) consider green growth as a development mode with sustainable resources and environment and harmonious relationship between human being and nature, which regard environment as internal productivity. Xia Guang (2010) argues that the core of green economy lies in mutually beneficial between economic development an environment protection. Hu Anganga et al(2014) assert that green growth emphasis on the integrity, coordination and systematicness among economic system, social system and natural system. According to Gu Shuzhong (2016)，green growth consists of four basic components: green economy, green society, green politics and green culture. Second, some theories stress that green industry and clean energy are the new economic growth points. For instance, ESA(2010) suggests that green industry is a new growth point of future economic development. South Korean (2010) also makes clear that green growth is a new development mode which uses green technology and clean energy to increase employment opportunities and growth momentum. The third kind of research regard green growth as a social inclusive economic development mode. For instance, World Bank(2010) and UNEP(2012) point out that green growth is a social inclusive economic development mode. Wang Hailong et al (2016) suggest that green growth demands the improvement of economic development and social welfare along with reducing environmental pollution and resource depletion, and realizing the decoupling of economy, environment and resources

At present, there are no direct indicators to measure green growth. The existing research evaluate it quantifiably mainly through constructing indicator system. Foreign representative research include the following. Targeting at the Asia Pacific region, UNESCAP(2009) establishes the eco efficiency indicator system which reflects the interactive relationship between economic growth and resource environment. OECD(2011) provides a framework of green economic growth index including economic, environment and human well-being for member states. UNEP(2012) constructs a green economic indicator system which covers economic transformation, resource efficiency, social economy and human welfare. California government NEXT10(2012) introduce the green innovation measurement system comprises of low-carbon economy, transportation, energy efficiency, renewable energy and green technology innovation. Domestic representative research includes the following The Sustainable Development Strategy Group of the Chinese Academy of Sciences (2006) builds the resources and environment performance index(REPI) which stresses on resource consumption intensity and pollutant emission intensity. Taking Beijing as a benchmark, Beijing Technology and Business University (2010) structures green economic index based on the efficiency of resources and environment, the essence of which is the simplified ecological efficiency evaluation indicator system. Beijing Normal University (2011) designs the green growth index which concentrates on the green degree of economic growth, resources and environmental carrying capacity and government policy support. Many domestic scholars have done extensive research on China's green growth. For instance, Xiang Shujian and Zhen Ruikun(2013) create green economic development index from the three dimensions of green production index, green consumption index and ecological health index. In refer to human development index, Li Xiaoxi (2014) devises the human green growth index and calculates the green development level of 123 countries. Guo Lingling(2016) et al ,Yu Jingtao and Zhang Yange (2016) construct a green growth indicator system by applying rough set method to filter the basic indicator.

2.2 Research on formation process and measurement of inclusive growth

Since the middle of the 20th Century, the concept of economic growth has gone through the evolution process of the simple emphasis on growth, broad-based growth, pro-poor growth and inclusive growth. The “trickle down hypothesis” springs from the latter half of the 20th century, which convinces people that poverty and inequality will be automatically removed because of the continued economic growth, and the simple emphasis on economic growth becomes the mainstream

consciousness. However, the practice runs counter to expectations. During the late 20th Century, the income of most people in many developing countries had not improved with GDP growth and industrial development, conversely, the wealthy benefited from this and made pots of money, besides, the income disparity and social inequality continued to expand. In 1990s, economists re-examined and criticized this traditional growth theory, meanwhile, advocated the establishment of positive interactive relation among economic growth, income distribution and poverty elimination. To this end, the world bank proposes broad-based growth in the World Development Report in 1990, which stresses economic growth and poverty reduction should always be together. Afterwards, pro-poor growth is presented in 2000, which urges the poverty elimination and poor friendly economic growth. In 21st Century, unfair income distribution and the social injustice aggravate with economic growth are still widespread in Asian countries. In this context, ADB (2007) first put forward inclusive growth, and calls for sustainable economic growth as well as equity and justice outcome sharing Subsequently. Reviewing China, in 2007, the 17th National Party Congress stresses that "a rational income distribution system is an important manifestation of social equity", which is the "Chinese prescription" for achieving inclusive development issued by the government and reflects the determination to pursuit universal equality of opportunity and minimize the social injustice. At this point, inclusive growth has become the core development concept of the international community. Thus, when it comes to the choice of inclusive growth mode, the background of the times, the stage of development and the well-being of the people are the logical destination and core consideration for countries around the world, including China.

At present, there is not unified conclusion about the connotation of inclusive growth, nonetheless, scholars at home and abroad have formed two consensuses. The first one suggests that inclusive growth is a development mode of equal opportunity, fair income and outcome sharing. Ali and Zhuang (2007) define inclusive growth as the growth with equal opportunity for all. According to Birdsall(2007), inclusive growth is the pro-poor growth, which highlights the concerns of poor people and income equality. Ren Baoping and Wang Jianxin(2012) argue that inclusive growth uphold the principle of opportunity equality and outcome sharing. Di Yuna(2016) considers opportunity equality, productive employment and sustainable development as the core connotation of inclusive development. Another conclude that inclusive development is a comprehensive and coordinated development of economy and society. Gao Chuansheng(2012) holds that the basic characteristics of inclusive development is comprehensive coordination, that is to say, the integration, comprehensiveness and coordination of the development contents. Zhou Xiaoliang(2012) points out that the key to practice inclusive development is solving coordination problem of the four significant interests: group, region, generation and international. Tang Xin(2015) highlights inclusive development contains the universality of the development theme, the coordination of the development process and the sharing of the development outcome. Ren Zheng and Meng Lirong (2016) underline inclusive development is the development following the social law as well as the development of open and sharing, which requires both economic social development and the harmonious of society development.

At present, the main method for quantitative evaluation of inclusive growth is by constructing the indicator system. However, there exist many differences in the actual situation and development focus among nations, which cause the construction of the indicator system focus on various issue respectively. From the view of foreign research, Ali and Son(2007) establish the social opportunity function to quantify the inclusive growth. This indicator system, which pays attention to the welfare availability of the poor and give greater weight to opportunities for the poor, is not suitable for evaluating the inclusive growth of countries or regions. Concerning the aspect of poor employment growth and absolute poverty reduction, Klasen(2010) estimates the inclusive development which reflects the inclusive growth of poor welfare. McKinley(2010) constructs inclusive growth index from the perspective of economic growth, productive employment, infrastructure, human capacity, social security, income poverty and fairness, which is inappropriate to China due to the low standard of many indicators. Sugden(2012) calculates the inclusive growth level of 11 developing countries in the Asia Pacific region from the dimensions of health conditions, educational opportunities and infrastructure. The result shows that the inclusiveness of growth mode in these countries has improved. In domestic research, Wei Jie and Ren Baoping (2011) use the indicators containing economic growth conditions, process, and consequences to create indicator system, by calculation, they find that China’s inclusiveness level of economic growth is just "basic inclusive" over the past 30 years. Concentrating on the level of economic development, social harmony, feasible ability and social security, Zhou Xiaoliang and Liu Wanli(2012) structure an inclusive development indicator system with people's livelihood as a core and social stratum difference. Yu Min and Wang Xiaolin (2012) create the inclusive growth index which covers the sustainability of economic growth, poverty reduction and income inequality, fairness of participating economic opportunity and access to basic social security, their estimation results shows during 1990 to 2009, China shows the

trend of low level of inclusiveness. Chen Honglei and Tan Weifang (2014) measure China's total factor productivity oriented toward income disparity in 1980-2011 Province, and find that the total factor productivity without considering the income disparity is greatly overestimated. Guo Suwen (2015) structures the inclusive growth indicator system including the sustainability of economic growth, rights acquirement and opportunity equality and outcome sharing dimensions. The calculated results reflect the large gap of China's provincial inclusive growth level, which shows the ladder distribution of high in the East and low in the West among regions.

2.3 Theoretical connotation analysis of inclusive green growth

By studying the existing research, we can find that either in terms of concept connotation or index selection, there exist both differences and similarities between green growth and inclusive growth. Green growth is put forward under the background of contradiction between the ecological environment and natural resources on one hand and economic and social development on the other. The core connotation of green growth lies in the coordinated and sustainable development of economy, resources and environment, what's more, green production, green consumption and good ecological environment are important manifestation of it. Green growth emphasizes mutual benefit and win-win between economic efficiency and environmental performance, which insist economic growth cannot be achieved at the expense of the environment and resources. But this does not mean to deny the economic growth, instead, we must look for new mode of economic growth which combines "development" with "green". The core connotation of inclusive growth rests with the coordinated development of economy and society, which is essentially a rational use of economic growth outcomes. To some extent, inclusive growth highlights the characteristics of "comprehensive", that is, social employment increase, growth results sharing, the mutual improvement of the income and non-income and the simultaneous development of economy and society when a country achieves economic growth. From the logical structure analysis, the theoretical core to achieve this kind of "comprehensive" depends on "the fairness and justice concept, universal participation process, the coordination content and the universal sharing results " of inclusive growth.

Thus it can be seen that both green growth and inclusive growth lay stress on the sustainability of economic growth and emphasize the rational distribution of growth outcomes and improvement of people's livelihood benefits. Nevertheless, green growth pay more attention to the coordination sustainability of economic growth and resource environment, and devote to creating a prosperous and healthy living environment for the people. On the other hand, inclusive growth concerns more about the overall coordination of economic growth and social development, moreover, if focuses on the social employment increase, income gap reduction and universal outcomes sharing. Obviously, neither of them can reflect the new content and new requirements of China's economic development mode transformation at this stage entirety. An economic development concept with richer connotation, more comprehensive content and more innovative logic must be put forward on the basis of this.

Inclusive green growth is sustainable and inclusive growth, with an emphasis on the opportunities and necessity of economic development path for "improving the human welfare and social equity while reducing environmental risks and ecological problems"(Zheng, 2016).Therefore, inclusive green growth covers but not equals to green growth and inclusive growth. It stresses the complementary and sustainable development of economic, social and environmental resources, which is the inevitable combination of green growth and inclusive growth under China's periodic task of economic transformation and upgrading. It is pointless to consider merely green and inclusive but neglect development; besides, focusing on development without concerning about green and inclusive is tantamount to drain the pond for getting all the fish. inclusive green growth, the core of which is "not only green and inclusive, but also development", emphasizes on the complement and coordination among "green", "tolerance" and "development".

The future development must be the scientific development following economic law, the sustainable development following the natural law and the inclusive growth following the social law. inclusive green growth concept, which is a new development strategy related to human development, transformation development, scientific development and harmonious and sustainable development, embodies the scientific nature, sustainability and inclusiveness of development. Its proposal accords with the new tasks and new requirements under the new situation. Compared with green growth and inclusive growth, inclusive green growth has a more comprehensive theoretical connotation and practical value, its logical starting point is the nationwide equality participation of development process; its theoretical characteristics is the comprehensive, coordinative and sustainable development content; its fundamental significance is the sharing of development outcomes; its value orientation is social equity and livelihood welfare; its important guarantee is production and consumption; its essential requirement is ecological environment protection. Therefore, this paper regards inclusive green growth as a long-

term development goal of economic system, social system and natural system. Besides, we define inclusive green growth as "a sustainable development mode which pursues economic growth, social equity, social welfare, outcome sharing, energy saving and environmental protection, as well as the comprehensive coordination of economic, social and resource environment". It's a new economic development mode with the deep social background of scientific development and new normal. China's economic development mode urgently requires making a fundamental change. Under this circumstance, the implementation of inclusive green growth strategy will effectively break down the "Zero-sum Game Dilemma" between economic growth and environmental resources. In addition, the implementation can also relieve the social conflicts caused by unbalanced development and unreasonable distribution, optimize the traditional resource allocation pattern and ultimately promote the improvement of livelihood benefits and harmonious development between "man and man, man and society, man and nature".

3 The theoretical basis of inclusive green growth

Inclusive green growth is an innovative concept proposed by mankind under the development trend of new era and the practical experience summary of human beings in the process of protecting ecological environment and pursuing people's livelihood happiness. This idea points out what kind of development way countries around the world should take in the future. This great idea innovation is rooted in the fertile soil of a series of classic Marx doctrine. The thought of harmony between human and nature, the concept of green development and the view of social equity and justice in Marxist thought have provided abundant theoretical support for it during the past hundred years, which makes Marx theory become the most profound theoretical basis of contemporary inclusive green growth concept at home and abroad, and important source of thought for human society to implement inclusive green growth strategy.

3.1 Marx's thought of harmony between human and nature is the theoretical basis for inclusive green growth to pursuit "sustainable development".

Inclusive green growth regards promoting harmony between human and nature as the essential requirement, and focuses on achieving sustainable development of human and nature. On one hand, Marx and Engels profoundly reveal that nature is the premise and foundation of human society's emergence, existence and development, which indicates that abundant natural resources and favorable ecological environment are the most basic material conditions for human society to achieve inclusive green growth.

Marx holds that human and nature have objectification relation, "Nature is the inorganic body of human in terms of himself, which is not the human body. Human lives on the natural world. That is to say, nature is the human body which human beings must continue to interact with in order not to die"(Marx & Engels, 2003), as well as integrated relation, "The so-called physical and spiritual life of human beings are related to nature, which is nothing else than that nature is related with itself, because human are one part of nature"(Marx & Engels, 2003). He points out that human have natural nature, as well as flesh and blood connection with nature, because "on the one hand, we have natural force and vitality, and we are dynamic natural existence..... On the other hand, human, as natural, physical, perceptual and object existence, are passivity, restricted and limited existence just like animal and plant(Marx & Engels, 2009). The general rules of material circulation and the flesh-and-blood ties between human and nature, become the objective basis of the harmony between man and nature. In essence, they are also the basic law that human society must follow for carrying out inclusive and green development.

On the other hand, Marx and Engels warn human beings to be friendly to nature and protect nature. Marx criticizes the abuse of land resources in capitalist production, "Any progress of capitalist agriculture, not only plunder the workers' skill, but also grab the lands' skills. in a certain period of time, any progress that improve soil fertility, is also the progress that destroy the lasting source of land fertility." (Marx & Engels, 2009). To Engels, human will be punished by nature if their activities violate the laws of nature, "we should not revel in our victory on the nature, because for each such victory, we are revenged." (Marx & Engels, 2009). Therefore, he advises that human beings should not become the opposite of nature when they use and transform nature: "Our rule over the nature is not like the conqueror over alien, we should not like people outside the nature——on the contrary, we together with our flesh, blood and brains belong to and exist in nature; all the ruling power over nature we have, is that we are stronger than all other creature, and we are able to understand and use natural law correctly." Human and nature should be an interdependent and interrelated entirety, so we can not only talk about the demand and use without the input and build. In this regard, Marx stresses we must pay attention to the intergenerational inheritance and influence of historical development. "Both the relationship between human and nature and among individuals, encounter a lot of productivity, capital and environment handed down from one generation to another. On the one hand, though the

productivity, capital and environment are changed by the new generation, on the other hand, they also prescribe the conditions of new generation, so that it can get certain development and has special nature." (Marx & Engels, 2009). This requires that inclusive green growth must respect the objective law that nature does not transfer from man's will, and take the interests of both contemporary and future generations into account.

Thus, inclusive green growth profoundly contains the notion of "the protection of the ecological environment is the protection of human, and the rational use of natural resources benefits mankind." This is the inheritance and deepening of Marx's thought of harmony between man and nature. This determines the inclusive green growth must take the natural law as the criterion, the bearing capacity of resources and environment as the basis, harmonious and sustainable development between human and nature as the goal, and promote economic development and social progress in line with the premise of the natural principle and the welfare of generations; Otherwise, if the natural resources are exhausted and the ecological environment are seriously damaged, social material production will not exist any longer, human beings could not continue to survive, the inclusive green growth goal of human society is out of the question.

3.2 Marxism inclusive green growth is the theory, guiding using resources efficiently and pursuing favorable ecology

The key subjects of inclusive green growth are increasing the efficiency of using kinds of resources and improving the natural environment, which is beneficial to reach the green restructuring in economy. Although Marx and Engels did not put forward the concept of green development straight, the main thoughts of green development were presented in Marxism. The reason is that Marxism stresses the ecological balance, environmental protection, saving natural sources and recycling which are all reveal the thoughts of green development. Firstly, Marx and Engels believe that capitalism development is harmful and inhuman, causing quantities of waste and pollution. He said:“So far as their utilization is concerned，the capitalist mode of production wastes them in enormous quantities. In London，for instance，they find no better use for the excrements of four and a half million human beings than to contaminate the Thames with it at heavy expense.” (Marx & Engels, 2003). Therefore, Marx criticized strongly the inhumanness and anti-ecology which are the figures of capitalism during the process of pursing profit：“Light，air，etc. -the simplest animal cleanliness -ceases to be a need for man. Filth，this stagnation and putrefaction of man -the sewage of civilization（speaking quite literally）-comes to be the element of life for him. Utter，unnatural depravation，putrefied nature，comes to be his life-element.” (Marx & Engels, 2009). In addition，Marx revealed the results of wasting resources and damaging the environment due to capitalism policies by the example of over-using land resource in capitalist society：“On the other hand，large landed property reduces the agricultural population to a continually decreasing minimum，and induces on the other side a continual increase of the industrial population crowded together in large city. In this way it creates conditions，which cause an incurable break in the interconnections of the social circulation of matter prescribed by the natural laws of life. As a result the strength of the soil is wasted ，and this prodigality is carried for beyond the boundaries of a certain country by commerce.” (Marx & Engels, 2004) .

Engels expressed great concern and dissatisfaction with the British working class being forced to work in harsh environments where air and water were contaminated: “All conceivable evils are heaped upon the heads of the poor. If the population of great cities is too dense in general, it is they in particular who are packed into the least space. As though the vitiated atmosphere of the streets were not enough, they are penned in dozens into single rooms, so that the air which they breathe at night is enough in itself to stifle them” (Marx & Engels, 2009). He also made it clear that there were serious ecological problems in industrialized countries: “Earthly depleted - as in the United States; forests disappear - as in the UK and France, now in Germany and the United States as well; climate change, river silt in Russia is probably worse than anywhere else.” (Marx & Engels, 2009). This vivid reveals the destruction of the ecological environment and the damage to ordinary workers physical and psychological caused by capitalist production. The capitalist system leads to the conflict between human and society or nature. If the capitalist state does not change the current social system and its mode of production, "the human plan not based on the great natural law will only bring disaster"(Marx & Engels, 1995). At present, being harmed from water pollution and air pollution further shows that human health not only depends on the land，but also determined by the ecological environment of clear air and clean water, which requires inclusive green growth must adhere to the people-oriented and green Production of the concept of development.

On the other hand, Marx and Engels emphasized that human beings must moderate consumption

and self-restraint so as to ease the opposition between human and nature. Engels argues that excessive consumption and hedonism under capitalist private ownership are a stark waste of resources:“but the progress of capitalist production not only creates a world of delights；it lays open，in speculation and the credit system，a thousand sources of sudden enrichment. When a certain stage of development has been reached，a conventional degree of prodigality，which is also an exhibition of wealth，and consequently a source of credit，becomes a business necessity to the ‘unfortunate’ capitalist，luxury enters into capital’s expenses of representation” (Marx & Engels, 2003). The greed of capitalism is the root of uncontrolled expansion of human consumption to stimulate demand. In order to meet this greed, it must continue to create new demands, stimulate the desire of human consumption and pleasure, so as to establish an excessive "consumer society" in developed countries. In this regard, Marx mercilessly exposed that the luxury consumer behavior and green development concept out of tune: “Luxury is the opposite of natural necessity. The necessary need is the personal need which come down to natural individuals.” (Marx & Engels, 2003). The final outcome of the infinite expansion of capital must be the disparity of nature and the fall of human society, which runs counter to the "sustainable sustainability and inclusiveness" principle of inclusive green growth. To this end, Marx put forward a great idea to elimination the ecological environment crisis caused by the opposition between human and natural：“The freedom in this field cannot consist of anything else but of the fact that socialized man，the associated products，regulate their interchange with nature rationally，bring it under their common control，instead of being ruled by it as by some blind power；that they accomplish their task with the least expenditure of energy and under conditions most adequate to their human nature and most worthy of it.” (Marx & Engels, 2004) That is to say, when the human beings step into the "free kingdom", will be in a worthy and most suitable way for human nature to transform nature, reasonable and moderate to complete the material transformation with nature, where the human nature is essentially " Ecological human nature ".

inclusive green growth advocates the effective use of resources and the bright development of ecological environment, not only requires human self-reflection and restraint, but also through the implementation of Marxist green development concept, which means moderating consumption, conservation of resources and environmental protection, to avoid the old way of changing resources and environment into material wealth in the process of economic growth, to eliminate the imbalance of green wealth between the region, urban and rural areas, and groups, to explore the ecological environment to protect the new impetus to economic growth model of innovation, and ultimately promote resource efficiency and ecological environment quality significantly improved to achieve economic, social and natural complement each other.

3.3 Marx's view of fairness and justice is the theoretical guidance of inclusive green growth and advocacy of "opportunity equality" and "achievement sharing"

inclusive green growth pursues equal participation in the process of economic growth and equitable sharing about achievements in economic growth among different countries, different nationalities and different groups. Social fairness and justice are the value orientation of inclusive green growth. Marx and Engels rarely mentioned justice concept, but their numerous writings clearly revealed the profound thinking of fairness and justice, and regarded social equality as fairness and justice. First of all, Marx and Engels thought that fairness and justice were concrete and historical, and the view of fairness and justice were changing with the transition of history. For Marx, the view of fairness and justice had different content in different times: "the Greeks and Romans believed that slavery was fair; bourgeois demanded the abolition of the feudal system, for it was said to be unfair in 1789." So, on the concept of fairness changes not only due to time and place, even it differs from each individual." (Marx & Engels, 1995) Engels pointed out: “no matter either in the bourgeois form, or in the form of the proletariat, the concept of equality itself is a product of history. The formation of this concept needs a certain historical condition which take past long history as the premise.” (Marx & Engels, 2009). Obviously, Marx and Engels denied that "eternal justice" could existed without historical conditions, because "if the concept of equality is everything, it is not the eternal truth"(Marx & Engels, 2003). Therefore, fairness and justice have the characteristics of social history and vary from different perspectives. Fairness and justice did not exist in the early development stage of society, until entering the class society then it began to produce and developed, but it will be “retire” after the establishment of the Communist society by human beings. Because “under communism and abound resources conditions…Who insists on requiring an equal product to him exactly, people will give him two copies to ridicule. Equality and justice can be found only in the repository of historical memories, but where else is it?" (Marx & Engels, 2009).

Secondly, Marx and Engels thought fairness and justice were relative and full of class attribute, and the concept of fairness and justice varied because of the alternation of different class status. Marx and

Engels criticized the so-called justice accepted by all people which had become the ruling class exclusive essentially. "It either defenses for the rule and interests of the ruling class, or on behalf of the oppressed against ruling class achieves their future interests when the oppressed becomes strong enough." (Marx & Engels, 1995). They thought that justice was deeply marked with the brand of class, such as the fairness and justice advocated by capitalist society was fair equivalent exchange freely among commodity owners. However, "The equality and freedom themselves were not equal and free"(Marx & Engels, 2003).Even entering into socialism, fairness and justice still retain the bourgeois right. Because "This is just born from capitalist society, therefore it is still with old society traces in all aspects including economy, moral and spiritual.…It is inevitable that it has just come out from the capitalist society after a long period of throes "(Marx & Engels, 2003).In this regard, Marx and Engels believed: "Real freedom and equality can be achieved only under communism "(Marx & Engels, 2003), and the social justice system is required by all members of the society. On the relativity of fairness and justice, Engels did not agree the feasibility of "Eliminating all social and political inequality" instead of "Eliminating all class distinctions", because "There will always be a kind of inequality in living conditions between countries, provinces and even local. This inequality can be reduced to a minimum, but will never be completely eliminated (Marx & Engels, 2003)," and "equality only exists in the confrontation with inequality, and justice only exists in the opposite of injustice "(Marx & Engels, 2003). So fairness and justice always included differential fairness and justice at any time.

In addition, Marx and Engels thought that fairness and justice depended on social productivity and production relations. Justice is essentially a kind of ideology. Historical materialism showed that economic base determines the superstructure and was constrained by social productivity. So the productivity level determined the level and nature of the superstructure, also the nature and level of justice. The lack of materials and fighting for the necessities of life are social economic reasons for lacking of fairness and justice, but class oppression caused by backward productivity is the political root. The bourgeois regarded capitalism itself as "In present conditions, the existing relationship among people is the most useful and most public relations"(Marx & Engels, 2003). It attempted to confuse the majority of workers to create surplus value for maintaining their own wealth production force and production relations. In this regard, Marx and Engels argued that although capitalism broke through human's plight of lacking material wealth, intensified new injustice to social reality. "It puts human dignity into exchange value with a free trade which has no conscience instead of countless franchising and freely earned freedom."(Marx & Engels, 1995). To pursue the profit using unscrupulous divisive tactics, this capitalist system severely havocked labor's health and fair rights and ruthlessly trampled ideology foundation of social development. This kind of capitalism "in the name of fairness and justice for the real profit" is selfish clearly. No wonder that Marx and Engels bluntly pointed capitalism was "equality in form, not in content "(Marx & Engels, 1995). Obviously, the fairness and justice of capitalism only served the bourgeoisie itself, but it was only a distant dream for the workers press. Because "people always have freedom in some area decided and premised by existing production capacity rather than people's ideals"(Marx & Engels, 2003). Marx and Engels was deeply aware that "rights can never go further beyond social economical structure and social culture development restricted by economic structure" (Marx & Engels, 2003), and the development of productive forces is the core condition for transformation of the production relations and the realization of the fairness and justice. Therefore they urged, capitalist system and its mode of production must be completely destroyed, and people should establish communist system to achieve the desire of all members for society justice, equality and freedom.

The opportunity equality and achievement sharing advocated by inclusive green growth are the important components of social fairness and justice. Opportunity equality reflects that inclusive green growth focuses on the participation for all citizens in the process of growth. It requires the elimination of inequality in development opportunities due to the differences in history, geography, institutional environment and personal background. Results sharing reflects that the inclusive green growth practices the benefit sharing in the distribution of growth results. It emphasizes to narrow income gap through relatively reasonable and equitable distribution of interests with humane care. inclusive green growth inherits and develops Marx's view of fairness and justice. Equality of opportunity and sharing of results are two concrete manifestation which abandons some logic errors such as "ideal concept", "absolute fair" and "income averaging". On the basis of relativity, historicity and objectivity, Mutual promotion and mutual complement drive productivity and production relationship forward in the reform between the unity of opposites.

4 Indicator System and Research Methods

4.1 The Construction of Indicator System

According to the connotation of inclusive green growth and related research, this paper constructs the indicator system from five dimensions: economic growth, social equity, livelihood welfare, green

production and consumption and ecological environment protection (As illustrated in Table 1). Adhering to the principles of comprehensiveness, rationality, representativeness and availability, we select the basic indicators of each dimension, specifically analyses as follows.

Economic growth dimension (EG). Economic growth is the core essence of inclusive green growth and the material basis for social progress and improvement of people's livelihood. It can be measured from three aspects: the quantity and speed of economic growth, the urban and rural incomes increased by economic growth, urbanization process promoted by economic growth: (1) In this paper, we choose the following basic indicators to reflect the economic growth. GDP per capita is a common standard used to measure people's living level of a country or region. GDP growth rate presents the pace and vitality of economic growth. Compared with GDP, both of them can better measure the development gap among regions. We use GDP per capita and GDP growth rate to represent the quantitative effect and speed effect of economic growth respectively. (2) Urbanization is an inevitable stage in the process of economic growth for countries around the world. We select urbanization rate to express the driving effect of economic growth on urbanization. (3) Per capita income level is an important sign of national life improvement created by economic growth. We use urban per capita disposable income, rural per capita net income to indicate the improvement effect of economic growth on income of urban and rural residents.

Social equity dimension (SE). Social equity is the value orientation of inclusive green growth, which concentrates on increasing employment, narrowing the gap between rich and poor and sharing public resources. It fully embodies economic growth's inclusiveness to equal opportunity, fair process and outcomes sharing. The World Bank (2006) uses educational and medical equity to reflect whether growth endow people with due rights equally. On the basis of this, we add the social employment and income gap to represent the social equity dimension: (1) Employment level is an important manifestation of the social opportunities equality degree, while the unemployment rate can mirror the fluctuations in employment. In view of the data availability, we select the urban registered unemployment rate to measure social employment level. (2) Gini Coefficient is a common measure of the gap between rich and poor. But we lack provincial statistics data. Considering that China have typical urban and rural dual economic structure and obvious urban-rural income gap, we adopt the urban-rural income ratio as an alternative indicator to show the gap between the rich and the poor, and specifically by calculating "the ratio of urban per capita disposable income to rural per capita net income". (3) Educational fairness is weighed from the aspects of universal educational degree and education resources etc. More specifically, we chose the proportion of illiterate population ratio① and education resources per million people① as the basic indicator. (4) Medical equity is assessed by the two basic medical conditions including number of doctors and beds, which are very prevalent. The specific indicators are the number of health technical workers per thousand population and the number of medical institution beds per thousand population.

Livelihood welfare dimension (LW). The welfare of the peoples livelihood is also the value orientation of inclusive green growth and the embodiment of "people-oriented" development concept. The "Five in One" constructions proposed by the 18th National Party Congress report take livelihood improvement as the starting point and foothold. In this paper, we analyze the people's livelihood dimensions from the aspects of family happiness, residents' consumption ability, infrastructure construction, urban population density and education funds input: (1) There is no direct measure of family happiness. In view of the fact that family happiness is closely related to marriage in modern society, the easily accessible divorce rate can reflect the family happiness reversely. (2) Material demand is the basic components of livelihood welfare, and the consume ability is the direct expression of the livelihood welfare on the material level. Accordingly, we regard household consumption expenditure per capita as basic indicator by calculating: "the urban per capita consumption expenditure and rural per capita consumption expenditure" concretely. (3) The infrastructure construction is of vital importance to the nation's economy and the people's livelihood. It plays a significant effect on the quality of people's lives and economic activities. This paper selects the length of transportation routes per ten thousand people and city road area per capita to reflect the transportation construction and city construction respectively. (4) Urbanization directly induced the "Big City Disease". The urban population expansion, road congestion and other issues have become increasingly prominent, which seriously affect the quality people's life. So we introduce urban population density as a reverse indicator. (5) As the most fundamental livelihood project, education has a significant impact on long-term development

① Illiterate population refer to people aged 18 and over who cannot read or can barely read; education resources per million people refer to school quantity, including colleges, ordinary middle schools, ordinary primary schools and special education school, due to serious lack of data, occupation high school and specialized secondary schools are removed.

of ordinary people and the national economy. However, the government has the long-term insufficient investment and many historical debts phenomenon in the field of education, increasing investment in education is still an important way to improve the people's livelihood in the future. We use the education funds input intensity as the basic indicator, which is calculated as “the ratio of national financial education funds to GDP” specifically.

Green production and consumption dimension (GPC). Green consumption is an important guarantee for inclusive green growth. It emphasizes the activities of production and consumption should improve resource utilization efficiency and reduce pollution emissions. Besides, it requires the supply of green products so as to promote the healthy development of human society. This paper select industrial structure, energy efficiency, pollution emissions, and low carbon consumption to reflect the green production and consumption dimensions: (1) Generally, the second industry is the pillar of the national economy, but also the main source of pollution. While the third industry is the optimization direction of industrial structure because of its high efficiency, low emission and low pollution in many countries. We use the second industry proportion and the third industry proportion as the basic indicator. (2) The improvement of energy efficiency will effectively save natural resources and increase economic benefits. We use energy consumption per unit of GDP as an indicator of energy efficiency. (3) It’s widely acknowledged that human industrial production is the “Arch-criminal” of environmental pollution. China has paid heavy environmental cost for the long-term extensive growth mode. This paper adopts the representative “Three Industrial Wastes” emission to reversely measure pollution emission level, which specific to the calculation of “Industrial waste water, sulfur dioxide and solid waste emissions per unit gross industrial product”. (4) For a long time, high carbon economy has seriously restricted the green process of China’s economic growth. Social consensus on developing low-carbon economy and low-carbon consumption are increasingly strong. The paper uses the carbon dioxide emission per capita to reflect low carbon consumption.

Ecological environment protection dimension (EEP). Ecological environment protection is the essential requirement of inclusive green growth. The economic growth under the restriction of ecological environment capacity and resource carrying capacity will effectively drive the inclusive green growth process. In this paper, we access the ecological environment protection dimension from the perspective of environmental restoration ability, environmental protection projects and environmental pollution control: (1) The ability of environmental restoration is a natural trend of environmental safeguard, which reflects the special function of environmental protection. In this paper, we use the self-purification capacity of water environment as a proxy indicator of environmental restoration ability. (2) Public green space planning and nature reserve establishment are important environmental protection projects, which satisfy residents’ demand of a good ecological environment adequately. We choose the public green area per capita and the ratio of natural reserve area to jurisdiction area as proxy indicators. (3) The sewage charges system achieves the goal of reducing emissions by imposing a certain amount on the main body of the sewage, and the intensity of the sewage charges reflects the scale and intensity of environmental pollution control. The investment in industrial pollution control is an important means to make up for the negative external effect of the environment under the environmental regulation, thus we use sewage charges levied intensity and industrial pollution control investment intensity to reflect environmental pollution control, which are specifically calculated as “ the ratio of sewage charges income to industrial pollution control completed investment and the ratio of industrial pollution control completed investment to gross industrial product”.

Table 1 Inclusive green growth indicator system

Dimension	Basic indicator	Unit	Property
EG	GDP per capita	Yuan/person	+
	GDP growth rate	%	+
	Urbanization rate	%	+
	Urban per capita disposable income	Yuan/person	+
	Rural per capita net income	Yuan /person	+
SE	Urban registered unemployment rate	%	-
	The urban-rural income ratio	/	-
	Illiterate population ratio	%	-
	Education resources per million people	Suo/ten thousand people	+
	The number of health technical workers per thousand population	Person/thousand people	+
	The number of medical institution beds per	Ge/thousand people	+

	Thousand population		
LW	Divorce rate	‰	-
	Household consumption expenditure per capita	Yuan/person	+
	The length of transportation routes per ten thousand people	Km/person	+
	City road area per capita	m^2/person	+
	Urban population density	Person/km^2	-
	Education funds input intensity	%	+
GPC	The second industry proportion	%	-
	The third industry proportion	%	+
	Energy consumption per unit of GDP	Ton/ten thousand yuan	-
	Industrial waste water emissions per unit product	Ton/ten thousand yuan	-
	Sulfur dioxide emissions per unit product	Ton/ten thousand yuan	-
	Solid waste emissions per unit product	Ton/ten thousand yuan	-
	Dioxide emissions per capita	Ton/person	-
EEP	Purification capacity of water environment	/	+
	The public green area per capita	m^2/person	+
	The ratio of natural reserve area to jurisdiction area	%	+
	Sewage charges levied intensity	%	+
	Industrial pollution control investment intensity	%	+

Note: The positive indicator shows that the larger the indicator value, the larger the inclusive green growth index. The negative indicator shows that the smaller the indicator value, the larger the inclusive green growth index.

4.2 Research Method

The determination of the indicator weight is the key step to measure the inclusive green growth index. At present, the weighting methods including the subjective weighting method and the objective weighting method are widely used. Subjective weighting method require the experts to make subjective judgment of each indicator and give weight in reference to their experience and knowledge, such as the binomial coefficient method and analytic hierarchy process. The objective weighting methods which use specific mathematical method to determine the weight of the indicator based on the relationship among a large number of raw data, have good mathematical theory basis. Considering that the objective weighting method will not affected by human subjective factors, this paper selects entropy weight method which belongs the objective weighting methods to empower the indicators.

According to the information entropy of each indicator and related information amount, entropy weight method calculates the weight of the corresponding indicators in the system. On this basis, we can get the final comprehensive score by weighting calculation. Although the calculation process of entropy weight is complicated, it has high precision, wide application range, and is not easy to be interfered by human factors, which make the result of entropy weight closer to reality. The basic steps of using entropy method to calculate the indicator weight and inclusive green growth index are as follows:

(1) Standardized processing of raw data. Due to the magnitude, positive and negative, and the measurement unit difference of original indicator data, the indicators cannot be calculated directly. We need carry out the standardized treatment. Learning from the calculation method of international authority index including human development index (HDI), global competitiveness index (GCI) and environmental performance index (EPI) and following the rule of "the bigger the positive indicator value, the better" and "the smaller the negative indicator value, the better", this paper uses the method of standardization to convert the original data as follows.

positive indicators: $$X_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})}$$

negative indicators: $$X_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})}$$

Where x_{ij} represents the original value of the jth indicator belonging to the ith evaluation object. X_{ij} is the value of x_{ij} after standardized treatment, and $X_{ij} \in [0,1]$, $\max(x_{ij}), \min(x_{ij})$ are defined as the maximum and minimum of original value under the jth indicator. After the standardized treatment, we eliminate the excessive disparity impact among magnitude or provincial level on the

original indicators.

(2) Calculation of the proportion of information entropy. Assume P_{ij} represents the proportion the ith evaluation object, which is under the jth indicator, take up of the jth indicator. E_j stands for information entropy of the jth indicator. The specific calculation process is as follows

$$P_{ij} = X_{ij} / \sum_{i=1}^{30} X_{ij} \ , i \in [1, m], j \in [1, n]$$

$$E_j = -[\ln(n)]^{-1} \times \sum_{i=1}^{m} [P_{ij} \times \ln(P_{ij})]$$

According to definition, information entropy $E_j \in [0,1]$, when the indicator has smaller information entropy, it has the greater dispersion degree, which indicates that more information amount is provided by the indicator and the greater weight will be given to the indicator, otherwise, the reverse. It should be noted that there are 30 provinces and 29 basic in the sample, so m and n value 30 and 29 respectively, that is, $i \in [1,30]$ and $j \in [1,29]$; if the proportion $P_{ij} = 0$, we will define $\lim_{P_{ij} \to 0} P_{ij} \times \ln(P_{ij}) = 0$.

(3) Calculation of indicator weight and score of evaluation object. We assume that W_j is the weight of the jth indicator and S_i is the score of the ith evaluation object, the specific calculation process is as follows

$$W_j = (1 - E_j) / \sum_{j=1}^{n} (1 - E_j)$$

$$S_i = \sum_{j=1}^{n} (W_j \times X_{ij})$$

We can calculate the weight of each indicator $W_1, W_2, ..., W_m$, with the weight formula. The indicator plays a more important role in the indicator system if the weight is higher. Then we can use the weigh and standardized sample data to work out the comprehensive score $S_1, S_2, ..., S_n$ of each evaluation object, which are the inclusive green growth index of different provinces.

4.3 Data sources and processing

This paper is based on 2001-2014 provincial panel data in China. Due to the lack of many data, Tibet is removed. In order to eliminate the impact of price fluctuations, GDP per capita, urban per capita disposable income, rural per capita net income and household consumption expenditure per capita are converted into the actual value which regard 2001 as the basis. Carbon dioxide data is form CEAD's database. Referred to the calculation methods of Zheng Changde(2016), we can get the data of self-purification capacity of water environment. Other variable data comes from 2002-2015 "China Statistical Yearbook" "China Environmental Statistics Yearbook", "China Energy Statistical Yearbook", "China Education Statistics Yearbook" and "China population and Employment Statistics Yearbook"

5 Measurement and gap analysis of inclusive green growth index

According to the entropy weight method mentioned above, we calculate the 2001-2014 regional and provincial inclusive green growth index as well as the weight and indicator of each dimension.

5.1 Analysis of the weight of inclusive green growth dimensions

As presented in Table 2, the weight of each dimension of the inclusive green growth indicator system shows different changing trends from 2001 to 2014. The weight of economic growth dimension shows a significant downward trend from 0.1946 in 2001 to 0.2743 in 2014, which implies that with the all-round development of Chinese economic, the contribution of social dimension to inclusive green growth process decreases gradually. Conversely, the weight of green production and consumption and ecological environment protection dimension increase apparently, from 0.1394, 0.1875 in 2001 to 0.1988, 0.2438 in 2014 respectively, which demonstrates that the green production and consumption and ecological environment protection dimension play an increasingly important role in driving inclusive green growth process, and the green transformation of China's economic growth is gradually advancing step by step. The weight of social fairness dimension increases firstly and then falls down. In addition,

the weight of livelihood welfare dimension presents a down trend firstly and then remains stable. Overall, these two dimensions' influence on inclusive green growth process are enhanced relatively. Compared with each other, the weight of economic growth and livelihood welfare dimension occupy the first place, which indicates that both contribute most to the inclusive green growth process; the weight of ecological environment protection and social equity dimension come second and the weight of livelihood welfare dimension rank at the bottom. But in general, the gap among the weight of five dimensions are relatively small, which also indirectly shows that five dimensions constitute the specific form of inclusive green growth, and the inclusive green growth goal cannot be achieved without any side.

Table 2 The weight of five dimensions

Dimension	2001	2003	2005	2007	2009	2011	2012	2013	2014
EG	0.2743	0.2945	0.2756	0.2443	0.2125	0.2186	0.2021	0.2250	0.1946
SE	0.1598	0.1483	0.1515	0.2353	0.2022	0.1833	0.1769	0.1739	0.1630
LW	0.2390	0.2136	0.2246	0.2060	0.2018	0.2182	0.2038	0.2123	0.1998
GPC	0.1394	0.1401	0.1336	0.1229	0.1514	0.1841	0.1731	0.1869	0.1988
EEP	0.1875	0.2035	0.2147	0.1915	0.2321	0.1958	0.2441	0.2019	0.2438

5.2 Analysis of inclusive green growth index

According to Table3, the inclusive green growth index in the Eastern, Central, Western and Northeastern regions of 2001-2014 are 0.4336, 0.3049, 0.3358 and 0.3405 respectively, which demonstrates that the inclusive green growth level in the Eastern region is significantly ahead of other regions, and inclusive green growth level of the four regions present ladder shaped distribution: West> Northeast> East> Central. The eastern region's economic growth index is 0.1226, which is well above other regions. Driven by this, Eastern region maintains a leading momentum of inclusive green growth, but its index of ecological environmental protection is only 0.059, which is in a relatively backward level. While the relatively lagged situation of Central region's inclusive green growth level originates from the poor performance of each dimension, which shows that the Central region is backward in many aspects. Relying on the good performance of social equity and livelihood welfare dimension, the inclusive green growth level in Northeast and West are superior to the Central. In the period of 2001-2005, 2006-2010 and 2011-2014, inclusive green growth index in the Eastern region is 0.4356, 0.4353 and 0.4287, respectively, which appears a slight decline. However, the green production and consumption index shows a significant upward trend, and reaches a peak of 0.103 during 2011-2014, while the rest dimensions show decrease or stagnation state. The Central region's inclusive green growth index are 0.28, 0.3096, 0.33, presenting an increasing trend, but except that social equity and livelihood welfare index achieve a certain increase, the others are declining or at standstill. inclusive green growth index in Northeast and Western regions both exhibit a rising trend, however, the increasing trend in Western region is more significantly. Overall speaking, each dimension index of two regions are in the trend of steady progress.

Table 3 China's regional inclusive green growth index and its decomposition

Region	Time interval	IGG	EG	SE	LW	GPC	EEP
East	2001-2005	0.4356	0.1294	0.0692	0.0932	0.0798	0.0641
	2006-2010	0.4353	0.1216	0.0856	0.0852	0.0850	0.0579
	2011-2014	0.4287	0.1155	0.0734	0.0827	0.1030	0.0541
	2001-2014	0.4336	0.1226	0.0762	0.0873	0.0883	0.0590
Central	2001-2005	0.2800	0.0422	0.0552	0.0578	0.0686	0.0562
	2006-2010	0.3096	0.0291	0.0678	0.0637	0.0673	0.0624
	2011-2014	0.3300	0.0570	0.0690	0.0742	0.0687	0.0611

	2001-2014	0.3049	0.0487	0.0636	0.0646	0.0682	0.0598
West	2001-2005	0.3045	0.0376	0.0480	0.0820	0.0652	0.0716
	2006-2010	0.3331	0.0486	0.0612	0.0864	0.0623	0.0790
	2011-2014	0.3782	0.0600	0.0694	0.1058	0.0660	0.0771
	2001-2014	0.3358	0.0463	0.0588	0.0904	0.0644	0.0758
Northeast	2001-2005	0.3217	0.0602	0.0778	0.0528	0.0643	0.0666
	2006-2010	0.3502	0.0205	0.0896	0.0547	0.0691	0.0683
	2011-2014	0.3519	0.0694	0.0801	0.0533	0.0770	0.0721
	2001-2014	0.3405	0.0657	0.0827	0.0536	0.0697	0.0688

According to table 4, provincial inclusive green growth index during 2001 to 2014 has the following characteristics: (1) The inclusive green growth level in the Eastern developed provinces is overall in the leading level, and a few underdeveloped provinces in the West are emerging. 7 of the top 10 inclusive green growth index provinces are from the Eastern region. Beijing, Shanghai and Tianjin are in the top 3, which originates from relatively good performance of economic growth, social equity and welfare dimension in their relevant provinces The Western region of Inner Mongolia and Qinghai rank at 8 and 10 respectively. The high index of economic growth and livelihood welfare index in Inner Mongolia offset the weak green production and consumption dimensions. The advantage of livelihood welfare and ecological environment protection dimensions in Qinghai can make up the short board of economic growth dimension. (2) Weak economic provinces' inclusive green growth level are overall lagging behind, a few strong economic province rank at the bottom. The last10 rank provinces of inclusive green growth index are mainly from the Midwest. Weak economy provinces such as Shanxi, Guangxi, Yunnan, Heilongjiang and Guizhou, account for most of them. The low economic growth index significantly inhibited the development of the provincial green inclusive process, It can be seen that inclusive green growth situation of traditional weak economy provinces is very grim. While some strong economic provinces such as Anhui, Hebei and Henan are, which should be mainly attributed to the drag of lagging ecological environment protection and economic growth dimensions. It can be illustrated that economic strength is not a sufficient condition for inclusive green growth and the traditional economy must pay attention to the quality of economic growth and ecological environment protection while promoting inclusive green growth process. (3) The unbalanced problem of inclusive green growth is prominent and the gap among provinces is significant. The inclusive green growth index of the top ranked Beijing and the bottom ranked Henan are 0.584 and 0.2563 respectively, the difference between them is more than doubled. The average inclusive green growth index of the top3 provinces and the last3 provinces are 0.5426 and 0.2756 respectively, the difference is almost double. It shows that the current level of inclusive green growth level in China have the characteristic of unbalanced development among regions, and the gap between the leading provinces and backward provinces is significant.

Table 4 China's regional inclusive green growth index and its decomposition

Province	IGG	EG	SE	LW	GPC	EEP
Beijing	0.5840	0.1488	0.1372	0.1006	0.1461	0.0514
Shanghai	0.5684	0.2192	0.0857	0.1024	0.1025	0.0585
Tianjin	0.4754	0.1704	0.0856	0.0825	0.0780	0.0589
Guangdong	0.4641	0.1465	0.0660	0.1055	0.0864	0.0597
Zhejiang	0.4332	0.1326	0.0701	0.1005	0.0774	0.0527
Jiangsu	0.4077	0.1229	0.0588	0.0856	0.0738	0.0667
Hainan	0.3951	0.0470	0.0702	0.0862	0.1122	0.0795

Inner Mongolia	0.3929	0.1074	0.0629	0.0982	0.0545	0.0700
Liaoning	0.3716	0.0819	0.0930	0.0549	0.0657	0.0761
Qinghai	0.3690	0.0400	0.0623	0.1134	0.0598	0.0935
Chongqing	0.3642	0.0737	0.0556	0.0831	0.0721	0.0797
Fujian	0.3639	0.1004	0.0561	0.0779	0.0772	0.0522
Shandong	0.3585	0.0859	0.0702	0.0754	0.0674	0.0596
Xinjiang	0.3441	0.0277	0.0950	0.0903	0.0596	0.0716
Jilin	0.3412	0.0609	0.0826	0.0594	0.0723	0.0660
Gansu	0.3356	0.0196	0.0641	0.0876	0.0703	0.0940
Sichuan	0.3309	0.0522	0.0498	0.0751	0.0751	0.0786
Hunan	0.3264	0.0589	0.0570	0.0724	0.0834	0.0547
Ningxia	0.3249	0.0323	0.0593	0.1001	0.0419	0.0913
Jiangxi	0.3209	0.0465	0.0637	0.0609	0.0718	0.0781
Hubei	0.3205	0.0632	0.0555	0.0729	0.0780	0.0509
Shanxi	0.3197	0.0399	0.0981	0.0655	0.0386	0.0776
Shaanxi	0.3153	0.0568	0.0710	0.0737	0.0594	0.0544
Guangxi	0.3129	0.0452	0.0540	0.0810	0.0717	0.0609
Yunnan	0.3124	0.0291	0.0382	0.1013	0.0771	0.0666
Heilongjiang	0.3087	0.0545	0.0724	0.0466	0.0709	0.0643
Guizhou	0.2914	0.0257	0.0349	0.0902	0.0670	0.0736
Anhui	0.2855	0.0453	0.0413	0.0720	0.0746	0.0524
Hebei	0.2852	0.0526	0.0626	0.0567	0.0620	0.0513
Henan	0.2563	0.0384	0.0662	0.0437	0.0627	0.0453

6 Conclusion and Enlightenment

Inclusive green growth is a kind of development mode which pursues economic growth, social equity, social welfare, achievement sharing, energy saving and environmental protection, as well as the comprehensive coordination of economic, social and resource environment pursuit of economic growth, and a new economic growth model with the deep social background of scientific development and new normal. In this paper, according to the connotation of inclusive green growth, we construct the inclusive green growth indicator system from the perspective of economic growth, social equity, livelihood welfare, green production and consumption and ecological environment protection. Based on the China's provincial panel data from 2001 to 2014, this paper calculates the inclusive green growth index by using entropy weight method and get the following conclusions. Firstly, the inclusive green growth level in the Eastern region is significantly ahead and there is a ladder distribution (East>Northeast>West>Central) among regions. Secondly, the overall inclusive green growth level of developed provinces is in the lead, while the traditionally weak economic provinces lag behind. A few Western underdeveloped provinces stand out abruptly, in the meanwhile, a minority of economically strong provinces rank at the bottom. The unbalanced development problem among provinces is prominent. Thirdly, in most of the provinces from the Central and West, the inclusive green growth takes on increasing trend. Part of the provinces come to the standstill, and few developed provinces even present the signs of retreat.

Since the reform and opening up, the inclusiveness and green degree of economic growth has not improved with the rapid economic growth. The goal of achieving economic and social sustainable development is still a long way to go. Based on the above research conclusions, this paper argues that more targeted measures should be taken to promote inclusive green growth process: First, we should continue to expand the opening up, strengthen trade exchanges and cooperation among provinces and countries, and make full use of the funds and technologies of developed provinces and countries, so as to improve the economic growth level of the region. Second, we must evolve around the requirement of supply-side reform, carry on the transformation and upgrading of industrial structure scientifically and give priority to the development of clean and environmental protection, employment increase and livelihood improvement industries. Specifically, it's important for the Eastern region to focus on the

development of green industries and high-end service industry; the Northeast to rejuvenate and upgrade traditional industry as well as strengthen personnel training and reserve with its own characteristics, the Midwest to plan and layout the transfer industries from the East rationally and pay particular attention to the harmonious development between economy and environment, in order to avoid the old routine of "resource environment sacrifice for growth. administration after the contamination". Third is to improve the environmental policy and encourage green production and consumption. The government should implement more stringent environmental protection mechanism of key polluting enterprises, preferential policies and tax incentives for energy-saving environmental protection enterprises, and strengthen publicity and education efforts for guiding people to establish a green, low-carbon consumption concept. Fourthly, the government should improve the income distribution system, guide the rational flow of resources, and increase investment in the people's livelihood of backward areas. It's essential to reform the income distribution system, eliminate the unfair human factors of distribution, and promote universal benefit share of the development outcomes. Besides, by driving urbanization and reforming dual urban and rural household registry system scientifically, the government should promote the rational resources flow among urban and rural areas as well as provincial, guide capital, technology and personnel and other factors of production overflow from the East into the Midwest, and eventually, narrow the urban and rural areas and the provincial income gap. What's more, there is no doubt that the government should increase investment of livelihood areas such as education, health care, social security and infrastructure in the backward areas, focus on helping the poor areas and people out of poverty, eliminate social contradictions and intergenerational transmission of poverty, and effectively protect the equal rights of ordinary people. In addition, the government should create inclusive green growth performance evaluation mechanism, guide and encourage the management departments at all levels to take initiatives in accordance with the nature requirements of inclusive green growth, effort to improve the quality of economic growth in all regions, so as to realize the inclusive and green goal of China's economic growth mode.

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A Research on the Residents Low - carbon Consumption Patterns in China to Promote the Upgrading of Industry and Trade

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Abstract

China as the world's most populous nation, its citizen's energy consumption activities plays an important role in the actual action to reduce emissions, so, it is of practical significance to study the emission reduction of Chinese residents in energy consumption. This paper comprehensively uses the IOOE model and the de-coupling elastic analysis method to analyze and judge the process of low-carbon development of current energy consumption patterns of Chinese residents, by observing the effect of China's total energy consumption, carbon emissions, economic growth, energy consumption structure and energy consumption reduction on the "consumption side" between 2000 and 2016. The results show that the energy consumption pattern of Chinese residents has entered a transitional phase of low-carbonation, the CO2 reduction of energy consumption by residents has achieved remarkable results: Economic development is accompanied by low-carbon growth, and the energy consumption structure of residents is gradually optimized. In terms of influence, the low-carbon development of Chinese residents' energy consumption patterns will further promote the transformation and upgrading of the "supply side" and "consumption side" on Chinese industries, which is the catalyst for upgrading industries and trade in the new era, and the fulcrum of economic growth, as well as an important part of building beautiful China. Finally, the paper puts forward some suggestions to realize the residents' low-carbon energy consumption pattern, which includes: forming the social cooperation effect of green emission reduction, strengthening the research and development of green energy and clean technology, and optimizing the strategic planning of urban low-carbon development.

Introduction

Carbon emissions as the primary cause of global warming, the current international community has generally reached a consensus on "carbon reduction." In order to tackle the problem of global climate change, at the 2015 global climate change conference held in Paris, 195 Contracting Parties signed the "Paris Agreement on Climate Change." They established a global action plan for tackling global warming after 2020 and a series of corresponding measures and targets about CO_2 reduction. At the same time, various countries have formulated their own CO_2 emission reduction programs. China has also set the target of achieving peak carbon emissions by 2030, 20% non-fossil energy development and 60-65% carbon intensity reduction. As the largest country in the world in population, China's energy consumption activities undoubtedly play an important role in the actual reduction of emissions. Therefore, it is of practical significance to study the CO_2 emission reduction of Chinese residents in energy consumption.

In recent years, more and more scholars have begun to pay attention to the research on residents' energy consumption activities. For example, one of the scholars used mixed life-cycle assessment (LCA) and environmental extended input-output (EE IO) analysis to assess the trends of carbon footprints of urban residents in the Finnish cities and energy consumption policies of "carbon reduction" (Juudit Ottelin&Jukka Heinonen&Seppo Junnila, 2018). Some scholars compared the carbon footprint of slums and non-slums in Rawalpindi City, analyzed the impact of different household consumption patterns on carbon emissions, put forward the conclusion that the affluence households have a significant correlation between the increase of consumer behavior and carbon emissions, achieving household low-carbon consumption target should through the development and promotion of energy-saving and emission-reduction products (Mian NazishAdnan et al., 2018); Another one used of questionnaire survey of urban households in Nanjing, China, analyzed the household energy consumption and its influencing factors, and finally it has been found that household use and transportation are two major contributors to China's energy consumption (ZHGu et al., 2013). There is a positive correlation between energy consumption and income level, economic and social factors have an important impact on energy efficiency.

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In China, some scholars discussed the role of low-carbon beliefs and functional value cognition in purchasing intention of low-carbon appliances through the conceptual model of influencing factors of low-carbon consumer behavior, found that consumers' Consumer attitudes play an important role in it, and put forward marketing strategies and policy implications for low-carbon products (Xiu-cun Wang et al., 2012). Other scholars used environmental input-output analysis' method and consumer product life-cycle analysis' method, analyze carbon emissions from indirect energy consumption by Chinese consumers. Finally, it is proposed the measures to reduce household carbon emissions: improving the energy efficiency of various departments, and advocating residents to adopt "green, low-carbon" consumption patterns (Jing-yan Fu et al., 2015). Another scholars by using the extended STIRPAT and Kaya models, build a dynamic panel data model of direct impact of household carbon emissions, and estimation of inter-provincial panel data samples, found that there is a regional difference in the spatial distribution of carbon emissions in the household sector, carbon emissions from energy consumption are presented significant inertia characteristics, while population size, consumption level, energy consumption structure, carbon intensity, energy intensity and urbanization factors all have a significant impact (Zhi-ying Ji et al., 2016). Finally, the author proposed of building a hierarchy of "carbon emission reduction adaptive expectations mechanism" and other policy recommendations.

All the above studies have made useful exploration on the issue of emission reduction of residents in the area of energy consumption. This paper, for the first time, tries to use the economic growth model (IOOE model) under the restriction of the ecological environment, measured the panel data of Chinese residents' energy consumption from 2000s to 2016s, observed and judged the development progress of the low-carbon energy consumption pattern of Chinese residents. On the basis of this, we can further analyze the structure of Chinese residents' energy consumption and its path of realizing low-carbon energy consumption mode, providing references for achieving China's emission reduction targets.

The progress of Chinese low-carbon energy consumption patterns

Studying the energy consumption of Chinese residents and the development process of their low-carbon consumption patterns, further discovering the existing problems of current energy consumption，is conducive to provide useful inspiration for achieving low-carbon energy consumption patterns.

Model

This paper uses IOOE model to empirically evaluate the development of low-carbon energy consumption patterns for Chinese residents. The panel data come from the public data of China National Bureau of Statistics and China National Energy Administration.

The so-called IOOE model (Liu Chuan-jiang et al.,2016)[3] refers to an economic growth model constituted by increasing the consumption (Ox) and emission (E) variables，which based on the idea of Romer's constrained economic growth model (David Romer, 1996). The functional form of the model can be expressed as:

$Y_{(t)} = K_{(t)}^{\square} R_{(t)}^{\beta} [A_{(t)} L_{(t)}]^{\lambda} Ox_{(t)}^{-\mu} E_{(t)}^{-\eta}$ （1）

K, R for capital and resources, AL for generalized labor, Ox for occupancy, and E for pollutant emissions. Among them, the model basic assumptions are as follows:

$K'(t) = sY(t) - \delta K(t)$ （2）

$L'(t) = nL(t)$ （3）

$A'(t) = gA(t)$ （4）

$R'(t) = -bR(t)$，$b \sim [-1,1)$ （5）

$Ox'(t) = -mOx(t)$，$m \sim [-1,1]$ （6）

$E'(t) = -dE(t)$，$m \sim [-1,1]$ （7）

S and δ are the social savings rate and the capital depreciation rate, respectively, n and g are the labor and technology growth rates, b is the resource consumption rate, m and d respectively are the declining rates of occupancy and emissions,.

Taking the logarithm of both sides of the formula (8) deduces:

$LnY(t) = \square \ln K(t) + \beta \ln R(t) + \lambda [\ln A(t) + \ln L(t)] - \mu \ln Ox(t) - \eta \ln E(t)$

The result of the formula derivation:

$$\frac{Y'(t)}{Y(t)} = \alpha \frac{K'(t)}{K(t)} + \beta \frac{R'(t)}{R(t)} + \lambda \left[\frac{A'(t)}{A(t)} + \frac{L'(t)}{L(t)} \right] - \mu \frac{Ox'(t)}{Ox(t)} - \eta \frac{E'(t)}{E(t)}$$

[3]Description: IOOE model was first proposed by Professor Liu Chuanjiang and other professors of Wuhan University. Please refer to the references for the specific source.

Substituting (3) (4) (5) (6) (7) into the above equation deduces:

$$\frac{Y'(t)}{Y(t)} = \alpha\frac{K'(t)}{K(t)} - b\beta + \lambda(g+n) + mu + dn \quad (8)$$

On this basis, keep Y / K unchanged, so that output and capital growth rate keep the same, and then get:

$$\frac{Y'(t)}{Y(t)} = \frac{\lambda(g+n) - b\beta}{1-\alpha} + \frac{mu}{1-\alpha} + \frac{dn}{1-\alpha} \quad (9)$$

The "gi", "gox", "goy" and "ge" respectively denote the growth rates of generalized inputs (I), occupy' amount (Ox), outputs (Oy) and emissions (E).

$go_y = g_I + gO_x + g_E$ (10)

Equation (9) shows the interaction between inputs (I), outputs (Oy), occupancy (Ox) and emissions (E) ， which be therefore called the IOOE model for short. According to the model structure, the impact of input on economic output is gI, of which the negative effect of resource consumption is -bβ / (1-α). The greater the consumption rate, the higher the restriction on economic output. The effect of output is gOx. When m is positive, it indicates that the larger the annual decline rate of occupys' amount, the decrease of occupancy has a positive effect on output. On the contrary, as the increase of occupys' amount, it is formed negative effect under the constraint of ecological environment; Similarly, the impact of emissions on economic output is gE. When d is positive, it indicates that the greater the annual reduction rate of emissions, the more the emissions contribute to output. Conversely, as carbon emissions increase year by year, the greater the resistance to the output.

Data Description

The statistical range of this paper is from the 2000s to 2016s, taking the energy consumption of Chinese residents as the research object. The basic data come from China Statistics Bureau and Energy Department. Among them, the data "input" is calculated from population, household energy consumption, and energy consumption prices; the data of “the amount of occupy” is calculated by product of the total ecological energy consumption of each energy source and the total energy consumption of each energy source; The data "output" is based on the historical GDP of China; the data of "emission" is calculated based on the energy consumption and the energy carbon emission factor.

Empirical Analysis

Based on the completion of data processing, IOOE model can be established. According to the results of the model output (see Table 1), the effects of inputs, occupancy and emissions in the recent five years (2012s-2016s) on China's overall economic output are different. Among them, the two components of "ecological energy consumption" and "carbon emissions" respectively have a positive effect on the overall economic output of China before 2013 and 2014, indicating that the greater the rate of decline in emissions and occupancy at the same output level , the more obvious the promotion for economic output. However, as the number of ecological footprints(Ox) and carbon emissions(E) increase, the overall economic output(Oy) gradually becomes obstructive. Based on this, it is tentatively enlightenment that Chinese residents practicing low-carbon energy consumption mode have realistic and economic significance.

Table 1 Change rate of recent five years list

years	*m*	*d*	*goy*	*gi*	*ge*	*gox*
2012	0.0104	0.0218	0.1044	0.9500	0.0024	0.6033
2013	0.0195	0.0278	0.1016	0.8982	0.0030	1.1302
2014	-0.0085	0.0051	0.0819	0.5507	0.0006	-0.4919
2015	-0.0214	-0.0036	0.0700	0.2810	-0.0004	-1.2375
2016	-0.0160	-0.0033	0.0791	0.3960	-0.0004	-0.9265

Note: The form is drawn by the author. Among them, m ~ [-1,1], d ~ [-1,1], the parameters are calculated according to the theoretical model formula.

Based on the theory classification of industrial ecological theory model, this paper divides energy consumption pattern transition under the restriction of the ecological environment into three types: industrial civilization energy consumption mode, low carbon transition transitional energy consumption mode and low carbon civilization type of energy consumption patterns. In order to more intuitively observe the process, between the 2000s and 2016s, of the change of low-carbon energy consumption patterns of Chinese residents, this paper draws a summary table of related data based on the data of

IOOE model (see Table 3) and provides a reference for judgment Table 2.

Table 2 The classification of the low-carbon energy consumption patterns process

Type	the Range of the Change Value
Low-carbon civilizational type	*gox* and *gI* and *gE* <0, *m* and *d* ~ [-1,0], *goy* ~ [0,1]
Transitional type	*gox* or *gI* or *gE* <= 0, *m* and *d* ~ (-1,1], *goy* ~ [0,1]
Industrial civilizational type	*gox* and *gI* and *gE* > 0, *m* and *d* ~ [0,1], *goy* ~ [-1,1]

First of all, combining Table 1 and Table 2, in the past five years (2012 ~ 2016), the transformation process of energy consumption pattern of Chinese residents mainly shows as follows: Before 2014s, the energy consumption pattern of Chinese residents shows high input, high amount of occupy, high output, and high emission. Therefore, it can be considered that the energy consumption pattern of Chinese residents in previous periods was in the stage of "industrial civilization", and was a form of traditional energy consumption with higher energy consumption. From the beginning of 2014s, Chinese residents' energy consumption Mode has been transformed into the transitional transition phase of low-carbon energy consumption mode. Since 2015, China has steadily entered the transitional phase of "low carbon transition". At this time, the energy consumption characteristics of Chinese residents are shown as Low emissions, low occupy, high output and high input. Among them, the generalized input still has the promotion effect to the economic output, but the growth impetus of China's economic output mainly shows as the consumption of resources and energy. However, along with the gradual control of the population growth rate in our country, the stimulating effect of the population on the economic growth is slowed down. Emissions and occupy played a negative role in economic output, indicating that the larger the number of energy resources and carbon emissions, the greater the impediment to economic output under the constraints of resources and environment. In light of this, China should step up its efforts to guide the transformation of residents' energy consumption patterns toward low-carbon ways, enhance the development and utilization of low-carbon products and clean energy, and achieve social economy and ecological environment's harmony and sustainable development.

To facilitate a more detailed and intuitive observation and judgment, we need to combine Figure 1 and Figure 2 to study. Among them, in order to avoid the influence of different unit indexes on the data, this paper normalizes the panel data in Table 2. On the basis of this, IOOE model is further applied to drawing the change process of Chinese low-carbon energy consumption in Figure 1.

Table 3 2000-2006 China's energy consumption IOOE model data summary table

Year	*I* (10^4 RMB)	*Oy* (10^4 RMB)	*Ox* (10^4 Ton)	*E* (10^4 Ton)	*I**	*Oy**	*Ox**	*E**
2000	471610703	1002801000	501978	96483	0.9002	0.9387	0.2812	0.3335
2001	508848849	1108631000	525643	100941	0.9458	0.9867	0.3547	0.4059
2002	552476353	1217174000	577444	110411	0.9992	1.0359	0.5156	0.5597
2003	595219562	1374220000	689030	129814	1.0516	1.1072	0.8621	0.8749
2004	667878344	1618402000	804537	151411	1.1406	1.2179	1.2208	1.2257
2005	754592876	1873189000	941383	173101	1.2468	1.3334	1.6458	1.5780
2006	843370368	2194385000	1032158	189605	1.3556	1.4791	1.9277	1.8461
2007	1000480788	2702323000	1123667	205877	1.5480	1.7095	2.2119	2.1104
2008	1156307014	3195155000	1138496	209527	1.7389	1.9330	2.2580	2.1696
2009	1269871636	3490814000	1194938	219480	1.8780	2.0671	2.4333	2.3313
2010	1464139629	4130303000	1237607	231870	2.1160	2.3571	2.5658	2.5326
2011	1769609490	4893006000	1352390	251447	2.4901	2.7030	2.9223	2.8505
2012	1990303396	5403674000	1366485	256917	2.7605	2.9346	2.9660	2.9394
2013	2203005680	5952444000	1393165	264069	3.0210	3.1835	3.0489	3.0556
2014	2431710396	6439740000	1381327	265420	3.3012	3.4045	3.0121	3.0775
2015	2666350414	6890521000	1351798	264452	3.5886	3.6089	2.9204	3.0618
2016	2935216788	7435850000	1330162	263576	3.9179	3.8562	2.8532	3.0475

Note: The data is converted according to the open data of China National Bureau of Statistics. The standardized data are marked with the symbol "*".

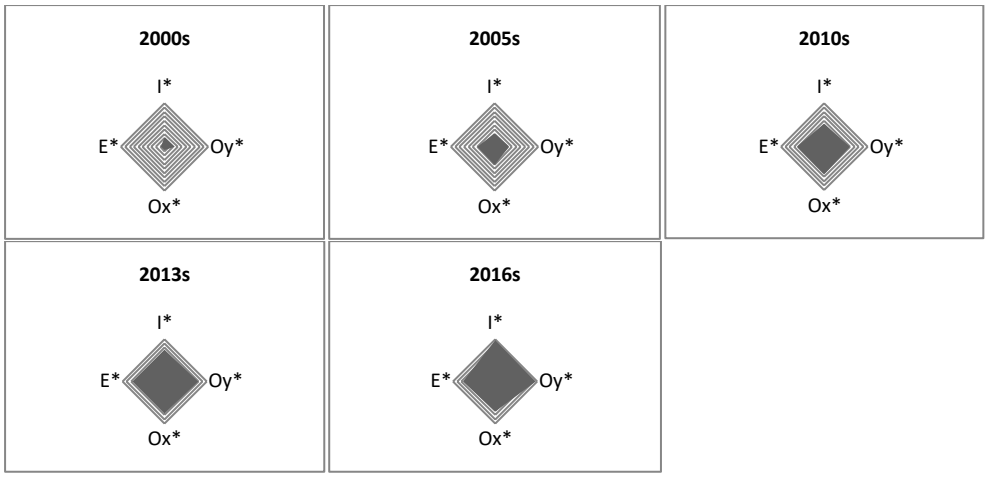

Figure 1 IOOE model map of low-carbon energy consumption of Chinese residents

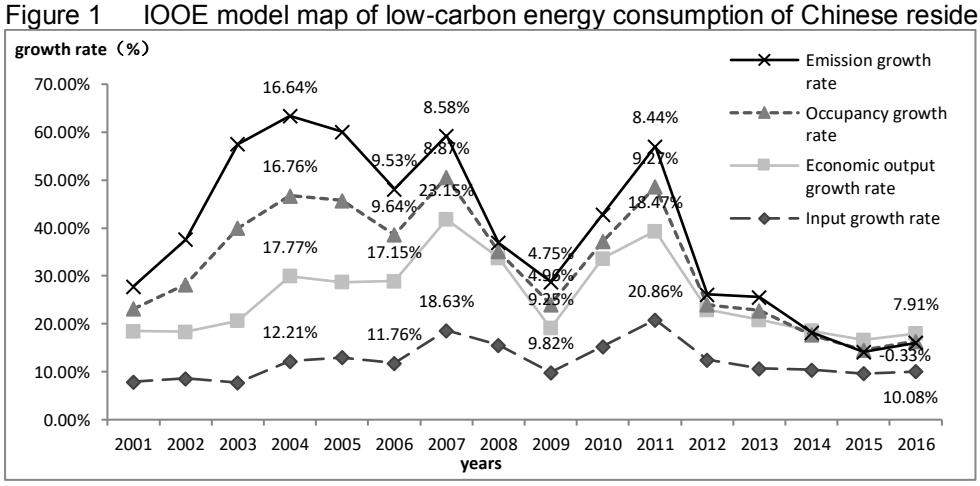

Figure 2 IOOE model changes in the four elements of historical growth rate chart

It can be seen from the above chart，during the 2001s ~ 2016s, that the four elements of broad input, economic output, carbon emissions and ecological occupancy of Chinese residents in energy consumption are mainly divided into two kinds of trends: First, during 2001s~ 2011s, the four factors showed rapid growth. Among them, the growth rate of emission is of the fastest, the growth rate of occupy amount is of the second, the growth rate of economic output and input is of the slowest. Second, during 2011s ~ 2016s, the four elements as a whole showed signs of slow growth and even negative growth. Especially after 2014s, the economic output growth rate ranked first. Among them, according to the change of IOOE model map, the energy consumption performance of Chinese residents was characterized by higher input, higher output, lower emission and lower occupy during the 2000s ~ 2005s; the energy consumption of Chinese residents in 2005s ~ 2010s was high emission, high occupy, low input and lower output. The energy consumption of Chinese residents in 2010s~2013s is characterized by "four highs": high input, high output, high emission and high occupy; During 2013s to 2015s, it is characterized by high input, high output, lower emission and lower occupy. To sum up, it can be judged that the current energy consumption pattern of Chinese residents has basically entered the typical "low carbon transition transitional" phase.

Table 4 Decoupling Analysis of Carbon Content and Economic Growth of Chinese Residents' Energy Consumption from 2001s to 2016s

Year	Carbon emissions growth rate	GDP growth rate	Carbon consumption decoupling flexibility of energy consumption	Decoupling state
2001	0.046	0.106	0.585	Weak decoupling
2002	0.094	0.098	1.094	Expand the connection
2003	0.176	0.129	2.271	Expansion negative decoupling
2004	0.166	0.178	1.363	Expansion negative decoupling
2005	0.143	0.157	1.103	Expand the connection
2006	0.095	0.171	0.810	Expand the connection
2007	0.086	0.231	0.461	Weak decoupling

2008	0.018	0.182	0.114	Weak decoupling
2009	0.048	0.093	0.484	Weak decoupling
2010	0.056	0.183	0.369	Weak decoupling
2011	0.084	0.185	0.405	Weak decoupling
2012	0.022	0.104	0.174	Weak decoupling
2013	0.028	0.102	0.260	Weak decoupling
2014	0.005	0.082	0.049	Weak decoupling
2015	-0.004	0.070	-0.038	Strong decoupling
2016	-0.003	0.079	-0.033	Strong decoupling

Data Source: The author according to China Statistics Bureau public data conversion finishing

Finally, in order to further observe and analyze the relationship between economic growth (output) and carbon emissions, this paper intends to use the "de-coupling elastic analysis method" to construct a de-coupling elastic model of economic growth and carbon emissions of Chinese residents' energy consumption:

$$ð = \frac{\Delta EP/EP}{\Delta GDP/GDP}$$

Among them, EP represents the carbon emissions of Chinese residents in energy consumption, GDP means a Gross national product, and ð means the decoupling index between the two. Based on the eight categories of decoupling status by Tapio, this paper draws a decoupled analysis table (see Table 4) on the carbon content and economic growth of Chinese residents in energy consumption from 2001s to 2016s in order to intuitively judge the current implementation of energy conservation and emission reduction in China effect. From the decoupling status of Table 4 in the past years, the direct relationship between the carbon content of energy consumption and economic growth of Chinese residents has generally undergone the development process: weak decoupling → expanding connection → expanding negative decoupling → expanding connection → weak decoupling → decoupling. Among them, the year of weak decoupling of carbon content in energy consumption of Chinese residents shows that carbon emissions and economic growth are increasing simultaneously. However, the growth rate of emissions is less than the economic growth rate and the emission reduction efforts of Chinese residents are beginning to take shape. The annual carbon intensity of energy consumption of Chinese residents shows a strong decoupling trend during 2015s and 2016s. The economic growth accompanied by a drop in the carbon emissions of residential energy consumption, indicating that Chinese residents are gradually shifting to a pattern of low-carbon energy consumption.

Status quo analysis in China's energy consumption

According to the previous research results show that the current energy consumption patterns of Chinese residents are in a typical "low carbon transition transitional" stage. Since 2015s, Chinese residents have made remarkable achievements in reducing energy consumption and gradually transformed themselves into low-carbon energy consumption patterns. On this basis, this paper makes a statistical analysis on the energy consumption of 50 departments and the energy consumption structure of Chinese residents released by China's Bureau of Statistics in 2015s, and divides the 50 departments into 8 major departments according to the industry characteristics of each department (specific classification See Table 5 for details). According to Figure 3, the top three sectors in total energy consumption in China are 003 sectors, 002 sectors, and 008 sectors in that order. Among them, manufacturing and metal smelting and processing industries consume the largest amount of energy in 003 sectors, accounting for 25.5% 800 million tons of standard coal and 850 million tons of standard coal. Among sectors in the 008 sectors, the largest amount of domestic energy consumption is about 500 million tons of standard coal, followed by transportation, storage, and postal services, accounting for about 383 million tons of standard coal (see Figure 3 and Figure 4). Thus, to achieve low-carbon development of Chinese residents' energy consumption patterns, attention should be paid to the improvement of living energy consumption structure, the development and application of energy-saving and emission-reduction means of transport, and the improvement of the technical content of the manufacturing product, gradually promote the development of residents' low-carbon energy consumption.

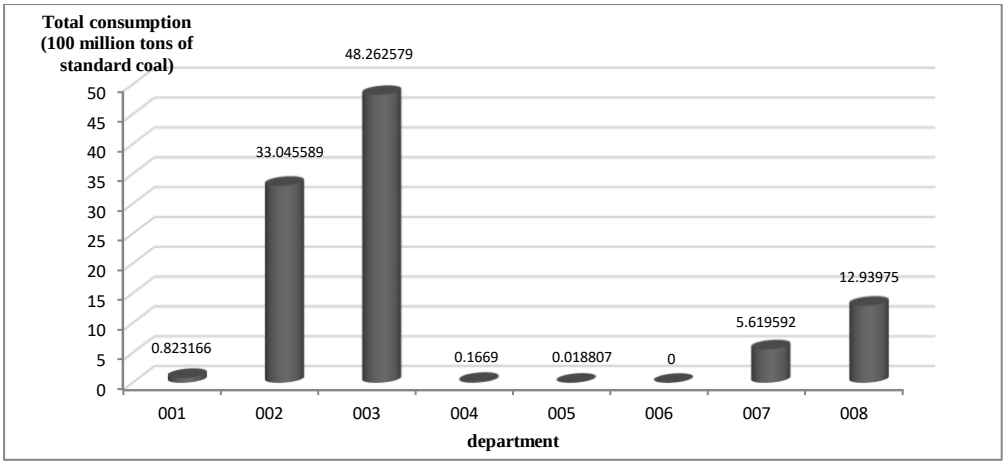

Figure 3 Total Energy Consumption by Sector in 2015

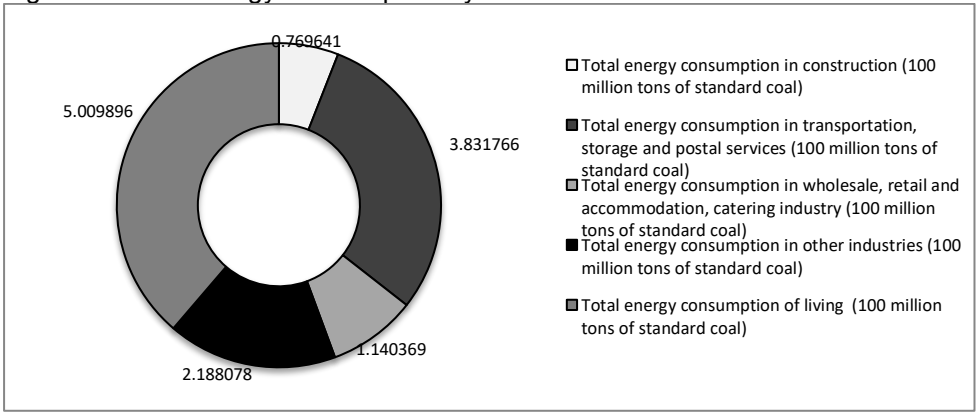

Figure 4 2015 008 main sectors of the sector energy consumption

Table 5 Sectoral Classification Table

Category	Specific department	Category	Specific department
001	Agriculture, forestry, animal husbandry, fishery and water conservancy	003	Agricultural food processing industry, food manufacturing, wine, beverage and refined tea manufacturing, tobacco products industry
002	Extractive industries, coal mining and washing industry, oil and gas exploration industry, ferrous metal mining industry, non-ferrous metal mining industry, non-metallic mining industry		Textile and garment, apparel industry, leather, fur, feathers and their products and footwear industry
	Auxiliary mining activities, other mining industry		Wood processing and wood, bamboo, rattan, palm, straw products industry, furniture manufacturing, paper and paper products industry, printing and recording media replication, culture, education and sporting goods manufacturing
004	Other manufacturing		Petroleum Processing, Coking and Nuclear Fuel Processing, Chemical Raw Materials and Chemical Products, Communication Equipment, Computer and Other Electronic Equipment Manufacturing, Instrumentation Manufacturing
005	Abandoned resources comprehensive utilization		Pharmaceutical manufacturing, chemical fiber manufacturing, rubber and plastic

	industry		products industry, rubber products industry, plastic products industry
006	Metal Products, Machinery and Equipment Repair Industry		Non-metallic mineral products industry, ferrous metal smelting and extension processing industry, non-ferrous metal smelting and rolling processing industry, metal products industry
007	Electricity, Gas and Water Production and Supply, Production and Supply of Electricity and Thermal Power, Gas Production and Supply, Production and Supply of Water		General equipment manufacturing, special equipment manufacturing, automobile manufacturing, railway, shipbuilding, aerospace and other transportation equipment manufacturing, electrical machinery and equipment manufacturing
008	Construction, Transportation, Storage and Post Services, Wholesale, Retail and Lodging, Restaurants, Other Industries, Consumer Lifestyle		

Data Source: The author according to China Statistics Bureau public data conversion finishing

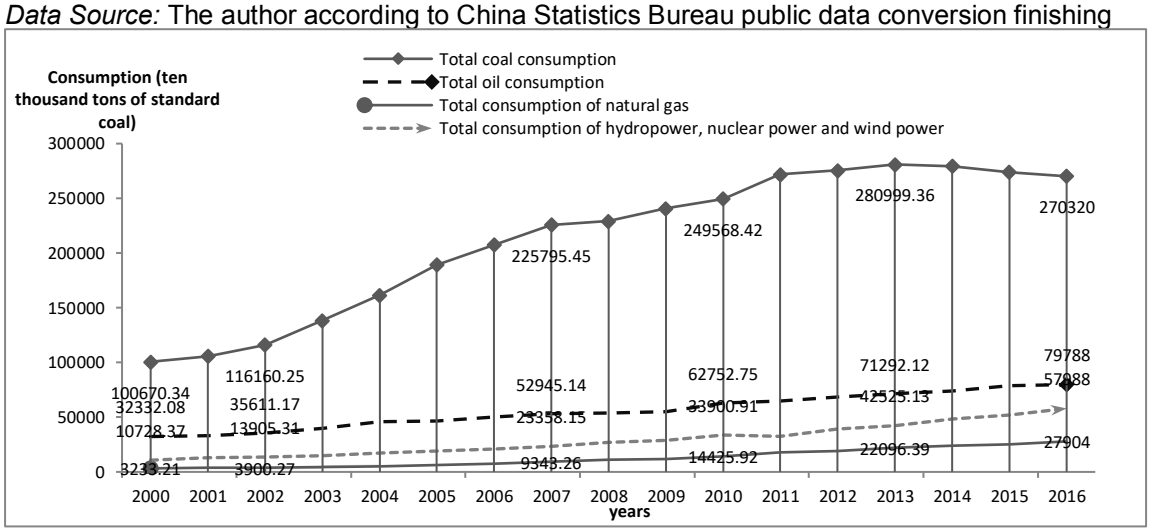

Figure 5 Main Energy Consumption of Chinese Residents from 2000s to 2016s

Finally, the energy consumption structure of Chinese residents has been gradually optimized. Figure 5 shows the changes in consumption of the four major Chinese energy sources between the 2000s and 2016s. Overall, the total energy consumption of Chinese residents has increased year by year, but the growth rate slowed down. The specific was showed from a high growth rate of 16.22% in 2003s to 1.42% in 2016s. Among them, the consumption of clean energy increased, such as the hydropower, nuclear power, wind power and natural gas's growth rates were reach at 11.48% and 10.01% respectively in 2016s. The total consumption of coal decreased from 19.01% in 2003s to 1.29% in 2016s, which shows that the energy consumption structure of Chinese residents has been optimized and improved. It is also an important factor that helps Chinese residents to achieve low-carbon energy consumption patterns.

Suggestions for Realizing Chinese Residents' Low-carbon Consumption Patterns

In order to realize the transformation of residents' energy consumption patterns, we must first form a consensus on the development of a low-carbon economy in our society as a whole and set a virtuous cycle management system that meets the needs of the development of contemporary society so that low-carbon energy consumption patterns become the norm in society. The virtuous cycle management systems include benign lifestyle of the social residents, continuous innovation and supply power of enterprises, the government give full play to the social guidance and supervision functions, and industry associations achieve the effective coordination of the economic interests of the main subjects.

Forming a social cooperation effect of green emission reduction

In terms of residents, we should widespread popular science education on knowledge of global climate and environment, promote universal awareness of environmental protection, set up scientific and rational consumption values, and encourage individuals to practice the philosophy of modern living

with low carbon and environmental protection. On the government side, take the leading role in the process of economic development and social regulatory functions, while giving play the incentive function of policy tools, and the constraints of laws and regulations; On the enterprises side, we must vigorously encourage them researching and developing low-carbon energy-saving products, promoting social services management innovation, so as to exert long-term guidance from the supply side of the consumer demand side; Finally, the resources and environmental protection should pay attention to the relevant industry associations on the coordination of resources and environmental governance, strengthen cooperation with the international Social organizations and the exchange of links, jointly promote China's energy consumption patterns change to low-carbon transition direction for realizing energy-saving emission reduction targets.

Strengthen research and development of the green energy and clean technology

At present, the energy consumption pattern of Chinese residents has entered a transitional phase of low carbon transition, in which the optimization of energy consumption structure plays an important role in the process of energy conservation and emission reduction. Therefore, it is of practical significance to optimize the structure of energy consumption and further reduce the residents' use of high-energy coal and other polluting energy sources. On the one hand, priority must be given to the development and utilization of green energy and clean technologies, enriching the alternative of renewable energy and improving the utilization of energy resources. On the other hand, as a high-energy-consuming industry, manufacturing industry should speed up its efforts on high energy consumption and high pollution and backward production capacity of the phase-out process, while fully exploiting the development potential of energy saving and emission reduction in the service and consumer life sectors, guiding the social energy demand side and the consumption side to a low-carbon direction.

Optimizing strategic planning for the development of urban low-carbon economy

Scientific urban planning and a good social and cultural environment are the effective safeguards for promoting the transition of residents to low-carbon energy consumption patterns. Specifically speaking, in the economic development of industry, we should further promote the rational distribution of industrial structure, reduce the development speed of high-energy consumption industries and improve the quality of development. Meanwhile, intensify the phase-out of high-energy consumption, high-pollution technologies, equipment, and enterprises ， and to develop various types of enterprises emission standards and increase related industries access threshold, from the decision-making to ensure that urban planning follows the principle of green and sustainable development. Secondly, on the traffic planning, we should further optimize the urban traffic planning and traffic mode, formulate a scientific and reasonable strategy of low-carbon traffic development, carry out the planning evaluation and technical control on the residents' traffic and travel tools and personal traffic frequency. Finally, in the aspect of urban building planning, laws and regulations should be put in place to improve the use of renewable energy of relevant industries and encourage building energy-saving technologies in the process of building design and construction. At the same time, the construction enterprises, raw material supply enterprises, and relevant government departments should be strengthened dialogue and communication, make it meet the low carbon construction standards in the direction of development. By creating a social and cultural environment for energy conservation and emission reduction, it is imperative for residents to reduce their consumption of low-carbon energy into social reality.

Summary and Outlook

Based on the economic growth model under the environment constraint (IOOE model), this paper analyzes the total energy consumption, energy consumption structure, carbon emissions and economic growth in China from 2000s to 2016s, determines the low-carbon development process of the current energy consumption pattern of Chinese residents, and on this basis, combined with the separation of elasticity analysis method, evaluated the data of the residents' energy consumption side of the emission reduction work results. The results show that the energy consumption pattern of Chinese residents has entered the transitional period of "low carbon transition" characterized by higher economic output, higher input, lower resource consumption and lower carbon emissions. At the same time, China's economic development is also accompanied by low-carbon growth. The energy consumption structure of residents is being optimized gradually. This is mainly reflected in the reduction of the total consumption of coal resources, the increase in the total consumption of low-carbon energy such as hydropower, wind power, nuclear power and natural gas, during the 2015s and 2016s, the residents' energy consumption entering the strong decoupling of carbon content, which shows that the current emission reduction work has achieved good results. Overall, the transition to a low-carbon energy consumption model for Chinese residents is a systematic, two-way and long-term progressive development project. In the future, it will surely further promote the transformation and

upgrading of the supply side and the consumption side of China's industries, become a catalyst for upgrading industries and trade in the new era, an important pivot for economic growth, and an important link in building a beautiful China. Finally, in view of the result of empirical analysis, this paper further discusses the workable path of residents' low-carbon energy consumption patterns, proposes the social cooperation effect of green emission reduction, strengthens the research and development of green energy and clean technologies, and optimizes the strategic planning of urban's low-carbon development. Finally, we use the IOOE model to study only the low carbonization process of Chinese residents in the macro-strategic level in the energy consumption pattern, and do not discuss the types of consumer groups at the mid-level and inter-provincial levels at the micro level. In the future research work, it will be the appropriate complement and improvement.

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The Influence of External Fairness of Executive Compensation of Coal Listed Companies on Corporate Performance

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Abstract

Coal is China's main energy and important industrial raw material. The development of the coal industry is related to the country's energy security and the healthy development of the national economy. The performance of coal companies is affected to a large extent by senior management personnel, and salary level is an important factor affecting the innovation management of senior management. By discussing the influence of external fairness of executive compensation of coal listed companies on corporate performance, the data is processed and analyzed through descriptive statistics, hypothesis testing, and regression analysis, and it is concluded that for state-owned coal listed companies and non-state-owned coal listed companies,positive compensation and additional compensation can have a significant positive impact on corporate performance, and executives' reasonable compensation and negative differential compensation have no significant effect on corporate performance,and provides suggestions and expectations for coal listed companies in formulating and managing executive compensation. It is helpful to build a more reasonable compensation system for coal companies and improve corporate performance.

Keywords: coal listed companies; executive compensation; external fairness; corporate performance

1 Introduction

1.1 Research Background and Significance

1.1.1 Research Background

Coal is an important basic energy resource, and it is a support for the development of almost all industries, especially in our traditional industries. Coal has always been an important irreplaceable position.

If there is a problem with coal resources, the entire country's industries will be disrupted, disrupt the orderly development of the national economy, and even threaten national security. Therefore, in the national environment for innovative development, the coal industry also needs to take the road of innovation in management, especially in the coal industry in recent years, the downward trend of the industry, whether the coal industry will develop steadily and survive this decline to a large extent influenced by senior executives of coal companies, salary is among the most important factor affecting the enthusiasm and management of senior executives.

The executive compensation allocation system of listed companies is an important aspect of company incentives and an important part of China's income distribution system. The rationality and fairness of its establishment are critical to the development of the company, and people have always overestimated the role of incentives and underestimate the meaning of fairness. Equity is very important to individuals and society. Equitable executive compensation will increase the enthusiasm of individuals and promote the harmonious development of society. Unfair executive compensation will bring strong negative emotions to individuals and affect their psychological and behavioral behavior,and affect the play of organizational functions as well as the harmonious and stable development of society.

The fairness of executive compensation has attracted the attention of the public and the government, especially from the perspective of the coal industry, which is of great significance. With the improvement of the salary disclosure mechanism, the management of a listed company can compare its remuneration level with that of other managements of the company, thus generating an

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understanding of the fairness of salary and adjusting its own performance accordingly. Then it has an impact on corporate performance. Therefore, the economic consequences of the fairness of executive compensation are the problems to be solved in the process of improving the salary system of listed companies.

1.1.2 Research Significance

(1) Theoretical significance

The issue of executive compensation has always been a long-standing hot spot in academia. Although our country started late in this field, with the increasing attention and deep research of scholars, the research on executive compensation has developed rapidly. The executive compensation system is an important mean to improve the governance structure of listed companies, and fairness is an important consideration for executive compensation design. At present, the academic research on executive compensation mainly focuses on the correlation between executive compensation and corporate performance and the side effects of incentives.

With the increasing development of the society, the fairness of executive compensation has received extensive attention. The fairness of executive compensation not only affects the society's perception of fairness, but also affects personal psychology and behavior, resulting in negative emotions that ultimately affect corporate performance.

This article takes China's coal listed companies as the research object, combines related theories, discusses and analyzes the unfair status of China's coal listed companies and their influence on corporate performance from the perspective of external fairness of executive compensation, in order to expand research on executive compensation. From the perspective of research, it enriches the content of the external fairness of executive compensation, and promotes the further improvement and development of the research on the executive compensation theory of coal listed companies.

(2) Practical significance

As an important part of China's economic entity, listed companies have directly influenced the development of the economy. However, due to the external factors such as politics, economy, and society as well as the internal factors such as company background and governance structure, there are widespread unreasonable and unfair phenomena in executive compensation of listed companies in China. The internal gaps and external gaps in executive compensation are big, and the mismatch between pay and compensation has increased the widening gap between the rich and the poor, causing public dissatisfaction. On the other hand, it has also severely dampened individual enthusiasm and weakened individual competition. Consciousness makes it work in a negative manner, thus affecting corporate performance.

This article provides a reference for the listed coal companies to formulate a reasonable executive compensation system through empirical research and analysis, and provides effective and feasible suggestions to promote the improvement of the listed company's executive compensation system, improve corporate governance structure, and enhance the fairness of executive compensation. As well as attracting executives, increasing personal enthusiasm and loyalty to companies and reducing the impact of personal negative emotions on corporate performance. On the other hand, we must strengthen supervision by government regulators on executive compensation, improve the disclosure of executive compensation information, balance company performance, maintain the stability of the capital market and promote the harmonious development of society.

1.2 Foreign and Domestic Research Status

1.2.1 Foreign Research Status

Foreign scholars have started to study the relationship between executive compensation gap and corporate performance. Some foreign scholars have found that increasing the executive compensation gap can have a positive impact on corporate performance. Jirjahn (2006) conducts empirical research on the manufacturing industry. The results show that the fairness of the compensation distribution process and the results in the company have a certain impact on the production efficiency, and then have an impact on corporate performance. The empirical research conclusion of Lee KW (2008) shows that the degree of dispersion of executive compensation is positively correlated with the performance of listed companies. Equalization of compensation is not conducive to improve corporate performance. Kale and Reis (2009) conducted research on 1,500 U.S. listed companies. The empirical results show that increasing the compensation gap between CEO and non-CEO executives has a positive impact on corporate performance.

Different from the above conclusions, some scholars believe that the increase in executive compensation gap will have a negative impact on corporate performance. Leventhal (1980) believes that companies should try to avoid dissatisfaction with their employees when designing compensation. When internal organizations need teamwork, they should reduce the compensation gap between employees. Shaw (2002) believes that when the company's work requires a higher level of

organizational cooperation, smaller internal compensation gaps can have a positive effect on corporate performance. Carpenter and Sanders (2004) analyze the internal fairness of executive compensation. They use the accounting performance to measure the company's performance and find that there is a negative correlation between the company executive compensation internal gap and the corporate performance.

In addition, some scholars' researches show that the executive compensation gap is not linearly related to corporate performance. Morris (2000) selects 42 listed companies in the US electronic information industry as samples. The study concludes that there is no significant correlation between executive compensation gap and corporate performance. Conyon's (2001) study of executive compensation gap supports Morris' conclusions. Bingley and Eriksson (2001) introduce the variable of human capital in the process of empirical analysis and find that within a certain limit, the compensation gap between white-collar workers shows a significant positive correlation with their work performance, but there is a negative correlation over a certain limit. The empirical research results of Martin et al (2006) show that there are interval effects between executive compensation incentive and corporate performance, but the two are not completely related and should be analyzed in detail.

1.2.2 Domestic Research Status

How the executive compensation gap has impacted corporate performance has been a hot issue for Chinese scholars in recent years. However, due to the perspective of research, research methods, and different choices of indicators, there is no unified conclusion about the relationship between executive compensation gap and corporate performance.

First, the view of some scholars is that the executive compensation gap can have a positive effect on corporate performance.

Some scholars such as Wang Yu (2014), Liu Ping (2015), Sheng Mingquan (2015) and Wang Xiaoning (2016) use descriptive statistics and regression analysis to study the executive compensation and corporate performance among different industries in listed companies. The relationship between the two, concluded that there is a significant positive correlation between the executive compensation of listed companies and corporate performance.

Scholars Li Zhengguang (2016) and Zhang Yanhong (2016) study the relationship between executive compensation and company performance of listed companies in Shanghai and Shenzhen, and conclude that there is a significant positive correlation between executive compensation and corporate performance of listed companies.

There are also scholars Qi Huaijin (2014) and Xu Dongying (2016) that use relative quantile to measure the external fairness of executive compensation. They respectively select listed companies in different industries to conduct empirical research and analyze the external fairness of executive compensation. It is concluded that the external fairness of executive compensation has a significant positive impact on corporate performance.

Tang Song and Sun Zheng (2014) study the relationship between the part of executive compensation and the corporate performance due to political connections. It is found that the higher executive compensation brought by political associations is significantly positively correlated with the performance of private enterprises, and corporate performance is significantly negatively correlated.

Secondly, there is no correlation or negative correlation between executive compensation gap and corporate performance.

Different from the above scholars' views, some scholars in our country believe there is no correlation or negative correlation between executive compensation gap and corporate performance. Some scholars, Lu Aimin and Huang Dehui (2015), Lan Songmin, and Dai Jianhua (2015), study respectively the listed companies and listed companies of media industry in Shanghai City and Shenzhen City. They study the relationship between executive compensation and corporate performance of listed companies and conduct the empirical research.

The following results are obtained: There is no significant negative correlation between executive compensation and company performance. In non-state-owned enterprises, positive extra pay is positively correlated with corporate performance; in state-owned enterprises, there is a negative correlation between the two; both state-owned and non-state-owned, negative additional compensation has no significant effect on corporate performance.

With the continuous deepening of China’s economic system reform, the continuous changes in enterprise management systems and compensation systems, and the continuous introduction of foreign advanced management theories, and the spread of compensation incentive,companies have increasingly attached importance to the formulation of compensation systems. The differences in factors such as different industries, different samples, and time intervals, etc., have led to the result that the research conclusions on this topic are still inconsistent.

The conclusion may be in two directions: (1) there is a significant correlation between executive compensation and corporate performance, including positive, negative and nonlinear correlations; (2) weak correlations between executive compensation and corporate performance or even irrelevance. Moreover, because domestic research on executive compensation and corporate performance is mostly based on data of all listed companies without selection, there is less research on a specific industry, which makes the research results have no practical significance.

1.3 Research Purpose and Content

1.3.1 Research Purpose

(1) Discuss whether the external fairness of compensation executives in coal listed companies has an impact on the corporate performance and what kind of impact it will have, and further improve the executive compensation incentive theory.

In recent years, there have been frequent reports of excessive compensation gaps among senior management personnel of different companies, which has led to discussions on the fairness of executive compensation distribution among all sectors of society. This article selects the perspective of external fairness of executive compensation to study its impact on the performance of coal listed companies and expects to enrich the related theory of executive compensation incentives.

(2) Provide policy recommendations for enterprises to formulate a scientific and reasonable remuneration system to obtain better executive compensation incentive effects.

The development of coal listed companies in China are facing various challenges. It is hoped that this paper will provide some guidance for coal listed companies to measure the fairness of executive compensation and formulate reasonable executive compensation.

1.3.2 Research Content

This article takes the relationship between executive compensation and corporate performance of China’s coal listed company as the research object, adopts a combination of qualitative research and quantitative research, and deepens the relationship between the external fairness of executive compensation and the corporate performance of the coal listed companies in China. Doing research and analysis then drawing conclusions and recommendations based on the findings.

The mathematical methods used in this quantitative study are descriptive statistical methods, correlation analysis and regression analysis, and models are established through these methods. In the establishment of the model, at first we need to put forward the research hypotheses that are suitable for this article according to the summary of the literature analysis section. Then we need to collect, sort out, count, and process the collected data concerning the executive compensation, corporate performance, and related factors of listed coal companies. The final processed data is brought into the model for research and analysis, and a reasonable explanation of the problems reflected in the result data is made. Finally, according to the results of empirical research, the issue of incentives for executives of coal listed companies in China is reflected, and reasonable suggestions are proposed.

2 Theoretical Analysis and Presenting Assumptions

2.1 Theoretic Analysis on the Factors of the Relationship between Executive Compensation External Fairness and Corporate Performance

When discussing the influence of the external fairness of listed company's executive compensation on corporate performance, the nature of the equity of the controlling shareholder is an important factor that needs to be considered. The nature of equity affects both the company's management and its performance. State-owned listed companies differ from non-state-owned listed companies in many aspects such as compensation management and performance evaluation. The long-standing compensation gap between the two has become an indisputable fact.

In the case of state-owned listed companies, the appointment of senior managers is usually not the result of simple market choices, but is more often determined by government departments through administrative decisions. Executives in state-owned enterprises are neither purely professional managers nor purely government workers, leading to multiple complex commissioned agency relationships and disorganized payroll management. In recent years, the existence of “inefficient and high-paying” phenomenon in state-controlled listed companies has caused fierce discussions in the society, and senior executives’ salaries in some state-owned enterprises are seriously out of line with corporate performance. The salary levels of senior managers in China's state-owned enterprises are inconsistent with the market value and cannot truly reflect the executive management capabilities of senior executives and the benefits created for the company. Compared with state-owned listed companies, executives in non-state-owned listed companies are usually created by market selection. The influence of political factors on the management of compensation is relatively small, and the company has greater autonomy in the formulation of remuneration. At the same time, when evaluating

executive performance, non-state listed companies pay more attention to the “performance-oriented” principle, and executive compensation has a higher degree of correlation with the performance and contribution of senior executives during their careers. Therefore, in non-state-owned listed companies, executive compensation can better reflect its market value and generate stronger incentives for compensation.

In view of the above-mentioned differences in executive compensation incentives between state-owned listed companies and non-state listed companies, this paper considers the nature of the equity of the controlling shareholder when studying the influence of external fairness of executive compensation of coal listed companies on corporate performance. The state-owned enterprises and non-state enterprises of coal listed companies respectively put forward the hypothesis and conduct relevant empirical analysis.

2.2 Assumptions related to the external fairness of executive compensation in coal listed companies affecting corporate performance

In empirical analysis studies, extra pay is usually used to measure the degree of unfairness of executive compensation. This article draws on the research methods of Wu Liansheng and others, and on the basis of analyzing the factors affecting executive compensation, establishes the executive compensation decision model,regression analysis is performed on the collected sample data for the year, and uses the regression analysis to find the residuals as additional pay scales to measure the external unfair degree of executive compensation. However, the extra salary calculated by using the salary decision model has a great dependence on the model. At present, there is no unified executive compensation decision model in the theoretical community, and there may be ignored variables in the model. Therefore, all executive compensation is used to measure executives. The degree of external unfair of remuneration may cause an overestimation of the degree of inequality.

Taking into account the limitations of the executive compensation decision model itself, combined with the status of incentive for executive compensation of listed companies in China, this paper classifies the extra pay according to the quarter-point method of statistics on the basis of executive compensation decision models. In the middle part of the extra pay rankings, although there is a gap between the compensation calculated by the listed company’s compensation and the salary calculation model, the gap is relatively small, considering that the model’s extra pay may result in unfairness. For this part of this article, we believe that the executives receive reasonable compensation. In the first quarter of the extra pay rankings, the listed company disclosed higher executive compensation than the compensation decision model, and the gap is relatively large. This article defines it as positive differential pay; in the latter quarter of the additional pay rankings, the listed company's disclosed executive compensation is lower than the salary calculated by the compensation decision model, and the gap is relatively big. This article defines it as negative compensation extra pay.

Therefore, this paper is divided into three directions when studying the influence of the external fairness of listed company's executive compensation on corporate performance. Firstly, the impact of executive compensation on the performance of coal listed companies during external fairness or when executive income is reasonable, and the second is the impact of extra pay on the performance of coal listed companies and the third is the impact of negative pay on the performance of coal listed companies.

2.2.1 Related Assumptions of Reasonable Compensation Affecting Corporate Performance of Coal Listed Companies

The external fairness of executive compensation is an important part of the fairness of compensation, and it is an important part of realizing the fairness of social income distribution. According to the equity theory, when executives compare the salary of other senior managers in the same industry and think that their income is reasonable, they will have a balanced mind when they feel the external fairness of the compensation, and will increase the enthusiasm and initiative of the work, and thus improve the corporate performance, therefore, this article believes that the fairness of the external distribution of executive compensation can motivate executives to work hard and create greater benefits for the company. For all companies, only when the company's external compensation is relatively fair and has market competitiveness, can it attract and retain talents, so as to better play the role of salary incentives. Therefore, this paper proposes hypothesis 1.

Hypothesis 1: When executive compensation is externally fair, it has a significant positive effect on the performance of state-owned coal listed companies and non-state-owned coal listed companies.

2.2.2 Related Assumptions of Positive Compensation Affecting Corporate Performance of Coal Listed Companies

Positive compensation extra pay means that the company’s executive compensation is higher than that of other senior executives in similar positions in the same industry. According to the social comparison theory, when senior executives of enterprises compare their salaries with executives of

other companies in the same industry, if they find that their own salaries are higher than their reference counterparts, they will form a comparative effect of downward comparisons and improve the evaluation of their salaries. This kind of comparison will have a positive impact on the enthusiasm and initiative of the work, improve the work efficiency and job performance of senior executives, thereby enhancing corporate performance and creating greater benefits for the company.

When analyzing the influence of compensation incentive resulting from positive compensation, it is necessary to consider the differences in the utility functions of the state-owned and non-state-owned enterprises. The entrusted agency relationship of state-owned enterprises is complex and the basis for remuneration allocation is not clear enough. The market has not played a decisive role in the allocation of state-owned enterprises' resources. The correlation between executive compensation levels and corporate performance is relatively low. In non-state-owned enterprises, their executive compensation has a higher degree of correlation with their job performance during their tenure. Compensation can better reflect their market value, so they can better play the incentive role of positive compensation. Based on this, this study proposes hypothesis 2 and hypothesis 3.

Hypothesis 2: There is no significant effect of positive compensation on the corporate performance of state-owned coal listed companies;

Hypothesis 3: There is a significant positive effect of positive compensation on the corporate performance of non-state listed coal companies;

2.2.3 Related Assumptions of Negative Compensation Affecting Corporate Performance of Coal Listed Companies

The negative compensation means that the company’s executive compensation is lower than the compensation of other senior managers in similar positions in the same industry. Negative compensation may have a positive effect on the performance of listed companies. According to the tournament theory, when business executives find that their compensation levels are lower than the industry average, they will feel pressure from the company and itself. Since the level of executive compensation is a reflection of the ability of senior executives to a certain extent, the excessively low executive compensation levels will often be considered by the outside world as insufficient of their own capabilities, which will affect the market value of senior executives. At the same time, negative compensation and additional compensation also represent a certain degree of business dissatisfaction with the performance of senior executives, and is sending warning signals to them. Under such circumstances, in order to improve the evaluation of their capabilities, the executives obtain the recognition of their own capabilities and will strive to improve their management level and corporate performance to prove themselves.

On the other hand, negative compensation may also have a negative impact on the performance of listed companies. According to the social comparison theory, when senior executives find that their compensation is lower than the industry level, they will form a comparative effect of upward comparison, expect to deviate from the reference target, reduce the assessment of their own compensation level, and thus create a sense of unfairness. This unfair perception may make the executives have a negative attitude, leading to a decline in work efficiency, and thus have a negative impact on corporate performance. It can be seen that negative compensation may have a positive incentive effect on corporate performance, and may also have a negative negative impact on corporate performance. This article synthesizes these two opposing views and argues that the effect of negative compensation on corporate performance is uncertain and may not be significant in empirical studies. Especially in China's state-owned listed companies, the correlation between executive compensation and corporate performance is relatively low, and the impact of negative compensation and additional compensation on corporate performance may be even more insignificant. Based on the above analysis, this study proposes hypothesis 4.

Hypothesis 4:There is no significant effect on negative compensation on the corporate performance of state-owned coal listed companies and non-state-owned listed companies.

3 Empirical Research Design

3.1 Sample Selection and Data Sources

This article uses China's listed coal companies as a basic sample to collect and process sample data. Due to the lagged effects of executive compensation incentives, the effect of compensation incentives usually cannot be reflected in the level of corporate performance in the current year. Therefore, this paper uses one year as the lag period, and the time span of executive compensation variables is 2011–2015, and the corporate performance variables are as follows: The other control variables have a time span of 2012-2016. In order to ensure the validity of the sample data and improve the quality of the data, this paper further filters the basic samples:

In the screening, in order to remove the samples that have an impact on the research results to make the data representative, this paper mainly adopts the following principles when selecting

samples:

(1) Sample data of listed coal companies with ST and ST* removed.

(2) Listed companies that were excluded from the analysis of the value of variables used during the study period were incomplete.

After screening the samples according to these principles, the paper adopted a total of 115 data from 23 companies that meet the requirements for research. The relevant data of this paper is mainly from the CSMAR database. A few data are extracted from the annual financial reports of each company. The basic data processing of the sample data is completed using Excel software. Descriptive statistical analysis, correlation analysis, and multiple regression are performed using SPSS 19 software. analysis.

3.2 Study Variable Selection and Variable Description

3.2.1 Explained variables

The explained variable in this paper is business performance. In the domestic and international literature, the indicators for measuring corporate performance are varied, and the common performance indicators include the profit rate of the main business, return on net assets, and Tobin's Q value. The first two reflect accounting performance, while the latter reflects market performance. In the empirical study, no matter which kind of performance indicators are used to measure corporate performance, they all have advantages and disadvantages. Considering that relative to market performance, accounting performance is less affected by external uncertainties, it can reflect the company's performance more truly, reflecting the executive's contribution to the company; on the other hand, the main business profit as the most important corporate profits The components can reflect the company's operating conditions and profitability more accurately and measure the company's operating results more accurately. Therefore, the main business profits (CP) after the standardization of total assets have been selected as indicators to measure corporate performance. At the same time, in order to enhance the comprehensiveness and comparability of the selected indicators, this paper uses the relative number, ie, the amount of change of the selected indicator, ΔCP to measure the performance of the company. Therefore, the explanatory variables selected in this paper are: $\Delta CP = CP_t - CP_{t-1}$.

3.2.2 Explanatory variables

This paper discusses the influence of external fairness of executives' remuneration in listed coal companies on firm performance. Therefore, the explanatory variable is the external fairness of executive compensation.

This paper uses extra pay to measure the external fairness of executive compensation. The residual payout of the executive compensation decision model is the external pay gap (UFt) of executive pay. This method considers factors such as company size and organizational structure that lead to executive pay gaps and can effectively avoid subjectivity.

Since the extra pay is a difference between the industry forecast value of executive compensation and the executive compensation disclosed by the listed company, there are positive and negative points. Therefore, the absolute value of executive external compensation (UFt) AUFt is used to measure the senior management of listed companies. External inequality of pay. The greater the absolute value AUFt, the greater the gap between the predicted value representing the executive compensation and the executive compensation disclosed by the listed company, and the more unfair the executive compensation. At the same time, due to the lagged effect of executive compensation incentives on company performance, this paper selected AUFt-1 as an explanatory variable. Executive compensation decision model is as follows:

$$In(comp)_t = \alpha_0 + \alpha_1 STATE + \alpha_2 ROA_t + \alpha_3 ROA_{t-1} + \alpha_4 LEV_t + \alpha_5 CBD_t + \alpha_6 BDS_t + \alpha_7 SIZE_t + \alpha_8 CON_t + \varepsilon$$

Table 3-1 Interpretation

name	Explanation
$In(comp)_t$	The natural logarithm of executive compensation
STATE	The nature of the equity of the controlling shareholder, if the company is a state-owned enterprise, it means 0, otherwise it is 1
ROA	The company's total asset profit rate reflects the company's profitability, divided by the net profit divided by the average total assets
LEV	The company's level of financial leverage, total liabilities divided by total assets
CBD	Whether the general manager and the chairman of the board are united: if the two jobs are combined, the CBD=1; otherwise, the CBD=0
BDS	Board of directors

SIZE	Company size, natural logarithm for the company's total assets
CON	Executive shareholding ratio
ε	The residuals of the model run, the extra pay

3.2.3 Control Variables

The correlation between the external fairness of executive compensation and the corporate performance of coal listed companies is the core issue discussed in this paper, but the relationship between the two will be affected by other factors such as organizational characteristics. Therefore, control variables need to be added to exclude other factors in the regression analysis. Interference, to examine the real relationship between the two. This article selects the following corporate governance characteristics variables as control variables to control the impact of these factors on business performance, including:

(1) Nature of equity (STATE)

The STATE property is a dummy variable. If the listed company is a state-owned company, it means STATE=0, otherwise it is STATE=1. Since this paper needs to conduct relevant empirical analysis on state-owned and non-state-owned companies, the variable AUFt-1×STATE is introduced. AUFt-1 × STATE is the interaction term for the interpretation of the variable AUFt-1 and the property STATE of the company: if the listed company is a non-state owned company, STATE = l, the interaction item is AUFt-1; if the listed company is a state-owned enterprise, STATE = 0, the interaction item is 0. In the empirical analysis, the impact of external fairness of executive compensation on the performance of non-state listed companies is determined through the analysis of the AUFt-1 × STATE estimation coefficient; on the basis of the above judgment, the estimation coefficient of AUFt-1 is used to judge executives. The Influence of External Fairness of Salary on the Performance of State - Owned Listed Companies .

(2) Company size (SIZE)

The company size is represented by the natural logarithm of the book value of the company's total assets at the end of the year. Paul A. Samuelson's research on economies of scale pointed out that when an enterprise is in a particular development period, expanding the scale of the company's operations can reduce the average cost of the product, which will lead to an increase in production efficiency and an increase in corporate profits. Schumpeter's innovation theory believes that with the expansion of the scale of the company, the company will have more abundant funds for technological innovation, so as to obtain high monopoly profits. This paper believes that with the expansion of the company's scale, the company's organizational structure is more complex, and its business activities are more diversified. It plays a positive role in enhancing the company's competitiveness in the market and overall business performance. It is expected that its coefficient is significantly positive.

(3) Board size (BDS)

The total number of board members. The more members there are on the board, the more professional professionals can propose constructive proposals when the company makes major business decisions. It can also effectively prevent management's manipulation of board resolutions, improve corporate governance and business performance. However, some scholars have pointed out that the excessively large board of directors may easily cause the directors to argue with each other, and it is difficult to form a unified opinion. The supervision efficiency and operational efficiency will be reduced due to the dispersion of the directors' rights.

(4) Whether the chairman and the general manager are in one place (CBD)

Whether the chairman and general manager of the CBD is a dummy variable, CBD = 0 if the two jobs are separated, otherwise the CBD = 1. Normally, the chairman and general manager are served by the same person means weak corporate governance and have an adverse impact on the effective supervision of senior management by the board of directors; and the separation of the two positions is a manifestation of the company's better governance structure, which can improve the efficiency of supervision and thus increase the efficiency. Corporate performance has a positive effect. This article expects its coefficient to be significantly negative.

(5) Management shareholding ratio (CON)

Managerial holdings are a means of long-term incentives for the management team, which can make the interests of managers and enterprises more consistent, help spur the business's vitality, and play a positive incentive role for the company's performance. However, the higher the management's shareholding ratio, the stronger the incentive for managers to plunder corporate resources or whitewash financial statements. At present, the correlation between the proportion of senior management holdings and company performance is still uncertain.

(6) Sales growth rate (GROWTH)

The growth rate of sales is represented by the difference between sales income of the current

period and sales income of the previous period, divided by sales income of the previous period. The sales growth rate is an important indicator reflecting the development status and competitiveness of the company, and is also an important factor in the growth of the company's business performance. The coefficient is expected to be significantly positive.

(7) Sales Profit Rate (SPR)

The sales profit ratio is expressed as the current net profit divided by the sales revenue. Sales profit rate is a commonly used indicator for evaluating company performance and reflects the profitability of the company. It is expected that its coefficient is significantly positive.

(8) The company's previous performance (CPt-1)

The company's first-period performance (CPt-1) is calculated by dividing the company's profit from its principal operations in the previous period by the total assets. The company's previous performance can have an impact on the growth of this period's performance. This article uses the company's previous performance (CPt-1) as a control variable and expects its coefficient to be significantly negative.

This article presents the various variables and calculation methods more clearly in the following table:

Table 3-2 Related variable definition and description

name	definition	Type
△CP	Mainly reflects the change in performance, which is roughly the same as the change in profitability.	Explained variable
AUF	The final numerical solution based on the relevant model	Explanatory variables
STATE	The nature of the equity of the controlling shareholder, if the company is a state-owned enterprise, it means 0, otherwise it is 1	
SIZE	Company size, natural logarithm for the company's total assets	
BDS	Total number of directors	
CBD	Whether the general manager and the chairman of the board are united: if the two positions are combined, the CBD=1, otherwise CBD=0	control system change
CON	Management's shareholding ratio, number of shares held by senior executives/total number of shares	the amount
GROWTH	sales growth rate	
SPR	Sales profit margin, net profit/sales revenue	
CP_{t-1}	The company's previous performance, main business profit / total assets	

3.3 Model Construction

In order to verify whether the four hypotheses that influence the external fairness of listed executives in listed companies in coal companies affect corporate performance, the multivariate linear regression analysis method is used for empirical analysis. The multiple regression model constructed is as follows:

$$\Delta CP = \beta_0 + \beta_1 AUF_{t-1} + \beta_2 AUF_{t-1} \times STATE + \beta_3 SIZE_t + \beta_4 BDS_t + \beta_5 CBD_t + \beta_6 CON_t + \beta_7 GROWTH + \beta_8 SPR_t + \beta_9 CP_{t-1} + \varepsilon_2$$

4 Empirical analysis

4.1 Descriptive statistical analysis

4.1.1 Descriptive statistical analysis of the overall sample

In order to mine the basic characteristics of the samples in the empirical analysis and find out the inherent laws of the sample data, the following describes the descriptive statistics analysis of the overall sample.

Table 4-3 Descriptive statistics for the overall sample

	N	Minimum	maximum	Mean	Standard deviation
SIZE	115	20.2294	27.0718	23.8588	1.4128
BDS	115	3	18	10.65	2.911

CON	115	0	0	0.00	0.002
growth	115	-0.6341	21.7037	0.2715	2.2666
SPR	115	-0.6572	0.4320	0.0380	0.1295
$CP_{(t-1)}$	115	-0.0449	0.3007	0.1306	0.0745
CP_t-$CP_{(t-1)}$	115	-0.2418	0.1092	-0.0302	0.0430
UF	115	-1.4832	0.9687	0.0000	0.4485
AUF	115	0.0037	1.4832	0.3465	0.2830
Valid N (list status)	115				

From the descriptive statistics of the overall sample in the above table, we can conclude that the maximum value of the interpreted variable ΔCP is 0.1092, the minimum value is -0.2418, the average value is -0.0302, the standard deviation is 0.0430, and both are close to 0. This shows that the annual performance of China's listed coal companies has not changed much, and there is no significant change in the overall corporate performance across the cross-section.

The executive compensation external gap (UF) is the executive compensation remuneration calculated through the executive remuneration decision model and the executive compensation gap disclosed by the listed company. Its maximum value is 0.9687, and the minimum value is -1.4832, indicating that China's coal There are two polarities in the listed company; the mean value is 0.0000, which indicates that the regression process guarantees the zero mean and normality.

The explanatory variable AUF is the absolute value of UF and is used to measure the external fairness of the executive compensation of listed companies. The larger the AUF value, the worse the external fairness of executive compensation. The maximum value of AUF is 1.4832, and the minimum value is 0.0037. There is a big difference between the two, indicating that the unfairness of the executive compensation of listed coal companies in China is widespread.

The company size (SIZE) is the natural logarithm of the company's total assets, the minimum value is 20.2294, the maximum is 27.0718, the average value is 23.8588, and the standard deviation is 1.4128, which means that the scale is fairly large among enterprises, and the gap is not great. The maximum number of directors of the company (BDS) is 18, the lowest is 3, and the average number is 10 people.

The minimum value of the senior management share ratio (CON) of listed coal companies is 0, the maximum value is 0, and the standard deviation is 0.002. This shows that the proportion of senior executives of listed coal companies in China is extremely low. Of the 23 listed coal companies to be studied in this paper, only 4 senior executives of coal listed companies hold shares, and the “zero shareholding” of top executives of coal industry listed companies is very serious. The average shareholding ratio of senior executives of the company is 0, indicating that the degree of implementation of management incentives for stocks by listed coal companies in China is very small, and the long-term incentive approach to equity incentives is not yet universal.

The sales growth rate (Growth) reflects the growth ability of the company, with a maximum value of 27.1037, a minimum value of -0.6341. The sales profit rate (SPR) reflects the profitability of the company, with a maximum value of 0.4320 and a minimum value of -0.6572. There is a big difference between the maximum and minimum values of the two, which indicates that different companies are in different stages of development and there is a big gap between growth and profitability.

The company's last-period performance (CPt-1) reflects the operating status of the company to a certain extent, the maximum value is 0.3007, the minimum value is -0.0449, and the average value is 0.1306, which indicates that some coal listed companies have poor competitiveness and profitability. There is a wide gap between the operating performance of different companies.

4.1.2 Descriptive statistical analysis of grouped samples

Considering that there are differences in the statistics of variables in different types of pay gaps, the following three sets of data on reasonable pay, positive differential pay, and negative differential pay are separately described for descriptive statistical analysis.

Table 4-4 Descriptive statistics of reasonable compensation

	N	Minimum	maximum	Mean	Standard deviation
SIZE	57	20.3839	27.0404	23.8187	1.4073
BDS	57	3	17	10.09	2.766
CON	57	0	0	0.00	0.003
growth	57	-0.5931	10.0805	0.2272	1.4517

SPR	57	-0.6572	0.4320	0.0343	0.1583
$CP_{(t-1)}$	57	-0.0449	0.3007	0.1361	0.0786
CP_t-$CP_{(t-1)}$	57	-0.2418	0.1092	-0.0351	0.0518
UF	57	-0.2927	0.2955	-0.0061	0.1538
AUF	57	0.0037	0.2955	0.1231	0.0908
Valid N (list status)	57				

Table 4-5 Descriptive statistics with positive compensation

	N	Minimum	maximum	Mean	Standard deviation
SIZE	29	20.2294	27.0718	23.9441	1.6972
BDS	29	8	17	11.45	3.054
CON	29	0	0	0.00	0.000
growth	29	-0.3041	21.7037	0.7292	4.0362
SPR	29	-0.0786	0.1613	0.0564	0.0521
$CP_{(t-1)}$	29	0.0500	0.2807	0.1331	0.0697
CP_t-$CP_{(t-1)}$	29	-0.1002	0.0242	-0.0264	0.0310
UF	29	-1.4832	-0.2980	-0.5599	0.2691
AUF	29	0.2980	1.4832	0.5599	0.2691
Valid N (list status)	29				

Table 4-6 Descriptive statistics of negative pay extra pay

	N	Minimum	maximum	Mean	Standard deviation
SIZE	29	20.9256	25.7043	23.8525	1.1286
BDS	29	7	18	10.97	2.909
CON	29	0	0	0.00	0.000
growth	29	-0.6341	0.4778	-0.0992	0.2206
SPR	29	-0.5363	0.2207	0.0269	0.1223
$CP_{(t-1)}$	29	-0.0365	0.2491	0.1173	0.0717
CP_t-$CP_{(t-1)}$	29	-0.0660	0.0899	-0.0243	0.0332
UF	29	0.2980	0.9687	0.5720	0.1888
AUF	29	0.2980	0.9687	0.5720	0.1888
Valid N (list status)	29				

Through the analysis of the above three tables, we can find: the average size of the company's size (SIZE) were 23.8187, 23.9441, 23.8525; the average number of company board of directors (BDS) was 10.09, 11.45, 10.97, respectively, and the number was basically 10 people. There are no major differences between the three groups in terms of company size and number of board members. The average value of the three groups of data held by senior executives (CON) is 0.00, which means that the companies in which the senior management of listed coal companies account for a very small part of the company, and can also indicate whether the listed companies are reasonable or not. For coal-listed companies that have received extra pay, or coal-listed companies that have been compensated for additional pay, the degree of executive incentives held by the company is very small. The maximum sales growth rate (GROWTH) was 10.0805, 21.7037, and 0.4778 respectively, and the minimum values were -0.5931, -0.3041, and -0.6341 respectively. The maximum sales margin (SPR) was 0.4320, 0.1613, and 0.2207, respectively. For -0.6572, -0.0786, and -0.5363, there are significant differences in the growth and profitability levels of different coal companies in the three groups of data. The indicator △CP, which reflects the performance of the company, is very small in both the average compensation and the standard deviation in the groups of reasonable compensation, positive differential additional compensation, and negative differential additional compensation, indicating that there is no significant change in the performance of listed coal companies.

4.2 Correlation Analysis of Major Variables

In the empirical study of this paper, multiple linear regression analysis is used to verify whether the hypothesis is valid. If there is a close correlation between the variables involved in the regression analysis, multiple collinearity problems may occur, which reduces the stability of the regression model and the reliability of the test. Therefore, the correlation analysis of each variable in the regression

model is performed in this paper. Pearson correlation coefficient is usually used in correlation analysis, but the use of this correlation coefficient must be a continuous variable, and some of the variables involved in this paper are dummy variables. The Pearson coefficient does not apply. This paper chooses spearman coefficient for correlation analysis because Spearman coefficient does not require the distribution of variables and the scope of application is more extensive. The analysis results are shown in the following table.

Table 4-7 Correlation coefficient of major variables

	SIZE	BDS	CBD	STATE	CON	growth	SPR	AUF	$CP_{(t-1)}$	CP_t-$CP_{(t-1)}$
SIZE	1.000	-0.086	-0.106	0.079	0.029	0.090	0.021	0.004	0.005	0.121
BDS	-0.086	1.000	-0.062	-0.269*	-0.019	-0.019	0.082	0.194*	0.283*	-0.234*
CBD	-0.106	-0.062	1.000	0.067	0.189*	-0.016	-0.033	-0.009	0.034	-0.154
STATE	0.079	-0.269**	0.067	1.000	0.216*	0.170	0.246**	-0.265**	-0.040	0.072
CON	0.029	-0.019	0.189*	0.216*	1.000	0.115	0.060	0.107	0.086	0.034
growth	0.090	-0.019	-0.016	0.170	0.115	1.000	0.400**	0.048	-0.024	0.409**
SPR	0.021	0.082	-0.033	0.246**	0.060	0.400**	1.000	-0.014	0.467*	0.065
AUF	0.004	0.194*	-0.009	-0.265*	0.107	0.048	-0.014	1.000	-0.069	0.137
$CP_{(t-1)}$	0.005	0.283**	0.034	-0.040	0.086	-0.024	0.467**	-0.069	1.000	-0.622*
CP_t-$CP_{(t-1)}$	0.121	-0.234*	-0.154	0.072	0.034	0.409**	0.065	0.137	-0.622**	1.000

**. The correlation is significant when the confidence (double measure) is 0.01

*. The correlation is significant when the confidence (double measure) is 0.05

From the correlation coefficients of the main variables in the table above, it can be seen that the correlation coefficient between different variables in the model is less than 0.5, indicating that there is no serious multicollinearity between variables, and the above variables can be introduced into the regression model for multiple linear regression. The company's last-period performance CPt-1 is negatively related to the company's performance change △CP at a significant level of 5%, which is due to CPt-1 being the decremented in △CP, when the company's previous performance is better, that is, CPt-1 When large, the difference between the current performance and the previous period's performance, △CP, is relatively small. However, the correlation analysis is only a simple reflection of the linear relationship between the two variables. To truly determine the relationship between variables, multiple regression equations need to be established to verify the multiple regression method.

4.3 Regression analysis of the effect of external fairness on corporate performance of listed executives in coal companies

4.3.1 Regression Analysis of the Effect of Reasonable Compensation on Firm Performance

Table 4-8 Anova[b]

model	sum of square	df	Mean square	F	Sig.
return	0.122	9	0.014	22.208	0.000[a]
Residual	0.029	47	0.001		
total	0.150	56			

a. Predictor: (Constant), $CP_{(t-1)}$, AUF*STATE, CBD, CON, growth, SIZE, BDS, AUF, SPR。

b. Dependent variable: △CP

Table 4-9 Regression results of reasonable compensation and corporate performance

model	Non-standardized coefficient		Standard coefficient trial version	t	Sig.	Colinear statistics	
	B	Standard error				Tolerance	VIF
(constant)	0.051	0.069		0.738	0.464		
AUF	-0.032	0.042	-0.057	-0.771	0.444	0.746	1.340
AUF × STATE	-0.069	0.054	-0.093	-1.293	0.202	0.777	1.287
SIZE	-0.002	0.003	-0.053	-0.732	0.468	0.765	1.306
BDS	0.003	0.001	0.146	2.006	0.051	0.769	1.300

CBD	-0.030	0.020	-0.107	-1.478	0.146	0.766	1.305
CON	-0.923	1.228	-0.056	-0.752	0.456	0.737	1.357
growth	0.002	0.002	0.058	0.880	0.384	0.937	1.067
SPR	0.280	0.026	0.856	10.570	0.000	0.618	1.618
CP $_{(t-1)}$	-0.507	0.052	-0.769	-9.695	0.000	0.643	1.555

a. Dependent variable: △CP

From Table 4-6, it can be seen that the F value of the multivariate regression model established in this paper is 22.208, and the Sig value is 0.000, which is significant at the level of 0.01, indicating that the model is reasonable and effective, and can better explain the company's performance. The table also shows the diagnosis result of multicollinearity. Multicollinearity is a linear correlation between independent variables, which makes the estimation of the regression parameters to be very unstable. It is generally believed that the VIF value is less than 10, ie there is no multicollinearity. relationship. From Table 4-7, the variance inflation factor (VIF) of all variables in the model is far less than 10, which basically eliminates the possibility of multiple collinearity in the model due to the high correlation.

From the regression results of reasonable compensation and corporate performance in Table 4-7, it can be seen that the absolute value of executive compensation gap (AUF) is estimated to be -0.032, and the Sig value is 0.404, indicating the change in company performance (△ There is a negative correlation between CP) and the absolute value of executive compensation gap (AUF), but the results are not significant; the estimated coefficient for the interaction term (AUF × STATE) is -0.069, and the Sig value is 0.202, indicating the change in company performance. (ΔCP) also has a negative correlation with the interaction term (AUF × STATE), but the result is not significant. The above results do not support the hypothesis 1 of this paper. The regression results show that for state-owned coal listed companies and non-state-owned coal listed companies, reasonable remuneration has no significant positive effect on corporate performance.

4.3.2 Regression Analysis of the Effect of Positive Compensation Extra Salary on Corporate Performance

Table 4-10 Anova[b]

model	sum of square	df	Mean square	F	Sig.
return	0.023	8	0.003	14.394	0.000[a]
Residual	0.004	20	0.000		
total	0.027	28			

a. Predictor: (Constant), CP $_{(t-1)}$, SIZE, growth, BDS, CBD, SPR, AUF, CON。

b. Dependent variable: △CP

Table 4-11 Positive Regression Result of Additional Compensation and Corporate Performance

model	Non-standardized coefficient		Standard coefficient trial version	t	Sig.	Colinear statistics	
	B	Standard error				Tolerance	VIF
(constant)	-0.119	0.046		-2.579	0.018		
AUF	0.056	0.015	0.483	3.649	0.002	0.422	2.371
SIZE	0.005	0.002	0.274	2.922	0.008	0.844	1.184
BDS	-0.002	0.001	-0.178	-1.891	0.073	0.836	1.196
CBD	-0.884	0.544	-5.294	-1.626	0.120	0.001	1433.338
CON	1459.878	876.586	5.437	1.665	0.111	0.001	1440.279
growth	-0.002	0.001	-0.259	-1.940	0.067	0.415	2.409
SPR	0.087	0.064	0.146	1.364	0.188	0.649	1.541
CP $_{(t-1)}$	-0.334	0.049	-0.750	-6.794	0.000	0.606	1.649

a. Dependent variable: △CP

Table 4-12 Excluded variables[b]

model	Beta In	t	Sig.	Partial correlation	Colinear statistics		
					Tolerance	VIF	Minimum tolerance
AUF × STATE	.[a]	.	.	.	0.000	.	0.000

a. Predictors in Model: (Constant), CP（t-1）, SIZE, growth, BDS, CBD, SPR, AUF, CON.

b. Dependent variable: △CP

From Table 4-8, we can see that the multivariate regression model established in this paper has

an F value of 14.394 and a Sig value of 0.000, which is significant at the level of 0.01, indicating that the model is reasonable and effective, and can better explain the company's performance. From Table 4-9, the variance expansion factor (VIF) of variable chairman and general manager (CBD) and senior management share ratio (CON) in the model is much larger than 10, indicating that these two variables are in the regression model. Due to the high correlation, there is a serious multicollinearity; the variance inflation factor (VIF) of the other variables is far less than 10, which basically excludes the possibility of multiple collinearity in the model due to the high correlation. As can be seen from Tables 4-9 and 4-10, in the regression of the model, the interaction term (AUF × STATE) is eliminated.

In view of the fact that there are some variables, ie, the combination of chairman and general manager (CBD) and senior management shareholding (CON), there is a serious multicollinearity, so these two variables are removed and the regression is repeated to get a more effective model.

Table 4-13 Anova[b]

model	sum of square	df	Mean square	F	Sig.
return	0.022	7	0.003	14.804	0.000[a]
Residual	0.005	21	0.000		
total	0.027	28			

a. Predictor: (Constant), $CP_{(t-1)}$, SIZE, growth, BDS, AUF × STATE, SPR, AUF。

b. Dependent variable: △CP

Table 4-14 Positive Regression Result of Additional Compensation and Corporate Performance

model	Non-standardized coefficient		Standard coefficient	t	Sig.	Colinear statistics	
	B	Standard error	trial version			Tolerance	VIF
(constant)	-0.115	0.048		-2.399	0.026		
AUF	0.055	0.016	0.480	3.479	0.002	0.422	2.371
SIZE	0.051	0.040	0.127	1.288	0.212	0.825	1.212
BDS	0.005	0.002	0.276	2.830	0.010	0.844	1.184
CBD	-0.002	0.001	-0.213	-2.230	0.037	0.880	1.136
CON	-0.002	0.001	-0.285	-2.062	0.052	0.421	2.377
growth	0.065	0.065	0.108	0.998	0.330	0.679	1.474
SPR	-0.308	0.049	-0.692	-6.344	0.000	0.674	1.484

a. Dependent variable: △CP

From Table 4-11, it can be seen that after removing the two variables of chairman and general manager (CBD) and senior management share ratio (CON), the F value of the multiple regression model is 14.804, and the Sig value is 0.000. Significant at the level of 0.01, indicating that the model is reasonable and effective, can better explain the performance of the company. From Table 4-12, the variance inflation factor (VIF) of all variables in the model is far less than 10, basically eliminating the possibility of multiple collinearity in the model due to the high correlation.

In Table 4-12, the regression results of positive additional pay and corporate performance can be seen that the estimated coefficient of the absolute value of executive compensation gap (AUF) is 0.055 and the value of Sig is 0.002, indicating the change in company performance (△ There is a significant positive correlation between CP) and the absolute value of executive compensation gap (AUF), which shows that when there is no differentiation in the nature of equity, executives of listed coal companies have a significant incentive to increase corporate performance. The estimated coefficient of AUF × STATE) is 0.051, and the Sig value is 0.212, indicating that (ΔCP) is positively correlated with the interaction term (AUF × STATE) but not significant. The above results support Hypothesis 3 of this paper but do not support Hypothesis 2. The regression results show that whether it is for state-owned coal listed companies or for non-state-owned coal listed companies, the executives' poor compensation can have a significant positive impact on corporate performance and play a role in salary incentives.

4.3.3 The Regression Analysis of the Effect of Negative Compensation Extra Salary on Corporate Performance

Table **4-15** Anova[b]

model	sum of square	df	Mean square	F	Sig.
return	0.023	9	0.003	6.347	0.000[a]
Residual	0.008	19	0.000		
total	0.031	28			

a. Predictor: (Constant), CP（t-1）, growth, CBD, AUF*STATE, AUF, SIZE, BDS, SPR, CON。
b. Dependent variable: △CP

Table 4-16 The results of the regression of negative compensation extra pay and business performance

model	Non-standardized coefficient		Standard coefficient	t	Sig.	Colinear statistics	
	B	Standard error	trial version			Tolerance	VIF
(constant)	-0.020	0.103		-0.194	0.848		
AUF	-0.025	0.025	-0.142	-1.009	0.326	0.666	1.502
AUF× STATE	-0.024	0.058	-0.051	-0.410	0.686	0.841	1.188
SIZE	0.003	0.004	0.090	0.606	0.552	0.597	1.676
BDS	0.000	0.002	0.012	0.080	0.937	0.641	1.561
CBD	0.005	0.030	0.030	0.178	0.861	0.456	2.195
CON	-842.587	863.105	-0.227	-0.976	0.341	0.243	4.108
growth	0.043	0.024	0.288	1.783	0.091	0.502	1.992
SPR	0.109	0.042	0.402	2.579	0.018	0.542	1.846
$CP_{(t-1)}$	-0.433	0.074	-0.935	-5.887	0.000	0.521	1.919

a. Dependent variable: △CP

From Table 4-13, it can be seen that the multivariate regression model established in this paper has a F value of 6.347 and a Sig value of 0.000, which is significant at the level of 0.01, indicating that the model is reasonable and effective and can better explain the company performance. From Table 4-14, the variance inflation factor (VIF) of all variables in the model is far less than 10, which basically eliminates the possibility of multiple collinearity in the model due to the high correlation.

In Table 4-14, we can see that the regression coefficient of negative compensation extra pay and corporate performance shows that the estimated coefficient of the executive compensation gap absolute value (AUF) is -0.025, and the Sig value is 0.326, which indicates the amount of change in company performance (There is no significant correlation between △ CP) and the absolute value of executive compensation gap (AUF), indicating that when there is no differentiation of the nature of stock rights, the executive compensation of coal listed companies has no significant incentive or disciplinary effect on corporate performance. The estimated coefficient for the interaction term (AUF × STATE) is -0.024, and the Sig value is 0.686, indicating that there is no significant negative correlation between (ΔCP) and the interaction term (AUF × STATE). The above results support hypothesis 4 of this paper. The regression results show that for non-state-owned listed coal companies, the negative compensation of executives can have a negative impact on corporate performance, but it is not significant.

5 Conclusions and Recommendations

5.1 Conclusion

This paper discusses the influence of external fairness of executives of listed coal companies on corporate performance. Based on the research of domestic and foreign scholars and related theories, this paper proposes the hypothesis of this study and collects the 2012-2016 listed coal companies in China. The empirical analysis of the financial data yields the following conclusions:

(1) The reasonable remuneration of senior executives and the negative remuneration and additional remuneration have no significant relationship with the performance of state-owned coal listed companies and non-state-owned listed companies. The reason why such a conclusion is drawn may indicate that in China's listed coal companies, income is not a major factor affecting performance. The reason for this phenomenon may be the low efficiency of the internal management of coal companies, the traditional business awareness and mode; the external reason may be that coal prices are high, coal companies can only make money by selling coal, and there is no incentive to improve management.

(2) Among state-owned coal listed companies and non-state-owned coal listed companies, senior executives can positively incentivize corporate performance when the additional compensation is within a certain range, and executive compensation negative compensation can negatively affect corporate performance. Retribution. The sense of unfairness generated by executives through salary

comparisons will have an impact on the enthusiasm and initiative of their work, which in turn will affect company performance.

(3) From the results of empirical analysis, it can be seen that the ratio of senior management holdings of control variables has no significant effect on corporate performance. Management's shareholding can make the management's interests more closely linked with the company's interests, thus inspiring management to create more value for the company. The reason why this kind of result was obtained during the empirical research is that the current phenomenon of the “zero shareholding” of senior executives of listed coal companies in China is serious, and the effect of the proportion of senior management holdings on the company’s performance is not significant, and management cannot be fully utilized. The positive effect of holdings on corporate performance.

5.2 Suggestions

5.2.1 Strengthening Information Disclosure of Listed Companies

The completeness and accuracy of the disclosure of remuneration information helps investors to fully grasp the performance assessment of senior managers and the financial status of the company, and helps external shareholders effectively monitor the behavior of senior executives. Judging from the comprehensive statistical results, some companies did not disclose full compensation information in accordance with the requirements of the China Securities Regulatory Commission, and the authenticity of the information is still open to question. At present, the incidents of accounting frauds of listed companies in our country are endless, and the coal industry is no exception. Therefore, the issuer, directors, supervisors and senior managers of listed companies should perform their duties faithfully and diligently to ensure that the disclosed information is true, accurate, complete, timely, and fair. The directors, supervisors and senior management personnel of listed companies shall be responsible for their due diligence, pay attention to the compilation of information disclosure documents, ensure that regular reports and interim reports are disclosed within the prescribed time limit, and cooperate with listed companies in fulfilling their obligation of information disclosure. The China Securities Regulatory Commission and the Exchange must take various measures to improve the truthfulness and transparency of information disclosure, impose severe penalties on companies that disclose incomplete and untrue information, and increase the awareness of the responsibility of information disclosure.

5.2.2 Strengthen the Equity Incentive of Listed Companies in the Coal Industry to Senior Executives

Coal industry market companies have characteristics such as large scale, high stability, and strong dependence on senior executives, which to a certain extent determine the feasibility of implementing equity incentives for senior executives. However, at present, the overall level of holdings of listed companies in the coal industry is not high, and the phenomenon of zero holdings by senior executives is serious. Among the 23 listed companies studied in this paper, 19 executives hold zero shares. This shows that the listed companies in the coal industry have not perfected long-term incentives for senior executives, resulting in no correlation between executive ownership and corporate performance. It is beneficial to the long-term development of the company and the improvement of its core competitiveness.

5.2.3 Establish Professional Manager Market Mechanism

There is greater occupational competition pressure in the perfect managerial market, which can force the incumbent managers to reduce short-term behavior, and also enable the business owner to accurately price the manager through the professional manager's market and change his short-sighted behavior. However, most of the senior executives of listed companies in the coal industry are directly appointed by the administrative department, which makes the executives lose their due binding force and competitiveness. A highly competitive professional manager market is a prerequisite for the effective implementation of the executive compensation system. Therefore, it is necessary to assess and identify professional managers through specialized agencies and experts to establish an effective and fair market for managers, and to standardize, fair, and institutionalize the selection mechanism. Only in such an environment can it help to continuously improve the management level and overall quality of senior management personnel, speed up the process of pay marketization and socialization, and increase the incentive effect of executive compensation.

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appendix Basic data of each indicator

公司名称	日期	ln(comp)	SIZE	BDS	CON	GROWTH	SPR	$CP_{(t-1)}$	$CP-CP_{(t-1)}$	STATE	ROA	$ROA_{(t-1)}$	LEV	CBD
靖远煤电	2011	12.411290												
	2012	12.532855	22.349190	13	0.000000	2.939314	0.110304	0.297570	-0.078908	0	0.153818	0.104316	0.573852	0
	2013	12.745680	22.469839	14	0.000000	-0.081695	0.115040	0.218661	-0.057356	0	0.079209	0.153818	0.545520	0
	2014	12.073874	22.564118	14	0.000000	-0.112990	0.100502	0.161306	-0.038715	0	0.055165	0.079209	0.570138	0
	2015	12.698429	22.948708	15	0.000000	-0.198763	0.068084	0.122591	-0.071650	0	0.023164	0.055165	0.338593	0
	2016		22.925090	15	0.000000	0.124941	0.074714	0.050941	0.006590	0	0.024315	0.023164	0.305095	0
新大洲	2011	13.859967												
	2012	13.968232	21.760451	9	0.000623	-0.026095	0.099240	0.213330	-0.040026	1	0.038986	0.083491	0.218432	1
	2013	13.932435	21.927502	9	0.000866	-0.025295	0.156054	0.173304	-0.026718	1	0.052231	0.038986	0.305101	0
	2014	13.814276	22.219846	7	0.013063	-0.075873	0.101314	0.146586	-0.063830	1	0.024728	0.052231	0.354891	0
	2015	13.979640	22.309294	7	0.014656	-0.036747	0.038309	0.082756	-0.014888	1	0.007513	0.024728	0.410649	0
	2016		22.331384	7	0.013863	-0.050864	0.000354	0.067869	-0.009688	1	0.000062	0.007513	0.420125	0
冀中能源	2011	13.834627												
	2012	13.821459	24.414830	15	0.000000	-0.199544	0.076973	0.234117	-0.036694	0	0.059231	0.096306	0.545574	0
	2013	13.470105	24.439321	9	0.000000	-0.140950	0.043448	0.197423	-0.048948	0	0.027642	0.059231	0.560152	0
	2014	12.918369	24.454331	9	0.000000	-0.293293	-0.008964	0.148475	-0.066005	0	-0.003952	0.027642	0.502378	0
	2015	12.995363	24.429693	9	0.000000	-0.313298	0.024201	0.082470	-0.007666	0	0.007362	-0.003952	0.509582	0
	2016		24.496410	9	0.000000	0.087632	0.011720	0.074804	-0.015515	0	0.003795	0.007362	0.538275	0
西山煤电	2011	13.074054												
	2012	13.042959	24.532721	11	0.000009	0.028195	0.063888	0.228696	-0.039306	0	0.047635	0.088914	0.609906	0
	2013	12.984786	24.555426	11	0.000009	-0.055354	0.043178	0.189390	-0.016120	0	0.027906	0.047635	0.592377	0
	2014	12.906692	24.598562	11	0.000009	-0.173193	0.014349	0.173270	-0.042176	0	0.007418	0.027906	0.611846	0
	2015	12.865318	24.678943	10	0.000011	-0.235032	0.011288	0.131094	-0.030028	0	0.004195	0.007418	0.636522	0
	2016		24.710066	9	0.000001	0.051059	0.022995	0.101066	-0.001799	0	0.008499	0.004195	0.640298	0
露天煤业	2011	12.969212												

	2012	12.933782	22.919118	12	0.000000	0.056538	0.229208	0.300721	-0.032532	0	0.184748	0.213384	0.367502	0
	2013	12.884445	23.013346	12	0.000001	-0.094481	0.146911	0.268189	-0.100167	0	0.096901	0.184748	0.358436	0
	2014	12.934265	23.357725	11	0.000003	0.005284	0.099484	0.168022	-0.062292	0	0.052257	0.096901	0.394971	0
	2015	13.065511	23.368020	12	0.000003	-0.106691	0.095348	0.105730	-0.018328	0	0.038027	0.052257	0.369467	0
	2016		23.358824	12	0.000003	-0.015369	0.150318	0.087402	0.009831	0	0.058996	0.038027	0.315029	0
	2011	13.564053												
	2012	13.624875	23.737531	9	0.000000	-0.000980	0.220723	0.225663	-0.037313	0	0.094350	0.109061	0.493287	0
兰花科创	2013	13.185025	23.742871	9	0.000000	-0.134597	0.133232	0.188350	-0.061916	0	0.042897	0.094350	0.488404	0
	2014	13.040792	23.806693	9	0.000000	-0.207009	-0.003248	0.126434	-0.065083	0	-0.000801	0.042897	0.532190	0
	2015	12.824855	23.819779	9	0.000000	-0.124884	-0.026253	0.061350	-0.012029	0	-0.005453	-0.000801	0.539731	0
	2016		23.905524	8	0.000000	-0.045329	-0.199604	0.049321	-0.026076	0	-0.037636	-0.005453	0.609202	0
	2011	13.410045												
	2012	13.410045	24.474384	8	0.000000	2.743567	0.154509	0.078309	-0.000229	1	0.041684	0.035590	0.598018	0
永泰能源	2013	13.482366	24.586411	8	0.000000	0.275310	0.063808	0.078079	-0.017533	1	0.013929	0.041684	0.718149	0
	2014	13.612986	24.676612	7	0.000000	-0.196195	0.061214	0.060547	-0.000611	1	0.009713	0.013929	0.737991	0
	2015	13.672410	25.195544	8	0.000000	0.363011	0.091275	0.059935	-0.007716	1	0.014096	0.009713	0.703247	0
	2016		25.309381	8	0.000000	0.270296	0.055869	0.052220	-0.003013	1	0.008244	0.014096	0.703085	0
	2011	13.476797												
	2012	13.397644	25.521546	11	0.000004	0.223612	0.093568	0.194781	-0.088720	0	0.051037	0.101497	0.604379	0
兖州煤业	2013	13.975450	25.557160	11	0.000004	-0.015869	0.005095	0.106061	-0.025856	0	0.002423	0.051037	0.661438	0
	2014	13.783332	25.599495	11	0.000004	0.088480	0.029073	0.080205	0.007547	0	0.014472	0.002423	0.667218	0
	2015	13.672448	25.658185	10	0.000035	0.079544	0.012045	0.087753	-0.019769	0	0.006153	0.014472	0.690781	1
	2016		25.704283	11	0.000035	0.477845	0.022481	0.067984	0.005819	0	0.016107	0.006153	0.649429	0
	2011	13.389332												
	2012	12.943157	24.173297	7	0.000000	0.410038	0.031409	0.225436	-0.045980	0	0.075614	0.108085	0.537185	0
阳泉煤业	2013	13.102025	24.024103	8	0.000000	-0.634085	0.027354	0.179456	-0.044102	0	0.024416	0.075614	0.481562	0
	2014	12.840266	24.127594	9	0.000000	-0.208128	0.030909	0.135354	-0.031057	0	0.022384	0.024416	0.553305	0
	2015	12.801974	24.240031	9	0.000000	-0.186210	-0.001220	0.104297	-0.038715	0	-0.000645	0.022384	0.603570	0

	2016		24.455995	9	0.000000	0.108961	0.024301	0.065582	0.013451	0	0.012044	-0.000645	0.664302	0
	2011	13.560016												
	2012	13.293624	23.359781	9	0.000000	0.055910	0.193951	0.238008	-0.028353	0	0.116750	0.167594	0.410201	0
盘江股份	2013	13.275084	23.358595	9	0.000000	-0.266243	0.054160	0.209656	-0.089474	0	0.022445	0.116750	0.446728	0
	2014	12.937960	23.115290	9	0.000000	-0.105270	0.059367	0.120181	0.009953	0	0.024692	0.022445	0.418202	0
	2015	12.781187	23.061898	9	0.000000	-0.213691	0.005702	0.130134	-0.069391	0	0.002178	0.024692	0.423863	0
	2016		23.166344	3	0.000000	-0.038044	0.050079	0.060743	0.009785	0	0.017922	0.002178	0.438631	0
	2011	12.887147												
	2012	12.751590	22.881177	10	0.000000	10.080511	0.019826	0.179918	-0.039129	0	0.061423	0.015999	0.573447	0
安源煤业	2013	13.474568	22.950662	9	0.000000	0.039320	0.012295	0.140789	-0.028739	0	0.023914	0.061423	0.575589	0
	2014	12.839558	22.944803	9	0.000000	-0.389082	0.006592	0.112050	-0.033886	0	0.007592	0.023914	0.618185	0
	2015	12.465612	23.110518	9	0.000000	-0.519655	0.000369	0.078163	-0.043864	0	0.000188	0.007592	0.679216	0
	2016		22.717308	8	0.000000	-0.362600	-0.657220	0.034299	-0.241832	0	-0.235162	0.000188	0.810156	1
	2011	13.215732												
	2012	13.415680	23.147892	11	0.000000	-0.035478	0.096191	0.269984	-0.075289	0	0.086005	0.147404	0.258858	1
上海能源	2013	13.531068	23.297207	10	0.000000	-0.129793	0.015983	0.194696	-0.112365	0	0.011078	0.086005	0.362292	0
	2014	13.332192	23.364861	9	0.000000	-0.249304	0.002484	0.082331	-0.016675	0	0.001162	0.011078	0.391749	0
	2015	13.216643	23.338497	8	0.000000	-0.219038	-0.005995	0.065657	-0.010444	0	-0.002147	0.001162	0.381146	0
	2016		23.361571	5	0.000000	0.044179	0.079819	0.055212	0.033957	0	0.029893	-0.002147	0.360812	0
	2011	12.896090												
	2012	12.623796	21.000669	11	0.000000	0.215272	0.022577	0.117729	-0.014436	0	0.009635	0.029952	0.674522	0
金瑞矿业	2013	12.847927	20.925578	11	0.000000	0.111559	0.039808	0.103293	0.012201	0	0.017837	0.009635	0.632245	0
	2014	12.879017	20.978874	11	0.000000	-0.250776	0.017399	0.115494	-0.034752	0	0.005907	0.017837	0.650862	0
	2015	12.631340	20.913848	11	0.000000	-0.232294	-0.110603	0.080741	-0.031849	0	-0.028993	0.005907	0.561370	0
	2016		20.383942	11	0.000000	-0.593128	0.432019	0.048892	0.109239	0	0.059955	-0.028993	0.173030	0
	2011	12.638612												
红阳能源	2012	12.481429	20.229397	9	0.000000	0.089552	0.069771	0.088119	-0.017770	0	0.027534	0.027569	0.471427	0
	2013	12.219811	20.422739	9	0.000000	0.101322	0.066206	0.070349	-0.004656	0	0.025999	0.027534	0.549052	0

	2014	12.047272	20.503099	9	0.000000	-0.016461	0.049522	0.065693	-0.013113	0	0.016745	0.025999	0.575539	0
	2015	12.508397	23.609255	9	0.000000	21.703721	-0.078583	0.052580	-0.002592	0	-0.049709	0.016745	0.722803	0
	2016		23.532130	9	0.000000	0.209172	0.024246	0.049988	0.024190	0	0.010061	-0.049709	0.689389	0
	2011	13.182706												
	2012	12.985168	23.322494	11	0.000000	0.099531	0.081735	0.185211	-0.042691	0	0.057707	0.084116	0.482020	0
恒源煤电	2013	12.758520	23.315985	11	0.000000	-0.109328	0.040044	0.142521	-0.045358	0	0.024309	0.057707	0.465022	0
	2014	12.926835	23.348930	9	0.000000	-0.208298	0.004655	0.097163	-0.036759	0	0.002208	0.024309	0.493659	0
	2015	12.969134	23.286109	11	0.000000	-0.384567	-0.346662	0.060404	-0.105324	0	-0.102660	0.002208	0.558758	0
	2016		23.329392	11	0.000000	0.166241	0.008678	-0.044920	0.091470	0	0.003027	-0.102660	0.572415	0
	2011	12.846171												
	2012	12.803993	23.792289	15	0.000000	0.198507	0.054961	0.280748	-0.076400	0	0.046997	0.126901	0.345918	0
大同煤业	2013	12.717998	23.728746	15	0.000000	-0.372474	-0.078937	0.204349	-0.050238	0	-0.041037	0.046997	0.460553	0
	2014	12.571526	23.928256	18	0.000000	-0.199875	0.076548	0.154111	-0.030829	0	0.029616	-0.041037	0.503047	0
	2015	12.042965	23.998193	16	0.000000	-0.178374	-0.256547	0.123282	-0.053278	0	-0.071583	0.029616	0.634083	0
	2016		23.991808	15	0.000000	0.036865	0.061904	0.070004	0.051853	0	0.017360	-0.071583	0.617126	0
	2011	13.816976												
	2012	14.259127	26.839723	9	0.000000	0.202035	0.222596	0.205150	-0.016096	0	0.130951	0.139810	0.331954	0
中国神华	2013	13.967716	26.953105	9	0.000000	0.134009	0.196292	0.189054	-0.008988	0	0.115944	0.130951	0.350889	0
	2014	13.716058	27.001029	8	0.000000	-0.124867	0.186717	0.180066	-0.027628	0	0.089156	0.115944	0.332276	0
	2015	13.787454	27.040367	7	0.000000	-0.287047	0.131384	0.152438	-0.051937	0	0.042821	0.089156	0.353466	0
	2016		27.071817	9	0.000000	0.034213	0.161287	0.100501	0.009586	0	0.052479	0.042821	0.335442	0
	2011	14.037053												
	2012	14.010831	23.173079	15	0.000000	-0.002528	0.133799	0.249103	-0.063521	0	0.083024	0.134307	0.260890	0
昊华能源	2013	13.654559	23.268849	15	0.000000	0.049182	0.072955	0.185582	-0.058826	0	0.043611	0.083024	0.343624	0
	2014	13.778293	23.380328	15	0.000000	-0.056951	0.028439	0.126756	-0.057104	0	0.014448	0.043611	0.413656	0
	2015	13.657452	23.709489	15	0.000000	-0.041985	0.008246	0.069652	-0.030732	0	0.003182	0.014448	0.454904	0
	2016		23.730553	15	0.000000	-0.223469	0.002476	0.038920	0.009770	0	0.000631	0.003182	0.459446	0
平煤股份	2011	13.352469												

	2012	13.180632	23.761183	14	0.000000	-0.115654	0.052791	0.243823	-0.057948	0	0.057757	0.093192	0.439901	0
	2013	13.030029	24.000551	15	0.000000	-0.136106	0.038555	0.185875	-0.049729	0	0.031179	0.057757	0.544650	0
	2014	12.925618	24.171740	15	0.000000	-0.158340	0.014005	0.136146	-0.057706	0	0.007791	0.031179	0.614619	0
	2015	12.770818	24.290343	14	0.000000	-0.228044	-0.172058	0.078440	-0.056663	0	-0.064039	0.007791	0.719141	0
	2016		24.364540	14	0.000000	0.182368	0.048153	0.021777	0.055458	0	0.019264	-0.064039	0.696938	0
	2011	13.285842												
	2012	13.288556	24.402418	17	0.000000	-0.105277	0.102156	0.282776	-0.078626	0	0.055262	0.104469	0.581711	0
潞安环能	2013	13.189648	24.543200	17	0.000000	-0.043126	0.060732	0.204150	-0.055727	0	0.027368	0.055262	0.620102	0
	2014	12.723874	24.664968	17	0.000000	-0.165086	0.046621	0.148423	-0.056082	0	0.015392	0.027368	0.640654	0
	2015	11.976156	24.647615	17	0.000000	-0.304106	-0.003729	0.092341	-0.037572	0	-0.000815	0.015392	0.652980	0
	2016		24.780663	17	0.000000	0.275559	0.049897	0.054769	0.011741	0	0.013094	-0.000815	0.689065	0
	2011	13.617872												
	2012	13.786082	25.937461	9	0.000000	-0.017787	0.114672	0.181235	-0.017830	0	0.058472	0.073784	0.452239	0
中煤能源	2013	13.528895	26.093642	9	0.000000	-0.056995	0.052186	0.163405	-0.048357	0	0.021543	0.058472	0.522329	0
	2014	13.311936	26.215118	8	0.000000	-0.141559	0.017294	0.115048	-0.032228	0	0.005341	0.021543	0.576834	0
	2015	13.276743	26.272262	8	0.000000	-0.161228	-0.034826	0.082820	-0.015876	0	-0.008262	0.005341	0.610797	0
	2016		26.211579	8	0.000000	0.022958	0.048353	0.066944	0.013492	0	0.011754	-0.008262	0.578412	0
	2011	13.664688												
	2012	13.491625	23.945687	9	0.000000	0.098871	0.151057	0.120006	-0.001876	0	0.056515	0.064511	0.650426	0
国投新集	2013	13.366720	24.016303	8	0.000000	-0.117477	0.001669	0.118131	-0.068403	0	0.000501	0.056515	0.675919	0
	2014	13.223415	24.086901	9	0.000000	-0.159962	-0.300380	0.049727	-0.067488	0	-0.070630	0.000501	0.758633	0
	2015	13.499638	24.139535	9	0.000000	-0.271732	-0.536288	-0.017761	-0.018773	0	-0.086371	-0.070630	0.849055	0
	2016		24.170486	9	0.000000	0.130758	0.052512	-0.036534	0.089914	0	0.009174	-0.086371	0.844362	0
	2011	13.959120												
	2012	13.908242	24.445753	11	0.000000	0.864219	0.225451	0.293324	-0.011854	1	0.205390	0.208065	0.469655	0
伊煤股份	2013	13.764708	24.540638	11	0.000000	-0.227943	0.156578	0.281470	-0.094322	1	0.090370	0.205390	0.450046	0
	2014	13.433713	24.796456	11	0.000000	0.013169	0.108741	0.187148	-0.064713	1	0.052986	0.090370	0.531925	0
	2015	13.790603	24.945252	11	0.000000	-0.229510	0.012917	0.122434	-0.066830	1	0.003983	0.052986	0.607322	0

2016	24.985123	11	0.000000	0.168306	0.092979	0.055604	0.022069	1	0.030556	0.003983	0.597298	0