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Resource abundance and resource dependence in China*

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Proposed running head: Resource abundance and dependence in China

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Abstract: This paper reconsiders the 'curse of resources' hypothesis for the case of China, and distinguishes between resource abundance, resource rents, and resource dependence. Resource abundance and resource rents are shown to be approximately equivalent, and their association with resource dependence varies with institutional quality. Resource abundance/rents has a positive impact on economic growth, while resource dependence has a negative impact. The impact of the 'West China Development Drive' policy, started in 2000, is substantial, and this is investigated through a comparative analysis based on cross-section samples, and through a panel-data time-varying coefficient approach for West and East provinces. Resource effects do change after the policy shock.

JEL Classification: O11, O13, O53, C21, Q0, Q33.

Keywords: Natural resource curse; Economic growth; China; Institutional quality; Resource abundance; Resource dependence; Regional differences; Policy change.

1 Introduction

The question whether economic growth depends on resource abundance, and if so how, has been much debated in the literature. After Habakkuk (1962) and Murphy et al. (1989) claimed that growth depends on resource abundance, Sachs and Warner (1995) showed that resource abundance can also lead to poor economic performance: the 'curse of resources' hypothesis. The curse can be due to the fact that non-resource sectors are crowded out by overdevelopment of resource sectors ('Dutch disease', see Sachs and Warner, 1999), or can be explained by a rent-seeking argument (Tornell and Lane, 1999; Baland and Francois, 2000). Others have noted, however, that not all countries with abundant resources are cursed, for example Canada, Australia, Norway, and Botswana, and they suggest that the principal force underlying the divergent performance of resource-rich countries is institutional (Mehlum et al., 2006; Sokoloff and Engerman, 2000).

Recently, Brunnschweiler and Bulte (2008) discussed how resources are measured and how this might affect the analysis. A common measure is the ratio of resource exports to GDP, and Brunnschweiler and Bulte argued that this is a measure of resource dependence rather than of resource abundance. Such a measure is likely to be endogenous with institutional quality and economy size, resulting in an endogeneity problem. To avoid this problem, Brunnschweiler and Bulte introduced an exogenous measure of resource abundance, and investigated the resource effects by controlling for both resource abundance and resource dependence in growth regressions. Their across-country empirical evidence supports the hypothesis that resource dependence is endogenously influenced by institutional quality. In addition, they found that instead of cursing the economy, resource abundance is good for institutional quality as well as for growth, while resource dependence has a negative but weak correlation with growth after controlling for abundance.

Since resource abundance and resource dependence have opposite impacts on economic growth, it is of interest to know when the positive effects of resource abundance/rents dominate and when the negative effects. Is is also unclear whether abundant resources always lead to strong resource dependence. If not, under what conditions does weak resource dependence occur in resource-abundant regions? These questions are relevant because, if conditions for positive net resource effects are known and controllable, then resource-abundant but underdeveloped regions can make proper use of rich resources to stimulate their economies. Similarly, if conditions for less resource dependence are known, resource-abundant regions can adjust and become less resource-dependent.

Most studies on resource effects employ cross-section data to study the long-run effects of resources (e.g., Sachs and Warner (1999); Mehlum et al. (2006); Brunnschweiler and Bulte (2008)). Using cross-section data reduces the possible bias caused by economic fluctuations, but it does not capture the dynamics. A cross-section analysis of resource effects assumes implicitly that these effects do not change over time. This may, however, not be the case, especially for regions in transition. For such regions, structural breaks may occur, and resources may play a different role before and after the breaks.

This paper attempts to pay attention to all these issues. We examine the resource effects in China, based on data from 28 provinces. There are several advantages of using within-country data. First, different countries can be very heterogeneous, and many relevant variables are hard to control, thus leading to omitted-variable and attenuation bias. A within-country study does not have this problem, at least not in the same degree. States or provinces in one country will have a lot in common, and therefore a within-country study allows a sharper focus on the resource effects and will provide more precise estimates. Second, within-country data allow us to study the dynamic effects of resources in the presence of structure breaks. If we focus on one country, it is easier to specify a common structural break, such as a policy change or a significant event.

While many studies compare different countries, there are only a few within-country studies on the resource curse. An important within-country study is Papyrakis and Gerlagh (2007), which employed data from 49 states in the USA, and concluded that resource-scarce states outperform resource-rich states. In China there are significant differences between provincial economies, and substantial variation in the importance of resource sectors. The Eastern provinces of China are generally more developed than the Western provinces. Since most Western provinces are resource-abundant, naturally the question arises which role resource abundance plays in determining the economic development of a province in China. Of special interest is a significant policy change, which occurred in 2000 when the government proposed the 'West China Development Drive', a policy initiative designed to promote the economies of Western provinces by intensifying natural resource exploitation, improving infrastructure, and opening up the region. This was a big change of policy, and natural resources may play a different role in the economy before and after 2000.

There is only a small literature on the relationship between resources and the economy in China. Xu and Wang (2006) used panel-data methods and found evidence supporting the hypothesis of a resource curse at the provincial level. Zhang et al. (2008) employed the energy resource production in 1985 as a measure of resource abundance, and associated a poor economy with rich resources, especially in rural regions. Neither of these two papers studies the effects of the 2000 policy change. In contrast, Shao and Qi (2009) compared the resource effects before and after the policy change by estimating two samples (before and after the shock) separately. Their results suggest that the West China Development Drive induced a resource curse and lead to an increased gap between East and West China. One problem with all three papers is the measurement of resource abundance. For example, Xu and Wang (2006) measured resource abundance by the proportion of mining workers or by the ratio of investment in the mining industry to total fixed asset investment, while Shao and Qi (2009) used the ratio of output in the resource industry to gross industrial output value. Such resource dependence measures suffer from endogeneity, thus resulting in inconsistent estimates.

To improve the accuracy of estimators and investigate the resource effects more precisely, we follow Brunnschweiler and Bulte (2008) and consider both resource abundance and resource dependence. Moreover, we distinguish between resource abundance and resource rents. Resource abundance is defined as the stock measure of resource wealth, while resource rents mainly concern the flow of income from resource extraction at specific points in time. Rich resources do not necessarily imply large resource rents, and hence we distinguish between abundance and rents when examining resource effects on economic growth. Another important variable is institutional quality. It is widely accepted that institutional quality plays an important role in the economy. But measuring institutional quality has proved difficult. We propose to use the confidence in courts as a proxy for institutional quality. Provincial-level data are used both from East and West China. To solve the endogeneity problem, instrumental variables for both resource dependence and institutional quality will considered, and (consistent) 2SLS and 3SLS estimates will be reported and compared with the OLS estimates.

Our paper uses both cross-section and time-series data. The advantage of using cross-section data is that it better captures the long-run effect, and reduces the possible bias caused by economic fluctuations. A functional-coefficient model is employed to describe the association between resource abundance/rents and resource dependence across institutional levels. In order to see whether natural resources play a different role before and after the 2000 policy change, we compare pre-shock and post-shock samples. Regional differences between Eastern (coastal) provinces and Western (inland) provinces regarding institutional quality, social structure, and other factors, are taken into account. The advantage of time-series data is that it provides a perspective of how resource impacts on the economy change over time. Estimating a time-varying coefficient model in a panel-data framework, we benefit from the larger sample size of panel data, and obtain insights in the dynamics of the resource effects.

Our results are not in general agreement with the current literature, and they confirm the results in Brunnschweiler and Bulte (2008) to a large extent. We find that both resource abundance and resource dependence are highly associated with institutional quality, which shows that resource dependence is an endogenous variable that needs to be instrumented. Although resource abundance/rents and resource dependence are strongly correlated, abundant resource does not necessarily lead to high resource dependence. This is where institutional quality plays a crucial role. The functional-coefficient estimates show that richness in resources results in high dependence in regions where institutional quality is extreme (either very low or very high), and low dependence in regions where institutional quality is moderate, even when these regions are resource-abundant. Resource abundance and resource dependence have an opposite effect on economic growth. Instead of cursing the economy, abundant resources have a positive influence on economic growth, while overdependence on resources is bad for growth. The resource effects on growth also varies across institutional quality. The West China Development Drive had an important impact on the role of resources in the economy, by intensifying resource exploitation of the Western provinces, resulting in an increase in income in the West. This increased income helped the economy for a short period, but did not last long. An overemphasis on resource exploitation crowded out activities in other sectors such as education and entrepreneurship, and it did not much to boost resource-related sectors such as industrialization. Thus, the positive effect of resource rents slowed down and even became negative.

The paper is organized as follows. In Section 2 we propose the models. The data are described in Section 3, where we also present some characteristics and preliminary analysis of the data. In Sections 4–6 we estimate cross-section models using the entire sample, and also provide before- and after-2000 analysis using two separate samples. Section 7 uses the time-varying coefficient model and presents the resulting estimates. Some conclusions are offered in Section 8.

2 Benchmark models

We now present the models which we shall use to study the resource effects on economic growth. As also noted by Brunnschweiler and Bulte (2008), the typically used resource measure is based on resource dependence, and this may be affected by either resource abundance or institutional quality or both, so that it fails to serve as an appropriate exogenous variable. Hence, we distinguish between resource abundance and resource dependence. Resource abundance may exert a direct influence on economic growth, while it also affects the economy indirectly through institutional quality and resource dependence. It will also be useful to distinguish between resource abundance and resource rents when examining the impacts of resource on growth. Resource abundance is a stock measure of *in situ* resource wealth, while resource rents measure the flow of income from extracting resource stock at some point in time. Although the two concepts are likely to be highly correlated, we cannot rule out the possibility that some regions are rich in resource, but still their income does not depend primarily on resource exploitation. Because of this concern, we distinguish between resource abundance and resource rents in our analysis.

In order to examine relations between resource abundance/rents, resource dependence, and institutional quality in China, we follow the framework of Brunnschweiler and Bulte (2008), and consider the regression model

$$\text{INS} = \beta_{0a} + \beta_{1a}\text{RA} + \beta_{2a}\text{RD} + \beta_{3a}\text{WEST} + \epsilon_{1a}, \qquad (1)$$

$$\text{INS} = \beta_{0r} + \beta_{1r}\text{RR} + \beta_{2r}\text{RD} + \beta_{3r}\text{WEST} + \epsilon_{1r}, \qquad (2)$$

where INS represents institutional quality, RA is resource abundance, RR is resource rents, RD is resource dependence, and WEST is a geographic dummy variable indicating the Western provinces, that is, WEST = 1 if the province lies in the West region of China and WEST = 0 otherwise. The subscripts 'a' and 'r' differentiate whether RA or RR is used in the regressions. The aim of Equations (1) and (2) is to examine the dependence of institutional quality on resource abundance when we control for geography and resource dependence. Resource abundance and rents are the main focus, since a negative coefficient of β_{1a} or β_{1r} provides new evidence supporting a rent-seeking theory, while a positive coefficient would support Brunnschweiler and Bulte's (2008) argument that resource abundance and institutional quality are positively linked, probably through an income effect. We add the West dummy as a control because there is non-negligible difference of institutional quality between Eastern and Western regions.

In order to examine the exogeneity of resource dependence, we study the determinants of resource dependence and consider the following model:

$$\text{RD} = \alpha_{0a} + \alpha_{1a}\text{RA} + \alpha_{2a}\text{INS} + \alpha_{3a}\text{WEST} + \epsilon_{2a}, \qquad (3)$$

$$\text{RD} = \alpha_{0r} + \alpha_{1r}\text{RR} + \alpha_{2r}\text{INS} + \alpha_{3r}\text{WEST} + \epsilon_{2r}. \qquad (4)$$

The endogeneity of resource dependence may be the result of the positive association with resource abundance caused by comparative advantage, but also of the negative influence of institutional quality, which might affect resource dependence by reducing the enthusiasm of investing and developing industrial or services sectors. If any of α_{1a}, α_{1r}, α_{2a}, or α_{2r} is significantly different from zero, this would be an indication that it is appropriate to treat resource dependence as endogenous.

Our main purpose is to study the effects of resource abundance on economic growth. To incorporate direct and indirect effects of resource abundance/rents through the channel of either resource dependence or institutional quality, we consider the model

$$y = \gamma_{0a} + \gamma_{1a}\text{RA} + \gamma_{2a}\text{RD} + \gamma_{3a}\text{INS} + \sum_{k=1}^{6}\theta_{ka}x_k + \epsilon_{3a}, \tag{5}$$

$$y = \gamma_{0r} + \gamma_{1r}\text{RR} + \gamma_{2r}\text{RD} + \gamma_{3r}\text{INS} + \sum_{k=1}^{6}\theta_{kr}x_k + \epsilon_{3r}, \tag{6}$$

where y denotes economic performance and

$$\big(x_1, \ldots, x_6\big) = \big(\text{EDU}, \text{IND}, \text{ENT}, \text{OPEN}, \text{INIT}, \text{WEST}\big)$$

contain auxiliary control variables: education (EDU), industrial development (IND), entrepreneurship (ENT), openness (OPEN), initial economy level (INIT), and the Western dummy (WEST). In Equations (5) and (6), γ_{1a} and γ_{1r} measure the direct effect of resource abundance, γ_{2a} and γ_{2r} the indirect effect through resource dependence, and γ_{3a} and γ_{3r} the indirect effect through institutional quality. The auxiliary variables affect the economy and are associated with resource abundance, and their inclusion will therefore reduce omitted variable bias. Education reflects investment in human capital, which is not much required in the primary sector. Therefore, resource abundance might undermine the incentives to invest in human capital, thus resulting in lower economic growth. Entrepreneurship stimulates innovation and hence the economy, but it might be 'squeezed out' by resource abundance (Sachs and Warner, 2001). Similarly, industrial development is included, since the 'Dutch disease' effect implies that industry is likely to be crowded out by the resource in regions rich in resource. Openness may be important, because the more a province enjoys resource abundance, the more self-sufficient it will be, and therefore the less likely to be open. Initial state of economy is necessary for capturing the long-run effect of resource. Finally, the West dummy controls the remarkable difference between the economies of Western and Eastern regions.

3 Data and descriptive statistics

We consider 28 'provinces' in China, namely 22 provinces, 4 municipalities directly under the Central Government, and 2 autonomous regions. We refer to all 28 'provinces' as provinces. Only inland provinces are considered, and hence Hong Kong, Macao, and Taiwan are not included. Three autonomous regions (Xinjiang, Inner Mongolia, and Tibet) are excluded because of lack of data. Each province is labeled either 'West' or 'East', depending on its geographic location; see Figure 1.

[Figure 1]

The measurement of resource abundance (RA) in China is typically based on resource rents (RR) (Zhang et al., 2008). However, resource abundance is not the same as resource rents, since RA measures the stock of resource reserves while RR measures the production of resources at specific points in time. In addition, measures of resource abundance typically only cover energy resources, but do not take into account the equally important mineral resources. In this paper, resource abundance is measured by the resource reserve explored and surveyed in 2003–2004, and it covers both energy and the most important mineral resources. There are no data on resource reserves in the China Statistical Yearbook (National Bureau of Statistics) until 2003. Since it is not likely that resource reserves vary greatly across years (as can be verified by comparing the reported statistics from 2003 to 2008), it seems reasonable to use the reserves rather than the production as a measure of resource abundance. For the purpose of comparison and in order to allow robustness checks, we shall report on both measurement concepts, hence not only RA but also the more common RR based on energy resource production.

The economy-related variables include economic growth, institutional quality, education, industrial development, entrepreneurship, openness, initial economic level, and investment in fixed assets. All of these, except institutional quality and initial economic level, contain observations in several years for each province. The time span varies across variables.

We emphasize the inclusion of institutional quality. This is a difficult concept to measure, and is therefore often ignored or measured using dubious proxies, such as the ratio of total trade over GDP; see Xu and Wang (2006) and Shao and Qi (2009). We propose to use the confidence in courts surveyed in 1995 by the World Bank as a measure of institutional quality. These data are at city level. To construct the provincial level data, we take a weighted average of all cities in one province where the weights are given by the proportion of the city's GDP in the province. This is clearly a subjective measure and can be biased, as pointed out by Olken (2009) in a different context. Still, we believe that confidence in courts is a better proxy to institutional quality than other proxies used in the literature. In addition, since we work with aggregated provincial data, the bias (if present) would be averaged out to some extent.

The resource reserve data come from the China Statistical Yearbook (National Bureau of Statistics). Resource rents and resource dependence data are available from the China Economic Information Network (CEINET). The economy-related variables are either from CEINET or from the World Bank. The measurement of all variables and their time span are described below.

Growth Growth of real GDP per capita. In the cross-section analysis, Growth is averaged between 1990 and 2008:

$$\text{Growth} = \frac{\log(\text{GDP}_T/\text{GDP}_{T_0})}{T - T_0},$$

where $T = 2008$ and $T_0 = 1990$. In the panel-data analysis, it is defined as the annual growth rate of real GDP per capita:

$$\text{Growth}_t = \log(\text{GDP}_t/\text{GDP}_{t-1}) \qquad (t = 1991, \dots, 2008).$$

RR Resource rents, measured by natural energy resource production, a combination of the production of raw coal, crude oil, and natural gas, calculated as suggested by the Chinese Academy of Sciences (Xu and Wang, 2006):

$$\begin{aligned}\text{RR (in tons)} &= \text{coal production (in tons)} \times 0.714 \\ &\quad + \text{oil production (in tons)} \times 1.43 \\ &\quad + \text{gas production (in } 1000m^3) \times 1.33.\end{aligned}$$

The time spans from 1989 to 2008. Some authors include, besides coal, oil, and gas, also hydro-electric power (Zhang et al., 2008), electric power, or nuclear power (Shao and Qi, 2009). We restrict ourselves to the primary energy sources (coal, oil, gas), because electric and nuclear power are more related to human activity than to natural resources.

RA Resource abundance, constructed by multiplying resource reserves by their average market prices in 2004. The resource reserves cover petroleum, natural gas, coal, iron ore, manganese ore, copper ore, lead mine, zinc ore, and bauxite, explored in 2003 or 2004. Energy resource data are from 2003, while mineral resource data are from 2004 due to many missing values in 2003. The energy resource data in 2003 and 2004 are very similar. The market prices are obtained from Worldwide Mining Business Website (http://www.wdore.com).

RD Resource dependence, the ratio of fixed asset investment in the mining industry over all fixed asset investment. The time span is from 1996 to 2008.

INS Institutional quality, measured by confidence in courts, which is a weighted average of city level data. Only cross-section data in 1995 are available.

EDU Education, the number of teachers as a proportion of provincial population, from 1989 to 2008. The number of teachers is obtained as the sum of all teachers in university, middle school, and elementary school.

IND Industrial development, ratio of value-added of industry to GDP, from 1992 to 2008.

ENT Entrepreneurship, also referred as private economic activity, measured by the number of people in non-state-owned companies divided by the provincial population, from 1992 to 2008. Employees in non-state-owned companies work either in private-owned companies or in self-employed households.

OPEN Openness, the ratio of actual inflow of foreign investment over gross investment in fixed assets, from 1989 to 2003.

INIT Initial economic level, defined as the logarithm of real GDP per capita in 1989.

INV Total investment in fixed assets, averaged over 1974 to 1989, used as an instrumental variable for resource dependence.

WEST Geographic dummy: WEST = 1 if the province lies in the Western region of China (as defined in Figure 1) and WEST = 0 otherwise.

DIS Distance to coast, defined as the distance from the provincial capital to the nearest harbor (source: Au and Henderson (2006)).

The last two variables are geographic rather than economy-related. Distance to coast (DIS) is sometimes used as an instrumental variable for institutional quality, based on the idea that coastal regions are typically more open than inland regions, and thus require higher institutional quality. More importantly, coastal regions in China enjoy preferential policies compared to inland regions.

[Table 1]

The 28 provinces are compared in Table 1 in terms of resource production, resource reserves, and resource dependence. As expected, resource production and resource reserves are highly correlated, although the provinces Shangdong, Heilongjiang, and Yunan are exceptions. In particular, Shangdong and Heilongjiang are among the top 3 in terms of resource production but they rank only 9 and 11 in terms of resource reserves. The reason is that these two provinces are especially rich in energy resources like oil and coal, but relatively poor in other mineral resources. Yunan province is among the top 10 in terms of resource reserves but ranks only 12 in terms of resource production. This is partly because Yunan province is famous for its rich mineral resources such as manganese ore, lead ore, and zinc ore, but more importantly because its resources are not fully exploited due to poor exploitation techniques and conditions, complex geological structure, and low economic coal reserves. (We note that Yunan is among the top 5 in terms of coal reserves, but that its coal production is quite low compared to its reserves.) Tianjin province is classified as resource-scarce according to resource reserves, although its energy production is relatively high. In fact, although Tianjin has few mineral resources, its surrounding sea produces a large amount of oil.

As for resource dependence, it is clear that provinces with low resource production generally show weak resource dependence. However, not all provinces with a high degree of resource dependence are associated with large resource production, for example Qinghai and Ningxia. On the other hand, some provinces (like Shandong) produce much resources but do not seem to be dependent on it. Both Qinghai and Ningxia are poor provinces, while Shandong is well-developed, and hence one might think that it is the high resource dependence rather than the abundant resource that curses the economy. Further investigation is required, however, before we can draw such conclusions.

[Table 2]

Table 2 provides descriptive statistics of the economy-related variables. By comparing the statistics of the East sample and the West sample, we see that the average growth rate in Eastern provinces is generally higher than in the Western provinces. On the other hand, Western provinces have relatively higher resource abundance, resource rents, and resource dependence than Eastern provinces, which suggests the possible existence of a resource curse in China.

[Figure 2]

To gain further insight we present a scatter plot and simple regression fits of the growth rate against resource abundance and resource dependence, respectively, in Figure 2. From these plots it becomes clear that the average resource production in Western provinces is greatly affected by Shanxi province, where resource plays a remarkable role. The last two columns in Table 2 present descriptive statistics of the Western provinces without Shanxi, and we see that it is now not so clear whether resource abundance, resource rents, and resource dependence are higher in Western provinces than in the East. Although resource abundance is still higher in Western than in Eastern regions, the Western regions also have larger standard errors. A simple regression fit shows a downward slope of the growth rate against resource dependence in the right panel of Figure 2. However, the correlation between growth rate and resource abundance is positive even when Shanxi province is included.

As for auxiliary control variables, a comparison between East sample and West sample shows that the Eastern region is more developed than the Western region in the sense of better institutional quality, higher education level, more flourishing industry, more entrepreneurs, and higher degree of openness. For the auxiliary variables, there is not much difference whether we include Shanxi province or not, which supports the classification of Shanxi province as a Western province.

In the following, we first perform cross-section analysis using data averaged across years. By using the averaged data, cross-section analysis reduces the possible bias caused by economic fluctuations. Since Chongqing is a municipality directly under the Central Government since 1997, all variables (and the average) for Chongqing are documented after 1997. For provinces with missing values in some years, averages are taken over the years with observations.

4 Cross-section analysis

We examine the resource curse by estimating Equations (1)–(6) using the cross-section data, that is, the data averaged over the whole time period.

[Table 3]

In Table 3 we present the relations between resource abundance, resource dependence, and institutional quality. In Equations (1) and (2), institutional quality is regressed on resource abundance/rents and resource dependence while controlling for geography (West dummy). The results in columns (a) and (b) show that both resource abundance and resource rents are positively (and significantly) correlated with institutional quality. This may be caused by the fact that a resource boom has an income effect, leading to an improvement in the quality of institutions. Brunnschweiler and Bulte (2008) list several possible transmission mechanisms between income and institutional quality (see also Barro (1996), Acemoglu et al. (2005), and Przeworski and Limongi (1993)). Although both estimates are 'significant', resource rents is more strongly related with institutional quality than resource abundance. This is to be expected, since the definition of resource rents implies that it is closely correlated with income. Resource dependence, on the other hand, is negatively correlated with institutional quality. One possible explanation of this negative correlation is the rent-seeking hypothesis, which suggests that local governments are more corrupt in resource-abundant regions (Jensen and Wantchekon, 2004). But Brunnschweiler and Bulte (2008) point out that an opposite effect may exist, that is, from institutional quality on resource dependence. Since resource dependence is significant when explaining institutional quality (columns (a) and (b)), but institutional quality does not play a significant role in explaining resource dependence (columns (c.1)–(d.2)), the transmission from institutional quality to resource dependence is not obvious in the case of China. Finally, the West dummy is significantly negative, confirming that there does exist a difference in institutional quality between the East and the West of China.

In Equations (3) and (4) we regress resource dependence on resource abundance/rents, institutional quality, and investment in fixed assets. Here we try to explore the endogeneity of resource dependence. In columns (c.1) and (d.1) the equations are estimated using OLS; in columns (c.2) and (d.2) using 2SLS. The OLS estimates show a strong association between resource dependence and resource abundance/rents, while institutional quality enters negatively, but either weakly significant or insignificant. Average total investment during the 1970s and 1980s (INV) is highly correlated with resource dependence, thus allowing the possibility of using it as an instrument for resource dependence. In the 2SLS estimates we have instrumented institutional quality by distance to the coast (DIS). (The validity of this instrument will be discussed shortly.) In general we conclude that both institutional quality and resource dependence are positively influenced by resource abundance/rents, and that they are negatively associated with each other. These results show that in China resource dependence has a negative effect on institutional quality, while resource abundance has a positive effect, thus challenging the conventional argument of resource curse on institutional quality, and partly confirming the findings in Brunnschweiler and Bulte (2008). Changing from resource abundance to resource rents does not change the results much, and this suggests that the two variables largely measure the same concept, and also shows the robustness of our results.

[Table 4]

Based on the above preliminary analysis, we now turn to the impacts of natural resources on economic growth, using Equations (5) and (6). The OLS results are given in Table 4. As a benchmark we present column (a), representing the classical literature in parsimonious form, where economic growth is explained by resource dependence, and West dummy and initial economy serve as controls. This regression shows a negative (but insignificant) coefficient of resource dependence, and a significant West dummy. The conclusion from column (a) would be that a resource curse exists, but this conclusion would be too simplistic as we shall see. If we include not only resource dependence but also resource abundance as explanatory variables, then we obtain different results. In columns (b) and (c), we see a positive (strongly significant) impact of resource abundance and rents, and a negative (weakly significant) impact of resource dependence. As expected, the West dummy has a negative (and significant) impact as well. Columns (d) and (e) include institutional quality as an additional explanatory variable. This reduces the significance of resource abundance, resource rents, and resource dependence. If we include more controls (education, industrialization, entrepreneurship, and openness), as we do in columns (f) and (g), then the significance of our estimates is further reduced.

We draw four conclusions from these estimates. First, resource abundance and resource rents seem to measure the same concept when applied to growth regressions in China. Most Chinese provinces with rich natural resources make full and exhaustive use of these resources. Abundant natural resources are therefore strongly associated with resource rents, which explains their near-equivalence. Second, a positive effect of resource abundance and rents on economic performance in columns (b)–(g) challenges the existence of a resource curse. On the contrary, it supports the argument that resource abundance plays an active role in promoting economic growth; see also Brunnschweiler and Bulte (2008). One explanation of this positive role of resource abundance is the 'windfall' flow of income from resource extraction, which has a direct effect on the economy as well as an indirect effect through improving institutional quality. Third, we find that resource dependence exerts a negative (weakly significant) influence on growth in China. This negative impact can be interpreted as a 'crowding-out' effect, in the sense that overemphasis on resource-related sectors crowds out the economic activity in other sectors such as education, industry, and entrepreneurship, thus impeding economic growth. The existence of such a 'crowding-out' effect follows from the fact that including EDU, IND, ENT, and OPEN in the regressions reduces the impact of resource dependence, while the effects of the controls themselves are positive (and significant, except for EDU). In this respect, our results bridge Brunnschweiler and Bulte's (2008) argument and the conventional 'resource curse' view. Finally, we emphasize the remarkable role of institutional quality. Its inclusion has a large effect on the significance of resource-related variables and the West dummy, and it has a strong association with the economic performance. More investigation on the role of institutional quality is provided in the next section.

[Table 5]

Before further examining the relations between institutional quality, natural resources, and economic growth, we ask whether the presence of endogeneity, which would render OLS inconsistent, is a problem in our set-up. Two variables may be endogenous: resource dependence and institutional quality. Resource dependence would be endogenous because the denominator of this variable, fixed asset investment, is associated with the size of the economy. The possible endogeneity of institutional quality has been widely studied in the growth literature (e.g., Acemoglu et al. (2005)). Thus, we introduce instruments, and this leads to Table 5. The regressions (f.1), (g.1), (f.2), and (g.2) are estimated by instrumenting resource dependence with resource abundance (RA in (f.1) and (f.2), RR in (g.1) and (g.2)) and total investment in fixed assets (INV); the remaining two regressions use the distance to coast (DIS) as instrument for institutional quality. The IV estimates generally agree with the OLS estimates showing that, without including institutional quality and other controls, resource abundance and rents are positively correlated with growth while resource dependence has a negative correlation. Also, if we include institutional quality and other controls, then these relations become less significant, while the effects of most of the controls are significant. The main difference between the OLS and IV estimates is that the significance of the resource variables is weaker when instruments are used.

The Shea partial R^2, first-stage F-statistic, and weak identification test all indicate that resource dependence is strongly correlated with its corresponding instruments, and the Sargan test implies that the exogeneity condition is satisfied for these instruments, which also confirms the exogeneity of our resource abundance measure. In contrast, the instrument of institutional quality turns out to be poor. The geographic factor ('distance to the coast' in our case) as an instrumental variable is clearly predetermined with respect to the error term. However, as also pointed out by Brock and Durlauf (2001), predetermination does not necessarily imply exogeneity. Therefore, distance to the coast might not be a valid instrument. In particular, we could imagine that distance to the coast affects economic growth through other factors besides institutional quality. For example, provinces closer to the coast may be characterized by a more open culture and the industrial structure would also be more export-oriented, both of which may lead to higher economic growth. This explains, in part, why distance to the coast does not serve as a good instrument in our case. The results when using this instrument (columns (f.3) and (g.3)) show a negative impact of resource abundance and a positive impact of resource dependence (although not significant), which differs from our previous findings, but these results should be treated with some caution.

[Table 6]

Table 6 presents the results of 3SLS estimation, in which two endogenous variables (resource dependence and institutional quality) are simultaneously instrumented (Davidson and Mackinnon, 1993). The estimation results are similar to the OLS and 2SLS estimates. In particular, since institutional quality is controlled and instrumented, neither the coefficients of resource abundance and rents nor of resource dependence are significant.

5 Institutional quality and the relation between RA and RD

We have seen that resource abundance and rents have a positive impact on economic growth, while resource dependence has a negative impact. Table 3, columns (a) and (b), also shows that abundance and dependence have a significant conflicting effect on institutional quality. These opposite effects are puzzling. What role does natural resource play in affecting the economy of Chinese provinces? More specially, since resource dependence is highly correlated with resource abundance/rents (Table 3) and their effects on economic growth are conflicting, when do abundant natural resources help and when do they hinder regional development? Also, under what conditions do the positive effects of resource abundance/rents dominate and under what conditions do the negative effects of resource dependence dominate?

All these questions can be answered if we associate resource abundance/rents and resource dependence with institutional quality. Our preliminary analysis has already provided evidence about the importance of institutional quality in explaining the variation of Chinese provincial economies. Institutional quality is positively related with resource abundance/rents, but negatively with resource dependence, and it appears to be a transmission channel from resource to economic growth, while also serving as a catalyst in economic growth. In addition, institutional quality plays a vital role in the relation between resource abundance/rents and resource dependence. In particular, the prosperity of many non-resource sectors is largely built on good institutional quality. Beck and Levine (2005) associated institutions with thrive in financial sectors, since good institutions lead to more willingness of savers to invest in firms, and a higher effectiveness of corporate governance. Nunn (2007) pointed out that better contract enforcement makes countries more specialized in the industries in which so-called relationship-specific investments play dominant roles. In this sense, provinces with poor institutional quality are supposed to lean on the existing resource to a higher degree. To examine whether such moderation effects exist in our case, we regress resource dependence on resource abundance and resource rents, respectively, while allowing the coefficients to be functions of institutional quality. By doing so, we capture how the influence of resource abundance/rents on resource dependence varies over different levels of institutional quality. We consider the functional-coefficient regression models

$$\mathrm{RD} = \delta_{0a} + \delta_{1a}\mathrm{RA} + \delta_{2a}\mathrm{INV} + \eta_a, \tag{7}$$

$$\mathrm{RD} = \delta_{0r} + \delta_{1r}\mathrm{RR} + \delta_{2r}\mathrm{INV} + \eta_r, \tag{8}$$

where the coefficients δ_{1a} and δ_{1r} are functions of institutional quality. The advantage of a functional-coefficient model over a model with an interaction term is that the latter can only report a positive or negative effect of institutional quality (the same value for all institutional quality levels), while the former provides information on how such an effect varies across different levels of institutional quality. The varying effect is important because it is not only institutional quality but also the *effect* of institutional quality that is likely to vary across provinces. In 'well-organized' provinces the effect will be higher than in less well-organized provinces. The parameters in this model are estimated non-parametrically by local linear estimation (Cai et al., 2000), where various data-driven methods could be employed for selecting smoothing variables, such as AIC, cross-validation, explanatory variables (Cai et al., 2000), and linear function of explanatory variables (Fan et al., 2003). Robustness checks show that the selection of smoothing variables does not change the main results.

[Figure 3]

In Figure 3 we show how the δ_1-parameter changes as a function of institutional quality. The typical 'U-shape' in both subfigures shows strong correlation between resource abundance and resource dependence in provinces with poor institutional quality. Resource-abundant provinces rely much on their abundant resource, and are therefore highly resource-dependent. As the institutional quality improves, the dependence decreases. This is intuitive because sectors that are highly dependent on institutional quality (e.g., financial sectors) cannot develop in provinces with poor institutional quality, and therefore these provinces have to rely more on their primary industries (e.g., resource sectors). For example, Shaanxi, Heilongjiang, Guizhou, and Ningxia provinces all have relatively low institutional quality, and therefore their economies largely depend on resource abundance, while non-resource sectors are poorly developed, see Table 1. Improvement of institutional quality helps the development of some non-resource sectors, thus generating less dependence on natural resources.

It is less intuitive, however, that provinces with especially strong institutional quality also exhibit high positive correlation between resource abundance and resource dependence. One possible explanation is that some of these provinces lack natural resources, and are thus hardly resource-dependent. The strong institutional quality is then explained either by their geography (near the coast or near an important river) or by some governmental policy (preferential treatment). Typical examples are Shanghai, Zhejiang, and Fujian provinces, all in Eastern China. Another possible explanation is that if provinces with high institutional quality are rich in natural resources, they are likely to make good use of these abundant resources. High resource dependence then does not crowd out non-resource sectors. Instead, non-resource sectors are stimulated by a combination of good institutional quality and good use of natural resources. Examples include Shandong, Jilin, Liaoning, Tianjin, and Henan provinces, most of which are traditional industrial provinces in North-East China. These provinces are rich in natural resources, especially mineral resources. Under high institutional quality, they properly exploit and efficiently use the resources. Thus, booms in resource sectors do not impede the development of non-resource sectors, but instead stimulate industries that are indirectly related with resources such as the automobile industry, shipbuilding industry, and equipment manufacturing industry. To test this hypothesis, we re-estimate the growth regressions, now allowing the coefficients to vary across institutional quality.

[Figure 4]

The results are shown in Figure 4. When institutional quality exceeds the median level, the negative impact of resource dependence on economic growth is weakened as institutional quality improves. Similar behavior is observed in the relation between resource abundance and economic growth. These results make good sense in the Chinese situation. Property rights on natural resources in China are owned by the government, and local residents therefore typically do not benefit much from rents derived from resource extraction (Zhang et al., 2008). Most income associated with resources goes to the government and state-owned enterprizes. Hence, for provinces poor in institutional quality, rising rents from the booming resource sectors are not used by the government to stimulate the economy, but often harm economic development, because they lead to increased prices for non-tradable goods and hurt the competitiveness of local economies (Zhang et al., 2008). On the other hand, if institutional quality is strong, rents from resources may be used in boosting the economic development, because better property rights result in higher growth by means of improving asset allocation (Claessens and Laeven, 2003).

We also note some less intuitive evidence. For provinces with institutional quality below the median, the resource-dependence effect on economic growth changes from positive to negative, as institutional quality increases. This is because in provinces where institutional quality is really poor, almost no non-resource sectors exist, and therefore resource sectors, as the 'only' industry, play a positive role in economic growth. An increase in institutional quality leads to the development of other industries, and thus weakens the dominance of the resource industry. As institutional quality increases further, the negative impact of resource dependence on growth reflects the 'resource curse' due to the crowding-out effect, which is the consensus view in the literature. But, as explained above, when the institutional quality increases even further, this crowding-out effect is weakened. We conclude and, to some extent, explain that resource abundance has a high positive correlation with resource dependence in provinces with extreme (very strong or very poor) institutional quality, that the effect of resources on the economy is highly dependent on institutional quality, and, more generally, that institutional quality plays a prominent part in the economy.

Although our study only considers China, this relation between resource abundance, resource dependence, and institutional quality may hold more generally. Countries with abundant resources but poor economic performance are often characterized by poor institutional quality (Zambia, Guyana, Mauritius), and these countries are also highly resource-dependent with underdeveloped non-resource sectors. In contrast, countries with abundant resources and a prosperous economy mostly have high institutional quality (Australia, Canada, New Zealand, Norway), and both resource and non-resource sectors are well-developed.

6 Cross section with a structural break

During the observed period 1989–2008, the Chinese economy experienced a significant event in the year 2000, when the central government proposed the 'West China Development Drive', designed to stimulate the economy of the Western regions. Since then, preferential policies for investment, education, and industry have been implemented, and these have resulted in more prosperity in the Western regions. Natural resources might play a different role before and after the policy change in 2000, and we investigate this in the current section.

[Figure 5]

We see from Figure 5 that real GDP per capita in the Western region developed quite differently in the two periods, with a spectacular increase after 2001. Some provinces, such as Shaanxi province, Ningxia Autonomous Region and Qinghai province, grow even faster than some of the Eastern regions. Value-added also increased sharply after 2002, and so did resource production. Apparently, the West China Development Drive has caused a faster-developing economy, considerable growth in resource production, and an acceleration in industrialization in the Western regions. It is of interest, therefore, to study whether this policy change has affected the resource effect.

We first re-estimate the growth regressions (5) and (6) with cross-section data in the two periods, respectively. Thus, we divide the sample in two periods: before and after 2000. All economy-related variables are averaged over these two periods, respectively. We only consider resource rents, because resource abundance is a stock measure of resource reserve that does not vary much over time, and also because resource rents are a more direct reflection of income from extracting resources and they do vary over time. Since the data on institutional quality come from a one-year survey, which have no values after 2000, we can not include institutional quality in this comparative analysis. Even though, a pre- and post-break comparison allows some important insights.

[Table 7]

Table 7 presents the pre- and post-break comparison of resource effects. We see that the resource effect does not change much between the two periods at an averaged level. In particular, resource rents play a positive role in both periods. After introducing more explanatory variables and instruments, the effect of resource rents becomes insignificant. The effect of resource dependence is strongly significant and negative before 2000 in the OLS regression without additional controls. After including additional controls, the resource dependence effect becomes insignificant. Instrumental variable estimation results in a positive but also insignificant coefficient of resource dependence. Resource dependence is insignificant in all after-2000 regressions. As for the auxiliary control variables, most are significant before 2000 except for IND, ENT, and INIT, but only EDU remains significant after 2000 (column (e)). However, EDU switches from negative (and significant) to positive (and significant), hence a great change from before to after the break. The West dummy is negative (and significant) before 2000, but after 2000 it becomes positive (and weakly significant). Hence, Western provinces grew at a lower rate than the Eastern provinces before 2000, but on average their growth rates exceed those of the East after 2000.

7 Panel data with time-varying coefficients

Although we have just seen that there seems to be no remarkable change of resource effects between the two periods before and after 2000, we can not yet draw a firm conclusion because our results are only based on averaged data and therefore contain no information about dynamics. In addition, we have only a small number of provinces. These problems can be largely overcome by using panel data. There are at least three advantages in using panel data. First, by incorporating not only variation in provinces but also in time, we are able to capture the dynamic behavior of the resource effect as well as other impacts on economic performance. Second, since the sample size is much enlarged, the accuracy of the estimates will be much better. Third, the panel-data approach allows us to incorporate heterogeneity, at least partially. It is not plausible to assume that the parameters of growth determinants are identical across provinces, especially for a big country like China. Although the functional-coefficient model considered above addresses this problem by allowing coefficients to depend on institutional quality, unobserved province-specific determinants still remain. Panel data models allow for province heterogeneity by including a fixed effect. This does not fully address the heterogeneity problem and the approach may suffer from limited time-dimension variation (Brock and Durlauf, 2001), but one would expect to gain useful additional information on the effects of growth determinants, especially on the time-varying features. Due to the limitation of data in some provinces in the early years, we focus on the period 1997–2007. For the same reason (see also Section 6), we do not take into account resource abundance (but only resource rents) and institutional quality in the panel-data models.

Our coefficients will be time-varying, in the same spirit as in the functional-coefficient model. This model allows us to gain some insights on how resource effects change annually. The time-varying coefficients panel-data model can be written as

$$y_{it} = c_i + x'_{it}\beta(t) + \epsilon_{it} \qquad (i = 1, \ldots, N, \ \ t = 1, \ldots, T), \tag{9}$$

where y_{it} denotes the growth rate of real GDP per capita in province i at year t, c_i is a province-specific effect, and x_{it} are the independent variables, that is, YEAR, RR, RD, EDU, IND, ENT, and OPEN, all in province i and at year t. The idiosyncratic error is denoted ϵ_{it} and it is assumed to be independent of x_{it}.

Unlike the cross-section analysis, initial economy level and West dummy are not included as explanatory variables here. This is because the panel-data model focuses on short-run dynamics, so that the initial state need not be controlled, and also because we employ a first-difference (FD) estimation method, as commonly used in such models, and therefore coefficients of time-invariant variables cannot be identified. Because of the same identification problem, no intercept appears in the regressions. The variable YEAR captures the time effect. In Equation (9), $\beta(t) = \{\beta_1(t), \beta_2(t), \ldots, \beta_k(t)\}'$ are the coefficients for the k control variables, all of which are smooth functions of t.

Preliminary analysis suggests that unobserved heterogeneity c_i among provinces is correlated with the regressors. This is what one would expect since unobserved heterogeneity, like differences in natural characteristics and human-induced social formation among provinces, is reflected in education, industrialization, openness, and so on, and therefore causes correlation with the regressors. For this reason, FD (or fixed-effects) estimators are more appropriate than pooled OLS or random-effects estimators. To implement the FD estimation, a first-difference transformation is made. Based on Hoover et al. (1998), the local polynomial estimator of $\hat{\beta}_l(t)$ for each $l \in \{1, \ldots, k\}$ can be obtained by estimating the local polynomial fit:

$$\hat{b}_l(t) = \left(\hat{b}_{1l}(t), \ldots, \hat{b}_{dl}(t)\right)'$$

with $d \geq 1$ but finite. This can be done by minimizing an appropriately locally weighted sum of squares. We estimate the coefficients using a special case of the local polynomial estimator with $d = 1$, that is, a local constant fit in which the weight is selected as the kernel function $K\left((t - t_0)/h\right)$ with bandwidth h. In this case, the estimated coefficient can be obtained by weighted-average least squares, which leads to

$$\hat{\beta}(t) = \left(\sum_{i=1}^{N} X'_i K(t) X_i\right)^{-1} \left(\sum_{i=1}^{N} X'_i K(t) y_i\right) \tag{10}$$

where $K(t) = \text{diag}\left(K((t-1)/h), \ldots, K((t-T)/h)\right)$, and

$$X_i = \begin{pmatrix} x_{i11} & \ldots & x_{i1k} \\ \vdots & & \vdots \\ x_{iT1} & \ldots & x_{iTk} \end{pmatrix}.$$

Several methods exist to select the bandwidth. We follow Hoover et al. (1998) and choose the bandwidth by minimizing average predictive squared error calculated with 'leave-one-out' cross-validation.

The remaining issue is how to tackle the endogeneity problem in the current panel-data setting. In contrast to the cross-section model, INV can not be used as an instrument now since it is time-invariant. Hence, other time-varying variables should be selected as an instrument for resource dependence. An obvious choice are lagged variables, and thus we include the first-order lag of resource dependence. To keep the estimation procedure simple, but without losing much explanatory power, only one instrument is used so that no over-identification problem arises. Instead of Equation (10), we now write the estimated time-varying coefficient estimate as

$$\hat{\beta}(t) = \left(\sum_{i=1}^{N} Z_i' K(t) X_i\right)^{-1} \left(\sum_{i=1}^{N} Z_i' K(t) y_i\right), \tag{11}$$

where $Z_i = (\text{YEAR}_i, \text{RR}_i, \text{LagRD}_i, \text{EDU}_i, \text{IND}_i, \text{ENT}_i, \text{OPEN}_i)'$.

Based on Equation (10) we present Figure 6 for the entire sample. The solid lines represent the estimated time-varying coefficients, and the dashed lines are confidence bounds based on bootstrap standard errors (calculated with 400 replications). The confidence bounds may not be completely accurate since smoothing bias is not taken into account. The dependent variable is real GDP growth rate per capita.

[Figure 6]

All coefficients vary over time. The coefficient of resource rents is negative in the period 1998–2000; positive and increasing from 2001–2004; and decreasing and negative from 2005–2007. The time-varying estimates do not contradict the previous cross-section comparative analysis. In the period before 2000 the impact of resource rents was less stable, and this is reflected in weak significance of the coefficient in the cross-section analysis (see Table 7, column (b)). In contrast, in the period after 2000, the impact is more significant. Although the impact becomes negative after 2005, this does not offset the positiveness during 2001 to 2004, which is in accordance with the significant and positive coefficient in the cross-section analysis (Table 7, column (e)). The coefficient of resource dependence is approximately zero until 2000; increases from 2000–2004; and then shows a 'U-shape'. This is also in line with the cross-section analysis: an insignificant coefficient before 2000 in the cross-section analysis is reflected by estimates around zero in the time-varying model, while an insignificant coefficient after 2000 is due to the offset of positiveness during 2000–2004 and negativeness during 2005–2006. The estimated time-varying estimates of the other explanatory variables are also in line with the results in the cross-section comparative analysis (except for EDU), and the bootstrap band shows that these results are strong.

[Figure 7]

Based on Equation (11), we present the IV estimates in Figure 7, again for the entire sample. Although these estimates deviate from the above results to some extent, they show similar behavior for the resource and other explanatory variables.

[Figure 8]   [Figure 9]

To gain further insight into the influence of the West China Development Drive policy, we study the resource effects in the Western and Eastern provinces separately. Since IV estimation gives very large standard errors when the sample size is small (and the conclusions are not affected), only the time-varying estimates based on Equation (10) are reported in Figures 8 and 9. Using only the West sample is very similar to using the entire sample. But the estimates of some variables using the East sample are not the same as using the entire sample. Both the resource rent effect and the resource dependence effect are uncertain with large standard errors compared to the entire-sample and West-sample estimates. Still, resource dependence generally exerts a positive influence on economic growth. Since Eastern provinces generally enjoy high institutional quality, such evidence supports the argument that large resource dependence might stimulate the economy in regions with good institutions. The very large standard error for openness after 2005 in both samples is due to the fact that data for this variable are missing during those years.

The implications of these results are summarized as follows. The effect of resource rents has indeed changed after the West China Development Drive. Since the Drive had an emphasis on natural resources, the resources in the Western provinces were exploited more intensively and used more efficiently. As a result, the income in these regions increased, stimulating economic growth, although not equally for all regions. As an example, let us consider

Qinghai and Sichuan provinces. These two provinces are rich in natural gas, and since the West-East natural gas transmission project constructed many pipelines, some resource-scarce regions in the East could use the resources from these two provinces. The production of natural gas brought considerable extra income to these provinces. On the other hand, the positive effect of resource rents was weakened and even became negative after 2004, while the effects of other regressors did not increase. This phenomenon reflects the current problems in resource exploitation in China. Although resource exploitation brought extra income to Western regions, it did not promote the development of other industries and sectors, which is demonstrated by the decreasing impacts of education, industrialization, and entrepreneurship in Western provinces after the policy change. These sectors, regarded as engines of economic growth, were crowded out by an overemphasis on resource sectors. The reason is again related with institutional quality. In particular, the policy change in Western provinces mostly resulted in more efforts in extracting resources, thus making these provinces more resource-dependent, but it did not much improve institutional quality and the development of other industries. Examples are Ningxia and Gansu provinces, where resource rents increased significantly after 2000, but other sectors like education, industrialization, and entrepreneurship did not increase much or even decreased. In addition, only part of the resource produced by the Western regions was used to improve the local economy, while most of it was sold cheaply to the East regions to meet the large demand of energy and resource there. For example, the most important gas field in Sichuan province transmitted more than 70% of its natural gas to Eastern provinces. This may also explain the decrease in resource effects. Education appears to be increasingly significant in economic growth, explaining in part the regional differences in growth patterns between East and West. In summary, the intensification of resource exploitation in the Western provinces went against its original purpose, and further enlarged the gap between East- and West-China.

8 Conclusions

Four conclusions emerge. First, institutional quality appears to be highly correlated with both resource abundance and resource dependence. Second, resource abundance and resource dependence are strongly related, and this relationship is affected by institutional quality. In provinces with poor institutional quality, rich resources lead to a high degree of resource dependence, while for regions with good institutional quality, resource abundance does not necessarily imply resource dependence. Third, resource abundance and resource rents influence economic growth, and the effects of resource abundance/rents and resource dependence are opposite. Abundant resources contribute to economic development, but overdependence on resources impedes growth. Fourth, immediately after the 2000 policy shock, resource rents had a strong positive impact on economic growth. But this effect did not last long; it decreased and even turned into a negative impact.

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Figure 1: Map of China

Note: The provinces left of the black solid line are defined as Western regions, most of which are affected by the 'West China Development Drive' policy. More precisely, the West China Development Drive policy covers Chongqing, Sichuan, Guizhou, Yunan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Inner Mongolia, and Guangxi. Source: Chinasource website, http://tmdhosting110.com/chsource/site. Although Shanxi province is usually treated as a central region, it is grouped here as a Western region since its economic structure is more like the Western provinces. The same applies to Inner Mongolia, which is in fact covered by the West China Development Drive policy. Guangxi province is sometimes grouped as an Eastern region, but since it is included in the West China Development Drive and has more common with Western regions, it is defined here as a Western province.

Figure 2: Relationship between growth and resource

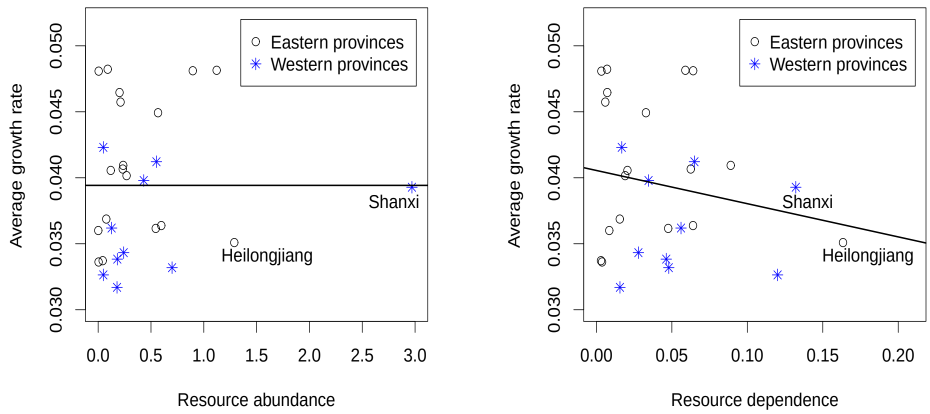


Figure 3: Marginal effect of RA and RR on resource dependence as a function of institutional quality

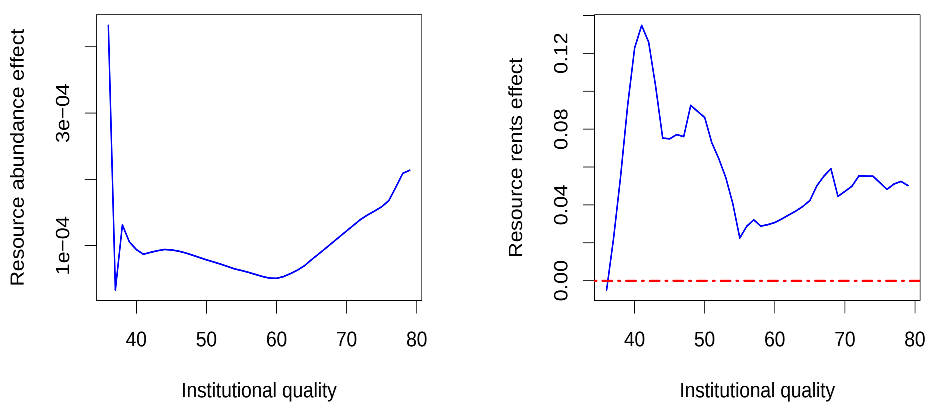


Figure 4: Marginal effect of RA and RD on growth as a function of institutional quality

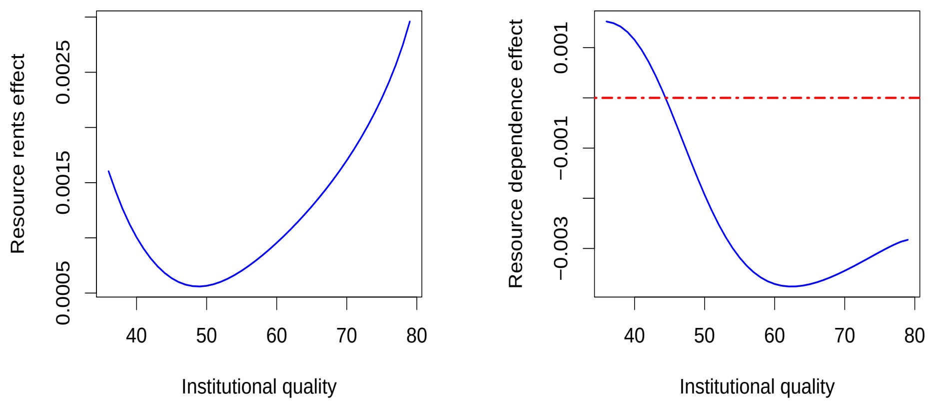
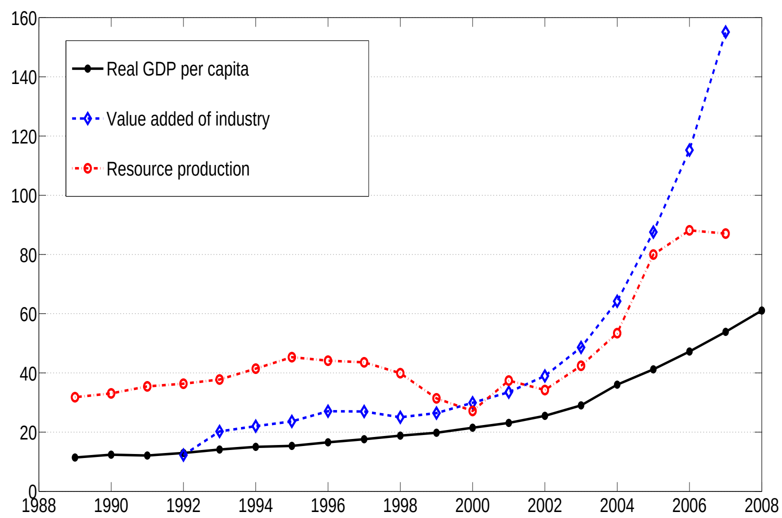
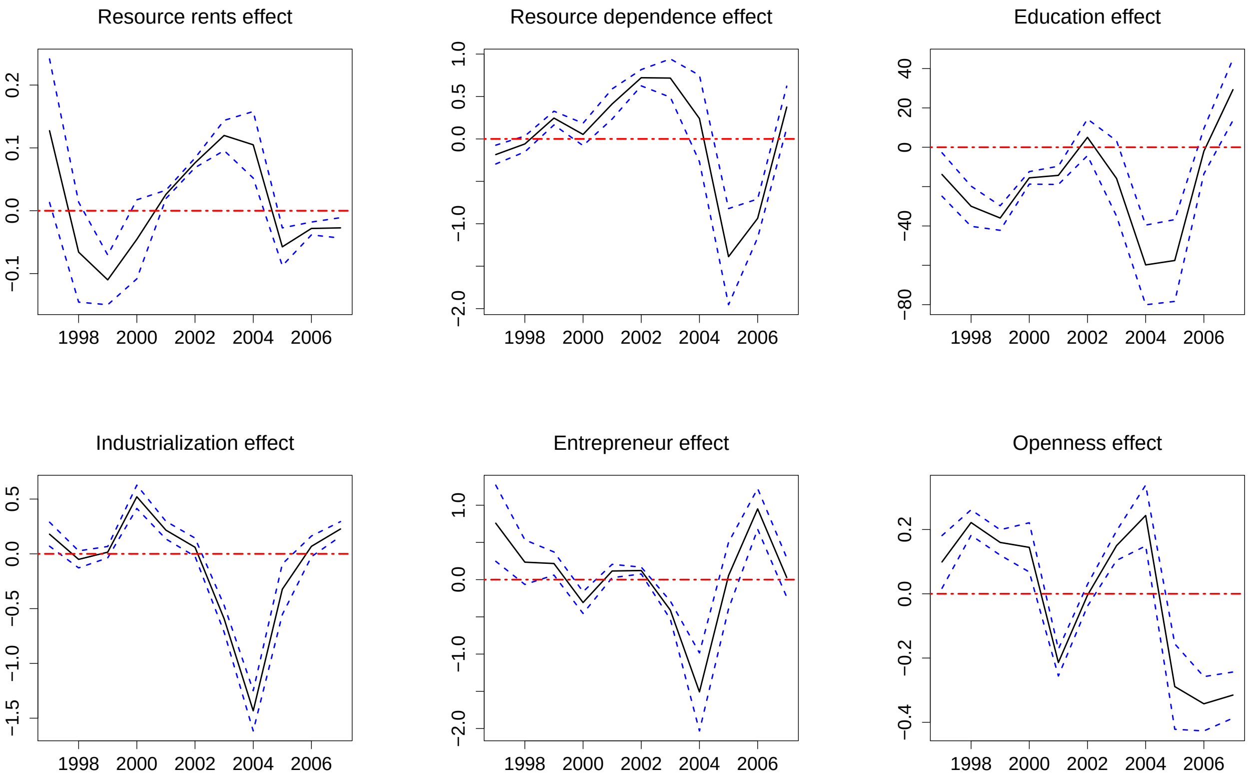


Figure 5: Time-series plot of three economy-related variables in the Western provinces



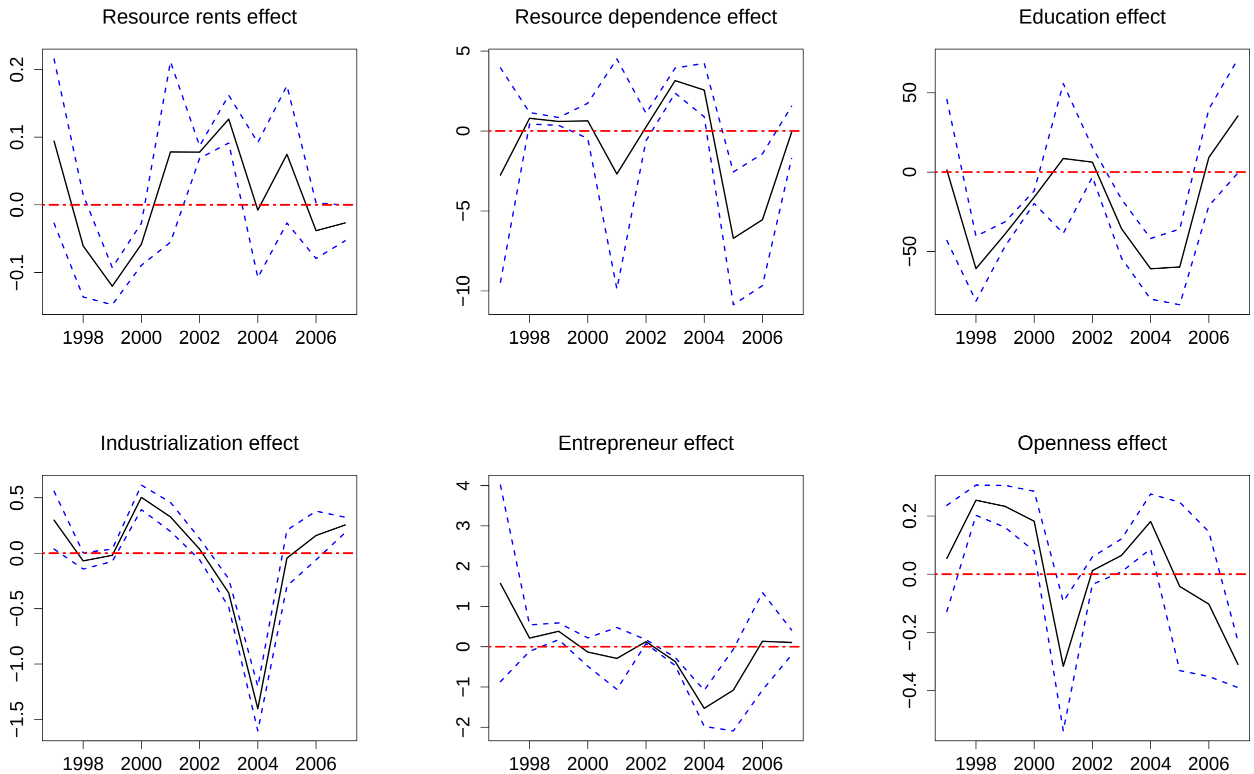
Note: The three variables are scaled so that they can be graphed in one picture. In particular, real GDP per capita is divided by 100, value added of industry is divided by 10, and resource production is multiplied by 100.

Figure 6: Time-varying coefficients: entire sample



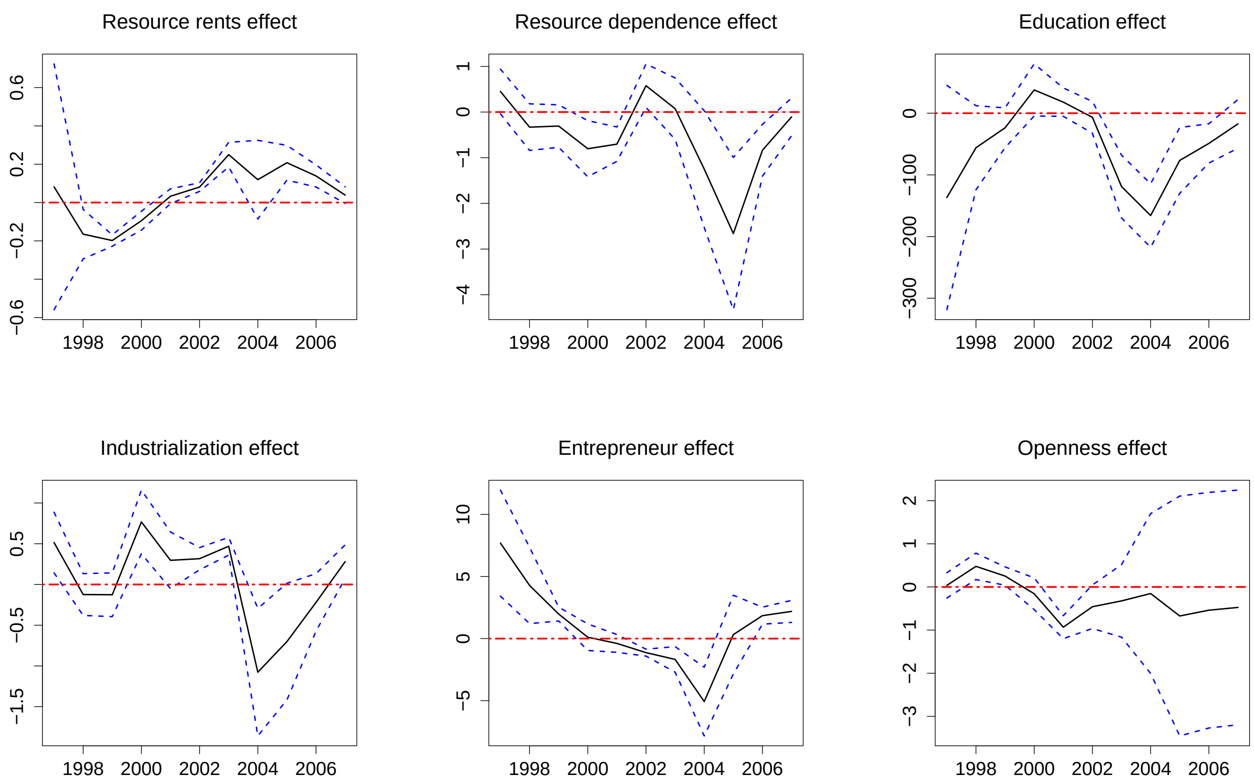
Note: The solid curve is the estimated coefficient of each regressor, and the two dashed curves represent bootstrap standard error bands. Such bootstrap bands are not exact confidence intervals since smoothing bias is not taken into account.

Figure 7: Time-varying coefficients: entire sample with instrument on RD



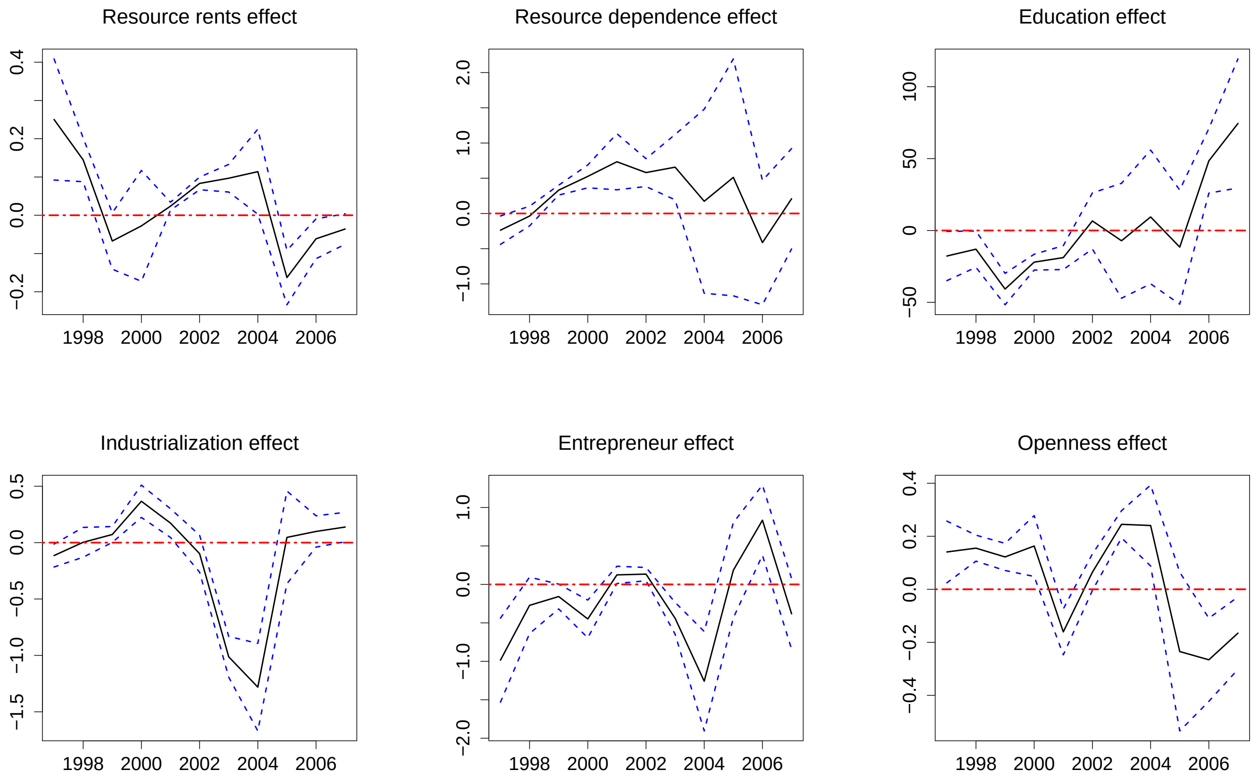
Note: The solid curve is the estimated coefficient of each regressor, and the two dashed curves represent bootstrap standard error bands. Such bootstrap bands are not exact confidence intervals since smoothing bias is not taken into account.

Figure 8: Time-varying coefficients: Western sample



Note: The solid curve is the estimated coefficient of each regressor, and the two dashed curves represent bootstrap standard error bands. Such bootstrap bands are not exact confidence intervals since smoothing bias is not taken into account.

Figure 9: Time-varying coefficients: Eastern sample



Note: The solid curve is the estimated coefficient of each regressor, and the two dashed curves represent bootstrap standard error bands. Such bootstrap bands are not exact confidence intervals since smoothing bias is not taken into account.

Table 1: Ranking of provinces based on resources

Resource production		Resource reserves		Resource dependence	
Top 10	Bottom 10	Top 10	Bottom 10	Top 10	Bottom 10
Shanxi	Hainan	Shanxi	Shanghai	Heilongjiang	Beijing
Heilongjiang	Shanghai	Guizhou	Zhejiang	Shanxi	Zhejiang
Shandong	Zhejiang	Shaanxi	Hainan	Qinghai	Shanghai
Henan	Beijing	Henan	Tianjin	Tianjin	Guangdong
Guizhou	Qinghai	Liaoning	Guangdong	Shaanxi	Fujian
Liaoning	Guangxi	Hebei	Beijing	Henan	Jiangsu
Hebei	Hubei	Yunan	Fujian	Liaoning	Hainan
Shaanxi	Fujian	Anhui	Jiangxi	Jilin	Hubei
Anhui	Jiangxi	Heilongjiang	Hubei	Shandong	Chongqing
Sichuan	Ningxia	Sichuan	Hunan	Ningxia	Guangxi

Table 2: Descriptive statistics of economy-related variables

	Entire sample (28 prov)		East sample (18 prov)		West sample (10 prov)		West without Shanxi (9 prov)	
Variable	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Growth	0.0394	0.0054	0.0411	0.0054	0.0364	0.0039	0.0361	0.0040
RR	0.4281	0.6028	0.3615	0.3943	0.5480	0.8784	0.2789	0.2304
RA	241.01	371.61	137.69	168.78	426.99	548.36	264.10	199.45
RD	0.0442	0.0414	0.0376	0.0416	0.0562	0.0402	0.0478	0.0319
INS	58.148	13.072	62.009	11.758	51.199	12.963	50.419	13.499
EDU	0.0085	0.0011	0.0086	0.0010	0.0083	0.0013	0.0081	0.0012
IND	0.2875	0.0665	0.2973	0.0752	0.2698	0.0452	0.2626	0.0414
ENT	0.0655	0.0278	0.0763	0.0283	0.0461	0.0126	0.0460	0.0134
OPEN	0.0963	0.0928	0.1305	0.0991	0.0347	0.0266	0.0354	0.0281
INIT	3.1876	0.2068	3.2626	0.2118	3.0527	0.1100	3.0435	0.1125

Table 3: Institution, resource dependence, and resource abundance

Dep. Variable	(a) INS	(b) INS	(c.1) RD	(d.1) RD	(c.2) RD	(d.2) RD
RR	9.3216		0.0428		0.0433	
	(3.74)		(3.34)		(4.25)	
RA		0.0099		0.0001		0.0001
		(3.06)		(4.96)		(2.73)
RD	−169.01	−120.16				
	(−3.20)	(−2.58)				
INS			−0.0007	−0.0004	−0.0018	−0.0014
			(−1.53)	(−0.76)	(−1.20)	(−0.86)
INV			0.1901	0.2240	0.1937	0.2261
			(1.93)	(2.59)	(1.30)	(1.36)
WEST	−9.3949	−11.4437				
	(−2.14)	(−2.33)				
Constant	64.9893	65.1549	0.0158	−0.0003	0.0794	0.0559
	(17.01)	(16.91)	(0.39)	(−0.01)	(0.66)	(0.42)

Note: The regressions (a)–(d.1) are estimated by OLS; the regressions (c.2) and (d.2) by 2SLS in which institutional quality is instrumented by distance to coast (DIS). t-values are in parentheses.

Table 4: Determinants of economic growth rate: OLS estimation

Growth	(a)	(b)	(c)	(d)	(e)	(f)	(g)
RR		0.0030		0.0014		0.0008	
		(3.09)		(1.53)		(0.69)	
RA			4.02e-6		2.37e-6		1.31e-6
			(3.40)		(1.45)		(0.61)
RD	−0.0142	−0.0429	−0.0304	−0.0131	−0.0085	−0.0027	−0.0001
	(−0.64)	(−1.87)	(−1.55)	(−0.78)	(−0.58)	(−0.12)	(−0.00)
INS				0.0002	0.0002	0.0002	0.0002
				(2.34)	(2.46)	(2.77)	(2.88)
EDU						1.1442	1.1137
						(1.10)	(1.02)
IND						0.0291	0.0293
						(2.05)	(2.07)
ENT						0.1751	0.1727
						(2.40)	(2.28)
OPEN						0.0318	0.0317
						(2.97)	(2.94)
INIT	−0.0090	−0.0081	−0.0082	−0.0051	−0.0050	−0.0358	−0.0355
	(−1.88)	(−1.59)	(−1.62)	(−1.04)	(−1.04)	(−4.55)	(−4.27)
WEST	−0.0063	−0.0061	−0.0070	−0.0038	−0.0042	−0.0009	−0.0011
	(−3.01)	(−3.07)	(−3.53)	(−1.36)	(−1.45)	(−0.27)	(−0.32)
Constant	0.0710	0.0680	0.0684	0.0463	0.0455	0.1106	0.1098
	(4.48)	(4.09)	(4.14)	(2.41)	(2.44)	(7.68)	(7.63)

Note: t-values are in parentheses.

Table 5: Determinants of economic growth rate: IV estimation

Growth	(f.1)	(g.1)	(f.2)	(g.2)	(f.3)	(g.3)
RR	0.0024		0.0009		−0.0021	
	(1.73)		(0.77)		(−0.25)	
RA		3.05e-6		1.27e-6		−7.93e-7
		(1.60)		(0.73)		(−0.12)
RD	−0.0289	−0.0132	−0.0051	0.0013	0.0385	0.0164
	(−0.79)	(−0.41)	(−0.15)	(0.05)	(0.31)	(0.30)
INS			0.0002	0.0002	0.0006	0.0004
			(3.41)	(3.66)	(0.52)	(0.62)
EDU			1.1688	1.0973	2.7648	2.1788
			(1.39)	(1.25)	(0.56)	(0.65)
IND			0.0296	0.0289	0.0248	0.0256
			(2.55)	(2.52)	(1.14)	(1.38)
ENT			0.1739	0.1735	0.2158	0.2006
			(2.97)	(2.88)	(1.27)	(1.54)
OPEN			0.0316	0.0318	0.0275	0.0290
			(3.81)	(3.78)	(1.95)	(2.92)
INIT	−0.0083	−0.0084	−0.0358	−0.0355	−0.0354	−0.0353
	(−1.89)	(−1.97)	(−5.69)	(−5.32)	(−2.42)	(−3.13)
WEST	−0.0063	−0.0070	−0.0009	−0.0011	0.0042	0.0025
	(−3.19)	(−3.86)	(−0.36)	(−0.41)	(0.27)	(0.21)
Constant	0.0683	0.0685	0.1105	0.1099	0.0700	0.0844
	(4.76)	(4.93)	(9.64)	(9.53)	(0.65)	(1.24)
Sargan stat. p-value	0.9121	0.8343	0.8171	0.9177		
Weak identification test	5.4470	8.4780	3.2050	4.9480	0.1680	0.3140
Shea partial R^2	0.4281	0.5721	0.3749	0.4789	0.0070	0.0133
1st stage F-stat. p-value	0.0120	0.0019	0.0659	0.0203	0.6870	0.5822

Note: In the regressions (f.1) and (f.2), resource dependence is instrumented by resource abundance (RA) and total investment in fixed assets (INV). In (g.1) and (g.2), resource dependence is instrumented by resource rents (RR) and total investment in fixed assets (INV). In (f.3) and (g.4), institutional quality is instrumented by distance to coast (DIS). Weak identification is tested using Kleibergen-Paap's robust Wald F-statistic, and employs the critical values from Stock and Yogo (2005). t-values are in parentheses.

Table 6: Determinants of economic growth rate: 3SLS estimation

	(a)	(b)	(c)	(d)
Growth rate				
RR	0.0144		0.0012	
	(0.70)		(0.19)	
RA		9.49e-6		1.05e-6
		(0.55)		(0.20)
RD	−0.2754	−0.1067	−0.0043	0.0056
	(−0.69)	(−0.44)	(−0.05)	(0.10)
INS	−0.0011	−0.0003	0.0001	0.0002
	(−0.53)	(−0.19)	(0.13)	(0.42)
EDU			−0.2886	0.6570
			(−0.07)	(0.23)
IND			0.0340	0.0313
			(1.78)	(1.70)
ENT			0.1212	0.1504
			(1.12)	(1.69)
OPEN			0.0292	0.0289
			(1.72)	(2.11)
INIT	−0.0529	−0.0351	−0.0362	−0.0358
	(−1.51)	(−1.33)	(−3.53)	(−3.83)
WEST	−0.0288	−0.0189	−0.0050	−0.0022
	(−1.20)	(−0.95)	(−0.43)	(−0.25)
Constant	0.2866	0.1762	0.1318	0.1125
	(1.17)	(0.98)	(1.37)	(1.70)
Resource dependence				
INV	0.2012	0.2479	0.1584	
	(1.70)	(1.76)	(1.59)	
RR	0.0427		0.0437	0.0210
	(5.18)		(5.22)	(1.75)
RA		0.0001		0.0001
		(3.21)		(3.14)
INS	−0.0008	−0.0001	−0.0015	−0.0009
	(−0.76)	(−0.99)	(−2.02)	(−0.98)
Constant	0.0189	−0.0258	0.0728	0.0301
	(0.22)	(−0.25)	(1.14)	(0.38)
Institutional quality				
DIS	−1.0431	−0.9615	−1.0306	−1.0075
	(−2.49)	(−2.29)	(−2.52)	(−2.42)
RR	0.2737		0.2769	
	(0.07)		(0.07)	
RA		−0.0020		−0.0020
		(−0.34)		(−0.33)
Constant	64.776	64.859	64.694	65.150
	(16.69)	(17.30)	(16.87)	(17.44)

Note: t-values are in parentheses.

Table 7: Determinants of economic growth rate: before and after 2000

	Before 2000			After 2000		
	(a)	(b)	(c)	(d)	(e)	(f)
RR	0.0048	0.0026	0.0003	0.0057	0.0044	0.0018
	(2.13)	(1.51)	(0.14)	(3.13)	(2.33)	(0.66)
RD	−0.0865	−0.0142	0.0259	−0.0262	−0.0813	0.0920
	(−3.31)	(−0.95)	(0.73)	(−0.49)	(−1.35)	(0.81)
EDU		−3.2356	−3.8328		3.7008	1.9694
		(−4.01)	(−5.02)		(2.35)	(1.05)
IND		−0.0014	−0.0053		0.0211	−0.0154
		(−0.08)	(−0.38)		(0.94)	(−0.52)
ENT		0.1445	0.1425		0.0265	0.0809
		(1.39)	(1.61)		(0.33)	(1.00)
OPEN		0.0420	0.0450		−0.0086	0.0312
		(2.11)	(2.59)		(−0.35)	(1.02)
INIT	−0.0071	−0.0048	−0.0036	−0.0018	−0.0111	−0.0210
	(−0.81)	(−0.85)	(−0.69)	(−0.20)	(−0.55)	(−0.97)
WEST	−0.0110	−0.0065	−0.0070	0.0052	0.0048	0.0042
	(−3.77)	(−1.81)	(−2.34)	(1.86)	(1.63)	(1.45)
Constant	0.0608	0.0652	0.0659	0.0535	0.0459	0.0901
	(2.14)	(3.78)	(4.32)	(1.93)	(0.95)	(1.71)

Note: The regressions (a)–(b) and (d)–(e) are estimated by OLS; the regressions (c) and (f) by 2SLS with resource dependence instrumented by total investment in fixed assets (INV). t-values are in parentheses.