Does diversification help improve the performance of coal companies? Evidence from China's listed coal companies

Abstract

As an important component of the natural resources and energy market, China's coal market has experienced a continuous downturn in recent years. Many coal enterprises have been diversifying their businesses in an effort to enhance their corporate performance. Although many studies have examined the relationship between diversification and performance, researchers have not reached a consensus regarding the nature of this relationship. Additionally, to our knowledge, no study has specifically examined this relationship in coal enterprises. In view of China's coal industry characteristics, such as natural resource dependence and state ownership, other industries' diversified development could not provide good consults for it. In this study, we investigate the relationship between diversification and corporate performance by analyzing the business data of all of China's listed coal enterprises. After determining 35 listed coal enterprises' main business and the proportion of their profit from the coal business, we choose 10 enterprises as representatives. Correlation and regression analyses including the time-series data analysis and panel data analysis are conducted to examine the relationship between diversification and performance. The results indicate that this relationship varies across firms; we observe nonlinear, positive linear, negative linear, and nonexistent relationships in the sample. Therefore, diversified development is not the "panacea" for the decline of coal enterprise. Enterprise performance is determined by integrated internal and external factors beyond diversification, including the market environment, the industry environment, and policy. Coal enterprises that aim to develop diversification strategy should be cautious. In addition, this study can serve as a reference for other energy enterprises that are planning to diversify their business to improve performance.

Keywords: Coal enterprises; diversification; performance; relationship

1. Introduction

Coal, as the main energy source in China, plays a pivotal role in supporting national economic development and protecting national energy safety [1–5]. Since 2012, China's coal enterprises have suffered extensive losses because of factors such as overcapacity, coal imports, increased environmental pressure, and weak downstream demand [6–8]. According to the China National Coal Association, the price of coal has fallen 60% in the past four years. Moreover, the gross profit of China's coal industries was 4.41 billion yuan in 2015, which is 10% of the profit in 2011 [9].

Coal enterprises' over-reliance on their main industry may restrict their development; operating in the coal market involves high risk because of limited coal resources. Additionally, coal production and consumption cause environmental problems such as carbon emission and air pollution [10–15]. According to the Action Plans for Energy Development Strategy (2014–2020)[16], coal consumption is expected to account for 62% of total primary energy consumption in 2020, while this proportion was 66% in 2014 [17]. At the policy level, the "ceiling" of coal consumption requires coal companies to change their development modes of "coal dominance" and single-product operation [18]. We investigate main coal enterprises' business data in China starting from when they were listed, including the number of main businesses, the main business income and the proportion business in coal. We find that China's coal enterprises have been trying to diversify their primary industry advantages by actively developing related industries, such as electricity, coal chemicals, coal equipment, and coal-based building material [19–21].

In general, business diversification includes the four patterns, horizontal diversification, vertical diversification, concentric diversification, and conglomerate diversification [22]. In terms of the business relevance, diversification could be classified into two types, the related diversification and unrelated diversification [23-24].

During a certain period of time in history, diversified operation was always arising from some enterprises' merger and reorganization. However, China's coal enterprises' diversification is gradually developing in the last twenty years. There exist two typical patterns of China's coal enterprises' diversification, which could also explain why enterprises take or accept the diversified strategy. Some non-coal enterprises set foot in coal industry during the so called "Golden Decade", from 2002 to 2012, when they found the enormous business opportunities from the coal industries. Almost during that same time, many traditional coal enterprises making a huge profit out of the coal, they have sufficient capital diversifying their businesses, such as steel, electricity, and real estate. Experts from different areas, such as microeconomics, corporate finance and strategic management, have done much research on the purpose of diversification. There exists many theories or views about the purpose of the diversification, the market power theory, resource view theory, principal-agent theory, debt capacity theory, internal capital market, defense view theory and so on [25].

Despite the controversy, the ultimate purpose of enterprises' diversification is improving their performance. Nevertheless, whether this initial goal could be achieved is indeterminate in theory and practice.

The motivation for diversification includes decreasing management risk, expanding the economy of scope, exploiting synergistic effects, and saving on transaction costs [26-30]. In enterprise diversification, new industries usually evolve from existing ones [31]. Although China's coal enterprises have developed coal-related industries to various

degrees, it remains a question whether diversification could help those enterprises get out of the quagmire.

Despite the abundance of studies on the relationship between diversification and performance, researchers have not reached consensus on the nature of this relationship. Additionally, to our knowledge, no study has examined this relationship in coal enterprises. In this study, we focus on China's coal enterprises to examine whether diversification enhances their performance. Based on the results, certain policy suggestions are provided for the governments, enterprise managers and stockholders.

2. Literature review

Based on the diversification phenomenon in business practices, Ansoff [29] first proposed the concept of diversification from the perspective of business growth strategy, defining "diversification" as the number of products generated by a business. Ansoff believed that businesses can grow in four directions: (1) growth within their current market, (2) sales of new products in their current market, (3) sales of existing products to new markets, and (4) sales of new products to new markets. The fourth direction is known as "diversification". One of the most topical issues regarding diversification is the relationship between diversification strategy and corporate performance and, as stated, researchers continue to debate on this topic [32]. Using data from different perspectives, various industries and several times, researchers have arrived at the following three conclusions.

2.1. Diversification damages corporate performance

The implementation of diversification strategy has been found to damage business performance; i.e., diversification negatively correlates with corporate economic performance. Comparing the Tobin's Q values of diversified companies and single-segment companies, Lang and Stulz [33] showed that highly diversified firms have significantly lower average and median Q ratios than single-segment firms. Berger analyzed the business operation and financial data of 3,600 companies with annual sales of more than $20 million from 1986 to 1991 and found that diversification caused an average loss of 13% to 15% in value during this period. They believed that overinvestment and cross-subsidization contributed to the value loss. Other researchers have also analyzed the relationship between diversification and performance and concluded that diversification or diversified acquisition damages business performance [34-38].

2.2. Diversification enhances corporate performance

Research in different countries has found a positive relationship between diversification and performance. For example, Villalonga [28] used the Business Information Tracking

Series to analyze US enterprise data from 1989 to 1996 and found that diversification results in a premium. Landskroner et al. [39] investigated five of Israel's largest banking groups in 1991-2001, and their results revealed gains from diversification. Zhang [40] examined how diversification strategy affects financial performance in Chinese companies listed on the China Growth Enterprise Market (GEM). The results showed that diversification strategy and financial performance are positively correlated; i.e., the diversification strategy of GEM-listed companies has a positive effect on their performance. US lodging firms' geographic diversification also positively affects their firms' performance, as shown in recent research by Kang and Lee [41]. Using stochastic frontier analysis with panel data of 377 urban hotels in Beijing from 1994 to 2005, Yang et al. [42] found a positive relationship between product diversification and property performance.

2.3. Diversification is unrelated to corporate performance

Some scholars question the evidence of a negative correlation between diversification and economic performance. Although these scholars do not deny the poor corporate economic performance of diversified companies, they believe that it is caused by factors other than diversification. Their suspicions about the negative correlation between diversification and economic performance are based on the belief that before the companies adopted a diversification strategy, their economic performance was already problematic [43]. Although diversified companies and specialized companies might be essentially different, the lack of control over endogenous variables implicated by the diversification strategy could lead to erroneous inferences [44]. Campa and Kedia [44] found that financial indicators—e.g., asset size, ratio of capital expenditure to sales revenue, ratio of earnings before interest and tax to sales revenue, industry growth rate, and ratio of research and development (R&D) expenses to sales revenue—are different in diversified businesses than in single-product businesses. They also found that after controlling these variables, the discount of diversification reduced or even completely disappeared. Liu et al. [45] used the risk-performance model to analyze the panel data of 19 major Chinese commercial banks from 2000 to 2010. The results showed that diversification in China's commercial banks has little impact on performance.

In summary, the relationship between diversification and corporate performance is a matter of dispute. Whether the arguments are based on experience or empirical research, there is evidence to support each of the three above-described propositions. Based on our analysis, we believe that the reasons for this conundrum are as follows. First, researchers adopt different perspectives; e.g., some examine all listed companies, whereas others choose specific industries or types of business. Second, the data used vary, as do the accuracy of the data and the method of excluding certain data from the samples, which inevitably leads to different conclusions [28]. Third, the choice of research method, which leads to the use of different diversification and performance indicators, leads to

different results. Certainly, enterprises' market environment and policy, among other factors, also affect the relationship between diversification and performance.

2.4. Energy and resource enterprises' diversification development

Despite the abundance of studies about the relationship between diversification and performance, researchers have not reached a consensus on the nature of this relationship. Some research has focused on the restructuring or reorganization of coal enterprises [46–48]. Nawrocki and Jonek-Kowalska [47] investigated coal-mining enterprises in Central and Eastern Europe and concluded that a high number of operation segments could lower operational risk. Some coal-related industries or businesses have emerged from restructuring processes. Hu [48] examined how the path-creation mechanism of the coal-chemical industry is related to the old path of the coal-mining industry and revealed that the rise of the new path benefits from the old one, to a limited extent.

In addition, some studies have focused on certain aspects of energy enterprise diversification, and they can provide some references for our research. Safarzynska [49] analyzed fuel diversification in the manufacturing sector between 1960 and 2010 in 216 countries and found that the diffusion of renewable energy may not be feasible in the short run. Regarding Poland's future energy policy, Wierzbowski et al. [50] suggested that policy should facilitate the transformation of the coal-based electricity generation system into a more sustainable and diversified energy mix. Examining whether Brazil has been able to diversify its electricity mix with respect to income growth, Kileber and Parente [51] found evidence that Brazil has succeeded in breaking its hydroelectric dependency. They believed that the diversification of electricity sources has occurred in Brazil. Heiskanen et al. [52] studied the case of Finland, which introduced policy measures to diversify its renewable energy portfolio; they found that diversification of investors supports diversification in renewable energy sources and brings in new investors undeterred by the financial downturn.

In short, current research about energy enterprises' diversification is not sufficient, especially the relationship between the performance and diversification degree. To our knowledge, no research has examined this relationship in coal enterprises. The reason for the insufficient research could be that diversification of coal enterprise is still in its infancy. The restructuring or reorganization of coal enterprises has been researched, which is one of the origins stages of coal enterprise's diversification.

In view of China's coal industry characteristics, such as natural resource dependence and state ownership, other industries' diversified development could not provide good consults for it. Extending prior research on energy enterprise diversification, particularly the restructuring or reorganization of coal enterprises, we examine the relationship between diversification and performance in China's coal enterprises, which can provide

the reference for the coal enterprises who are diversifying or plan to diversify their business.

3. Method

3.1. Measurement of diversification and performance

To analyze the relationship between diversification and corporate performance, the first step is to calculate the indicator of diversification, which is the independent variable in our study. We use the entropy index to evaluate the degree of diversification in enterprises; see Equation 1. The entropy index was developed by Jacquemin and Berry [53] to measure diversification. It has obvious advantages over the Herfindahl index and SIC codes because it can reflect the degree of correlation between different industries and the distribution of different industries' sales revenue [53-55].

$$DT = \sum_{i=1}^{n} p_i \ln(\frac{1}{p_i}) \quad \text{Equation 1}$$

In Equation 1, *DT* is the overall degree of diversification; *n* is the number of sectors operated by an enterprise, reflected by the three-digit SIC code; and P_i represents the proportion of business income from the primary business in the total business income.

As for the dependent variable, we use rate of return on common stockholders' equity (ROE) for the relationship model of diversification and performance. ROE refers to the ratio of net income to the average net assets of an enterprise, which is a financial indicator that is highly comprehensive and reflects the ultimate profitability of the shareholders' investment.

ROE = Net profits owned by owners of the parent company/ average net assets — Equation 2

3.2. Regression analysis-time series analysis

Based on a literature survey [32,56], the findings of previous studies reveal four different relationships between diversification and corporate performance: (1) positive linear correlation, (2) negative linear correlation, (3) nonlinear correlation, and (4) no correlation. Therefore, we propose the same four possible hypotheses in our study to explore the relationship between enterprises' diversification and their performance.

We use a regression analysis to test the four proposed relationships. The potential linear correlations are examined using a linear regression equation, both positive and negative, whereas the nonlinear relationship between diversification and performance is investigated using curve regression analysis (curve estimation). In the regression analyses, taking into account the possible linear and nonlinear relationships identified in previous

research (e.g., Palich et al. [32]), we apply a curve estimation including linear, logarithmic, inverse, quadratic, cubic, compound, power, S, growth, exponential, and logistic regression models to analyze the relationship between diversification and performance for every coal enterprise. Equation 3 and Equation 4 refer to the linear and quadratic regression models, respectively. *y* is corporate performance, *x* is an indicator of the corporate diversification-entropy index, *a* is the constant term, b_1 is the coefficient corresponding to *x*, and b_2 is the coefficient corresponding to x^2.

$$y = a + b_1 x \quad \text{Equation 3}$$

$$y = a + b_1 \mathrm{x} + b_2 x^2 \quad \text{Equation 4}$$

3.3. Regression analysis-panel data analysis

Generally, panel data analysis could provide more information, more variability, less collinearity among the variables, more degrees of freedom and more efficiency[57]. So, we have conducted the panel data analysis to test that if there exists common law in the coal enterprises' diversified development, including the data stationary test (unit root test), co-integration test, and panel data regressive analysis.

A panel data regression is different from a time-series regression in that it has a double subscript on its variables,i.e.[57]

$$y_{it} = a + bx_{it}^{'} + u_{it} \quad i=1,\ldots,N;\ t=1,\ldots,T \quad \text{Equation 5}$$

In this paper, *i* denoting the coal enterprises and *t* denoting time. The *i* subscript denotes the cross-section dimension whereas t denotes the time-series dimension.

Unit root tests are always employed to test the stationary for the panel data. In this paper, we carry out three common testing methods, including Levin-Lin-Chu (LLC) tests[60], Augmented Dickey–Fuller (ADF) tests[59], and Phillips–Perron (PP) tests[60].

Following the unit root tests, cointegration.test should be conducted to check whether there exists some long-run equilibrium relationship among variables. We employ the Kao Residual Cointegration Test which is proposed by Kao(1999)[61].

Then we proposed three kinds of model, which are shown as Equation 6, Equation 7, and Equation 8.

$$y_i = a_i + b_i x_i + u_i \quad \text{Equation 6}$$

$$y_i = m + bx_i + a_i^{*} + u_i \quad \text{Equation 7}$$

$$y_i = a + bx_i + u_i \quad \text{Equation 8}$$

3.4. Cases selection and data collection

According to our survey and statistics, 35 enterprises engaging in coal mining and washing are currently listed on China's stock market. Of them, 26 are primarily engaged in the coal-mining industry; we select these as the subjects of this study. These companies' main businesses are analyzed, and the numbers of the main businesses are shown in Table 1. The data on coal enterprises are collected from their annual reports, which are published on the website *http://www.sse.com.cn*.

Table 1 Summary of the number of businesses operated by large-scale coal enterprises

Enterprises	2010	2011	2012	2013	2014	Enterprises	2010	2011	2012	2013	2014
China Shenhua Energy Company (CSEC)	3	3	3	3	3	Qinghai Jinrui Mineral Development (QHJR)	2	2	1	1	1
China Coal Energy Company (CCEC)	4	3	2	2	3	Gansu Jingyuan Coal industry and Electricity Power (GSJY)	1	1	1	1	1
Shanxi Xishan Coal and Electricity Power (SXCEP)	2	3	3	3	3	Shanxi Lu'an Environmental Energy Development (SXLA)	1	1	1	2	2
Zhengzhou Coal Industry and Electricity Power (ZCE)	3	2	2	2	2	Guizhou Panjiang Refined Coal (GZPJ)	1	1	1	1	1
Kailuan Energy Chemical (KEC)	2	2	2	2	2	Shanghai Datun Energy Resource (SHDT)	3	3	3	3	2
Jizhong Energy Resources (JZEG)	2	2	1	2	2	Sundiro Holding (SDH)	2	3	2	3	3
Inner Mongolia Yitai Coal (IMYCC)	1	1	1	2	2	WINTIME Energy (WTECL)	2	2	2	2	2
Shanxi Coal International Energy (SCIE)	1	1	1	1	1	Taiyuan Coal Gasification (TCGC)	2	1	2	1	1
Henan Shenhuo Coal and Electricity (HSCE)	2	2	3	3	3	Huolinhe Open Cut Coal Industry (HLH)	1	1	1	1	2

Anyuanmeiye Coal Industry (ACIG)	4	3	2	2	2	Henyuan Coal and Electricity (HYCE)	1	1	1	1	1
Shanxi Lanhua SCI-TECHVENTURE (SLSVC)	2	2	2	2	2	Yanzhou Coal Mining (YZCM)	1	1	1	1	1
Xinjiang Baihuacun (BHC)	2	2	2	2	2	Yangquan Coal Industry (YQMY)	1	1	1	1	1
Beijing Haohua Energy Resource (BJHH)	1	1	1	1	1	Datong Coal Industry (DTCIC)	1	1	1	1	1

.

Table 1 shows that 11 enterprises, SCIE, BJHH, QHJR, GSJY, GZPJ, TCGC, HLH, HYCE, YZCM, YQMY, and DTCIC, have a single industrial structure. Moreover, although IMYCC and SXLA have already diversified their industry process, the two companies' operating incomes derived from the coal industry continue to account for approximately 90% of their total income. In other words, for the two companies, corporate financial performance essentially depends on coal prices and annual sales. The 13 companies mentioned above do not fulfill this study's requirements. In this study, we include only enterprises whose coal business revenue is less than or equal to 85% of their total main business revenue.

Additionally, the main business of BHC, SDH, and WTECL are outside of the coal industry, rendering these firms atypical coal enterprises. BHC is primarily engaged in the commercial trade and catering service sectors; SDH is primarily engaged in motorcycles, electric cars, pharmaceuticals, logistics and real estate; and WTECL is primarily engaged in oil products and real estate, although it transitioned to a coal-based business in 2009. These three enterprises are thus removed.

Therefore, we selected 10 typical diversified coal enterprises as research objects in this study after removing 13 single-industrial enterprises and three atypical coal companies, shown in Table 1. Figure 1 shows the proportion of coal business income within total income of the 10 selected coal companies. The main businesses of the 10 selected enterprises are listed in Table 2. Overall, coal companies gradually diversified, and the degree of diversification increased significantly.

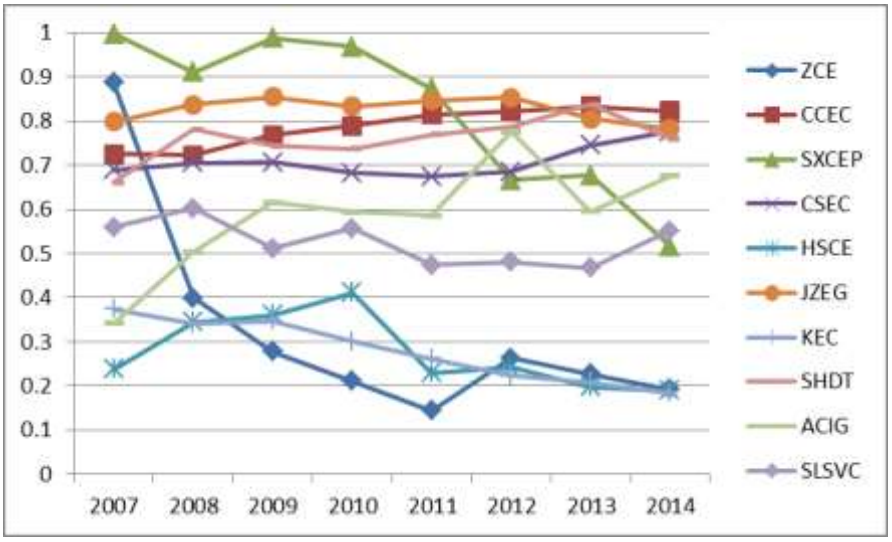

Figure 1 Coal business revenue proportion of the 10 selected coal companies

Table 2 Main business/products of the 10 selected coal companies

No.	Enterprise	Main business/product
1	CSEC	coal, transportation, electric
2	CCEC	coal, chemical, electric, equipment
3	SXCEP	coal, chemical, equipment
4	ZCE	coal, transportation, electric, real estate
5	KEC	coal, chemical, other
6	JZEG	coal, chemical, electric, building materials
7	HSCE	coal, electric, nonferrous metal, real estate, aluminum product
8	ACIG	coal, fuel, building materials, other
9	SLSVC	coal, chemical, pharmacy
10	SHDT	coal, transportation, electric, aluminum product

4. Results

4.1. Descriptive statistics of diversification and performance

Descriptive statistical analysis (e.g., frequency analysis, trend analysis) provides a statistical description of relevant data for all variables.

We calculate the entropy index and ROE of the 10 case coal enterprises. As shown in Table 3, the maximum, minimum, and mean values of CSEC, CCEC, KEC, ACIG, SLSVC and SHDT are all above 0.5, indicating that the six companies had earlier diversification development and have maintained a high level of diversification. Although the means of SXCEP, ZCE, JZEG, and HSCE are all higher than 0.5, their minimum values are much lower

than 0.5. This indicates that the diversification level of the four companies was relatively low in the early stage but developed rapidly, showing a remarkable increasing trend and a high level of diversification. ACIG has a high overall level of diversification, but following its listing in 2002, its level of diversification declined. As shown in Figure 2, the entropy index in 2014 declined in comparison with the average value. Combining the number of operating businesses and the entropy index revealed that for ACIG, the number of businesses operated decreased from 6 to 2, the entropy index decreased from 1.6 to 0.6, and the main businesses transformed from metallurgy, power, chemical, building materials, coal, oil, and transportation to coal, maintenance and repair, and supply sales, of which coal accounts for approximately 65%.

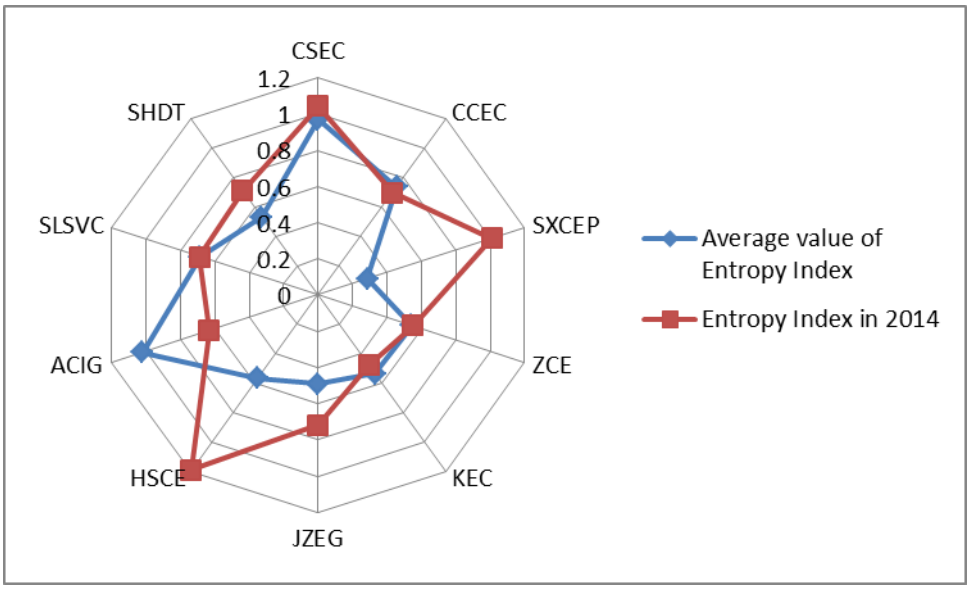

Figure 2 Comparing the average value and the 2014 value of the entropy Index

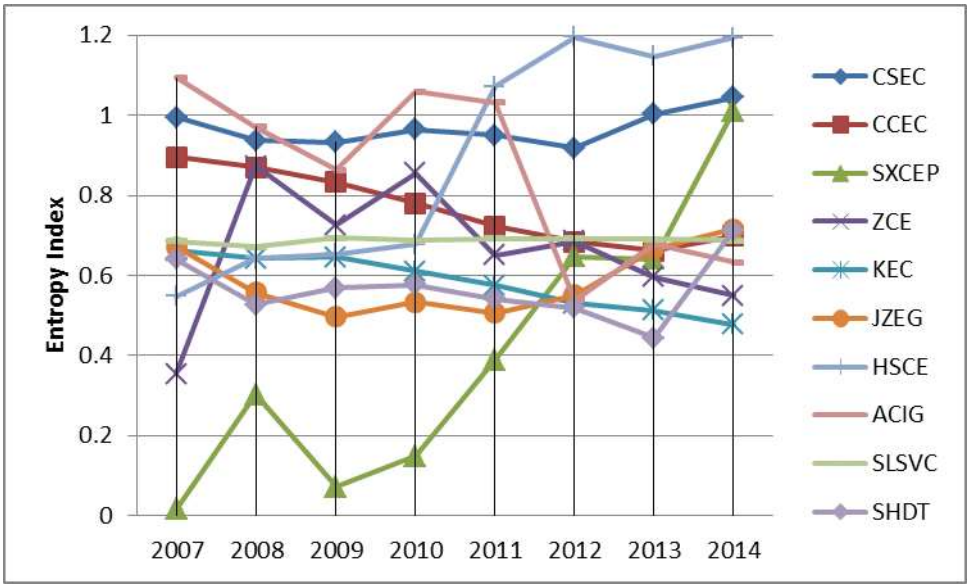

Figure 3 Entropy index of the 10 coal enterprises from 2007 to 2014

Figure 3 shows the variation trend of the 10 selected coal enterprises, revealing a general growth tendency. Generally, the diversification degree of coal enterprises is increasing over the sample period. However, the diversification degree of ZCE and KEC has declined, even if not obviously or sharply. Figure 3 also demonstrates that the diversification degree of CSEC remains at high levels. HSCE and SXCEP continue to markedly increase their diversified development.

Table 3 Statistic analysis results of the entropy index of 10 coal enterprises

Enterprise Name	Minimum	Maximum	Mean
CSEC	0.9179	1.0446	0.9681
CCEC	0.6223	0.8902	0.7391
SXCEP	0.0169	1.0109	0.2870
ZCE	0.3538	0.8735	0.5425
KEC	0	0.6611	0.5384
JZEG	0.0941	0.7168	0.4896
HSCE	0.0816	1.1957	0.5660
ACIG	0.5379	1.6702	1.0215
SLSVC	0.6359	0.7219	0.6844
SHDT	0.2383	0.9146	0.5337

As shown in Table , the operating performance of CSEC, CCEC and KEC has plummeted, with CCEC and KEC showing a large decline and CSEC remaining relatively stable. The performance of SXCEP and SLSVC exhibits an inverted U-shaped trend, and ROE first increased and then decreased; both experienced a turning point in 2008. ACIG's business performance shows a U-shaped trend, and ROE first decreased and then increased, with the turning point in 2008. ZCE, JZEG, HSCE and SHDT's business performance showed a

peak-shape change. ZCE peaked in 2005, 2007 and 2012; JZEG peaked in 2004 and 2008; HSCE peaked in 2005 and 2008; and SHDT showed multiple peaks, the highest of which appeared in 2010. Overall, the coal companies' business performance either exhibit a downward trend or first increased and then decreased.

As shown in Figure 4, the ROE of the 10 coal enterprises declined uniformly , which indicates that the performance of the coal enterprises in China has decreased in recent years, especially starting in 2012. However, the performance of CSEC has remained stable, although the ROE declined slightly starting in 2012. As the largest coal enterprise in terms of both operating income and retained profits, CSEC has remained more financially stable than others. The ROE of CSEC has exceeded the other 9 coal enterprises since 2012, when the performance of coal enterprises in China started to generally decline.

Table 4 The Statistic analysis results of ROE of 10 coal enterprises

Enterprise Name	Minimum	Maximum	Mean
CSEC	0.1305	0.2108	0.1873
CCEC	0.0088	0.1934	0.0571
SXCEP	0.0171	0.3965	0.1723
ZCE	0.0123	0.1865	0.0910
KEC	0.0184	0.1953	0.1344
JZEG	0.0014	0.3728	0.1693
HSCE	-0.0508	0.4462	0.1917
ACIG	-0.3077	0.0968	0.0168
SLSVC	0.0069	0.3251	0.1834
SHDT	0.0062	0.2963	0.1637

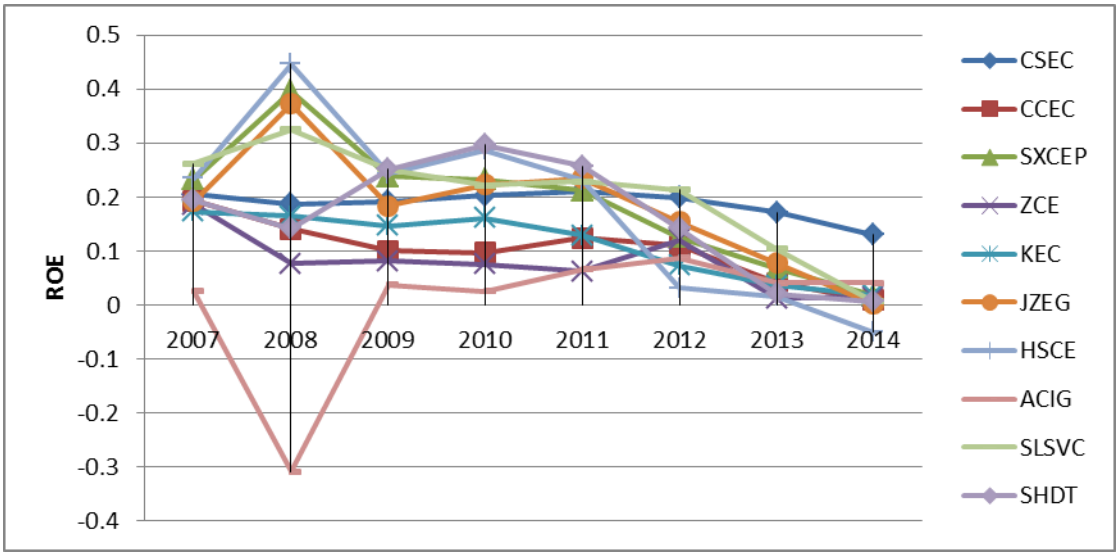

Figure 4 ROE of the 10 coal enterprises from 2007 to 2014

4.2. **Regression analysis-time series analysis**

In this study, the relationship between diversification and business performance is verified using curve estimation. The results are shown in the **Error! Reference source not found.** to Table 10.

Regression analyses determined the causal relationships among variables, and the results show the following: CCEC and SLSVC verified the hypothesis of the linear correlation; CSEC, SXCEP, ZCE, KEC, JZEG and HSCE verified the hypothesis of the curve correlation; and ACIG and SHDT did not pass the significance test. Figure 5 shows the curve fitting results of the regression analysis of the relationship between diversification and performance for each company.

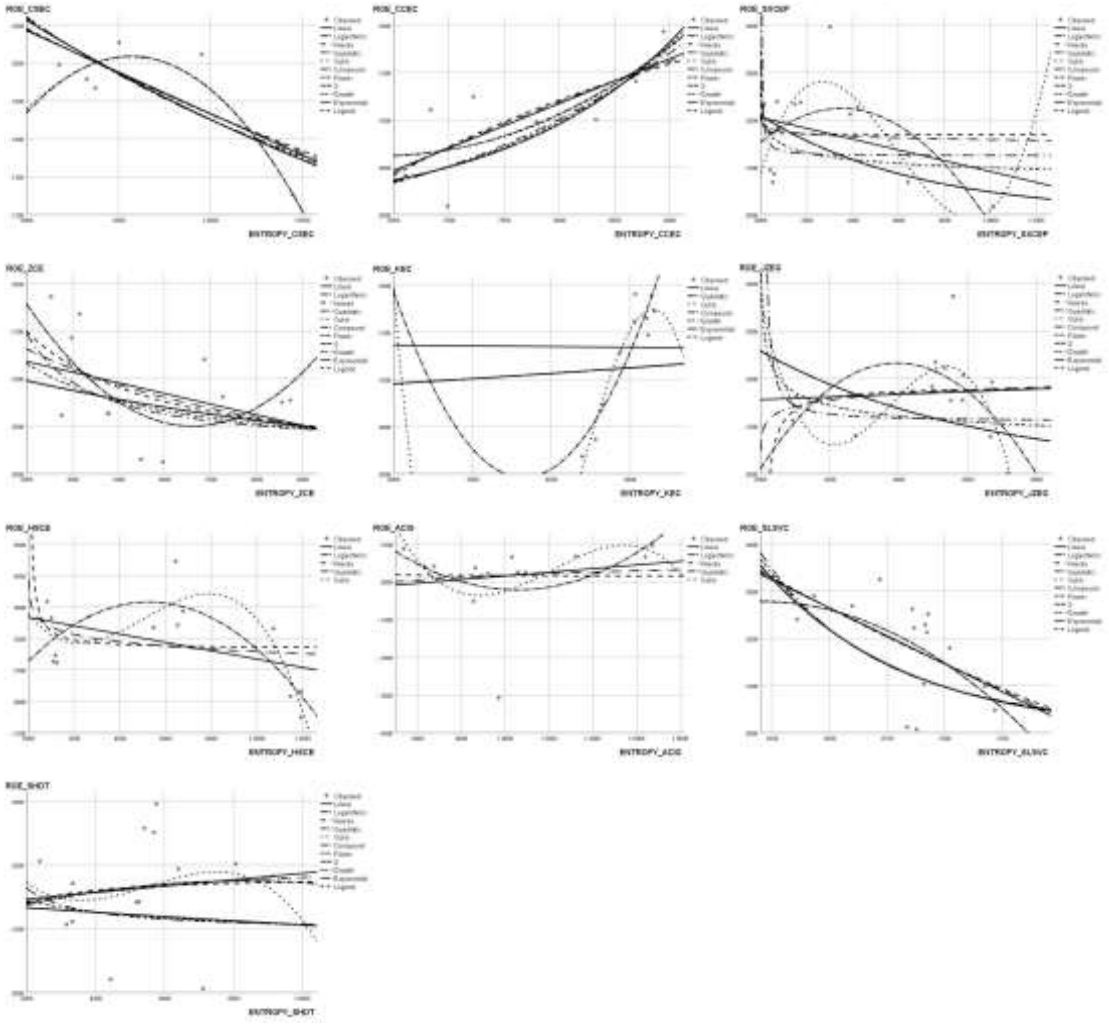

Figure 5 Regression curve fitting of the relationship between diversification and performance among 10 coal company cases.

For CSEC, the relationship between diversification and performance at CSEC was found to be a cubic curve:

$Y=-2.525+8.937X^2-6.225X^3$.

Similarly, the relationship between the diversification and performance of the other 9 companies were analyzed and predicted, and the results are shown in Table 5.

ACIG and SHDT did not pass the significance test. The regression analysis of the relationship between diversification and performance and curve fitting showed that the dots corresponding to the relationships between diversification and performance at SHDT and ACIG had a relatively high degree of discretion and did not show a clear trend; i.e., there was no correlation between diversification and performance in the cases of ACIG and SHDT.

Regression analyses results show that the 10 coal companies have not the consistent relationship between the diversification and performance. The results have confirmed some previous research. The primary reason of the multiple effects in Figure 5 is that the coal company's performance is affected by multiple factors. These factors could be macroeconomic environment, industrial policy, industrial competition, enterprise scale, manager capacity and so on. Diversified operation is a kind of operating strategy. This operating strategy could affect enterprise performance, but we have not observed a uniform relationship in the tested 10 coal companies.

Table 5 Regression equations for the diversification-performance relationship in the 10 coal enterprises

Diversification-performance	Representative enterprise	Equation
Nonlinear correlation	CSEC	$Y=-2.525+8.937X^2-6.225X^3$
	SXCEP	$Y=0.088+1.596X-3.847X^2+2.174X^3$
	ZCE	$Y=0.482-1.308X+0.99X^2$
	KEC	$Y=0.195-4.886X+14.710X^2-11.146X^3$
	JZEG	$Y=0.367-3.313X+10.852X^2-9.641X^3$（X>0）
	HSCE	$Y=0.128+0.713X-0.675X^2$
Positive linear correlation	CCEC	$Y=-0.261+0.472X$
Negative linear correlation	SLSVC	$Y=1.806-2.372X$
No correlation	ACIG, SHDT	

4.3. Regression analysis-panel data analysis

Firstly, using the unit root test to check the panel data's stationary. The results are shown in Table 6 and Table 7.

Table 6 Unit root test for Entropy Index (EI)

Series: EI_CSEC, EI_CCEC, EI_SXCEP, EI_ZCE, EI_KEC, EI_JZEG, EI_HSCE, EI_ACIG, EI_SLSVC, EI_SHDT

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-10.5377	0.0000	10	60
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-3.06397	0.0011	10	60
ADF - Fisher Chi-square	47.9579	0.0004	10	60
PP - Fisher Chi-square	54.1950	0.0001	10	60

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Table 7 Unit root test for ROE

Series: ROE_CSEC, ROE_CCEC, ROE_SXCEP, ROE_ZCE, ROE_KEC, ROE_JZEG, ROE_HSCE, ROE_ACIG, ROE_SLSVC, ROE_SHDT

Method	Statistic	Prob.**	Cross-sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-16.7614	0.0000	10	60
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-5.85316	0.0000	10	60
ADF - Fisher Chi-square	70.7345	0.0000	10	60
PP - Fisher Chi-square	89.1451	0.0000	10	60

** Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

On the basis of the observations for each test, we could conduct the further cointegration test between the EI and ROE. The Kao residual cointegration results are shown in Table 8.

Table 8 Kao Residual Cointegration Test
Null Hypothesis: No cointegration

	t-Statistic	Prob.
ADF	-4.643673	0.0000
Residual variance	0.042731	
HAC variance	0.014686	

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESID?)
Method: Panel Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESID?(-1)	-1.288656	0.113517	-11.35212	0.0000
R-squared	0.685822	Mean dependent var		0.004234
Adjusted R-squared	0.685822	S.D. dependent var		0.208585
S.E. of regression	0.116915	Akaike info criterion		-1.438215
Sum squared resid	0.806476	Schwarz criterion		-1.403309
Log likelihood	44.14646	Hannan-Quinn criter.		-1.424562
Durbin-Watson stat	2.021276			

Based on co-integration test, we find there is a co-integration relation between EI and ROE. So, we could conduct the regression analysis for the panel data of the 10 coal enterprise. The three regression analysis results are shown in Table 9, Table 10, Table 11.

Table 9 Results of varying-coefficient models

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.028034	0.015450	-1.814467	0.0756
CSEC--EICSEC	-0.133494	0.882173	-0.151325	0.8803
CCEC--EICCEC	-0.472783	1.343423	-0.351924	0.7264
SXCEP--EI1SXCEP	0.258341	0.205666	1.256119	0.2149
ZCE--EIZCE	-0.109342	0.175684	-0.622375	0.5365
KEC--EIKEC	0.293389	2.671323	0.109829	0.9130
JZEG--EIJZEG	-0.629801	0.554227	-1.136359	0.2612
HSCE--EIHSCE	-0.025394	0.296015	-0.085787	0.9320
ACIG--EIACIG	-0.051593	0.191588	-0.269291	0.7888
SLSVC--EISLSVC	-2.399766	3.946207	-0.608120	0.5459
SHDT--EISHDT	0.235359	0.343546	0.685088	0.4965
Fixed Effects (Cross)				
CSEC--C	0.018376			
CCEC--C	-0.011542			
SXCEP--C	-0.039451			
ZCE--C	0.006616			
KEC--C	0.013675			
JZEG--C	0.004872			
HSCE--C	-0.010424			
ACIG--C	0.026932			
SLSVC--C	-0.007821			
SHDT--C	-0.001234			

Table 10 Results of fixed effects models

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.024381	0.012136	-2.008962	0.0491
EI	0.002461	0.092142	0.026709	0.9788
Fixed Effects (Cross)				
CSEC--C	0.013764			
CCEC--C	-0.001922			

SXCEP--C	-0.006769
ZCE--C	-0.000159
KEC--C	0.002417
JZEG--C	-0.002935
HSCE--C	-0.016646
ACIG--C	0.026843
SLSVC--C	-0.012091
SHDT--C	-0.002501

Table 11 Results of fixed effects models

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.024035	0.011376	-2.112694	0.0383
EI	-0.018340	0.079231	-0.231470	0.8176

The three kinds of regression analysis were performed and show that the estimated models are not good except at 5% significance level. From the analysis results of the overall panel data, we conclude that coal enterprises' diversification has not definite effects on the performance.

Compared with regression analysis results, the panel data analysis could provide more information from the limited data. In addition, we could use this analytical method to exam whether there exists a clear and explicit relationship between the coal enterprises' diversification and performance. According to the data analysis results, the degree of consistency was not satisfactory. Combining the analysis results of time-series data, we conclude that the relationship of diversification and performance varies from coal enterprise to enterprise. The panel data analysis could not cover up and conceal the relationship's difference among the coal enterprises.

The mixed relations between performance and diversification could provide inspirations for the coal enterprises, especially those traditional coal enterprises who are seeking large-scale expansion to non-coal business. On the one hand, only from the data analysis, the regression analysis results do not support that the active diversified operation could lead to performance improvement. On the other hand, considering China's coal enterprises' business practices, the business performance could be influenced by multiple factors, not only the diversified operation.

Actually, in this paper, we are not going to pursue a consistent and definitive conclusion about the relationship between the coal enterprises' diversification and performance. According to the results of the analyses, multiple relationships would remind the managers that blind expansion and excessive merger and reorganization will not always improve the performance.

5. **Discussion**

The above analyses of the relationship between coal companies' diversification and performance leads to the following discussion.

5.1. The relationship between diversification and performance is nonlinear

Based on the degree of business diversification, companies' diversification development can be divided into three stages: the initial stage, the growth stage, and the mature stage.

In the initial stage, the implementation of a diversification strategy decreases the enterprise's performance. Although enterprises are trying to achieve diversification at this stage, the level of diversification development is relatively low. Because of trade barriers, industrial expansion requires an increase in agency costs, and enterprises incur high transaction costs before forming good collaboration among different industries. Therefore, at this stage, the benefits of diversification are far less than the costs.

In the growth stage, diversification starts to improve corporate performance. Enterprises develop from a low degree of diversification into a higher degree of diversification and form stronger advantages in aspects such as lowering administrative costs and internal transaction costs through industry coordination. The benefits begin to outweigh the costs.

In the mature stage, diversification reduces business performance. When the pursuit of diversification becomes excessive, enterprises indulge in overinvestment using previously accumulated funds. With this expansion in the scale of diversification, the span of enterprise management drastically increases. This increases management costs and internal transaction costs, which ultimately leads to lower benefits than costs.

Additional potential reasons for the nonlinear relationship between diversification and performance include the following:

If an enterprise chooses related diversified industries, both learning and transaction costs can be reduced because of the presence of synergies in technology, markets or resources, whereas if the enterprise chooses unrelated diversified industries, the costs of diversification might be more than its benefits because of differences in technology, resources and profit levels. Therefore, at the initial stage of diversification, input costs are often relatively high, leading to decreased business performance with an increasing diversification level. However, with continuous investment, non-related industries gradually develop, mature and gain market recognition, which might improve business performance.

5.2. Diversification and enterprise performance have a positive linear correlation

Through the diversification and cooperation of multiple industries, coal enterprises can improve their performance. When different industries are closely linked and coordinate in various aspects, such as capital, resources, management, and marketing, the utilization efficiency of companies' existing resources and capacities can improve. Internal

transactions can also be performed among industries, including the coal industry, the coal-chemical industry, the electric power industry and the coal equipment industry, thus greatly reducing transaction costs related to both trading and transport.

In addition, companies engaged in diversification development can choose an industry in which products are sold at lower prices, thereby earning a competitive edge and obtaining long-term profits. The loss at the early stage of diversification can be subsidized by the profits reaped by other industries with better efficiency. Over time, a market monopoly can be achieved, and the corresponding markets can be dominated.

5.3. Diversification and enterprise performance have a negative linear correlation

When an enterprise enters the markets of related or unrelated industries through diversification from specialization, it will encounter a variety of uncertainties, thereby facing high risk.

If the enterprise overinvests, it is highly possible that it will invest in a project or sector with very low or even negative returns on investment, leading to insolvency in that project or sector. To survive and develop, an enterprise must use profits from other sectors to subsidize the loss, which reduces the enterprise's overall performance.

In the case of excessive diversification, the extending roles resulting from the main business' core competencies and the coordinating effect in aspects such as resources, information and management decrease, leading to decreased business performance. Diversification may excessively disperse corporate resources and therefore lower those resources' value-creation rate, whereas information asymmetry or agency costs lead to low efficiency of resource allocation within the enterprise, generating X-inefficiency. Therefore, with an increasing diversification level, the enterprise's business performance will decline.

5.4. Diversification and enterprise performance are unrelated

In the diversification process, it is inevitable that enterprises will experience performance change. However, factors that affect performance include not only the degree of diversification but also external and internal factors.

For coal enterprises, external environment factors include the following. Policy influences: The development of coal enterprises has been affected by national macroeconomic regulation and control. For example, the *Action Plans for Energy Development Strategy (2014–2020)* [16] proposed strategies of prioritizing conservation and low-carbon use to control total coal consumption and gradually reduce the proportion of coal consumption. Market factors: since 2012, affected by, for example, overcapacity, coal imports,

environmental protection pressures, and weak downstream demand, the coal industry's business performance has fluctuated.

Internal factors include the following. Enterprise scale: the impact of enterprise scale on performance is two-sided. On one hand, as an enterprise expands its scale, it obtains more resources, which can generate economies of scale and economies of scope. On the other, the cost of enterprise management also increases. Asset-liability ratio: an excessively high asset-liability ratio forces an enterprise to repay its outstanding debt with a large amount of capital, which leads to decreased financing capacity in its internal capital market. Asset liquidity: the higher the asset liquidity, the higher the enterprise's debt capacity, and the more business opportunities for reinvestment enjoyed by the enterprise. Management level: the more complete the company's internal management system, the clearer the corporate strategy and the more reasonable the governance structure in the enterprise. The level of management thus increases, which is more conducive to improving performance. R&D capability: an enterprise's independent R&D capability can improve the competitiveness of its products.

6. **Conclusion and policy implications**

This study investigated the relationship between diversification and enterprise performance in China's major coal companies. We collected the business data of China's coal enterprises from their annual reports. After screening for the number of main business sectors, the main business and the proportion of coal business, we chose 10 representative companies: CSEC, CCEC, SXCEP, ZCE, KEC, JZEG, HSCE, ACIG, SLSVC, and SHDT. The entropy index was selected as the independent variable to measure corporate diversification, and ROE was used as the dependent variable to measure corporate performance. The operating data for the 10 companies since their listing were analyzed to examine the relationship between diversification and performance.

1) Generally, the degree of diversification in coal enterprises has increased in the past 8 years. At CSEC, it has remained at high levels, and at HSCE and SXCEP, it has continued to markedly increase.
2) The performance of the coal enterprises in China has declined in recent years. However, the performance of CSEC has remained and at a high level. Combining the regression analysis results of the entropy index and ROE of CSEC, we observe that diversification has improved the performance of CSEC.
3) The relationship between diversification and performance varies across coal enterprises, according to the regression analysis results. For CSEC, SXCEP, ZCE, KEC, JZEG, and HSCE, diversification and performance have a nonlinear relationship; for CCEC, diversification and performance have a positive linear correlation; for SLSVC, diversification and performance have a negative linear correlation; and for ACIG and SHDT, diversification and performance are unrelated.

For the decision makers both from coal enterprises and competent authorities, we have some suggestions.

1) For the traditional coal enterprises, their business performance mainly affected by the coal market price. If they have sufficient capital to expand its business, they should consider at least these factors, including the new business's market circumstances, external policy environment, upfront cost of stepping into the new business, industrial properties barriers. We want to stress that the traditional coal enterprises should carefully expand their business in the coal market fluctuation period. A large amount of capital money poured in the unfamiliar business could bring a potential danger.
2) For those non-coal enterprises who are going to set foot in the coal industry, should be more cautious. As we know, the so called "Golden Decade of Coal" in China has gone. Affected by the energy and environmental policy in China, more "clean coal" are encouraged. That means, those extensive operation and production in the coal industry is restricted or forbidden. Clean production of coal has high technical requirements. It is bound to increase operating costs. In addition, for non-coal enterprises, to master the clean coal production technology still need more economic input and more time.
3) For competent authorities from government, when leading the merger and reorganization of coal enterprise and non-coal enterprise, should be aware the fact that the business diversification not always improve the performance. Diversified development is not the "panacea" for the coal enterprises' business decline. Enterprise performance is determined by integrated internal and external factors beyond diversification, including not only the status of diversification but also the companies' internal and external environments, including the market environment, the industry environment, and policy.
4) For coal enterprises strategic management researchers, we would suggest that more coal enterprises could be selected as the case study to exam the relationship between diversification and performance, on the premise of business data available. Besides, more multiform and fitting econometric model could be employed in this relation test research.

7. Limitations and future research

(1) The major limitation of this study is the limited availability of coal enterprises' business data. The authors had access to the business data only through the published annual reports of each listed company. It is therefore recommended that additional data be gathered in the future to analyze the internal coordination relationships among different industries.

(2) More importantly, industry coordination or synergy could act as intervening variables or control variables in correlation and regression analyses.

(3) Another limitation is that the model used ROE as the dependent variable to value enterprise performance. However, if more accurate and detailed business data can be gathered, a comprehensive performance appraisal should be conducted. A comprehensive performance appraisal in the context of diversification would be an interesting research direction.

(4) Additionally, the authors researched all listed coal enterprises in China. Although these listed enterprises have gained a main market share in China's coal market, more coal enterprises should be investigated in the future.

(5) Also, if more data is available, the time-lag between the diversification and performance of coal enterprises should be tested.

Above, the principal factors for the future research is more detailed data and precise information of the China's coal enterprises. We would suggest that the further research of the relationship between the diversification and enterprise performance could be started with the followings:

(1) More coal enterprises selected as research samples would supplement or amend the correlation analysis and regression analysis results.
(2) Adding intervening variables or control variables could make the influence mechanism of this relationship clearer. One of the important variables is industry coordination.
(3) Further research on moderating variables, such as CEO personality, industry policy, and enterprise scale, could improve the reliability of the correlation analysis results.
(4) In addition, selecting some typical diversified enterprises as tracking study case could provide more detailed information of the relationship between the diversification and enterprise performance. This is one of the most valued research directions.

Acknowledgments

References

[1] Project Group of China's Medium-to-Long-Term Energy Development Strategy Research. Research on China's Medium-to-Long-Term Energy Development Strategy (2030、2050) ,Energy Saving and Coal Volume. Beijing: Science Press; 2011.

[2] Tang X, Snowden S, McLellan BC, Hook M. Clean coal use in China: Challenges and policy implications. Energy Policy 2015;87:517–23. doi:10.1016/j.enpol.2015.09.041.

[3] Wang J, Feng L, Tverberg GE. An analysis of China's coal supply and its impact on China's future economic growth. Energy Policy 2013;57:542–51. doi:10.1016/j.enpol.2013.02.034.

[4] Li C, Nie R, Wang D. Scientific mining in China - problems, progress, and prospects. Electron J Geotech Eng 2015;20:6491–506.

[5] Chen ZM. Inflationary effect of coal price change on the Chinese economy. Appl Energy 2014;114:301–9. doi:10.1016/j.apenergy.2013.09.068.

[6] Song M, Wang J. Coal price fluctuations in China: Economic effects and policy implications. J Renew Sustain Energy 2016;8. doi:10.1063/1.4966694.

[7] Tang X, Jin Y, McLellan BC, Wang J, Li S. China's coal consumption declining—Impermanent or permanent? Resour Conserv Recycl n.d. doi:http://dx.doi.org/10.1016/j.resconrec.2016.07.018.

[8] Li C-M, Nie R. An evaluating system for scientific mining of China's coal resources. Resour Policy 2017;53:317–27. doi:https://doi.org/10.1016/j.resourpol.2017.07.012.

[9] Li C. The price of coal fell by 60% in recent four years and the gross profit of China's coal industries in 2015 is the equivalent of 10% of the 2011. Sina Financ 2016. http://finance.sina.com.cn/roll/2016-04-26/doc-ifxrpvcy4465733.shtml.

[10] Lv C, Xu J, Xie H, Zeng Z, Wu Y. Equilibrium strategy based coal blending method for combined carbon and PM10 emissions reductions. Appl Energy 2016;183:1035–52. doi:10.1016/j.apenergy.2016.09.028.

[11] Yu S, Wei YM, Guo H, Ding L. Carbon emission coefficient measurement of the coal-to-power energy chain in China. Appl Energy 2014;114:290–300. doi:10.1016/j.apenergy.2013.09.062.

[12] Smrekar J, Potočnik P, Senegačnik A. Multi-step-ahead prediction of NOx emissions for a coal-based boiler. Appl Energy 2013;106:89–99. doi:10.1016/j.apenergy.2012.10.056.

[13] Pudasainee D, Seo Y-C, Sung J-H, Jang H-N, Gupta R. Mercury Co-beneficial Capture in Air Pollution Control Devices of Coal-fired Power Plants. Int J Coal Geol 2016;170:6–11. doi:10.1016/j.coal.2016.08.013.

[14] Shan Y, Liu J, Liu Z, Xu X, Shao S, Wang P, et al. New provincial CO 2 emission inventories in China based on apparent energy consumption data and updated emission factors. Appl Energy 2016;184:742–50.

[15] Pan K-X, Zhu H-X, Chang Z, Wu K-H, Shan Y-L, Liu Z-X. Estimation of coal-related CO2 emissions: the case of China. Energy Environ 2013;24:1309–21.

[16] General Office of the State Council of China. Action plans for energy development strategy (2014–2020) (in Chinese) 2014. http://www.gov.cn/zhengce/content/2014-11/19/content_9222.htm (accessed December 20, 2016).

[17] National Bureau of Statistic of China. Statistical Communiqué of the People's Republic of China on the 2014 National Economic and Social Development 2015. http://www.stats.gov.cn/english/PressRelease/201502/t20150228_687439.html (accessed February 20, 2016).

[18] Li C-M, Cui T, Nie R, Shan Y, Wang J, Qian X. A Decision Model to Predict the Optimal Size of the Diversified Management Industry from the View of Profit Maximization and Coordination of Industrial Scale. Sustainability 2017;9.

[19] Cui T, Nie R, Li C-M. The Relationship between Diversification, Industry Synergy and Performance of Coal Enterprises. China Coal 2016;42:25–9.

[20] Li C, Cui T, Nie R, Yan X, Qian X. Establishment of the Industry Synergy Mode for Large Coal Enterprises. Electron J Geotech Eng 2016;21:4025–37.

[21] Li C, Cui T, Nie R, Yan X. Measurement of the Industrial Collaboration of the Diversified Coal Industry : China Coal Energy Company as an Example. Math Probl Eng 2017;2017.

[22] Ansoff, H.I.: Corporate Strategy: An Analytic Approach to Business Policy for Growth and Expansion. McGraw-Hill, New York (1965)

[23] Patrisia, D., & Dastgir, S. (2017). Diversification and corporate social performance in manufacturing companies. Eurasian Business Review, 7(1), 121-139.)

[24] Chang, W. C. , Lin, H. Y. , & Koo, M. . (2017). The effect of diversification on auditor selection in business groups: a case from taiwan. International Review of Economics & Finance, 49.

[25] Pan RJ.Empirical study on diversification of China's listed companies. Shanghai University of Finance and Economics Press,Shanghai(2009).

[26] Martin JD, Sayrak A. Corporate diversification and shareholder value: a survey of recent literature. J Corp Financ 2003;9:37–57.

[27] Villalonga B. An empirical analysis of diversification motives. Unpubl Manuscript, Univ California, Los Angeles 2000.

[28] Villalonga B. Diversification discount or premium? New evidence from the business information tracking series. J Finance 2004;59:479–506.

[29] Ansoff HI. Strategies for diversification. Harv Bus Rev 1957;35:113–24.

[30] Lee W, Lee NS. Understanding Samsung's Diversification Strategy: The Case of Samsung Motors Inc. Long Range Plann 2007;40:488–504. doi:10.1016/j.lrp.2007.06.011.

[31] Zhou YM. Synergy, coordination costs, and diversification choices. Strateg Manag J 2011;32:624–39. doi:10.1002/smj.889.

[32] Palich LE, Cardinal LB, Miller CC. Curvilinearity in the diversification–performance linkage: an examination of over three decades of research. Strateg Manag J 2000;21:155–74.

[33] Lang LHP, Stulz RM. Tobin's q, corporate diversification, and firm performance. J Polit Econ 1994;102:1248–80.

[34] Berger AN, Hasan I, Zhou M. The effects of focus versus diversification on bank performance: Evidence from Chinese banks. J Bank Financ 2010;34:1417–35.

[35] Servaes H. The value of diversification during the conglomerate merger wave. J Finance 1996;51:1201–25.

[36] Lamont OA, Polk C. Does diversification destroy value? Evidence from the industry shocks. J Financ Econ 2002;63:51–77.

[37] Hoyt RE, Trieschmann JS. Risk/return relationships for life-health, property-liability, and diversified insurers. J Risk Insur 1991:322–30.

[38] Lin X. Studies on motivation and performance of diversification of China's listed companies. Xiamen University, 2008.

[39] Landskroner Y, Ruthenberg D, Zaken D. Diversification and performance in banking: The Israeli case. J Financ Serv Res 2005;27:27–49.

[40] Zhang L. The Relationship among Corporate Governance, Diversification Strategy and Financial Performance: Empirical Study on the Companies Listed on GEM. Jilin University, 2013.

[41] Kang KH, Lee S. The moderating role of brand diversification on the relationship between geographic diversification and firm performance in the US lodging industry. Int J Hosp Manag 2014;38:106–17. doi:http://dx.doi.org/10.1016/j.ijhm.2013.01.001.

[42] Yang Y, Cao Y, Yang LT (Grace). Product diversification and property performance in the urban lodging market: The relationship and its moderators. Tour Manag 2017;59:363–75. doi:10.1016/j.tourman.2016.08.018.

[43] Graham JR, Lemmon ML, Wolf JG. Does corporate diversification destroy value? J Finance 2002;57:695–720.

[44] Campa JM, Kedia S. Explaining the diversification discount. J Finance 2002;57:1731–62.

[45] Liu M, Zhang X, Zhang C. Correlation study on business diversification, operating performance and risk in China's commercial banks. Stud Int Financ 2012:59–69.

[46] Dervaric E, Medved M, Malenkovic V. Strategic factors and a model of enterprise restructuring in the coal industry in Europe with emphasis on experiences in a Slovenia-Valenje coal mine case. J SOUTH AFRICAN Inst Min Metall 2008;108:627–40.

[47] Nawrocki TL, Jonek-Kowalska I. Assessing operational risk in coal mining enterprises ??? Internal, industrial and international perspectives. Resour Policy 2016;48:50–67. doi:10.1016/j.resourpol.2016.02.008.

[48] Hu X. From Coal Mining to Coal Chemicals? Unpacking New Path Creation in an Old Industrial Region of Transitional China. Growth Change 2017;0. doi:10.1111/grow.12190.

[49] Safarzynska K. The Implications of Industrial Development for Diversification of Fuels. Ecol Econ 2017;137:37–46. doi:10.1016/j.ecolecon.2017.03.005.

[50] Wierzbowski M, Filipiak I, Lyzwa W. Polish energy policy 2050 – An instrument to develop a diversified and sustainable electricity generation mix in coal-based energy system. Renew Sustain Energy Rev 2017;74:51–70. doi:10.1016/j.rser.2017.02.046.

[51] Kileber S, Parente V. Diversifying the Brazilian electricity mix: Income level, the endowment effect, and governance capacity. Renew Sustain Energy Rev 2015;49:1180–9. doi:10.1016/j.rser.2015.04.109.

[52] Heiskanen E, Jalas M, Juntunen JK, Nissilä H. Small streams, diverse sources: Who invests in renewable energy in Finland during the financial downturn? Energy Policy 2017;106:191–200. doi:10.1016/j.enpol.2017.03.013.

[53] Jacquemin AP, Berry CH. Entropy measure of diversification and corporate growth. J Ind Econ 1979:359–69.

[54] Palepu K. Diversification strategy, profit performance and the entropy measure. Strateg Manag J 1985;6:239–55.

[55] Cainelli G, Iacobucci D. Local variety and firm diversification: an evolutionary economic geography perspective. J Econ Geogr 2016;16:1079–100.

[56] Lu JW, Beamish PW. International diversification and firm performance: The S-curve hypothesis. Acad Manag J 2004;47:598–609.

[57] Baltagi B. Econometric analysis of panel data. John Wiley & Sons; 2008.

[58] Levin A, Lin C-F, Chu C-SJ. Unit root tests in panel data: asymptotic and finite-sample properties. J Econom 2002;108:1–24.

[59] Dickey DA, Fuller WA. Likelihood ratio statistics for autoregressive time series with a unit root. Econom J Econom Soc 1981:1057–72.

[60] Phillips PCB, Perron P. Testing for a unit root in time series regression. Biometrika 1988;75:335–46.

[61] Kao C. Spurious regression and residual-based tests for cointegration in panel data. J Econom 1999;90:1–44.