Natural Resource and Growth: A Geological Approach

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Abstract

The primary purpose of this paper is to identify whether the resource curse is present using a new and more likely exogenous measure for resource abundance than those used in the previous literature. This data is from the United States Geological Survey, and takes into account all previous extraction in addition to being distinct from GDP growth. Using this data, and building off the theories presented in the existing literature, I find that there is a negative and significant effect on GDP growth when resources and bad institutions are present and a positive effect when resources and good institutions are present. Due to the exogenous endowment nature of the data set, these results are robust to both endogeneity and reverse causality.

Acknowledgments

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1 Introduction

The finding that natural resources, and therefore national wealth, can negatively affect developmental outcomes is counter to traditional economic thought. However, these findings have been demonstrated throughout the extensive literature a number of times, and as such the effect can not be disregarded. This effect, however, has been demonstrated to be only conditionally true, with successful countries such as Norway and Botswana experiencing positive outcomes, while countries such as Nigeria and Venezuela experience prolonged economic stagnation or even contraction. Furthermore, some articles find that the effect may be non-existent or reversed. This discrepancy in outcomes is discussed in the natural resource and development literature, where authors identify some conditions under which the presence, extraction, or both of natural resources can positively or negatively affect output, education outcomes, health outcomes, and other developmental indicators. The articles in support of the resource curse attribute the negative outcomes to five main factors: "dutch disease," rent-seeking behaviour, institutional structure, political structure, and neglecting human capital expansion.

The early literature that studies the effect natural resource abundance has on growth measures resources with respect to GDP or national wealth. However, this measure is not a resource abundance measure, but rather a measure of resource dependency.[1] Furthermore, this measure of resource abundance is likely endogenous since it is tied to the outcome variable of interest. This measure of resource abundance has been the centrepiece for an expanding literature that criticizes the results found. This literature includes Stijns (2005), Brunnschweiler and Bulte (2008), and Brunnschweiler (2008), who opt to use measures of resource reserves per capita or resource wealth per capita. How-

[1] This is the the most prominent argument against the results found using GDP tied data. e.g. Sachs and Warner (1995)

ever, these measures are also endogenous since reserves do not account for past extraction, which will affect both GDP growth and reserves. In this paper, I provide a new measurement for natural resource endowments by pairing a new core geological data set provided by the United States Geological Survey with geographical data provided by ARCGIS and the Flanders Institute, to measure resource endowments rather than reserves. Using this raw data for resource endowments, I expand on the work by Sachs and Warner (2001) and Mehlum et al. (2006) regarding resource abundance and institutions, using data that is similar to Stijns (2005) but is less likely to be exogenous. I find that when using my measure for resource endowment, an increase in resource endowments negatively affects growth, similar to the results initially found by Sachs and Warner (1995). Furthermore, I find that when controlling for political form, changes in life expectancy, continental differences, and initial income, raw resource endowments have a negative effect on economic growth. Additionally, similar to the findings by Mehlum et al. (2006), I find that in the presence of strong institutions, resources can have a positive effect on growth. From these results, I conclude that when using my exogenous resource measurement, natural resource abundance and bad institutions lead to a decrease in growth while with good institutions, an increase growth. These results support the idea that a resource curse exists and that institutions are important in determining the magnitude and direction the effect takes.

The paper proceeds in the following format. Section 2 discusses previous literature regarding the resource curse. In section 3, I present my methodology and regressions specifications. In sections 4 and section 5 I discuss the data and results. Finally, section 6 contains my conclusion and section 7 contains the appendix.

2 Related Literature

The literature on natural resources and growth has many facets. The early prominent empirical finding on the resource curse can be found in Sachs and Warner (1995), who show that natural resource abundance negatively affects GDP growth. This finding appears to contradict conventional growth models that indicate that an increase in (natural) capital should increase output. Traditionally, natural resources are thought to increase wealth, purchasing power, and investment. However, the authors' empirical results indicate that countries with high levels of natural resource exports as a percentage of GDP tend to grow more slowly, even when controlling for factors such as investment, trade policy, and initial income. To explain these seemingly counter-intuitive results, four explanations have been used; rent-seeking behaviour by politicians, dutch disease hindering export development, domestic crowding-out by the resource industry, and detrimental political incentive structures.

To understand the initial findings in the resource curse literature, a review of the summaries provided in Sachs and Warner (2001), and Gylfason (2001) is necessary. Sachs and Warner (2001), building on their initial findings in Sachs and Warner (1995), provide an overview of the effect resource abundance has on growth. Using natural resources as a percentage of GDP as their measure of resource abundance, the authors find that countries with natural resources experience, on average, lower levels of growth than those with little or no resource exports. They find that this result is consistently negative when accounting for geographic variation, climatic variation, institutions, and previous growth rates. Gylfason (2001) provides findings that show that, in addition to growth, education expenditure is affected by natural resources. The author's paper states four main channels of transmission from natural resource abundance to negative developmental outcomes. First, natural resources exports drive up the real exchange rate, and crowd out exports from the high-tech and manufacturing industries, which are important for a diverse and well-developed economy (dutch disease). Second, natural resource economies appear to suffer from higher level of business and government corruption. Third, the easy wealth that is provided through natural resource extraction reduces the incentive to find new ways to create wealth; essentially, the public and the government become lazy and overconfident. Fourth, natural resource extraction investment crowds out investment in human capital. This leads to reduced educational attainment and lower levels of labour productivity in the long run. To show that natural resources lead to lower levels of growth and educational investment, Gylfason (2001) studies the relationship between natural resource wealth as a percentage of national wealth and education attainment, expenditure, and enrollment. The authors also support Sachs and Warner (1995) and Sachs and Warner (2001) findings that resource abundance negatively affects growth.

However, a major criticism of the aforementioned papers is their measure of resource abundance. An early criticism of this measurement is found in Stijns (2005), who argues that measuring resources as a percentage of GDP or national wealth is invalid as it is likely endogenous. Stijns argues that a better measurement of resources is the stock per capita measurement of natural wealth. To measure resources, Stijns (2005) uses oil reserve data from the International Energy Agency, and mineral data from the USGS's Mineral Commodity Summaries. These measurements, similar to the ones I use, estimate the stock of resources per capita in a country, while not including GDP. The author's results indicate that the effect natural resource abundance has on growth is varying in direction and is insignificant for different measures. From this, Stijns (2005) concludes that the resource curse is more complicated and less certain than Sachs and Warner (2001) indicate, and that further analysis of the effect is required.

A parallel literature that must be acknowledged to understand the resource curse is provided by Acemoglu et al. (2001) and Rodrik et al. (2002) who state that institutional development plays the most important role in economic development. Acemoglu et al. (2001) approach institutions by finding an exogenous instrument for them in the form of 19th century settler mortality. When accounting for institutions using their IV, the authors find that they play a key role in development. Their results indicate that geographical and health variables play, at best, a minimal role in development, while institutions explain most of the variation in growth. This result is both supported and criticized by Rodrik et al. (2002). When measuring the relative importance of institutions, trade integration, and geography with respect to development, Rodrik et al. (2002) find that institutions trump the other explanatory factors. However, contrary to Acemoglu et al. (2001), they believe that the instrument used by Acemoglu et al. (2001) as the main finding in their paper does little to address institutions' role in development, but rather indicates that colonial mortality plays a role in the development of ex-colonial countries. They find that the difference between the development of countries that were settled by europeans and those that were not, is not sufficient to indicate that european settlement and the adoption of their institutions is a necessary or even contributing factor in development. However, Rodrik et al. (2002) do applaud Acemoglu et al. (2001) for their use of settler mortality as an exogenous instrument to show the role institutions play in development. Interpretation of colonial mortality aside, Acemoglu et al. (2001) and Rodrik et al. (2002) both find that institutions play a key role in modern economic development.

These two seemingly competing literatures are brought together by Mehlum et al. (2006), who find that institutions contribute a key piece to the resource curse puzzle. Although this result refutes parts of both the early resource curse literature and the institutions literature, together they provide a better explanation of why different countries grow at different rates. The authors argue that when institutions are "grabber" friendly, resource rents do not contribute positively to growth, while when institutions are "producer" friendly, resource rents do contribute positively to growth. They provide a theoretical framework that indicates that there is a point where the effect of resources on growth is reversed, helping to explain why Norway and Botswana are resource success stories while Venezuela and Nigeria have faired poorly despite being well endowed. Empirically, Mehlum et al. (2006) find that resources by themselves contribute negatively to GDP growth, however resources paired with institutions contribute positively. Their results are statistically significant when using different samples and when controlling for other contributing factors such as investment, ethnic fractionalization, and language fractionalization. These results are consistent with the results found by Salai-Martin and Subramanian (2003) while studying the economic contraction in Nigeria due to corruption. These results are further supported by Boschini et al. (2007) who finds that different measures of resources lead to a negative and significant effect, although when present with strong institutions, the effect resources have on growth is positive. Furthermore, Boschini et al. (2007) shows that the more appropriable the resource is, the larger the variation in the effect.

These results all indicate that the resource curse exists. Arguing that this is not true, Brunnschweiler and Bulte (2008) and Brunnschweiler (2008) provide empirical evidence that the effect resource abundance has on growth has been largely positive. Using a World Bank indicator for resource wealth per capita, Brunnschweiler and Bulte (2008) show that the effect resources have on GDP growth has been largely positive, but when using a similar specification in

Brunnschweiler (2008) and including an interaction term between institutions and resource wealth, the results show that, when paired with strong institutions, the benefit of resource abundance decreases. This result is the exact opposite of that found by Mehlum et al. (2006), and states that institutions are bad for growth. Given the overwhelming evidence that institutions benefit growth, these results are very interesting, but future research is necessary to validate the author's claim.

The results found by Mehlum et al. (2006) and Boschini et al. (2007) support the growing theoretical literature on rent-seeking activity in countries with resources and corruption. Notable articles on rent-seeking behaviour include: Lane and Tornell (1996), Tornell and Lane (1999), Baland and Francois (2000), and Torvik (2002). Lane and Tornell (1996) and Tornell and Lane (1999) contain a model where there is a formal sector, which is productive and can be taxed, and an informal sector, which is less productive and free from taxation. According to the model, there exist several powerful (government) groups that have the ability to extract rents from each other when rents are present. When there is an economic windfall such as a resource discovery, the authors argue that in some cases groups try to grab a greater share of national wealth, which consequently leads to capital being transferred from the formal sector to the informal sector. They argue that the redistribution of capital can be larger than the benefit from the windfall, and therefore the aggregate growth rate decreases. Lane and Tornell (1996) call this effect the "voracity effect." Using a different approach, Baland and Francois (2000) create a model which shows that rent-seeking behaviour is dependent upon the number of entrepreneurs in the economy at the time of a windfall. They show that when the number of entrepreneurs in an economy is initially low, rent-seeking behaviour is more prevalent, while when there are many entrepreneurs, there is less rent-seeking behaviour. They state that this difference in initial amount of entrepreneurs is what leads to different outcomes. Torvik (2002) uses a similar mechanism, citing the balance between rent-seeking and modern production profits, to explain why windfalls may either increase or decrease welfare.

The latest contributing factor the resource curse literature has focused on is how the political environment in a country affects developmental outcomes. Robinson et al. (2006) show that politicians are subjected to conflicting incentives with regards to resource booms. They demonstrate that when an economy is subjected to a resource boom, the politician extracts resource at a more efficient rate; however, the increase in value of the resources strengthens the leaders rule and therefore negatively affects how the rents are allocated within the economy. Hodler (2006) shows that internal conflict in fractionalized countries leads to reduced property rights. In his model, natural resources cause fighting, and this leads to a decrease in productivity through weakened institutions, which can offset the income effect from the natural resources. Empirically, the author finds that natural capital (resources) increases GNI in homogenous societies, but when paired with fractionalization, the effect on GNI is negative. Similar to this, Bjorvatn et al. (2012) finds that in countries where there are many small political groups (fractionalization), resources tend to have a deleterious effect, while when there is a strong singular government, resources positively effect growth. Finally, using a panel regression, Bhattacharyya and Hodler (2010) finds that in the presence of strong democratic institutions, resources lead to positive growth and a decrease in corruption, while countries with poor democratic institutions experience an increase in corruption. Their results are consistent when controlling for income, time fixed-effects, regional fixed-effects, legal origins, and fractionalization.

3 Methodology

The primary purpose of this paper is to identify whether the resource curse is present using a new and more likely exogenous measure for resource abundance than those used in previous literature. Given the endowment nature of the data and its inherent invariance over time, my empirical study, like those previously carried out, is limited to cross-sectional analysis.

In Sachs and Warner (1995), Sachs and Warner (2001), and Mehlum et al. (2006), the authors use resource exports as a percentage of GDP and natural wealth as a percentage of national wealth, which have the resource specific portion of the measurement either directly or indirectly tied to our outcome variable. This creates a situation whereby an increase in resource abundance (as a ratio of GDP or wealth) is due to either to an increase in resource exports or wealth, or due to a decrease in GDP or national wealth (which is related to past GDP). This leads to an endogeneity issue. The endogeneity arises from the fact that the original measure of resource dependency is tied to GDP. If there is a shock that increases GDP but does not change resource exports, it will change both the GDP growth variable and the resource dependency variable. Due to this, specifications using these variables are very sensitive to omitted variables that drive growth. By using resource endowments rather than dependency, I am able to mitigate this endogeneity.

A better approach than that used by Sachs and Warner (1995) is that used by Stijns (2005). Using geological data from the USGS, Stijns avoids this form of endogeneity. However, Stijns (2005) data is subjected to a different form of endogeneity in the way of using oil reserves in 1994 rather than oil endowments accounting for previous extraction. Since oil reserves are depleted over the period of time that they are extracted, measuring oil reserves after extraction has occurred leads to a discrepancy between the amount of oil that was present when measured, and the amount of oil available for exploitation prior to the initial extraction. The endogeneity arises if the choice of extraction that a country makes is driven by the growth at that point. Countries that extract resources to compensate for low GDP growth will have relatively lower levels of growth (hence the decision to extract more resources) and relatively less resources if measured at the end of the extraction period. This may lead to a positive bias on the coefficient estimate for resource abundance. To account for this, I use oil endowment data rather than reserves data, leading to a resource endowment measure that is separate from the choice to extract. A more thorough overview of the data is available in Section 4.3.

The measure of institutions I use is the same one used by both Mehlum et al. (2006) and Sachs and Warner (2001). Although using the risk of expropriation and instrumenting for it using settler mortality, as Acemoglu et al. (2001) does, is an option, I opt to use the measure used by Sachs and Warner (2001) and Mehlum et al. (2006). Although this measure is possibly endogenous since natural resources can affect both growth and institutions[2], by including both natural resources and institutions, and using an interaction term, this form of endogeneity is likely not a major concern.

To control for other factors that lead to growth, I include the logarithm of GDP in 1970, a control for the AIDS epidemic, political structure, and continental dummy variables. The logarithm of GDP in 1970 is included to control for differences in growth between countries due to their initial GDP. Furthermore, when using the measure of natural resource abundance in terms of GDP, controlling for GDP is necessary since countries with similar resource rents but different GDPs will have vastly different measure of resource abundance.

To control for the HIV/AIDS epidemic that is ongoing in Africa (and else-

[2]Natural Resources may lead to the suppression of institutions by leaders, so that rent-grabbing is more possible

where), I include a change in life expectancy variable between 1980 and 2000. The HIV/AIDS epidemic has led to the destruction of human capital, as well as a decrease in the labour force. For most countries, this measure is generally positive, but for those that are severely affected by this epidemic, the change in life expectancy is negative. The time period was chosen because it spans the most severe part of the epidemic.

The literature on the resource curse has proposed many mechanisms that affect economic outcomes; some of these pertain to the political form. To account for the differences in growth between democratic and non-democratic countries I include the polity2 variable from the Polity IV project.

Finally, to account for continental differences with regards to historical events, proximity for trade, business perceptions, and other factors, I include four continental dummy variables. These dummy variables are Asia, Africa, North America, and South America leaving Europe and Oceania (Australia, New Zealand, Timor-Liste) as the base continent. The choice to group Europe and Oceania together is based on the size of the Oceania sample, and that they have very intertwined cultures and histories.

To test whether there is a significant difference in the results when using natural resource rents as a percentage of GDP and geological data for natural resource, I run six regressions. Regressions (1) through (3) use the geological data released by the United States Geological Survey while regressions (4) and (5) use the resource rents as a percentage of GDP as the measure of resource abundance. Regressions (6) uses both resource rents and geological data to determine which variable has a larger effect on growth.[3] The regressions specifications are as follows; regression (1) does not include the logarithm of GDP in 1970 or the interaction term between institutions and natural resource abun-

[3] The inclusion of both terms is possible because the correlation between the two measures of natural resources is low. This low correlation further validates that the measurements are very different in nature, however the results are quite similar

dance. This specification is used since the USGS data is not tied to GDP, and therefore is not necessarily required in the regression. Regression (2) includes the logarithm of GDP in 1970 . Regressions (3) includes both the logarithm of GDP in 1970 and the interaction term. This specification is similar to that used by Mehlum et al. (2006). Regression (4) has the same form as regression (2) except it uses natural resource rents as a percentage of GDP rather than the USGS data. Regression (5) includes both the logarithm of GDP in 1970 and the interaction term using resource rents. Finally, regression (6) uses both forms of natural resources and both interaction terms as well as the logarithm of GDP in 1970. To test whether this effect only pertains to Africa, I run the model with Africa excluded. By using this reduced sample, I verify that the resource curse is not just an African effect but that it can be extrapolated to the rest of the world. An overview of the data is provided in the next section, the results are located in Section 5, and the results when Africa is excluded are in Appendix B.

4 Data

4.1 Sample

The sample used consists of 66 or 67 countries depending on the measure of natural resources. This sample is not selectively limited but rather is limited by data constraints; however, the United States is dropped from the sample since the United States Geological Survey provides the data regarding petroleum reserves and mineral abundance, and as such, the available data for the United States is far more detailed than that for all the other countries. This difference in detail could make the data for the United States incomparable with that of the other countries. A pictorial representation of the sample is provided in

Figure 1 below.

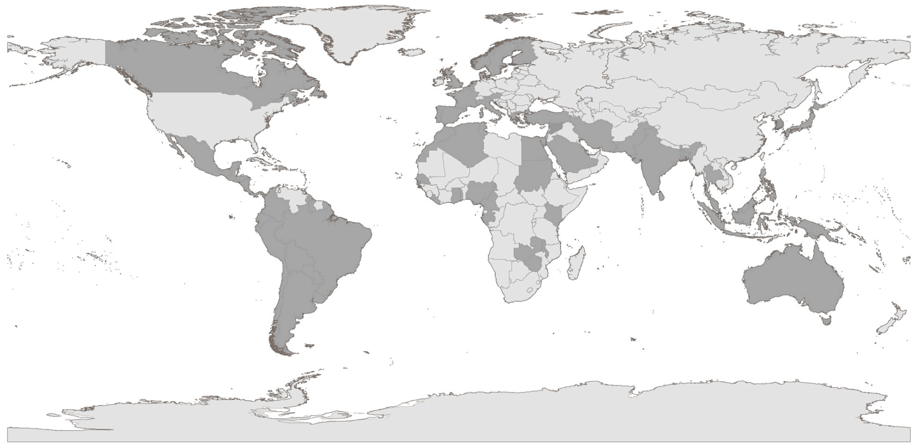

Figure 1: Regression Sample

One notable limitation in the data is the exclusion of the Soviet Union and its satellite states. Since the Soviet Union was a communist country, there is no reliable GDP data for years before 1990. Excluding the Soviet Union, however, should not bias the results, since the inclusion of it would subject the findings to the confounding factor of political reconstruction in the 1990s. Besides this, the sample spans all continents, and there appears to be little selection bias with regards to the variables discussed below.

4.2 Dependent Variables

Summary statistics for all the variables are in Appendix A. For the dependent variable, I use average real GDP growth between 1970 and 2000. To create this variable, I subtract the logarithms of the 2000 GDP and 1970 GDP values reported by the World Bank (2012)[4], and divide by the number of years

[4]The GDP variable is measured in 2000 USD

spanned. Countries that do not have their 1970 GDP reported in the World Bank database are excluded from the sample. It was possible to use later year values to calculate GDP growth over a shorter period, but under that calculation, countries would not be comparable since global time trends would not be accounted for. The time period of 1970-2000 is used since it is most similar to that used by Sachs and Warner (2001) except extended 10 additional years to account for the difference in the dates written. Furthermore, there is more data available for countries in 2000 than 1990 and in the interest of having a richer sample, the time period was extended.

4.3 Explanatory Variables

My main contribution to the existing literature is my usage of an exogenous measures for resource endowment rather than a measure which is related to previous development. To make my results comparable to those found by Sachs and Warner (2001) and Mehlum et al. (2006), I use natural resource rents as a percentage of GDP in addition to my new measure.[5]

To measure the abundance of oil, gas, and natural gas liquids, I use the 2000 World Petroleum Assessment data released by the United States Geological Survey. This dataset was created by combining the findings of several studies regarding all non-US energy reserves, their cumulative extraction, remaining reserves, estimation of their unknown reserves, and aggregate endowments. The authors believe this data set includes upwards of 95% of the worlds petroleum reserves. The data field used for this model is "petroleum endowment." This field reports the amount of petroleum[6] that has been discovered as well as the mean undiscovered petroleum estimate, measured in million barrels of oil

[5] Sachs and Warner (2001) use Natural Resource Exports as a percentage of GDP. These indicator are similar in that they are both related to GDP and therefore suffer from the same endogeneity issue

[6] Composed of Oil, Gas, and Natural Gas Liquids

equivalent. The data is organized by geologic province (as determined by the USGS) with no political affiliation so, to attribute each geologic provinces to a country (or countries), I overlay the geologic provinces onto a political map of the world. The political map I use can be found ARCGIS titled *World Countries.* Additionally, to account for offshore reserves, I overlay the geologic provinces onto The Flanders Institute's maritime economic exclusion zone GIS data. This data set includes maritime economic exclusion zones by offshore distance as well as those resulting from sovereignty disputes. In instances where a geologic province spans more than one country, the resources in the geologic province are divided amongst countries by their percentage of coverage. By dividing the energy resources amongst countries rather than attributing the full value of the resources to all countries in the province, I avoid double counting petroleum endowments. To account for joint development zones, I divide the resources according to the percentage stated on the joint development zone websites.[7] A map of these geologic regions and their location relative to countries is provided in Figure 2.

To measure mineral abundance, I use data from the United States Geological Survey's Mineral Resources Data System (MRDS).[8] This dataset is composed of resource occurrence results gathered from around the world over several decades. To aggregate the data, I use the number of producer, occurrence, prospect, and unknown mineral sites within a country as a proxy for the amount of mineral resources that the country holds.[9] A similar dataset is used by Stijns (2005) who aggregates the dataset by using principle components. This form of ranking does not take into consideration the different minerals and their value, but

[7] They are: Nigeria (60%) and Sao Tome and Principe (40%); and Australia (10%) and Timor-Leste (90%).

[8] This Data is available on the USGS website. Details are available in Appendix D

[9] With this data, it is possible to determine the type of resource at each site, but due to the vast nature of the dataset and the inefficient recording of that measure, I consider all mineral types equal.

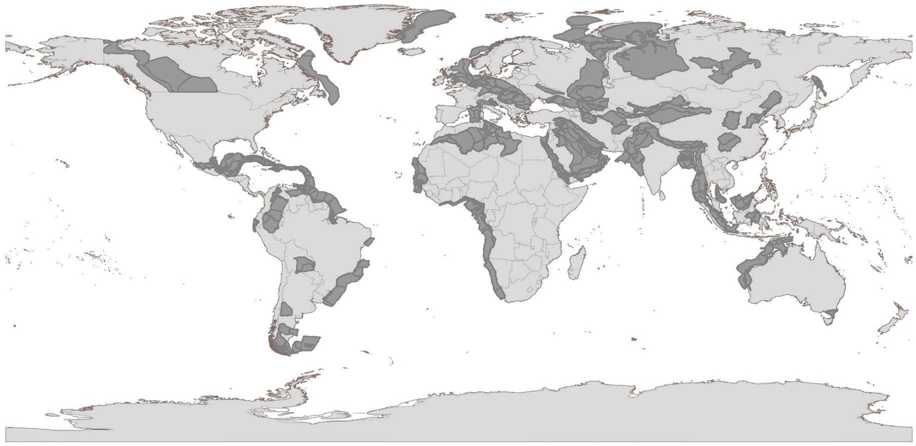

Figure 2: Oil and gas fields of the world. (excl. United States)

rather focuses on just the weight. My measure has similar measurement error in that it does not consider the value of the mineral but rather considers all occurrences equal. This measurement error likely leads to attenuation of the coefficient estimates in the results, and so by reducing this measurement error, the results may become larger in magnitude. Despite this, this data is the most accurate data of its kind available, and therefore a good candidate for use as a geological source for resource abundance. A map containing the data point locations is available in Figure 3.

To combine the petroleum data with the mineral data, I determine the percentage of each resource per capita (measured in tens of millions) in each country. Then by taking an average of the two, I find the total percentage of resources per capita for each country[10], and use the that as a measure of resource abundance. This measure of resources is independent from previous growth. Finally, I use a per capita measure because it is more indicative of resource abundance than a total measure.

[10]I weight petroleum and minerals evenly based on the assumption that petroleum and mineral resources are equal in importance

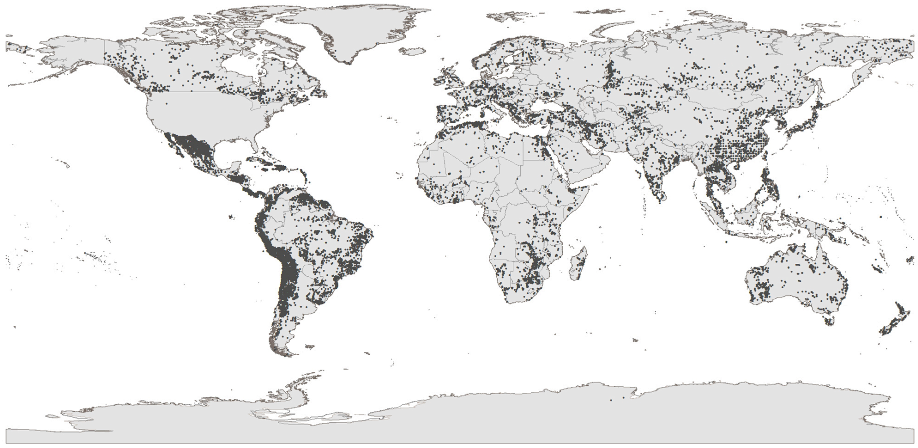

Figure 3: Mineral Occurrences (excl. United States)

The final resource abundance variable I use is natural resource rents as a percentage of GDP in 1970. This variable is slightly different then that used by Sachs and Warner (1995) and Sachs and Warner (2001), since this variable is natural resource rents rather than natural resource exports. This data is available though the World Banks data bank. Finally, to make the two resource abundance measures comparable for interpretation, I standardize them. This was done so as to keep the data linear while allowing for easier interpretation. This means that an increase in resources by 1 can be interpreted as an increase in 1 standard deviation.

The institutions variable I use is the same variable used by Sachs and Warner (1995) and Mehlum et al. (2006).[11] This index ranges from zero to unity and is a composite index with equal weight for five indices of institutional quality. These indices measure rule of law, bureaucratic quality, government corrup-

[11] This data is available on the Centre for International Development's website at http://www.cid.harvard.edu/ciddata/ciddata.html. The calculation of the index is available Knack and Keefer (1995).

tion, expropriation risk, and a government repudiation of contracts. Since this composite index measures of a number of types of institutions it is likely more relevant than any individual measure itself.

4.4 Control Variables

To isolate the effect natural resource abundance has on growth, I use the following controls: GDP in 1970, government form, the change in life expectancy, and continental differences.

The GDP per capita data for 1970 is drawn from the World Bank's World Development Indicators. It is measured in constant USD for the year 2000. I use GDP in 1970 because, when using the World Bank measure for resource abundance, if the initial GDP is not controlled for, countries with equal resource abundance but different GDPs would have different values for resources. By controlling for this, these differences are partially accounted for.

The data for government form is drawn from the Polity IV project. The indicator used is the polity2 variable which ranges from a value of -10 to 10, where -10 represents a completely autocratic government and 10 represents a completely democratic country. This data is subjectively created using input from social scientist from a variety of fields, then aggregated to create a dataset that best represents countries' political form. This dataset is reviewed on an ongoing basis and changes are made as required.

To control for the AIDS epidemic and its effect on growth, I use the change in life expectancy at birth from 1980 to 2000. The data used is available in the World Development Indicators database in the World Bank's data bank. The variable is created by differencing the life expectancy for 1980 and that for 2000. This leads to a linear scale ranging from -15.91 to 13.68. The period of 1980 to 2000 is used because it spans the main years of the epidemic. Furthermore, growth is measured up to 2000, so later changes in life expectancy would not be captured in the GDP growth variable used.

The continent dummies include Asia, Africa, South America, and North America, leaving Oceania and Europe as the base group. This data is drawn from the GIS data and therefore is definitionally accurate. That is, Central American countries are defined as part of North America and Middle Eastern Countries are defined as part of Asia.

5 Results

The results from the regressions using the USGS endowment data (1-3) are available in Table 1 and the results from the regressions using the World Bank's resource rents as a percentage of GDP (4-6) are available in Table 2. Comparing the results from the regressions using the USGS resource measure to those from the regressions using the World Bank resource measure, it is apparent that the direction and significance levels are similar. The results in regression (1) and regression (2) indicate that an increase in resource endowments by 1 standard deviation corresponds with a 3.5 % to 3.9 % decrease in a countries growth rate.

In all three regressions, the results indicate that institutions play a significant role in the resource curse, yielding approximately a 4% increase in the growth rate by going from the lowest possible measure to the highest.[12] Comparing regression (1) to regression (2), it should be noted that including the logarithm of GDP for 1970 does not significantly change the magnitude of the coefficient for endowments. In regression (3) we find similar findings to those found by Mehlum et al. (2006). An increase in a countries resource endowment alone leads to a decrease in the growth rate; however, if the increase is paired with strong institutions, the growth rate will increase. According to the results

[12] Note: the range of this indicator is from 0 to 1

in regression (3), the effect an increase in resource endowments has on growth can be approximated with the following equation.

$$\frac{\delta Growth}{\delta Endowment} = -0.780 + 0.916 * Institutions$$

Table 1: Resource Endowment Results

	Average GDP Growth 1970-2000		
	(1)	(2)	(3)
R. Endowment	-0.354	-0.385	-0.780
	(0.175)**	(0.182)**	(0.229)***
Interaction			0.916
			(0.438)**
Institutions	3.767	4.042	3.835
	(0.863)***	(0.719)***	(0.753)***
$\log(GDP_{1970})$		-0.097	-0.092
		(0.121)	(0.120)
Change in Life Exp.	-0.015	-0.006	-0.010
	(0.061)	(0.066)	(0.066)
Polity	-0.150	-0.150	-0.156
	(0.047)***	(0.046)***	(0.046)***
Asia	2.667	2.633	2.660
	(0.634)***	(0.608)***	(0.593)***
Africa	0.153	-0.038	-0.104
	(1.013)	(1.043)	(1.039)
S. America	0.922	0.795	0.853
	(0.581)	(0.635)	(0.624)
N. America	1.287	1.144	1.149
	(0.664)*	(0.665)*	(0.662)*
Constant	0.653	2.878	2.770
	(0.904)	(3.218)	(3.164)
R^2	0.48	0.49	0.50
N	66	66	66

Standard errors are in parentheses

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

From this it can be noted that the cross-over point between a decrease and increase in growth occurs at an institution measure of 0.85. This figure is very comparable to the figure of 0.93 found by Mehlum et al. (2006). For reference, the closest country to 0.85 is Portugal, who has an institutional value of 0.86. The results are opposite those found by Brunnschweiler (2008), who finds that resource abundance positively affect growth, however when paired with good institutions, this positive effect decreases. The difference in these results may be attributed to their using a valuation of resources rather than the quantity of resources. This valuation may be subjected to large swings due to changes in commodity prices. A further analysis of this discrepancy would require a closer look at the data used and their methodology than is afforded in the author's article. Finally, the R^2 of approximately 0.50 indicates that half of the variation in annual growth rates is explained by this model.

The results for the regressions using the World Bank indicator for resource abundance are found in Table 2, regressions (4) and (5). Comparing these values found with the traditional indicator to those found in Table 1, we can see that the significance levels are similar; however, the magnitudes are approximately double those found when using resource abundance, indicating that resource dependency has a larger effect than resource abundance[13]. Furthermore, the critical value when using resource rents is 0.58, which is significantly lower than both Mehlum et al. (2006)'s result and the one found in regression 3. This value for institutions is equivalent to that for Costa Rica. The effect resource rents as a percentage of GDP influences growth can be approximated with the following equation.

$$\frac{\delta Growth}{\delta Endowment} = -1.460 + 2.479 * Institutions$$

[13]Ignoring the endogeneity issue.

Table 2: Natural Resource Exports / GDP Results

	Average GDP Growth 1970-2000		
	(4)	(5)	(6)
Resource Rents	-0.596	-1.460	-1.410
	(0.206)***	(0.389)***	(0.469)***
Rent. Interaction		2.479	2.350
		(0.864)***	(1.029)**
R. Endowment			-0.218
			(0.442)
End. Interaction			0.202
			(0.629)
Institutions	3.879	2.602	2.617
	(0.668)***	(0.870)***	(0.891)***
$\log(\text{GDP}_{1970})$	-0.191	-0.199	-0.208
	(0.104)*	(0.096)**	(0.098)**
Change in Life Exp.	-0.024	-0.007	-0.011
	(0.051)	(0.041)	(0.042)
Polity	-0.128	-0.115	-0.128
	(0.038)***	(0.037)***	(0.046)***
Asia	2.773	2.397	2.343
	(0.541)***	(0.488)***	(0.490)***
Africa	0.410	0.079	-0.152
	(0.833)	(0.770)	(0.919)
S. America	1.006	0.531	0.470
	(0.570)*	(0.550)	(0.604)
N. America	1.345	0.842	0.759
	(0.552)**	(0.561)	(0.573)
Constant	4.974	5.451	5.801
	(2.636)*	(2.346)**	(2.458)**
R^2	0.63	0.68	0.67
N	67	67	66

Standard errors are in parentheses

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

The results from regression 6 show an interesting result; when controlling for both resource rents and resource endowments, it is apparent that resource rents play a bigger role in determining the growth rate. The magnitudes of the coefficient estimates remains relatively consistent between regressions (5) and

(6) while the significance level decreases slightly. The decrease in significance may be due to the loss of one data point. The R^2 for these regressions is approximately 0.66, indicating that resource rent data explains growth better than resource abundance. However, given that the resource rent data is endogenous, these results are likely biased.

Finally, comparing the results in Table 1 and Table 2 with the results when Africa is excluded[14], we can see that the signs and significance of the variables do not change significantly for resource endowments, however those for resource dependency decrease. Comparing the results in regression (12) with those in regression (6), the resource endowment interaction term is the only statistically significant variable[15]. The magnitudes of the coefficient estimates when using natural resource endowment are very similar, as is the critical value for institutions; however, the magnitudes of the estimates from the resource rent regressions are approximately half those found in Table 2. Furthermore, initial GDP becomes much more significant. The results using the resource rent data is still likely endogenous, and so no conclusions should be drawn from them.

6 Conclusion

By using geological resource endowment data, this article further supports the literature popularized by Sachs and Warner (2001) and extended by Mehlum et al. (2006). The results indicate that the resource curse is not a certainty, but rather conditional on institutional structure. The combination of poor property rights, corruption, and a weak legal system combined with resource abundance leads to poor results. However, in countries with strong institutional endowments, resource endowments can lead to greater levels of growth. This result

[14]Located in Appendix B, Table 3 and Table 4

[15]This term is significant at a 10% significance level but due to the small sample size, this is reasonable

is opposite to those found by Brunnschweiler (2008) while using an exogenous measure for resource abundance.

To better understand the effect, future research must be carried out. The main shortcomings of the literature lie in the quality of the data used. Despite having reliable petroleum data, a more comprehensive measure of mineral endowments would allow for a reduction in measurement error, and a reduction in attenuation bias. Furthermore, the results in table 2, and in particular regression (6), indicate that resource dependency may be the factor with the largest effect on growth. Finding an exogenous measure of resource dependency would allow for an interesting analysis of whether this is true. Despite these shortcomings, when using the best data available, my results indicate that the resource curse is present, and that institutions play a pivotal role in the direction and magnitude the effect takes. Since resource endowments are exogenous, future growth in the developing world must be driven by both the improvement of institutions and the exploitation of endowments rather than exploitation alone.

7 Appendix

7.1 Appendix A: Summary Statistics

Table 3: Resource Endowment (Excluding Africa)

Variable	Mean	Median	Std. Dev.	Min	Max
Growth	3.381	3.273	1.842	-2.422	9.959
Resource (USGS)	0.000	–0.269	1.000	-0.281	9.449
Resource (World Bank)	0.000	-0.329	1.000	-0.651	6.223
Institutions	0.548	0.480	0.287	0.160	1.00
$\log(GDP_{1970})$	22.824	22.413	2.191	18.460	28.183
Change in Life Exp.	2.137	2.346	3.667	-15.911	13.683
Polity	-0.193	-0.195	6.489	-10.000	10.000
Asia	0.200				
Africa	0.374				
S. America	0.067				
N. America	0.100				

Includes all observations

7.2 Appendix B: Results excluding Africa

Table 3: Resource Endowment (Excluding Africa)

	Average GDP Growth 1970-2000		
	(7)	(8)	(9)
R. Endowment	-0.399	-0.481	-0.857
	(0.187)**	(0.211)**	(0.263)***
Interaction			0.868
			(0.467)*
Institutions	3.172	4.103	3.883
	(0.819)***	(0.685)***	(0.711)***
$\log(GDP_{1970})$		-0.278	-0.270
		(0.105)**	(0.103)**
Change in Life Exp.	-0.152	-0.101	-0.106
	(0.107)	(0.106)	(0.108)
Polity	-0.135	-0.133	-0.139
	(0.040)***	(0.037)***	(0.037)***
Asia	2.683	2.619	2.642
	(0.622)***	(0.518)***	(0.506)***
S. America	0.921	0.596	0.650
	(0.559)	(0.570)	(0.561)
N. America	1.234	0.864	0.868
	(0.634)*	(0.538)	(0.534)
Constant	1.352	7.533	7.373
	(0.928)	(2.647)***	(2.563)***
R^2	0.62	0.67	0.69
N	50	50	50

Standard errors are in parentheses

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

Table 4: Natural Resource Exports / GDP (Excluding Africa)

	Average GDP Growth 1970-2000		
	(10)	(11)	(12)
Resource Rents	-0.366	-0.857	-0.499
	(0.312)	(0.412)**	(0.431)
Rent Interaction		1.401	0.783
		(0.665)**	(0.702)
R. Endowment			-0.633
			(0.346)*
End. Interaction			0.596
			(0.571)
Institutions	4.066	3.366	3.543
	(0.684)***	(0.822)***	(0.823)***
$\log(GDP_{1970})$	-0.294	-0.290	-0.295
	(0.114)**	(0.110)**	(0.109)**
Change in Life Exp.	-0.095	-0.096	-0.111
	(0.104)	(0.108)	(0.107)
Polity	-0.112	-0.108	-0.134
	(0.033)***	(0.034)***	(0.040)***
Asia	2.839	2.632	2.561
	(0.518)***	(0.511)***	(0.518)***
S. America	0.874	0.624	0.573
	(0.564)	(0.583)	(0.610)
N. America	1.191	0.936	0.807
	(0.544)**	(0.569)	(0.571)
Constant	7.587	7.665	8.005
	(2.771)***	(2.625)***	(2.646)***
R^2	0.67	0.68	0.69
N	51	51	50

Standard errors are in parentheses

* $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

7.3 Appendix C: Sample

Sample Countries			
Algeria	El Salvador	Kenya	Saudi Arabia
Argentina	Finland	Korea, South	Senegal
Australia	France	Liberia	Singapore
Austria	Gabon	Malawi	Spain
Bangladesh	Germany	Malaysia	Sri Lanka
Belgium	Ghana	Mexico	Sudan
Bolivia	Greece	Morocco	Sweden
Brazil	Guatemala	Netherlands	Syria
Cameroon	Guyana	Nicaragua	Thailand
Canada	Honduras	Nigeria	Togo
Chile	India	Norway	Tunisia
Colombia	Indonesia	Pakistan	Turkey
Costa Rica	Iran	Panama	United Kingdom
Denmark	Israel	Paraguay	Uruguay
Dominican Republic	Italy	Peru	Zambia
Ecuador	Jamaica	Philippines	Zimbabwe
Egypt	Japan	Portugal	

Syria is not included in regressions 1, 2, 3, and 6

7.4 Appendix D: Data Sources

Data Sources	
Growth	World Bank, World Development Indicators
Resource (USGS)	USGS, 2000 World Petroleum Assessment
	USGS, Mineral and Resources Data System
Resource (World Bank)	World Bank , World Development Indicators
Institutions	Sachs and Warner (1995)
	from http://www.cid.harvard.edu/ciddata/ciddata.html
$\log(GDP_{1970})$	World Bank , World Development Indicators
Change in Life Exp.	World Bank , World Development Indicators
Polity	Polity IV Project
Continent	ESRI ARCGIS, DeLorme Publishing Company, Inc.

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