Environmental Science and Pollution Research (2019) 26:3666–3674
https://doi.org/10.1007/s11356-018-3853-6

RESEARCH ARTICLE

How does natural resource dependence affect public education spending?

Hua-ping Sun [1,2] · Wei-feng Sun [3] · Yong Geng [2,1] · Xi Yang [1] · Bless Kofi Edziah [1]

Received: 9 September 2018 / Accepted: 26 November 2018 / Published online: 8 December 2018

Abstract

The "resource curse" phenomenon has been the subject of extensive research, with its causes and transmission mechanisms primarily examined from the perspectives of economic development and rent seeking. Education is a major factor contributing to economically sustainable development, owing to its potential for improving cognition and skill levels and thereby enhancing worker productivity. The crowding-out or crowding-in effect of natural resource dependence on public education spending has been identified as one of the key mechanisms of the resource curse or blessing. Using panel data from 31 Chinese provinces, this empirical study revealed a positive correlation between natural resource dependence and public education expenditure, demonstrating the impact of the crowding-in effect, exerted by natural resource dependence, on public education expenditure. Abundant natural resources can provide funds for education expenditure. The sample was further divided into eastern and central and western regions. The results indicate that the crowding-out effect of natural resource dependence only affects public education expenditure in the Eastern region, while the crowding-in effect of natural resource dependence on public education expenditure in the central and western regions. Research shows that the regional differences of crowding-out or crowding-in effect are very obvious, so the government should adopt transfer payment to promote balanced regional development. Better economic and social policies will help to translate wealth from natural resources into economic growth. Thus, a "resource blessing" may emerge to replace the "resource curse." Fairly distributed and higher quality education will enhance human capital, thereby promoting economic growth from its current resource-driven pattern to a knowledge-driven pattern.

Keywords Natural resource dependence · Public education spending · Resource curse · Crowding-in effect

Introduction

The term "resource curse," also referred to as the "paradox of plenty," was coined by Richard Auty in 1993 to describe the paradoxical incapacity of countries rich in mineral resources to use that wealth to boost their economies. Theoretically, natural resources provide a valuable source of revenue and thus may be expected to promote economic development. However, several previous studies have observed lower rates of economic growth in countries rich in natural resources, in contrast to those without abundant natural resources. It is this phenomenon in particular that is termed the resource curse. Over the past few decades, a large number of literatures have focused on the relationship of economic growth and natural resources in developed and developing countries (Auty 1990, 2003; Grossman and Krueger 1995; Alexeev and Conrad 2009; Shao and Qi 2009; Shao et al. 2016; Van der Ploeg and Venables 2009; Van der Ploeg 2011; Van Der Ploeg and Poelhekke 2017; Apergis and Payne 2014; Gilberthorpe and

Highlights 1. The crowding-in effect of natural resource dependence on public education expenditure behavior has been identified.
2. The crowding-in effect of natural resource dependence only affects public education expenditure behavior in the central and western regions.
3. It is recommended that areas rich in natural resources increase investment in public education.

Responsible editor: Philippe Garrigues

✉ Hua-ping Sun
shp797@163.com

[1] Institute of Industrial Economics, Jiangsu University, Zhenjiang 212013, China

[2] School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai 200240, China

[3] Department of Economics and Management, Yuncheng University, Yuncheng 044000, China

Papyrakis 2015; Venables 2016; Havranek et al. 2016; Sun et al. 2018a, b). The resource curse typically emerges when a country or region begins to focus its entire production means on a single industry, such as mining, neglecting investment in other major sectors. A commonly cited example is the Dutch disease, a situation that occurred in the Netherlands following a large natural gas find. Previous studies have examined the Dutch disease from the perspectives of crowding-out effects, the price volatility of natural resource products, and economic institutions. According to the "resource curse" theory, the excellent resource endowment of the late-developing regions will hinder the economic growth of the region and even make it fall into a vicious circle of "backwardness—dependence on resources—further backwardness." However, it should be noted that although there is some commonality among transmission mechanisms at the national and regional levels, there are also significant differences. Under the influence of the Dutch disease, the export of natural resources leads to an increase in the exchange rate and a decline in industrial competitiveness. However, at the regional level, trade-in natural resources do not have a significant impact on the exchange rate. As such, the impact of the Dutch disease is insufficient to account for the resource curse phenomenon at the regional level in China. Based on the pioneering empirical study of Auty (1990), the impact of natural resources on economic growth has produced a wealth of literature covering different geographical regions and time spans. Mainly, the literatures supported the resource curse hypothesis such as Papyrakis and Gerlagh (2007), Satti et al. (2014), and Ross (2015). On the other hand, some other researchers such as Michaels (2011), Weber (2014), James (2017), Law and Moradbeigi (2017) and Shahbaz et al. (2018) found evidence of the resource bless hypothesis. Stijns (2005) reported both positive and negative relationships between natural resources and economic growth. Neumayer (2004) and Sachs (2007) argued the resource curse hypothesis is only partly true. Koitsiwe and Adachi (2015) empirically investigated the dynamic relationships between mining revenue, government consumption, exchange rate, and economic growth in Botswana based on VAR model. Badeeb et al. (2016) empirically examined the role of investment in the finance-growth nexus and the oil curse in Malaysia. Ahmed et al. (2016) discussed the case of Iran and tested the resource curse hypothesis from the view of labor using the updated time-series data. Ojakorotu (2017) examined resource control and conflict in Africa. Dauvin and Guerreiro (2017) discussed the paradox of plenty via meta-analysis. Badeeb et al. (2017) analyzed the evolution of the natural resource curse thesis based on a critical literature survey. Moradbeigi and Law (2017) found better financial development dampened the negative impact of oil abundance on economic growth. Song et al. (2018) analyzed the resource curse phenomenon in locations with high coal-consuming industries based on large-scale data. Ben-Salha et al. (2018) tested the causal linkages between economic growth and total natural resource rents using a sample of top resource-abundant countries based on PMG estimation.

When governments are reliant on the wealth generated by natural resources, poor economic performance and governance challenges frequently ensue. Sachs and Warner (2001) explored the relationship between natural resources and economic development from the resource curse perspective. Recent research has increasingly focused on the causes of the resource curse. Regarding the institutional factor, its influence is more significant at the national level than at the regional level, where the crowding-out effect is the most significant economic consequence of the resource curse. Mehlum et al. (2006) argued that the institutions are decisive for the resource curse. Anne et al. (2007) argued that mineral-rich countries are cursed only if they have low-quality institutions, while the curse is reversed when institutions are of sufficiently good quality. Boschini et al. (2013) also reported similar findings from the perspective of institutional quality. Hamdi and Sbia (2013a, b) discussed the dynamic relationship between natural resources rents, trade openness, government spending, and economic growth in different countries. James and Aadland (2011), James (2015) confirmed the importance of regional and industrial heterogeneity in resource-dependent countries. Dissou et al. (2016) analyzed the impact of government spending on education, human capital accumulation, and growth. Long et al. (2017) reported that environmental innovation behavior has a greater effect on environmental performance than economic performance. Sun et al. (2018a, b) argued patent pool and relevant industrial standards should be established for China's NEV industry. Mensah et al. (2018) discussed the effect of innovation on carbon emissions of OECD countries–based data from 1990 to 2014. Shao et al. (2018) found that the wealthy have a higher willingness to pay for environmental protection. Because education can increase income level, it can be predicted that education expenditure has an intrinsic relationship with resource dependence and environmental protection.

On the basis of the neoclassical theory of economic growth and the theory of endogenous growth, there is a tendency among researchers to examine the crowding-out effect of the resource curse from the perspectives of physical capital and technological progress (Hu and Xiao 2007; Shao et al. 2013; Han and Zhang 2015; Long et al. 2018). Shao and Yang (2014) analyzed China's resource curse phenomenon at the regional level from the perspective of human capital accumulation. Using Chinese regional data, Xu and Wang (2006), Shao et al. (2013), and Zhou and Guo (2015) have all confirmed the presence of the resource curse phenomenon. Using city-level panel data, Sun and Ye (2011) investigated the interplay between resource dependence, geographical position, and economic growth, revealing a significant and negative impact of resource dependence on the economic growth of cities following the control of geographical position. Therefore, although some countries rich in natural resources have sustained high and

stable rates of economic growth over long periods, the existence of the resource curse remains incontestable (Zhang et al. 2016).

In this paper, we aim to investigate the crowding-out effects of the resource curse from the perspective of public education expenditure. Previous literature has consistently confirmed the negative impact of natural resource dependence on public education expenditure. Gylfason (2001) observed a negative correlation between public education expenditure and girls' schooling duration and natural resource dependence; Douangngeune et al. (2005) compared education levels and economic development among Thailand, Japan, and Korea and confirmed that crowding-out effects were associated with the lands' resources; and Cockx and Francken (2016) also observed a negative relationship between natural resource dependence and public education expenditure. While James (2017) find public spending on education in resource-rich states greatly exceeds that in resource-scarce ones.

To our knowledge, no research has yet been carried out on the effect of natural resource dependence on public education expenditure at the regional level in China. This paper focuses on public education expenditure for two reasons: first, investment in public education is the main factor contributing to the accumulation of human capital (Qian et al. 2014); human capital theory holds that education improves cognition and competence, ultimately resulting in increased productivity, and the theory of endogenous growth suggests that higher human capital levels contribute significantly to technological progress (Aghion and Howitt 1998). Therefore, educational investment is an important determinant of human capital and technological progress. Second, public education expenditure is under the direct control of the government. The results of this study are expected to yield useful recommendations for policymakers.

Theoretical analysis

We consider a household whose utility (U) function is composed of consumption(C) and leisure (H). Their relationship can be expressed as follows.

$$U = C^{*}H^{1}/_{2} \tag{1}$$

Here, the utility is positively related to consumption and leisure. Consumption is financed by remuneration for labor performed by the members of the household. Time limitations dictate that increased work will result in decreased leisure time. The question is, therefore, how long should a household spend working? If only a single period is considered, in accordance with classical economic theories, the optimal choice respects the following condition: the marginal utility of 1 more hour of work equals the marginal utility provided by 1 h of leisure. When achieving economic equilibrium, we can get the following function:

$$\frac{\partial U}{\partial C} = \frac{\partial U}{\partial H} \tag{2}$$

If only a single period is in question, savings and investments need not be taken into consideration. However, in reality, there are several periods to consider. Assuming that there are two periods, the discounting problem, i.e., the household's time preference rate, should be considered. Generally, the household prefers consumption. We assume that the discount rate is d. The marginal substitution rate of future consumption and current consumption reveals the subjective preference rate (discount rate d) of consumers for time at that time point. So, we have the following function:

$$MRS_{C_0}^{C_1} = \frac{\partial C_1}{\partial C_0}\bigg|_{U=C} = -(1 + d_i) \tag{3}$$

In the first period, the household's revenue may be used in two ways: it may be spent in its entirety on consumption or it may be distributed evenly between consumption and savings and investments. Assuming that the saving is S, the household can regain $(1 + r)*S$, where r denotes the return rate. Further to this, we assume that while the household can save, it cannot borrow from banks or other lending institutions. In this case, the household can only save on the condition that r exceeds d. In contrast, if the return rate is lower than the discount rate, the household revenue will be spent in its entirety during the first period. Economically speaking, where r is lower than d, there can be no savings and, therefore, no increase.

Supposing that the situation should change, with r now exceeding d (as a result of an increase in r, a decrease in d, or a combination of both scenarios), the household will be encouraged to invest. As borrowing is not an option, funds for investment are accessed through a decrease in consumption or an increase in revenue (i.e., working for longer). Generally, when r is elevated in excess of d, a reasonable person will reduce consumption, work more, and invest all their savings and additional revenue. Thereby, the household will contribute to economic growth by providing more labor and investing in high-yield projects.

Under which conditions are these effects most significant? For poorer households with fewer consumer goods, significant reductions in consumption cannot be realized. Therefore, increased investment will result primarily from the increased revenue associated with additional labor hours. This effect is more pronounced if the marginal productivity of labor does not decrease massively in proportion to the increased labor supply. Thus, the government can assist in promoting economic growth: governmental intervention should help to improve the investment return rate and marginal productivity of labor.

Education is an important investment commodity. As such, in advance of making these decisions, the household will compare its rate of return with the time preference rate (i.e., the discount rate). If the return rate exceeds the discount rate, the

household will be motivated to invest their additional revenue in education. In this case, the demand for education will increase, leading to an accumulation of human capital. If the government simultaneously implements appropriate education policies, educational investment may be expected to reduce revenue inequality and promote economic growth, thereby increasing the demand for education even further. This in turn leads to a rise in the educational investment return rate, and thus a virtuous cycle emerges.

What role does the government play in this virtuous cycle? On one hand, the government can help to raise demand for human capital through the development strategies that they adopt, while on the other hand, public spending in education can help to improve educational infrastructure and thereby reduce the cost of educational investment for households. All of these efforts on the part of the government will encourage households to invest privately in education, resulting in an educational input-output virtuous cycle that can be insured and amplified by public education expenditure. That means:

$$\frac{\partial E}{\partial U} > 0 \tag{4}$$

The majority of governments advocate the importance of education. However, recognizing the importance of education is one thing. Increasing investment in education is another matter. It depends on two factors: the ability and willingness to increase investment in education. Whether we can increase investment in education depends on capital. Public education investment may be limited owing to a lack of funding. Under other equal conditions, countries rich in natural resources can make transfer payments, which come from the use of income generated by the exploitation of these natural resources to increase their expenditure on public education. Taking resource tax as an example, resource tax can increase the financial revenue of resource-rich areas and be used for local economic and social development of resource-producing areas. From the comparison of different regions in China, the eastern region is resource-poor, the central and western regions are resource-rich, and the resource tax revenue of the eastern region lags far behind the central and western regions. From 1999 to 2015, in the eastern region, Shanghai's resource tax revenue was 0; Beijing's resource tax revenue increased from 16 million Yuan to 91 million Yuan, less than five times; and Tianjin's resource tax revenue increased from 40 million Yuan to 210 million Yuan, four times; but compared with the central and western regions of Shanxi and Inner Mongolia, there is still a big gap. From 1999 to 2015, the resource tax revenue of Shanxi Province increased from 462 million Yuan to 14.318 billion Yuan, an increase of more than 30 times; the resource tax revenue of Inner Mongolia increased from 259 million Yuan to 10.53 billion Yuan, also more than 30 times. In addition to resource tax, resource-rich areas can also earn large amounts of income by collecting resource rents. Therefore, in terms of the ability to increase investment in education, natural resources can provide funds for public education investment in resource-rich areas.

However, having the ability to invest does not mean that it will invest. It also depends on the willingness to invest. For the following three reasons, rich natural resources may reduce public education input: first, revenue inequality is more pronounced in regions rich in natural resources. Due to the staggering levels of corruption associated with these regions, revenue accruing from these resources tends to be diverted by corrupt business and government officials who lack the insight necessary for spending in public education. Second, the chief industries in regions rich in natural resources are mining and chemical industries, both of which require highly qualified human capital. Third, the inhabitants of regions rich in natural resources tend to pay greater attention to the resources' direct economic value, leading to insufficient public education spending. In summary, education is a crucial determinant of regional economic growth. On the one hand, abundant natural resources can provide funds for education expenditure; on the other hand, it will reduce the willingness to invest in education. Therefore, theoretically, it is impossible to determine the direction of the impact of natural resource dependence on public education investment, and empirical tests are needed.

Data and methodology

Using panel data from 31 Chinese provinces accumulated between 1999 and 2015, this paper reports an empirical study of the interplay between public education expenditure and natural resource dependence. The data come from the CSMAR database, a compilation of Chinese statistics gathered over a 60-year period (1949–2008), and provincial statistical bulletins pertaining to national economic and social development.

We apply the following model to investigate the effects of natural resource dependence on public education expenditure:

$$\mathrm{PEI}_{it} = \beta_0 + \beta_1 \mathrm{N}RD_{it} + \beta_2 \mathrm{growth}_{it} + \beta_3 \mathrm{IS}_{it} + \beta_4 \mathrm{Town}_{it} + \varepsilon_{it} \tag{5}$$

Where i denotes the province and t indicates the period. The dependent variable PEI is the public education investment measured by the ratio of public education investment to GDP; the explanatory variable NRD is natural resource dependence, measured by the ratio of the mining industry's workforce to the working population of the entire province. As other factors may also affect public education investment, we introduce three control variables: "growth" is the provincial GDP growth rate; "IS" represents the industrial structure. Given by the proportion of the provincial GDP accounted for by

Table 1 Descriptive statistics

	Whole sample (1)		Eastern region (2)		Central and western regions (3)		*t* test on difference between (2) and (3), *p* value
	Average	Std. dev.	Average	Std. dev.	Average	Std. dev.	
Public education expenditure	0.032	0.000	0.023	0.000	0.037	0.000	< 0.001
Natural resource dependence (NRD)	0.031	0.001	0.016	0.0003	0.044	0.0009	< 0.001
Economic growth rate	0.11	0.001	0.112	0.006	0.113	0.007	0.804
Industrial structure (%)	46.19	67.05	46.16	102.86	46.21	47.6	0.954
Urbanization	0.476	0.026	0.606	0.029	0.404	0.01	< 0.001
Obs.	527		187		340		

p value is obtained by a two-tailed test

the second industry in; "Town" is the urbanization level, given by the ratio of the city population to the whole population; and ε is the residual.

Regional development levels in China are largely heterogeneous and the East has experienced greater development than has the West. Does development heterogeneity affect the relationship between natural resource dependence and public education investment? To answer this question, we divided the sample into two subsamples, eastern regions and central and western regions, and then performed the analyses. The descriptive statistics are presented in Table 1.

The data presented in Table 1 demonstrate that the ratio of public education investment to GDP in the central and western regions is significantly higher than that in the east[1], indicating that natural resource dependence is much higher in the West, the urbanization level in the east is much higher than it is in the central and western regions, and no significant difference was detected between industrial structure and economic growth rate in either region.

Regression results

Whole-sample regression

The results of the Hausman test, adopting a fixed-effect model, are presented in Table 2.

Model 1 is the result of a simple regression, demonstrating that natural resource dependence is positively correlated with public education investment. An increase of 0.01 in natural resource dependence leads to an increase of 0.00068 in public education investment. Considering that the average public education investment is 0.032, this positive effect is relatively significant. Model 2 introduces the economic growth rate as a control variable. However, the positive effect of natural resource dependence on public education investment remains significant. Model 3 adds industrial structure as a control variable in the regression model, and the positive effect is even seen to increase. Finally, we added the urbanization level as a control variable. In this case, the positive impact of natural resource dependence on public education investment remains significant, although the amplitude is much smaller. From the economic point of view, public education investment increased by 0.00069 while the natural resource dependence rose by 0.01, with the effect remaining relatively significant.

Subsample regressions

In the subsequent analyses, we divided the sample into subsamples of eastern and central and western regions and repeated the regression in accordance with Eq. (1). The results of these analyses are presented in Table 3. Models 1 and 3 are simple regressions. When the results were compared, it emerged that the negative impact of natural resource dependence on public education investment was present in the eastern region, while in the central and western regions, the impact is positive. Following the introduction of the control variables, the significant negative effects disappeared from the eastern region results. For the central and western regions, however, the positive impact remained significant, although the coefficient was smaller. Therefore, the results confirm the crowding-out effect exerted by the dependence on natural resources for public education investment, but only for the Eastern region and not very significant.

Robustness checks

Using public education investment per capita (PEP) or per students (PES) as substitute independent variable, we did

[1] This is counterintuitive: generally, the East is better developed. Eastern provinces should pay greater attention to, and invest more in, education. We propose two possible explanations for this counterintuitive phenomenon: first, GDP is higher in the East. As a result, the ratio of education investment to GDP is not high enough. However, it does not necessarily follow that the absolute value of education investment is low. Second, in recent years, China has adopted development strategies such as "The Grand Western Development Program" and "The Rise of Central China." These policies are aimed at enhancing public transfer to Central and Western regions, leading to increased investment in education in these regions.

Table 2 Effects of natural resource dependence on public education expenditure: whole-sample regressions

Explanatory variable	Model 1		Model 2		Model 3		Model 4	
	Coeff.	*p* value	Coeff.	*p* value	Coeff.	*p* value	Coeff.	*p* value
Constant	0.029	0.000	0.029	0.000	− 0.009	0.058	− 0.029	0.000
NRD	0.068	0.002	0.068	0.002	0.09	0.000	0.069	0.000
Growth			0.00001	0.950	− 0.00076	0.000	− 0.00039	0.029
IS					− 0.001	0.000	0.0005	0.000
Town							0.0838	0.000
R^2	0.684		0.684		0.81		0.90	
F test	36.69		36.61		37.42		73.20	
Obs.	527		527		527		527	

more robustness check regressions. The results of these analyses are presented in Table 4. It can be seen that the results of the regression are consistent with the foregoing results. The overall sample and the central and western regions still showed significant positive effects, while the eastern region is negative, but it is still not very significant.

Conclusions and recommendations

Research content and results

Education is one of the fundamental elements of development, and the quality of education is a key determinant of the pace at which a region achieves economic growth. Education can

Table 3 Effects of natural resource dependence on public education expenditure: subsample regressions

Explanatory variable	Eastern				Central and western			
	Model 1		Model 2		Model 3		Model 4	
	Coeff.	*p* value	Coeff.	*p* value	Coeff.	*p* value	Coeff.	*p* value
Constant	0.031	0.000	0.0025	0.752	0.333	0.000	− 0.031	0.000
NRD	− 0.471	0.000	− 0.055	0.524	0.079	0.002	0.072	0.001
Growth			− 0.0005	0.006			− 0.0002	0.477
IS			− 0.0001	0.279			0.0007	0.000
Town			0.064	0.000			0.084	0.000
R^2	0.641		0.86		0.68		0. 874	
F test	12.10		19.89		34.23		54.01	
Obs.	187		187		340		340	

Table 4 Effects of natural resource dependence on public education expenditure: subsample regressions

Explanatory variable	Total (PES)		Eastern (PEP)		Central and western (PES)	
	Model 1		Model 2		Model 3	
	Coeff.	*p* value	Coeff.	*p* value	Coeff.	*p* value
Constant	8.493	0.000	1.7038	0.009	0.05	0.000
NRD	1.709	0.010	− 10.257	0.147	2.133	0.002
Growth	− 0.062	0.000	− 0.0269	0.083	− 0.049	0.000
IS	0.005	0.213	− 0.0335	0.002	0.025	0.000
Town	5.595	0.000	11.23	0.000	5.126	0.000
R^2	0.90		0.951		0.881	
F test	198.75		41.89		62.36	
Obs.	527		187		340	

promote sustainable economic development through several channels, including enhancing labor productivity, promoting good governance, reducing income inequality, and aiding the public health sector. Despite the numerous economic and social benefits accruing from investment in education, resource-rich regions have failed in their efforts to invest in it. The chief reason behind this failure relates to the excessive concentration of (or dependence on) natural resources at the expense of human capital development, resulting in a crowding-out effect of natural resources on human capital. Birdsall et al. (2000) detected a negative relationship between the abundance of natural resources and human capital levels. They argued that natural resources crowd out human capital and contract economic growth. Auty (2007) observed that natural resources are associated with significant restraining effects on human capital accumulation. Blanco and Grier (2012) found that resource dependence had no significant or direct influence on human capital. However, in studying subcategories of natural resources, they observed that dependence on exporting oil and agricultural commodities is associated with long-term negative effects on human capital accumulation. Thus, this paper considered the relationship between natural resources and public policy. Bringing to bear panel data from 31 Chinese provinces, this empirical study found that natural resource dependence and public education expenditure were positively correlated, evincing the crowding-in effect exerted by the dependence on natural resources for public education expenditure. From an economic perspective, the crowding-in effect is relatively significant. Taking into consideration China's large surface area and the uneven distribution of regional development, the sample was divided into eastern and central and western regions. The results indicate that the crowding-out effect exerted by dependence on natural resources for public education expenditure exists only in the eastern region.

Future prospects

It is worth considering that the key issue may not be the natural resources themselves, but rather inappropriate policies implemented by the government. Research shows that the regional differences of crowding-out or crowding-in effect are very obvious, so the government should adopt transfer payment to promote balanced regional development. Better economic and social policies will help to translate wealth from natural resources into economic growth. Thus, a "resource blessing" may emerge to replace the "resource curse." Fairly distributed and higher quality education will enhance human capital, thereby promoting economic growth from its current resource-driven pattern to a knowledge-driven pattern. Regions poor in natural resources should therefore increase their investment in public education by regional transfer payment, and the government should adjust its policy of revenue allocation and channel more revenue from the natural resource sector into public education, thereby enhancing human capital levels. The current study is only for samples at the provincial level. In the future, we will conduct more detailed tests based on China's more microscopic urban samples.

Acknowledgements The authors appreciate the valuable comments of the anonymous referees. The English in this document has been checked by at least two professional editors, both native speakers of English.

Funding information The authors are grateful for the financial support provided by the National Natural Science Foundation of China (Nos. 71810107001, 71774071, 71690241, 71573121, 71473233), the China Postdoctoral Science Foundation (No. 2016M601568), the Soft Science Project in Zhenjiang (YJ2018004), the Young Academic Leader Project of Jiangsu University (No. 5521380003), and the Education Science Research Project of Shanxi (GH-16082).

References

Aghion P, Howitt P (1998) Endogenous growth theory. MIT Press, Cambridge

Ahmed K, Mahalik MK, Shahbaz M (2016) Dynamics between economic growth, labor, capital and natural resource abundance in Iran: an application of the combined cointegration approach. Res Policy 49: 213–221

Alexeev M, Conrad R (2009) The elusive curse of oil. Rev Econ Stat 91(3):586–598

Anne DB, Jan P, Jesper R (2007) Resource curse or not: a question of appropriability, the. Scand J Econ 109(3):593–617

Apergis N, Payne JE (2014) The oil curse, institutional quality, and growth in MENA countries: evidence from time-varying cointegration. Energy Econ 46:1–9

Auty RM (1990) Resource-based industrialization: sowing the oil in eight developing countries. Oxford University Press, New York

Auty RM (1993) Sustaining development in mineral economies: the resource curse thesis. Routledge, London

Auty RM (2003) Natural resources, development models and sustainable development. Environmental Economics Programme Discussion Paper 03–01. International Institute for Environment and Development (IIED), London

Auty RM (2007) Natural resources, capital accumulation and the resource curse. Ecol Econ 61(4):627–634

Badeeb RA, Lean HH, Smyth R (2016) Oil curse and finance–growth nexus in Malaysia: the role of investment. Energy Econ 57:154–165

Badeeb RA, Lean HH, Clark J (2017) The evolution of the natural resource curse thesis: a critical literature survey. Res Policy 51: 123–134

Ben-Salha O, Dachraoui H, Sebri M (2018) Natural resource rents and economic growth in the top resource-abundant countries: a PMG estimation. Res Policy. https://doi.org/10.1016/j.resourpol.2018.07.005

Birdsall N, Pinckney T, Sabot R (2000) Natural resources, human capital, and growth. Carnegie Endowment Working Papers, http://carnegieendowment.org/files/natresources.pdf. Accessed 29 Oct 2018.

Blanco L, Grier R (2012) Natural resource dependence and the accumulation of physical and human capital in Latin America. Res Policy 37(3):281–295

Boschini A, Pettersson J, Roine J (2013) The resource curse and its potential reversal. World Dev 43:19–41

Cockx L, Francken N (2016) Natural resources: a curse on education spending? Energy Policy 92:394–408
Dauvin M, Guerreiro D (2017) The paradox of plenty: a meta-analysis. World Dev 94:212–231
Dissou Y, Didic S, Yakautsava T (2016) Government spending on education, human capital accumulation, and growth. Econ Model 58:9–21
Douangngeune B, Hayami Y, Godo Y (2005) Education and natural resources in economic development: Thailand compared with Japan and Korea. J Asian Econ 16(2):179–204
Gilberthorpe E, Papyrakis E (2015) The extractive industries and development: the resource curse at the micro, meso and macro levels. Extr Ind Soc 2(2):381–390
Grossman GM, Krueger AB (1995) Economic growth and the environment. Q J Econ 110(2):353–377
Gylfason T (2001) Natural resources, education, and economic development. Eur Econ Rev 45(4–6):847–859
Hamdi H, Sbia R (2013a) The relationship between natural resources rents, trade openness and economic growth in Algeria. Econ Bull 33:1649–1659
Hamdi H, Sbia R (2013b) Dynamic relationships between oil revenues, government spending and economic growth in an oil dependent economy. Econ Model 35:118–125
Han HY, Zhang ZJ (2015) "Resource curse" transmission mechanism: an empirical analysis based on provincial data. Journal of Arid Land Resources and Environment 29(7):1–6
Havranek T, Horvathb R, Zeynalov A (2016) Natural resources and economic growth: a meta-analysis. World Dev 88:134–151
Hu YC, Xiao DY (2007) The threshold of economic growth and the natural resource curse. Management World 4:15–23
James A (2015) The resource curse: a statistical mirage? J Dev Econ 114: 55–63
James A (2017) Natural resources and education outcomes in the United States. Resour Energy Econ 49:150–164
James A, Aadland D (2011) The curse of natural resources: an empirical investigation of U.S. counties. Resour Energy Econ 33(2):440–453
Koitsiwe K, Adachi T (2015) Relationship between mining revenue, government consumption, exchange rate and economic growth in Botswana. Contad Y Adm 60: 133–148.
Law SH, Moradbeigi M (2017) Financial development and oil resource abundance–growth relations: evidence from panel data. Environ Sci Pollut Res 24:22458–22475
Long XL, Chen YQ, Du JG, Oh KY, Han IS (2017) Environmental innovation and its impact on economic and environmental performance: evidence from Korean-owned firms in China. Energy Policy 107:131–137
Long XL, Luo YS, Sun HP, Tian G (2018) Fertilizer using intensity and environmental efficiency for China's agriculture sector from 1997 to 2014. Nat Hazards 92(3):1573–1591
Mehlum H, Moene K, Torvik R (2006) Institutions and the resource curse. Econ J 116(508):1–20
Mensah CN, Long X, Boamah KB, Bediako IA, Dauda L (2018) The effect of innovation on CO2 emissions of OCED countries from 1990 to 2014. Environ Sci Pollut Res 25:29678–29698
Michaels G (2011) The long term consequences of resource-based specialization. Econ J 121(551):31–57
Moradbeigi M, Law SH (2017) The role of financial development in the oil-growth nexus. Res Policy 53:164–172
Neumayer E (2004) Does the "resource curse" hold for growth in genuine income as well? World Dev 32:1627–1640
Ojakorotu V (2017) Resource control and conflict in Africa. In: Oloruntoba SO, Falola T (eds) The Palgrave Handbook of African Politics, Governance and Development. Palgrave Macmillan, New York, pp 367–385
Papyrakis E, Gerlagh R (2007) Resource abundance and economic growth in the United States. Eur Econ Rev 51(4):1011–1039
Qian XY, MIU RY, HU BW (2014) The human capital accumulation efficiency of educational input: a study based on the stochastic frontier educational production function model. Chinese Journal of Population Science 2:74–83
Ross ML (2015) What have we learned about the resource curse? Annu Rev Polit Sci 18:239–259
Sachs JD (2007) How to handle the macroeconomics of oil wealth. In: Humphreys M, Sachs JD, Stiglitz JE (eds) Escaping the resource curse. Columbia University Press, New York, pp 173–193
Sachs JD, Warner AM (2001) Natural resources and economic development: the curse of natural resources. Eur Econ Rev, 45(4–6): 827–838.
Satti SL, Farooq A, Loganathan N, Shahbaz M (2014) Empirical evidence on the resource curse hypothesis in oil abundant economy. Econ Model 42:421–429
Shahbaz M, Naeem M, Ahad M, Tahir I (2018) Is natural resource abundance a stimulus for financial development in the USA? Resour. Policy 55:223–232
Shao S, Qi ZY (2009) Energy exploitation and economic growth in western China: an empirical analysis based on the resource curse hypothesis. Frontiers of Economics in China 4(1):125–152
Shao S, Yang LL (2014) Natural resource dependence, human capital accumulation, and economic growth: a combined explanation for the resource curse and the resource blessing. Energy Policy 74(33):632–642
Shao S, Fan MT, Yang LL (2013) How does resource industry dependence affect economic development efficiency? Management World 2:32–63
Shao S, Liu JH, Geng Y, Miao Z, Yang YC (2016) Uncovering driving factors of carbon emissions from China's mining sector. Appl Energy 166:220–238
Shao S, Tian ZH, Fan MT (2018) Do the rich have stronger willingness to pay for environmental protection? New evidence from a survey in China. World Dev 105:83–94
Song ML, Wang JL, Zhao JJ (2018) Coal endowment, resource curse, and high coal-consuming industries location: analysis based on large-scale data. Resour Conserv Recycl 129:333–344
Stijns JPC (2005) Natural resource abundance and economic growth revisited. Res Policy 30(2):107–130
Sun YP, Ye CS (2011) Resource dependence, geographical location and urban economic growth modern economic. science 1:114–123
Sun HP, Geng Y, Hu LX, Shi LY, Xu T (2018a) Measuring China's new energy vehicle patents: a social network analysis approach. Energy 153:685–693
Sun HP, Sun WF, Geng Y, Kong YS (2018b) Natural resource dependence, public education investment, and human capital accumulation. Pet Sci 15(3):657–665
Van der Ploeg F (2011) Natural resources: curse or blessing? J Econ Lit 49:366–420
Van Der Ploeg F, Poelhekke S (2017) The impact of natural resources: survey of recent quantitative evidence. J Dev Stud 53:205–216
Van der Ploeg F, Venables T (2009) Symposium on resource rich economies introduction. Oxf Econ Pap 61:625–627
Venables AJ (2016) Using natural resources for development: why has it proven so difficult? J Econ Perspect 30:161–184
Weber JG (2014) A decade of natural gas development: the makings of a resource curse? Resour Energy Econ 37:168–183
Xu KN, Wang J (2006) An empirical study of a linkage between natural resource abundance and economic development. Economic Research Journal 1:78–89
Zhang FM et al (2016) Escaping the resource curse mining revenue factor allocation and social welfare. Business Press, Beijing

Zhou XJ, Guo PB (2015) On-spot transformation of coal resources and avoidance of the resource curse. Resources Science 37(2):318–324

Mr. Hua-ping Sun born in 1979 in Jining, Shandong Province, is a Ph.D. in Economics, Associate Professor in the School of Finance and Economics/Institute of Industrial Economics, Jiangsu University, and a post-doctoral fellow in the School of Environmental Science and Engineering, Shanghai Jiao Tong University. His main research field is low-carbon economics.

Mr. Wei-feng Sun born in 1980 in Linyi, Shandong Province, is a professor at Yuncheng University. His main research fields are resource economics and regional economics.

Mr. Yong Geng born in 1971 in Dalian, Liaoning Province, is a professor, dean of the School of Environmental Science and Engineering, Shanghai Jiao Tong University. His main research fields are industrial ecology and regional circular economy.

Ms. Xi Yang born in 1984 in Jining, Shandong Province, is a Ph.D. in Economics, Assistant Professor in the School of Finance and Economics/Institute of Industrial Economics, Jiangsu University. Her main research fields are public policy and banking economics.

Mr. Bless Kofi Edziah is a Ph.D. candidate in the School of Finance and Economics/Institute of Industrial Economics, Jiangsu University. His main research field is low-carbon economics.