Are Resources Cursed? An Investigation of Chinese Provinces

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Abstract

The phenomenon of low economic growth in resource-rich regions is recognized as the "resource curse". This research empirically shows the existence of a resource curse at the Chinese province level. Of two widely offered explanations for the resource curse, our analysis supports the crowding-out effect in China rather than the institution explanation. Education and R&D are the two main crowded-out factors.

Key Words: Crowding-out, Economic growth, Institution, Resource curse

JEL Classifications: Q20, Q30, O13, O51, C23

1. Introduction

Economic growth depends on production factors, such as capital, labor, and natural resources. But does resource abundance promote economic development? Although a "*yes*" answer seems obvious, some of the fastest growing economies over recent decades are regions with little natural wealth, whereas some countries with enormous resources suffer from poor economic performance, such as Angola, Nigeria and the Democratic Republic of Congo. The phenomenon that resource-rich regions develop less quickly is called the *resource curse*. It was formally presented by Auty in 1993 and, since then, it has become "one of the most intriguing puzzles in economics development and a great example of how organized empirical observations can guide economic theory and inform policy" (James and Aadland 2011, p440).

The resource curse has attracted numerous studies and intensive debate. Two main hypotheses have been proposed to explain the phenomenon. The crowding-out effect suggests that resource abundance crowds out certain growth-friendly factors such as investment, human capital, innovation and so on, which hinders the growth. On the other hand, the institution explanation argues that whether resource abundance is a curse or not depends on the institutional quality of the resource-rich region. Economic development will not be cursed in the presence of higher institution quality. Both explanations have been supported by certain empirical work (Sachs and Warner 1995, 1999 and 2001; Mehlum, Moene, and Torvik 2006; Michaels 2011).

While a larger cross-countries literature documents the resource curse, within-country evidence have also emerged (Papyrakis and Gerlagh 2007; Shao and Qi 2009; Weber 2013). However, the mechanism, the crowding-out effect or the institution explanation, was either left untested or tested separately with different sample in different studies. Moreover, most studies use cross-sectional data that omits state fixed effect and time effect.

In this study, we ask whether a resource curse exists at the Chinese provincial level and if so, what explains the resource curse in China, the crowding-out effect or the institution explanation. We collect a panel dataset of 30 provinces in China from 1997 to 2008 and apply Fixed Effect model with Driscoll and Kraay standard errors to test the resource curse hypothesis. This study contributes to the literature applying the Fixed Effect panel model to investigate the resource curse within China and testing the two competing mechanisms simultaneously in one setting.

2. Literature Review

2.1 Resource Curse across countries

Are natural resources a "curse" or a "blessing"? The experiences of resource-rich countries are diverse, and so is the empirical evidence: some economists investigated a large sample of countries from 1960s to 2000s and recognized the resource curse as a general phenomenon (Sachs and Warner, 1995; Papyrakis and Gerlagh, 2004; et al.). Others refuted the resource curse explanation (Brunnschweiler and Bulte, 2008; et al.). In fact, the inconsistencies in the empirical literature are so remarkable that the same author could claim two opposing views in different studies: Bulte and Damania (2005) used resource exports relative to total exports as a proxy for resource abundance and found that resource-intensive countries tend to suffer lower levels of human development. However, with a similar sample and time frame, Brunnschweiler and Bulte (2008) claimed that the resource curse may be a red herring because the commonly used measure of “resource abundance” is actually a proxy for “resource dependence,” which is endogenous to underlying structural factors. Using total natural capital and subsoil assets as measures, they found that resource abundance positively affects growth. As summarized in Van der Ploeg (2011, p370), the effects of natural resources on the economy vary from country to country and across different episodes in history.

2.2 Why are resources a curse? Crowding-out effect vs. Institutions

Economists have developed two main mechanisms to explain the resource curse: the crowding-out effect and the institution explanation. (See Van der Ploeg, 2011.)

The crowding-out effect can be summarized as resource abundance reducing the amount of activity X, where X drives growth. Different crowding-out stories focus on different X activities. Sachs and Warner (1995, 1999, and 2001) developed the Dutch Disease mechanism, which identified X as the manufacture of traded goods: the extra wealth generated by the sale of natural resources induces appreciation of the real exchange rate, so that natural resource windfalls cause deindustrialization (Corden and Neary, 1982; Corden, 1984) and crowd out the traded manufacturing sector. This model assumes that a labor-augmenting technical progress (i.e., learning by doing) in the manufacturing sector is the source of growth. Thus, shrinking the manufacturing sector lowers growth in the long run. In line with this logic, education (Gylfason, 2001), human capital investment (Stijns, 2006), and knowledge creation (Papyrakis and Gerlagh, 2004) could also be crowded out by natural resource windfalls.

Other crowding-out factors include saving and investment. A windfall from natural resources enhances future income, so that less saving is desired. Investment adjusts to savings, which slows the growth process (Papyrakis and Gerlagh, 2006 and 2004). Resource-abundant economies are also associated with less development of financial systems. Enterprises receive less external financing and bank loans in resource-abundant economies, thus inhibiting growth (Beck, 2011).

No matter which *X* factors are examined, the crowding-out explanation suggests that the problem lies in resources themselves: the production function of the resource sector is inferior due to lack of knowledge accumulation (Sachs and Warner, 1995) or fewer backward or forward linkages (Hirschman, 1958). Though the resource boom brings out higher returns at first, the expansion of the resource sector drags the economy into a lower growth path in the long run. This explanation, however, does not explain notable counter examples, such as Norway and Botswana.

The institution explanation suggests that whether resources are blessed or cursed depends on the quality of institutions. Mehlum, Moene, and Torvik (2006a, 2006b) modeled a resource-abundant economy with *grabber-friendly* or *producer-friendly* institutions. The allocation of entrepreneurs between production and grabbing (i.e., rent-seeking) depends on the quality of institutions. In a grabber-friendly economy, a resource boom pulls entrepreneurs into grabbing, which pushes aggregate income down. In contrast, a resource boom lifts demand and boosts productive profits in a producer-friendly economy. They used Sachs and Warner's dataset to test the institution explanation and concluded that institutions are decisive for the effect of resources. Boschini, Pettersson and Roine (2007) also concluded that countries rich in minerals are cursed only if they have low-quality institutions where the legal system is dysfunctional; transparency is low, and rent seeking gains a higher return. The curse is reversed if institutions are adequate.

Further, resource revenues may encourage bad institutional practices, such as imperfect markets, poorly functioning legal systems, buying off the opposition, or overspending on public service employment (Gelb, 1988; Auty, 2001a; Ross, 1999; Brunnschweiler and Bulte, 2008). Economists have sorted natural resources into diffuse and point resources. The former includes agriculture, forestry, and fishing, while the latter consists of oil, coal, gas, and so on. The type of natural resource matters because point resources generate concentrated production and revenue patterns, which are more likely to be controlled by relatively small groups of society, so called "executive discretion in revenue allocation" (Jensen and Wantchekon, 2004), and lead to highly skewed distribution of income and political problems. Murshed (2004) showed that point resources tend to breed rent-seeking behaviors and harm political institutions, while diffuse resources are better and manufactured goods are best for development of good governance institutions. However, in a case study of the political implications of Russia's resource-based economy, Tompson (2005) concluded that it was unconvincing to attribute Russia's politics to its resource-based structure and the causality between resource abundance and poor governance may superficial.

Note that the foregoing argument still lies in the crowding-out explanation camp even though it also recognized institutions as the crucial link. The pivotal distinction between the two arguments rests in the role of institutions. With the crowding-out effect, institutional development is another growth-friendly factor *X* that is retarded by natural resource abundance, whereas in the institution explanation, *ex-ante* institutional quality in a resource-abundant economy matters. Though resource rents could be captured by the elite and minority interest groups for personal enrichment, they can be allocated into a productive economy as well. The channel into which it goes depends on institutional qualities. Indeed, whether the windfall is from either natural resources or foreign aid does not alter the nature of the problem—it is a *revenue curse* due to bad institutions rather than a resource curse (Morrison, 2010). In summary, the institution explanation suggests that good-quality institutions can reverse the curse. Australia, Canada, the United States, New Zealand, Iceland, Norway and Botswana are all examples of resource-rich countries with strong institutions (Acemoglu et al., 2003; Acemoglu et al., 2003).

2.3 Within-country variation on resource curse

While most of the literature is exploring resource curse via cross-countries cases, empirical work focusing on different regions within a nation is limited. This paper is most closely related to the work by Shao and Qi (2009) , and Boschini, Pettersson and Roine (2007). Based on the crowding-out framework, Shao and Qi (2009) confirmed resource curse hypothesis in China and the crowding-out effect is mainly towards human capital input. The institution explanation was left untested. Moreover, Shao and Qi (2009) sampled 10 provinces from western China, which may lead to selection bias because they are all from inland China with lower initial development comparing to the East. Boschini, Pettersson and Roine (2007) introduced the interaction term of natural resource and institution variables to verify the institution explanation. Though they explored institution explanation only, the econometric framework presented is helpful to test both crowding-out effect and institution explanation.

We contribute to the literature by using a more complete panel dataset at Chinese provincial level to test the resource curse hypothesis and investigate the two mechanisms simultaneously in one sample. At the province level, previous studies have independently tested the two mechanisms with different time frames. In addition, most studies rely on cross-sectional data, which limits the sample size in state-level research and omits state fixed effects and time effects. Panel data models can isolate and control for state-specific effects, such as social norms or physiological behavior patterns, to reduce omitted variable bias.

3. Empirical Model and Data

There are two goals in the empirical analyses: to test for the resource curse hypothesis at the Chinese provincial level, and to test the competing mechanism explanations, crowding-out effect and institution explanations.

3.1 The resource curse hypothesis test

In tradition of Kormendi and Meguire (1985), Barro and Sala-i-Martin (1992), Sachs and Warner (1995, 1999a), and Papyrakis and Gerlagh (2007), a growth model of income convergence is used to test the resource curse hypothesis:

$$G_{i,t} = \beta_0 + \beta_1 lnY_{i,t-1} + \beta_2 Resource_{i,t} + \beta_3 Resource_{i,t}^2 + \boldsymbol{X}'_{i,t}\gamma + s_i + v_{i,t} \qquad (1)$$

Where *i* indicates provinces and *t* refers to time. *G* is economic performance indicator. Both annual growth rates in personal income per capita and provincial GDP per capita are examined in this study. *Y* is income level lagged one period. $Resource$ is a measure of resource abundance. In this study, we focus on the point resource such as oil, coal, gas and so on. In order to test the robustness of the results, we will employ three different proxies for $Resource$, which are provincial annual energy production per capita, provincial annual energy production, and ratio of the regional energy production over GDP. Finally, $\boldsymbol{X}$ is a matrix of other growth-related controls including investment, education, R&D expenditure, finance correlation ratio, and institution quality proxies. Table 1 lists all variable definition and summary of descriptive statistics. s_i is a state-specific fixed effect for each state *i*.

[Insert table 1 here]

Linear models rather than a quadratic specification were presented in literature, where β_2 alone indicates the direct effect from resource abundance to growth. In general, squared and higher power terms tend to wipe out other interesting impacts in the regression, especially when the dataset itself doesn't contain rich information. Since most of resource curse literature employed cross-sectional database rather than panel dataset, linear specification is widely engaged. However, the relationship of resource abundance and growth might not be linear in Chinese case. Li and Wang (2010) investigated resource curse in China provincial level with a quadratic regression model. And the application of panel dataset in this study allows us to include square terms to test the hypothesis. Thus, in the specification of equation (1), the marginal effect of resources on growth is $(\beta_2 + 2\beta_3 \times Resource)$. Three elements, β_2, β_3, and the resource abundance level will jointly determine the existence of Resource Curse.

We apply the Fixed Effect model to estimate equation (1). Shao and Qi (2009) used Random Effect panel estimate and assumed that unobserved individual heteroskedasity was uncorrelated with independent variables. In the dataset at the Chinese provincial level, social norms and psychological behavior patterns enter the error as unobservable common factors (s_i), which tend to relate to the independent variables such as human capital, R&D activity, and especially the institutional quality. With our dataset, a Hausman test rejects Random Effect model as the proper estimate. In addition, a Pesaran's test rejects the cross sectional independence in the data and a wooldgridge test cannot reject the autocorrelation. So we apply Driscoll and Kraay standard errors (Driscoll and Kraay, 1998) in a Fixed Effect model to correct for heteroscedasticity, autocorrelation, and spatial dependence issues.

3.2 The mechanism test: Crowding-out or Institutions?

Once the resource curse hypothesis is confirmed, I continue to test the two competing mechanism hypotheses: the crowding-out effect and the institution explanation.

In the literature, the crowding-out effect was tested in regressions of growth-friendly factors (x) on the resource variable (Sachs and Warner 1995; Papyrakis and Gerlagh 2007; Shao and Qi 2009) as in equation (2):

$$x_{i,t} = \alpha_0 + \alpha_1 Resource_{i,t} + \alpha_2 lnY_{i,t-1} + s_i + \mu_{i,t} \qquad (2)$$

where *x* is one vector in matrix $\boldsymbol{X}$. A negative α_2 implies that factor *x* decreases with the resource abundance level so that *x* is crowded-out by the resource boom. Different growth-friendly factors are tested separately, such as investment, human capital, R&D, and good institutions (table 1).

Mehlum, Moene and Torvik (2006a and 2006b) first introduced an interaction term between the resource variable and the institutional quality proxy to test the institution explanation:

$$G_{i,t} = \beta_0 + \beta_1 lnY_{i,t-1} + \beta_2 Resource_{i,t} + \beta_3 Resource_{i,t}^2 + \beta_4 \left(Resource_{i,t} x_{i,t}\right) + \boldsymbol{X}'_{i,t}\gamma + s_i + \varepsilon_{i,t} \quad (3)$$

When *x* vector is an institutional quality proxy, equation (3) is the specification to test institution explanation. With the interaction term, the marginal effect of resources on growth is given by $(\beta_2 + 2\beta_3 \times Resource + \beta_4 \times Institution)$. Positive institutional effect in $(\beta_4 \times Institution)$ can overcome the curse of resources. I continue with this framework to test the institutional explanation.

Interacting the resource variable with not only institutional quality proxies but each growth-related factor in $\boldsymbol{X}$ differentiates this study from other empirical work. The term $\left(Resource_{i,t} x_{i,t}\right)$

in equation (3) captures the interactions between resource abundance and each growth-related factor. In a crowding-out story, a negative β_4 implies that the marginal effect of *x* on growth, which is $(\gamma + \beta_3 \times R)$, is decreasing in the resource abundance level. The diminishing marginal effect of *x* explains the crowding-out effect on *x* in a resource-rich region. In line with the logic of the institution explanation, a positive β_4 signals a healing factor *x* that can potentially break the curse: as the marginal effect of the resource on growth is given as $(\beta_2 + 2\beta_3 \times Resource + \beta_4 \times x)$, a sufficient high level of *x* can offset the negative resource effect.

For the same reasons discussed in section 3.1, equation (2) and (3) are separately estimated by Fixed Effect model with Driscoll and Kraay standard errors. In each specification, the factor *x* refers to investment, education, R&D expenditure, finance correlation ratio, and three proxies of the institutional quality respectively (table 1).

One empirical concern of institution explanation in subnational level is the proxies for Institution Quality (IQ). In cross-country studies on the resource curse, scholars have employed different proxies to indicate institution quality, such as the degree of democracy (Murshed 2004), rule of law and government effectiveness measured by the World Bank (Bulte, Damania, and Deacon 2005), transparency (Williams 2011), and so on. However, proxies relying on trade restrictions, economic turmoil, or civil conflict are unlikely to be the cause of the resource curse across relatively homogeneous Chinese provinces. Thus, based on literature and data availability, I suggest three indices of institutional quality, including corruption, openness, and Foreign Direct Investment (FDI) ratio.

3.3 Data Description

Panel data is applied in this study. The dataset covers 30 provincial level regions of mainland China. Mainland China consists of 22 provinces, 5 minority autonomous regions, 4 municipalities and 2 special autonomous regions, but one minority autonomous region (Tibet) and 2 special autonomous regions (Hong Kong and Macao) were omitted because of missing data. Notice that Shao and Qi (2009) only included 10 western China provinces, which would cause selection bias problem. Since western China is all inland, the higher energy exploitation intensity is not only because of higher resource reserves but also due to less development in the first place. The negative relationship from energy exploitation intensity to growth could be reversed due to selection bias. To address this problem, full sample of Chinese provinces are employed in this study.

Most of the data were downloaded from China National Bureau of Statistics website (http://www.stats.gov.cn/tjsj/ndsj/) and China Economic Information Network (http://db.cei.gov.cn/). In 1996, Chongqing is separated from Sichuan Province as the fourth municipality after Beijing, Shanghai, and Tianjin. So I set the time range as 1997 till 2008, and all prices are in 1990 Yuan (Chinese currency). All in all, there would be 360 observations. Table 1 presents the definitions and descriptive statistics for all variables.

Across 360 observations, the average growth in annual personal income and GDP per capita are 9.8% and 10.5% respectively. The average annual energy production of a typical province is 57.752 million standard tons of coal with substantial variation. Energy production includes the produce of coal, oil, natural gas, electric power, heat and other power. All other energy forms rather than coal are converted into standard coal unit via the coal consumption method.

The problem of endogeneity related to the resource abundance measure is challenging in the resource curse literature. Flow measures are used by Sachs and Warner (1995) and Mehlum, Moene and Torvik (2006a and 2006b), such as share of natural resources in export or GDP. Other studies employed stock measures such as the share of natural capital in total capital or the value of subsoil assets (Alexeev and Conrad, 2001, Brunnschweiler and Bulte, 2008, Gylfason, 2001; Hodler, 2006). Stock measures are suggested to suffer fewer problems with endogeneity. However, how well a stock measure fits the narrative remains a question. On one hand, unexploited resources may be only tenuously connected with economic performance. It is when resources come into the production process that they become a factor to influence growth. On the other hand, if resource reserve is employed as an instrumental variable, then whether it is highly correlated with resource exploitation remains as a question. For example, a national resource conservation strategy could disturb the relationship.

Monetary flow proxies could reverse the causality because the higher proportions of energy industry in total output may be due to bad economic performance. Also, price rise in resource goods or price drop in other non-resource goods would both give rise to increase of resource proxies. However, resource abundance does not change in both cases. Based on these reasons and restricted by the availability of data, I present resource variables as three candidate proxies by energy production in physical unit, which avoid the disturbance from the price variation.

A scatter plot between average annual energy production and average annual growth rate from 1997 to 2008 is given in Figure 1. Energy production levels disperse much among provinces. The most recourse abundant province, ShanXi, produces 313.00 million standard tons of coal per year on average while the lowest annual average energy production is given by HaiNan province at 0.82 million standard tons of coal. Due to the poor economic performance, ShanXi provice was nominated as the first national reform pilot area focusing on the resource sector transformation in 2010. However, no obvious linear trend is shown in this preliminary statistic result. The trend line presents a quadratic curve which rises first and then follows a downward trend. Weak preliminary result may due to small magnitude from natural resource sector to economic growth and interaction among growth-related factors. More careful investigation will be done with econometric models in the next section.

[Insert figure 1 here]

4. Discussion of the Econometric Results

We found evidence that the resource curse existed at the Chinese provincial level. The resource boom tends to crowd out education and R&D thus hinders regional growth.

4.1 The Existence of Resource Curse and the Robustness

The results from testing the resource curse hypothesis (equation 1) are summarized in table 2. We estimate seven different models that control for initial income, investment, education, R&D activities, finance development and institution quality indicator corruptions. Starting from regression (2), the coefficients of *Resource* are positive while $Resource^2$ coefficients are negative and consistently significant. Based on results from regression (7), the marginal effect of resources on growth is given as (0.0100-2×0.000671×*Resource*), which depends on both the coefficients and the resource abundance level. This implies a threshold level of resource abundance at 7.452 standard tons of coal per capita. When annual per capita energy production exceeds the threshold level, the marginal effect of resource becomes negative and the resource curse occurs.

[Insert table 2 here]

On average, a typical province in China produces 1.650 standard tons of coal per capita, which suggests 0.00777 marginal effect of the resources (0.0100-2×0.000671×1.650). Thus on average, one additional standard ton of coal in per capita energy production is associate with 0.777% increase in per capita personal income growth, all else equal. However, in regions with higher energy production than 7.552 standard tons of coal per capita, the increasing energy production will hinder the growth and the local economy is cursed by the resources. For example, the maximum energy production per capita took place in Neimenggu province in 2008 at 15.746 standard tons of coal. In this case, an additional standard ton of coal production per capita will result in a 1.113% drop in annual per capita personal income growth. So the resource curse do exists in resource abundant provinces of China.

The negative resource effect shows up on the second order due to the quadratic model specification in our study. In a linear model, only the negative sign on the coefficient of resource variable suggests a direct negative effect of resource abundance on growth. In results of a quadratic specification, the resource abundance will not be a curse until it reaches a threshold high level. This makes more sense because it suggests that resources were a blessed endowment for a region in its early development stage. In other words, the economy could benefit from keeping the resource sector within a certain level. Thus, a quadratic model accounts for the potencies of that resources could be a blessing, and the problem lies in the process of resource exploitation rather than the congenital deficiency of resource abundance.

To test the robustness of the resource curse in China, more models with different indices of growth and resource variables are examined. In Table 3, regression (8) employs growth rate of personal income per capita (G1) as dependent variable and annual energy production per capita (Resource1) as resource variable, which is identical with regression (7) in table 2. Two more indicators for resource abundance are tested: annual total energy production by province (Resource2) and ratio of annual energy production over provincial GDP (Resource3). Regional per capita GDP growth (G2) replaces growth rate of personal income per capita (G1) as the dependent variable in regression (11), (12), and (13). The results on resource variables are consistent across regressions with different indices. Positive signs show up on the linear resource variables while the coefficient of the square term is significant negative. Therefore the existence of resource curse in China is robust and it is conditional on the regional energy production level.

[Insert table 3 here]

The intervening from the central government to the economy is another concern when investigating resource curse in China. The Reform and Opening-up Policy implemented in 1978 benefits the eastern coastline of China with high growth rate in 1980s and 1990s. While most of western China provinces are inland *and* resource abundant regions, the less development of western China during this period is mainly a result of the national plan rather than the curse of the resource abundance. However, the Western China Development Strategy was carried out in 1999, which includes the implementation of energy projects such as "Gas, Oil, and Coal transmission from West to East". Since then, the central government started to stimulate the growth in western China by encouraging the energy industry in the west. The time range of our dataset is from 1997 to 2008, which lies mostly in the Western China Development Strategy period when the central government focus more on the development of the resource abundant western regions. Our results suggest that increase earning from energy production sector could be a good policy to improve growth in the early development phase. However, the resource abundance could turn into the curse if energy production exceeds certain threshold level.

4.2 Crowding-out Effect or Institutions?

In order to test the crowding-out effect, we regress the growth-related factors, such as investment, education, R&D, finance and institution proxies on the resource variable. Table 4 shows the results of crowding-out effect specification as in equation (2). All else equal, higher point resource share is associated with higher investment level, lower education, less R&D expenditure, less finance development and openness index. It seems that resource abundance crowds out education, R&D, finance development and local trade. However, why these factors rather than others the crowded-out factors? Most interestingly, why is investment not another crowded-out factor but instead positively related to the point resource share?

[Insert table 4 here]

To further investigate the resource influence on growth-related factors, we introduce interaction terms in the regressions. The marginal effect of growth-friendly factor x on growth is given by equation (4), where γ is the coefficient on x and β_4 is the coefficient on interaction terms ($Resource_{i,t}x_{i,t}$).

$$\partial G/\partial x = \gamma + \beta_4 \times Resource \tag{4}$$

For the growth-friendly factors of education and R&D expenditure, the coefficients of the interaction terms are negative and significant (table 5). For instant, on average and all else equal, the marginal effect of education on growth is 4.427-0.339× $Resource$ (regression 22), which decreases in the point resource share (*Resource*). In other words, the returns from additional education to the economy are declining with the mining development and the diminishing return of education lessens the incentive to invest in education. A higher point resource share in GSP crowds out regional education level as a result. Similar relationship applies to R&D. A resource boom harms the marginal return of R&D on growth, which in turn worsens the incentive to invest and accelerates the crowding-out effect on R&D. On the other hand, no significant evidences show on resource and investment interactions.

[Insert table 5 here]

The results of the crowding-out effect are intuitive. Firstly, industries related with resource exploitation such as mining are capital-intense industries. Higher resource specification in one region will lead to higher investment, especially in newly increased fixed assets. Second, mining in China, specifically coal mining is of lower technical content and with less need of high skilled labor force. Regardless the income, lower returns of educational investment wear away the demand for schooling: there would be no urgency and pressure to increase the education input. As a result, the resource boom squeezes out education development in the region, slowing down local growth. In Shanxi and Neimenggu, the top two energy production provinces of China, the average percentages of college student number over population are 6.5% and 8.0% respectively, which are both lower than the national average level at 9.2%. Finally, the significant development of energy industry attracts more less educated or lower skilled labor force from outside, which in turn reduces the local human capital endowment. It would hinder the rise of other industries which treat high skilled labor forces as an important production factor, such as manufacturing sector. Consequently, local economic growth falls into the curse in the long run.

The natural defects of the mining industry are the story that the crowding-out explanation tells. The policy implications deduced from it are pessimistic: one cannot simply compensate the crowded-out factors. According to the symmetric property of the interaction specification in the empirical model, the marginal effect of the point resource share also depends on growth related factors. In the case of R&D (regression 23 in table 5), the marginal effect of the resource on growth is given as ($\partial G/\partial R = -0.0119 - 2 * 0.00075 * Resource - 0.143 * R\&D$), which is decreasing in R&D expenditure. That is the injected investment on R&D would be locked in the mining industry which further weakens the marginal returns. Therefore, increasing education or R&D via policy does not help to escape from the curse but rather may worsen the situation.

To investigate institutional explanation, we apply the same interaction framework with three indices for institution quality: Corruption, Openness, and FDI ratio. Corruption proxy is a measure for rent-seeking behaviors of the government, and negatively related with institution quality. Openness indicates trade freedom degree and marketization level of one region, and is positively related with institution quality. FDI ratio is an indirect indicator with the assumption that regional institution quality is a crucial factor for the foreign investors to make the investment decision. The better the institution quality a region holds, the more likely that it would reveal higher FDI ratio.

Institutional explanation emphasizes the marginal effect of resource conditional on institution quality. Equation (5) gives this marginal effect, where β_2 and β_3 indicates the coefficient of resource variables and β_4 is the coefficient of the interaction term between resource variable and institution proxies. If β_4 is positive and significant, it implies the marginal effect of resources on growth could be positive as long as the positive institution factor ($\beta_4 \times Institution$) is high enough to overwhelm the curse represented by the negativity on ($\beta_2 + 2\beta_3 \times Resource$), which suggests a threshold level for institution quality.

$$\partial G / \partial Resource = \beta_2 + 2\beta_3 \times Resource + \beta_4 \times Institution \qquad (5)$$

The results in table 6 show no evidence to favor institutional explanation. In regression (25) and (26), neither Openness nor FDI ratio themselves shows significant positive effect on growth. The coefficients on interaction terms (*Resource*Openness* and *Resource*FDI*) are both positive but not significant. For Corruption variable, though it suggests significant negative effect on growth on its own, the interaction term is not intuitive. One reason for this may lie in the measure of institution quality at subnational level. In cross-countries studies of the Resource Curse, politic institution indices are widely applied such as degree of democracy. However, within one national, the politic system stays the same while other indicator like rule of law or government effectiveness varies a little. So it will not be surprise to have insignificant results on subnational institution qualities.

[Insert table 6 here]

5. Conclusion

The resource curse hypothesis – resource abundance economies tent to underperform in economic growth – has been tested across countries. In this study, we tested the resource curse hypothesis and the two mechanisms across provinces in China. The results show evidence that the resource curse is present when regional annual energy production exceeds the threshold level at 7.452 standard tons of coal per capita, even after controlling for initial income, investment, human capital, R&D activities, and the institutional quality. This calls caution on the Western China Development Strategy carried out in 1999. The national policy aims to stimulate growth in western China with energy project such as "Gas, Oil, and Coal transmission from the West to the East". While taking advantage of regional natural resource endowment to increase earning from energy production sector could be a good start, the resource abundance could turn into the curse if energy production is too much.

The comparison between the crowding-out effect and institutional explanation at a subnational level offers a better understanding of the mechanism of the recourse curse. Evidence also suggests that the resources crowd out growth-friendly factors like education and R&D expenditure thus hinders growth. The marginal effect analyses in this study is of particular interest for policy making: with the marginal effect of natural resources decreasing in education and R&D, simply compensating education and R&D activities without reducing the resource production does not help to escape from the curse. This suggests that it is necessary to transform the highly resource-specialized industrial structure into diverse manufacturing structure so that the resource abundance region can well benefit from public investment in education and R&D.

Based on our results, the crowding-out effect seems explain the resource curse better than institution explanation in the Chinese case. On one hand, insignificant results from testing the institution explanation are not surprising due to the limited variation on institutional qualities within one nation. Further discussion on subnational level institution and proper proxies for the institution quality may help more. On the other hand, education and R&D are key links of the resource curse in China rather than institution quality. Glaeser et al.(2004) suggested that human capital is a more basic source of growth than are the institutions. While what ultimately drives growth remains as an open question, the resource curse phenomenon proposes a good opportunity and angle to investigate the answer.

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Table 1 Variable Definitions and Descriptive Statistics

Variable	Definition	Mean	Standard Deviation	Min	Max
G1	Annual growth in personal disposable income per capita	0.105	0.041	-0.024	0.228
G2	Annual growth in GDP per capita	0.098	0.055	-0.061	0.328
Resources1	Annual energy production per capita (standard ton of coal)	1.650	2.210	0	15.746
Resources2	Annual energy production (million standard tons of coal)	57.752	69.830	0	479.671
Resources3	Ratio of annual energy production over GDP (standard ton of coal per 10,000 ￥)	2.037	2.505	0	16.729
Investment	Ratio of annual newly increased fixed assets over GDP	0.416	0.116	0.205	0.784
Education	Annual college student proportion over regional population	0.0092	0.0071	0.0011	0.0358
R&D	Percentage of local government expenditure in R&D activities	0.011	0.012	0.001	0.144
Finance	Ratio of total deposit and loan over GDP	2.334	0.779	0.925	5.899
IQ_Corruption	Number of duty crimes every 10,000 workers	3.897	2.347	0.480	20.465
IQ_Openness	Ratio of provincial export over GDP	0.312	0.404	0.032	1.721
IQ_FDI	Annual percentage of Foreign Direct Investment over regional total investment	0.043	0.039	0.0006	0.2051

Notes: "0" indicates presence of missing data. Energy production data of Ningxia autonomous region in year 2000, 2001, 2002 and Hainan province in 2002 are missing. Duty crimes are crimes that committed by working personnel in government or state-owned companies, enterprises, institutions, and organizations, such as corruption, bribery, engaging in malpractices for personal gain, abuse their powers, and neglect their duties.

Table 2 the Existence of Resource Curse, China, 1997-2008

G1	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\ln Y_{t-1}$	0.0624***	0.0574***	0.0493**	0.00435	0.00352	-0.000564	-0.00611
	(0.0113)	(0.0100)	(0.0149)	(0.0349)	(0.0350)	(0.0344)	(0.0436)
Resource	0.000214	0.00962**	0.00830**	0.00818*	0.00820*	0.00665	0.0100**
	(0.00117)	(0.00296)	(0.00281)	(0.00334)	(0.00334)	(0.00348)	(0.00286)
$Resource^2$		-0.000611**	-0.000599***	-0.000556**	-0.000555**	-0.000520*	-0.000671***
		(0.000182)	(0.000159)	(0.000185)	(0.000186)	(0.000191)	(0.000166)
$Investment_{t-1}$			0.0799*	0.101*	0.103*	0.101*	0.0761
			(0.0294)	(0.0408)	(0.0415)	(0.0440)	(0.0515)
Education				2.764	2.762*	3.393*	3.622*
				(1.354)	(1.335)	(1.461)	(1.748)
$R\&D_{t-1}$					0.100	0.121	0.124
					(0.0903)	(0.0865)	(0.0932)
Finance						-0.0239***	-0.0248**
						(0.00617)	(0.00758)
$IQ\_Corruption_{t-2}$							-0.00374***
							(0.000678)
Constant	-0.454***	-0.420***	-0.379**	-0.00980	-0.00421	0.0859	0.156
	(0.0998)	(0.0894)	(0.123)	(0.287)	(0.287)	(0.284)	(0.362)
N	360	360	330	330	330	330	300
Within R^2	0.2660	0.2762	0.3107	0.3227	0.3231	0.3409	0.3919

Note: Driscoll and Kraay standard errors are in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; the number of observations varies because of lagged variables.

Table 3 Robustness Check with Different Indices

	(8) G1	(9) G1	(10) G1	(11) G2	(12) G2	(13) G2
$\ln(Y1_{t-1})$	-0.00611	-0.00270	-0.00576			
	(0.0436)	(0.0447)	(0.0433)			
$\ln(Y2_{t-1})$				-0.0886**	-0.0922**	-0.0611*
				(0.0320)	(0.0305)	(0.0292)
Resource1	0.0100**			0.0140**		
	(0.00286)			(0.00490)		
$(\text{Resource1})^2$	-0.000671***			-0.000501		
	(0.000166)			(0.000258)		
Resource2		0.000351***			0.000685***	
		(0.0000843)			(0.000135)	
$(\text{Resource2})^2$		-0.000000808***			-0.000000936***	
		(0.000000165)			(0.000000230)	
Resource3			0.0124**			-0.00452
			(0.00385)			(0.00506)
$(\text{Resource3})^2$			-0.00105*			0.000624
			(0.000504)			(0.000366)
Investment_{t-1}	0.0761	0.0649	0.0781	0.131***	0.110*	0.150***
	(0.0515)	(0.0537)	(0.0506)	(0.0356)	(0.0430)	(0.0385)
Education	3.622*	3.561	3.904*	3.398**	3.384**	2.797*
	(1.748)	(1.793)	(1.752)	(1.222)	(1.181)	(1.291)
$\text{R\&D}_{t-1}$	0.124	0.0952	0.127	-0.786***	-0.847***	-0.828***
	(0.0932)	(0.0900)	(0.0936)	(0.174)	(0.184)	(0.169)
Finance	-0.0248**	-0.0247**	-0.0256***	-0.0124	-0.0117	-0.0157
	(0.00758)	(0.00755)	(0.00685)	(0.0239)	(0.0243)	(0.0238)
$\text{IQ\_Corruption}_{t-2}$	-0.00374***	-0.00349***	-0.00379***	0.00223	0.00264	0.00260
	(0.000678)	(0.000717)	(0.000604)	(0.00147)	(0.00140)	(0.00140)
Constant	0.156	0.128	0.149	0.817*	0.842*	0.593
	(0.362)	(0.370)	(0.359)	(0.325)	(0.309)	(0.301)
N	300	300	300	300	300	300
Within R^2	0.3919	0.3944	0.3907	0.1302	0.1386	0.1140

Note: Driscoll and Kraay standard errors are in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 4 Test for Crowding-out Effect

	(14) Investment	(15) Education	(16) R&D	(17) Finance	(18) Corruption	(19) Openness	(20) FDI ratio
Resource1	0.0118*	-0.000287***	-0.000847***	-0.0638***	0.327	-0.0241***	-0.000725
	(0.00442)	(0.0000542)	(0.000229)	(0.0136)	(0.200)	(0.00329)	(0.00149)
$\ln(Y_{t-1})$	0.207***	0.0145***	0.00598**	0.328	-2.695	0.220***	-0.00274
	(0.0152)	(0.000588)	(0.00204)	(0.176)	(1.429)	(0.0285)	(0.0116)
Constant	-1.459***	-0.120***	-0.0415*	-0.497	27.51*	-1.623***	0.0683
	(0.132)	(0.00525)	(0.0176)	(1.551)	(12.74)	(0.248)	(0.104)
N	360	360	360	360	360	360	360
Within R^2	0.5937	0.8742	0.0267	0.1182	0.1457	0.2941	0.0074

Note: Driscoll and Kraay standard errors are in parentheses; * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 5 the Crowding-out Effect Estimations with Interactions

G1	(21)	(22)	(23)
$\ln(Y_{t-1})$	-0.00614	-0.0118	-0.0121
	(0.0436)	(0.0430)	(0.0417)
Resource	0.0109**	0.0120***	0.0119***
	(0.00362)	(0.00216)	(0.00296)
$Resource^2$	-0.000650**	-0.000534*	-0.000750***
	(0.000224)	(0.000228)	(0.000163)
$Investment_{t-1}$	0.0794†	0.0747	0.0798
	(0.0443)	(0.0511)	(0.0498)
Education	3.613	4.427*	3.923*
	(1.780)	(1.747)	(1.687)
$R\&D_{t-1}$	0.126	0.125	0.269*
	(0.0900)	(0.0949)	(0.110)
Finance	-0.0253**	-0.0286**	-0.0260**
	(0.00716)	(0.00794)	(0.00780)
$IQ\_Corruption_{t-2}$	-0.00375***	-0.00373***	-0.00378***
	(0.000663)	(0.000693)	(0.000677)
Resource*Inv.	-0.00238		
	(0.00936)		
Resource*Edu.		-0.339†	
		(0.186)	
Resource*R&D			-0.143***
			(0.0364)
Constant	0.156	0.210	0.207
	(0.363)	(0.358)	(0.348)
N	300	300	300
Within R^2	0.3920	0.3953	0.3941

Note: Driscoll and Kraay standard errors are in parentheses; † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Table 6 the Institutional Explanation Estimations

G1	(24)	(25)	(26)
$\ln(Y_{t-1})$	-0.00947	0.00374	0.00160
	(0.0438)	(0.0414)	(0.0369)
Resource	0.00870^{**}	0.00597^{*}	$0.00627^{\dagger}$
	(0.00271)	(0.00270)	(0.00334)
Resource^2	-0.000730^{***}	-0.000506^{*}	-0.000502^{**}
	(0.000169)	(0.000190)	(0.000165)
Investment_{t-1}	0.0835	$0.0953^{\dagger}$	0.102^{*}
	(0.0533)	(0.0493)	(0.0459)
Education	3.651^{*}	$3.323^{\dagger}$	$3.224^{\dagger}$
	(1.732)	(1.766)	(1.678)
$\text{R\&D}_{t-1}$	0.123	0.138	0.130
	(0.0903)	(0.0824)	(0.0894)
Finance	-0.0243^{**}	-0.0228^{**}	-0.0241^{***}
	(0.00705)	(0.00793)	(0.00657)
$\text{IQ\_Corruption}_{t-2}$	-0.00493^{***}		
	(0.000867)		
Resource*Corruption	0.00112^{**}		
	(0.000315)		
IQ_Openness_{t-1}		-0.0123	
		(0.0242)	
Resource*Openness		0.00332	
		(0.0121)	
IQ_FDI			-0.0659
			(0.147)
Resource*FDI			0.0215
			(0.0742)
Constant	0.183	0.0512	0.0705
	(0.362)	(0.342)	(0.304)
N	300	300	300
Within R^2	0.3964	0.3415	0.3414

Note: Driscoll and Kraay standard errors are in parentheses; $^{\dagger}\, p < 0.10$, $^{*}\, p < 0.05$, $^{**}\, p < 0.01$, $^{***}\, p < 0.001$.

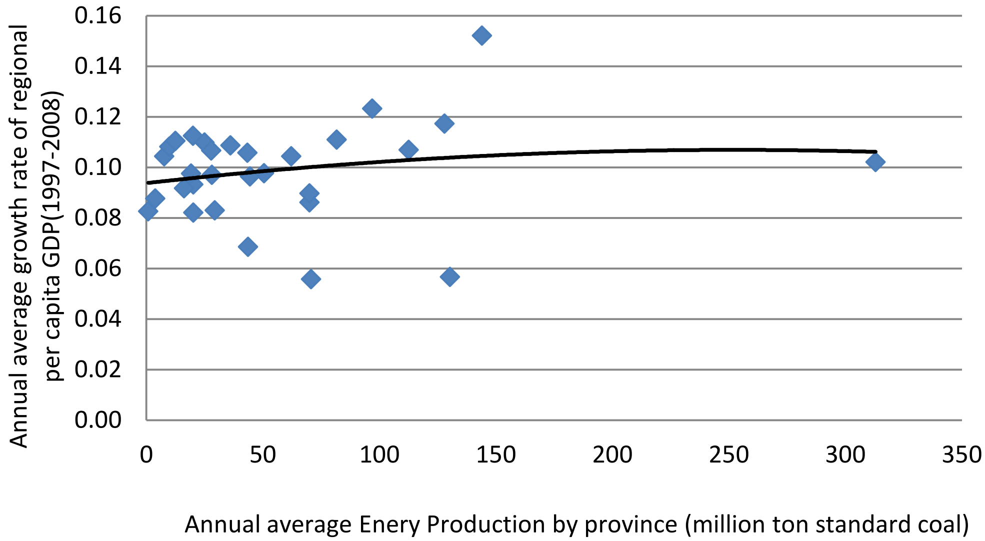

Figure 1 Energy Production and Economic Growth