NATURAL RESOURCE DEPLETION AND THE RESOURCE CURSE

Submitted by

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Abstract

This thesis studies the relationship between natural resources and economic wealth, in two parts. Previous studies have found a negative relationship between natural resources and economic wealth, a phenomenon known as the curse of natural resources. Later studies reject the resource curse, in its simplest form, as their findings show a positive relationship when measuring economic wealth by GDP levels instead of growth. The argument is that the inclusion of initial GDP, when using GDP growth as measurement, will result in biased estimates due to the short time horizon. However, a third group of studies advocates the existence of a resource curse conditional upon institutional quality. In this case, resource endowment only affects the economic welfare negatively if the quality of institutions is sufficiently bad.

In this thesis the measurement of economic wealth is further expanded. Taking into account that extraction of resources is a negative flow of the nation's wealth gives a better understating of the change in welfare, and removes some of the positive bias of exploiting natural resources on economic wealth. An empirical analysis, utilizing data on a total of 263 countries in year 2000, is conducted to find whether the resource curse is still rejected when including depletion of natural resources to the analysis. None of the estimation methods or model specifications in this thesis are able to confirm the existence of a resource curse, and in its simplest form the rejection is supported. Also the conditional resource curse is rejected by the data material, meaning that countries with poor institutions do not seem to have a more negative, or less positive, impact of natural resources on GDP levels adjusted for depletion of natural resources than countries with good institutions. However, be aware of the limitations of the data, in particular the absence of a truly exogenous variable of resource endowment.

Acknowledgments

Though this master thesis is a result of my own work, several individuals have been of crucial help and influence. Foremost, the analysis could not possibly have been conducted without the data and do-files provided by Dr. Alexeev. For this help I am truly thankful. The inputs from my advisor Ragnar Torvik has also been of great importance, thank you for introducing me to this intriguing topic [1]. I would also like to thank the Department of Economics at NTNU for the solid collaboration this year, and especially Anne L. Viken, thanks to you my duties as the students' representative has been a delight.

I am also grateful to my close friends at my study hall for the encouragement through this process, and my dear Bjørn-Erik for the thorough review. Finally, mum and dad, thanks for teaching me good and sound values. This thesis represents the end of my master's degree in Economics, and it is with joy that I now look forward to new challenges.

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[1] My advisor dared me to come up with a truly exogenous variable for natural resource endowment, and promised me a Nobel Prize in return. I have not yet given up on this task, and will gladly be contacted by anyone having inputs on the topic.

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1 Introduction

1.1 Presentation of the Problem

Influencing the well-being of a nation and its people is amongst the politicians' most important tasks. Economic theory is designed to help with this work. Well-being, or welfare, can be thought of as the satisfaction of wants derived from its dealings with scarce goods in a group (Hueting 1987). This is clearly in the category of personal experience, and not measurable in cardinal units. In order to use economic theory to influence the quality of life, proxies for welfare measurable in cardinal units, must be found. The typical practice has been to use economic wealth, and in particular economic growth, defined as the increase of gross domestic product (GDP) and GDP levels. These are measures of a nation's production, and factors such as income distribution, labour conditions and environmental conditions are neglected. The list of factors that should be included to properly measure the development of welfare is near inexhaustible. Cultural, environmental, educational and institutional conditions all play an important role. Is the narrow-minded definition of economic wealth, GDP, the best indicator to be found for a nation's well-being? And, if a more diverse indicator of economic wealth were to be used, would economic theory provide different advises for the politicians on how to intervene in the economic relations of our societies?

Finding a perfect proxy for welfare is a near impossible task. However, much work is not needed to find a more including indicator. In particular, one important factor was left out when the GDP term was invented; resource depletion. For some reason GDP was constructed to exclude, or fail to include, the extraction of natural resources in the budget. Imagine a country endowed with 10 units of a non-renewable natural resource in the entrance to year 1. The country extracts 5 units resource during year 1 and sells it at market price. All else equal, after year 1 this country will appear to be 5 units worth of resource richer as the GDP growth equals the value of the 5 units resource. In reality however, the country is exactly as well off as it was entering year 1. This is because the country now has 5 units resource worth less embedded in its nature, and 5 units resource worth more in financial assets. It is now clear that if not adjusted for, resource depletion will result in larger GDP levels and growth rates than the true value of economic wealth.

In this thesis the relationship between economic welfare and natural resource endowment will be examined. The relationship have been in the spotlight for several decades, and earlier findings have been mixed. Some findings suggest a negative relation between natural resources and economic prosperity. This is known as the resource curse, and in its simples form it simply predicts that countries rich in natural resources are poorer than they would have been without the resources. Other studies argue that the resource curse only exists conditional upon country specific factors, such as institutional quality. A third group of studies rejects the resource curse, and even argue to find a positive relationship between GDP levels and resource endowment. An interesting question then follows: *How is the resource curse prediction affected by depletion of natural resources?* This will form the main question of this thesis. The second objective of the thesis is to investigate the conditional resource curse prediction. *Can the resource curse be proven in countries with specific characteristics when adjusting for depletion of natural resources?* Hopefully the results will enable economic theory to provide policy makes with a better understanding of the complex relationship between a nations natural resource endowment and its population's well-being.

1.2 Outline of the Paper

Following this section, section 2 will provide an overview of the relevant theory on the topic. Key aspects here will be the structural economic theory and the ground-breaking results found by Sachs & Warner (1995). These results will thoroughly be examined, making the fundament behind the resource curse clear. The results of Alexeev & Conrad (2009) are then presented as a counterargument to the resource curse. Some of the shortcomings of studies on the topic are discussed, and the effort of finding a more diverse indicator for welfare is described. Section 3 goes through the regression analysis conducted by Alexeev & Conrad (2009), and explains the adjustments made to correct GDP for resource depletion. A thorough explanation of the analysis is then provided, and in section 4 the results are presented and interpreted. The results show that the resource curse cannot be supported when GDP levels corrected for resource depletion is used as dependent variable. This underpins the results of Alexeev & Conrad (2009). However, the positive correlation between economic wealth and resource endowment is less economically significant when resource depletion is taken into account.

The findings will be critically evaluated before the conditional resource curse is investigated in section 5. The same data material will be used when analyzing the impact of an interaction term consisting of institutional quality and natural resource endowment, and the results are compared to those of Alexeev & Conrad (2009). All the results will be further elaborated on in section 7, which summarizes and concludes the thesis. Throughout the thesis references, tables and figures will be provided to support and explain the findings. The appendices provide a derivation of the choice of estimation method, test results and all estimation results.

2 Theory

Several researchers have asked the question of whether discovering valuable natural resources necessarily implies increased prospects of economic wealth. In this section some of the main arguments and results on the topic are presented. Questions of their validity and theoretical background will then be raised, and it is argued that a more homogenous measure of economic wealth could be the next step in detecting the true relationship.

2.1 Structuralism

Typically, resource abundant countries are specialized in primary production, while countries less abundant in natural resources are forced to develop other skills, such as manufacturing production. On this basis, the centre-periphery concept was developed in the 1950 by the structuralist approach (Oman & Wignaraja 1991). It was argued that the structure of primary production is heterogeneous and specialized, and therefore backward production techniques and low productivity will occur (Cypher & Dietz 2009). Countries with these characteristics are called the periphery. Here, exports are limited to a few primary products, while local demand of consumer manufactures is met with imports. By contrast, the centre is characterized by using modern production techniques throughout the economy. These economies produce a wide range of goods and services, resulting in homogeneous and diversified production. The structuralists assume that, in general, the periphery exports primary goods and imports manufacturing goods, while the opposite is true for the centre. This is the structuralist traditional division of labour (Oman & Wignaraja 1991).

The implication for the resource abundant periphery is, according to the Prebisch-Singer hypothesis, deteriorating terms of trade (ToT) (Cypher & Dietz 2009). The hypothesis reasons that the antagonistic and detrimental relationship between the periphery and the centre derive from several conditions. The ever-changing impact of technology will increase worker productivity, inducing different impacts in the periphery and centre nations. Labour institutions tend to be stronger in the centre, in addition to centre producers tending to be relatively more dominated by oligopolistic industries than the periphery.

Cost-saving technology will increase wages in the centre, while reduced supplier prices is more likely in the periphery, due to competition and surplus labour. Improved technology will change the relative product price in favour of centre-produced products due to these differences in structural conditions (Cypher & Dietz 2009). The outcome is improved ToT for the centre and deteriorating ToT for the periphery.

The differences in income elasticity for the peripheral and central produced products, amplifies the result above. When world income rises, the demand for primary products will increase by relatively less according to Engle‘s law (Cypher & Dietz 2009). If the income rises by one per cent, demand for periphery products will then increase by less than one per cent, and the opposite will be true for the centre-produced products. As a consequence, a boom in the world economy will increase the price of centre produced products relative to the periphery-produced products, contributing to the deterioration of the peripheries ToT. If the hypothesis is to be true, then the periphery will forever have to increase its exports in order to keep a constant level of imports. This is obviously bad news for economic wealth and development. The structuralist approach therefore concludes that natural resource dependency is negative for long-term economic growth and wealth. These arguments accords to the prediction of a natural resource curse.

2.2 The Resource Curse Prediction

Although the large net flow of resources from underdeveloped to advanced nations cannot be denied, there has been little proof of the Prebisch-Singer hypothesis. Quite on the contrary, it seems like ToT for resource abundant countries has been improving since the hypothesis was launched. Countries with few natural resources and large populations, such as the "Asian Tigers", have been growing rapidly. This has increased the price of primary products relatively to manufactures, making resource-rich countries better of in terms of cheaper imports and more profitable exports (Torvik 2009). In other words, the periphery has not experienced deteriorating terms of trade, predicted by the Prebisch-Singer hypothesis.

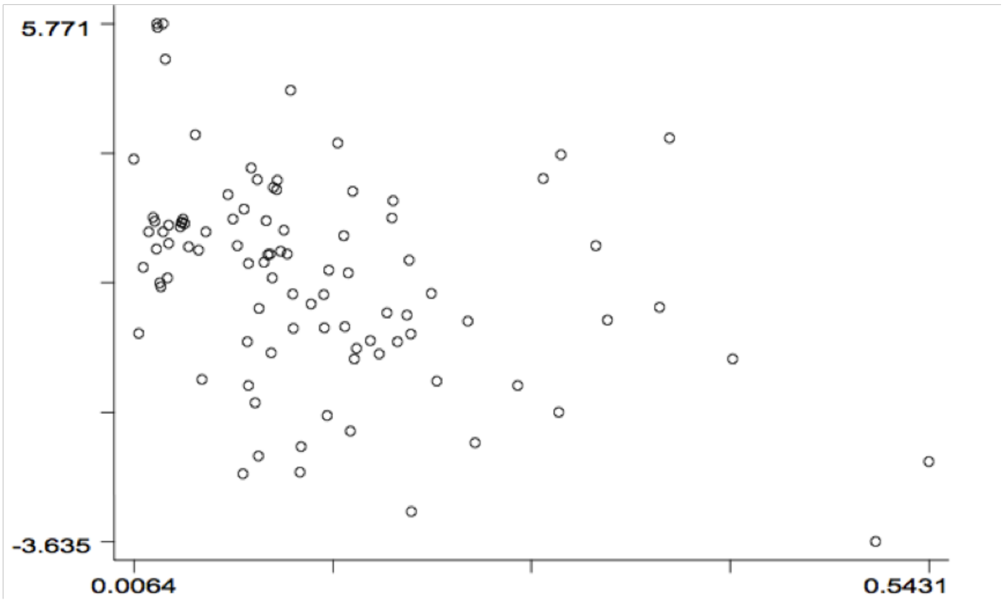

Figure 1: Annual Growth Rate and Natural Resource Based Exports, Sachs & Warner 1995

Several case studies in the second half of the 20th century led to the debated topic of the paradox of plenty, or the resource curse. This is the tendency of a negative relationship between economic wealth and natural resource endowment. Only in 1995, Jeffrey Sachs and Andrew Warner conducted a regression analysis, finally contributing to systematic information by aggregating the experiences of several countries. Their results underpinned the prediction of the resource curse. The findings are illustrated in figure 1, showing a clear negative relationship between "annual GDP growth" on the y-axis and "resource based exports" on the x-axis. Although the analysis has been heavily criticized, which will be further assessed later on, the contribution has been important for the development of recent research on the relationship between natural resources and economic growth, and therefore deserves a thorough review.

2.2.1 The Regression Analysis of Sachs and Warner, 1995

Sachs & Warner's (1995) regression analysis indicates that there is a significant negative effect of natural resource abundance on economic growth. They use the real per capita growth of GDP per annum in the years from 1970 to 1989, denoted as G7089, as dependent variable. The explanatory variable of interest, SXP, is "the share of primary-product exports to GDP in 1970". The other explanatory variables included are the initial income in 1970 (LGDP70), the fraction of years integrated with the global economies between years 1965 and 1989 (SOPEN), the average investment to GDP ratio from 1970 to 1989 (INV7089), a quality of bureaucracy index in the period 1980-1983 (BUR), the standard deviation of the log of the external ToT-index from 1971 to 1989 (TTSD) and the ratio of the income share of the top two to the bottom two deciles of households (INEQ). Estimation gives the regression model:

$$\text{G7089} = 12.067 - 1.891\times\text{LGDP70} - 5.925\times\text{SXP} + 2.246\times\text{SOPEN} + 13.665\times\text{INV7089}$$
$$+ 0.166\times\text{BUR} - 0.006\times\text{TTSD} + 0.067\times\text{INEQ}$$

This regression yields non-significant estimates of TTSD and INEQ at a 5 per cent level. Sachs and Warner therefore proceed by excluding these variables, but continue to control for several other factors. The robustness of the natural resource effect is controlled by omitting outliers and data with possible measurement errors, in addition to experimenting with alternative measures of primary resource abundance. These are the share of mineral production in GDP in 1971, the fraction of primary exports in total exports in 1971, and the log of land area per person in 1971. All the alternative measures are discarded to the advantage of SXP, as SXP covers and measures primary production better than the alternatives, and is believed to have the least measurement error (Sachs & Warner 1995). Although not important for this analysis, it is noteworthy that the significant negative coefficient of initial GDP supports the conditional convergence hypothesis put forward by neoclassical models of economic growth.

Notice that SXP can influence economic growth through more than one of the variables in the regression model. Based on their best estimates of the magnitude of direct and indirect effects of primary resource intensity on economic growth, Sachs and Warner find that the sum of effects aggregates to −12.491. The indirect effect of resource endowment through bureaucracy is statistically and economically insignificant. Also the indirect effects through relative prices of investment goods and investment rates are found to be small. The indirect effect through trade openness on the other hand is significant, and the evidence supports a U-shaped relation. This is explained by Dutch Disease effects, where resource abundance squeezes the manufacturing sector, which provokes protectionist responses to reduce openness to trade through industrialization (Sachs & Warner 1995). But, for those nations being the most highly resource endowed, openness to trade tends to be high because the resource base is so vast that the protectionist pressure does not develop. This indirect effect is estimated to be of -3.171. In addition to the indirect effect through openness, the indirect effect through domestic investments is found to be significant with an estimate of -1.292.

The direct effect of SXP on economic growth is found to be about twice as large as all the indirect effects combined. As Sachs & Warner (1995) believes the investment variable to be endogenously determined, they prefer instrumented variable estimators when assessing the direct effect of resource endowment on economic growth. The instruments used are the log of the ratio of the investment deflator to the GDP deflator in 1970, the share of mineral production in GDP in 1971 and the log of total land area to population in 1971. This gives a direct effect of SXP on G7089 of -7.663. The mechanisms of which the direct effects are believed to work, known as Dutch Disease mechanisms, are presented in the next subsection.

Interpreting the effects above is quite simple. Given that the standard deviation of the variable SXP is 0.1344, the indirect, direct and combined effect of a standard deviation increase in SNX on G7089, which is the *growth* in GDP, is found to be:

Indirect effect: $0.1344 \times (-3.171 - 1.292) = -0.540$
Direct effect: $0.1344 \times (-7.633) = -1.026$
Total effect: $0.1344 \times (-12.096) = -1.626$

Interpeting the effect of natural resources on GDP *level* is more complicated. Recall that the dependent variable is given as the real growth rate per annum, and therefore specified as:

$$G7089 = \tfrac{1}{19}[ln(GDP89) - ln(GDP70)] \quad \Rightarrow \quad 19 \times G7089 = ln(GDP89) - ln(GDP70)$$

Knowing that $e^{ln(x)} = x$, gives:

$$e^{19\times G7089} = e^{ln(GDP89)} - e^{ln(GDP70)} = GDP89 - GDP70$$

The effect of a marginal change in SXP on the GDP level in 1989, given the level in 1970, can now be found; utilizing that the derivative of e with a functional exponent is equal to e with that exponent times the derivative of that exponent:

$$\frac{\partial GDP89}{\partial SXP} = -12.096 \times e^{19\times G7089}$$

Recall that the SXP level is included in the regression model for G7089. This means that there is an exponential growth in the effect of natural resources on the GDP level. Finding the level change in GDP89 of a standard deviation increase in SXP requires data on the country's specific variable values. The main point is however, that the effect is negative. These conclusions are the fundament of Sachs & Warner's (1995) assessment of the resource curse prediction. The results have also been used as a base for later studies. Before reviewing some of them, the mechanism of which the resource curse works through, according to Sachs & Warner (1995), is derived.

2.2.2 The Dutch Disease Model

Sachs & Warner (1995) uses a dynamic Dutch-disease endogenous growth model with overlapping generations when explaining the direct effects of natural resource endowment on economic growth. Based on the dynamic solution of the model, two propositions are put forward. Proposition 1 states that economies experiencing a temporary resource boom will have a lower rate of growth for several periods after the boom, compared to otherwise identical economies with no resource boom. The proposition is supported by the structural changes of labour. As wealth increases, there is a shock to the consumption possibility frontier. More of the wealth will be spent in the non-traded sector, drawing labour from traded to non-traded sector. This is good news in the short term, but not so much in the long term, according to Sachs and Warner. When defining H_t as the productivity in the economy at time t, and θ_{t-1} as the share of the working force employed in traded sector at time t-1, it is assumed that:

$$H_t = H_{t-1}(1 + \theta_{t-1}) \tag{1}$$

This stipulates that the growth in relative productivity is equal to the share of labour in the traded sector. The implication is that a resource boom reduces productivity growth and therefore economic growth for some periods, as labour is drawn from traded to non-traded sector. Learning by doing effects is used to explain the equation above. It is argued that traded sector contains more tacit knowledge, and therefore more dynamic growth effects, than non-traded sector, resulting in less productivity growth due to the structural changes in labour. However, these arguments can easily be criticized, as there are several examples of reduced traded sector resulting in higher degree of innovation and tacit knowledge (such as the expansion of oil industry in Norway). A more realistic model could include three sectors, the last one being a non-trading sector trading with the trading sector. This would of course complicate the theory and remove the benefit of economic modelling as comprehensible approaches to reality.

The second proposition states that the effect of a rise in the natural resource endowment on the level of non-resource GDP, depends on the capital intensities of traded and non-traded sector. Using the factor income decomposition of GDP it is found that:

$$GDP = R + wH + r(K^n + K^m) \tag{2}$$

where R is the amount of resources, w is the real wage rate, H is labour productivity, r is the interest rate and K is capital in non-traded (n) and traded (m) sector. Inserting for units of effective labour:

$$k^m = \frac{K^m}{\theta H} \quad , \quad k^n = \frac{K^n}{(1-\theta)H} \tag{3}$$

gives

$$GDP = R + H(w + r)[k^n + \theta(k^m - k^n)] \tag{4}$$

From this it is true that a reduction of the labour share in traded sector will lower θ and affect GDP negatively only if capital intensity in traded sector is greater than in

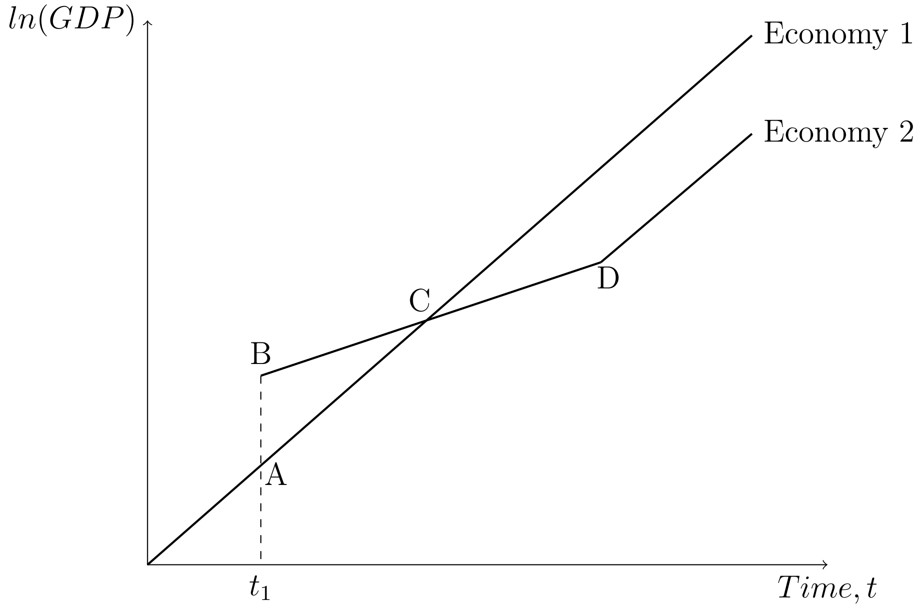

Figure 2: Effects of a resource boom in the Dutch Disease model by Sachs and Warner, 1995.

non-traded sector. This negative effect could surpass the positive effect of increased R on GDP. This means that the relative share of capital intensity in traded and non-traded sector will define the effect of a rise in natural resource endowment on the level of non-resource GDP.

The results of proposition 1 and 2 are presented in Figure 1. Two economies are assessed, initially starting off with the same GDP level and growth rate. The logarithm of GDP for both economies therefore follows a straight line from point 0 at time $t = 0$ to point A at time $t = t_1$. At t= t_1 a resource boom hits economy 2, and the GDP level in economy 2 immediately rises to point B. Economy 1 is not affected, and will therefore continue its linear growth path over time. In economy 2 the resource boom has induced a period of slower growth, due to the mechanisms discussed in propositions 1 and 2. This slow growth could result in the GDP level of economy 2 falling below that of economy 1, as illustrated beyond point C. At point D, where the resource is depleted, the growth rate in economy 2 catches up with its pre-boom value, but with a permanently lower GDP level than economy 1. These are the mechanisms of which Sachs & Warner (1995) explains the curse of natural resources. But clearly, questions of the resource curse prediction should, and has been, raised.

2.3 Challenges to the Resource Curse Prediction

Sachs & Warner (1995) are aware of the possible downward bias in their estimated coefficients due to measurement errors in the independent variables. This could be overestimating the negative impact of resource abundance on economic growth. It is not unlikely that countries with low productivity become more resource dependent, as they specialize in primary production because of this industry's relative low productivity requirements. On the opposite, it is also possible that more productive countries diversifies their productive activity, and thereby becomes less resource dependent. In this fashion, the SXP variable is endogenously determined by productivity, or skills. By omitting this "skills"-variable the negative effect of natural resource dependency will be overvalued for the less productive countries, and undervalued for the more productive countries. Using a country fixed effects model specification would correct for this problem. However, this requires a within transformation, in which valuable information of the differences between rich and poor countries would be lost.

In their analysis, Alexeev & Conrad (2009) measures long-term growth via GDP per capita levels, in contrast to Sachs & Warner (1995) who uses the growth rate in GDP per capita between the years from 1970 to 1989. Sachs & Warner (1995) includes initial per capita GDP as a control variable. Including GDP level in the variable explaining recourse dependency will therefore not give biased estimates of high-income countries appearing as less resource dependent than low income countries. However, Alexeev & Conrad (2009) find that most major oil exporters began commercial exploitation of their oil wealth well before 1950, which is well before the time period assessed by Sachs and Warner. It is possible, and possibly also optimal, that extraction of natural resources is vast in the early stages, and declines over time. This would induce a high growth rate at the early stages, and slower rates as the extraction declines. The relatively slow growth of oil producers with partly depleted resource endowments will therefore be reflected in the impact of resource dependency on economic growth when GDP growth rates are directly used as dependent variable, unless the time period is sufficiently long.

Alexeev & Conrad (2009) find that oil endowments are associated with high per capita GDP levels, which means that these nations must have been growing fast at some point in time. This directly contradicts the strong version of the resource curse. The weak version states that only after a sufficient period of time will the GDP of a resource-extracting nation eventually fall below a similar but non-extracting nation' s GDP (Alexeev & Conrad 2009). In order to prove this, it must be found that resource rich economies are richer than they would have been if they where to be resource poor. This is clearly a challenge. In their analysis, Alexeev & Conrad (2009) performs an income-level regression, which will be further assessed in the next section. The result however, is near indisputable. The relationship between point source resource endowment and GDP levels is positive and statistically and economically significant. The authors conclude that not only does the analysis dismiss the resource curse, it also indicates a positive effect of point source resources on long-term economic growth. Figure 3 shows a clearly positive relationship between oil endowment and GDP level both in year 1970 and year 2000 in Alexeev & Conrad's (2009) data material.

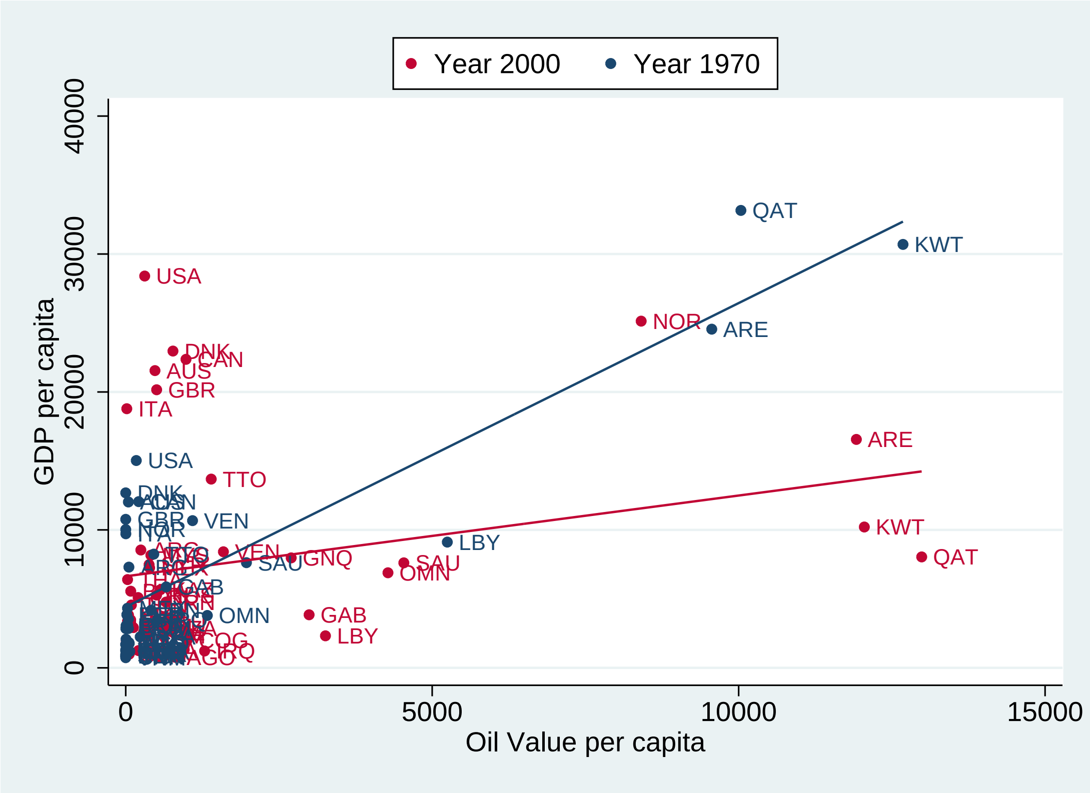

Figure 3: Per capita GDP Level and Oil Value

The clear reduction in the positive relationship from 1970 to 2000 is a teaser. Notice that the three nations with the largest per capita oil endowment all seems to have been caught in the resource curse between 1970 and 2000. But, Kuwait and Qatar had their first year of oil extraction in 1938 and 1939 respectively. Their oil extraction might very well have peaked before 1970. Only Norway seems to have escaped the curse, but Norway only started extracting oil in 1969, and the dutch disease effects would hardly worsen the economic welfare in just one year. In the next section the same data will be used to replicate Alexeev & Conrad's (2009) regressions. These results will indicate a significant positive relationship, which casts serious doubt on the resource curse.

A major drawback with regard to all results form regressions of resource endowment on economic wealth must be pointed out. Using endowment of natural resources directly as explanatory variable is likely to give positively biased estimates. The richer the nation, the more effort can be used in discovering natural resources. Poor nations are not able to spend resources to find their entire endowment of natural resources. Observed endowment of natural resources is therefore not a truly exogenous variable, but endogenously determined by the GDP level. In addition, Cust & Harding (2014) finds that in two out of three cases investors choose to drill on the side with better institutional quality at national borders when searching for resources. The result indicates that institutions strongly influence the location of the search for oil and gas, and supports the view that institutions shape incentives to invest. A nation's observed natural resource endowment is therefore likely to be endogenously determined with respect to institutions. From this it can be learned that there exists a complicated relationship between economic wealth, institutions and natural resource abundance. The obvious solution to the endogeneity problem would be to find a truly exogenous measure of natural resource endowment. This is a task still undefeated.

2.4 Sustainable Development

An other drawback of the results this far is the likely positive bias in the estimates due to the use of GDP as an indicator for economic wealth. This problem was introduced in the last section. GDP gives the value of production in an economy. The value of all goods and services is aggregated, including the revenue of primary production. Depletion of natural resources is not taken into account. As was discussed in the introduction, welfare is more than the value of produced assets. The indicator for economic wealth should be diversified to include depletion of natural resources, the health ecosystems and development of human resources. Economic growth must at heart be sustainable.

Natural resources are roughly considered as renewable or non-renewable resources. The issue of sustainability obviously arises with regard to non-renewable resources, but also the exploitation speed of renewable resources must be regarded. The Brundtland report defines sustainable development as development that seeks to meet the needs and aspirations of the present without compromising the ability to meet those of the future (The World Commission on Environment & Development 1987). According to the Hartwick rule, a non-declining consumption path through time is feasible, given the savings rule. This means that future generations can achieve at least the level of todays welfare if resource income today is saved and invested to bring on the future value of capital lost in resource depletion today. A necessary efficiency condition for the Hartwick rule is the Hotelling rule, stating that the socially optimal extraction path is the one along which the resource price follows the interest rate (Perman, Ma, Common, Maddison & McGilvray 2011). Given these rules, sustainable development can be achieved by investing all rent arising from extraction of natural resources entirely in reproducible capital. Total value of the stock of capital together with the stock of non-renewable resources is then held constant over time, and efficient and egalitarian consumption paths can be followed.

2.4.1 Genuine Savings

Sustainable development requires economic wealth to develop so that future generations can maintain the level of current wealth. In the introduction it was argued that GDP level or growth is not a sufficient measurement of a nations well-being. Sustainable economic growth must include more than just the value of production. The simultaneous earnings of exports and depletion of stocks and degradation of the environment should be embedded in national accounting standards. In Pearce & Atkinson (1993) the concept of genuine savings, also called adjusted net savings, was formally introduced. 20 countries were studied, and many of them found to have gross savings smaller than the combined sum of conventional capital depreciation and natural resource depletion. In terms of genuine savings these countries were assessed to be on an unsustainable path. In the long run this is interpreted to have negative effects on welfare and development (Everett & Wilks 1999). Since then the World Bank has further developed the measurement and collected data for more than 150 countries between 1970 and the present (The World Bank 2011). The framework of adjusted net savings takes a broader view than standard national accounting upon the production, and therefore the well-being of a nation. Investments in the future does not only consist of produced capital assets, but also natural and human capital assets. The World Bank (2006) calculates genuine savings in the following way:

$$ANS = NNS + EE - ED - MD - NFD - CO_2D - PM_{10}D \tag{5}$$

where

- ANS = Adjusted net savings
- NNS = Net national saving
- EE = Education expenditure
- ED = Energy depletion
- MD = Mineral depeletion
- NFD = Net forest depletion
- $\mathrm{CO_2D}$ = Carbon dioxide damage
- $\mathrm{PM_{10}D}$ = Particulate emissions damage

Economic theory suggests that the present value of well-being is increasing if a nations genuine savings is positive (Everett & Wilks 1999). There are, however, several problematic points one must be aware of when using the genuine savings approach. For one, there are measurement problems due to the difficulty of putting money values on environmental and human conditions. Only the direct value of natural resources is therefore included in ANS, which clearly oversimplifies the relationship between the environment and the economy. Also, the ignorance of environmental thresholds in the weak sustainability approach that ANS is built on, is highly criticized (Everett & Wilks 1999). Omitting the existence of a resource threshold could result in irreversible damage. Another problem of the genuine savings framework is that it seems to justify a high consumption path in rich countries, as nations with strongly positive GDP are less likely to obtain weak ANS results. This bias distracts attention from the discussion of global consumption inequalities. Despite these drawbacks, the use of genuine savings figures helps including human, social, structural and environmental conditions alongside the economic aspect of a nations well-being. It is reasonable to believe that the relationship between resource endowment and economic wealth would be very different if genuine savings where to be introduced in the place for GDP.

2.4.2 Adjusting GDP for Resource Depletion

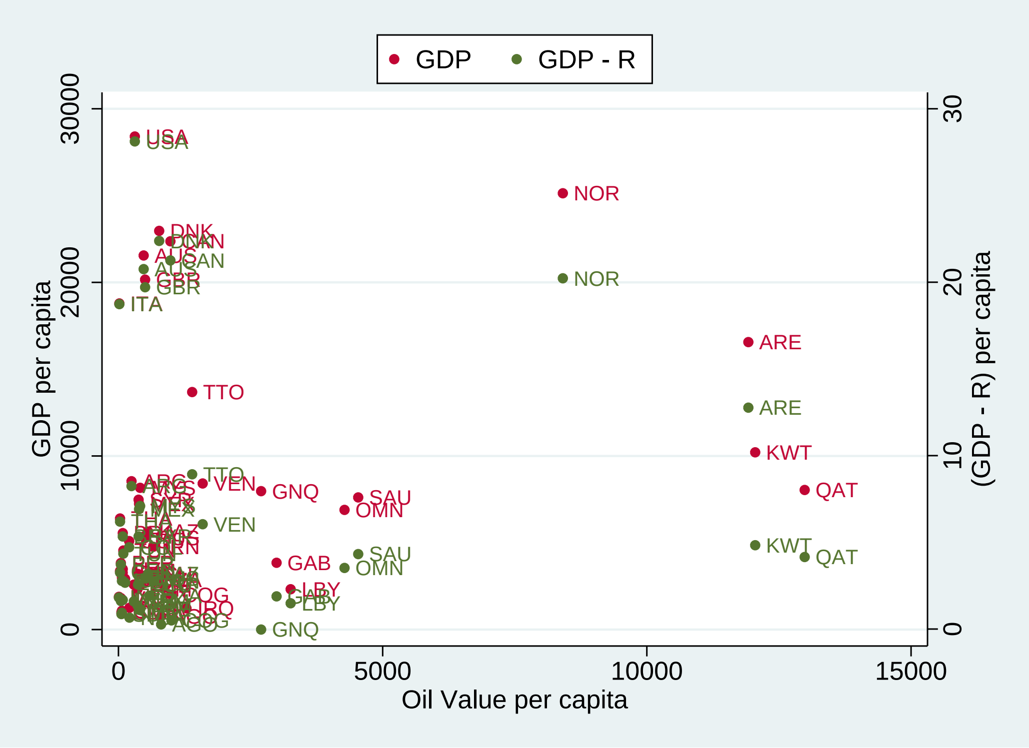

Figure 4: GDP versus GDP-R and Oil Value

This thesis will not complete the task of studying the relationship between natural resource endowment and genuine saving. Instead, a measurement of depletion of natural resources will be examined and deducted from the dependent variable of Alexeev & Conrad's (2009) analysis. This will result in a new dependent variable, GDP - R, which is the GDP level minus depletion of natural resources. The new dependent variable gives a more diverse measurement for economic wealth as the negative value of depletion is taken into account.

Figure 4 gives the relationship between each of the two measurements for economic wealth and oil wealth in year 2000. GDP is measured on the left vertical axis, and GDP-R on the right vertical axis. Notice that the two dependent variables are measured by very different scale, but both measurements seems to be positively related with oil wealth. Resource rents, and thereby resource depletion, accounts for a large fraction some nations gross national product, and near nothing in other nations. It makes sense that the nations with large oil endowments are also those where R is a considerable fraction of the nations GDP. This is confirmed in figure 4. In the next section these relations will be further assessed though a regression analysis, where the effect of oil and mineral endowment on economic wealth will be studied.

3 The Data and the Regression Analysis

This section will provide an overview of the construction of the econometric model and the data used to explore the relationship between resource wealth and economic wealth. Comparing the results of Alexeev & Conrad (2009) and the results when adjusting GDP for resource depletion will give useful insight of the role of resource abundance.

3.1 Functional Form

The variables used to measure point source resource endowment will be specified as the logarithm of 1 plus some value for the resource of interest. Also the dependent variables are specified as logarithms of their value. This way the nonlinearity in the relationship between economic and resource wealth is incorporated in the model. Using the logarithmic functional form will also make the coefficients less sensitive to outliers. The logarithmic transformation gives a constant elasticity model, which allows for simple interpretation of the results (Woolridge 2013). The coefficients in front of the point-source resource variable will simply give the percentage change in the dependent variable when the resource variable increases by 1 per cent. This relationship is not linear because a β_m per cent change in a small number is less than a β_m per cent change in a large number. Notice that a linear method of estimation can still be used on the econometric model, only the interpretation of the coefficients is affected by the logarithmic model specification.

One limitation of using the logarithmic functional form is that the natural logarithm cannot be used if a variable takes on zero or negative values. It is not unlikely that the value of a point source resource endowment in a country is zero. There are for example a total of 164 zero-value observations for oil output in year 2000 out of 212 observations in the dataset. Only 48 countries did actually have a positive value of oil output in 2000. Using 1 plus the value of oil output allows the logarithm to be taken even for the zero-value observations. As the oil output of those observations with positive values is of a much greater scale than 1, the interpretation of the coefficients is closely preserved. But, the large fraction of zero-value observations in this particular analysis is worrisome (Woolridge 2013). This should be kept in mind when the coefficients are interpreted in section 4.

3.2 Descriptive Statistics

The analysis will be conducted in the tradition of Alexeev & Conrad (2009). Income-level regressions are used to test whether oil and mineral endowments are associated with high levels of economic wealth. Table 1 provides descriptive statistics of the variables. GDP$_{PC}$ and (GDP-R)$_{PC}$ represents the two dependent variables that will be compared, while the rest are used as regressors. The information in the table will be of interest when interpreting the results in the section 4.

Table 1: Descriptive statistics of the variables

Variable	Obs.	Mean	Stand. deviation	Min	Max
GDP$_{PC}$	157	8.151	1.168	5.380	10.254
(GDP-R)$_{PC}$	149	1.1576	1.186	-1.318	3.336
Hydrocarb. deposits$_{PC}$	115	0.754	4.603	-4.605	10.595
Value of oil output$_{PC}$	159	1.779	2.916	0	9.472
Oil/GDP ratio	159	0.058	0.167	0	0.961
Mining output$_{PC}$	118	3.597	2.572	0	8.379
Mining/GDP ratio	129	0.053	0.078	0	0.425
Absolute latitude	136	22.401	15.727	0.228	63.892
European population	138	0.167	0.374	0	1
Latin Am. country	138	0.210	0.409	0	1
East Asian country	138	0.116	0.321	0	1
Ethnic fractionalization	162	0.377	0.289	0	1
English speaking frac.	132	0.095	0.269	0	1
WestEuro speaking frac.	132	0.299	0.289	0	1.004
Settler mortality	82	4.644	1.199	2.146	7.986

3.2.1 Recreating the Analysis of Alexeev & Conrad (2009)

The regression function used by Alexeev & Conrad (2009) takes the form:

$$GDP_{PC} = \beta_0 + \sum \beta_j X + \gamma N + \epsilon, \tag{6}$$

In this model ϵ is the idiosyncratic error term and GDP_{PC} represents the logarithm of per capita GDP adjusted for purchasing power parity (PPP) in time t=2000. The PPP GDP data is collected from Maddison (2006). As previously discussed, Alexeev & Conrad (2009) use the level of GDP, simply because if country A has a higher income level than country B, then country A must have had a faster long term growth than country B. This is contrary to Sachs & Warner (1995), who uses the GDP growth rate over a relatively short period of time.

X is a matrix of control variables. Alexeev & Conrad (2009) use two different approaches of regressors, one not instrumented and one instrumented. The first approach only consists of clearly exogenous control variables: "Absolute value of latitude" and dummy variables for "European population", "Latin American country" and "East Asian country". The instrumented approach includes institutional quality and the degree of ethnic fractionalization in addition to the dummy variables. The institutional quality is measured though instruments for rule of law. These are "the fraction of the English-speaking population", "the fraction of the population speaking a major West European language", and "the absolute latitude". Also a second set of instruments are estimated, "settler mortality" and "absolute latitude". It can be seen from table 1 that data on settler morality only exists for 82 observations. As this instrument is unavailable for several countries, in particular some major oil producers, the sample size is dramatically lowered in the estimations where settler mortality is included. This means that these estimations are conducted on less information than the previous ones. However, they are still useful to study, as this approach to instrumenting rule of law has been used in several previous studies (e.g. Acemoglu, Johnson & Robinson 2001).

The regressor of particular interest is N, which is a measure of point source resource endowment. Several measurements for the two point source resources oil and mineral wealth are used. The first measurement for oil wealth is the logarithm of 1993 hydrocarbon deposits per capita, with data obtained from Sala-i-Martin, Doppelhofer & Miller (2004). The second measurement is the logarithm of 1 plus the country‘s per capita production of oil in year 2000 at world market prices, with data from BP Statistical Review

(2005) (Alexeev & Conrad 2009). The third measurement is included to accommodate Sachs & Warner's (1995) statement that the importance of natural resources in the whole economy is of interest rather then just endowment per capita. The measurement consists of the logarithm of 1 plus the ratio of average value of oil output in year 2000 to PPP GDP. Similarly to the last two measurements for oil wealth, the measurements for mineral wealth is the logarithm of 1 plus per capita mining output, and the logarithm of 1 plus the ratio of mining to GDP PPP.

3.2.2 Adjusting GDP for Depletion of Natural Resources

The only addition to Alexeev & Conrad (2009) in this analysis will be the deduction of natural resource depletion in the dependent variable. By doing so the national income is adjusted for the value of the resource that is depleted. When a country extracts oil from the ground, sells it at market price, and receives the income, the transaction in reality adds up to zero because of the depletion of the oil from the ground. Here it is assumed that the value of the depletion of natural resources corresponds to rent received for natural resources. This is a questionable assumption as there obviously will exists more negative externalities than taken into account by the market. The true social value of resource depletion is practically impossible to measure, and resource rent will therefore be used for simplicity. R denotes total resource rent.

Deducting the total natural resource rent from GDP PPP gives a new dependent variable, denoted as GDP-R, which is a more diversified measurement of economic wealth than GDP alone. The data on total natural resource rent is a part of the primary World Bank time series on development indicators, compiled from officially recognized international sources (The World Bank 2011). The variable of interest is defined as the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents (The World Bank 2011). The data for resource rent is given as percentage of GDP, denoted below by r%. It is therefore necessary to transform the data to level values of total natural resource rents before deducting the value from GDP. This is done by multiplying per capita GDP in year 2000 from Maddison (2006) by the World Development Indicator of total natural resource rent as percentage of GDP, and divide by 100. R_{PC} can now be deducted from GDP_{PC}. In addition, the measurement must be modified to per capita and natural logarithm specification. The data for year 2000 is used for all the variables GDP, resource rent and population. The procedure is shown below. Notice the small letters indicating true levels for the variables, while capital letters indicates logarithmic values.

- Generate resource adjusted GDP: $gdp - r = gdp - \frac{gdp \times r\%}{100}$
- Generate per capita GDP-R: $(gdp - r)_{PC} = \frac{gdp-r}{population}$
- Take the natural logarithm: $(GDP - R)_{PC} = ln[(gdp - r)_{PC}]$

The new income-level econometric model is specified as:

$$(GDP - R)_{PC} = \beta_0 + \sum \beta_s X + \delta N + \epsilon \tag{7}$$

Using the same methods of estimation on model (6) and model (7) will enable comparison of the impact of point source resource wealth on the two measures of economic wealth: Per capita GDP and per capita GDP adjusted for resource depletion. In terms of the two models, the comparison will be of the economic significance of the γ's and the δ's.

3.3 The Methods of Estimation

Through a regression analysis the relationship between two or more variables is estimated using a statistical method. In this particular analysis the relationship between economic wealth and point source resource wealth is of interest. The regressions are run by ordinary least squares (OLS) estimation and by instrumented variable two stage least squares (IV 2SLS) estimation. OLS estimation minimizes the sum of squared residuals (Woolridge 2013). The residuals are the difference between the actual value and the fitted, or predicted, value for the dependent variable given its regressors. Squaring and summing all the vertical distances from an observation to the regression line will give best linear unbiased estimates (BLUE), given the Gauss-Markov assumptions (Woolridge 2013). The assumptions states that the population model is linear in its parameters, the sample is random, that there are no perfect linear relationships among the regressors and that the expected value of the error term is zero and has the same variance given any value of the regressors. Given all this, there is no other statistical method of estimation that will give unbiased and linear estimates with smaller variance than the OLS-estimators. In appendix A these assumptions are listed and the proof for the Gauss-Markov theorem is provided together with a derivation of the OLS estimates.

The assumption of zero mean in the error term is questionable with regard to the analysis at hand. If the covariance between an explanatory variable and the error term is non-zero, then the expected value of the error term given the value of the explanatory variable is non-zero as well. This is called an endogeneity problem, and if this exists the OLS estimators will be biased and inefficient (Leighton 2004). Due to the possibility of an endogeneity problem, regressions are also run with an instrumented variable two stage least squares estimation. Several authors have pointed out that the institutional quality might very well be correlated with both economic and natural resource wealth. In this case there is a simultaneity problem. Due to this, the OLS estimations do not include an institutional variable. The problem then arises because the effect of institutional quality will be represented in the idiosyncratic error. When there is a correlation between the error term and an included regressor, the result will be biased estimates (Woolridge 2013). The problem is solved through IV 2SLS estimation where one or more instruments is used to capture the effect of institutional quality on economic wealth and not on resource endowment. This means that the instruments must satisfy two conditions to be valid. First, the instrument must be exogenous, meaning it must be uncorrelated with the idiosyncratic error term. Secondly, the instrument must be relevant. The instrument is relevant if there is sufficient empirical correlation between the endogenous variable and the instrument. If this correlation is weak, called weak identification, the IV estimation will be less precise than OLS estimation (Woolridge 2013). A test of weak identification therefore should, and will be, conducted.

The IV 2SLS estimator can be obtained in two stages, hence the name. In the first step a reduced form model is estimated by normal OLS (Verbeek 2013). The reduced form model is the endogenous regressor from the original model, from now called the structural model, as left hand side variable and the instruments and the exogenous variables from the structural model as regressors. In the second stage the predicted values from the reduced form replaces the endogenous regressor in the structural model. OLS is now used to regress the dependent variable on the instrumented variable. In the case of using the rule of law index for institutional quality, and fraction of the English-speaking population, fraction of the population speaking a major West European language and absolute latitude as instrument, the procedure is preformed as follows:

Step 1: Compute the OLS regression of "Rule of law" on all the instruments and the exogenous variables (represented by the X matrix) from the structural model. μ represents the error term from the reduced form regression.

$$\begin{aligned}\text{Rule of law} = \quad & \gamma_1(\text{English speaking frac.}) + \gamma_2(\text{WestEuro speaking frac.}) \\ & + \widehat{\gamma}_3(\text{Absolute latitude}) + \sum \beta_m X + \mu\end{aligned} \tag{8}$$

Step 2: Use OLS to regress the structural model with the instrumental variable, "Rule of law", included:

$$GDP = \beta_0^{IV} + \beta_1 N + \beta_2 \text{Rule of law} + \sum \beta_m X + \epsilon \tag{9}$$

The result will give the IV estimates:

$$\widehat{GDP} = \hat{\beta}_0^{IV} + \hat{\beta}_1 \hat{N} + \hat{\beta}_2^{IV} \widehat{\text{Rule of law}} + \sum \hat{\beta}_m^{IV} \hat{X} \tag{10}$$

Notice that the hats indicate predicted values and that IV denotes the instrumented variable estimates. The two regression methods presented, OLS and IV 2SLS, are the ones that will be used to study the relationship between resource and economic wealth. All regressions in this analysis is run in the software package STATA, and all the estimated coefficients are presented in Appendix C.

3.4 Inferential Statistics

The similar structure of the OLS and the IV 2SLS estimators gives similar statistical inference for the two methods of regression. Statistical inference allows deduction about the population model from the random sample described by the descriptive statistics (Woolridge 2013). To preform inference on the coefficients, an additional assumption must be made to the Gauss-Markov assumptions. The distribution of the coefficients depends on the underlying distribution of the errors. Assuming the errors to be normally distributed, together with the zero conditional mean and homoscedasticity condition, is formally expressed as:

$$\epsilon \sim \text{Normal}(0, \sigma^2),$$

whith σ^2 being the constant variance for any given value of the regressors. In the case of instrumented variables, the homoscedasticity assumption is stated conditional on the instrumental variable, and not the endogenous instrumented variable. Under these assumptions it can be shown that a coefficient $\hat{\beta_m}$ is normally distributed with the expected value β_m and variance $\text{var}(\hat{\beta_m})$ where β_m is the true population coefficient and $\hat{\beta_m}$ is the estimated coefficient (Woolridge 2013). This implies that:

$$\frac{\hat{\beta_m}-\beta_m}{sd(\hat{\beta_j})} \sim \text{Normal}(0, 1),$$

where $sd(\hat{\beta_m})$ is the standard deviation of the coefficient. This result is used to construct test statistics. The estimated standard deviation is called the standard error, and denoted as $se(\beta_m)$.

3.4.1 Testing the Estimates

The estimated coefficients will give the marginal effect of its corresponding variable on the dependent variable. In order to prove the statistical significance of the coefficients they must be tested. Given the assumptions made above, the test statistic, t_{df}, is student-t distributed, so that:

$$\frac{\hat{\beta_m} - \beta_m}{se(\hat{\beta_m})} \sim t_{n-k-1} = t_{df} \tag{11}$$

where k+1 is the number of unknown parameters, n is the number of observations and m corresponds to any of the k explanatory variables. The sum of unknown parameters and number of observations gives the degrees of freedom (Woolridge 2013). A t-test can now be preformed to test the hypothesis about any single parameter in the population regression function. The primary interest lies in testing the null hypothesis that there is no marginal effect of natural resources on economic wealth:

$H_0 : \beta_m = 0$

The null hypothesis states that after controlling for the other explanatory variables, the variable corresponding to β_m is believed to have no effect on the expected value of the dependent variable. The alternative hypothesis is two-sided in a two-tailed test:

$H_A : \beta_m \neq 0$

and one-sided in a one-tailed test:

$H_A : \beta_m > 0 \quad \text{or} \quad \beta_m < 0$

From here on the focus will lie on the two-sided alternative, as a positive deviation from zero is a just as interesting result as a negative deviation. If the rejection rule chosen is that rejection of H_0 will occur for 5 per cent of all random samples when H_0 is in fact true, then the level of significance is 5 per cent. The critical value of rejection of H_0 is given by the level of significance, degrees of freedom and the t-distribution. H_0 is rejected in favour of H_A if the absolute value of the test observer is greater than the critical value:

$|t_{df}| > t_{crit}$

The null hypothesis is highly relevant for the coefficients corresponding to the point source resource variable as the interest of this analysis is to study the effect of natural resources on economic wealth. Also relevant is finding a 95 per cent confidence interval for the coefficient. This is the interval of all values for $\widehat{\beta_m}$ of which there is 95 per cent certainty of the true coefficient β_m to lie within (Leighton 2004). The interval is found by solving the following expression:

$$\widehat{\beta_m} \pm t_{0.025} \times se(\beta_m)$$

All regressions in this analysis are run with approximately a 100 observations. The critical t-value for a 95 per cent interval is then found in a student-t distribution table to be $t_{0.025} = 1.98$. Confidence intervals will not be reported in this thesis, but the intervals are easily found using the estimates reported in section 4.

The IV 2SLS estimates can be tested in the same way as the OLS estimates. Notice that the correct standard errors are not automatically provided in the second step of the regression when computed manually, and the test statistics obtained would be invalid. The reason for this is that the error term in the last stage fails to include the error term from the reduced form regression (Woolridge 2013). However, since the estimations in this analysis are preformed by the software package STATA, the standard errors will be correctly estimated, and the statistical inference is valid. The t-values of all the estimates found on the natural resource variables in the thesis are reported in Appendix B. For most estimates the null hypothesis is rejected at a level of significance at 1 per cent. Oil to GDP ratio in the regressions run with resource adjusted GDP is not significant at a 10 per cent level for the OLS and 2SLS IV estimation with the large sample. With regard to the regressions run on mineral wealth and resource adjusted GDP, the only significant estimate is per capita mining output, which is significant at a 5 per cent level. Clearly, this indicates that the results of mining wealth on GDP-R is highly questionable, something which should be kept in mind when interpreting the results.

Some testing should also be done to test whether the instrumented variable is truly endogenous and whether the instruments are sufficiently correlated with the instrumented variable. If the correlation is not significant the instrument is weak. The explanatory power of the instrument is weak if the coefficient of the instrument from the reduced form regression is insignificant (Verbeek 2013). The software package STATA reports the value of the F-statistic, which is a measure of the information content contained in the instruments. A simple rule-of-thumb says that one need not worry about weak instruments if the F-statistic exceeds 10. All F-statistics from the regression of economic wealth in this thesis exceeds the rule-of-thumb, and are reported in Appendix B.

If the instrumented variable is not endogenous the IV 2SLS estimator is less efficient, meaning it has a larger standard error, than the OLS estimator (Woolridge 2013). Endogeneity can be tested using a Hausman test. First, the reduced form model is estimated and the residuals $\hat{\mu}$ is obtained. Adding $\hat{\mu}$ to the structural equation, without substituting the instrumented variable, will now allow testing for the significance of $\hat{\mu}$. This procedure is illustrated in equation 12.

$$\widehat{GDP^{OLS}} = \beta_0^{\hat{OLS}} + \beta_1^{\hat{OLS}}\hat{N} + \beta_2^{\hat{OLS}}\widehat{\text{Rule of law}} + \hat{\beta}\hat{X} + \theta^{\hat{OLS}}\hat{\mu} \tag{12}$$

Regressing equation 12 by OLS will provide a coefficient for $\hat{\mu}$, $\theta^{\hat{OLS}}$, which can be tested using a simple t-test with $H_0 : \theta = 0$. In equation 9, it is assumed that each instrument is uncorrelated with ϵ. The instrument "Rule of law" is therefore exogenous only if μ is uncorrelated with ϵ, which will only occur if H_0 is true. If $\theta^{\hat{OLS}}$ is statistically different from zero it can be concluded that "Rule of law" is indeed endogenous. In this case "Rule of law" is not a valid instrument. In Appendix B the results of Husman testing is provided. Through the software package STATA the test can be run without estimating the reduced form equation. Here, the null hypothesis is that the instrument is exogenous, and under this hypothesis the test statistic is chi-squared distributed with the number of degrees of freedom equal to the number of regressors being tested for endogeneity. H_0 is rejected if the test statistic exceeds the critical chi-squared value at a chosen level of significance (Baum, Schaffer & Stillman 2003). When H_0 is rejected here, there is an endogeneity problem because the instrument does not fulfil the exogeneity condition. Unfortunately, the test results in Appendix B indicate that several of the regressions suffers from this problem. This advocates the use of OLS estimation to 2SLS IV in these regressions.

An IV model is exactly identified if the number of instruments equals the number of endogenous regressors, and overidentified if the number of instruments exceeds the number of endogenous regressors (Verbeek 2013). The analysis conducted here uses two different sets of instruments, both containing more instruments than the one endogenous variable "institutional quality". This gives overidentified models, and an overidentifying restrictions test, also called a Sargan test, should be conducted (Verbeek 2013). With the typical sample size available severe biases in the IV 2SLS estimates can be created when too many instruments are added. Through a Sargan test it is found whether any of the instruments correlates with the structural error term. The null hypothesis is that the model is correctly overidentified. This is tested by estimating the structural equation by IV 2SLS and obtaining the residuals $\hat{\epsilon}$. Then the estimated residuals are regressed on all exogenous variables and the R-squared from this regression is obtained: R_1^2. Under the null hypothesis it is true that the Sargan statistic is asymptotically chi-squared distributed:

$$nR_1^2 \sim \chi_q^2,$$

where q is the number of instruments minus the number of endogenous regressors, and n is the number of observations (Verbeek 2013). If the statistic exceeds the critical value chosen in the chi-squared distribution the null hypothesis is rejected. This could mean that the model is misspecified because an instrument is correlated with the error, or that an instrument is omitted as a variable in the model. The set of instruments should then be revisited because at least one of the instruments is invalid. The Sargan statistics are reported in Appendix B. They conclude that in all regressions the null hypothesis cannot be rejected, indicating that the overidentifying restrictions in the model is correct.

3.5 The Hypothesis

Being provided with the very same data used in Alexeev & Conrad's (2009) analysis, the results of this regression will be of interest in two main aspects. First, is the effect of natural resources on economic wealth affected by depletion of natural resources? The expected answer is of course yes. As GDP alone does not include the pre-extraction value of resource endowment the effect of resource endowment on economic wealth is likely to be too large when regressing upon GDP. It is highly reasonable that the positive effect of resources on economic wealth is less prominent when resource depletion is adjusted for.

Secondly, is the resources curse hypothesis still rejected when correcting the regression for resource depletion? The expectations are not so clear for this question. Earlier it was discussed that there are reasons to believe that Alexeev & Conrad (2009) analysis is positively biased due to endogeny problems in the explanatory variable of interest. This problem would still occur in the current analysis. The negative bias in Sachs & Warner (1995) due to the short time period in the GDP growth rate used as dependent variable is corrected by using levels rather than growth. With the expected negative effect of correcting GDP for resource depletion and the positive effect of using levels rather than growth proven by Alexeev & Conrad (2009), it is reasonable to believe that the regression at hand will be some sort of a compromise between the analysis of Sachs & Warner (1995) and Alexeev & Conrad (2009). But only a negative impact of natural resource wealth on economic wealth can underpin the prediction of a resource curse.

The hypothesis is supported by the results presented in the next section. Including resource depletion gives lower estimated effect of natural resources on economic wealth. The effect is, however, still shown to be positive, which suggests that the resource curse should, in its simplest form, be rejected. As was briefly discussed earlier, there may still be reasons to believe that this conclusion may be changed if one were to find true exogenous vacation in the measure of resource wealth. Also, there may exist a conditional resource curse, meaning that the resource curse only occurs under certain conditions. This topic will be further elaborated on in section 5.

4 Presentation and Interpretation of the Results

This section will compare the results of Alexeev & Conrad (2009) to the results of the the same analysis when adjusting for resource depletion. First the effects of oil wealth are presented, and next the effects of mineral wealth. Running the regressions described in the previous section provide the results expected: The effect of point source resource wealth on economic wealth is a compromise between Alexeev & Conrad (2009) and Sachs & Warner (1995) when GDP is adjusted for resource depletion. The results are presented in tables 2 to 7, together with the results of Alexeev & Conrad (2009), so that they can easily be compared. The regressions on oil wealth are presented in tables 2, 3 and 4, while regressions on mining wealth are presented in tables 5, 6 and 7. For simplicity, only the coefficients of the variables measuring the point source resource are presented together with the robust standard errors in parenthesis. A full presentation of the results can be found in Appendix C.

4.1 The Effect of Oil Wealth

The results of Alexeev & Conrad (2009) are indisputable: Countries rich in oil tend to have relatively high levels of GDP. The estimates of the impact of oil endowment are all positive and highly statistically significant. The estimates vary between 0.26 and 2.57, and are therefore also economically significant. Remember that the dependent variable is specified in natural logarithm and so are all the variables measuring resource endowment. The results must therefore be interpreted as elasticities (Woolridge 2013). From table 2, the coefficient in front of the variable "per capita hydrocarbon deposits" equals 0.059 with a robust standard error at 0.016. All else equal, the coefficient is interpreted as the elasticity between per capita GDP and hydrocarbon deposits. This is easily seen by taking the partial derivative from the regression:

$$\begin{aligned} ln(GDP_{PC}9 = 6.712 + 0.059 ln(Hydro.dep_{PC}) + 0.037 abs.latitude \\ +1.340 euro.pop + 1.018 latin.am + 1.703 east.asia, \end{aligned} \tag{13}$$

which will wield:

$$\frac{1}{GDP_{PC}} \times \partial GDP_{PC} = 0.059 \times \frac{1}{Hydro.dep_{PC}} \times \partial Hydro.dep_{PC} \tag{14}$$

The elasticity is now found as:

$$\frac{\partial GDP_{PC} \times 100}{GDP_{PC}} = 0.059 \times \frac{\partial Hydro.dep_{PC} \times 100}{Hydro.dep_{PC}} \tag{15}$$

$$\Rightarrow \qquad \%\Delta GDP_{PC} = \%\Delta Hydro.dep_{PC} \times 0.059 \tag{16}$$

Table 2: OLS estimation - Effect of Oil Wealth on Economic Wealth

Line	Explanatory variable	Dependent variable	Coefficient	
1	Hydrocarb. deposits$_{PC}$	GDP$_{PC}$	0.059 (0.016)	
2	Hydrocarb. deposits$_{PC}$	(GDP-R)$_{PC}$		0.041 (0.015)
3	Value of oil output$_{PC}$	GDP$_{PC}$	0.096 (0.023)	
4	Value of oil output$_{PC}$	(GDP-R)$_{PC}$		0.054 (0.023)
5	Oil/GDP ratio	GDP$_{PC}$	1.507 (0.693)	
6	Oil/GDP ratio	(GDP-R)$_{PC}$		0.793 (0.714)

The elasticity is constant throughout, meaning that a 1 per cent increase in the per capita hydrocarbon deposits on average, all else equal, will increase the per capita GDP by 0.059 per cent. What this essentially means is that the function form is assumed to have the following quality: When hydrocarbon deposits increases towards infinity, the marginal impact of a change in hydrocarbon deposits on GDP levels goes towards zero. In other words, the impact of hydrocarbon deposits on GDP levels are always positive, but in a decreasing manner.

Table 3: IV 2SLS estimation - Effect of Oil Wealth on Economic Wealth

Line	Explanatory variable	Dependent variable	Coefficient	
1	Hydrocarb. deposits$_{PC}$	GDP$_{PC}$	0.051 (0.010)	
2	Hydrocarb. deposits$_{PC}$	(GDP-R)$_{PC}$		0.025 (0.010)
3	Value of oil output$_{PC}$	GDP$_{PC}$	0.086 (0.015)	
4	Value of oil output$_{PC}$	(GDP-R)$_{PC}$		0.036 (0.016)
5	Oil/GDP ratio	GDP$_{PC}$	1.255 (0.313)	
6	Oil/GDP ratio	(GDP-R)$_{PC}$		-0.002 (0.344)

Comparing the effect of hydrocarbon deposits on GDP to the effect of hydrocarbon deposits on resource rent corrected GDP, yields the results expected. The two first lines in table 2 shows a less positive impact of per capita hydrocarbon deposits on GDP - R than on GDP alone. The coefficient of 0.059 with a t-value of 3.79 is statistically significant even at a 1 per cent significance level. Interpretation of this coefficient yields that a 1 per cent increase in per capita hydrocarbon deposits would yield 0.059 per cent increase in GDP per capita. The difference in impact predicted by Alexeev & Conrad (2009) is substantially larger than the impact on economic wealth when resource depletion is accounted for. A 1 per cent increase in hydrocarbon deposits only yields a 0.041 per cent increase in the adjusted dependent variable.

The mean of the variable GDP is found to be 8.239. From the two last lines in table 2 it is seen that a 1 per cent increase in Oil/GDP ratio is predicted to increase GDP by 1.507 per cent. For the mean value country, this would imply an increase in PPP GDP per capita of 0.12 units:

$$\frac{1.507 \times 8.239}{100} = 0.12 \tag{17}$$

The same increase in Oil/GDP ratio is predicted to increase adjusted measure, GDP - R, by 0.793 per cent. Since the mean per capita GDP - R equals 1.1576, the effect would be 0.01 units:

$$\frac{0.793 \times 1.1576}{100} = 0.01 \tag{18}$$

As expected, the impact is less economically significant when depletion of natural resources is taken into account. In this case however, as will be shown to also be true for the larger fraction of the other regressions preformed in this thesis, the resource curse is still not rejected when economic wealth is measured as GDP minus resource rent. The results from the regressions using the per capita value of oil output as regressor shows that the elasticity on per capita GDP is 0.096, while it is 0.054 for the same measure corrected for resource rents. All results in table 2 is statistically significant at a 1 per cent significance level.

In the previous section it was argued why a IV 2SLS estimation is also included. The results are presented in table 3. Note that the measures for oil endowment are the same as in table 2, however the remaining regressors are not identical. The details can be found in Appendix C. The trend in table 3 shows the same as table 2: When deducting resource rent from GDP the positive effect of oil endowment on economic wealth is reduced. Only the last estimation, where the share of oil to GDP is regressed upon GDP adjusted for resource depletion, gives a slightly negative coefficient. This effect is not significant even at a 10 per cent significance level, and therefore not further discussed. The other effects on the adjusted GDP variable is significant at a 5 per cent significance level, while the effects from Alexeev & Conrad's (2009) estimations are all significant at a 1 per cent level. All the reported F-statistics on weak identification is above 10, and weak instruments is therefore not a problem here according to the rule-of-thumb.

Table 4 uses the same method of estimation as table 3, only with other instruments. As settler mortality is unavailable for many of the observations the sample size in these regressions are substantially smaller. But still, the results for table 4 shows the same trend as the tables above. When GDP is corrected for depletion of natural resources the coefficients are less positive. Alexeev & Conrad's (2009) estimates are significant at a 1

Table 4: Effect of Oil Wealth on Economic Wealth - smaller sample

Line	Explanatory variable	Dependent variable	Coefficient	
1	Hydrocarb. deposits$_{PC}$	GDP$_{PC}$	0.064 (0.013)	
2	Hydrocarb. deposits$_{PC}$	(GDP-R)$_{PC}$		0.038 (0.012)
3	Value of oil output$_{PC}$	GDP$_{PC}$	0.131 (0.018)	
4	Value of oil output$_{PC}$	(GDP-R)$_{PC}$		0.079 (0.019)
5	Oil/GDP ratio	GDP$_{PC}$	2.567 (0.712)	
6	Oil/GDP ratio	(GDP-R)$_{PC}$		0.993 (0.574)

per cent level. The effect of hydrocarbon deposits and the value of oil output on adjusted GDP is significant at a 1 per cent significance level, while the effect of the oil to GDP ratio, in the last line of table 4, only is significant at a 10 per cent level. Also here all reported F-statistics indicates that there is no problem of weak instruments.

4.2 The Effect of Mineral Wealth

The results of the regressions run with mineral wealth as regressor is presented in tables 5, 6 and 7. Also these regressions have a log-log function form, and the coefficients can be interpreted as elasticities. As an example, the first two lines in table 5 shows that a 1 per cent increase in per capita mining output will increase per capita GDP by 0.094 per cent, but per capita GDP adjusted for resource depletion will only be increased by 0.061 per cent. Using the same exercise used earlier for the hydrocarbon deposits, it is now found that a 1 per cent increase in the share of mining to GDP will increase per capita GDP by 0.21 units:

$$\frac{2.603 \times 8.239}{100} = 0.21 \tag{19}$$

The same increase in mining to GDP ratio will only increase per capita GDP adjusted for resource depletion by 0.02 units:

$$\frac{1.618 \times 1.1576}{100} = 0.02 \tag{20}$$

Un this particular regression, the difference in the marginal effect of point source resource endowment is of 1.9 percentage points.

Table 5: OLS estimation - Effect of Mineral Wealth on Economic Wealth

Line	Explanatory variable	Dependent variable	Coefficient	
1	Mining output$_{PC}$	GDP$_{PC}$	0.094 (0.028)	
2	Mining output$_{PC}$	(GDP-R)$_{PC}$		0.061 (0.027)
3	Mining/GDP ratio	GDP$_{PC}$	2.603 (1.111)	
4	Mining/GDP ratio	(GDP-R)$_{PC}$		1.618 (1.040)

The same trend is seen when using IV estimation in tables 6 and 7. Mining to GDP ratio positively effects GDP with a coefficient on 1.444 in the fourth line of table 6. When resource rents are deducted the same coefficient becomes slightly negative. However, the coefficient is only statistically significant at a 10 per cent level. The effect of the value of mining output, showed in the second line, is not statistically significant even at a 10 per cent significance level. In table 7 the smaller sample size regressions give the same trends. Unfortunately the results of the effect on adjusted GDP is not very robust since none of the variables for mining wealth are statistically significant even at a 10 per cent significance level. The overall results however underpins the results from the analysis on oil endowment: When adjusting GDP for resource rents the effect of mineral wealth is reduced.

Based on the estimation results of oil and mineral endowment on economic wealth, it can be stated that the positive effect of resource endowment on economic wealth is reduced

Table 6: IV 2SLS estimation - Effect of Mineral Wealth on Economic Wealth

Line	Explanatory variable	Dependent variable	Coefficient	
1	Mining output$_{PC}$	GDP$_{PC}$	0.062 (0.020)	
2	Mining output$_{PC}$	(GDP-R)$_{PC}$		0.025 (0.019)
3	Mining/GDP ratio	GDP$_{PC}$	1.444 (0.846)	
4	Mining/GDP ratio	(GDP-R)$_{PC}$		-0.488 (0.721)

Table 7: Effect of Mineral Wealth on Economic Wealth - smaller sample

Line	Explanatory variable	Dependent variable	Coefficient	
1	Mining output$_{PC}$	GDP$_{PC}$	0.082 (0.029)	
2	Mining output$_{PC}$	(GDP-R)$_{PC}$		0.036 (0.027)
3	Mining/GDP ratio	GDP$_{PC}$	4.506 (1.372)	
4	Mining/GDP ratio	(GDP-R)$_{PC}$		1.621 (1.327)

when depletion of resources is taken into account. The results also suggests that adjusting GDP for resource depletion does not change the conclusion of Alexeev & Conrad (2009). The prediction of a resource curse seems to be false, or at the very least can not be verified. Even when adding the depletion of natural resources, the effect of being rich in point source resources seems to have a positive effect on economic wealth. These conclusions may however change if only a conditional resource curse is what is hypotezised. What if countries with some characteristics suffers from the resource curse, while others do not? So far the resource curse has been studied in its simplest form. The next section will assess the conditional resource curse prediction.

5 The Conditional Resource Curse Prediction

The analysis thus far has not been able to confirm the existence of a resource curse in the sense that, all else equal, countries rich in resources are to be less economically wealthy. But, as was shown in figure 1, the fact that some countries rich in resources tend to preform poorly in economical terms cannot be disputed. One of the interesting aspects of this topic is the huge variation in the economic performance of resource-rich nations. In this section different dimensions in which "cursed" and "non-cursed" resource-rich countries differ, are identified to examine possible variables that the curse could be conditional upon. The hypothesis of a resource curse conditional upon institutional quality is commonly used. Some theory on this topic will be presented here, and an analysis in the tradition of Alexeev & Conrad (2009) is then conducted. Like in the previous sections, the measurement for economic wealth will be expanded to include resource depletion.

5.1 What could the Resource Curse be Conditional Upon?

In Torvik's (2009) search for dimensions in which resource abundant winners and losers differ, the following six are identified. The first one is saving of resource income. The mechanism and intuition of genuine savings, or net adjusted savings, was introduced in section 2. According to Torvik (2009), there is systematic differences in the resource-adjusted savings rates between those countries that have escaped the resource curse and those that have not. However, causality can not be proven. There is a tendency for those economies that has escaped to have higher genuine savings than those who have not escaped the curse. But, there is no way of knowing if the degree of saving resource income affects the economic development, or if poor economic development has resulted in overspending of resource income. The finding is interesting and underpins the importance of using diversified indicators when measuring economic wealth. This discussion is closely related to the analysis conducted later on in this section, where the conditional curse is tested using resource-adjusted GDP as dependent variable.

A second dimension identified by Torvik (2009) is the type of natural resources in the economy. Clearly the value of different resources will differ, and therefore the influence on intersectional structure, inducement to rent seeking and influence on political incentives will depend on type of resource endowment. Resources such as oil and minerals are valuable, while agricultural products often are not. Torvik (2009) shows that the tendency of a resource curse is stronger when valuable resources are regressed upon. This is the reason why Alexeev & Conrad (2009), and several others, uses valuable resources in particular when studying the relationship between economic and resource wealth. The types of resources most prone to launch a resource curse are the easily appropriable point source resources that also are lootable. Diamonds are the prime example of such a resource. Also offshore versus onshore oil endowment have been shown to be a dimension in which winners and losers differ. In addition to onshore oil increasing the risk for violent conflicts, which negatively affects growth, offshore oil has the advantage of requiring advanced technology. Development of this technology induces positive knowledge externalities, and the predictions from Dutch decease theory is turned on its head. A dimension is also the early industrializing economies, who today are the winners, which had their growth driven by exploiting natural resources. Torvik (2009) speculates that the positive effect of resources might have changed over time, but the explanation for why late industrialization would not be able to reap the benefits of natural resources remains unidentified.

Yet another dimension in which resource abundant winners and losers differ is the choice of constitutional system. Andersen & Aslaksen (2013) find that having a parliamentary or a presidential system matters more for the effect of natural resources on economic growth than being a democratic or an autocratic nation. The resource curse only seems to be relevant in presidential democratic countries, and not in the parliamentary democratic countries. To explain this result, van der Ploeg (2011) points out that presidential systems are less accountable and less representative than parliamentary systems. The scope for resource rent extraction might therefore be larger in presidential systems, while the broader representation makes parliamentary democracies better suited to allocate resource rents into productive use, and so to increase economic wealth.

The constitutional dimension introduces the hypothesis that the broader distribution of political power, the smaller is the negative impact of resource endowment on economic development. Acemoglu & Robinson (2012) introduces the terms inclusive and exclusive political and economic institutions. The broader the distribution of power, the more inclusive are the political institutions. Extractive political institutions on the other hand, concentrate the power within a small elite, and put few constraints on how the power is used. Acemoglu & Robinson (2012) go on arguing that there is strong feedback loops the economic and political institutions, and extractive economic institutions will hinder the engines of economic growth and development through biased distribution of resources. In this case, the more resources available, the more will the political elite have to gain on maintaining a narrow distribution of power. The exclusive economic institutions will be maintained so that the elite can continue to extract resources. This synergistic relationship can be broken trough critical junctures, which are stochastic events affecting the institutional arrangements. Notice that the feedback loops generates a multicollinearity problem because institutions are endogenously determined by natural resources. This could cause biased estimates in the regression analysis.

5.2 Institutional Quality as Condition

To some degree many of the dimensions described above are clearly linked to institutional quality. North (1991) defines institutions as *"the humanly devised constraints that structure political, economic and social interaction"*. They are rules that describe both what is allowed to do and also what is actually done, by agents and organizations in a society. The institutions can be formal, like laws and property rights, or informal, like traditions, customs or taboos. By providing the incentive structure in the societies they also directs the economic development towards growth and prosperity, stagnation or even decline. With this in mind it is safe to state that understanding institutions is important for understanding the determinants of economic development and wealth. The hypothesis that the resource curse could be conditional upon institutional quality should be investigated.

At least two questions can be researched with regard to the role of institutions in regressing natural resource wealth upon economic wealth. First, will the amount of natural resources affect the quality of a nation's institutions? Secondly, will a nations existing institutional quality affect the impact of resource endowment on economic prosperity? The first question is well elaborated in the rent seeking theory. It is believed that resource abundance deteriorates institutional quality through rent seeking activities, which will increase the rent seekers wealth without creating additional wealth in the society. The result is reduced economic efficiency through reduced wealth creation, deteriorated resource allocations and potentially reduced economic wealth (Dabla-Norris & Wade 2001). On the basis that they find at most weak correlation between resource abundance and institutional quality, Sachs & Warner (1995) dismisses the possibility of resources having an impact on institutions. This also eliminates the multicollinearity problem discussed earlier. On the basis on this they dismiss the conditional curse, and uses Dutch disease explanations to support the negative impact of resources on economic performance.

Mehlum, Moene & Torvik (2006) finds that institutions are decisive for the resource curse, contradicting Sachs & Warner's (1995) claims. This relates to the second question. The hypothesis that poor institutional quality is the cause of the resource curse and that good enough institutions can eliminate the curse entirely is confirmed by including an interaction term in Sachs & Warner's (1995) regressions. The regression model is expanded by the term $SXP \times IQ$, where IQ measures institutional quality. Using the same data as Sachs & Warner (1995), Mehlum et al. (2006) find the effect of a marginal increase in SXP on GDP growth to be:

$$\frac{\partial(G7089)}{\partial(SXP)} = -14.34 + 15.40(IQ) \tag{21}$$

The means that the effect of a marginal increase in resource abundance on economic growth depends on institutional quality. The IQ variable is an unweighted average of five indexes measuring different aspects of the institutional quality, and the index ranges from zero to unity [2]. An institutional quality value of one would imply perfect institutions, while zero would imply the poorest possible quality. To escape the resource curse, a country must have a value of institutional quality exceeding the threshold, $IQ^0 = 0.93$:

$$-14.34 + 15.40(IQ^0) = 0 \qquad \Rightarrow \qquad IQ^0 = 14.34/15.40 = 0.93.$$

The above result is explained through a model where entrepreneurs are either grabbers

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[2] The index is based on data from Political Risk Services. It consists of a rule of law, bureaucratic quality, corruption in government, risk of expropriation and government repudiation of contracts index, measured as of 1982.

who appropriate as much possible of the resource rent, or productive producers generating economic growth. Grabber friendly institutions will induce entrepreneurs to switch from productive to grabber activities, which lowers growth. Producer friendly institutions on the other hand, enables a country to take full advantage of its resources, preventing the negative resource curse effect. The crucial threshold of producer friendly institutions, derived above, was found to be at 0.93. In the sample of Mehlum et al. (2006) it was found that the resource curse prediction is not valid for top 20 percent with regard to institutional quality. This strongly indicates a resource curse conditional upon institutional quality.

There are some potential problems in the analysis preformed by Mehlum et al. (2006). Although the effects of secondary school enrollment and ethnic and language fractionalization are tested for, a problem of omitted variable bias could still occur. Resource abundance could be correlated with an excluded measure of underdevelopment. As previously discussed, the finding of a truly exogenous measurement of resource wealth would prevent this issue. Mehlum et al. (2006) worries that the empirical results might be driven by a correlation between underdevelopment and specialization in agricultural exports, for instance. Land is less lootable and taxable than many other natural resources, and resource grabbing might therefore be less likely to occur in countries rich in agricultural resources. This possible bias is tested by investigating the relationship between GDP growth and mineral abundance, which is a lootable resource. The direct negative effect of resources on economic growth increases in this regression. Also the interaction term increases. This indicates that lootable resources are particularly harmful for growth in countries with poor institutional quality. The result strengthens the prediction of a conditional curse, as the mechanism through grabber friendly institutions seems to work even better when only lootable resources are assessed. Without a truly exogenous measure for resource wealth however, awareness of omitted variable bias must be made.

According to rent seeking theory, the positive effect of natural resources on economic wealth found by Alexeev & Conrad (2009) is flawed due to the time horizon. With time, natural resources could deteriorate institutional quality, which would be negative for economic development. Alexeev & Conrad (2009) dismisses the conditional resource curse and argues that oil and minerals are largely neutral with respect to institutional quality. They believe that studies finding a negative relationship between natural resources and institutions are flawed due to the inclusion of per capita GDP as a control variable. As was discussed in section 2, the relationship between resource wealth and GDP is argued to be flawed because early extraction of resources has influenced the GDP levels of later periods. Given this positive relationship, and the positive relationship between GDP and institutions, the estimates of natural resources on institutions are negatively biased. This is proved through an analysis by Alexeev & Conrad (2009), which will be thoroughly examined below.

The point, Alexeev & Conrad (2009) argues, is that natural resources does not hurt institutions, it simply does not improve them either. For now, imagine that it is true that resources increases GDP, but have no simultaneous effect on institutions in the short and medium term. Two identical countries are compared with regard to resources, institutions and economic wealth. As manna from heaven, country 1 becomes rich in oil. The GDP level increases, but institutional quality remain. The ratio between institutional quality and GDP is now better for country 2 than for country 1, because the denominator of country 1 is larger. Institutional quality in country 2, given the GDP level, is relatively better than for that of country 1. Before country 1 was "blessed" with oil, this ratio was equal. So, apparently, oil will induce a negative effect on institutional quality. Clearly, the effect is flawed and only represents the positive effect of natural resources on the initial GDP level.

Not surprisingly, the results in the previous section show positive coefficients for the instrument "Rule of law", which means that institutions correlates positively with economic wealth. However, Alexeev & Conrad (2009) also finds that countries with weaker institutions benefits more from natural resources, through a regression where the interaction term "Rule of law × Natural Resources", or "IQ × N", is included. Due to the potential endogeneity between institutions and GDP, the predicted values of IQ are obtained from the first stage in the 2SLS IV regressions described earlier. These are marked by the subscript p. They are then inserted to the regression function, which now takes the form:

$$GDP_{PC} = \beta_0 + \sum \beta_j X + \gamma N + \theta(IQ_p \times N) + \epsilon, \tag{22}$$

where θ measures the effect of the interaction term. Here, the regressions from table 3 and 6 are reconstructed to include the interaction term. The coefficients of the interaction term are negative in all regressions, but only with a small negative economic effect compared to the positive effect of resources alone. Also, in two out of the five regressions the estimates are not statistically significant at a 10 per cent level. These results contradicts Mehlum et al.'s (2006) findings, where a positive effect of the interaction term was found to be highly economically significant. Notice however that Alexeev & Conrad (2009) regresses upon GDP levels, whereas Mehlum et al. (2006) dependent variable is the growth in GDP. Also, the data on institutional quality is not the same. While Mehlum et al. (2006) uses the index described above, which also is used by Sachs & Warner (1997) and therefore comparable to their results, Alexeev & Conrad (2009) uses the government indicators from 1996 to 2004 from Kaufmann, Kraay & Mastruzzi (2005). The government indicators in the sample ranges from -2.31 to 2.2 with the mean observation of 0.000 and standard deviation 1.000. The results can therefore not be compared.

The negative estimates of Alexeev & Conrad (2009) should not be interpreted to mean that good institutions would hurt long-term economic growth. With regard to the second question asked earlier, how existing institutions affect in impact of resources on economic wealth, the answer here is that the positive effect of natural resources on economic wealth is more prominent in countries with poor institutions where GDP would be low without the resource extraction. The estimations described here will be thoroughly examined next when the estimates from Alexeev & Conrad's (2009) analysis on the conditional course is compared to the same estimates using the expanded measurement of economic wealth.

5.3 Regression Analysis on the Conditional Resource Curse

The discussion so far can be quickly summarized:

- Sachs & Warner (1995) find that natural resources have a negative impact on GDP growth, and hence conclude that a resource curse exists. They find no correlation between resources and institutions, and therefore explain the findings by Dutch disease mechanisms.

- Mehlum et al. (2006) argue that the resource course is conditional upon institutional quality. The curse will be avoided in producer friendly economies where the institutional quality exceeds a threshold of 0.93.
- Alexeev & Conrad (2009) find that even when controlling for initial income the estimates becomes biased due to the shortness in time horizon. When regressing upon GDP levels instead of growth, a positive impact of point source resources is found. Hence, the resource curse in its simplest form is rejected.
- Alexeev & Conrad (2009) continue the search for a conditional resource curse. The findings imply that the positive effect of resources on GDP levels declines with improving institutional quality. However, the positive effect of resources cannot be completely cancelled out by institutional quality.

In previous sections it has been argued that the measurement used for economic wealth is too narrow, and should be expanded to include at least the depletion of natural resources. When resource depletion is taken into account, the positive effect found by Alexeev & Conrad (2009) is less economically significant, which matches the hypothesis. Clearly, the very last task left to do in this thesis is to test if Alexeev & Conrad's (2009) findings with regard to the impact of changes in institutional quality when the dependent variable is adjusted for resource depletion. The hypothesis is that the interaction term will be of a less absolute value, due to the lower direct effect of resource wealth on economic wealth found in section 4. The analysis and interpretation of the results are carried out in the remaining of this section.

The method used for the regression analysis follows Alexeev & Conrad's (2009) tradition, with deduction of resource depletion in the dependent variable. They divide the investigation of the role of institutional quality into two parts. First, the interaction term that was described earlier, is introduced. This gives the following regression model:

$$(GDP - R)_{PC} = \beta_0 + \sum \beta X + \gamma N + \lambda (IQ \times N) \tag{23}$$

where the estimates will be compared to those found by Alexeev & Conrad (2009) in equation 22. Due to the potential endogeneity between institutions and GDP, fitted values of "Rule of law" is created by regressing the explanatory variables absolute latitude, ethnic fractionalization, the regional dummies and a point source resource measurement. This produces predicted values for "Rule of law". The process is repeated for all five measurements of point source resources: Hydrocarbon deposits, the value of oil output, oil to GDP ratio, mining output and mining to GDP ratio. Using the predicted values derived by their respective measurement for point source resources, the relationship between economic and resource wealth can now be found by regressing equation 22 and 23. The effect of the interaction term will be given by the coefficients θ and λ. The results are presented in table 8 in the next subsection. The results are tested using ordinary t-testing, with the results presented in Appendix B. For the adjusted measurement, only hydrocarbons deposits yields a statistical significant coefficient.

The second part of the investigation looks at the relationship between point source resources and institutional quality directly. A regression is performed in two stages. First, values are generated to predict the per capita GDP levels the countries could expect to have if they never where to have had any oil endowment. The predictions are found by regressing the logarithm of per capita GDP in 1970, alone and adjusted for resource depletion, upon the exogenous geographic variables of absolute latitude, and the dummies for European population and African and East Asian countries:

$$GDP_{1970} = \beta_0 + \sum \beta X + u \tag{24}$$

and

$$(GDP - R)_{1970} = \beta_{0R} + \sum \beta_R X_i + u_R \tag{25}$$

The footnote R indicates that the coefficient corresponds to resource depletion adjusted estimation. When the fitted values are obtained, the predicted value for economic wealth in 1970 is denoted by $\widehat{GDP_{1970}}$ and $(\widehat{GDP - R})_{1970}$. These are used as control variables when regressing the effect of natural resource endowment on institutional quality, through the regression models:

$$IQ_i = \alpha_{0,f} + \sum \alpha_f X + v_{1,f}\widehat{GDP_{1970}} + v_{2,f}N + e_f \tag{26}$$

and

$$IQ_i = \alpha_{0R,f} + \sum \alpha_{R,f} X + v_{1R,f}\widehat{(GDP - R)}_{1970} + v_{2R,f}N + e_{R,f} \tag{27}$$

where e is the idiosyncratic error term and the f indicates that the coefficients represent fitted value effects. These estimates can now be compared to the estimates from regressing:

$$IQ_i = \alpha_{0,o} + \sum \alpha_o X + v_{1,o}GDP_{1970} + v_{2,o}N + \epsilon_o \tag{28}$$

and

$$IQ_i = \alpha_{0R,o} + \sum \alpha_{R,o} X + v_{1R,o}(GDP - R)_{1970} + v_{2R,o}N + \epsilon_{oR} \tag{29}$$

where the fitted values for GDP and R in equations 26 and 27 are replaced by the observed values, hence the f's are replaced by o's. Here the endogenous negative link between resources and institutions is eliminated, and the analysis can provide insight of the true relationship between point source resource wealth and institutional quality.

5.3.1 Results and Interpretation of the Estimates

The first part of the investigation looks at the total effect of the point source resource wealth on economic wealth when the interaction effect through institutional quality is included. The results of regressing the models in equations 22 and 23 are presented in table 8. Robust standard errors are reported in parenthesis. The two last columns provide the estimates of the interaction terms and the direct effect of the point source resource respectively.

As described earlier, all the regressions using GDP per capita as dependent variable show a negative effect of the interaction term. This would imply that countries with weaker institutions benefit more from natural resources. This does not match the rent seeking theory. However, the economic significance is small relative to the direct effect of natural resources. Also, the estimates in regressions 5 and 7 are not statistically significant. As was discussed earlier, Alexeev & Conrad (2009) interpret the results to mean that

Table 8: Effect of Interaction between Institutions and Natural Resources

Line	Explanatory variable	Dependent variable	Interaction Term	N
1	Hydrocarb. deposits$_{PC}$	GDP$_{PC}$	-0.041 (0.012)	0.056 (0.014)
2	Hydrocarb. deposits$_{PC}$	(GDP-R)$_{PC}$	-0.029 (0.012)	0.036 (0.014)
3	Value of oil output$_{PC}$	GDP$_{PC}$	-0.062 (0.017)	0.095 (0.017)
4	Value of oil output$_{PC}$	(GDP-R)$_{PC}$	-0.030 (0.020)	0.046 (0.024)
5	Oil/GDP ratio	GDP$_{PC}$	-0.835 (0.913)	1.139 (0.679)
6	Oil/GDP ratio	(GDP-R)$_{PC}$	0.387 (0.789)	0.610 (0.558)
7	Mining/GDP ratio	GDP$_{PC}$	-1.534 (2.197)	1.645 (1.138)
8	Mining/GDP ratio	(GDP-R)$_{PC}$	1.507 (1.879)	1.027 (1.019)
9	Mining output$_{PC}$	GDP$_{PC}$	-0.053 (0.913)	0.072 (0.028)
10	Mining output$_{PC}$	(GDP-R)$_{PC}$	-0.033 (0.020)	0.033 (0.029)

Alexeev & Conrad (2009) reports -0.065 as the estimate for the interaction term in line 3. The regression here is preformed using the exact same data and statistical methods. Regardless, the economic significance is only marginal, and the issue is therefore ignored.

countries with good institutions tend to benefit less from the positive effect of natural resources, relative to countries with poor institutions. The regressions performed with GDP adjusted for resource depletion as dependent variable basically show the same results. Here the effect is even less economic significant, and in regression 6 and 8 the effect becomes positive but, not statistically significant.

The estimates from lines 1 and 2 in table 8 can be used to investigate the effect of a 1 per cent increase in hydrocarbon deposits on economic wealth. The direct effect is a 0.056 per cent increase in GDP per capita and a 0.036 per cent increase in GDP-R per capita. The total effect will however depend on institutional quality. The mean institutional quality of the sample is 0.0001064. This provides the following effects of a 1 per cent increase in hydrocarbon deposits in a mean value institutions country:

$$\partial GDP_{PC} = 0.056 - 0.041 \times 0.0001064 = 0.056 \tag{30}$$

and

$$\partial (GDP - R)_{PC} = 0.036 - 0.029 \times 0.0001064 = 0.036 \tag{31}$$

As described in section 4, the logistic model specification allows for interpreting the estimates as percentage changes. In these examples the total effect is a 0.056 percentage increase in per capita GDP and 0.036 percentage increase in per capita GDP-R. The effect of the interaction term is too small to counter the direct positive effect of resource wealth on economic wealth. But, for the countries scoring the maximum institutional value IQ = 2.2, the effect of the interaction term counters the direct effect, so that the total effect is negative:

$$\partial GDP_{PC} = 0.056 - 0.041 \times 2.2 = -0.034 \tag{32}$$

and

$$\partial (GDP - R)_{PC} = 0.036 - 0.029 \times 2.2 = -0.028 \tag{33}$$

The neutrality thresholds for GDP and GDP-R respectively, are:

$$0.056 - 0.041(IQ^0) = 0 \qquad \Rightarrow \qquad IQ^0 = 0.056/0.041 = 1.366$$

$$0.036 - 0.029(IQ^0) = 0 \qquad \Rightarrow \qquad IQ^0 = 0.036/0.029 = 1.241.$$

The interpretation is that countries with institutional quality scores at 1.366 in total will have no impact of an marginal increase in hydrocarbon deposits on GDP. For the impact on resource depletion adjusted GDP to be negligible, the institutional quality only has to score 1.241. The results clearly do not confirm the traditional hypothesis of a resource curse conditional upon institutional quality. Quite on the contrary it seems like having a high IQ score is a secure pathway towards the resource curse. Notice however that only 23 out of the 260 countries in the sample scores above the 1.366 threshold, and only 28 above the 1.241 threshold. This matches Alexeev & Conrad's (2009) conclusions that the importance of institutions in the resource curse prediction does not seem to be of any significance.

The second part of Alexeev & Conrad's (2009) investigation of the conditional curse would yield deeper insight to the issue. Running regressions on equations from 24 though out 29 would produce the fitted values for economic wealth. These could be used to investigate the change in the impact of resources on institutional quality when using predicted and observed initial per capita GDP and GDP-R values as control variables. Unfortunately, due to lack of data, these regressions cannot be run for the resource-adjusted measurement of economic wealth. The results of Alexeev & Conrad (2009) is however helpful. They indicate that the positive link between natural resources and GDP explains previous findings of significant negative coefficients for resource endowment in regressions on institutional quality [3].

When regressing "Rule of Law" on hydrocarbon deposits, the control variable "Observed per capita GDP in 1970", is estimated to have a positive marginal effect of 0.570. Using the fitted values for per capita GDP in 1970 estimates a positive marginal effect of 0.508. Both estimates are significant at a 1 per cent level. This indicates that the initial interaction term overvalues the positive effect of economic wealth on institutional quality. In addition, the marginal effect of "Hydrocarbon deposits" on "Rule of Law" diminishes from -0.042 to -0.005 and is no longer statistically significant. When fitted values are used this trend is visible for all the measurements on point source resources. The effect of resource wealth on institutional quality declines in absolute value when fitted values of economic wealth are used as control rather than observed values. On basis of this Alexeev & Conrad (2009) dismiss the conditional resource curse. Point source resource endowment does not seem to deteriorate institutional quality, it simply does not improve it. The findings supports the view that the causality is more likely to go from institutions to economic growth, and not the other way around, which contradicts the rent-seeking arguments.

To complete the summation of the discussion in this thesis, the following points are

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[3] e.g. in Sala-i-Martin & Subramanian (2003).

added:

- Alexeev & Conrad's (2009) negative interaction term becomes less negative when the measurement for economic wealth is expanded to extract depletion of natural resources. This corresponds with the hypothesis, which was based on the direct positive effect of resource wealth on economic wealth being less economically significant when using the resource adjusted GDP rather than GDP alone.
- Alexeev & Conrad (2009) also find that the effect of resource wealth on institutional quality is insignificant when regressing upon fitted values of initial GDP. This contrasts the rent-seeking argument of resource wealth having a negative impact on institutions, and thereby on economic growth.

The analysis on resource adjusted GDP levels is not able to confirm the existence of a conditional resource curse. On the contrary, the findings of this section supports Alexeev & Conrad's (2009) rejection of the conditional resource curse. Unfortunately, the fitted values for per capita GDP adjusted for resource depletion could not be obtained, and the results therefore not confirmed. However, the finding of a smaller absolute value of the interaction term indicates that institutional quality does not play much of a role in the relationship between natural resources and economic wealth.

6 Summary and Conclusions

This thesis has aimed to expand the on-going resource curse discussion, adjusting the measurement of economic wealth for resource depletion. Arguably, by including resource depletion in addition to GDP in the measurement for economic wealth, the discussion is more easily approachable to the reality. The reality is complex and the task of economists is to make simplifications, but not simplifications distorting the truth. By expanding the measurement, a more correct response of resource extraction on economic wealth can be found. Resource adjusted GDP still is a simplification, and several more factors could, and probably should, be included. However, this is a first step of expanding our understanding of economic wealth as an indicator of well-being.

Here, the analysis of Alexeev & Conrad (2009) has been used as a benchmark. On the basis of their analysis, Alexeev & Conrad (2009) rejects the resource curse prediction. They argue that the negative relationship between economic and natural resource wealth found in earlier studies is flawed due to the use of GDP growth rates instead of levels. Using growth rates and controlling for initial income will not prevent the bias of early resource discovery influencing the initial income level unless a sufficient long time period is assessed. Sachs & Warner (1995), who was amongst the early debaters advocating the resource curse, used the growth rate between 1970 and 1989 as dependent variable, and the income level in 1970 as control. The findings of Alexeev & Conrad (2009) shows that several countries rich in point source resources started extracting the resource well before the control year, which might have influenced their initial income level positively. As the resource income tend to decline towards the end of its quantity, these countries might therefore appear to have been negatively affected by their resource endowment.

Alexeev & Conrad's (2009) hypothesis clearly contradicts the resource curse prediction. However, there exists many theories and hypothesis of why resources could have a negative impact on economic wealth. The Dutch disease explanation used by Sachs & Warner (1995) argues that labour is drawn from traded to non-traded sector, where the dynamic growth effects through learning by doing are smaller. This decreases productivity in the economy, explaining why natural resource wealth could have a negative impact on economic wealth. The structuralist approach, blooming in the 1950's, blamed the negative impact on declining terms of trade for the countries specializing in exploitation of natural resources. Several other researches have blamed the resource curse on internal conflicts, rent seeking, income inequality and declined saving and investments, amongst other. With so many arguments of why resource wealth has a negative effect on economic wealth, the findings of Alexeev & Conrad (2009) is clearly of great importance, questioning the entire existence of the resource curse prediction in its simplest form.

By deducting resource rents from the GDP levels, the results of Alexeev & Conrad (2009) have been put to a test. Deducting the income of resource exploitation will make doing business in natural resources less attractive than when GDP levels are used alone. In this analysis, the results of Alexeev & Conrad (2009) passed the test. Estimation using the very same data, in addition to data on resource rents from the same period in time, and the same methods of estimation, showed that point source resource wealth has a positive impact on GDP adjusted for resource depletion. With the warnings of the weaknesses of the analysis in mind, the results support the rejection of the resource curse in its simplest form. But clearly, the interesting question is not how the average country would respond to a marginal increase of natural resources, but rather what is the difference between those countries escaping and those not escaping the resource curse?

The conditional resource curse prediction seeks to find a dimension amongst with resource-endowed escapers differs from the non-escapers of the curse. Several dimensions are identified by Torvik (2009). The dimension receiving the most attention from researchers is institutional quality. Studies using institutional quality as condition for the curse have found that only those countries with poor institutional quality are affected by the resource curse (Mehlum et al. 2006). The positive interaction term implies an indirect effect of resources on economic wealth through institutions. A threshold of institutional quality is identified to distinguish the curse escapers from the non-escapers. For those nations with institutional quality falling short of the neutral threshold, there is a negative impact of natural resources on economic wealth. But, how can it be that "manna from heaven" has a negative impact on the economy? The threshold divides the so-called producer friendly economies from the grabber friendly economies. In compliance with rent-seeking theory it is argued that rent seeking activities is enhanced by natural resource wealth in grabber friendly economies. In sum, resource wealth therefore reduces economic prosperity in these economies.

Alexeev & Conrad (2009) expands their analysis to test for a resource curse conditional upon institutional quality. Finding predicted values for income if the resource was never to be extracted, they are able to put forth highly credible arguments of the significance of resource wealth on institutional quality. An analysis is conducted with an interaction term, which is found to have a negative effect while the direct effect is still positive. The economic significance of the interaction term is however small, and it is therefore concluded that the positive effect of natural resources on economic wealth is simply more prominent in poorly institutionalized countries. This statement is put to a test by including resource depletion to the measurement for economic wealth. In doing so, it is found that the absolute value of the negative interaction term is reduced. Also the direct positive effect of point source resources is reduced. It makes sense that all effects of resources on economic wealth is reduced when the clearly positive effect of resource rent is deducted from the equation. The results of testing the conditional curse on resource adjusted GDP are however questionable, as both the economical and statistical significance is weak.

More work should be conducted to further capture the reality when searching for the relationship between natural resource wealth, economic wealth and other factors affecting the relationship. Hopefully, future studies will continue to expand the analysis, so that economic theory can provide the decision makers with as accurate information as possible on how a country can exploit its natural resources efficiently.

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A The Gauss-Markov Theorem

Section 3.3 briefly describes the Gauss-Markov assumptions, and states the Gauss-Markov theorem that under these assumptions the OLS estimators are BLUE. Here, the proof will be derived.

The assumptions, following Woolridge (2013), states that:

- **Assumption 1:** The Population Model is Linear in its Parameters
  The population model can then be written

$$y = \beta_0 + \beta_1 x_1 + ... + \beta_k x_k + u \tag{34}$$

  where $\beta_0, \beta_1, ..., \beta_k$ are unknown coefficients, $x_1, ..., x_k$ are the explanatory independent variables, and u is the unobserved random error.

- **Assumption 2:** Random Sampling
  All the n observations of $x_{1,i}, ..., x_{k,i}, y_i$ (where i = 1, 2, .., n) in the sample is random.

- **Assumption 3:** No Perfect Collinearity
  None of the explanatory variables are constant, and there is no exact linear relationships among the explanatory variables in the sample.

- **Assumption 4:** Zero Conditional Mean
  Given any value of the explanatory variables, the idiosyncratic error term u is expected to take the value zero:

$$E(u|x_1, ..., x_k) = 0 \tag{35}$$

- **Assumption 5:** Homoskedasticity
  Given any value of the explanatory variables, the idiosyncratic error term u has the same variance:

$$Var(u|x_1, ..., x_k) = \sigma^2 \tag{36}$$

Lets first derive the OLS estimator and find the proof that the OLS estimator is unbiased. This will be done in matrix form, expressed by bold letters. The population model is then assumed to take the form:

$$\boldsymbol{y} = \boldsymbol{X\beta} + \boldsymbol{u} \tag{37}$$

where **y** is a n×1 vector of observations of the dependent variable, **X** is a matrix of the n×(k+1) observed explanatory variables and the constant term, $\boldsymbol{\beta}$ is a (k+1) vector of coefficients and **u** is a (N+1) vector of unobservable error. Estimates of $\boldsymbol{\beta}$ and **u** must be found, and these will be denoted by $\hat{\boldsymbol{\beta}}$ and $\hat{\boldsymbol{u}}$. The OLS estimates are obtained by minimizing the sum of squared residuals, SSR. Formally:

$$Min \quad SSR = \hat{\boldsymbol{u}}'\boldsymbol{u} = (\hat{u_1}, \hat{u_2}, ..., \hat{u_N}) \begin{pmatrix} \hat{u_1} \\ \hat{u_2} \\ \vdots \\ \hat{u_N} \end{pmatrix} = \hat{u_1}^2 + \hat{u_2}^2 + ... + \hat{u_N}^2 = \sum_{i=1}^{N} \hat{u_i}^2 \tag{38}$$

The model can be rewritten to yield:

$$\hat{\boldsymbol{u}} = \boldsymbol{y} - \boldsymbol{X}\hat{\boldsymbol{\beta}} \tag{39}$$

which yields the squared sum of residuals:

$$SSR = (\boldsymbol{y}-\boldsymbol{X\beta})'(\boldsymbol{y}-\boldsymbol{X\beta}) = (\boldsymbol{y}'-\hat{\boldsymbol{\beta}}'\boldsymbol{X}\text{‘})(\boldsymbol{y}-\boldsymbol{X}\hat{\boldsymbol{\beta}}) = \boldsymbol{y}'\boldsymbol{y}-\boldsymbol{y}'\boldsymbol{X}\hat{\boldsymbol{\beta}}-\hat{\boldsymbol{\beta}}'\boldsymbol{X}'\boldsymbol{X}\hat{\boldsymbol{\beta}} \tag{40}$$

By finding the derivate of SSR with respect to $\boldsymbol{\beta}$ the β‘s minimizing SSR is found, and these will be the OLS-estimates:

$$\frac{\partial SSR}{\partial \hat{\boldsymbol{\beta}}} = 0 - \boldsymbol{X}'\boldsymbol{y} - \boldsymbol{X}'\boldsymbol{y} + 2\boldsymbol{X}'\boldsymbol{X}\hat{\boldsymbol{\beta}} = 0 \tag{41}$$

The OLS-estimators is solved using simple matrix rules:

$$\widehat{\beta_{\boldsymbol{OLS}}} = (\boldsymbol{X}'\boldsymbol{X})^{-1}\boldsymbol{X}'\boldsymbol{y} \tag{42}$$

The estimator is unbiased if its expectation equals β. Inserting for $\boldsymbol{y} = \boldsymbol{X\beta} + \boldsymbol{u}$ in the expression above, yields:

$$\hat{\boldsymbol{\beta_{OLS}}} = \boldsymbol{(X'X)^{-1}X'X\beta} + \boldsymbol{(X'X)^{-1}X'u} = \boldsymbol{\beta} + \boldsymbol{(X'X)^{-1}X'u} \tag{43}$$

Taking the expectation yields:

$$E(\hat{\boldsymbol{\beta_{OLS}}}) = \boldsymbol{\beta} + \boldsymbol{(X'X)^{-1}X'E(u)} \tag{44}$$

Using Assumption 4 of zero conditional mean, the last term vanishes, so that:

$$E(\hat{\boldsymbol{\beta_{OLS}}}) = \boldsymbol{\beta} \tag{45}$$

This proves that $\hat{\boldsymbol{\beta_{OLS}}}$ is an unbiased estimate of $\boldsymbol{\beta}$.

To prove that the OLS estimator is the **best** linear unbiased estimator, given the Gauss-Markov assumptions, it must be proven that the variance of the OLS estimator always will be smaller or equal to the variance of any other linear unbiased estimator. Lets denote the OLS estimator as β^{OLS} and the other unbiased estimator as $\tilde{\beta}$. It must then be true that:

$$Var(\boldsymbol{\beta^{OLS}}) \leq Var(\tilde{\boldsymbol{\beta}}) \tag{46}$$

The variance of the OLS-estimator is derived by exploiting the matrix rule that the variance of an expression $\boldsymbol{AX}$ equals $\boldsymbol{Avar(X)A'}$. Using the rules that $\boldsymbol{(AB)'} = \boldsymbol{B'A'}$ and $\boldsymbol{(A^{-1})'} = \boldsymbol{(A')^{-1}}$, it is now true that:

$$var(\boldsymbol{\beta_{OLS}}) = \boldsymbol{(X'X)^{-1}X'}var(\boldsymbol{y})\boldsymbol{X(X'X)^{-1}} \tag{47}$$

Assumptions 3 and 5 implies that $var(\boldsymbol{U|X}) = var(\boldsymbol{y}) = \sigma^2\boldsymbol{I}$, where $\boldsymbol{I}$ is the identity matrix. The variance of β_{OLS} can now be expressed as:

$$var(\hat{\boldsymbol{\beta_{OLS}}}) = \boldsymbol{(X'X)^{-1}}\sigma^2\boldsymbol{IX(X'X)^{-1}} = \sigma^2\boldsymbol{(X'X)^{-1}} \tag{48}$$

To prove that this variance is at least as small as the variance of an alternative linear estimator, the alternative estimator is now defined as:

$$(\tilde{\boldsymbol{\beta}}) = \hat{\boldsymbol{\beta_{OLS}}} + \boldsymbol{Dy} = (\boldsymbol{X}\,\acute{}\,\boldsymbol{X})^{\boldsymbol{-1}}\boldsymbol{X}\,\acute{}\,\boldsymbol{y} + \boldsymbol{Dy} = [(\boldsymbol{X}\,\acute{}\,\boldsymbol{X})^{\boldsymbol{-1}}\boldsymbol{X}\,\acute{} + \boldsymbol{D}]\boldsymbol{y} \tag{49}$$

Notice that the estimator $\tilde{\boldsymbol{\beta}}$ only is unbiased when $\boldsymbol{DX} = 0$. Using the same matrix rules as above, it is found that:

$$var(\tilde{\boldsymbol{\beta}}) = \sigma^2[(\boldsymbol{X}\,\acute{}\,\boldsymbol{X})^{\boldsymbol{-1}} + \boldsymbol{DD}\,\acute{}\,] = var(\hat{\boldsymbol{\beta_{OLS}}}) + \sigma^2\boldsymbol{DD}\,\acute{} \tag{50}$$

Since a matrix multiplied with its inverse always will be a positive semi defined matrix, the last term will always be larger or equal to zero. This finishes the proof that there exists no other linear unbiased estimator with a variance smaller than the OLS-estimator. Given the Gauss-Markov assumptions, the Gauss-Markov theorem holds.

B Test Results

Tables 9 to 15 reports the results of the test procedures described in section 3.

t-statistics

All t-test are preformed under the null hypothesis: $H_0 : \beta_m = 0$ where β_m is the coefficient of the natural resource. The null hypothesis is tested against the two-sided alternative $H_A : \beta_m \neq 0$. This means that the null hypothesis is rejected whenever the t-value exceeds the critical value for the following levels of significance:

- 1% level: $t_{0.01} = 2.62$, indicated by ***
- 5% level: $t_{0.05} = 1.98$, indicated by **
- 10% level: $t_{0.10} = 1.66$, indicated by *

F-statistics

The F-values of the instrumented estimations are also reported below. They all satisfy the rule-of-thumb as they all exceed a value of 10.

The Hausman Test

The Hausman test results are obtained through STATA, like described in section 3. All tests are run under the H_0 : The instrument is exogenous. Under this hypothesis the test statistic is chi-squared distributed with 1 degree of freedom, as only the one instrument "Rule of Law" is tested for endogeneity. H_0 is rejected whenever the test statistic exceeds the critical value for the following levels of significance:

- 1% level: $t_{0.01} = 6.63$, indicated by *
- 5% level: $t_{0.05} = 3.84$, indicated by **
- 10% level: $t_{0.10} = 2.71$, indicated by ***

Sargan Test

The Sargan test statistics is here found though regression in STATA. The procedure is described in section 3. The test statistic reported in table 10 and 13 has 2 degrees of freedom since there are 3 instruments and 1 endogenous regressor. The Sargan test statistic in table 11 and 14 has only 1 degree of freedom as these are estimated with only 2 instruments. All the absolute values of the Sargan test statistics are found to be well below the critical value of rejection for a 1% level of significance, which are 2.71 and 4.61 with 1 and 2 degrees of freedom respectively. The null hypothesis that the model is correctly overidentified is therefore not rejected in neither of the estimations.

Tables 9 to 12 reports the test statistics for the regressions in section 4. Table 13 reports t-test statistics for the estimates on the conditional curse in section 6.

Table 9: Test statistics of estimates from table 2

Explanatory variable	Dependent variable	t-value	
Hydrocarb. deposits$_{PC}$	GDP$_{PC}$	3.79***	
Hydrocarb. deposits$_{PC}$	(GDP-R)$_{PC}$		2.67***
Value of oil output$_{PC}$	GDP$_{PC}$	4.17***	
Value of oil output$_{PC}$	(GDP-R)$_{PC}$		2.30**
Oil/GDP ratio	GDP$_{PC}$	2.17**	
Oil/GDP ratio	(GDP-R)$_{PC}$		1.11

Table 10: Test statistics of estimates from table 3

Explanatory var.	Dependent var.	t-value		F-value	Hausman	Sargan
Hydrocarb. dep.$_{PC}$	GDP$_{PC}$	5.11***		10.931	6.29*	2.21
Hydrocarb. dep.$_{PC}$	(GDP-R)$_{PC}$		2.42**	10.772	6.94	3.10
Value of oil output$_{PC}$	GDP$_{PC}$	5.77***		12.496	2.99**	3.12
Value of oil output$_{PC}$	(GDP-R)$_{PC}$		2.28**	12.910	3.52**	3.00
Oil/GDP ratio	GDP$_{PC}$	4.01***		12.041	5.26*	0.460
Oil/GDP ratio	(GDP-R)$_{PC}$		-0.01	12.448	5.46*	1.28

Table 11: Test statistics of estimates from table 4

Explanatory var.	Dependent var.	t-value		F-value	Hausman	Sargan
Hydrocarb. dep.$_{PC}$	GDP$_{PC}$	5.03***		21.287	2.78**	0.00
Hydrocarb. dep.$_{PC}$	(GDP-R)$_{PC}$		3.10***	21.130	6.81	0.01
Value of oil output$_{PC}$	GDP$_{PC}$	7.45***		21.856	6.11*	0.00
Value of oil output$_{PC}$	(GDP-R)$_{PC}$		4.10***	22.030	9.04	0.04
Oil/GDP ratio	GDP$_{PC}$	3.60***		21.240	9.46	0.02
Oil/GDP ratio	(GDP-R)$_{PC}$		1.73*	21.290	10.79	0.04

Table 12: Test statistics of estimates from table 5

Explanatory variable	Dependent variable	t-value	
Mining output$_{PC}$	GDP$_{PC}$	3.40***	
Mining output$_{PC}$	(GDP-R)$_{PC}$		2.21**
Mining/GDP ratio	GDP$_{PC}$	2.34**	
Mining/GDP ratio	(GDP-R)$_{PC}$		1.56

Table 13: Test statistics of estimates from table 6

Explanatory var.	Dependent var.	t-value		F-value	Hausman	Sargan
Mining output$_{PC}$	GDP$_{PC}$	3.13***		10.629	3.50**	1.84
Mining output$_{PC}$	(GDP-R)$_{PC}$		1.35	11.407	3.80**	2.09
Mining/GDP ratio	GDP$_{PC}$	1.71*		11.006	5.64*	0.63
Mining/GDP ratio	(GDP-R)$_{PC}$		-0.68	11.554	5.61*	1.13

Table 14: Test statistics of estimates from table 7

Explanatory var.	Dependent var.	t-value		F-value	Hausman	Sargan
Mining output$_{PC}$	GDP$_{PC}$	2.81***		20.724	7.92	0.44
Mining output$_{PC}$	(GDP-R)$_{PC}$		1.33	20.743	11.02	0.03
Mining/GDP ratio	GDP$_{PC}$	3.29***		20.159	9.22	0.81
Mining/GDP ratio	(GDP-R)$_{PC}$		1.22	21.125	11.07	0.05

Table 15: Test statistics of estimates from table 8

Line	Explanatory var.	Dependent var.	t-value of interaction term	t-value of N
1	Hydrocarb. dep.$_{PC}$	GDP$_{PC}$	-3.39***	3.93***
2	Hydrocarb. dep.$_{PC}$	(GDP-R)$_{PC}$	-2.35**	2.25**
3	Value of oil output$_{PC}$	GDP$_{PC}$	-3.64***	4.47***
4	Value of oil output$_{PC}$	(GDP-R)$_{PC}$	-1.49	1.93*
5	Oil/GDP ratio	GDP$_{PC}$	-0.91	1.68*
6	Oil/GDP ratio	(GDP-R)$_{PC}$	0.49	1.09
7	Mining/GDP ratio	GDP$_{PC}$	-0.70	1.45
8	Mining/GDP ratio	(GDP-R)$_{PC}$	0.80	1.01
9	Mining output$_{PC}$	GDP$_{PC}$	-2.76***	2.54**
10	Mining output$_{PC}$	(GDP-R)$_{PC}$	-1.66	1.15

C Full Presentation of the Regression Results

All regression results are presented here. The data material is available on request.

Table 16: OLS estimation results on oil wealth

Regressors	Dependent variable					
	GDP	GDP-R	GDP	GDP-R	GDP	GDP-R
Absolute latitude	0.037	0.040	0.038	0.040	0.038	0.041
European pop.	1.340	1.386	1.300	1.359	1.433	1.418
Latin Am. country	1.018	1.070	0.926	1.001	1.056	1.067
East Asian country	1.703	1.714	1.668	1.704	1.767	1.759
Hydrocarb.deposit	0.059	0.041				
Value of oil output			0.096	0.054		
Oil/GDP ratio					1.507	0.793
Constant	6.711	-0.366	6.593	-0.412	6.631	-0.387

Table 17: OLS estimation results on oil wealth with the interaction term

Regressors	Dependent variable					
	GDP	GDP-R	GDP	GDP-R	GDP	GDP-R
Rule of Law×N	-0.041	-0.029	-0.062	0.030	-0.835	0.387
Rule of Law	1.142	1.181	1.119	1.126	1.146	1.097
Ethnic fractionalization	-0.179	-0.277	-0.474	-0.522	-0.453	-0.506
European pop.	0.019	-0.002	0.121	0.838	-0.028	0.061
East Asian country	0.530	0.569	0.534	0.576	0.557	0.615
Latin Am. country	0.763	0.781	0.607	0.679	0.750	0.746
Hydrocarb.deposit	0.056	0.036				
Value of oil output			0.095	0.046		
Oil/GDP ratio					1.139	0.610
Constant	7.937	0.971	7.912	0.997	7.988	1.027

Table 18: OLS estimation results on mineral wealth

Regressors	Dependent variable			
	GDP	GDP-R	GDP	GDP-R
Absolute latitude	0.036	0.039	0.038	0.040
European pop.	1.377	1.489	1.300	1.467
Latin Am. country	0.941	1.046	0.926	1.070
East Asian country	1.628	1.734	1.668	1.734
Mining/GDP ratio			2.603	1.618
Mining output	0.094	0.061		
Constant	6.463	-0.509	6.567	-0.438

Table 19: OLS estimation results on mineral wealth with the interaction term

Regressors	Dependent variable			
	GDP	GDP-R	GDP	GDP-R
Rule of Law×N	-1.533	1.507	-0.053	-0.033
Rule of Law	1.130	0.992	1.192	1.197
Ethnic fractionalization	-0.486	-0.434	-0.474	-0.511
European pop.	0.051	0.271	0.129	0.077
East Asian country	0.744	0.835	0.552	0.573
Latin Am. country	0.702	0.716	0.638	0.698
Mining/GDP ratio	1.645	1.027		
Mining output			0.072	0.033
Constant	7.914	0.929	7.836	0.965

Table 20: All 2SLS IV estimation results on oil wealth

Regressors	Dependent variable											
	GDP	GDP-R	GDP	GDP-R	GDP	GDP-R	GDP*	GDP-R*	GDP*	GDP-R*	GDP*	GDP-R*
Rule of law	1.127	1.204	1.020	1.083	1.094	1.156	1.086	1.235	1.136	1.265	1.307	1.356
Ethnic fractionalization	-0.170	-0.167	-0.455	-0.442	-0.436	-0.375	0.107	0.124	0.227	0.192	0.204	0.193
European pop.	-0.54	0.023	0.097	0.161	0.066	0.055						
Latin Am. country	0.814	0.935	0.662	0.800	0.774	0.839	1.024	1.104	1.024	1.113	1.149	1.180
East Asian country	0.572	0.609	0.594	0.642	0.618	0.596	0.707	0.614	0.557	0.534	0.569	0.540
Hydrocarb.deposit	0.051	0.025					0.064	0.038				
Value of oil output			0.086	0.036					0.131	0.079		
Oil/GDP ratio					1.255	-0.002					2.567	0.993
Constant	7.893	0.814	7.890	0.893	7.951	0.941	7.616	0.600	7.343	0.428	7.493	0.533

* estimation using the small sample size, where rule of law is instrumented by mortality and absolute latitude.

Table 21: All 2SLS IV estimation results on mineral wealth

Regressors	Dependent variable							
	GDP	GDP-R	GDP	GDP-R	GDP*	GDP-R*	GDP*	GDP-R*
Rule of law	1.042	1.097	1.120	1.179	1.190	1.308	1.300	1.353
Ethnic fractionalization	-0.432	-0.422	-0.416	-0.339	0.288	0.235	0.216	0.206
European pop.	0.081	0.150	0.022	-0.005				
Latin Am. country	0.690	0.817	0.748	0.838	1.056	1.141	1.097	1.161
East Asian country	0.574	0.646	0.561	0.563	0.625	0.563	0.467	0.500
Mining output	0.062	0.025			0.082	0.036		
Mining/GDP ratio			1.444	-0.488			4.506	1.621
Constant	7.817	0.859	7.949	0.963	7.293	0.439	7.408	0.503

* estimation using the small sample size, where rule of law is instrumented by mortality and absolute latitude.