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Resource Curse or Not: A Question of Appropriability*

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Abstract

Whether natural resources are good or bad for a country's development are shown to depend on the interaction between institutional setting and, crucially, the types of resources possessed by the country. Some natural resources are, for economical and technical reasons, more likely to cause problems such as rent-seeking and conflicts than others. This potential problem can, however, be countered by good institutional quality. In contrast to the traditional resource curse hypothesis, we show the impact of natural resources on economic growth to be non-monotonic in institutional quality, and increasingly so for certain types of resources. In particular, countries rich in minerals are cursed only if they have low-quality institutions, while the curse is reversed if institutions are sufficiently good. Furthermore, if countries are rich in diamonds and precious metals, these effects—both positive and negative—are larger.

Keywords: Natural resources; appropriability; property rights; institutions; economic growth; development

JEL classification: *O*40; *O*57; *P*16; *O*13; *N*50

I. Introduction

A major puzzle in economic development is the existence of a negative correlation between economic growth and natural resources. Some of the fastest growing economies over the last few decades are countries with very little natural wealth (such as Hong Kong, Singapore, Korea and Taiwan), whereas

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some of the poorest economic performers (like Angola, Sierra Leone and the Democratic Republic of Congo) are countries with enormous resources. A number of recent studies have concluded that the negative relationship between resource abundance and growth also holds for large samples of countries after controlling for other relevant characteristics.[1] This relationship, the so-called "resource curse", has become "widely accepted as one of the stylized facts of our times"; Wright (2001, p.1). However, the resource curse seems far from inevitable. While oil appears to have been the cause of recurrent problems in countries like Venezuela and Ecuador, Norway has become one of the world's richest economies largely thanks to its oil endowments. The possession of diamonds has arguably been disastrous for the development of countries like Sierra Leone, Liberia and the Democratic Republic of Congo. However, this does not seem to be the case in countries like Australia, South Africa or Botswana—with Botswana as one of the world's fastest growing economies over the past 30 years. There are several examples of countries rich in similar resources that have experienced extremely different economic growth. Table 1 gives a few examples and suggests that for just about every failure there is a counterexample of success.

In this paper we show how the empirical fact that natural resources are negatively correlated with economic growth can be reconciled with the fact that resources seem to have very different effects on economic development across countries. More precisely, we demonstrate that the effect of resources is not determined by resource endowments alone, but rather by the interaction between the *type of resources* that a country possesses, and the *quality of its institutions*. This combination of factors determines what we call the *appropriability* of a resource. The concept of appropriability captures the likelihood that natural resources lead to rent-seeking, corruption or conflicts which, in turn, harm economic development. We show that in countries where resources are highly appropriable—as determined by *both* the type of resources and institutional quality—resource abundance is problematic, while in countries where resources are less appropriable, they can contribute to economic growth.[2]

[1] See e.g. Sachs and Warner (1995), Gylfason, Herbertson, and Zoega (1999) and Leite and Weidmann (1999). Ross (1999) provides an overview of much of this literature.

[2] Our theory is about long-term development rather than growth over some shorter period. It could indeed be argued that finding new (or additional) resources should have a positive level effect, but at the same time harm growth, for example by changing the "optimal mix" between sectors in the economy. However, we claim that such effects are of second-order importance compared to the more fundamental question of whether there are institutions in place which enable a country to realize the gains from its resource or if they instead tend to lead to non-productive, appropriative behavior, and that this effect should be reflected even in the growth rate.

Table 1. *Relative growth performance in 10 resource-rich economies*

Countries[a]	Growth 1975–1998	Main resource[b]	Institutional quality[c]
Botswana	4.99	Diamonds	0.706
Chile	3.71	Copper	0.668
Norway	2.82	Crude Petrol	0.966
Australia	1.97	Minerals	0.932
Canada	1.73	Minerals	0.974
Sample Average	1.53		0.638
Ecuador	−0.79	Crude Petrol	0.592
Niger	−1.45	Minerals	0.520
Zambia	−1.94	Copper	0.434
Sierra Leone	−2.05	Diamonds	0.406
Congo, Democratic Rep.	−5.39	Ores and Metals	0.232

[a]The countries are selected to illustrate the exsistence of both successes and failures in resource-rich countries. The *sample average*, however, refers to all 80 countries in our sample.
[b]The listing of main resources is based on UNCTAD data on export structure in 1975.
[c]The measure of institutional quality is a "Property Rights Index" based on data from Keefer and Knack (2002). The index score for a country is between zero and one, where higher scores mean better institutional quality. See Section III for details.

It is important to stress the two dimensions of our concept. On the one hand, due to their physical and economical characteristics, certain resources are more likely to cause appropriative behavior. We call this dimension the *technical appropriability* of a resource. Resources which are very valuable, can be stored, are easily transported (or smuggled) and are easily sold are, for obvious reasons, more attractive to anyone interested in short-term illegitimate gains. This suggests that resources such as diamonds or precious metals are potentially more problematic than, say, agricultural products.[3] On the other hand, this does not mean that all countries with potentially problematic types of resources will suffer, while those with less "attractive" resources from an appropriation point of view will do fine. The potential problem of having certain types of resources can be countered by having good institutions. Given the right institutional framework, oil or diamonds have the potential of boosting a country's economic development, while the same resources are likely to lead to problems in a country with poor institutions. Hence, institutional quality determines the *institutional appropriability* of a resource.

In the following we show that the economic impact of resource endowments systematically depends on the interaction between the types

[3] Indeed, many case studies of development failure and resource abundance are concerned with mineral rich countries, rather than countries rich in natural resources in general. Campbell (2002) deals with conflict diamonds, Karl (1997) gives examples of problems related to oil, and Auty (1993) studies countries dependent on non-ferrous metals.

of resources and a country's institutions (where both dimensions are important in explaining the data). In Section II, we relate our ideas to previous work on the effects of resource abundance on economic development. In Section III, we specify our hypothesis and present our data. We report how we have constructed our measures for different types of resources, in particular our measure of the most appropriable resources which is based on new data. In Section IV, we test our hypothesis using OLS regressions of GDP growth on measures of different types of natural resources, institutions and their interactions. We also address the issue of endogenous institutions and run 2SLS regressions instrumenting for institutional quality. In Section V we check the robustness of our results with respect to, for example, influential observations, sample size, the influence of armed conflicts and the choice of institutional variables. Section VI concludes.

II. Related Literature

While natural resources historically seem to have been important for economic development, there is strong evidence that countries with abundant resources have had lower average growth rates in the postwar period as compared to their resource-poor counterparts.[4] There is, however, little agreement on why this relationship exists. The different theories that have been advanced can usefully be grouped into economic and political-economy explanations which we discuss in turn.

Most of the recent *economic explanations* are versions of the so-called "Dutch Disease".[5] The basic argument in these models is that windfall gains from natural resources (either through sudden increases in the price of the resource, or through the discovery of new resources) have a crowding-out effect on other sectors of the economy. For example, in Sachs and Warner (1995), following Matsuyama (1992), positive externalities in the form of learning-by-doing are assumed to only be present in the manufacturing sector of the economy. This implies that the larger the natural resource sector (and the smaller the manufacturing sector), the smaller the positive externality feeding the growth process. While these theories can match the empirical finding that resource-rich countries on average have had lower growth rates than resource-poor countries, a number of problems remain. First, empirical support for the suggested mechanisms is weak. In Gelb (1988), several studies find that resource booms have not shifted capital and labor away from manufacturing. Second, these theories typically

[4] See e.g. Findlay and Lundahl (1999) on resource-led growth in the period 1870-1914.
[5] See e.g. Corden and Neary (1982), Neary and van Wijnbergen (1986) and Krugman (1987). For other economic theories based on, for example, declines in terms-of-trade and sensitivity to volatile commodity prices, see the overview in Ross (1999).

predict that the effect of natural resources on growth should unambiguously be negative: the more natural wealth, the worse the outcome.[6] The empirical fact, however, seems to be that countries differ in their experience of how growth has been affected by natural resources. As such, these theories cannot explain why Botswana and Norway have been successful, while Sierra Leone and Ecuador have not. Third, these theories do not distinguish between the types of resources that a country is endowed with. As we will show, this is also crucial for explaining the data.

A number of papers have offered *politico-economic explanations* for why natural resources have negative effects on growth.[7] Lane and Tornell (1999) and Torvik (2002) have developed theoretical models of rent-seeking where resource abundance increases the incentives to engage in "non-productive" activities to capture the rents from the resources. Even though these papers provide important insights, they also predict a monotone-adverse effect of natural resources on economic growth and they do not distinguish between the effects of different types of resources. Miguel, Satyanath and Sergenti (2004) present evidence on the effects of economic shocks on the likelihood of conflict, and Collier and Hoeffler (1998, 2004) point to resources as a source of armed conflict. They find a non-linear relationship between natural resources and the risk of armed conflicts, but they still do not explain why some resource-rich countries prosper whereas others fail.[8]

Auty (1997), Woolcook, Pritchett, and Isham (2001) and Isham, Woolcook, Pritchett and Busby (2005) have emphasized—as we do in this paper—the importance of different types of resources. What they term "point source" resources, such as plantation crops and minerals, are argued to be more likely to cause problems than "diffuse" natural resources, such as rice, wheat and livestock. This prediction seems to be supported by data. However, these theories are not able to account for the facts in Table 1. Why is it that when comparing countries with similar, or even the same, natural resources, some seem to gain from their endowments when others lose? The reason we suggest is that the relationship between natural resources

[6] It is important to make a distinction between the effect of resources on the level of income and on the growth rate. More natural resources (or higher income from them) could increase the income level (just like any windfall gain) but, by crowding out manufacturing, they could be harmful to growth. Natural resource-rich economies would then tend to "converge from above". Bravo-Ortega and De Gregorio (2005) present a model along these lines. In their empirical analysis, they find a negative effect from resources on growth, but the support for a positive effect from resources on the level of income seems to be weak, i.e., significant (at 5 per cent) in only one of four specifications. We address this issue in more detail below.

[7] One could, of course, add "purely" political explanations, such as "rentier effects" and (anti) "modernization effects", as in Ross (2001), as well as sociological studies of negative effects of resources on development; see Ross (1999, fn. 2)

[8] Given the insights on the importance of conflicts, we control for this and show that our results are not driven solely by resources which give rise to conflict, thereby harming growth.

and growth is non-monotonic in institutional quality and differently so depending on the type of resources. In terms of theories of resources as a source of rent-seeking or conflict, the idea is that better institutions increase the costs of such non-productive activities.[9] In relation to theories that different types of resources have different economic effects, we suggest that non-monotonicity will depend on what resources a country has in abundance. More specifically, our prediction is that institutional quality is most crucial for countries rich in diamonds and precious metals. Such countries, which have poor institutions, are expected to have the largest negative effects of their resources, while countries endowed with these resources and which also have good institutions are predicted to have large gains from them.[10]

This paper is most closely related to recent and independent work by Mehlum, Moene and Torvik (2006). Their paper shares our prediction that resources have a non-monotonic effect on growth depending on the quality of institutions. They develop this point formally in a model where entrepreneurs choose between becoming “producers” or “grabbers”. The relative payoff from these activities depends on how “grabber friendly” the institutions are, which also determines the effect of natural resources on the economy. More natural resources raise national income if institutions are “production friendly”, but reduce national income if they are “grabber friendly”.[11] Mehlum *et al.* (2006) also find preliminary empirical support by running an (OLS) regression based on data from Sachs and Warner (1997) and adding a variable which captures the interaction of resources and institutions. While the idea that the effect of natural resources on economic development depends on the institutional environment is the same as in our paper, we show that stressing the different types of resources is

[9] This idea echoes Rodrik (1999), who stresses the role of institutions in conflict management.

[10] There are, of course, other dimensions in which resources differ. For example, resources may be renewable or not. This distinction is clearly important in models of optimal extraction paths, which mainly focus on non-renewable resources, since the main concern is the limit of resources and sustainability of extraction; see e.g. Stiglitz (1974). Another distinction is between durable and non-durable resources. This is important for the net price of resources since the price of non-durable resources (such as gas and oil) is related to existing reserves while the price of durable resources (such as diamonds and gold) depends on the existing stock of already extracted resources. See e.g. Hotelling (1931), Devarajan and Fisher (1981), Levhari and Pindyck (1981) and Pindyck (1993) for theoretical models, and Miller and Upton (1985) and Halvorsen and Smith (1991) for empirical evaluations of “the Hotelling r-percent rule”. As we do not believe that these dimensions, *per se*, affect the appropriability of the resource, they are not emphasized here.

[11] Robinson, Torvik and Verdier (2002) develop a model with similar predictions regarding the non-monotonic effect of resources depending on institutional quality, but with political incentives generated by resources as the key feature. In countries with good institutions, resources are positive because perverse political incentives are mitigated, but in countries with bad institutions resources remain a curse.

crucial for this effect to hold in the data. As we will show, the interaction between a broad measure of resources, such as the Sachs and Warner "Primary Exports" measure used by Mehlum *et al.* (2006), turns out to be statistically weak. Instead we find that significant and robust effects appear only when isolating technically appropriable types of resources, and that the interaction effect becomes more important the more technically appropriable the resources are, thus suggesting that emphasis on the type of resources is as important as the effect of institutions. We also address the potential problems of endogenous institutions and show that our results hold when instrumenting for institutional quality.

III. Our Hypothesis and Data

Our main hypothesis emphasizes the interaction effect between resources and institutions, as well as the difference in this effect across different types of resources. In the institutional dimension, we suggest that natural resource abundance is negative for economic development only if the country lacks the proper institutions for dealing with the potential conflicts and rent-seeking behavior which the resources may otherwise bring about. In the resource-type dimension, we claim that a lack of proper institutions is likely to be more serious for countries rich in resources which are easier to appropriate. We use different measures of natural resources (specified below) ranging from a measure with all types of resources to one which includes only the value of diamonds and precious metals mined in the country to test the following two-dimensional hypothesis:

(i) *The institutional dimension of appropriability*: The effect of natural resources on economic development improves with institutional quality.

(ii) *The technical dimension of appropriability*: The interaction of institutional quality and natural resources depends on the type of resources. More precisely, the more technically appropriable are a country's resources, the more important is it to have good institutions.

The basic econometric specification for testing the proposed effects of resources and institutions in country i becomes

$$growth_i = X_i'\alpha + \beta_1 NR_i + \beta_2 Inst_i + \beta_3 (NR_i \times Inst_i) + \varepsilon_i, \tag{1}$$

where *growth* is the average yearly growth rate of GDP, X is a vector of controls including initial GDP per capita level, period averages of openness and investment ratios, dummy variables for sub-Saharan Africa and Latin America, respectively, and a constant. *NR* is a measure of natural resource wealth (for which we use four measures discussed below) and *Inst* is our measure of institutional quality. $NR \times Inst$ is the interaction between natural resources and institutional quality. According to part (i) of our hypothesis, β_1 should be negative (the standard resource curse finding), β_2 should be positive (the standard finding that good institutional quality is beneficial for growth), and β_3 the coefficient for the interaction between natural resources, should be positive and—if it is to reverse the resource curse—have an absolute value larger than β_1.[12] This would mean that as long as institutional quality is good enough, natural resources will have a positive net effect on economic growth. Furthermore, part (ii) of our hypothesis implies that the impact on the growth rate of GDP of both the negative effect of the resources themselves (β_1) and the interaction with institutional quality (β_3) should be stronger, the more appropriable are resources and the weaker are institutions. Put differently, the institutional quality is more important for countries rich in technically appropriable resources than for others. When addressing part (ii) of our hypothesis, we are limited by the availability of data for all natural resource measures for each country. This leaves us with a sample of 80 countries, both industrialized and developing.[13] Our dependent variable, *growth*, is defined as the average yearly growth rate of GDP per capita between 1975 and 1998 (series rgdpch from Penn World Tables, Mark 6.1).

We use four different measures of natural resources to capture a gradual increase in physical and economical appropriability. As the broadest measure we use the share of primary exports to GNP from Sachs and Warner (1995), *PrimExp* (which they label *SXP*). In terms of appropriability, this measure includes everything from meat to precious metals. The second broadest is *OrMetExp*, which includes exports of ores and metals as a share of GDP; see UNCTAD (1975, 1979). A similar measure in terms of appropriability is *MinProd*, the share of mineral production in GNP.[14] This differs in two respects, however. It does not include ores and it is a production—not an export—measure. If technically appropriable resources are likely to be diverted on their way from production to export, this proxy is expected to contain less measurement error. Our fourth measure *MidasProd*, which isolates only the most appropriable resources, is the value of production of gold, silver and diamonds (industrial as well as gemstone) as a share of GDP. This measure is based on a combination of production and price data. Production data are from the *Minerals Yearbook*, where production is reported in volumes. For price data on silver and gold,

[12] The fact that our measure of institutional quality has been rescaled to a 0–1 measure allows us to directly compare the coefficients.
[13] A complete listing of the countries and descriptive statistics of all variables can be found in a working-paper version available on request.
[14] This measure is also taken from Sachs and Warner (1995), where it is called *SNR*.

we use average yearly market prices reported by the U.S. Geological Survey (1999). There are no such prices for diamonds because of the large variation in quality. Instead we rely on U.S. import quantities and values of diamonds (industrial and gemstone) from different countries. These are used to obtain the per carat price for each country and quality, which we multiply by production data. The total value of gold, silver and diamonds for each country is divided by GDP to obtain *MidasProd*.[15]

An alternative to using export and production measures would be to use estimates of endowments. While such measures are likely to be exogenous, they do not capture what we are after. Our focus is on the relative importance of resources vis-à-vis the rest of the economy, which we capture using measures of exports and production relative to GDP. Moreover, it is not likely that the behavioral effects of agents are linked to known endowments of resources. Rather, contested resources are those that are "up for grabs".[16] To reduce the risk of reverse causality we use initial year measures for all four resource proxies.[17] To capture institutional quality we use the (unweighted) average of indexes for the quality of the bureaucracy, corruption in government, rule of law, the risk of expropriation of private investment, and repudiation of contracts by the government, from Keefer and Knack (2002). Our control variables are the level of GDP per capita in 1975, investment and trade openness, all taken from Penn World Tables, Mark 6.1.[18]

Table 2 reports the correlations between these main variables and enables us to address a number of issues. First, it indicates that the measures of

[15] A distinction is often made based on the type of diamond deposits since this determines extraction methods (and, hence, extraction costs). All diamonds are formed at a depth greater than 150 kilometers beneath the surface of the earth and brought to the surface by volcanic activity. Diamonds in an earlier phase of this process, called *kimberlitic* (or primary) diamonds, are still embedded in rock and require relatively advanced mining techniques, while so-called *alluvial* (or secondary) diamonds have been separated from the surrounding rock due to erosion. Alluvial diamonds are usually located in river terrace gravel close to the surface and can be mined with very simple equipment. In terms of our terminology, alluvial diamonds are hence likely to be appropriable. We cannot completely control for this, but we do include data on differences in deposits in our analysis (see footnote 38).

[16] We have checked our results using data on country endowments of 44 minerals from Parker (1997), used in e.g. Parker (2000) and Acemoglu, Johnson and Robinson (2001). Using these alternative data does not alter our basic results. Regressions are available from the authors on request.

[17] The exception is *MidasProd*. Due to large price volatility in the mid-1970s, we use the average of 1972, 1974, 1976, 1978 and 1980, to avoid the choice of a specific starting year which might influence our results. Our findings are similar when using *MidasProd* for 1974 or 1976, however.

[18] Since it is highly correlated with the other control variables, we have excluded average years of schooling in the population; see Barro and Lee (2000). The regression results are robust to the inclusion of *schooling*, however.

Table 2. *Correlation matrix for the entire sample*

	Growth	*Inst*	*Prim*	*OrMet*	*Min*	*Midas*	*GDP75*	*Open*
Institutions	**0.39***	1						
PrimExp	**−0.34***	**−0.29***	1					
OrMetExp	−0.14	−0.12	**0.47***	1				
MinProd	**−0.45***	**−0.33***	**0.40***	**0.42***	1			
MidasProd	−0.03	−0.07	−0.02	**0.31***	**0.30***	1		
GDP75	**0.19**	**0.83***	**−0.31***	−0.17	**−0.22**	−0.14	1	
Openness	**0.23**	0.17	**0.30***	**0.30***	−0.01	0.03	0.08	1
Investments	**0.55***	**0.73***	**−0.31***	−0.11	**−0.31***	−0.15	**0.69***	**0.30***

Note: Figures in bold denote significance at least at the 10 percent level; * at the 1 percent level.

natural resources in themselves are not proxies for a country's level of development. In fact, the correlation between per capita GDP in 1975 and the different measures of natural resources is fairly low. Moreover, this potential problem seems to be largest for the broadest measure of natural resources (*PrimExp*), while the narrower measures are less correlated with the GDP level. Second, in Table 2, we find institutions to be quite modestly (negatively) correlated with the measures of natural resources. Third, Table 2 reports the initial GDP level and investments to be highly correlated with institutions. This is addressed in Section V below.

IV. Main Results

To test our hypotheses, we ran regressions where the main variables of interest are the effects of natural resources, institutions and their interaction on economic growth; see equation (1). We ran separate regressions using four different measures of natural resources varying in their degree of technical appropriability. All regressions also included a number of controls (reported in the tables below), a constant, as well as regional dummies (not reported). If more appropriable resources are better for economic development when institutional quality is good, as well as increasingly problematic when institutions are bad, this should appear in the regression outcomes. In terms of the regression coefficients we expect the (negative) effect of resources (β_1) as well as the (positive) effect of the interaction term (β_3) to be more pronounced as the measure of natural resources narrows down toward more technically appropriable resources.

Columns (1)–(4) in Table 3 show our main results. The first column reports the broadest measure of natural resources (*PrimExp*). The signs of our three regressors of interest are in line with part (i) of our hypothesis, and while resources and the interaction are not individually significant, they are jointly significant at the 5 percent level. The interaction effect is

Table 3. *The main results*

	(1) *PrimExp*	(2) *OrMetExp*	(3) *MinProd*	(4) *MidasProd*
Resources	−6.392	−25.424***	−20.106***	−95.656***
	(4.084)	(8.596)	(4.548)	(27.804)
Institutions	6.763***	4.893***	4.614***	5.564***
	(1.963)	(1.644)	(1.362)	(1.357)
ResInst	4.152	49.602***	36.408***	167.251***
	(6.156)	(18.609)	(8.971)	(38.508)
GDP*75*	−2.212***	−2.046***	−1.955***	−2.019***
	(0.377)	(0.326)	(0.309)	(0.288)
Openness	0.504*	0.218	0.277	0.142
	(0.274)	(0.298)	(0.246)	(0.245)
Investments	0.087***	0.092***	0.103***	0.089***
	(0.026)	(0.028)	(0.027)	(0.026)
Observations	80	80	80	80
R^2	0.63	0.65	0.67	0.70
Joint(*p*)	0.044	0.009	0.000	0.000

Notes: Dependent variable is *growth*. Robust standard errors in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%. All regressions include a constant term and regional dummies for Latin America and sub-Saharan Africa (not shown). *Joint*(*p*) denotes whether the coefficient estimates of resources, and the interaction of resources and institutions, are jointly significant.

not sufficiently large to outweigh the direct negative effect of resources, however. This first regression is fairly similar to that in Mehlum *et al.* (2006). However, they use different data, consider the period 1965-1990 and use a slightly different specification which can explain the differences in our results.[19] All control variables are significant and have the expected signs. We then narrow down the measure towards more technically appropriable resources, reported in columns (2)–(4) in Table 3. Now, natural resources, institutions and their interaction are all significant at the 1 percent level (and resources and the interaction are jointly significant). The interaction effect outweighs the impact of resources and, hence, resources tend to be positive for growth for good enough quality of institutions. This supports our hypothesis that institutional quality is increasingly important the more technically appropriable resources are.

However, since the magnitudes of the natural resource variables differ greatly, a direct comparison of the coefficient estimates is not informative.

[19] They use the same data set as Sachs and Warner (1997) which includes 87 countries. The data from the Penn World Table are from Mark 5.6, while we use Mark 6.1, so revisions may be one explanation for the difference in our results. They also use another variable for openness. But, in particular, they do not use any regional dummies, which we believe make the largest difference. When excluding regional dummies from our regression reported in Table 3, column (1), we obtained results very similar to theirs.

Table 4. *Marginal effects of resources on growth (for different levels of institutional quality)*

	PrimExp	*OrMetExp*	*MinProd*	*MidasProd*
Worst *institutions*	−0.548	−0.946	−1.127	−1.425
Average *institutions*	−0.378	0.425	0.304	0.279
Aver. + 1 st. dev. *institutions*	−0.288	1.152	1.062	1.183
Best *institutions*	−0.228	1.629	1.560	1.776

To evaluate the impact of different resources, we calculated the marginal effects of a standard deviation change at different levels of institutional quality, using the coefficients from Table 3, columns (1)–(4). Formally,

$$\Delta growth = (\widehat{\beta}_1 + \widehat{\beta}_3 \widetilde{Inst}) \times sdNR,$$

where $\widetilde{Inst}$ is the level of institutional quality, and *sdNR* is a standard deviation change in the resource measures.[20] In Table 4 we report the growth impact from a one standard deviation increase in each of our four resource measures, evaluated at four different levels of institutional quality.[21]

The results confirm both parts of our hypothesis. First, reading the table top-down, starting with the first column, the calculations suggest that a one standard deviation increase in the broadest measure of resources (*PrimExp*) is always negative but less so as institutional quality improves. For the other measures (columns (2)–(4)) the pattern is the same; the effect of resources becomes more positive as institutional quality improves, but with an important difference. Resources now turn from having a negative effect on growth only for countries with poor institutions, whereas the contribution is positive if institutional quality is equal to the average value as well as increasing as institutional quality improves. As suggested by part (i) of our hypothesis, the effect of natural resources on economic development improves with institutional quality. Second, reading the table from left to right, it shows that, for a country with institutional quality equal to the worst in our sample, an increase in resources is always negative, but importantly, it is increasingly negative the more technically appropriable are the resources. While a one standard deviation increase in resources in

[20] For example, using *MinProd* (i.e., the coefficients in Table 1, column (3)) and the mean level of *institutions* (0.638) gives: $(-20.1 + 36.4 * 0.638) * 0.097 = 0.304$. The interpretation is that, *ceteris paribus*, a country with an average level of institutional quality would increase its annual growth rate by 0.3 per cent if it were to increase its mineral production by one standard deviation.

[21] The minimum level in the sample, 0.232, is the value for Democratic Republic of Congo; the average, 0.634, lies between the values for Trinidad and Tobago and Costa Rica; the average plus one standard deviation, 0.854, is between Hong Kong and Singapore; and the maximum value of institutional quality, 0.995, is that of Switzerland.

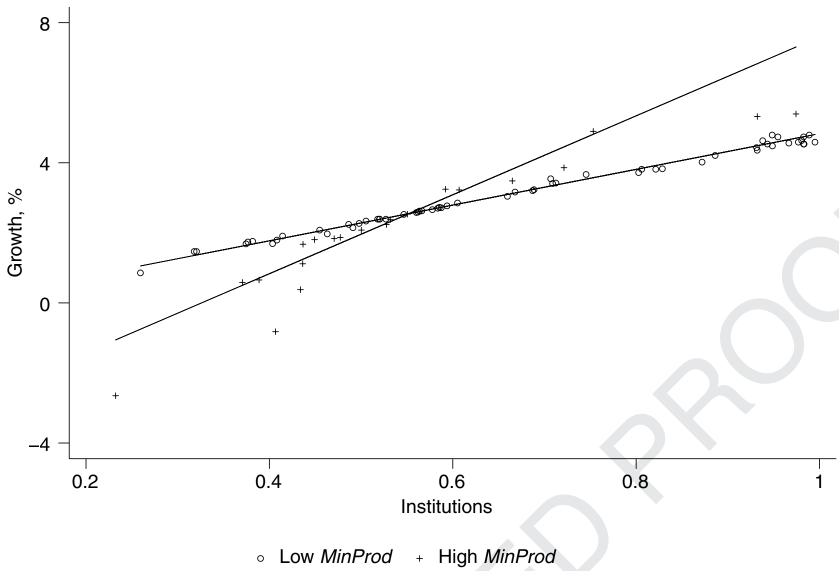

Fig. 1. The partial effect of *institutions* on *growth* when dividing the sample into groups of below-average and above-average natural resources

general (*PrimExp*) would decrease the yearly growth rate in such a country by 0.548 percent, the same increase in the most potentially problematic resources would lower growth by 1.425 percent. For a country with the highest institutional quality, on the other hand, the same increase in resources in general would lead to a smaller negative effect on the growth rate (−0.228 percent), but an increase in *MidasProd* would instead increase the growth rate by 1.776 percent. In terms of part (ii) of our hypothesis, this suggests that the more technically appropriable are a country's resources, the more important is it to have good institutions.

Figure 1 shows another way of illustrating our main results by plotting the *partial effects* of the combination of institutions and natural resources on economic growth. The sample is divided into two groups depending on whether a country has a natural resource level above the mean. Countries with less than the mean production of minerals (*MinProd*) are represented by "circles", while countries with a higher than mean production of natural resources have a "plus".[22] We fit two regression lines (one for each group) by using the regression coefficients in column (3) of Table 3,

[22] Analogous figures when using the other three measures of natural resources are available from the authors on request.

and the respective group averages.[23] As hypothesized, countries with fewer natural resources score better than those with plenty of natural resources when institutions are poor. However, for sufficiently good institutions, the effect is reversed. From the coefficients in Table 3, we calculate this institutional threshold level to be 0.55.[24] Above this cutoff level, the partial contribution of resources is higher for a high *MinProd* country than for low *MinProd* country, while the opposite holds below the institutional cutoff.[25] In other words, better institutional quality always improves the growth effect from resources but it is relatively more important for countries with more resources compared to those with fewer. Moreover, the institutional threshold level increases somewhat in the technical appropriability of the resource. More specifically, for *OrMetExp* the institutional cutoff is 0.51, for *MinProd* 0.55, and for *MidasProd* 0.57.

Given the recent insights provided by Acemoglu, Johnson and Robinson (2001, 2002) and Rodrik, Subramanian and Trebbi (2004) regarding the importance of the quality of institutions for economic development, the role of institutions in our regression (1) should be examined in more detail. There are basically two concerns. The first is that natural resources would determine institutions, which in turn would drive economic development—as hypothesized by e.g. Engerman and Sokoloff (2002) and Isham *et al.* (2005).[26] If this were the case, our empirical model would still be correctly but inefficiently specified. Even if we agree with the general idea that resources (or more generally geographic conditions) have been an important determinant in shaping institutions historically, we do not think this is a major problem in our data. As was shown in Table 2, the correlations between our different measures of natural resources and institutions are low. Furthermore, resources which are important today (or have been in past decades) have in many cases become major exports rather recently; in some cases they are even based on recent discoveries. This means that many of the resource measures in our data set do not fit the description of given, exogenous endowments which have shaped institutions over the very

[23] Using *MinProd* for country i in our structural model, $growth_i = \widehat{\beta}_1 \overline{MinProd}_j + \widehat{\beta}_2 Inst_i + \widehat{\beta}_3(\overline{MinProd}_j \times Inst_i)$, where $\overline{MinProd}_j$ is the group mean of group j with $j \in \{low; high\}$. The mean of *MinProd* is 0.058, while the average value for those countries with *MinProd* less than the mean is 0.013 and the average for those countries with more than the mean is 0.182.

[24] That is, $inst_{cutoff} = -\widehat{\beta}_1/\widehat{\beta}_3$.

[25] This would be true even if we allowed non-linearities (which could be called for as it seems a concave curve would fit the *MinProd* scatter better).

[26] Sala-i-Martin and Subramanian (2003) also suggest a similar mechanism and present empirical evidence for this hypothesis in a different setting.

long run as in e.g. Engerman and Sokoloff (2002).[27] The second concern is that institutions may be correlated with the error term in our regression equation (1), so that our specification would suffer from endogeneity. To address this concern we performed a regression-based Hausman test for endogeneity, which fails to reject the null hypothesis that *institutions* and the interaction term of *institutions* and *natural resources* are exogenous, as reported in Table 3.[28] For one measure, however, *OrMetExp*, the hypothesis is rejected at the 5 percent level. Even though these tests do not indicate that endogeneity is a major concern in our data, we instruments *institutions* (and the interaction) with *latitude* and *EurFrac*, the fraction that speaks any European language (and *latitude* interacted with resources).[29] This set of instruments is from Hall and Jones (1999) and is also used in Alcalá and Ciccone (2004).

Table 5 reports the results from these estimations, with the first-stage regressions in the two lower panels. In terms of instrument relevance, the excluded instruments enter as jointly significant in every first-stage regression. Importantly, in none of the specifications is a single "good" instrument alone responsible for the significance in both first-stage regressions (in which case the model would be unidentified). The Hansen J-test of exogeneity of excluded instruments, *Ovid*, suggests that the instruments are valid.[30] In all four regressions, the coefficient for *institutions* is larger as compared to those obtained under OLS, which is consistent with attenuation bias due to measurement error in the OLS-estimates. As the 2SLS coefficients are measured less precisely, *institutions* loses in significance. Turning to our resource measures, in column (1), the coefficient of

[27] As an example, Norway and Ecuador discovered oil in the late 1960s (at a time when institutional differences between these countries were already large). The same is true for diamonds in Australia and Botswana. As regards resource dependence in many African countries, the resources which dominated exports in the 1970s and 1980s had a zero or close to zero contribution to exports in 1960 see e.g. the listing in Boahen (1987). Generally, even though institutional change is a continuous process, most probably also affected by resources, we want to emphasize that, in many cases, resources have been discovered (or become important) after institutions had already been established and as such cannot have shaped these institutions.

[28] In our structural model $growth = X_i'\alpha + \beta_1 NR_i + \beta_2 Inst_i + \beta_3(NR_i \times Inst_i) + \varepsilon_i$, we suspect *Inst* and hence $NR \times Inst$ to be endogenous. We run the first-stage reduced form regressions $Inst_i = X_i'\alpha + \beta_1 NR_i + Z_i'\gamma + v_1$ and $NR_i \times Inst_i = X_i'\alpha + \beta_1 NR_i + Z_i'\eta + v_2$, where Z' is our set of instruments. Then, we included the least squares residuals $\widehat{v}_1$ and $\widehat{v}_2$ in the structural equation. In one specification out of four (using *OrMetExp*) we reject exogeneity of *Inst* and $NR \times Inst$, i.e., the joint F-test for the OLS residuals is significant.

[29] The Hausman test is not unproblematic, and given that endogeneity in many settings similar to ours has been considered a problem, we prefer to address this even when the tests do not indicate endogeneity.

[30] In addition, we also tried including *latitude* directly in the OLS specification and while it entered with a positive coefficient in all regressions, it was not significant.

Table 5. *Results when instrumenting for institutions*

	(1) *PrimExp*	(2) *OrMetExp*	(3) *MinProd*	(4) *MidasProd*
Resources	−4.443	−12.461	−16.998***	−89.995***
	(4.771)	(9.859)	(6.259)	(28.203)
Institutions	7.592**	6.839*	6.021	6.554*
	(3.463)	(3.788)	(4.019)	(3.452)
ResInst	0.664	23.586	30.646**	158.769***
	(7.112)	(20.405)	(12.699)	(39.762)
GDP75	−2.294***	−2.250***	−2.161***	−2.184***
	(0.646)	(0.649)	(0.762)	(0.626)
Openness	0.508*	0.229	0.261	0.138
	(0.271)	(0.293)	(0.261)	(0.254)
Investments	0.082***	0.090***	0.096***	0.084***
	(0.027)	(0.028)	(0.027)	(0.027)
Observations	80	80	80	80
R^2	0.62	0.63	0.66	0.70
Joint(*p*)	0.026	0.431	0.028	0.000
Ovid	0.207	0.311	0.134	0.511
Hausman	0.697	0.030	0.787	0.797
		First-stage: Institutions equation:		
Latitude	0.198**	0.152*	0.195**	0.210***
	(0.093)	(0.086)	(0.076)	(0.074)
ResLat	0.297	2.433***	−0.574	8.970**
	(0.434)	(0.864)	(0.960)	(4.072)
Eurfrac	0.094***	0.095***	0.084***	0.091***
	(0.026)	(0.026)	(0.024)	(0.026)
$F(3, 70)$	6.38	8.18	4.99	8.14
p-Value	0.001	0.000	0.003	0.000
		Institutions interacted with resources equation:		
Latitude	−0.066***	−0.014**	−0.031***	−0.000
	(0.023)	(0.007)	(0.011)	(0.001)
ResLat	0.789***	0.979***	0.803***	1.747***
	(0.181)	(0.141)	(0.256)	(0.152)
Eurfrac	0.004	0.002	0.004	0.000
	(0.006)	(0.002)	(0.003)	(0.000)
$F(3, 70)$	8.22	16.68	7.94	76.39
p-Value	0.000	0.000	0.000	0.000

Notes: Dependent variable is *growth*. Robust standard errors in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%. All regressions include a constant term and regional dummies for Latin America and sub-saharan Africa (not shown). *Joint*(*p*) denotes whether the coefficient estimates of resources, and the interaction of resources and institutions, are jointly significant. *Ovid* reports the *p*-values from the Hansen *J*-overidentification test for instruments. *Hausman* reports *p*-values of the regression-based Hausman test for endogeneity as explained in the text. The null hypothesis is that *institutions* are exogenous. The dependent variable in the first-stage regressions is *institutions* in the first panel, and the interaction of *institutions* and natural resources in the lowest panel. Significance of instruments reports the *F*-test for joint significance of excluded instruments. See text for details.

PrimExp falls by around 30 percent, and the interaction is now virtually zero. In column (2), our second export-based measure, *OrMetExp*, retains its expected properties, though both coefficients are around half the OLS estimates and not significant. However, for the (production-based) measures of highly technically appropriable resources, which we regard as having the most important effects, the outcomes shown in columns (3)–(4) are similar to those obtained under OLS, both regarding coefficient values and statistical significance.

We also used settler mortality—as suggested in Acemoglu *et al.* (2001)—as an instrument for *institutions*. But this instrument is problematic in our data set because it only exists for 50 of our countries. OLS estimates in this smaller sample are similar to our main results.[31] While the IV results are qualitatively similar to those obtained for the full sample (except for our broadest measure, *PrimExp*), their precision is lower. On balance, our conclusion is that the 2SLS estimates do not differ substantially from the OLS regressions.

V. Robustness of the Results

We now check the robustness of our results in several ways. Under four subheadings we study the effect of excluding developed countries while excluding potentially problematic continents, excluding outliers, including the effect of war and using alternative measures of institutions.

Regional Effects

Although it is reassuring that our hypothesis finds empirical support in a large sample of countries, much of the *resource curse* debate has concerned the lack of development in resource-intensive developing countries over the last decades. Do our hypotheses hold if the sample is restricted to developing countries? This would seem quite challenging for our results since, by dropping rich countries, we exclude many countries with high institutional quality, some of which are rich in natural resources and may be driving the "positive" side of the interaction effect. Columns (1)–(4) in Table 6 report the results when all the countries that were members of the OECD in 1975 are excluded.[32] These results support a non-monotonic relation between natural resources and growth, even when considering the developing countries separately. Good institutions are still crucial when there are plenty of highly technically appropriable resources. If anything,

[31] The results from instrumentation are available from the authors on request.
[32] The excluded countries are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, United Kingdom and USA.

institutional quality in itself appears to be somewhat more important for growth in developing countries. Our results might also be driven by particular regions. Africa is known to be a continent with abundant resources, in particular precious metals, but also for its wars and low levels of income per capita. It is thus a concern that our main results (in Table 3) could be driven by the development of the African continent. However, if the African countries are dropped from our sample, the results are not affected. Similarly, we have also checked whether excluding Latin American countries matters for our results (estimation results available on request).

Are Botswana and Sierra Leone Driving the Results?

Needless to say, same of the countries in our sample differ considerably from all the rest. Several countries are outliers with respect to either their growth performance over the period or their initial endowment of natural resources. This is especially true for the *MidasProd* measure of natural resources where countries such as Botswana, Sierra Leone and South Africa stand out. To check for influential observations, i.e., with either a high leverage or a large residual, we used the DFITS index to estimate equation (1). Observations with a DFITS index larger than the absolute value of $2\sqrt{k/n}$ (where k is the number of independent variables, including the constant, and n the number of observations), were excluded from the sample.[33] We thus obtained a specific sample for each measure of natural resource endowment. Columns (5)–(8) in Table 6 report the results and the countries excluded from the sample with each measure of natural resources. The outcome varies to a surprisingly small extent when outliers are excluded. The qualitative results are in general the same, but the individual coefficients for natural resources measured as *MidasProd* turn insignificant.[34] However, they are still highly jointly significant, i.e. the appropriability effect is in line with the basic results.[35]

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[33] $DFITS_i = r_i\sqrt{h_i/(1-h_i)}$, where r_i are the Studentized residuals and h_i the leverage.
[34] *MidasProd* may be problematic in two ways. Besides the clear outliers, many countries in the sample simply do not have any production of diamonds or precious metals. In addition to excluding influential observations using DFITS, we also ran regressions on *MidasProd* while excluding extreme observations. Excluding countries with zero production has little effect. When also dropping all observations with a *MidasProd* at least as high as that of the Dominican Republic (leaving us with a sample of 43 countries), the interaction term turns insignificant (p-value 0.14), though the three variables of interest are still jointly significant at the 99 percent level. These estimates are available from the authors on request.
[35] As an alternative to using DFITS, we also ran median regressions as well as so-called robust regression; see e.g. Berk (1990). Our results are not sensitive to the way we chose to address outlying observations (results available on request).

Table 6. *Results for developing countries and when excluding outliers*

	Developing countries				Excluding outliers			
	(1) *PrimExp*	(2) *OrMetExp*	(3) *MinProd*	(4) *MidasProd*	(5) *PrimExp*	(6) *OrMetExp*	(7) *MinProd*	(8) *MidasProd*
Resources	−3.613	−35.257***	−18.034***	−87.623***	−8.110**	−20.416**	−22.293***	−89.245
	(7.049)	(7.416)	(6.057)	(28.932)	(3.069)	(7.859)	(3.679)	(74.173)
Institutions	9.579***	5.502**	5.932***	6.832***	4.317***	3.656***	3.327***	5.142***
	(3.232)	(2.264)	(2.178)	(2.063)	(1.314)	(1.370)	(1.250)	(1.347)
ResInst	−0.430	71.792***	32.108**	153.329***	7.227	36.804**	39.733***	159.326
	(12.691)	(14.261)	(13.160)	(41.081)	(4.969)	(17.732)	(7.610)	(98.810)
GDP75	−2.038***	−1.872***	−1.855***	−1.938***	−1.795***	−1.650***	−1.633***	−1.856***
	(0.408)	(0.348)	(0.415)	(0.350)	(0.244)	(0.248)	(0.249)	(0.276)
Openness	0.451	0.261	0.231	0.115	0.543**	0.267	0.370*	0.253
	(0.357)	(0.357)	(0.302)	(0.299)	(0.219)	(0.232)	(0.215)	(0.218)
Investments	0.058	0.077**	0.093**	0.080**	0.084***	0.080***	0.093***	0.085***
	(0.037)	(0.038)	(0.040)	(0.036)	(0.020)	(0.024)	(0.022)	(0.023)
Observations	58	58	58	58	73	74	74	75
R^2	0.65	0.71	0.68	0.72	0.74	0.71	0.71	0.68
Joint(p)	0.129	0.000	0.008	0.000	0.002	0.002	0.000	0.000

Notes: Dependent variable is *growth*. Robust standard errors in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%. All regressions include a constant term and regional dummies for Latin America and sub-Saharan Africa (not shown). *Joint*(*p*) denotes whether the coefficient estimates of resources, and the interaction of resources and institutions, are jointly significant. Excluded countries in (5) are: Botswana, Dem. Rep. of Congo, Guyana, Haiti, Nicaragua and South Africa; in (6): Belgium, Botswana, Dem. Rep. of Congo, Haiti, Hong Kong, and Nicaragua; in (7): Botswana, Dem. Rep. of Congo, Haiti, Nicaragua, Sierra Leone and Venezuela; and in (8): Botswana, Dem. Rep. of Congo, Haiti, Nicaragua and Sierra Leone.

Robustness to Other Institutional Measures

Even though institutional measures in general tend to be highly correlated, we tested whether our basic equation (1) holds for a variety of different institutional measures: *Polity* from the Polity IV data set, which basically measures how democratic a country is, as in Marshall and Jaggers (2002); sub-components of the *Institutions* measure used in our main regressions;[36] the *Rule of Law* measure from Kaufmann, Kraay and Zoido-Lobatón (2002). The results are robust to alternative institutional measures. However, the magnitude of the appropriability effect is approximately five times larger when using *Repudiation of Contracts by Government*, instead of *Polity*, given the same level of natural resources (*Institutions* has a quantitatively intermediate appropriability effect). These results (available on request) are suggestive of the mechanisms that drive the appropriability of a resource. Copper, oil, kimberlitic diamonds and other investment-intensive and highly valuable resources are probably very sensitive to the investment climate in a country and, in particular, to a regime that repudiates contracts, since this radically increases the riskiness of investments. But the extent of democratic rule, as captured by *Polity*, seems less important for investment decisions as long as the companies are on friendly terms with the regime.

Additional Robustness Checks

Besides the robustness checks, we also checked for a number of other potential concerns and alternative hypotheses.[37] A first additional concern is the reverse causality discussed in Sachs and Warner (2001). To address this we included growth of GDP per capita in the previous period (in our case 1960–1974). Including lagged GDP growth does not alter our main results in any significant respect. Another potential concern is that Table 2 reported a high correlation between institutions and initial GDP level and investments. To check to what extent these correlations influence our conclusions, we used a more parsimonious empirical specification by dropping and adding control variables: our main results are not sensitive to the inclusion (or exclusion) of controls. To address the level vs. growth discussion briefly touched on in Section II, we also ran regressions using the level of GDP instead of growth as the dependent variable. The results (OLS as well as IV) are not significantly different from what we find using growth. Hence, we conclude that our hypothesis is valid in a level as well as in a growth setting. Furthermore, in light of the discussion in Glaeser, La Porta, de Silanes and Shleifer (2004) concerning a possible interrelation between

[36] Namely *Rule of Law*, *Protection of Property Rights*, *Risk of Expropriation and Repudiation of Contracts by Government*.
[37] All results are available from the authors on request.

human capital and institutions, as well as the hypothesis in Bravo-Ortega and De Gregorio (2005), that human capital accumulation may reverse the resource curse, it seems important to control for human capital. Using the average number of years of education in the population, also found in Bravo-Ortega and De Gregorio (2005) we controlled for human capital in three alternative ways: as a main effect only, interacted with natural resources while keeping the interaction between institutions and resources, and simply replacing *institutions* (as well as the interaction) with *schooling* in our original specification. We found no support for the view that human capital either proxies for institutions or works as an alternative explanation for the reversal of the resource curse.

Finally, a potentially important mechanism through which natural resources could affect economic development is by creating conflicts. Perhaps the best-known resource in terms of generating (and sustaining) conflict is diamonds, although oil (as in Sudan and Nigeria) has also fueled many conflicts.[38] We tested whether conflicts affect the importance of appropriability for economic development by including two different measures: a dummy for the occurrence of any type of conflict (international or internal) with at least 25 battle-related deaths per year during the period, using data from Strand, Wilhelmsen and Gleditsch (2002) and, alternatively, a dummy indicating a civil war with at least a thousand battle-related deaths in the period, based on data from Collier and Hoeffler (2002). Neither dummy has a significant effect on the results. If anything, the appropriability effect of resources becomes slightly more important. These results show that our main results are not driven by conflicts.

VI. Summary and Concluding Remarks

When referring to Zambia's poor economic performance, Kenneth Kaunda, the former President of Zambia, was quoted as saying, "We are in part to blame, but this is the curse of being born with a copper spoon in our mouths"; see Ross (1999). In reference to the deterministic, negative effects of having abundant resources, Leonardo Simão (Minister of Foreign Affairs of Mozambique) stated, "Mozambique is different [from Angola]. We are fortunate not to have oil and not to have diamonds".[39] This paper suggests that such statements call for some modification. The problem for Zambia, and many other countries, does not lie in resource richness *per se*, but in the

[38] Given that many conflicts over diamonds are, to be more precise, over (secondary) alluvial deposits, as an additional robustness check, we included a dummy for countries with mainly alluvial deposits in our main specification. Our results remain and, while the alluvial dummy is negative, it is not significant. Results are available on request.

[39] Speech delivered at the Swedish Institute of International Affairs, Stockholm, Sweden, on June 18, 1999.

combination of poor institutions and resource wealth. Our results indicate that a sufficient improvement in institutional quality turns resource abundance into an asset rather than a curse. Furthermore, we have shown the type of natural resources a country possesses to be of crucial importance. The negative effects of poor institutional quality are much more severe in countries rich in potentially more problematic types of resources, as compared to those rich in other natural resources. Conversely, the greatest rewards for good institutions are found in countries with more appropriable types of resources. For all our measures of mineral intensity, the positive interaction term outweighs the negative effect of the resources themselves, and this effect is highly significant. We find the strongest and most significant effects when using the value of production of precious metals and diamonds.

What are the quantitative implications of our findings? given that the point estimates are taken seriously, our results suggest that if a country such as Sierra Leone (with an average growth rate of −2.05 percent since 1975) were to close the gap in institutional quality with a country like Botswana (with a growth rate of 4.99 percent over the period), then its yearly growth rate would also approach that of Botswana. Thus, Sierra Leone has the potential of performing like Botswana, but it lacks the necessary institutional setting. This paper challenges the traditional *resource curse* which, taken literally, would simply suggest that a country would be better off without its resources. We find this hard to believe. By identifying a non-monotone relationship between institutions and resources and, in particular, the role of the types of resources, we show that it is possible to reverse the curse. The literal policy advice of this paper would thus be: “Get your institutions right, especially if you have plenty of diamonds and precious metals”. This is not very informative in terms of implementation, but it does suggest that countries can do something more to improve their economic situation than ignoring their resources—as suggested by the resource curse hypothesis.

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