AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

No endorsement of AgEcon Search or its fundraising activities by the author(s) of the following work or their employer(s) is intended or implied.

The Australian Journal of
Agricultural and
Resource Economics

AARES
AUSTRALASIAN AGRICULTURAL & RESOURCE ECONOMICS SOCIETY

Australian Journal of Agricultural and Resource Economics, 65, pp. 413–448

Curse or blessing: how does natural resource dependence affect city-level economic development in China?*

Xuan Xie, Ke Li, Zhiqiang Liu and Hongshan Ai†

Based on the 'resource curse' theory, this study uses panel data for 256 prefecture-level cities in China from 2003 to 2016 to test the relationship and mechanism between natural resource dependence and economic development. The panel model and instrumental variable regression results show that natural resources generally promote economic development, but for 109 resource-based cities, the influence of natural resources on economic development seems quite different. The panel threshold model shows that in the resource-based cities, (i) resources have a 'blessing effect' on economic development during economic prosperity (GDP growth rate is greater than 12.1 per cent); (ii) the relationship is not statistically significant when the GDP growth rate is between 5 per cent and 12.1 per cent; and (iii) when the GDP growth rate is lower than 5 per cent, natural resources have a 'curse effect' on economic development. Furthermore, the results of the mediation effect model show that the mediation effect of industrial diversification on the relationship between resource dependence and economic development suppresses the promotion of natural resource on economy. An excessive concentration of resource industries has a crowding-out effect on non-resource industries in resource-based cities, which reduces the level of industrial diversification and is not conducive to economic development.

Key words: mediation effect, natural resource dependence, resource curse, threshold panel model.

1. Introduction

Early economic theories highlight the positive effects of natural resources on economic growth (Murphy and Cummins 1989; Wright 1990). However, since the middle and later periods of the 20th century, countries and territories such as Japan, Taiwan, Singapore and Hong Kong have

* We acknowledge the financial support from the National Natural Science Foundation of China (Nos. 71804044, 71974054, 71773028, 71703120 and 71603079); the Hunan Natural Science Foundation (No. 2019JJ40039); Science Technology Innovation Platform and Talents Program of Hunan Province, China (2019TP1053); and Technical Service Items of Economic and Technological Research Institute in Hunan Electric Power Company (5216A220000A).

†Xuan Xie is an Associate Professor and Ke Li is a Professor at the Key Laboratory of Computing and Stochastic Mathematics (Ministry of Education of China), School of Mathematics and Statistics, Hunan Normal University, Changsha, Hunan 410081, China. Zhiqiang Liu is a Graduate Student at Hunan Normal University, Changsha, Hunan, China. Hongshan Ai (email: hongshanai@foxmail.com) is a Professor at School of Economics and Trade, Hunan University, Changsha 410082, Hunan, China. All authors contributed equally to this analysis.

© 2021 Australasian Agricultural and Resource Economics Society Inc.
doi: 10.1111/1467-8489.12423

experienced rapid economic growth despite their scarcity of resources; by contrast, economies with abundant resources such as Iran, Venezuela, Libya, Iraq and Kuwait have been declining. This has forced economists to re-examine the role of natural resources in the long-term economic growth process. Auty and Warhurst (1993) observed that countries with abundant natural resources grew more slowly than countries with relatively poor natural resources, and therefore proposed the 'resource curse' hypothesis. The conclusions in the literature on whether natural resources are a 'curse' or a 'blessing' to economic growth are inconsistent. Generally, the relevant research can be divided into three perspectives: natural resources are a 'blessing' (Boyce and Emery 2011; Weber 2014; Smith 2015); natural resources are a 'curse' (Moradbeigi and Law 2016; Badeeb and Lean 2017; Kim and Lin 2017; Song *et al.* 2018); or resources are a 'conditional curse' (Corden and Neary 1982; Kim and Knaap 2001; Mehlum *et al.* 2006; Mehrara 2009; Shao and Yang 2014) to economic growth.

Obviously, natural resources themselves do not have a 'curse' effect on human development. In order to unpack the black box of the 'curse effect' of natural resources, researchers have investigated the causes and transmission mechanisms of this phenomenon. Many scholars have revealed the reasons for the 'resource curse' from related research into the 'Dutch disease'. Corden and Neary (1982) analysed the development of the coastal areas of the Netherlands, showing that the large-scale excavations and exports of gas fields led to a significant increase in the exchange rate, which in turn led to a significant increase in imported products and ultimately caused a sharp decline in the productivity of the manufacturing sector of the country and, consequently, an unbalanced market economy. This reduced the ability of the region to sustain economic development. This type of phenomenon is therefore referred to as the 'Dutch disease' by scholars. Since then, Frankel (2012), Beine *et al.* (2012) and Pegg (2010) have further verified these mechanisms from different perspectives. The second economic channel through which the resource curse may operate is the volatile nature of natural resource prices in global markets. Economists have suggested that this volatility reduces economic growth, quite apart from trends in commodity prices (Davis and Tilton, 2005; Frankel, 2012).

In addition, government-related policy mechanisms play a crucial role in determining whether natural resources can effectively promote regional economic growth. If natural resources do not have clear property rights, it is easy for the government to find a stable and reliable source of income, the so-called rent-seeking phenomenon, which leads to a waste of resources. Therefore, some scholars have explained the 'resource curse' from the perspective of institutional quality and rent-seeking. The main representative scholars are Van der Ploeg (2011) and Deacon (2011). People seek political rents when they try to obtain benefits for themselves through their political influence. Many economists, such as Halvor *et al.* (2006), Iimi (2007), Deacon and Rode (2012), argue that in some countries, the windfall of resource

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

revenues increases the power of elites, who have the capacity to widen income inequalities.

Besides, scholars believe that the financial development is an efficient way for natural resources to influence economic growth (Pradhan *et al.* 2016; Nawaz *et al.*, 2019). Specifically, Zaidi *et al.* (2019) adopted the continuously updated fully modified ordinary least-squares (Cup-FMOLS) method to study the relationship among natural resources, financial development and economic growth. Khan *et al.* (2020) used panel cointegration techniques to test the 'resource curse' hypothesis in the case of China for the period of 1987–2017 and found that natural resource abundance is negatively linked with financial development in China.

To a large extent, areas with richer natural resources will allocate more labour into the resource industry sector. In the long run, the government and the people will have the illusion that there is a market demand only for labour with basic technical skills, thus ignoring regional educational development and the improvement of science and technology, which will have a seriously negative impact on the sustainable development of the economy in this region; consequently, it has a 'crowding-out effect'. Gylfason (2001) and Walker (2013) believe that a huge endowment of natural resources leads to overconfidence and the illusion of economic security, which will reduce the enthusiasm of local residents to invest in education and will lead to insufficient investment in human capital.

In addressing the 'resource curse', scholars have mainly discussed it from the perspective of industrial diversification, but the conclusions are not consistent. Dissart (2003) points out that if a region's economy aims to achieve steady growth, the basis is to have a relatively sound industrial structure. Hanson (2001) believes that the speed of economic development depends on the level of industrial diversification in this region. In contrast, Gao (2004) concluded that diversified industries did not have any impact on economic growth.

As for China, its economy has developed rapidly since the reform and opening-up in 1978. However, the country also has a large population and its per capita resources are scarce. In addition, the distribution of resources in various regions of China is not related to their economic development level. The uneven distribution of primary energy production is the most prominent example. Specifically, the eastern region in China is scarce in natural resources, while the western region enjoys an abundance. According to the China Energy Statistical Yearbook, in 2016, primary energy production in the eastern, central, north-eastern and western regions of China was 330, 860, 180 and 1800 million tons of coal equivalent, respectively, of which the total output in the western region accounted for 56.9 per cent; with more than half of the country's output, it has the highest concentration of primary energy distribution. In terms of primary energy production, coal, crude oil, natural gas, electricity and others produced in the western region accounted for 57.1 per cent, 35.2 per cent, 90.8 per cent and 54.9 per cent of the corresponding

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

national totals, respectively; the corresponding proportions in the eastern region were 6.6 per cent, 37.7 per cent, 2.3 per cent and 30.0 per cent. However, comparing the economic development measured by GDP per capita, we found that the average per capita GDP of the eastern region and western region is 84,000 Yuan and 44,000 Yuan, respectively. Whether there is a 'resource curse' problem in the western regions of China is an issue scholars have studied from different aspects (Fang *et al.* 2011; Shao *et al.* 2013; Li and Xu 2018). However, at the city level, do all cities in China face the same resource curse? Are there different effects of natural resources on economic development at various stages of economic cycle? Is the strategy for developing diversified industries proposed by existing research effective in resolving the 'resource curse' at the city-level in China? Existing research does not lead to clear conclusions on the above issues.

This paper makes three main contributions to the literature. First, compared with previous studies, the city classification of this paper is more accurate and the results are relatively more scientific. We take 256 prefecture-level cities in China as the sample and divide them into 109 resource-based cities (RBCs) and 147 non-resource-based cities (NRBCs) based on the National Sustainable Development Plan for Resource-based Cities (2013–2020) issued by the State Council of China; then, the relationship between natural resource dependence and economic development is analysed using panel data from 2003 to 2016. The results show that, in general, dependence on natural resources has a positive effect on the development of urban economies. However, for resource-based cities, this positive effect of natural resources has been largely suppressed.

The second contribution of this paper is that we verify the existence of the threshold effect between natural resource dependence and economic development. Specifically, we discuss the effects of natural resource dependence on economic development under different economic growth rates. The results reveal that natural resources can be observed as having a 'blessing effect' or 'curse effect' according to different GDP growth rates in the previous period. Particularly, when the economy is at a low-speed growth stage (growth rate less than 5 per cent for resource-based cities), natural resource dependence has a 'curse effect'.

Finally, this paper uses the mediation effect model to analyse the effect of industrial diversification on the relationship between resource dependence and economic development, and find that in the resource-based cities, the indirect effect of industrial diversification is manifested as a suppression effect. This is because abundant natural resources lead to excessive concentration of resource industries, which has a crowding-out effect on non-resource industries, thereby reducing industrial diversity and going against economic development. This is the third contribution of this article.

The structure of this study is as follows. The second part is mainly concerned with the study object and variable selection; the third part provides the basic regression results and some robustness checks; the fourth part tests

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

the economic cycle effect between natural resource dependence and economic development; the fifth part tests the mediation effect of industrial diversification; and finally, the sixth part provides the conclusion and countermeasures.

2. Study objects, variable selection and data sources

2.1 Study objects

According to the National Sustainable Development Plan for Resource-based Cities (2013–2020) issued by the State Council of China, resource-based cities are distributed across 24 provinces in China, including 110 prefecture-level resource-based urban administrative regions. Figure 1 shows the distribution

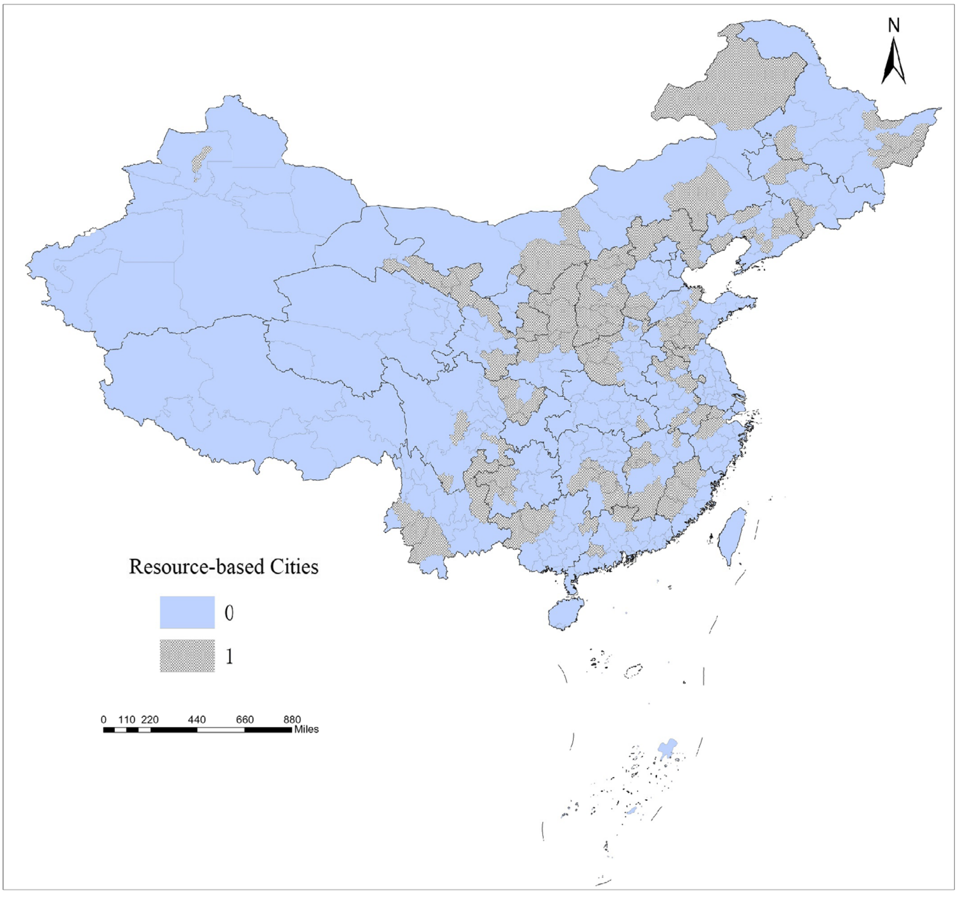

Figure 1 The distribution of resource-based cities.
Note: 1 represents RBCs, and 0 represents NRBCs. [Colour figure can be viewed at wileyonline library.com]

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 1 Number of RBCs in each province

Province	Number	Province	Number	Province	Number	Province	Number	Province	Number
Hebei	5	Shanxi	10	Neimenggu	5	Liaoning	6	Jilin	3
Jiangsu	2	Zhejiang	1	Heilongjiang	5	Anhui	9	Jiangxi	5
Shandong	7	Henan	7	Hubei	2	Hunan	4	Guangdong	2
Guangxi	3	Guizhou	3	Yunnan	5	Shaanxi	6	Gansu	7
Ningxia	1	Xinjiang	1	Fujian	3	Sichuan	8		

of 110 prefecture-level resource-based cities across the country; Table 1 shows the number of the resource-based cities in each province. It can be seen from Table 1 that 60 of the 110 resource-based cities are distributed in the central region, accounting for 54.5 per cent; 31 are distributed in the western region, accounting for 28.2 per cent; and 14 and 29 are distributed in the eastern and north-eastern regions, respectively, accounting for 12.7 per cent and 17.3 per cent of all resource-based cities.

To explore the relationship between natural resource dependence and economic development in prefecture-level cities in China, this study divides cities into resource-based cities (RBCs) and non-resource-based cities (NRBCs). Specifically, there are 109 resource-based prefecture-level cities (excluding Bijie due to missing data). For NRBCs, we select 147 prefecture-level cities with complete data. Therefore, the paper selects 256 prefecture-level cities' data as the research object, to analyse the relationship between natural resource dependence and economic development.

2.2 Variable description

2.2.1 Natural resource dependence

The purpose of this paper was to explore the role of regional natural resource dependence on economic development and its transmission mechanism. Therefore, natural resource dependence is the core explanatory variable.

There are many indicators that can be used to measure natural resource dependence. Ding *et al.* (2007) used the ratio of workers' income in mining industries to the total income of regional employees; and Shao and Qi (2008) adopted the ratio of the output value of the energy industry to the total industrial output value. These indicators are closely related to GDP. If the GDP of urban areas grows at a faster rate, then this growth can easily be considered to be related to the lack of natural resources. At the same time, when we use variables related to GDP, such as GDP per capita and GDP growth rate as explanatory variables, it is easy to frame problems as being 'endogenous' and to conclude that there is a 'resource curse'.

Therefore, we use the ratio of the number of employees in the mining industry to the number of people in the local population to measure natural resource dependence. The mining industry contains many subsectors in the

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

resource industry, which are closely related to natural resources. It can relatively comprehensively cover many factors involved in natural resource development and to a certain extent can reflect the existing state of the resource. Since the total population of each urban area is generally stable, the variable denominator we selected is the total size of the local population, which can to a certain extent avoid possible endogeneity problems. The data come from the China City Statistical Yearbook.

2.2.2 The variable of economic development

This paper measures economic development by real GDP per capita (expressed as *PGDP*). The average annual growth rate of *PGDP* in 2003–2016 is adopted to measure the degree of regional economic growth; its calculation formula is $\frac{1}{13}\ln\frac{PGDP_{2016}}{PGDP_{2003}}$. The data come from the China Urban Statistical Yearbook.

Figure 2 shows the relationship between resource dependence and economic growth. The black line represents the linear fit of all samples, while the red line is the linear fit after removing the city with the highest resource dependence (the resource dependency of Karamay City in Xinjiang Province is 17.65 per cent). It can be seen from the figure that the natural resource dependence of non-resource cities is basically between 0 per cent and 1 per cent, and most cities with relatively high natural resource dependence are RBCs, indicating that RBCs are more inclined to develop resource-based industries and thus have a relatively high natural resource dependence. In addition, Figure 2 clearly shows that there is a significant negative relationship between resource dependence and the growth rate of real GDP per capita, which means that in 2003–2016, the economic growth rate of regions

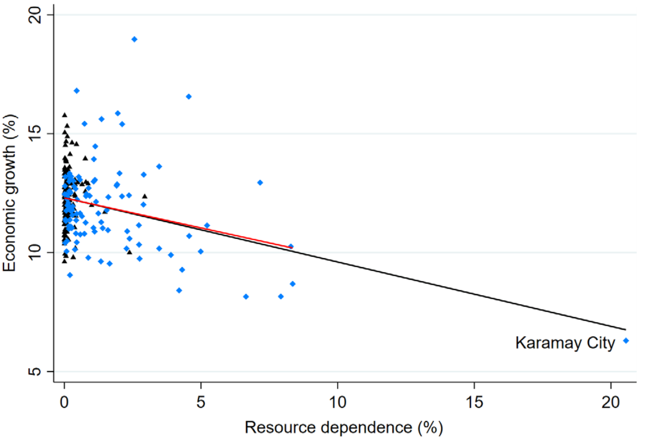

Figure 2 The relationship between resource dependence and economic growth. *Note*: The black points represent NRBCs, and the blue points represent RBCs. [Colour figure can be viewed at wileyonlinelibrary.com]

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

with high resource dependence is lower than that of low resource dependence areas.

2.2.3 Control variables

In addition to the above-mentioned core variables affecting economic development, the existing literature provides examples of seven variables closely related to the ‘resource curse’, mentioned below as control variables. In order to explore other transmission mechanism variables of the resource curse, this paper mainly considers the impact of industrial diversification on economic development. The relevant data sources for the following control variables are the China City Statistical Yearbook.

Industrial diversification index (IDV). Browning and Singelmann (1975) summarise the subsectors in the China City Statistical Yearbook into six categories: primary industry, secondary industry, liquidity service industry, social service industry, production service industry and consumer service industry. Based on these six industrial categories, the Hirschman –Herfindahl index (*HHI*) is used to construct an industrial structure diversification index. The *HHI* is derived from the proportion of the number of employed people in each subsector of the region; its value is obtained by squaring this ratio, with the calculation formula being $HHI_i = \sum_j s_{ij}^2$. To facilitate easier explanations, this paper uses the reciprocal of the *HHI* to measure industrial diversification; in other words, the industrial structure diversification index (*DI*) of the *i*-th region is calculated by the following formula:

$$DI_i = \frac{1}{\sum_j s_{ij}^2}$$

where s_{ij} refers to the ratio of the labour of industry j of city i to the total labour in the city. If the industrial intensities of all departments in a region are high, they can be regarded as representing only one industrial sector and the value of *DI* will at least be equal to 1. If the diversity level of a region is higher, the value of *DI* is larger.

However, the *DI* value is an absolute value. Considering that natural resource dependence is a relative indicator, this paper constructs a relative industrial diversification index (*IDV*) to compare the industrial structure of each region. The calculation method is as follows:

$$IDV_i = \frac{1}{\sum_j \left| s_{ij} - s_j \right|}$$

Here, s_{ij} refers to the ratio of the labour of industry j of city i to the total labour in the city; s_j refers to the ratio of the labour of industry j to the total labour nationwide.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

If the gap between different industries in a certain region is relatively small and the distribution is relatively balanced, the industrial diversification of the region will have a higher level; if the industries in the region are relatively concentrated, the industrial gap will be large and industrial diversity will be at a low level.

Investment in physical capital (PC). This study uses the ratio of fixed asset investment to GDP to measure the investment in physical capital.

Scientific and technological level (ST). The ratio of the expenditure of scientific undertakings in the local budget to GDP is used to measure *ST*.

Degree of government intervention (GI). The implementation of relevant government policies plays a very important role in the economic development of regions. In particular, prefecture-level governments often administer significant resources; therefore, the government's decisions will affect the overall direction of the entire region's economy. The government's asset investments will directly affect the demand and supply relationships underlying the region's economic development, so here we use the ratio of fiscal expenditure (after deducting education and science expenditures) to GDP to measure *GI*.

Human capital level (HC). In general, average education years or educational expenditures are measures applicable to HCs; considering the availability of data, we use the ratio of the total number of primary, secondary and various types of college teachers to the total local population to measure *HC*.

Private economy development level (PE). This paper uses the ratio of private and individual business employees in the region to the total population of the city to measure *PE*.

Table 2 Statistical description of the full-sample variables

Variables	Obs	Mean	SD	Min	Max
PGDP	3584	27417.93	29636.72	1924.86	331115.2
RD	3584	0.7907	1.9119	0.0003	23.8976
IDV	3584	1.2631	0.5148	-0.3772	3.4230
PC	3584	0.6356	0.2699	0.1022	2.1969
ST	3584	0.1623	0.2142	0.0015	6.3100
GI	3584	12.3786	6.9723	2.8058	145.5586
HC	3584	0.9051	0.2188	0.4397	2.7973
PE	3584	10.1342	12.3523	0.2725	173.0881
OP	3584	2.0458	2.3003	0.0012	37.6834

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 3 Statistical description of resource-based cities sample variables

Variables	Obs	Mean	SD	Min	Max
PGDP	1526	22481.06	21788.45	1924.86	168638.3
RD	1526	1.6187	2.6837	0.0013	23.8976
IDV	1526	1.2160	0.4858	−0.0542	2.5452
PC	1526	0.6745	0.2909	0.1022	2.1969
ST	1526	0.1373	0.2221	0.0015	6.3100
GI	1526	13.5996	8.0521	2.8058	91.0967
HC	1526	0.8877	0.1431	0.4397	1.5363
PE	1526	7.6662	6.2032	0.2725	86.2978
OP	1526	1.4283	1.6189	0.0012	11.6142

Degree of regional openness (OP). Import and export values or foreign direct investment are often used in the literature to measure openness. Due to the lack of data on imports and exports in some prefecture-level cities in China, this paper uses the ratio of foreign direct investment to GDP to measure *OP*.

2.2.4 Descriptive statistics

Table 2 shows the statistical description of the core variables and control variables of the full sample. Table 3 shows the statistical description of the core variables and control variables of the RBCs.

From Table 2 and Table 3, the real GDP per capita of RBCs is less than the real GDP per capita of the full sample. That is, RBCs have richer natural resources, but their average development level is lower than that of NRBCs. The natural resource dependence of RBCs is higher than that of the full sample, indicating that China's RBCs are different from other regions in terms of industrial structure, and RBCs with relatively abundant resources rely more on natural resource industries. The industrial diversification of RBCs is lower than that of the full sample, which may indicate that the industrial sector is too concentrated in the RBCs, with the development of natural resource departments being emphasised, while the coordinated development of other economic sectors is neglected.

For regions with relatively low economic development level – supposing that they have rich natural resources – if they increase the exploitation and use of natural resources and increase the dependence of the region on natural resources, they will indeed stimulate the rapid development of the regional economy in the short term. However, in the long run, excessive dependence on natural resources can easily lead to the 'resource curse' phenomenon. However, as the dependence on natural resources changes in different periods, the level of economic development will also change, and the corresponding industrial diversification will be different. To maintain the sustainable development of the regional economy, it is necessary to accommodate the different stages of natural resource dependence. In this

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

sense, it is necessary to analyse the 'resource curse' from the perspective of industrial diversification and economic cycles.

3. Basic model and empirical results

3.1 Baseline regressions

We divide 256 prefecture-level cities into 109 prefecture-level RBCs and 147 prefecture-level NRBCs. According to National Sustainable Development Plan for Resource-Based Cities (2013–2020), resource-based cities are defined as cities in which the mining and processing of natural resources such as minerals and forests in the region are the leading industries. Although RBCs have a higher degree of natural resource dependence than NRBCs, this type of city classification is not only related to the resource dependence, but also related to the characteristics of the city's industrial structure and so on. We analyse the impact of resource dependence on the regional economic development level in different types of city and construct the following measurement models:

$$\ln y_{it} = \beta_0 + \beta_1 RD_{it} + \beta_2 Z_i * RD_{it} + \boldsymbol{C}_{it} A + u_i + \eta_t + \varepsilon_{it} \quad (1)$$

where y_{it} represents the real GDP per capita (*PGDP*) of year t in city i, RD_{it} represents the resource dependence of year t in city i, and Z_i is a dummy variable with value 1 when the city i is a resource-based city and 0 for a non-resource-based city; u_i and η_t represent regional and time effects, respectively; and $\boldsymbol{C}_{it}$ is a matrix of control variables, including the six variables specified above, namely *PC*, *ST*, *GI*, *HC*, *PE* and *OP*.

For the analysis of panel data, we generally have three choices: the fixed-effects model, the random-effects model and the mixed regression model. The appropriate choice for the corresponding data is directly related to the accuracy of the empirical research. To check this, we generally verify the three models through the F and Hausman tests. The value of the *F*-test is 48.23 (*P*-value = 0.00), while the value of the Hausman test is 255.51 (*P*-value = 0.00). The results show that the fixed-effects model is preferred. Therefore, we use the fixed-effects method to estimate equation (1) and the empirical results are shown in Panel A of Table 4.

In Panel B of Table 4, we employed the panel cointegration tests to check whether the relationship between natural resource dependence and economic development revealed by the panel fixed-effects models is credible in the long term. The cross-section dependence test and panel unit root tests (shown in Table A1 and Table A2 in Appendix) indicate all the variables are integrated of order one (i.e. I(1)). Then, two panel cointegration tests proposed by Pedroni (1999, 2004) and Westerlund (2005) were adopted. The results in Panel B of Table 4 indicate that the null hypothesis, that is there is no cointegration relationship among variables, can be strongly rejected. These

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 4 Estimation of the impact of natural resource dependence on economic development and panel cointegration tests

Models	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Panel fixed-effects model								
RD	0.038**	0.037**	0.038**	0.039**	0.039**	0.039**	0.039**	−0.001
	(2.24)	(2.18)	(2.29)	(2.35)	(2.34)	(2.36)	(2.35)	(−0.34)
*Z*RD*	−0.038**	−0.037**	−0.039**	−0.041**	−0.041**	−0.042**	−0.042**	
	(−2.22)	(−2.20)	(−2.31)	(−2.45)	(−2.43)	(−2.45)	(−2.45)	
PC		0.043***	0.043***	0.058***	0.057***	0.057***	0.057***	0.057***
		(4.74)	(4.71)	(6.17)	(6.09)	(6.02)	(5.93)	(5.92)
ST			−0.042***	−0.041***	−0.041***	−0.041***	−0.041***	−0.040***
			(−4.74)	(−4.73)	(−4.66)	(−4.63)	(−4.62)	(−4.56)
GI				−0.002***	−0.002***	−0.002***	−0.002***	−0.002***
				(−6.37)	(−6.38)	(−6.40)	(−6.40)	(−6.35)
HC					−0.010	−0.008	−0.008	−0.010
					(−0.50)	(−0.39)	(−0.38)	(−0.47)
PE						−0.000	−0.000	−0.000
						(−0.65)	(−0.64)	(−0.55)
OP							0.000	0.000
							(0.06)	(0.10)
Constant	9.093***	9.077***	9.078***	9.094***	9.103***	9.102***	9.102***	9.106***
	(1605.97)	(1381.12)	(1384.39)	(1308.58)	(460.86)	(460.04)	(442.86)	(444.63)
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3584	3584	3584	3584	3584	3584	3584	3584
Panel B: Panel cointegration test								
Pedroni cointegration test (H0: no cointegration; H1: all panels are cointegrated)								
Modified PP	19.805***	20.874***	22.570***	24.673***	28.289***	31.244***	–†	29.607***
PP	16.557***	8.852***	4.213***	1.432*	−5.320***	−8.040***	–†	−20.687***
ADF	24.469***	13.759***	5.559***	2.032**	−3.618***	−4.960***	–†	−15.108***
Westerlund cointegration test (H0: no cointegration; H1: some panels are cointegrated)								
Variance ratio	34.665***	29.203***	25.812***	29.564***	31.041***	36.228***	–†	27.131***

Note: The values in parentheses are *t* values, and *, ** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent, respectively.
†Panel cointegration tests were not adopted in Model (7), because the number of regressors may not exceed 7 in these two tests.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 5 The differences in the relationship between natural resource dependence and economic development between NRBCs and RBCs

	NRBCs (Z = 0)		RBCs (Z = 1)	
	(9)	(10)	(11)	(12)
RD	0.048***	0.053***	−0.001	−0.005
	(3.18)	(3.74)	(−0.40)	(−1.64)
Control variables	None	All	None	All
Year	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
N	2058	2058	1526	1526

Note: The values in parentheses are *t* values, and *, ** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent, respectively.

results confirm the consistency of estimator by using the ordinary least-squares (OLS) method (Saboori and Sulaiman 2013; Hdom and Fuinhas 2020). Therefore, the results in Panel A reveal a credible long-term relationship, rather than a spurious regression.

According to Table 4, if the city types are not distinguished, the coefficient of *RD* is not significant (see Column (8)), indicating that the impact of *RD* on economic development is not clear in the full sample. However, after using the dummy variable *Z* to distinguish the city types, no matter what control strategy we adopt, the estimated coefficients of the variables *RD* and *Z*RD* are significant at the 5 per cent level, indicating that the above estimation results are robust. Specifically, all the estimated coefficients of the *RD* variable are positive, indicating that natural resource dependence has a positive effect on the economy development in NRBCs; all the estimated coefficients of the *Z*RD* variable are negative, indicating that in RBCs, the positive impact of resource dependence on economic development is much smaller than that in NRBCs. However, the absolute values of estimated coefficients of the variables *RD* and *Z*RD* are not much different, so it is difficult to judge the sign of the influence of *RD* on economic development in RBCs. Therefore, we performed regressions on RBCs and NRBCs, respectively (see Table 5). The results also show that for NRBCs, *RD* has a positive effect on economic development, while for RBCs, this effect is negative but not significant.

The above results imply that the impact of resource dependence on economic development may have different mechanisms between different types of cities. In NRBCs, natural resources are not abundant, and economic development does not rely on resource-based industries. As production factors, natural resources are conducive to the economic growth and development of NRBCs. Therefore, natural resources play a 'blessing effect' on economic development. For RBCs, although natural resources can still play the role of production factor to promote economic development, if they

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

rely excessively on natural resources, it is easy to contract the ‘Dutch disease’, which makes the resource-based industrial sector over-concentrated and shrinks the manufacturing industry, thereby offsetting the positive impact of natural resources on economic development, and even causing a ‘curse effect’.

3.2 Endogeneity issue

3.2.1 IV regressions

The key explanatory variable of this analysis is natural resource dependence, which is endogenous to economic development to a certain extent, so when studying the relationship between resource dependence and economic development, it cannot be regarded as an exogenous variable (Wright and Czelusta 2004; Shao and Yang 2014). In addition, the dummy variable Z that distinguishes city categories in this analysis comes from the central government’s definition of resource-based cities, and is also affected by factors such as the level of regional economic development, so it cannot fully meet the exogenous requirements. Therefore, we use the instrumental variable estimation method to solve the endogeneity problem, thereby verifying the impact of resource dependence on economic development.

We have selected three variables as the instrumental variables (IV) of RD and $Z^{*}RD$, namely coal reserves, number of employees in the mining industry and number of mining accidents.

Coal reserves. Coal reserves are natural resource endowments and are usually regarded as exogenous variables. Coal resources are widely distributed in China and are suitable as a representative of natural resources. Generally, the richer the resource reserves, the higher the local resource dependence. Since there is no coal reserve data for prefecture-level cities, we use the data of the province where the prefecture-level city is located instead. The data come from China Statistical Yearbook.

Number of employees in the mining industry (2002). The variable of employee number before the sample period can satisfy the exogeneity condition. The more people employed in the mining industry, the higher the natural resource dependence. The data come from China City Statistical Yearbook.

Number of mining accidents. We choose the average number of mining accidents in each region from 1995 to 1998. The number of mining accidents that occurred before the sample interval is exogenous from our regression model system. In addition, more mining accidents may indicate that the city’s natural resources are abundant and resource dependence is high. The data come from China Labour Statistical Yearbook.

In order to comprehensively analyse the impact of RD on economic development in different types of cities, we conducted three instrumental variable regressions. The results are shown in Table 6. In IV regression (1),

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 6 IV regression results of the relationship between resource dependence and economic development

	IV regression (1) (Z = 1 denotes RBCs)				IV regression (2) (Z' = 1 denotes NRBCs)				IV regression (3) Full sample		
	2sls estimation			GMM	2sls estimation			GMM	2sls estimation		GMM
	1st stage		2nd stage		1st stage		2nd stage		1st stage	2nd stage	
	RD	*Z*RD*			*RD*	*Z'*RD*			*RD*		
RD			0.896***	0.885***			−0.028	−0.026		0.029***	0.031***
			(3.59)	(3.58)			(−1.55)	(−1.48)		(3.49)	(3.72)
*Z*RD*			−0.923***	−0.911***							
			(−3.50)	(−3.49)							
*Z'*RD*							0.923***	0.911***			
							(3.50)	(3.49)			
IV: ln coal reserves	0.070***	0.061***			0.070***	0.009***			0.081***		
	(5.74)	(4.92)			(5.74)	(4.50)			(6.88)		
IV: ln number of workers (2002)	0.511***	0.479***			0.511***	0.032***			0.507***		
	(24.55)	(22.35)			(24.55)	(10.78)			(24.38)		
IV: ln number of accidents	0.100***	0.186***			0.100***	-0.086***					
	(2.61)	(4.38)			(2.61)	(−4.15)					
Control variables	All	All	All	All	All	All	All	All	All	All	All
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region	No	No	No	No	No	No	No	No	No	No	No
N	3584	3584	3584	3584	3584	3584	3584	3584	3584	3584	3584
adj R^2	0.274	0.238	0.591	0.595	0.274	0.078	0.591	0.595	0.273	0.724	0.723
F(Wald)	38.84	32.85	4545.21	4711.56	38.84	6.66	4545.11	4711.52	40.61	5704.48	5883.77
Weak instruments Test (MES)	22.73				22.73				558.09		
Sargan test (score Chi2(1)) /Hansen's J statistics	0.428 [0.5129]				0.429 [0.5127]				3.048 [0.0809]		
DWH test (score Chi2(2))	42.68 [0.0000]			42.28 [0.0000]	42.68 [0.0000]			42.28 [0.0000]	10.32 [0.0013]		8.81 [0.0030]

Note: The prefix 'ln' before the explanatory variables denotes taking the logarithmic form. The values in parentheses are *t* values or *Z* values, and the values in brackets are *P*-values. *, ** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent, respectively.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

$Z = 1$ refers to RBCs, so the coefficient of *RD* represents the impact of *RD* on economic development in NRBCs, and the coefficient of Z^*RD represents the difference between this impact in RBCs and that in NRBCs. In IV regression (2), $Z' = 1$ denotes NRBCs, so the coefficient of *RD* represents the impact of *RD* on economic development in RBCs, and the coefficient of Z'^*RD represents the difference between this impact in NRBCs and that in RBCs. In IV regression (3), without adding city type variables, the coefficient of *RD* represents the impact of *RD* on economic development in the full sample. In IV regression (1) and IV regression (2), we use all three IVs to perform two-stage least-squares estimation and GMM estimation. In IV regression (3), because there is only one endogenous explanatory variable – *RD*, in order to prevent the problem of over-identification, only two instrumental variables – coal reserves and number of employees (2002) – are used.

Table 6 reports the results of both 2SLS and GMM estimations of the three IV regression models. In fact, IV regression (1) and IV regression (2) represent the same regression model. As shown in the table, in the first-stage regression of these three models, the coefficients of all IVs are significant at 1 per cent level, which means the IVs are strongly correlated with the endogenous explanatory variables. The minimum eigenvalue statistics are all much greater than 10, indicating the IVs all pass the weak IV test. The Sargan test results (or Hansen's J Statistics) show that all IVs are valid and exogenous at least at 10 per cent significance level.

According to the results of second-stage regressions, in the full sample, *RD* has a positive impact on economic development (0.029, significant at 1 per cent level). In the NRBCs, this positive effect (0.896) is much greater than that in the full sample. In the RBCs, the impact of *RD* on economic development is still negative and not significant. The results of GMM estimation are very similar to those of 2SLS estimation. Thus, after using IV regression to address the endogeneity problems, the relationships between *RD* and economic development both in RBCs and in NRBCs are found to be robust.

3.2.2 Dynamic regressions

In the baseline regressions, we adopted a static analysis without considering the dynamic nature of each variable, especially the dependent variable, economic development, which is highly correlated with its lagged term. Moreover, there are concerns that static panel estimators may not adequately account for potential endogeneity concerns in the relationships between natural resource dependence and economic development (Mawejje 2019). Therefore, we re-estimate the models following the dynamic panel generalised methods of moment (GMM) estimators. The empirical dynamic model that we estimate is provided in equation (2).

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 7 Dynamic panel data model (system GMM)

	(d1)	(d2)	(d3)	(d4)	(d5)	(d6)	(d7)	(d8)
$\ln y_{it-1}$	0.954***	0.938***	0.935***	0.936***	0.935***	0.945***	0.946***	0.944***
	(307.07)	(161.31)	(149.79)	(151.81)	(149.45)	(120.56)	(118.63)	(119.96)
RD	0.175**	0.194**	0.198**	0.198**	0.175**	0.169**	0.169**	−0.005
	(2.44)	(2.42)	(2.43)	(2.45)	(2.21)	(2.10)	(2.08)	(−0.89)
*Z*RD*	−0.182**	−0.198**	−0.202**	−0.203**	−0.181**	−0.174**	−0.173**	
	(−2.57)	(−2.50)	(−2.51)	(−2.53)	(−2.33)	(−2.20)	(−2.19)	
PC		0.044***	0.043***	0.045***	0.052***	0.051***	0.051***	0.053***
		(3.44)	(3.49)	(3.42)	(3.93)	(3.89)	(3.94)	(4.18)
ST			0.017	0.017	0.014	0.014	0.013	0.014
			(1.16)	(1.16)	(1.22)	(1.21)	(1.20)	(1.33)
GI				−0.0001	−0.0001	−0.0001	−0.0001	−0.0001
				(−0.49)	(−0.66)	(−0.58)	(−0.65)	(−0.44)
HC					0.158**	0.177**	0.182**	0.164*
					(2.01)	(2.39)	(2.37)	(1.87)
PE						−0.001**	−0.002**	−0.002**
						(−2.22)	(−2.25)	(−2.35)
OP							0.002	0.002
							(1.19)	(1.18)
Constant	0.544***	0.664***	0.692***	0.690***	0.552***	0.457***	0.437***	0.483***
	(16.30)	(12.77)	(12.39)	(12.50)	(6.44)	(4.54)	(4.07)	(4.50)
AR1 test (*P*-value)	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
AR2 test (*P*-value)	0.321	0.457	0.474	0.480	0.603	0.840	0.835	0.765
N	3328	3328	3328	3328	3328	3328	3328	3328

Note: The values in parentheses are *t* values, and *, ** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent, respectively. AR1 and AR2 test, respectively, represent the first-order and second-order autocorrelation tests of the difference in disturbance term, and the null hypothesis is that there is no autocorrelation.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

$$\ln y_{it} = \beta_0 + \rho \ln y_{it-1} + \beta_1 RD_{it} + \beta_2 Z_i * RD_{it} + \boldsymbol{C}_{it} A + u_i + \varepsilon_{it} \quad (2)$$

where y_{it-1} is the lagged term of y_{it}, and it represents the real GDP per capita (*PGDP*) of year *t*-1 in city *i*. The other variables and parameters are the same as those in equation (1).

For dynamic panel data, because the explanatory variable is related to the disturbance term, the general within-group estimator (fixed-effects estimate) is also inconsistent. This phenomenon is called 'dynamic panel bias'. In order to solve this kind of bias, the differential GMM method (Arellano and Bond 1991) and the system GMM method (Blundell and Bond 1998) can be used to estimate the dynamic panel equation. In this study, we adopt the two-stage system GMM method (Windmeijer 2005) to estimate equation (2), and the results are shown in Table 7.

Table 7 shows that the lagged economic development ($\ln y_{it-1}$) has high persistence, ranging from 0.935 to 0.954, which is statistically significant at the 1 per cent level. The parameters of *RD* and *Z*RD* in Table 6 are consistent with Table 4. In the full sample (see Column (d8)), the impact of natural resource dependence on economic development is negative but not significant. However, in the other seven models, the coefficients of *RD* are all positive and the coefficients of *Z*RD* are all negative at 5 per cent significance level. The results show that from the perspective of dynamic changes, in NRBCs, natural resources have a significant positive impact on the level of economic development, while for RBCs, this positive impact is greatly reduced. This is consistent with Section 3.1, indicating the robustness of this conclusion: in the non-resource-based cities, the natural resource is a 'blessing' for economic development, while in resource-based cities, this 'blessing effect' has gone.

4. Analysis of the threshold effect of natural resource dependence on economic development

The above conclusions only reflect the overall impact of natural resource dependence on economic development, and unfortunately, it is still not clear how resource dependence affects economic development in resource-based cities. In fact, the relationship between natural resource dependence and urban economic development is not linear, but is affected by many factors (Halvor *et al.* 2006; Boschini and Roine 2007). These factors will affect whether natural resources cause the 'blessing effect' or the 'curse effect', and include institutional factors, manufacturing level and marketisation degree.

Regional economic growth rates will also affect the impact of natural resource dependence on economic development. For example, in the 2000s, when China's economic growth rate was quite high, typical resource-based cities were always in the news with their amazing wealth, while after the

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

slowdown of China's economic growth in recent years, the topic of how to transform resource-based cities has begun to attract attention again.

The economic growth rate reflects the region's stage of the economic cycle. In the short term, the impact of resource dependence on the economy will vary greatly in different stages of the economic cycle. In order to explore the influence of resource dependence on cities' economic development under different economic growth rates, this paper uses the panel threshold model for further analysis.

4.1 Setting and estimation method of the threshold panel model

Based on the above theoretical analysis, this paper discusses the possible nonlinear relationship between natural resource dependence and economic development. In order to prevent errors caused by subjectivity, we refer to the panel threshold model proposed by Hansen (1999), which can better explore the regular characteristics of the data and then scientifically and rationally distinguish the stages. The basic panel threshold regression model can be expressed as follows:

$$\ln y_{it} = \mu_i + \beta_1 RD_{it} I(q_{it} \leq \gamma) + \beta_2 RD_{it} I(q_{it} > \gamma) + \theta' x_{it} + \varepsilon_{it} \tag{3}$$

Here, i refers to different regions; t refers to time; $\ln y_{it} and RD_{it}$ refer to per capita real GDP and natural resource dependence; x_{it} refers to a set of control variables that have an impact on the level of economic development, including *PC*, *HC*, *ST*, *PE*, *OP* and *GI*; θ' refers to the coefficient vector; q_{it} refers to the threshold variable in the model; γ refers to an estimated threshold, which divides the equation into two regimes with coefficients β_1 and β_2; $I(\bullet)$ refers to a indicator function; μ_i refers to fixed effects in each prefecture-level city; and $\varepsilon_{it} \sim iidN(0, \sigma^2)$ refers to a random interference term.

In fact, if the influence of the threshold variable on the relationship between *RD* and economic development is more complicated, then there may be more than one threshold in the model. Taking two thresholds as an example, the corresponding model is constructed as follows:

$$\ln y_{it} = \mu_i + \beta_1 RD_{it} I(q_{it} \leq \gamma_1) + \beta_2 RD_{it} I(\gamma_1 < q_{it} \leq \gamma_2) + \beta_3 RD_{it} I(q_{it} > \gamma_2) + \theta' x_{it} + \varepsilon_{it} \tag{4}$$

Here, γ_1 and γ_2 are the thresholds that divide the equation into three regimes with coefficients β_1, β_2 and β_3. The estimation of the double-threshold value should be based on a single-threshold model; we need to fix the previously estimated $\hat{\gamma}_1$ and assume it is known, and then calculate the second threshold value γ_2, thereby obtaining the desired result. The expression is as follows:

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

$$S_2^r = \begin{pmatrix} S(\hat{\gamma}_1, \gamma_2) if \hat{\gamma}_1 < \gamma_2 \\ S(\gamma_2, \hat{\gamma}_1) if \gamma_2 < \hat{\gamma}_1 \end{pmatrix} \tag{5}$$

$$\widehat{\gamma}_2^r = \underset{\gamma_2}{argmin} S_2^r(\gamma_2) \tag{6}$$

Bai (1997) tests that $\widehat{\gamma}_2^r$ is a progressively effective value and further evaluates $\widehat{\gamma}_1$. After repeated searching, we can calculate a valid estimated $\widehat{\gamma}_1^r$, which is better in establishing a more precise double-threshold model.

The choice of threshold variable is the focus of this section. Our purpose is to explore the impact of the region's stage of economic cycle on the effect of *RD*, so naturally, we first consider whether the real GDP growth rate (denoted as GGDP, or *g* for short) can be used as a threshold variable. But, Hansen (1999) requires the threshold variable to be exogenous, that is the variable is not affected by the explained variable, per capita real GDP (*PGDP*), but the current GGDP(g_{it}) cannot meet this condition. Therefore, we use the lagged GGDP (g_{it-1}) as the threshold variable. The current *PGDP* cannot affect the real GDP growth rate of the previous period. In other words, g_{it-1} is a predetermined variable. This approach can solve the endogeneity problem to a certain extent.

In order to further reduce the endogeneity of the threshold variable, we will use the lagged economic growth rate of the province where the city is located (denoted as $provg_{it-1}$) as the threshold variable to verify the robustness of the model.

4.2 Results and analysis

According to the conclusions of Section 3, in different types of cities, natural resource dependence has different effects on economic development. Therefore, we perform panel threshold regression on the full sample, RBCs and NRBCs, respectively.

First, we need to clarify the number of thresholds in order to further determine the appropriate model. After estimating the possible threshold values, we obtain the test results in Table 8. Based on these results, we can see that for the full sample and RBC sample, the null hypothesis that there is no threshold and only one threshold can be rejected at the 5 per cent significance level, and the null hypothesis that there are two thresholds cannot be rejected, so we establish a double threshold model for parameter estimation. For NRBC samples, the null hypothesis without threshold can be rejected, but the null hypothesis with only one threshold cannot be rejected, so we build a single threshold model for it.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 8 Threshold effect test of GDP growth rate

Threshold effect test		Full sample		RBCs		NRBCs	
H0	H1	F value [P-value]	Accept or reject H0	F value [P-value]	Accept or reject H0	F value [P-value]	Accept or reject H0
None	Single	172.60*** [0.000]	Reject	128.52*** [0.000]	Reject	68.37*** [0.003]	Reject
Single	Double	46.97*** [0.003]	Reject	26.31** [0.033]	Reject	14.57 [0.130]	Accept
Double	Triple	30.46 [0.873]	Accept	18.80 [0.547]	Accept		

Note: The values in brackets are P-values, and *, ** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent, respectively.

Table 9 Threshold estimation results

	Full sample		RBCs		NRBCs	
	Estimation	95% CI	Estimation	95% CI	Estimation	95% CI
First threshold parameter $\hat{\gamma}_1^r$	6.81	[6.36, 6.90]	5.00	[4.37, 8.55]	8.90	[8.88, 8.95]
Second threshold parameter $\hat{\gamma}_2^r$	12.10	[12.00, 12.13]	12.10	[12.02, 12.11]		

Note: CI, denotes confidence interval.

Table 9 presents the estimated values for the thresholds and the 95 per cent confidence intervals. Figure 3 is the likelihood ratio function diagram of the full sample and presents the construction process of corresponding values. The dotted line parallel to the horizontal axis in the figure corresponds to the critical value of LR = 7.35, so that it is more intuitively presented on the confidence interval. From the results, the first and second threshold estimates in the double-threshold model are 6.81 and 12.10. The diagrams of RBC sample and NRBC sample are omitted for simplicity.

Table 10 shows the number of cities in the different growth intervals for each year. It shows that before 2011, the economic growth rate was higher than 6.81 per cent in most prefecture-level cities. After 2012, most of the growth rates fell into the interval below 12.10 per cent. The resource-based cities show the characteristics of greater changes in growth rate: when the general economic growth rate of cities is relatively high, the proportion of RBCs falling into the high-speed growth zone is very high, even higher than that of NRBCs; but when the economic growth rate slowed down, quite a lot of RBCs fell into the low-speed growth zone, and the proportion of cities still able to maintain high-speed growth was much smaller than that of NRBCs.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

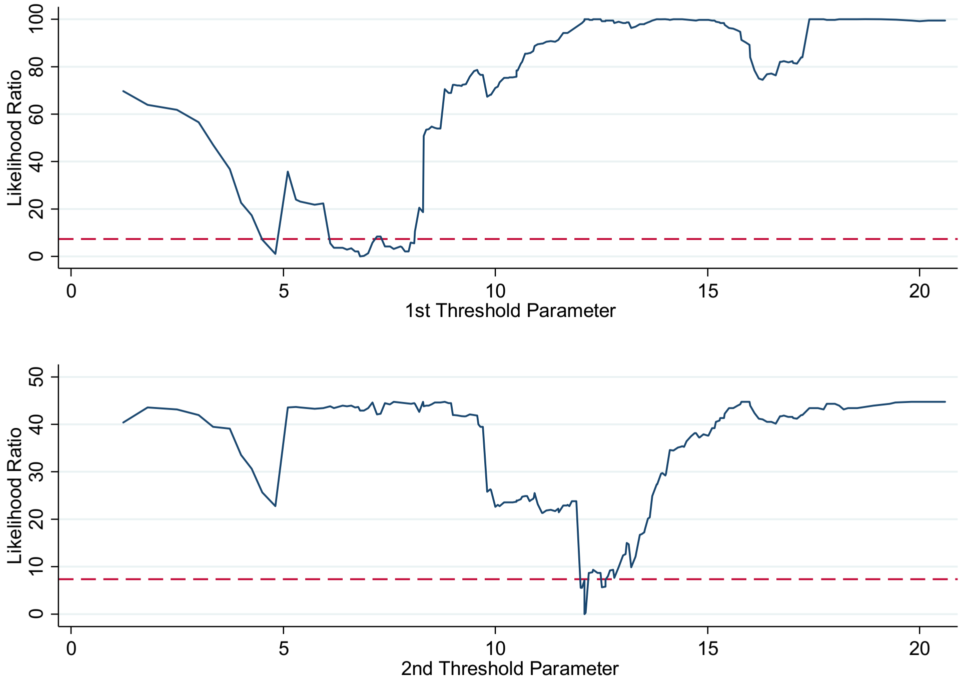

Figure 3 The threshold estimates and confidence interval in the double-threshold model (for full sample). [Colour figure can be viewed at wileyonlinelibrary.com]

Table 10 Number of cities in each growth interval in different years

Growth interval						
Year	$g_{it-1} \leq 6.81\%$		$6.81\% < g_{it-1} \leq 12.10\%$		$g_{it-1} \geq 12.10\%$	
	Full sample	RBCs	Full sample	RBCs	Full sample	RBCs
2004	13	5	106	50	137	54
2005	0	0	53	21	203	88
2006	2	1	55	21	199	87
2007	1	1	45	21	210	87
2008	0	0	19	15	237	94
2009	6	5	68	31	182	73
2010	10	6	72	34	174	69
2011	0	0	25	13	231	96
2012	5	4	64	21	187	84
2013	6	3	146	60	104	46
2014	52	38	149	49	55	22
2015	54	34	194	73	8	2
2016	62	41	189	67	5	1

The results of the parameter estimation of the model are presented in Table 11. For the full sample, when the economic growth rate of the previous year was less than 6.81 per cent, every 1 per cent increase in *RD* would reduce

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 11 Parameter estimation of the panel threshold model (threshold variable: g_{it-1})

Variable	Full sample $\gamma_1 = 6.81, \gamma_2 = 12.10$	RBCs $\gamma_1 = 5.00, \gamma_2 = 12.10$	NRBCs $\gamma_1 = \gamma_2 = 8.90$
$RD_{it}I(g_{it-1} \leq \gamma_1)$	−0.0150***	−0.0187***	−0.0094
	(−4.13)	(−4.65)	(−0.44)
$RD_{it}I(\gamma_1 < g_{it-1} \leq \gamma_2)$	0.0026	0.0009	
	(0.81)	(0.26)	
$RD_{it}I(g_{it-1} > \gamma_2)$	0.0161***	0.0125***	0.0962***
	(4.67)	(3.24)	(5.92)
PC	0.0492***	−0.0254	0.1101***
	(4.75)	(−1.57)	(8.54)
OP	0.0010	0.0013	−0.0005
	(0.77)	(0.53)	(−0.35)
GI	−0.0015***	−0.0018***	−0.0011**
	(−3.60)	(−2.66)	(−2.43)
PE	−0.0007***	0.0002	−0.0009***
	(−3.07)	(0.25)	(−3.90)
HC	0.0219	0.3167***	−0.1115***
	(0.91)	(7.35)	(−4.05)
ST	−0.0201**	0.0123	−0.0688***
	(−2.15)	(1.00)	(−4.67)
Constant	9.1300***	8.7388***	9.3256***
	(393.13)	(219.58)	(341.09)
Time effect	Yes	Yes	Yes
Obs	3328	1417	1911

Note:: The values in parentheses are *t* values, and *, ** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent, respectively.

per capita real GDP (*PGDP*) by 0.015 per cent; when the economic growth rate of the previous year was greater than 12.1 per cent, every 1 per cent increase in *RD* would increase *PGDP* by 0.016 per cent; and when the growth rate was between 6.81 per cent and 12.1 per cent, the impact of *RD* on the economic level was not significant. Next, we analyse the results in detail according to different city types.

In the RBCs, the results show that when the GDP growth rate of the previous year is less than 5 per cent, that is, when the economy is in the low-speed growth zone, the estimated coefficient is −0.019 (significant at 1 per cent level). This shows that resource dependence has inhibited economic development, indicating that natural resource dependence has a 'curse effect'. When the GDP growth rate of the previous year is between 5 per cent and 12.1 per cent, that is, when the economy is in the medium-speed growth zone, the estimated coefficient is not significant, indicating that natural resource dependence has no significant impact on economic development. Natural resource dependence does not have 'blessing effect' or 'curse effect'. When the GDP growth rate of the previous year is greater than 12.10 per cent, that is, when the economy is in the high-speed growth zone, the estimated coefficient is 0.013 and significant at the 1 per cent level. In general, natural resource dependence plays a significant role in promoting economic development, indicating that it has a 'blessing effect'.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 12 Parameter estimation of the panel threshold model (threshold variable: $provg_{it-1}$)

Variable	Full sample $\gamma_1 = 4.90, \gamma_2 = 10.70$	RBCs $\gamma_1 = 4.90, \gamma_2 = 10.20$	NRBCs $\gamma_1 = \gamma_2 = 9.10$
$RD_{it}I(provg_{it-1} \leq \gamma_1)$	-0.0522^{***}	-0.0502^{***}	-0.0155
	(−9.78)	(−8.49)	(−0.70)
$RD_{it}I(\gamma_1 < provg_{it-1} \leq \gamma_2)$	-0.0048	-0.0095^{**}	
	(−1.39)	(−2.49)	
$RD_{it}I(provg_{it-1} > \gamma_2)$	0.0123^{***}	0.0080^{**}	0.0843^{***}
	(3.88)	(2.27)	(5.14)
Control variables	All	All	All
Time effect	Yes	Yes	Yes
Obs	3328	1417	1911

Note: The values in parentheses are *t* values, and *, ** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent, respectively.

In the NRBCs, the only threshold divides the sample into two parts. When the economic growth rate is relatively low ($g_{it-1} \leq 8.9\%$), the impact of *RD* on economic development is small and statistically insignificant; when the economic growth rate is relatively high ($g_{it-1} > 8.9\%$), *RD* can significantly promote economic development, every 1 per cent increase in *RD* would increase *PGDP* by 0.096 per cent. Therefore, in general, in non-resource-based cities, natural resource dependence has a 'blessing effect' on economic development.

In order to test the robustness of the results, we use the one-period lagging economic growth rate of the province where the city is located (denoted as $provg_{it-1}$) as the threshold variable to re-estimate the above three panel threshold models. The numbers of thresholds are the same as the previous results. In the full sample, RBC sample and NRBC sample, they are double threshold, double threshold and single threshold, respectively. The specific regression results are shown in Table 12. The results are similar to Table 11, and the signs of the main variables are exactly the same, indicating that the above results are robust.

Based on the above results, the following inferences can be made: when the economy grows rapidly, that is, when the economy is in a boom stage, the manufacturing and construction industries develop quickly, so the demand for natural resources increases, the growth rate of the resource industry will be faster, and the returns of the resource sector will increase. At this time, cities with high resource dependence can obtain more economic growth dividends, so that resource dependence can promote their economic development. However, when the economic growth rate slows down, the demand for natural resources begins to decline from the peak, and the returns of the resource sector are greatly reduced. If the RBCs are too dependent on resources, they cannot transform from resource-based industries to other industries such as manufacturing in time, then they will inevitably pay a greater price during economic recession, and resource dependence will have a

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

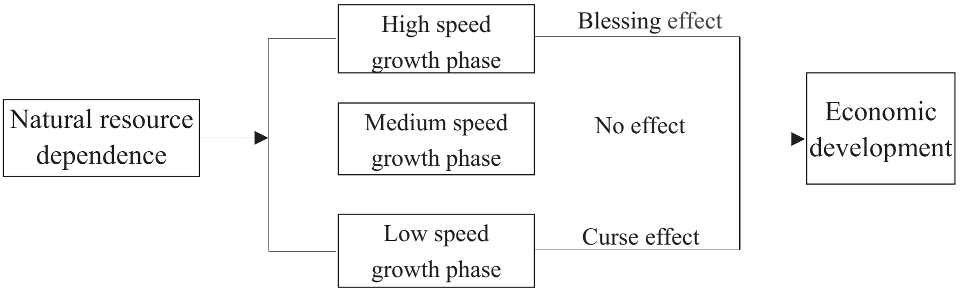

Figure 4 The impact of natural resource dependence on economic development at different stages of economic growth (for RBCs).

negative impact on economic development. For NRBCs, their dependence on natural resources is much lower than that of RBCs, so during economic recession this 'resource curse effect' is much smaller, while during an economic boom, with a balanced industrial structure, abundant natural resource can greatly support economic development.

The above results are summarised in Figure 4. The results show that for resource-based cities, although resource dependence can bring 'blessing effect' to economic development during economic prosperity, for the sustainable development of cities, local economies cannot be overly dependent on the natural resource industrial sector. Instead, we should seize the opportunity of rapid growth to promote the transformation of the economy to non-resource industries as soon as possible, so as to avoid the 'resource curse' that may arise when the overall economic growth slows down.

5. The mediation effect of industrial diversification on the relationship between natural resource dependence and economic development

Studies have shown that simplification of the industrial structure is the main reason for RBCs to fall into the 'resource curse' condition (Glaeser *et al.* 1992; Liang *et al.* 2016). This section takes the diversification of industrial structure (*IDV*) as a mediating variable and uses the mediation effect model to explore how industrial diversification affects the relationship between natural resource dependence and economic development.

5.1 Setting and testing of the mediation effect model

To a large extent, the role of the mediator variable is to explain the interaction between the explanatory variable and the interpreted variable via a mechanism of conduction. To put it simply, if there is an independent variable X, a dependent variable Y, and one other variable M, we need to analyse the effect of X on Y. If X can impact on Y by means of M, then we consider M to be an mediating variable.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Thus, if X has some effect on Y by means of M, we use M as a mediator for X to influence Y. In a simple mediation model, the relationship between variables can be expressed as follows:

$$Y = cX + e_1 \tag{7}$$

$$M = aX + e_2 \tag{8}$$

$$Y = c'X + bM + e_3 \tag{9}$$

where the coefficient c is the total effect of X on Y; the coefficient a is the effect of X on M; the coefficient b is the effect of the mediating variable M on Y after controlling the influence of X; c' is the direct effect X on Y after

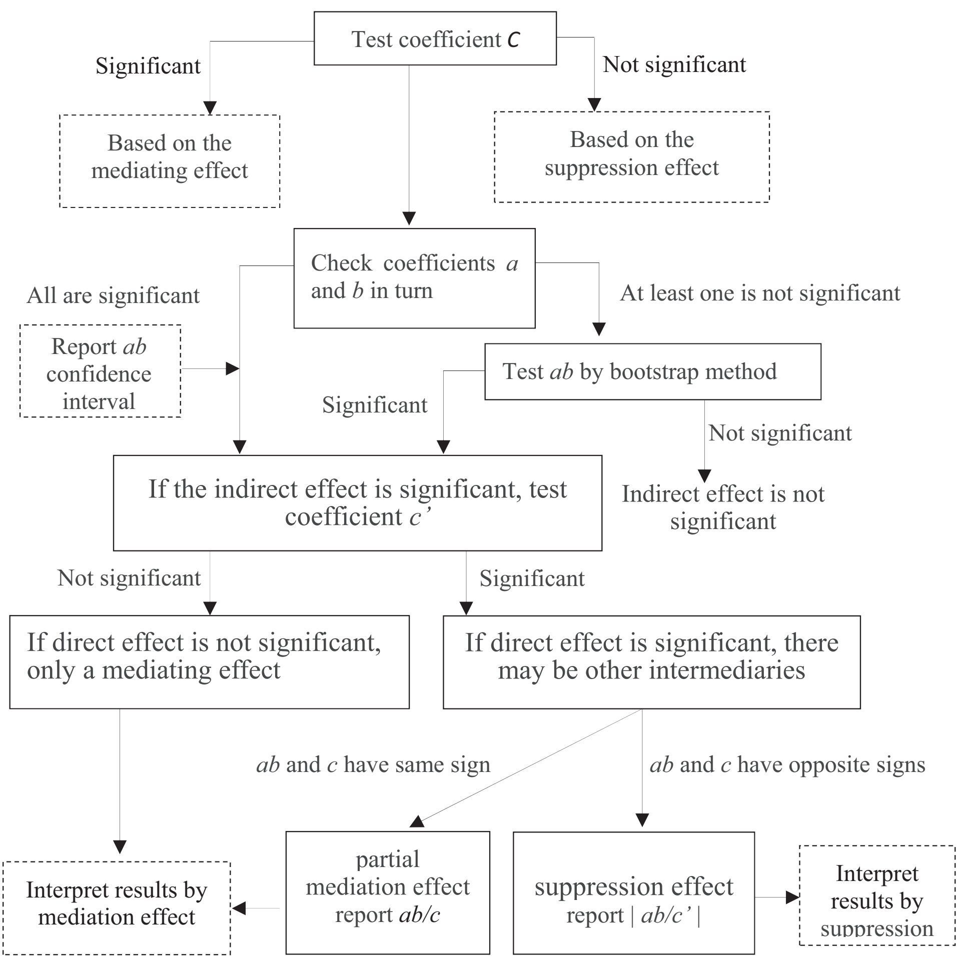

Figure 5 Mediation effect inspection process.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

controlling the mediating variable M; and e_1, e_2, and e_3 are random disturbance terms.

The mediation effect we are talking about is the indirect effect (ab) presented in the above model. In the model, there is an equation describing the relationship between ab, c and c'. The expression is as follows:

$$c = c' + ab \tag{10}$$

The mediation effect test procedure used in this paper refers to the approach of Wen and Ye (2014). The specific steps are as follows (the corresponding flow chart is shown in Figure 5:

1. The coefficient c is tested first. If the null hypothesis of $c = 0$ is rejected, it is considered to have a mediation effect; otherwise, it is considered to have a suppression effect, which indicates that the effect of the independent variable on the dependent variable is suppressed due to the influence of the mediating variable. From the perspective of the model equation, after adding the mediating variable, the regression coefficient between the independent variable and the dependent variable will become larger (MacKinnon *et al.* 2000). Next steps continue regardless of the result.
2. Check the coefficients a and b, respectively. If both the two null hypotheses ($a = 0$ and $b = 0$) can be rejected, it means there is an indirect effect, then we jump directly to the fourth step; if we cannot reject the both of the null hypotheses, we should carry out the third step test.
3. The coefficient product is directly tested by the bootstrap method. If the null hypothesis $ab = 0$ can be rejected, which means indirect effect exists, we will carry out the fourth step test; otherwise, it means there is no indirect effect, and the test should be terminated.
4. After testing the coefficient c', if the null hypothesis of $c' = 0$ cannot be rejected, it means there is no direct effect, indicating that there is only mediation effect. Otherwise, it indicates that there is a direct effect and we carry out the fifth step test.
5. First, we compare the sign of the product ab and the coefficient c'; if they have the same sign, there is a partial mediation effect; if they have contrary signs, it is considered that there is a suppression effect.

Based on the above analysis, the relationship between natural resource dependence and urban economic development level may be mediated by industrial diversification. Therefore, the relationship can be expressed as follows:

$$lny_{it} = cRD_{it} + \boldsymbol{W\beta} + \mu_i + \lambda_t + e_{1,it} \tag{11}$$

$$IDV_{it} = aRD_{it} + \boldsymbol{W\beta} + \mu_i + \lambda_t + e_{2,it} \tag{12}$$

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Table 13 Analysis results of mediation effect

Effect	Coef.	Full sample		RBCs		NRBCs	
		(1) Without CV	(2) With CV	(3) Without CV	(4) With CV	(5) Without CV	(6) With CV
Direct effect							
RD → *IDV*	*a*	−0.0303***	−0.0359***	−0.0317***	−0.0342***	0.0446	0.0563
		(−6.01)	(−7.47)	(−3.47)	(−3.74)	(0.87)	(1.14)
IDV → lny	*b*	0.3669***	0.1774***	0.0861*	0.1877***	0.3683***	0.1798***
		(19.86)	(14.23)	(1.74)	(4.84)	(14.02)	(10.98)
RD → lny	*c'*	0.0680***	0.0538***	−0.0093	0.0268**	−0.0077	0.0831***
		(12.19)	(14.97)	(−0.55)	(2.00)	(−0.13)	(2.30)
Indirect effect (Sobel mediation test)							
RD → ln*y*	*ab*	−0.0111***	−0.0064***	−0.0027	−0.0064***	0.0164	0.0101
		(−5.75)	(−6.61)	(−1.55)	(−2.96)	(0.86)	(1.13)
Total effect							
RD → ln*y*	c	0.0569***	0.0474***	−0.0121	0.0204	0.0088	0.0932***
		(9.72)	(12.93)	(−0.71)	(1.52)	(0.14)	(2.50)
Conclusion		Suppression effect		Suppression effect		No mediation effect	
	$\lvert ab/c' \rvert$	0.1637	0.1185	–	0.2394	–	–

Note: CV denotes control variables, including all the control variables mentioned above. The values in parentheses are *t* values, and *, ** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent, respectively.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

$$lny_{it} = c' RD_{it} + bIDV_{it} + \boldsymbol{W\beta} + \mu_i + \lambda_t + e_{3,it} \quad (13)$$

Here, *RD* is natural resource dependence; *y* means real GDP per capita (*PGDP*); *IDV* is industrial diversification; ***W*** denotes the control variables mentioned above (including *PC*, *ST*, *GI*, *HC*, *PE* and *OP*); *c* denotes the direct impact of resource dependence on economic development; *a* indicates the influence coefficient of resource dependence on industrial diversification; *b* is the influence coefficient of industrial diversification on economic development after controlling the influence of resource dependence; and *c'* is the influence coefficient of natural resource dependence on economic development after controlling the industrial diversification.

5.2 Results and analysis

Table 13 shows the results of the mediation effect of the city's industrial diversification on the impact of natural resource dependence on economic development. Since *RD* has different effects on economic development in RBCs and NRBCs, the results of the mediation effect of industrial diversification are also represented by different types of cities. According to the model results after adding other control variables (shown in Columns (2), (4) and (6)), in general, in the full sample and RBCs, *IDV* operates as a suppressor in the process of natural resource dependence affecting economic development; in NRBCs, *IDV* has no mediation effect on the relationship between *RD* and economic development.

In the full-sample mediation model, considering the impact of industrial diversification, the direct effect of *RD* on economic development is 0.0538 (significant at 1 per cent level). However, because *RD* decreases *IDV* of the city (coefficient a is significantly negative), and *IDV* has a positive impact on economic development, the indirect effect of *RD* on economic development through *IDV* is –0.0064 (ab, significant at 1 per cent level through the Sobel test). Without considering the impact of industrial diversification, the total effect of *RD* on economic development is 0.0474 (significant at 1 per cent level). Since the total effect is suppressed by the opposite signs of direct and indirect effects, the absolute value of the total effect is lower than expected. Specifically, the positive impact of *RD* on economic development is offset by 11.85 per cent through *IDV*. That is to say, viewed from the full sample, industrial diversification plays a suppression role in the impact of resource dependence on economic development. However, this influence mechanism differs between RBCs and NRBCs.

For RBCs, as is shown in column (4) of Table 13, the increase in resource dependence inhibits industrial diversification ($a = -0.0342$, significant at 1 per cent level), meanwhile industrial diversification is conducive to economic development ($b = 0.1877$, significant at 1 per cent level), which leads to the

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

negative indirect effect of *RD* on economic development ($ab = -0.0064$, significant at 1 per cent level). The indirect effect through industrial diversification offsets parts of the direct effect of natural resource dependence on economic development ($c' = 0.0268$, significant at 5 per cent level), resulting in a non-significant total effect of *RD* on economic development (0.0204, $P = 0.1295$). In general, the mediation effect of *IDV* limits the impact of *RD* on economic development by 23.94 per cent, indicating that *IDV* is a suppressor between *RD* and economic development in RBCs.

For NRBCs, as is shown in column (6) of Table 13, the impact of *RD* on *IDV* is positive but not significant (0.0563, $P = 0.2539$), therefore, although *IDV* still has a positive influence on economic development (0.1798, significant at 1 per cent level), the indirect effect of *RD* on economic development through *IDV* is not significant (0.0101, $P = 0.2564$). Both the direct and total effect are positive, and their values are very close (0.0831 and 0.0932, respectively). In this case, the mediation effect of *IDV* on the relationship between *RD* and economic development does not exist, that is *IDV* is not one of the channels for *RD* to influence economic development in NRBCs.

Through the above analysis, it can be found that in this case study, for RBCs, resource dependence inhibits its positive impact on economic development through the indirect effect of industrial diversification, while in NRBCs, this indirect effect does not exist. This explains the conclusion of Section 3 to a certain extent: the impact of *RD* on economic development is positive in NRBCs, but not significant in RBCs. Obviously, the diversification of the industrial structure is conducive to the economic development of the city. In NRBCs, resource-based industries are not local advantageous industries, so the natural resource dependence will not inhibit the diversification of the industrial structure, while in RBCs, abundant natural resources increase the returns of resource-based industries, so the local government and enterprises have the motivation to give priority to the resource-based industries, which will crowd out non-resource-based industries in terms of human capital, technological innovation and other aspects, thereby reducing the diversification of the industrial structure and having a negative impact on economic development (Sachs and Warner 2001; Papyrakis and Gerlagh 2007). The impact mechanism of resource dependence on economic development through industrial diversification in RBCs is concluded and shown in Figure 6. Therefore, for RBCs, corresponding strategies should be adopted to reduce the crowding-out effect caused by natural resource dependence, appropriately improve the diversification level of industries and let economic development enter a virtuous circle and maintain the sustainable economic development of the region.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

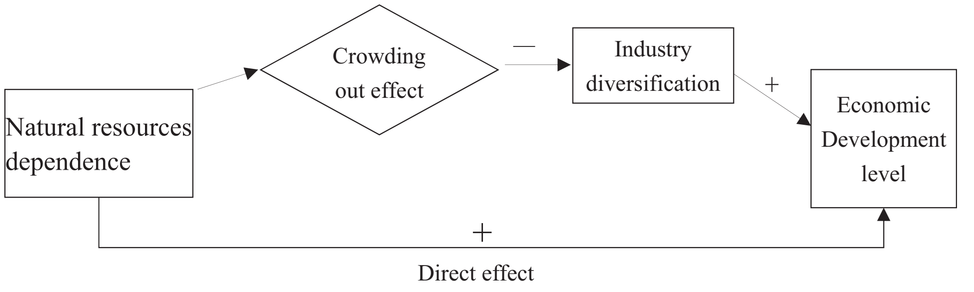

Figure 6 The impact mechanism of resource dependence on economic development through industrial diversification in RBCs.

6. Conclusions

This paper takes 256 prefecture-level cities (109 resource-based cities and 147 non-resource-based cities) as the research object, uses panel data from 2003 to 2016 to analyse empirically the relationship between natural resource dependence and economic development, and adopts dynamic model and instrumental variable methods to verify the robustness Then, by using the panel threshold model, we discuss the influence of natural resource dependence on economic development under different economic growth rates. Finally, the mediation effect model is used to analyse the mediation effect of industrial diversification. It turns out that the impact of natural resource dependence on economic development shows completely different characteristics in resource-based cities and non-resource-based cities. Therefore, our research needs to be carried out separately for different types of cities.

The following conclusions are drawn: for non-resource-based cities, generally, their resource dependence is very low, and natural resources have a significant 'blessing effect' on economic development. According to the results of the panel threshold model, even in a period of relatively slow economic growth (GDP growth rate is less than 8.9 per cent), resource dependence will not restrict the economic development of non-resource-based cities; in a period of economic prosperity (GDP growth rate is greater than 8.9 per cent), natural resources can greatly promote economic development. However, the mediation effect of industrial diversification on the relationship between resource dependence and economic development is not obvious. The resource dependence of non-resource-based cities will not affect the level of industrial diversification.

For resource-based cities, even after controlling the endogeneity of variables by the instrumental variable method, the overall effect of natural resource dependence on economic development is still not significant. However, through threshold regression, we find that in the economic prosperity stage (GDP growth rate is greater than 12.1 per cent), dependence

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

on natural resources can promote the economic development of cities, but when the economy is in recession (GDP growth rate is less than 5 per cent), natural resources have a 'curse effect' on economic development; when economic growth rate is at a medium-speed growth stage (between 5 per cent and 12.15 per cent), the effect of natural resource dependence is insignificant. Next, through the mediation effect model, we found that an important reason for the insignificant effect of resource dependence on economic development is the suppression effect of industrial diversification. The excessive concentration of resource industries has a crowding-out effect on non-resource-based industries, thereby reducing the level of industrial diversification and restraining economic development.

Currently, under the new normal of China's economy, many cities with rapid development before 2012 have gradually entered the stage of medium–low-speed development, indicating that the natural resource dependence will have a 'curse effect' on economic development in the resource-based cities according to the above conclusions. Therefore, we should pay more attention to the negative effects of excessive resource dependence on the economy. According to the mediation effect of industrial diversification, the resource-based cities should reduce the crowding-out effect caused by natural resource dependence, the central and local governments should increase support for related manufacturing, private enterprises and innovative enterprises, improve the diversification of industries and realise the common development of multiple industry sectors.

Finally, there are some limitations in this study. In the empirical analysis, taking the economic growth rate as the threshold variable, this paper only considers the relationship between resource dependence and economic development in different economic growth stages and does not investigate or analyse other possible thresholds. In addition, based on the existing research, the diversification of industry can be decomposed into related and irrelevant diversification. This paper does not decompose the industrial diversification and only roughly considers the impact of industrial diversification between resource dependence and economic development. We will try to develop these aspects in our further research.

Conflict of interests

The authors declare that they have no competing interests.

Data availability statement

The data used to support the findings of this study are available from the corresponding author upon request.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

References

Arellano, M. and Bond, S. (1991). Some tests of specification for panel data: monte carlo evidence and an application to employment equations, *The Review of Economic Studies* 58, 277.

Auty, R. and Warhurst, A. (1993). Sustainable development in mineral exporting economies, *Resources Policy* 19, 14–29.

Badeeb, R.A. and Lean, H.H. (2017). Financial development, oil dependence and economic growth: Evidence from the Republic of Yemen, *Studies in Economics and Finance* 34, 281–298.

Beine, M., Bos, C.S. and Coulombe, S. (2012). Does the Canadian economy suffer from Dutch disease?, *Resource and Energy Economics* 34, 468–492.

Blundell, R. and Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models, *Journal of Econometrics* 87, 115–143.

Boschini, A.D. and Roine, P.J. (2007). Resource curse or not: a question of appropriability, *Scandinavian Journal of Economics* 109, 593–617.

Boyce, J.R. and Emery, J.H. (2011). Is a negative correlation between resource abundance and growth sufficient evidence that there is a "resource curse"?, *Resources Policy* 36, 1–13.

Browning, H.L. and Singelmann, J. (1975). The emergence of a service society: demographic and sociological aspects of the sectoral transformation of the labor force in the USA. National Technical Information Service.

Corden, W.M. and Neary, J.P. (1982). Booming sector and de-industrialisation in a small open economy, *The Economic Journal* 92, 825–848.

Deacon, R.T. (2011). The political economy of the natural resource curse: a survey of theory and evidence, *Foundations and Trends® in Microeconomics* 7, 111–208.

Deacon, R.T. and Rode, A. (2015). Rent seeking and the resource curse. In *Companion to the political economy of rent seeking*. Edward Elgar Publishing.

Davis, G. A., & Tilton, J. E. (2005). The resource curse. In *Natural resources forum* (Vol. 29(3), pp. 233–242). Oxford, UK: Blackwell Publishing Ltd.

Ding, J., Wang, Y. and Deng, K. (2007). Is there a curse of resources in China's economic development, *World Economy (Chinese)* 9, 38–46.

Dissart, J.C. (2003). Regional economic diversity and regional economic stability: research results and agenda, *International Regional Science Review* 26, 423–446.

Fang, Y., Ji, Y. and Zhao, Y. (2011). Is there a curse of resources in China?, *World Economy (Chinese)* 4, 144–160.

Frankel, J.A. (2012). The natural resource curse: A survey of diagnoses and some prescriptions. HKS Faculty Research Working Paper Series.

Gao, T. (2004). Regional industrial growth: evidence from Chinese industries, *Regional Science and Urban Economics* 34, 101–124.

Glaeser, E.L., Kallal, H.D., Scheinkman, J.A. and Shleifer, A. (1992). Growth in cities, *Journal of Political Economy* 100, 1126–1152.

Gylfason, T. (2001). Natural resources, education, and economic development, *European Economic Review* 45, 847–859.

Halvor, M., Karl, M. and Ragnar, T. (2006). Institutions and the resource curse, *Economic Journal* 116, 1–20.

Hansen, B.E. (1999). Threshold effects in non-dynamic panels: estimation, testing, and inference, *Journal of Econometrics* 93, 345–368.

Hanson, G.H. (2001). Scale economies and the geographic concentration of industry, *Journal of Economic Geography* 1, 255–276.

Hdom, H.A.D. and Fuinhas, J.A. (2020). Energy production and trade openness: assessing economic growth, CO2 emissions and the applicability of the cointegration analysis, *Energy Strategy Reviews* 30, 100488.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Im, K.S., Pesaran, M.H. and Shin, Y. (2003). Testing for unit roots in heterogeneous panels, *Journal of Econometrics* 115, 53–74.

Iimi, A. (2007). Escaping from the Resource Curse: Evidence from Botswana and the Rest of the World, *IMF Staff Papers* 54(4), 663–699.

Khan, Z., Hussain, M., Shahbaz, M., Yang, S. and Jiao, Z. (2020). Natural resource abundance, technological innovation, and human capital nexus with financial development: a case study of China, *Resources Policy* 65, 101585.

Kim, D.-H. and Lin, S.-C. (2017). Natural resources and economic development: new panel evidence, *Environmental and Resource Economics* 66, 363–391.

Kim, T.J. and Knaap, G. (2001). The spatial dispersion of economic activities and development trends in China: 1952–1985, *The Annals of Regional Science* 35, 39–57.

Li, J. and Xu, B. (2018). "Curse" or "Gospel": how does the degree of resource abundance affect China's green economic growth?, *Economic Research Journal(Chinese)* 11, 151–167.

Liang, B., Lian, Y. and Ji, X. (2016). Resource Boom, Industrial Structure and Economic Growth in a DSGE Model. In *2016 5th International Conference on Social Science, Education and Humanities Research*. Atlantis Press.

MacKinnon, D.P., Krull, J.L. and Lockwood, C.M. (2000). Equivalence of the mediation, confounding and suppression effect, *Prevention Science* 1, 173–181.

Mawejje, J. (2019). Natural resources governance and tax revenue mobilization in sub saharan Africa: The role of EITI, *Resources Policy* 62, 176–183.

Mehlum, H., Moene, K. and Torvik, R. (2006). Institutions and the resource curse, *The economic journal* 116, 1–20.

Mehrara, M. (2009). Reconsidering the resource curse in oil-exporting countries, *Energy Policy* 37, 1165–1169.

Moradbeigi, M. and Law, S.H. (2016). Growth volatility and resource curse: does financial development dampen the oil shocks?, *Resources Policy* 48, 97–103.

Murphy, D.J. and Cummins, I. (1989). Biosynthesis of seed storage products during embryogenesis in rapeseed, Brassica napus, *Journal of Plant Physiology* 135, 63–69.

Nawaz, K., Lahiani, A. and Roubaud, D. (2019). Natural resources as blessings and finance-growth nexus: A bootstrap ARDL approach in an emerging economy, *Resources Policy* 60, 277–287.

Papyrakis, E. and Gerlagh, R. (2007). Resource abundance and economic growth in the United States, *European Economic Review* 51, 1011–1039.

Pedroni, P. (1999). Critical values for cointegration tests in heterogeneous panels with multiple regressors, *Oxford Bulletin of Economics & Statistics* 61, 653–670.

Pedroni, P. (2004). Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis, *Econometric Theory* 20, 597–625.

Pegg, S. (2010). Is there a dutch disease in Botswana? *Resources Policy* 35, 14–19.

Pesaran, M.H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure, *Econometrica* 74, 967–1012.

Pesaran, M.H. (2007). A simple panel unit root test in the presence of cross section dependence, *Journal of Applied Econometrics* 22, 265–312.

Pradhan, R.P., Arvin, M.B., Hall, J.H. and Nair, M. (2016). Innovation, financial development and economic growth in Eurozone countries, *Applied Economics Letters* 23(16), 1141–1144.

Saboori, B. and Sulaiman, J. (2013). CO2 emissions, energy consumption and economic growth in Association of Southeast Asian Nations (ASEAN) countries: a cointegration approach, *Energy* 55, 813–822.

Sachs, J.D. and Warner, A.M. (2001). The curse of natural resources, *European Economic Review* 45, 827–838.

Shao, S., Fan, M. and Yang, L. (2013). How does resource industry dependence affect economic development efficiency?–Test and explanation of the conditional resource curse hypothesis, *Management World (Chinese)* 2, 32–63.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Shao, S. and Qi, Z. (2008). Energy development and economic growth in Western China: an empirical analysis based on the "Resource Curse" hypothesis, *Economic Research Journal (Chinese)* 4, 76.

Shao, S. and Yang, L. (2014). Natural resource dependence, human capital accumulation, and economic growth: A combined explanation for the resource curse and the resource blessing, *Energy Policy* 74, 632–642.

Smith, B. (2015). The resource curse exorcised: Evidence from a panel of countries, *Journal of Development Economics* 116, 57–73.

Song, M., Wang, J. and Zhao, J. (2018). Coal endowment, resource curse, and high coal-consuming industries location: analysis based on large-scale data, *Resources, Conservation and Recycling* 129, 333–344.

Van der Ploeg, F. (2011). Natural resources: curse or blessing?, *Journal of Economic Literature* 49, 366–420.

Walker, A. (2013). *An Empirical Analysis of Resource Curse Channels in the Appalachian Region*. West Virginia University, Morgantown, WV.

Weber, J.G. (2014). A decade of natural gas development: The makings of a resource curse?, *Resource and Energy Economics* 37, 168–183.

Wen, Z. and Ye, B. (2014). Mediation effect analysis: method and model development, *Progress in Psychological Science(Chinese)* 22, 731–745.

Westerlund, J. (2005). New simple tests for panel cointegration, *Econometric Reviews* 24, 297–316.

Wright, G. and Czelusta, J. (2004). Why economies slow: the myth of the resource curse, *Challenge* 47, 6–38.

Wright, P. (1990). Application of vaginal cytology and plasma Srogesterone eterminations to the management of reproduction in the bitch, *Journal of Small Animal Practice* 31, 335–340.

Zaidi, S.A.H., Wei, Z., Gedikli, A., Zafar, M.W., Hou, F. and Iftikhar, Y. (2019). The impact of globalization, natural resources *abundance*, and human capital on financial development: evidence from thirty-one OECD countries, *Resources Policy* 64, 101476.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Appendix

Cross-section dependence test and Panel unit root tests

In order to check the stationarity of the variables in our panel data, we first adopt the cross-section dependence test proposed by Pesaran (2006). The results are shown in Table A1. The null hypothesis of cross-section independence is strongly rejected for all the variables, which implies that the cross-section dependence should be considered in the panel unit root tests.

Table A2 presents the results of panel unit root tests by both Im *et al.* (2003) (referred as IPS) and Pesaran (2007) (referred as CIPS). The results show that, when the cross-section dependence is considered, all the variables are integrated of order one (I-1).

Table A1 Cross-section dependence test

Variable	CD test	*P*-value	Corr	abs(corr)
ln y	667.83***	0.0000	0.988	0.988
RD	41.54***	0.0000	0.061	0.398
IV	11.04***	0.0000	0.016	0.42
PC	388.74***	0.0000	0.575	0.664
ST	496.87***	0.0000	0.735	0.736
GI	507.28***	0.0000	0.75	0.772
HC	21.65***	0.0000	0.032	0.456
PE	264.7***	0.0000	0.392	0.501
OP	13.12***	0.0000	0.019	0.403

Note: Under the null hypothesis of cross-sectional independence, the CD statistic is distributed as a two-tailed standard normal. Results are based on the test of Pesaran (2006). The *P*-values are for a one-sided test based on the normal distribution. Correlation and absolute (correlation) are the average (absolute) value of the off-diagonal elements of the cross-sectional correlation matrix of residuals. ****P* < 1 per cent.

Table A2 Panel unit root tests of variables

	IPS				CIPS			
	Levels		Diff		Levels		Diff	
	W-t-bar	*P*-value	W-t-bar	*P*-value	Zt-bar	*P*-value	Zt-bar	*P*-value
In y	**21.84**	**1.000**	−6.54***	0.000	**5.44**	**1.000**	−1.93***	0.027
RD	−13.79***	0.000	−23.34***	0.000	0.76	0.776	−17.36***	0.000
IV	3.43	1.000	−10.18***	0.000	2.69	0.996	−7.05***	0.000
PC	**3.26**	**1.000**	−7.01***	0.000	**10.93**	**1.000**	−13.24***	0.000
ST	**5.68**	**1.000**	−11.10***	0.000	**7.61**	**1.000**	−4.28***	0.000
GI	**3.88**	**1.000**	−7.57***	0.000	**7.05**	**1.000**	−3.83***	0.000
HC	2.61	0.996	−8.14***	0.000	2.37	0.991	−10.45***	0.000
PE	**0.92**	**0.820**	−10.55***	0.000	**7.38**	**1.000**	−10.87***	0.000
OP	**−4.81*** **	**0.000**	−15.49***	0.000	**5.88**	**1.000**	−11.38***	0.000

Note: Levels and Diff denote the panel unit root tests in levels and first differences, respectively. Boldface values denote that time trend is included in the test. The null hypotheses of IPS test and CIPS test are both: All panels contain unit roots. ****P* < 1 per cent.

© 2021 Australasian Agricultural and Resource Economics Society Inc.

14678489, 2021, 2, Downloaded from https://onlinelibrary.wiley.com/doi/10.1111/1467-8489.12423 by UNIVERSITY OF MINNESOTA 170 WILSON LIBRARY, Wiley Online Library on [16/04/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License