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Energy Abundance and China's Economic Growth: 2000–2014

SUN Dongqi[1], LU Dadao[1], LI Yu[1], ZHOU Liang[2], ZHANG Mingdou[3]

(1. *Key Laboratory of Regional Sustainable Development Modeling*, *Institute of Geographic Sciences and Natural Resources Research*, *Chinese Academy of Sciences*, *Beijing* 100101, *China*; 2. *Faculty of Geomatics*, *Lanzhou Jiaotong University*, *Lanzhou* 730070, *China*; 3. *School of Public Administration*, *Dongbei University of Finance and Economics*, *Dalian* 116025, *China*)

Abstract: Based on the interprovincial panel data of 2000–2014, this paper carries out an empirical analysis on the relationship between energy abundance and economic growth to test the theoretical hypothesis of 'resource curse' and explore its transmission mechanism for China and its three regions. The results show that, at the national level, positive correlation is present between energy abundance and economic growth, proving that the 'resource curse' phenomenon does not exist in China as a whole. Moreover, material capital input, human capital input and the level of opening to the outside world could promote economic growth, while technology innovation input may hinder economic growth. As seen by region, a positive correlation also exists between the energy abundance and economic growth in the eastern and western regions, and there is no 'resource curse' phenomenon either. In all three regions, the human capital input could promote economic growth. Material capital input could promote economic growth in the eastern but hinder economic growth in the western region; the level of opening to the outside world could promote economic growth in the eastern region. It is known through further survey and analysis on the transmission mechanism of resource curse that, at the national level, material capital input, human capital input, and the level of opening to the outside world present positive correlation with energy abundance, indicating that energy development becomes an important transmission factor by strengthening material capital input and human capital input and raising the level of opening to the outside world. However, technology innovation input presents negative correlation with energy development. As seen by region, both the material capital input and human capital input present positive correlation with energy development strength in the three regions. Similar as the eastern region, the level of opening to the outside world presents positive correlation with energy industry development in the middle and western regions; however, the energy development presents negative correlation with technology input level in the western region.

Keywords: energy abundance; resource curse; economic growth; transmission mechanism; China

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1 Introduction

The relationship between natural resources and economic growth has always been an important research topic in the field of economics. Researchers, however, still can not reach a consensus on this relationship, and no inexorable law has been observed (Wright, 1990). Early economists held an affirmative attitude towards the positive role of natural resources in economic growth. Good natural resource endowments, especially abundant mineral resources, were considered as the foundation of initial industrialization and the engine of economic growth (Wright and Czelusta, 2004). However, since the 1960s this viewpoint has been gradually overturned by the fact that most of the countries with resource-led development (such as some countries in South America) have witnessed a general decline in economic growth, while many resource-scarce countries

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Corresponding author: ZHANG Mingdou. E-mail: zhangmingdou0537@126.com

(e.g., Japan, Singapore, and Korea) have experienced remarkable economic growth. In 1993, the concept of the 'resource curse' was first put forward by (Auty and Warhurst, 1993; Auty, 2002): abundant natural resources could be harmful rather than beneficial to economic growth in some countries. Since then, several scholars have conducted empirical research into this phenomenon. Sachs and Warner (1997; 2001) carried out a pioneering empirical test of the resource curse hypothesis. In addition, Papyrakis and Gerlagh (2007), Gylfason (2001), Gylfason and Zoega (2006), and others obtained highly consistent results (Huang *et al*., 2014).

Since the launch of reforms and opening-up in 1978, China has made tremendous achievements in economic development, attracting worldwide attention (Sun *et al*., 2013). The annual average growth rate of GDP between 1978 and 2013 was 9.2%, however, with relatively large regional differences. The economic growth rate in the eastern region was far higher than the growth rates in the central and western regions. Between 1978 and 2014, the annual average GDP growth rate in the eastern region was 9.5%, while the rates in the central and western regions were 8.2% and 7.8% respectively (According to the classification standard of China National Bureau of statistics, the eastern region includes Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; the central region includes Heilongjiang, Jilin, Shanxi, Anhui, Jiangxi, Henan, Hubei, and Hunan; and the western region includes Sichuan, Chongqing, Guizhou Yunnan, Tibet, Shaanxi, Inner Mongolia, Guangxi, Gansu, Qinghai, Ningxia, and Xinjiang). Yet it should be pointed out, that China's natural resources, especially the principal energy resources such as coal, petroleum, and natural gas, were concentrated mainly in the provinces of the central region and western regions. According to Chinese Government statistics for 2013, the proven coal reserves in China were 2.36×10^{11} t, 92.8% of which were distributed in central and western China. China's proven land-accessible oil reserves were 2.87×10^9 t, 70.9% of which were distributed in central and western China. The proven land-accessible natural gas reserves were 4.31×10^{12} m^3, 97.3% of which were distributed in central and western China (Wu and Lei, 2016).

Based on this knowledge, it is important to know whether the slow economic growth in the western China could be attributed to constraint in the presence of resource abundance. In other word, is there resource doom in the western China? In general, the impacts of natural resources on economic growth have attracted much attention, while few have systematically analyzed the relationship between energy resource and economic growth. Gong and Zhao (2012) believed that rapid development of heavy chemical industry in China since 2000. Therefore, the research period of this paper is from 2000 to 2014. We use a panel data regression model and a transmission mechanism model to verify the relationship between energy resources and economic growth in China and propose corresponding policy suggestions. In the current study, we made our contribution in two points. First, we focus on the impact of specific energy resource on economic growth. Second, we focus on the relationship between energy development and economic growth at the regional level.

2 Literature Review

2.1 Review of resource curse

In the 1950s, the Netherlands discovered plentiful deposits of petroleum and natural gas. As a result, the government strove to develop industries based on these resources and achieved a sharp increase in exports, a favorable balance of international revenue and expenditure, and a flourishing economy. However, the booming natural gas industry severely impacted agricultural and other industrial sectors in the Netherlands and weakened the international competitiveness of export industries. At the beginning of the 1980s, the country was plagued by raised inflation, a drop in exports of finished products, a lowering of income growth rate, and an increase in the unemployment rate, which collectively were referred to internationally as 'Dutch Disease' (Kamas, 1986). The Dutch Disease model first constructed by Matsuyama (1992) evolved for the purpose of analyzing the functions of natural resources in economic growth. Auty (1990) observed resource-oriented countries from a relatively early stage and proposed an important question: are resource abundance and resource-oriented industries a blessing or a curse for economic development? Auty and Warhurst (1993) proposed the concept of resource curse based on this, that is to say, abundant natural resources are not a sufficient beneficial condition, but rather a kind of restriction, for the economic growth of some countries. Sachs and Warner (1997; 2001), on the basis of the Matsuyama model, constructed an analysis framework to explain the Dutch Disease phenomenon. They carried out seminal empirical tests on the resource curse hypothesis and published several highly cited papers on this issue. They took 95 developing countries as the samples, used the proportion of primary product exports to GDP to reflect their resource endowment level, and collected data for the period 1970–1989 to conduct a regression analysis. The results showed that significant negative correlation existed between resource endowment and economic growth, and even if more explanatory variables were included in the regression equation, such as institutional arrangement, regional effects, price fluctuation, geography, climate, and others, a negative correlation still existed. Following the pioneering research of Auty (2002), Sachs and Warner (1997; 2001), empirical studies of the resource curse have continued, and the conclusions can generally be classified into three types: 1) the theory of the existence of the resource curse; 2) the theory of the non-existence of the resource curse; and 3) the theory of the conditional existence of the resource curse (Wu and Lei, 2016).

Among the papers supporting the theory of the resource curse, Gylfason (2001) analyzed the correlation between the natural capital and growth performance of 22 countries and proved the existence of the resource curse effect. Torvik (2002) applied the rent-seeking model to proving a negative monotonic relationship between natural resources and economic growth. Atkinson and Hamilton (2003) utilized the proportion of resource rents to GDP as an index to evaluate the relationship between resource abundance and economic growth, discovering that negative correlation existed between this index and the growth rate of per capita GDP. Papyrakis and Gerlagh (2007) discovered that natural resources have more indirect negative effects than direct promotion effects on economic growth, which justify the existence of resource curse phenomenon. Gylfason and Zoega (2006) also discovered through empirical research an inverse relationship between resource dependence ratio and economic development efficiency.

However, some studies have denied the existence of the resource curse (Davis and Tilton, 2005). Ding and Barry (2005) first distinguished the two concepts 'resource dependence' and 'resource endowment', and pointed out that the categorical index was actually a measure of the degree of resource dependence and reflected the degree of dependence of an economic entity or region on resource-related industries, instead of the true resource abundance index. Later, they applied the sum of the value of each country's resources, as estimated by the World Bank, to obtain the resource abundance index. Their research findings showed that economic growth had a significant negative correlation with resource dependence and had a significant positive correlation with resource abundance. Brunnschweiler and Bulte (2008) used the estimated value of natural capital as a resource abundance index and, after controlling the institutional variables, discovered that resources, especially mineral resources, had a positive correlation with economic growth.

Concerning the theory of the existence of the resource curse, researchers holding this view have emphasized that the phenomenon can not generally be considered to exist or not, but should be researched more precisely and thoroughly. They have commonly considered that the resource curse phenomenon exists, but not unconditionally, only that some natural resources or some types of natural resources are subject to such phenomenon (Humphreys, 2005; Hodler, 2006; Wick and Bulte, 2006). For example, Stijns (2005) carried out a study on large samples of data, and came to the conclusion that an abundance of land resources, petroleum, and natural gas had negative correlations with economic growth, and coal had undetermined relationship, while mineral reserves had a positive correlation with economic growth.

2.2 Causes of resource curse and its transmission mechanism

Since the second half of the twentieth century, the resource curse phenomenon has become widespread in the world, and research into it has also gradually moved from the debate of existence to the discussion of its causes and transmission mechanism. The following seven viewpoints cover the range of discussion of the resource curse:

(1) Resources are primary products, which require less specialization compared with manufacturing and relatively weak linkage with upstream and downstream industries. Thus it is difficult to produce a strong driving

force for national economy if a country's economic resources over concentrated in primary sectors (Hirschman, 1958; Seers, 1964). Botta (2010) thought that over-development of natural resources industries can not drive other relevant industries effectively, and might even induce 'deindustrialization'.

(2) Over-concentration of economic resources in primary sectors will produce a crowdingout effect, competing with other industries, education, and public service resources, while the latter is the key factor supporting national (regional) competitiveness (Matsuyama, 1992).

(3) The Dutch Disease effect exists. Resource industries with relatively large profits will only increase a country's income levels but also costs of production, push a rise in the exchange rate and a drop in exports, deteriorating trading conditions, and hinder a country's development (Gylfason, 2001).

(4) The theory of trading conditions deterioration exists. In the long run, the price of primary products gradually drops compared with industrial goods, leading to the decline in value added resource rich regions, forming the core and peripheral structure of the regional economy (Sarkar and Singer, 1991).

(5) Natural resources feature low price elasticity and low supply elasticity. Price fluctuations bring high instability to the overall economy, and in turn, sudden rises or falls in resource prices will also induce drastic fluctuations in interest rates and exchange rates, increase the risks borne by investors, and diminished the social investments necessary for economic growth (Auty, 2002).

(6) The investment and consumption structures are distorted. For example, by studying countries with large petroleum outputs, Bacon (2001) discovered that in order to change the pattern of the resource curse, it is necessary to change the profit distribution pattern, specifically applying the profit obtained from natural resources to investment instead of consumption.

(7) The phenomenon of system weakening exists. Some scholars consider that the irrationality of the property rights system and the imperfect nature of laws lead to resource industries being controlled by a handful of people, produce a relatively large rent-seeking space (Lane and Tornell, 1996), and even arouse political turbulence and war (Angrist and Kugler, 2008).

Based on the above review of the resource curse, we consider that: 1) most studies have focused mainly on the relationship between natural resources in general and economic growth. There are few studies on energy resources in particular. However, there are abundant energy resources in the eastern, central region, and western regions of China, which demonstrates the necessity of such study. 2) In Western literature, there are few studies on the resource curse in developing countries and, compared with developed countries, developing countries present more serious regional differences (Wu and Lei, 2016). 3) China's economy has sustained high-speed growth and needs an enormous quantity of energy, so it is necessary to thoroughly study the relationship between energy development and economic growth.

3 Methods and Data

Based on the improvement (Shao and Qi, 2008) of the model used by Sachs and Warner (1995), and Papyrakis and Gerlagh (2007), this paper has established a panel data regression model, as shown below:

$$y_t^i = \alpha_0 + \alpha_1 \ln GP_{t-1}^i + \alpha_2 E_t^i + \alpha_3 Z_t^i + \varepsilon_t^i \quad (1)$$

where y represents per capita GDP growth rate, GP_{t-1} represents the natural logarithm of per capita GDP of the lag period, E represents energy development intensity, Z represents the vector set consisting of the control variables, i corresponds to the section unit of each province, t represents time in years, α_0 represents a constant vector term, α_1, α_2, and α_3 are coefficient vectors, and ε represents a random residual term.

In the process of actual economic development, each province shows differences across multiple dimensions, such as development rate, population scale, spatial area, and regional policy, among others. It is irrational to compare each region only using the absolute index. Therefore, this paper selects the relative index value to measure each economic variable. The growth rate of per capita GDP (represented by GP) is calculated as $(GP_t - GP_{t-1})/GP_{t-1}$. Usually, it is difficult to find direct data source to measure the energy resource abundance. In turn, some indicators were designed and widely used to indirectly measure it (Shao and Qi, 2008), this paper adopts the index of 'the proportion of the total output value of the energy industry (i.e., coal mining and dressing industry, the oil and gas extraction industry, petroleum processing, the coking and nuclear fuel processing industry, the electric power and electric heating production and supply industry, and the gas production and supply industry) to gross industrial output value', which is denoted by *E*.

According to the economic theory of production factors, control variables *Z* mainly include material capital input, human capital input, technology innovation, and economic system conditions, among others. With respect to the input of material capital, according to previous literature (Shao and Qi, 2008), this paper applies the ratio of society's total fixed asset investment to GDP as a measurement index of material capital investment, which is denoted by In*v*. With respect to the index of human capital input, some papers use the ratio of education expenditure to local fiscal expenditure but such flow indicators could not truly reflects the inventory level of human capital that affects economic growth. Thus we select the inventory index 'the average number of on-campus college students per 1000 of the population' as the measurement of human capital input, indicated as *Edu*. With respect to the index of technology innovation, some papers adopt the ratio of expenditure for research and development to local fiscal expenditure as the measurement index, which is a typical flow index. This paper, instead, selects 'the ratio of the number of jobholders in research and development institutions to the total number of jobholders' as the measurement index of scientific and technological innovation, denoted by *RD*. With respect to economic system conditions, the common variables include non-state-owned level, the degree of opening up, and the degree of marketization, among others. Considering the economic development achieved by China is largely influenced by its opening up policy, this paper selects this degree of openness as the variable to describe economic system conditions. The degree of opening up is directly reflected by the level of import and export trading, thus this paper adopts the ratio of the total quantity of import and export trading, expressed in RMB, to GDP, denoted by *Ope*.

Based on the variables described above, the final model used in this paper is given by Equation (2):

$$y_t^i = \alpha_0 + \alpha_1 \ln GP_{t-1}^i + \alpha_2 E_t^i + \alpha_3 Inv_t^i + \alpha_4 Edu_t^i + \alpha_5 RD_t^i + \alpha_6 Ope_t^i + \varepsilon_t^i \quad (2)$$

In previous studies of the resource curse, the time range of sample data used by most researchers was mostly greater than 20 years. Obviously, a relatively long time span could better reflect a normal state of economic growth by eliminating influences from the economic cycle compared with a relatively short time span. However, restricted by the availability of data, this paper used the year 2000 as its starting point, and the most recent published statistical data allowed us to extend the research period to the year 2014. In this way, the overall panel data set at our disposal included data for 465 samples in 31 section units (exclude Hong Kong, Macao and Taiwan)

The existing studies suggest that the recourse curse has several typical mechanisms. These pathways may be reflected through the relationship between substitution variables and resource abundance. Therefore, this paper establishes the following equation to study the correlation between potential pathway variables and energy abundance in order to explore the intermediate pathways for energy abundance to affect economic growth.

$$Z_t^i = \beta_0 + \beta_1 E_t^i + \mu_t^i \quad (3)$$

4 Results and Analysis

4.1 Relationship between energy abundance and economic growth

It can be seen from Table 1 that a period of 15 years was adopted (14 years actually measured), there were 434 observed values for 31 provinces (exclude Hong Kong, Macao and Taiwan), cities, and districts, The standard errors of the selected indexes, except for the *Ope* variable, were relatively small and the distributions are

Table 1 Descriptive statistics of analysis variables

Variable	Obs.	Mean	SD	Min.	Max.
y	434	0.145	0.063	−0.069	0.445
ln*GP*	434	9.767	0.784	7.887	11.509
E	434	19.946	15.362	1.780	68.460
Inv	434	58.312	20.313	25.360	124.220
Edu	434	14.213	6.984	2.570	35.650
RD	434	0.487	0.406	0.110	2.210
Ope	434	31.335	39.565	2.710	172.150

Notes: *y* represents per capita GDP growth rate; *GP* represents Gross Domestic Product; *E* represents the proportion of the total output value of the energy industry to gross industrial output value; *Inv* represents the ratio of society's total fixed asset investment to GDP; *Edu* represents the average number of on-campus college students per 1000 of the population; *RD* represents the ratio of the number of jobholders in research and development institutions to the total number of jobholders; *Ope* represents the total quantity of import and export trading appropriately normal, indicating that the sampling is valid and reliable. Therefore, in order to avoid the influences of abnormal values of *Ope* on the regression result, this paper the *Ope* variable data winsorized by ±7.5%.

It can be seen from Table 2 that the influence of energy abundance on economic growth passed the 1% significance test and that a 1% increase in energy abundance would increase GDP growth rate by 0.00110%. This positive relationship shows that for the period 2000–2014, the resource curse phenomenon was not experienced by China. This was closely related to the regional policies embodied in the Great Western Development Strategy and the Rise of Central China Plan of 2004. This period massively promoted the development of the energy industry and thus drove the growth of the economy.

Material capital input, human capital input, and level of opening up passed the significance test, and the influential coefficients were 0.000528, 0.00499, and 0.000409, respectively. This indicates that a 1% increase in each of capital, education, and foreign trade would promote GDP growth rate by 0.000528%, 0.00499%, and 0.000409%, respectively. This clearly shows that material capital input still has an obvious positive contribution to China's economic growth. Also, this reveals that the economic growth is characterized by capital input, which is still an important driving force (Lin *et al*., 2010; Lu, 2015). Therefore, for economic growth in the coming years, the transition from the mode of 'element-driven' to 'efficiency-driven' will continue as the general trend.

The coefficient of human capital input demonstrates that the effect of human capital became increasingly important in China's economic growth. This was closely related to not only the spillover and cumulative effects of human capital (Tian and Wu, 2006), but also to the policy emphasis on labor force quality over quantity (Chao and Shen, 2014).

The coefficient of the level of opening up shows relatively significant influences too. Many Chinese scholars consider that the period since 2001 has been the new era of opening-up symbolized by China's accession to the World Trade Organization (Zhang and Li, 2012). During this period, the formulation of China's policy of opening up was the principal driving force for economic growth. For example, Zhang and Xia (2013) calculated that nearly all provinces in China had kept enhancing their level of opening up since 2001, and they believed that this constant improvement in internal systems promoted China's economic growth.

Table 2 Test results of resource abundance and economic growth

Variables	China	Eastern region of China	Central region of China	Western region of China
lg*dp*	−0.0627***	−0.0781***	−0.0923***	−0.0187
	(0.00858)	(0.00979)	(0.0277)	(0.0154)
Energy	0.00110***	0.00114**	0.000384	0.000678*
	(0.000262)	(0.000463)	(0.000482)	(0.000411)
Capital	0.000528**	0.000901**	0.000562	−0.000713*
	(0.000219)	(0.000362)	(0.000506)	(0.000423)
Education	0.00499***	0.00465***	0.00875***	0.00517**
	(0.000946)	(0.00117)	(0.00299)	(0.00201)
Technology	−0.0387***	−0.0527***	−0.0420	−0.0318
	(0.0111)	(0.0118)	(0.0876)	(0.0215)
Trade	0.000409**	0.000793***	0.00118	−0.000773
	(0.000170)	(0.000194)	(0.00172)	(0.000881)
Constant	0.642***	0.769***	0.868***	0.337***
	(0.0692)	(0.0859)	(0.237)	(0.121)
Observations	434	154	112	168
R^2	0.2109	0.3734	0.2463	0.1254
F	76.53	73.84	18.41	15.67

Notes: *t*-values are listed in the brackets below the estimation coefficient. *** represents the significance at the levels of 1%, ** represent the significance at the levels of 5%, * represent the significance at the levels of 10%

The coefficient of scientific and technological input passed the 1% significance test, but the influence coefficient was −0.0387, indicating that an increase of 1% would induce a 0.0387% decrease in GPD growth rate. China's scientific and technological input rose year after year implying technology and innovation has yet been effectively transferred into production (Pang *et al*., 2014). Zhu (2007) pointed out that when increasing the input of science and technology into the economy, more attention should be given to the structure and utilization efficiency of such input.

Considering different regions, the influence of energy abundance on economic growth in the eastern and western regions passed the 1% significance test. The coefficients of influence were 0.00114 and 0.000678, respectively, indicating that energy abundance had a positive effect on economic growth and that a 1% increase would drive economic growth by 0.00114% and 0.000678%, respectively. This was similar to the situation for China as a whole. No resource curse phenomenon was found in the eastern and western regions. The main reasons for this are:

(1) In the eastern region the levels of economic development and of scientific and technological innovation were both relatively high. Although despite the high energy demand, the quantity of regional energy resources was relatively small. Therefore, energy utilization efficiency has been greatly enhanced and the economic effect of energy utilization is strengthened in this region (Qiu *et al*., 2008).

(2) In the western region there were abundant energy resources, such as coal, petroleum, and natural gas. The rapid growth of the economy was usually driven by the consumption of energy resources as a typically extensive growth mode (Wu *et al*., 2006).

(3) In the central region, the influence of energy abundance on economic growth is not statistically significant. In these regions there were relatively abundant energy resources, but due to excessive mining and excavation, energy utilization efficiency and the economic growth rate were relatively slow. Some cities even experienced resource depletion. Among the 69 national resource depletion cities (counties, districts) approved by the State Council, 32 cities (counties, districts) were in the central region, accounting for 46% of the total.

Both at the national level and regional level, human capital input is a significant factor. The coefficients of influence were 0.00465, 0.00875, and 0.00517, respectively, indicating that a 1% increase in human capital input would increase GDP growth rate in these regions by 0.00465, 0.00875, and 0.00517%, respectively. This shows the importance of human capital in the three regions as well as its relatively strong trend in the progressive increase of marginal returns.

The most distinctive difference among the three regions was material capital input. In the eastern regions, material capital input had a positive impact. A 1% increase in material capital input would increase GDP growth rate by 0.000901%. This not only indicates the impact of material capital input but also showed that in the eastern regions economic growth has been a capital-driven mode. Some regions that still depended on investment, infrastructure construction, and manufacturing industry became the main driving forces for economic growth. Even though domestic demand was expanding constantly, the effects were minuscule. In the western regions, material capital input has a negative blocking function on economic growth, and a 1% increase in material capital input results in a decrease in economic growth by 0.000713%. This suggested that the lack of coordination between material capital input and other capital inputs impede realizing the full potential of resources. Especially in an imperfect market, a plentiful supply of non-performing assets was generated, and, as a result, excessive investment in some industries and insufficient investment in others co-existed, bringing a fall in economic output.

Compared with the central and western regions, the level of opening up in the eastern region passed the significance test. The coefficient was 0.000793, indicating that a 1% increase in the level would increase economic growth by 0.00793%. This is not only closely related to the superior geographical location of eastern region but also the results of better implemented policies and industrial structure in the region. It, therefore, becomes essential to continually strengthen this policy of opening up across the country.

4.2 Analysis of transmission mechanism of resource curse

It may be seen from the regression result (Table 3) that at the national scale material capital input, human capital input, and the level of opening up all showed positive correlations with energy abundance, indicating that strengthening material capital input and human capital input, raising the level of opening up are potential ways through which energy development promoted the economic growth. The energy industry is a capital-intensive industry. Its development would surely drive an increase in material capital input, such as fixed assets, among others. Based on aforementioned discussion regarding the influence of material capital input on economic growth, it shows that China still adheres to the model of capital-driven economic growth. Therefore, the development of the energy industry would accelerate the rapid growth of the economy. In addition, China's traditional energy industry is still in a state of extensive utilization. While in transition from a utilization model based on quantity to one based on quality, in order to further increase the utilization efficiency, many regions began paying attention to human capital investment to strengthen the employment structure, to enhance the human capital advantage, and to drive economic growth. With regard to China's overall industrialization level, some regions, especially the central and western regions, are still at the initial stage of industrialization with industrial products produced mainly for local consumption (Chen *et al.*, 2006).

Scientific and technological input presented a negative correlation with energy development intensity, indicating that energy development may have negative impacts on scientific and technological innovation thus restrict economic growth. There are two main reasons:

(1) Compared with other manufacturing industries, the energy industry had a relatively low degree of intrinsic industrial correlation, rate of technical updating, level of technical innovation, and demand for scientific and technological innovation. This may lead to lack of motivation for innovation;

(2) China's energy industry belongs mostly to national monopoly industries. The production and operation of petroleum and natural gas, in particular, are uniformly deployed and controlled by national or local governments who own certain monopoly rights and are not completely market-oriented. The level of input to scientific and technological innovation has been relatively low, and this has restricted the diffusion of technological innovation in regional economic development and thus has slowed down economic growth.

Regionally speaking, in the eastern, central, and western zones both material capital input and human capital input showed positive correlations with energy development. It indicates that energy development might promote economic growth by increasing the input of both material and human capital, as consistent with the regression results of the national samples. Besides the overall national economic growth pattern, this was also related to the intrinsic attributes of the energy industry.

On the one hand, compared with the eastern and central regions, energy development in the western region shows a negative correlation with the level of scientific and technological input. The main reason for this may be that the increase in energy industry input induced a decrease in input in other manufacturing industries in the western region. In the western region, where the scientific and technological level was low, a high-share energy industry would indirectly bring a decline in those manufacturing industries that require advanced technologies and relatively high-value-added products. This will confine the diffusion of technical innovation into regional economic development, blocking scientific and

Table 3 Indirect effects of transmission mechanisms

Variables	Capital				Education				Technology				Trade			
Regional	China	Eastern region of China	Central region of China	Western region of China	China	Eastern region of China	Central region of China	Western region of China	China	Eastern region of China	Central region of China	Western region of China	China	Eastern region of China	Central region of China	Western region of China
E	0.147***	0.143***	0.0577**	0.223***	0.843***	0.750***	0.452***	1.326***	−11.18***	1.434	16.35	−26.69***	0.0552*	0.0360	0.688***	0.238*
	(0.0176)	(0.0403)	(0.0226)	(0.0274)	(0.0552)	(0.0931)	(0.0822)	(0.0887)	(4.018)	(3.328)	(11.46)	(7.413)	(0.0334)	(0.0358)	(0.140)	(0.123)
Cons.	10.18***	5.705**	15.11***	9.490**	7.096***	−0.219	12.06**	10.57***	24.02***	11.73***	11.96*	37.17***	16.98***	10.33***	11.17**	21.71***
	(2.204)	(2.659)	(4.791)	(3.964)	(2.231)	(2.601)	(5.121)	(3.696)	(2.903)	(2.717)	(6.464)	(5.154)	(2.212)	(2.977)	(5.159)	(3.830)
R^2	0.1346	0.0673	0.0573	0.2822	0.3634	0.3098	0.2141	0.5730	0.0431	0.0317	0.0239	0.1261	0.0241	0.0251	0.1769	0.0219
F	70.08	12.67	6.53	66.42	233.40	64.86	30.23	223.60	7.74	0.19	2.04	12.97	2.72	1.01	24.28	3.71

Notes: *t*-values are listed in the brackets below the estimation coefficient. *** represents the significance at the levels of 1%, ** represent the significance at the levels of 5%, * represent the significance at the levels of 10%

technological advancement in the western regions, and restricting economic growth.

On the other hand, western region, which lagged behind in terms of their economic ideologies, lacks motivation for entrepreneurial and technological innovation. Therefore, talented entrepreneurs moved to the central and eastern regions to seek opportunities. Otherwise, the entrepreneurs consciously or unconsciously either turned to coal mining industry which required a low technical input, or devoted their energies to rent-seeking activities, instead of management and technical innovation, leading to the crowding out effect of energy industry on innovation behaviors and inhibition of economic growth. Compared with the eastern regions, the level of opening up in the central and western regions showed a positive correlation with energy industry development, indicating that the energy industry promoted economic growth by raising the level of opening up. The central and western regions are currently at the preliminary stage of industrialization, and most industrial products are for local consumption. To take full advantage of resources with policy support, developing primary product production and processing industries could bring an increase in the export of primary products including energy resources, allowing energy development to support opening up. For the eastern regions, this level of opening up could promote economic growth, but the strength of energy development was unable to promote economic growth through the pathway of opening up. It is not difficult to explain this theoretically, and the main reason is because, in the eastern region, there was a low reserve of traditional energy resources and basically no exports or imports by the energy industry, but rather the foreign trade of high-tech products. Thus basic energy use, such as west-to-east gas transfer and west-to-east electricity transfer, among others, was sourced mostly from the central and western regions.

5 Conclusions and Suggestions

This paper studied the relationship between energy abundance and economic growth in 31 provinces, cities, and districts of China in the period 2000–2014 and found:

(1) At the national level, energy abundance showed a positive correlation with economic growth. China did not display the resource curse phenomenon on the whole, and the three control variables, material capital input, human capital input, and level of opening up, were able to promote economic growth, while input into scientific and technological innovation hampered economic growth. This highlights that, despite the increasing input into scientific and technological innovation, scientific and technological innovation didn't provide effective support economic growth due to inefficient technology transfer and diffusion.

(2) At the regional level, the results are consistent with the regression result of the national samples. In the eastern and western regions, energy abundance and economic growth showed positive correlations, indicating no resource curse phenomenon. Concerning the control variables, in the eastern, central, and western regions, human capital input was able to promote economic growth; in the eastern and western regions, material capital input displayed mixed effects on economic growth; in the eastern regions, the level of opening up promoted economic growth.

The results of our analysis on the transmission mechanism for the resource curse show that:

(1) At the national scale, material capital input, human capital input, and level of opening up showed positive correlations with energy abundance, indicating that energy development promoted economic growth by strengthening material capital input and human capital input and raising the level of opening up. However, input into scientific and technological innovation showed a negative correlation with the strength of energy development, and revealed that energy development restricted economic growth by weakening input into scientific and technological innovation.

(2) At the regional level, the results are consistent with the regression result of the national samples. In the eastern, central, and western zones, both material capital input and human capital input showed positive correlations with the strength of energy development, indicating that energy development promoted economic growth by increasing the input of material capital and human capital. Compared with the eastern regions, the level of opening up in the central and western regions showed a positive correlation with energy industry development, indicating that the energy industry promoted economic growth by raising the level of opening up. However, energy development and scientific and technological input showed negative correlations in the western re-

gion, indicating that energy development lowered economic growth by reducing input into scientific and technological research and development in these western regions.

We make the following suggestions for policy adoption:

(1) Almost all previous studies of energy abundance and economic growth were developed from the perspective of economics, took education input level, human capital level, the degree of opening up, among others, as their main variables, and seldom considered geographical influence. For example, in the eastern region, Shandong Province, as a large energy-using province, owned abundant resources, including coal, petroleum, and natural gas, among others, but still maintained relatively rapid economic growth, and was ranked third in China for GDP in 2015. Obviously, as a coastal region, Shandong Province has a good geographical location and transportation infrastructures, which undoubtedly promoted the development and utilization of energy resources and contributed to economic growth. Therefore, future research into energy abundance and economic growth should take into consideration the influences brought about by geographical factors.

(2) We advocate strengthening the development of manufacturing industry to give full play to its advantages in driving economic and employment growth. In the central and western regions, the energy-dependent development path has often crowded out labor-intensive manufacturing industries and confined the sustained growth of economy and employment. Thus when strengthening energy development, attention should be paid to the development of manufacturing industry, encouraging technical innovation, supporting modern service industries, and optimize local industrial structure. Industrial structure upgrades should be accelerated and newly industrialized development paths should be followed in order to gain advantages such as the economies of scale of manufacturing industries, to promote the long-term sustainable development of the economy, to attract diverse levels of technical personnel, and to raise the employment growth rate.

(3) The level of investment in human capital should be raised to promote economic growth. Energy-abundant regions have often neglected human capital input, and education expenditure has often lagged behind economic growth. Low-level human capital has affected the continuity of technical innovation and hampered the long-term development of the economy, such that strengthening the input and accumulation of human capital must not be ignored. First, the mechanism for the cultivation of high-quality talents should be reformed by increasing education input, cultivating research-type talents, and conveying better workers to society. Then, education expenditure should be increased, optimizing the structure of education outlay, paying attention to basic education and enhance the continuing education of the general workforce, enhancing the quality of the workforce, keeping skills up-to-date with technical advances, and making efforts to avoid structural unemployment.

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