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Study of the Impact of the Rise and Fall of the Coal Industry on the Regional Economy

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ABSTRACT

Coal has always been an important foundation for China's economy. The booming and declining of the coal industry can directly impact the regional economy. This study researches the impact of the rise and fall of the coal industry on the regional economy, finance, and employment by establishing a panel data model. The results show that the economic growth rate of coal-producing areas is vulnerable to the rise and fall of the coal industry, and the impact is uneven. That is, the prosperity of the coal industry has a slightly greater impact on regional economic growth than that of a recession. The fiscal revenue and expenditure of coal-producing areas has been substantially affected during the coal industry recession, and the fiscal deficit has risen remarkably. The employment situation of urban workers in coal-producing areas is almost unaffected by the rise and fall of the coal industry.

KEYWORDS

Coal Industry, Control Groups, Declining Period, Fiscal Deficit, Panel Data, Per Capita GDP, Regional Economy, Registered Urban Unemployment Rate, Rising Period, Treatment Groups

1. INTRODUCTION

Coal has always been an important foundation for China's economic development. The booming and declining of the coal industry can directly affect the economic development of the region and the country. Like other industries, the coal industry has experienced many periodical fluctuations. Since the founding of New China, China's coal production has been increasing and its supply capacity has been improving. In 1949, China's coal production was 32.43 million tons. By 1996, China had become the world's top coal producing country, with coal production reaching 1.38 billion tons. Due to the financial crisis, coal production declined yearly from 1996 to 2000. Since 2002, China's economy has continued to grow and the production of raw coal increased from 1.55 billion tons in 2002 to 3.764 billion tons in 2011. The annual production of raw coal increased by 2.214 billion tons in 10 years, with an average annual growth rate of 10.36%. After 2011, owing to the slowdown of China's economic growth, optimization of economic structure, and transformation of energy structure, the domestic demand for coal continued to decrease. By 2015, the pace of China's economic development had entered a new normal and the overall consumption of coal gradually decreased. By 2017, the country's cumulative production of raw coal was 3.524 billion tons. This was 450 million tons less than the peak of 3.974 billion tons in 2013. Owing to the capacity release of the previous coal

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investments and the pursuit of short-term benefits by enterprises, the supply in the coal market has been increasing. Imported coal has also enlarged the market supply to a certain extent (Guan and Li, 2015) which has led to an excessive coal supply.

The changes in coal supply and demand, capacity changes, and price fluctuations are relatively extensive. As an upstream industry of the national economy, coal has an impact on the cost and price of its relevant downstream coal-consuming industries. This impact will continue to ripple further downstream and will ultimately have an impact on the Chinese or regional economy. The volatility of the coal industry has caused substantial harm to the industry itself, and brought very negative impact to related industries, the whole economy, and society. With the continuous growth and expansion of the volume of the coal industry, the instability of its economic operation has increased its impact on the economy and society, especially in the period and context of China's reform of the coal supply front. Studying the impact of the fluctuation of the coal industry on China's regional economy can help the government formulate relevant policies to alleviate the overcapacity. This is important for the sustainable and healthy development of the regional and national economy.

The remainder of this paper is organized as follows. Section 2 discusses related literature. Section 3 introduces the development history of the Chinese coal industry. Section 4 discusses the data selection and model establishment. Section 5 discusses the estimation and testing of model parameters, and section 6 provides the conclusion and prospects.

2. LITERATURE REVIEW

The development of the coal industry has been the major concern of many scholars. As a pillar industry of the national economy, the coal industry experiences broad fluctuations in output value during severe price fluctuations. This leads to fluctuations in the regional economy and even the national economy. These economic fluctuations are more dramatic in resource-based regions (Zhao et al., 2011). China's coal reserves are distributed chiefly in northern and northwestern China. The five regions including Inner Mongolia, Shanxi, Xinjiang, Shaanxi, and Guizhou hold 956.1 billion tons of proven resource reserves, accounting for 81% of the national total (Guo, 2010). Some scholars have studied different coal-rich regions, including Shanxi, Anhui, Shaanxi, and Xinjiang (He, 2013; Huang et al., 2012; Wang and Feng, 2013; Zhang et al., 2015) using econometrics and state-space models. They discussed the effectiveness, time lag of impact, and correlation between the fluctuation of coal prices and regional GDP. Regarding the impact of price fluctuations on national GDP, Ding et al. (2013) and Li et al. (2015) used data in different time periods and measured by different methods. The results of both studies indicated that there is asymmetry in the impact of coal price fluctuations on China's economic growth. Specifically, decreases in the price of coal have a greater impact on China's economic growth than coal price increases. However, Hou and Yang (2016) used different research methods and time period data to conclude the opposite of the above study. Their study suggests the impact on China's macro economy is much stronger when coal prices are rising than when prices are falling.

Coal resources in coal-producing regions can have an impact on local fiscal revenues. There are barriers in transforming resource advantages into fiscal and economic advantages (Deng et al., 2014). For some regions that rely on the coal industry, government revenues depend largely on the revenues from the coal industry. For example, coal resources in Shanxi Province have always had a positive effect on the fiscal balance (Deng and Xue, 2018). Coal resource development in Shanxi has a catalytic effect on the improvement of the regional fiscal situation and residents' income (Yang and Huang, 2015). The changes in the booming and declining of the coal industry are closely related to the economic development and fiscal revenue of the region, and affect the employment of people in the region. The development of the coal industry creates employment opportunities directly and indirectly (Zhao and Li, 2014). Du (2014) conducted one-dimensional linear regression and structural deviation analysis using data from 1992 to 2010 in Shanxi Province. The results showed that when

coal production increased by 1%, employment increased by 1.202%. Owing to the high dependence of resource economic growth on resource extraction, the prosperity of the resource sector, the continuous heavy development of economic structure, the extrusion of innovative factors, and the increase of uncertainty in economic development, resource-based regions face more serious problems of total employment imbalance, employment structural contradictions, and serious employment risks than non-resource-based regions (Zhao et al., 2015). The prosperity of the resource sector will cause the leakage of labor resources in the manufacturing sector (Neary et al., 1982).

Existing studies have primarily focused on the impact of fluctuations in coal prices, consumption, and production capacity on economic growth. Most scholars use econometric models, such as time series models (Hang and Tu, 2006), VAR (Yang and Li, 2006), and input-output models (Zhou et al., 2010) to empirically study the impact caused by fluctuations in coal prices. These econometric models have endogenous problems, and the input-output approach does not reflect the true economic operating relationships or the behavior of economic agents (Li and Gao, 2016). In this study, this paper adopted the panel data model and the method of setting up treatment and control groups used in Black et al. (2005) to explore the impact of the booming and declining of the coal industry on the labor market. This can better solve the endogenous problems of the econometric model and improve the reliability of the research results. In this study, 80 prefectures (cities) in eight regions were selected as sample sites according to certain criteria. The sites were divided into treatment and control groups based on whether the region produced coal during 2005–2015. The impact of the booming and declining of the coal industry on the regions' economy, fiscal situation, and employment was estimated by building a panel data model and then comparing the gap between the two groups.

The main contributions of this study are: first, setting up control and treatment groups. Then, to the best of our knowledge, we were the first to use a panel data model to quantitatively assess the degree of influence of the booming and declining of the coal industry on the regions' economy, fiscal situation, and employment. This can better solve the endogenous problem of the econometric model and improve the reliability of the research results. Second, the development history of the Chinese coal industry was reviewed and summarized. Based on historical data, a statistical analysis was conducted to describe how the Chinese coal industry has experienced several cyclical fluctuations. Finally, the analysis of the results of the study was carried out to propose some targeted suggestions which can help local governments formulate more precise and appropriate policies in facing the problem of coal overcapacity in the context of China's reform of the supply front. This is conducive to promoting the transformation of the national economic structure and making the regional economic development more robust.

3. THE DEVELOPMENT HISTORY OF THE CHINESE COAL INDUSTRY

Since the 21st century, the speed of economic development across the country has increased rapidly. The consequent expansion of the regional infrastructure has also promoted the further lateral development of energy-intensive industries.The economic development of the Chinese coal industry has not been steady for many years, and has experienced many cyclical fluctuations and shocks (as shown in Figure 1 and Figure 2). Zhan et al. (2008) analyzed the development cycle of the coal industry including the expansion and contraction periods. Zhao et al. (2011) argued that the coal industry shows obvious periodicity, with alternating cycles of economic expansion and economic contraction. Wu (2018) used the CF filter, a mainstream analytical tool for periodic problems, to validate the economic cycle of the Chinese coal industry using coal production, consumption, industrial operating income, and industrial profit as indicators. In this study, starting from the historical phenomena and referring to Wu (2018) analysis of the economic trend of the coal industry, we describe the periodic fluctuations of the coal industry as an operational characteristic by combing the data on profits, production, and consumption of the Chinese coal industry from 1978 to 2017 (data from the National Bureau of Statistics, Coal Industry Yearbook, China Coal Journal, and a small amount of data based

on the statistical bulletin of the National Bureau of Statistics of China). With the year 2000 as the milestone (as shown in Figure 1 and Figure 2), the development history of China's coal industry can be summarized into distinct periods as described in the sections below.

Figure 1. Change (Preceding year is the base period) in total profit in the Chinese coal industry from 1978 to 2000

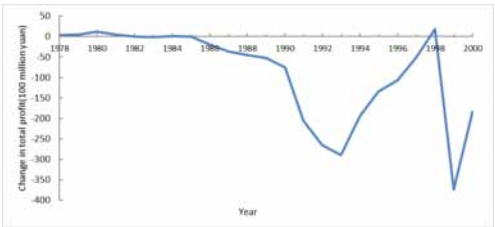
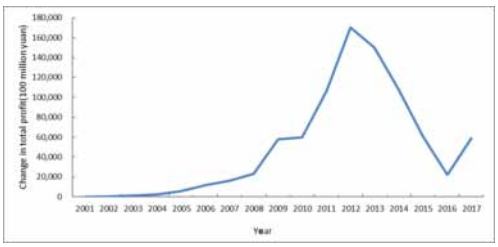


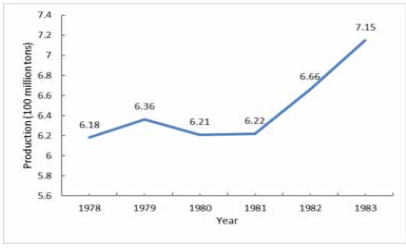
Figure 2. Change (Preceding year is the base period) in total profit in the Chinese coal industry from 2001 to 2017



3.1 The Early Stage of Economic Reform and Open Up, 1978–1983

At the early stage of the economic reform and open up, the Chinese national economy improved. The coal industry realized a profit of 370 million yuan in 1978. This followed a shift from financial loss to a profit of more than 10 million yuan in 1977. In 1978, under the impetus of tapping and renovating old mines and strengthening the administration of comprehensive and general mining, the national coal output reached 618 million tons, an increase of 67.18 million tons. Coal production continued to increase rapidly, reaching 715 million tons in 1983 (Figure 3). However, owing to a series of activities intended to increase production and expansion, costs increased. This impacted prices, wages, financial and other system reforms, as well as industrial technology transformations, resulting in a sharp decline in industrial profits from 780 million yuan in 1979 to 400 million yuan in 1980. By 1981, the industry experienced only a small profit of 8.66 million yuan, and 1982 resulted in a loss of 88.33 million yuan.

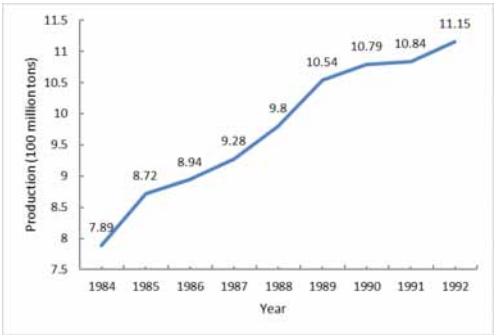
Figure 3. Chinese coal production, 1978–1983



3.2 The Middle and Late 1980s

In 1984, China continued to speed up the progress of the whole economic system reform with emphasis on cities, and the GDP growth rate reached 15.2%. The economic "boom" during this period drove the "overheating" of investment and the massive demand for coal from various industries. The construction of coal mines continued to accelerate.Under the guidance of the development policy of "Quick Flow of Water," the government implemented a series of supportive policies for the construction of local coal mines, and coal production continued to be enhanced. Coal production exceeded 700 million tons in 1983, then 800 million tons, 900 million tons, and 1 billion tons in 1985, 1987, and 1989, respectively. Coal output was close to 1.1 billion tons in 1990 and 1991, and exceeded 1.1 to 1.115 billion tons in 1992 (Figure 4).Many unfavorable factors such as long-term low coal prices, increasing coal mine construction costs, and increasing industry tax burdens, led to the coal industry experiencing increasing financial losses since 1984.

Figure 4. Chinese coal production 1984–1992



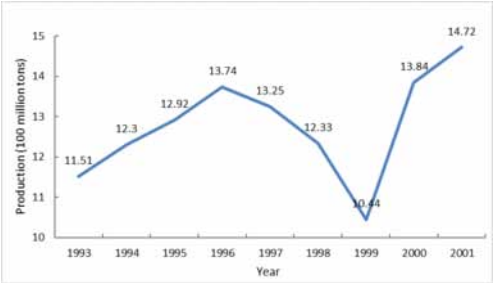
3.3 The 1990s

In 1992, Deng Xiaoping's south tour talks accelerated the progress of economic reform and open up. Coal production continued to grow under the guidance of the policy of increasing production during the "Eighth Five-Year Plan," with the yearly growth rate rising from 0.4% in 1991 to 5% in 1995. A total output of 1.292 billion tons of coal in 1995 exceeded the planned targets. By the "Ninth Five-Year Plan" period, the imbalance of coal overproduction intensified as the worldwide financial crisis occurred in 1998. Chinese economic development was also affected to a certain extent by the impact of this crisis. The demand for coal was seriously insufficient, the coal industry was in serious decline, and the social coal inventory was in a continuing high level of about 200 million tons. The Chinese coal industry was in a long-term state of financial loss during the period of the 1990s.

3.4 The "Tenth Five-Year Plan" Period

During the "Tenth Five-Year Plan" period, with the strong pull of the market and the support of national policies, the demand for coal increased greatly and coal production was pushed up rapidly. An average annual growth rate of 11% resulted in the production of 1.38 billion tons and 1.47 billion tons of coal in 2000 and 2001, respectively (Figure 5). In 2002, China further increased the progress of economic reform and open up. The market-oriented reform of China's coal industry intensified with the restructuring of state-owned coal enterprises and the rapid development of private coal enterprises. The role of market allocation of resources was growing. During the "Tenth Five-Year Plan" period, the development of China's coal industry was stable and soaring.

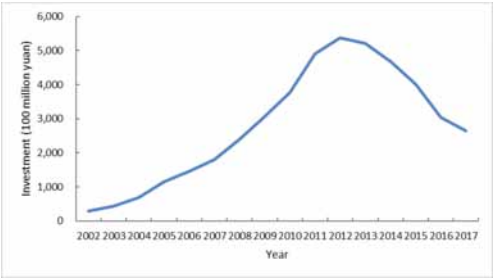
Figure 5. Chinese coal production 1993–2001



3.5 The End of the "Eleventh Five-Year Plan" and the "Twelfth Five-Year Plan" Period

After experiencing a severe contraction during the "Ninth Five-Year Plan" period, the fixed investment in the coal industry exploded after entering the "Tenth Five-Year Plan period." From 2000 to 2005, the fixed assets of the coal industry reached 276.2 billion yuan, exceeding the total investment of the first nine "five-year plans." By 2011, investment was close to 500 billion yuan. In 2012, the investment enthusiasm continued, with investments reaching a record high of 537 billion yuan. Moreover, the cumulative investment in the industry during the "Twelfth Five-Year Plan" period reached 2,418 billion yuan, exceeding the total investment in the ten-year golden development period (2001–2011) (Figure 6).

Figure 6. Coal mining and washing industry fixed asset investment (excluding farmers)



After a brief slowdown in 2008, the growth rate of coal production regained momentum, reaching 6.1% in 2009 and a high level of 12.2% in 2012 (Figure 7). With the continued slowdown in consumption growth, the rate of China's coal overcapacity continued to rise during 2011–2015, reaching 8%, 14%, 20.7%, 24.3%, and 30.4%, respectively (Figure 8). From the supply state, the social coal inventory during the "Twelfth Five-Year Plan" period was at a high level of 300 million tons for several years, and the imbalance between oversupply and demand was very prominent.

Figure 7. Coal production (left vertical axis) and its growth rate (right vertical axis), 2000–2012

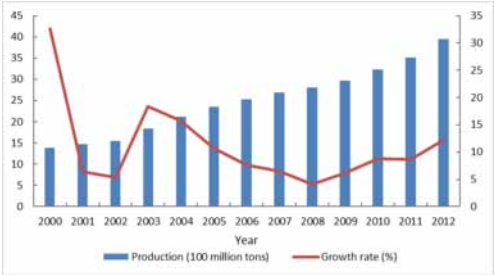
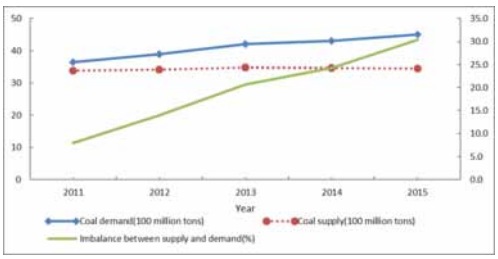


Figure 8. 2011–2015 China coal capacity supply, demand (left vertical axis), and the imbalance (right vertical axis)

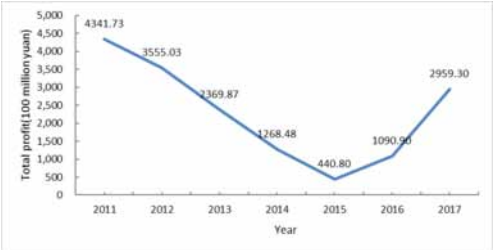


In addition, coal prices continued to fall and industry profits plummeted. As a result of the continued sharp decline in coal prices, the total profits of the coal industry fell rapidly, reaching 88.5% from 2011 to 2015, which was comparable to 2005 levels. Industry sales profit margins, which had been up to 14.3% in 2011, fell to only 1.86% (lower than the 2001 levels and less than half of the average level for all industries). Of the only 40 billion yuan in profits remaining, if the profits of non-coal industries are excluded from the contribution, the coal industry was almost a total loss. In this period, the Chinese coal industry economic development trasitioned from a brief surge to a pronounced decline.

3.6 The Early Portion of the "Thirteenth Five-Year Plan"

At the end of the "Twelfth Five-Year Plan," China entered the new economic normal. The national economy shifted from high speed economic growth to medium-high economic growth, while the coal industry was in the process of deteriorating towards the extreme point of losing almost the entire industry. At the beginning of the "Thirteenth Five-Year Plan," to pull the coal industry out of this predicament, the State Council issued the "Opinions on the coal industry to resolve excess capacity to achieve development" (National Development and Reform Commission [2016] No. 7). The results of implementing this policy have been demonstrated to be very effective. The economy of the coal industry gradually rebounded since the second half of 2016, and coal prices rebounded rapidly, achieving industrial profits of 109.1 billion yuan that year, with a sales profit margin of 4.7%. In 2017, when the national economy continued to run steadily, the benefits of the coal industry continued to be improved, achieving a profit of 295.9 billion yuan (as shown in Figure 9), with a sales profit margin of 11.6%.

Figure 9. Total profit of the Chinese coal industry, 2011–2017 (100 million yuan)



The dramatic change in China's coal supply and demand situation also symbolizes the end of the "golden decade" of rapid development of China's coal industry (Hao and Chai, 2013). In this study, this paper selected the most recent period of rise and fall fluctuations (the rising period of 2006–2011 and the declining period of 2012–2015) as representative periods of the booming and declining of the coal industry. Based on these periods, this paper conducted an empirical study to investigate the impact of the booming and declining of the coal industry on the regions' economy, fiscal situation, and employment.

4. DATA AND MODELING

4.1 Grouping of Data

In September 2016, the China National Coal Association issued the "Notice on the Release of Raw Coal Production in Key Coal-Producing Regions, Prefectures (Cities), and Counties (Cities) for the Year 2015" ("Notice"). According to the "List of Coal Producing Prefectures (Cities) with Raw Coal Production Above 10 Million Tons in 2015," the main coal producing provinces include 8 provinces (autonomous regions) such as Shanxi, Inner Mongolia, Shaanxi, Guizhou, Shandong, Xinjiang, Anhui and Henan, involving 59 Prefectures (Cities).

In order to eliminate other factors that may exist that affect the economy, finance, and employment in coal-producing regions, a treatment group and a control group were defined with the single variable of whether or not the region produced coal. The sample prefectures in the two groups are located in the same eight regions, governed by the same local policies, and subject to the same regional influence. The sample area of the treatment group was restricted to 59 coal-producing prefectures with original coal production of more than 10 million tons in the Notice. The sample area of the control group was restricted to prefectures with almost no coal production. Considering that the population size and economic development of the treatment and control groups should be roughly equivalent, the population size of the two groups was restricted to 1.0422–8.5003 million (2015) and the GDP was restricted to 55.3429–2405.75 (100 million yuan in 2006). This resulted in the selection of 38 prefectures as the sample of the treatment group and 42 prefectures as the control group sample. The results of the selection of the treatment and control group samples are shown in Table 1.

Table 1. Results of the selection of the treatment group and control group

Region	Treatment Group	Control Group
Shanxi	Taiyuan Datong Yangquan Linfen Changzhi Jincheng Shuozhou Jinzhong Xinzhou Lvliang	Yuncheng
Shaanxi	Weinan Xianyang Yulin Yan'an	Xi'an Hanzhong Ankang Shangluo
Shandong	Heze Jining Tai'an Zaozhuang	Jinan Yantai Liaocheng Dezhou Zibo Binzhou Rizhao Weihai Dongying Laiwu
Inner Mongolia	Erdos Xilinguole League Baotou Hulunbeier Chifeng Tongliao	Wulanchabu Xingan League
Guizhou	Bijie Qianxinan Liupanshui	Guiyang Qiandongnan Tongren
Xinjiang	Urumqi Changji Hui Autonomous Prefecture Aksu Administrative Offices Ili Kazakh Autonomous Prefecture	Bayingoleng Mongol Autonomous Prefecture Kashgar Administrative Offices Hotan Administrative Offices
Anhui	Huainan Huaibei Fuyang Suzhou	Hefei Wuhu Bengbu Maanshan Tongling Anqing Huangshan Chuzhou Luan Bozhou Chizhou Xuancheng
Henan	Pingdingshan Xuchang Shangqiu	Kaifeng Anyang Xinxiang Puyang Luohe Xinyang Zhumadian

According to the grouping results in Table 1, the value of the variable for prefectures in the treatment group was set to 1 and the value for the control group was set to 0. All the relevant prefectures in our treatment group are from the major coal-producing prefectures, all the relevant prefectures in the control group are from the same regions as the treatment group but with almost no coal production.

4.2 Selection of Indicators and Data Sources of Relevant Variables

The per capita GDP (RGDP) was used as an indicator to measure the regional economic development, the per capita GDP index can better reflect the economic development than the GDP index. In measuring the regional financial situation, the absolute value of the difference between local general public budget revenue and expenditure (i.e., the absolute value of local fiscal deficit, CZSZ) was selected for the relevant analysis (Deng and Xue, 2018), this index can well reflect the fiscal revenue and expenditure surplus or deficit of local governments. There are two indicators of employment, namely, the registered urban unemployment rate and the surveyed urban unemployment rate(Liu,2016). The surveyed urban unemployment rate has been released since 2018, which is inconsistent with the research period of this paper. Based on the availability of data, the registered urban unemployment rate (SYL) was selected as an indicator to measure the regional employment situation. The SYL is the proportion of the total number of registered urban unemployed persons in the sum of the total number of urban employees and the actual registered urban unemployed persons at the end of the reporting period.

The data in this study were mainly obtained from the Shanxi Statistical Yearbook, Shaanxi Statistical Yearbook, Shandong Statistical Yearbook, and other provincial and regional statistical yearbooks (2005–2015), statistical bulletins on national economic and social development of each prefecture (2005–2015), the website of Search Data, and the EPS global statistical analysis platform. Among them, the data related to per capita GDP and the data related to general public budget revenue and expenditure included in the financial revenue and expenditure indicators of 80 prefectures in the eight regions included in the treatment and control groups were mainly obtained from the statistical

yearbooks (2005–2015). Databases of each regions and the data related to the registered urban unemployment rate were mainly obtained from the statistical bulletin on national economic and social development (2005–2015) and databases issued by the statistical bureaus of each prefecture. In the data query, the data of registered urban unemployment rate from 2006 to 2008 in Lvliang City, Shanxi Province, and the registered urban unemployment rate from 2006 to 2013 in Yan'an, Shaanxi Province, were missing. According to the formula of registered urban unemployment rate, the number of registered urban unemployed and employed workers at the end of the reporting period of each city were found in the web page. The urban unemployment rate of the city was then calculated. The registered urban unemployment rate of some prefectures in 2005 was calculated according to the registered unemployment rate of prefectures in the region. Descriptive statistics for each indicator are shown in Table 2.

Table 2. Descriptive statistics of the data from the treatment group and control group

Group	Sample size	Variables	Mean	Standard error	Median	Minimum value	Maximum value
Treatment group	418	Per capita GDP (yuan)	32,433	28,144	26,164	3200	207,163
		Fiscal deficit in absolute terms (100 million yuan)	87.01	67.92	67.64	0	373.11
		Registered urban unemployment rate (%)	3.27	0.74	3.40	1.30	6.21
Control group	462	Per capita GDP (yuan)	31,616	25,252	24,733	2712	163,982
		Fiscal deficit in absolute terms (100 million yuan)	82.63	65.21	64.12	3.11	362.76
		Registered urban unemployment rate (%)	3.28	0.80	3.30	0.94	7.00

4.3 Modelling

The panel data model is divided into a constant coefficient model, a variable intercept model, and a variable coefficient model. Combined with the research objective of this study — the effect of the rise and fall of China's regional coal industry on regional economy, regional fiscal situation, and local employment — the variable intercept model was used to measure the prediction. The variable intercept model indicated that there was no structural change and there were individual effects in each cross-section. That is, the structural parameters of the explanatory variables are the same in different cross-sections, but the intercept terms are different, where the individual effects can be accounted for by the differences in the intercept terms. The variable intercept models are classified as fixed effect models and random effect models. In practical analysis, if the individual members in the data used are the whole sample of the research object, the changes of parameters in the model are almost the same as the differences between samples (Gao, 2006). And whether the real model is fixed effect model or random effect model, the estimation coefficients of individual fixed effect model are consistent. Because the sample selected in this study meets the above conditions of a reasonable model, the fixed-effects model was used in this study for measurement and analysis.

To eliminate the trendiness that may be contained in the data series and the heteroskedasticity of the data model, the variable series were logarithmized. LNRGDP, LNCZSZ, and LNSYL were used to represent the logarithmic values of the explanatory variables per capita GDP (RGDP),

fiscal balance (CZSZ), and registered urban unemployment rate (SYL), respectively. To ensure the continuous smoothness of the panel data and the validity of the parameter estimates, and to avoid spurious regressions or pseudo-regressions, the unit root test of LNRGDP, LNCZSZ, and LNSYL in related years was carried out. If the original hypothesis of "existence of unit root" was rejected, the series was considered as a smooth series, while the opposite was a non-smooth series.

The unit root test of variables has a variety of test methods, such as LLC, Breitung, IPS, and ADF-Fisher. In this study, the variables were tested by LLC, Breitung, IPS, and ADF-Fisher. Because the time series of per capita GDP, the absolute value of fiscal deficit, and the logarithm of unemployment rate of each city in the sample show intercept and trend, the unit root test of these three explanatory variables was conducted with the model containing intercept and trend. The results of the tests are shown in Table 3.

Table 3. Unit root test results for the three explained variables

Variable	LLC	Breitung	IPS	ADF-Fisher
LNRGDP	0.0000	0.8902	0.6916	0.9252
D(LNRGDP)	0.0000	0.6343	0.0000	0.0000
LNCZSZ	0.0000	0.9657	0.0425	0.9399
D(LNCZSZ)	0.0000	0.3581	0.0000	0.0000
LNSYL	0.0000	0.8182	0.000	1.0000
D(LNSYL)	0.0000	0.2338	0.0000	0.0000

Note: The data in the table are P values.

The original hypothesis of the LLC, Breitung, IPS, and ADF-Fisher unit root test is that the variables are non-stationary series. As can be seen from Table 3, for the unit root test results of the explanatory variable LNRGDP, only the LLC test showed that it was stable ($P < 0.05$). All other tests failed, indicating that LNRGDP has a unit root and is non-stationary. In the unit root test results of D (LNRGDP), except for Breitung test, the other three test results show that D (LNRGDP) is a stationary sequence. That is, the first-order difference of LNRGDP is a stationary series. The unit root test result of the explained variable LNCZSZ cannot be used to determine whether it is stable or not. The LLC test, IPS test, and ADF-Fisher test of D (LNCZSZ) consider it to be stationary, so the first-order difference of LNCZSZ was divided into stationary series. Compared with the original variable, the first-order difference variable of the explained variable LNSYL was considered to be a stationary series by three tests, so D (LNSYL) is a stationary series. Therefore, the panel data model was set as follows:

$$D(LNRGDP_{ist}) = \beta_1 Z_i P_{1t} + \beta_2 Z_i P_{2t} + (region_s, year_t)\phi + \varepsilon_{ist} \tag{1}$$

$$D(LNCZSZ_{ist}) = \beta_1 Z_i P_{1t} + \beta_2 Z_i P_{2t} + (region_s, year_t)\phi + \varepsilon_{ist} \tag{2}$$

$$D(LNSYL_{ist}) = \beta_1 Z_i P_{1t} + \beta_2 Z_i P_{2t} + (region_s, year_t)\phi + \varepsilon_{ist} \tag{3}$$

Among them,

$$D(LNGDP_{ist}) = \ln(GDP_{ist}) - \ln(GDP_{ist-1}) \tag{4}$$

$$D(LNCZSZ_{ist}) = \ln(CZSZ_{ist}) - \ln(CZSZ_{ist-1}) \tag{5}$$

$$D(LNSYL_{ist}) = \ln(SYL_{ist}) - \ln(SYL_{ist-1}) \tag{6}$$

In Equation (1), (2), and (3), Z_i is an indicator variable of whether the prefecture is in the treatment group. If prefecture i belongs to the treatment group, then Z was assigned as 1. Otherwise, it was assigned as 0. Variables P_{1t} and P_{2t} are indicator variables of time period. The subscript 1t refers to the year corresponding to the rising period of total profit of coal enterprises above the scale (2006–2011). The subscript 2t refers to the year corresponding to the declining period of profit of coal enterprises above the scale (2012–2015). Variables β_1 and β_2 measure the differences in the average growth rate between the treatment group and control group in the rising and falling periods, respectively.

$$(region_s, year_t)\phi = \gamma \sum_{s=1}^{8} region_s + \delta \sum_{t=2006}^{2015} year_t \ , \tag{7}$$

where $region_s$ is a region dummy variable to control for the effect of unobservable region characteristics on each explanatory variable and $year_t$ is a year dummy variable to control for the effect of unobservable time variation on each explanatory variable. We included eight coal-producing regions with raw coal production of more than 100 million tons in the analysis. Considering the impact of industrial structure on economic growth, fiscal revenue and expenditure and employment, different industrial structures have different demand for energy such as coal, the consumption of energy such as coal in tertiary industry is small, while the demand for energy in secondary industry such as industry is relatively large, so it is necessary to control the factors of industrial structure in the study of the impact of the rise and fall of coal industry on the economy. Therefore, in the follow-up analysis, this paper also adds the proportion of tertiary industry in GDP for robustness analysis.

5. PARAMETER ESTIMATION AND TESTING

For the selected variable intercept fixed effects model, we used Stata16 software for estimation. The estimation results of the relevant panel data models are as follows.

Table 4. Estimated results: differences in annual growth rates in economy, finance, and employment between the treatment group and the control group

Explained variables (by period)	Difference (treatment group - control group)	Difference (treatment group - control group)
Per capita GDP (N=800)		
Rising period (2006–2011)	0.0198	0.0162
	[0.0002]	[0.018]
Declining period (2012–2015)	-0.0169	-0.0160
	[0.050]	[0.075]
The fiscal balance (N=800)		
Rising period (2006–2011)	-0.0383	0.0665
	[0.433]	[0.290]
Declining period (2012–2015)	0.0149	0.0164
	[0.132]	[0.093]
Registered urban unemployment rate (N=800)		
Rising period (2006–2011)	-0.0141	-0.0146
	[0.170]	[0.152]
Declining period (2012–2015)	-0.0063	-0.0072
	[0.501]	[0.427]
Control variable	None	Industrial structure (proportion of tertiary industry in GDP)

Note: The P value in shown in brackets.

As can be seen from Table 4, the economic, fiscal situation, and employment of the relevant prefectures in the treatment group and control group are not equally affected by the booming and declining of the coal industry. In the parameter estimation results of the economic development panel data model, the coefficients, as the relevant variables in the P_{1t} period passed the P-value test ($P < 0.05$). The coefficient β_1 of the related variables in this period had clear economic and statistical significance. The coefficient β_2 of related variables in the P_{2t} period was significant at the 10% significance level ($P < 0.1$), so it also had clear economic and statistical significance. After adding the control variable of industrial structure (the proportion of tertiary industry in GDP), the significance of the correlation coefficient had not changed. That is, during the period of rising profitability of the coal industry, the economic growth rate of the treated prefectures was faster than that of the control group. During the period of declining profitability of the coal industry, the economic growth rate of the treated prefectures was slower than that of the control group. Compared to the control group, per capita GDP in the treatment group of prefectures grew by an average of 1.98% during the rising period and decreased by an average of 1.69% during the declining period.

In the parameter estimation results of the panel data model of the fiscal situation, because the relevant variables in the P_{1t} period were not significant, the related variables in the P_{2t} period were significant at 10% significant level after adding industrial structure control variables. Therefore, coefficient β_1 of the variable of interest in the P_{1t} period had only clear economic significance and no statistical significance, while coefficient β_2 of the variable of interest in the P_{2t} period had a

clear economic and statistical significance. That is, the absolute value of the fiscal deficit in the treatment group grew at a rate almost indistinguishable from that of the control group during the period of increasing profitability of the coal industry. The absolute value of the fiscal deficit in the treatment group grew faster than that of the control group during the decline in the profitability of the coal industry. Compared to the control group, the fiscal deficit in the treatment group of prefectures increased by an average of 2.4% during the declining period.

In the parameter estimation results of the panel data model of employment status, the coefficients β_1 and β_2 of the relevant variables in the P_{1t} and P_{2t} periods had only clear economic significance and no statistical significance because they did not pass the p-value test (all p-values were greater than 0.05). That is, the growth rate of the registered urban unemployment rate in the treatment group of cities during the period of increasing profitability of the coal industry and the period of recession had almost no significant difference from the control group. This indicates that the booming and declining of the coal industry had little effect on the employment status of the regional urban population.

6. CONCLUSION

Using a panel data model, a treatment group and a control group were defined and compared to the difference between the two groups to reveal the impact of the booming and declining of the coal industry on the regions' economy, fiscal situation, and employment. The following conclusions were drawn.

First, the economic growth rate of coal-producing regions was easily affected by the booming and declining of the coal industry, and the impact was uneven. During the booming period of the coal industry (2006–2011), the economic growth rate of the treatment group prefectures was faster than that of the control group. During the declining period (2012–2015), the economic growth rate of the treatment group prefectures was slower than that of the control group. The impact of the booming coal industry on the regions' economic growth was slightly larger than that of the declining period.

Second, the fiscal revenues of coal-producing regions were more significantly affected during the declining period of the coal industry. During the booming period of the coal industry, the absolute growth rate of fiscal deficit in the treatment group prefectures was almost no different from the control group. During the recession period (2012–2015), the absolute growth rate of fiscal deficit in the treatment group prefectures was faster than the control group, and the fiscal revenue of coal-producing regions decreased significantly. In 2016, China's Ministry of Finance introduced the incentive policy of rewarding the steel and coal industries for resolving excess capacity. According to the conclusion of this study, the coal industry's overcapacity caused the fiscal revenue of coal-dependent regions to decline. The national "Reward" policy treats all regions equally, without considering that different regions are facing different degrees of overcapacity. Therefore, it is necessary to implement a "Regionalization" policy. That is, each region should give more subsidies to the regions with serious overcapacity according to local conditions, which can help to alleviate the pressure of short-term financial growth falling in coal-producing regions.

Third, the employment of urban workers in coal-producing regions was minimally affected by the booming and declining of the coal industry. Whether during the coal industry's booming period or its declining period, the employment situation of the two groups of study subjects demonstrated little or negligible difference. The results of this study suggest that this situation may be explained by two reasons. First, most of the employees in the coal industry are migrant labor are not included in the statistics of urban workers' employment data. Second, approximately 70% of Chinese coal enterprises are state-owned enterprises which have relied on the government for many years, making it difficult for the coal industry to "win the best and lose the worst." Even in the period of coal industry recession,

there were still many enterprises with losses that used loans to pay wages, so the employment of workers did not suffer a big immediate impact due to the recession of the coal industry.

The future prospect of this study is the impact of the rise and fall of the coal industry on employment, which is a hot topic in this research field. Due to the limitations of the existing employment data, only the registered urban unemployment rate data can be used, which may be different from the actual employment situation. With the further enrichment of employment data, if the later research can be combined with the surveyed urban unemployment rate data to carry out empirical research, it will have more valuable empirical research conclusions.

CONFLICT OF INTEREST

The authors of this publication declare there is no conflict of interest.

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