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Corruption, Development and the Curse of Natural Resources

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Corruption, Development and the Curse of Natural Resources

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Abstract

In 1995, Jeffrey Sachs and Andrew Warner found a negative relationship between natural resources and economic growth, and claimed that natural resources are a curse. Their work has been widely cited, with many economists now accepting the curse of natural resources as a well-documented explanation of poor economic growth in some economies (e.g., Papyrakis and

Gerlagh, 2004; Kronenberg, 2004). In this paper, we provide an alternative econometric framework for evaluating this claim, although we begin with a discussion of possible explanations for the curse and a critical assessment of the extant theory underlying the curse. Our approach is to identify natural resources that have the greatest rents and potential for exploitation through rent-seeking agents. The transmission mechanism that we specify works through the effect that rent seeking has on corruption and how that, in turn, impacts wellbeing. Our measure of wellbeing is the Human Development Index, although we find similar results for per capita GDP. While we find that resource abundance does not directly impact economic development, we do find that petroleum resources are associated with rent-seeking behavior that negatively affects wellbeing. Our regression results are robust to various model specifications and sensitivity analyses.

Keywords: natural resource curse, petroleum resources, unbalanced panels and GMM estimation

JEL Categories: O12, Q32, Q34, O43, O47

Corruption, Development and the Curse of Natural Resources

1. Introduction

In the late nineteenth and early twentieth century, Britain and France gained economic prosperity by exploiting the natural resources of their colonies. Britain benefited from gold and diamond extraction in South Africa, and France from harvesting rubber and mining bauxite in Guinea. During the nineteenth century, land was one of the most important natural resources, and land abundant countries such as Canada, the United States and Australia had some of the highest real wages in the world (Weil, 2005). Britain, Germany and the US relied heavily on coal and iron ores deposits during their industrialization phases (Sachs and Warner, 1995). Indeed, some developed countries still rely heavily on natural resources to this day (e.g., the forest sector accounts for some 5% of all jobs in Canada). These examples suggest that natural resources promote economic development.

History also tells us that natural resource abundance is not a requirement for economic prosperity. Switzerland is one of the wealthiest countries in the world today, but its path to economic prosperity depended on the financial and manufacturing sectors, not extraction of natural resources. More recently, Hong Kong, Singapore, South Korea and Taiwan developed despite a relative scarcity of natural resources. Nor does natural resource abundance guarantee economic prosperity. South Africa and Venezuela possess abundant natural resources but neither enjoys a high standard of living, as they are plagued by corruption, civil unrest and income inequality. These examples suggest that natural resources have a negative influence on economic development.

Cursory evidence suggests that natural resources are not a necessary condition for economic development, nor are they a sufficient condition for development. However, when in 1995 Jeffrey Sachs and Andrew Warner found a negative relationship between natural resources and economic growth, many economists accepted that natural resources might be an obstacle – indeed, a curse – to economic development (e.g., Papyrakis and Gerlagh, 2004; Kronenberg, 2004). But not all economists agree. Despite widespread acceptance of the curse hypothesis, there is significant contradictory evidence that suggests natural resource abundance may not hinder economic outcomes (e.g., Sala-i-Martin and Subramanian, 2003).

So, are natural resources a curse or a blessing? In this paper, we evaluate this question by developing a framework that differs somewhat from that used by others. We begin in section 2 by reviewing the extant literature, followed by a discussion of possible explanations for the existence of the curse. Then, in section 3, we provide a theoretical discussion about how the resource curse should be specified. In section 4, we develop an empirical model for evaluating the validity of the resource curse hypothesis, presenting the findings in section 5. We end with some concluding remarks.

2. Evidence For and Against the 'Curse' and Possible Explanations

In the resource curse literature, the most commonly cited work is by Sachs and Warner (1995; also 1997a, 1997b, 1999, 2001), who found a negative relationship between the share of primary exports in GDP and economic growth between 1970 and 1989. Although the cross country regressions they estimated indicate a negative relationship between natural resources and economic growth, the mechanism through which the resource curse operates is unclear. The authors claim to provide evidence of the negative effect of resource abundance on growth, but their measure of 'abundance' (share of primary exports in GDP) can better be interpreted as a measure of ‘dependence’ (the degree to which the economy depends on natural resources for its economic livelihood). To be fair, Sachs and Warner (1995) show that their results are robust to alternative specifications of resource abundance, but each of these has its problems. Two of the alternative measures they test (share of mineral production in GDP and fraction of primary exports in total exports) are similar to their first measure in that they really capture resource dependence, not resource abundance. (Similar results are found in Sala-i-Martin (1997), and Sala-i-Martin, Doppelhofer and Miller (2003).) The authors’ third specification (land area per person) does indeed constitute a measure of resource abundance, but, since not all land is the same, it is a very imprecise measure of primary sector productivity, as the authors recognize.

Additional support for the resource curse hypothesis is found in Naidoo (2004), who measures extraction of forest resources by using the area of forest cover that a country cleared during the period 1960-1999. He finds a negative association between the liquidation of forest resources and economic growth rates. Again, this measure may really reflect the degree to which a country is dependent on natural resources. Countries that cleared a large proportion of their forests in a given period may have done so out of necessity (there were no other feasible options to earn income). Naidoo controls for the absolute size of a country (to distinguish large, resource poor countries from small, resource rich ones), but fails to control for the impact of population when measuring a country’s resource abundance.

Sala-i-Martin and Subramanian (2003) find that, upon controlling for institutional quality, natural resources are not significantly related to economic growth. They also show that the effect of natural resources depends on the particular ones being considered. Fuel and mineral resources negatively impact institutions (and hence economic growth), but the relationships between economic growth and other types of resources are generally found to be statistically insignificant.

This is a very important finding, because it suggests that the curse of natural resources may really be a curse of particular natural resources.

Papyrakis and Gerlagh (2004) concur with these findings. Upon taking corruption, investment, openness, terms of trade and schooling into account, they find natural resource abundance to have a positive impact on growth. Focusing on these additional explanatory variables may hold the key to unlocking the mystery of the resource curse. However, although these authors claim to have found a connection between natural resource abundance and economic growth, their measure of resource abundance (share of mineral production in GDP) remains problematic. This variable measures resource intensity and not abundance, but, as shown by Sala-i-Martin and Subramanian (2003), abundance of mineral and fuel resources may not yield the same economic outcome as abundance of other natural resources.

Manzano and Rigobon (2001) build on Sachs and Warner's model by re-estimating the effect of natural resources on economic growth using panel data and alternative measures of the non-resource side of the economy. Interestingly, in every specification they use, the negative impact of the resource curse appears in their cross-sectional data, but is insignificant when they estimate a fixed-effects panel data model.

The literature also provides a number of possible explanations for the natural resource curse. We consider six possible explanations. First, the Dutch disease phenomenon historically described the situation where a rise in the value of natural resource exports caused a country's real exchange rate to appreciate, thereby making it more difficult for that country to compete internationally. An increase in natural resource exports could be caused by increases in export commodity prices, or by an increase in the commodity export volume (perhaps due to the discovery of new resources, as was the case in the Netherlands with the discovery of natural gas in the late 1950s). Economists expect increased emphasis on primary sector production and reduced attention to the secondary or manufacturing sector to have a negative impact on economic growth (Kronenberg, 2004; Papyrakis and Gerlagh, 2004). More recently, the Dutch disease explanation has placed less emphasis on exchange rate movements and more on economic distortions that encourage growth of the primary sector at the expense of more advanced sectors, such as manufacturing (Barbier, 2003). Further, volatility of commodity prices could harm the domestic economy by creating uncertainty that reduces exports, trade and foreign investment (Gylfason, 2001).

Second, Barbier (2003) points out that "any depreciation of natural resources must be offset by investment in other productive assets" (p.263). However, he finds that in many developing countries resource rents are not generally channelled into productive investments, but are frequently dissipated through corruption, bureaucratic inefficiency and policies aimed at rent-seeking interest groups. A major focus in this paper is on the relationship between natural resources and rent seeking behavior.

Third, countries with abundant natural resources may have reduced incentives to invest in human capital. Temporary wealth from resource sales may cause countries to under-estimate the need to accumulate the human capital needed to foster long-term growth. There is some evidence that public spending on education is negatively related to abundance of natural resources (Gylfason, 2001).

Fourth, Gylfason (2001, 2002) considers how abundance of natural resources reduces incentives to save and invest, thereby limiting physical capital formation and economic growth. In his argument the demand for capital falls as owners of capital earn a higher share of output, thus lowering real interest rates and reducing investment.

Fifth, there is an interesting and expansive literature that examines the relationship between resource rents and civil war. Collier and Hoeffler (2004) argue that extortion of natural resources provides an opportunity to finance rebellion. Lujala, Gleditsch and Gilmore (2005) show how rebel groups have used resource rents to finance warfare and personal incomes; resource rents provide income for corrupt governments while simultaneously making it more desirable to hold political power. Further, existence of resource rents provides an incentive to overthrow the government, while an abundance of natural resources creates opportunities for looting and extortion that provide insurgents with the financial means to undertake rebellion.

Using logit regression to predict the outbreak of civil war, Collier and Hoeffler (2004) find that the share of primary commodity exports in GDP is a significant predictor of conflict. However, upon disaggregating commodity exports into various subgroups, only oil exports turn out to be a significant predictor of conflict. Further evidence supporting this claim comes from Fearon (2005), and from Lujala, Gleditsch and Gilmore (2005), who find a positive relationship between diamond production and the incidence of civil war. The latter find, however, that this is the case only for secondary diamonds that can be looted, while production of primary diamonds (that cannot be looted) is negatively related to the incidence of civil war. Clearly, resource characteristics and their ability to generate rents must be taken into account when investigating the resource curse.

Finally, Sachs and Warner (2001) claim that the natural resource curse exists independent of commodity prices, but others believe it is a result of commodity price volatility. For example, Manzano and Rigobon (2001) argue that high commodity prices in the 1970s encouraged resource-abundant developing countries to borrow heavily. When commodity prices dropped in the 1980s, these countries were left with a large debt burden and a lower stream of resource rents to service this debt. The resource curse disappears once this ‘debt-overhang’ problem is taken into account (Manzano and Rigobon, 2001). Similar arguments relating to commodity price volatility are made by Deaton (1999), Gelb (1988) and Auty (1993). Interestingly, Deaton shows that commodity prices, while highly volatile, lack a distinct upward trend. If real commodity prices do not grow over time, any country dependent on them will have difficulty achieving long-run growth. Meanwhile, Collier and Goderis (2007) used a panel cointegration method to show that commodity booms have positive short-term effects on output, but adverse effects in the long run. However, these adverse effects are confined to non-agricultural commodities.

3. Defining the “Curse of Natural Resources”

While the curse of natural resources implies a negative relationship between natural resources and wellbeing, it is well to ask how this relationship is defined. After all, natural resource *dependence* might result in low levels of wellbeing (however wellbeing is interpreted), or it might inhibit economic growth (of GDP or per capita GDP). Alternatively, *abundance* of natural resources might lead to low wellbeing or inhibit growth. Each of these relationships might operate through any one of the transmission mechanisms described above. While natural resources might affect economic growth rates, a country with slow economic growth but a relatively high standard of living cannot be considered cursed. Therefore, the most relevant research question should relate to levels of wellbeing and not to economic growth rates.

Even more important, using economic growth to address the resource curse hypothesis may result in spurious correlation between economic growth and natural resources. For example, suppose abundance of natural resources is good for economic development. As countries experience rising income levels, they tend to find that their economic growth rates decline.

Developed countries typically grow at relatively low, stable rates. Furthermore, they may find slow, stable growth desirable and attempt to prevent their economies from growing too quickly (to mitigate inflation, say). If natural resource abundance is good for economic development, most resource abundant countries will be developed nations, currently experiencing relatively slow but stable economic growth. In contrast, resource poor countries will tend to be less developed nations, and may experience more volatile economic growth rates. Hence, regressing economic growth rates on abundance of natural resources may lead to spurious correlation between these two variables.

While natural resource dependence might prevent countries from achieving a high standard of living, dependence on agricultural products can be easily accounted for by structural change theories of economic development. These theories suggest that economic development occurs as economies transition away from subsistence agriculture toward industrially diverse manufacturing and service sectors (Todaro and Smith, 2002; Lewis, 1954). It is the transition towards manufacturing and services that improve a country's total productivity. If countries do not make this structural transformation, and remain dependent on agriculture, it is unlikely that they will have the means to achieve higher productivity and increased standards of living.

The relatively simple concept of 'value-added' can also explain how resource dependence might inhibit economic development. Activities in the secondary and tertiary sectors of the economy tend to add more value than activities in the primary sector. The process of converting raw material into an automobile clearly adds more value than the process of extracting those raw materials. Because the secondary and tertiary sectors of the economy create more value added, economies with large secondary and tertiary sectors support higher standards of living. Economies with large primary sectors (high dependence on natural resources as a source of income) are not able to support these same standards of living. Virtually every country that has experienced rapid productivity gains in the past two centuries has done so by industrializing (Murphy, Shleifer and Vishny, 1989). The decreased importance of the primary sector allowed these countries to enjoy higher living standards. In this case, the natural resource curse seems to be a certainty, and researching it would not provide particularly novel insights.

Measuring Wellbeing and Resource Abundance

This only leaves the question of the relationship between resource abundance and levels of wellbeing. How should we specify wellbeing? Modern development economists, such as Amartya Sen, view development as a multi-faceted goal that can only be achieved holistically by increasing material, physical and psychological wellbeing. The common indicators used to measure these objectives include per capita GDP, the Gini coefficient (a measure of income inequality), infant mortality rates, life expectancy, literacy rates, and rates of enrolment in primary education. To address the resource curse hypothesis properly, therefore, the dependent variable should be specified in a way that captures this multi-dimensional aspect. A popular development index is the United Nations' *Human Development Index,* which equally weights income levels, health and education, but neglects the distribution of income. However, given that reliable estimates of income inequality are only available for selected countries at certain times, we employ both the Human Development Index (HDI) and GDP per capita to measure average standards of living across countries, although our focus will primarily be on the former.

We also need a proper measure of resource abundance. Gylfason (2002) identifies three possibilities: (i) the share of primary exports in total exports or share in GDP; (ii) the share of primary production in employment; and (iii) the share of natural capital in national wealth.

However, each of these measures fails to capture the true notion of resource abundance. We should think in absolute terms; for example, we could consider the absolute size of a country's inventory of natural resources, or natural resources per capita. To measure a country's natural resource abundance, we should not consider the size of its primary sector relative to the non-primary ones. Resource production as a share of total goods and services production, employment in the natural resource industry compared to other industries, or the value of natural resources compared to the value of all of other assets can more accurately be described as measuring the relative degree of resource dependence. The problem is that countries can have abundant natural resources (in terms of available resources per capita) and not have resources make up a large share of exports, employment or wealth. As a country develops other sectors of its economy, the share of natural resources in exports, employment and wealth should fall. Thus, it is important to distinguish between measuring natural resource abundance in relative terms (relative to the size of other sectors of the economy) and absolute terms (available natural resources per capita).

Of the measures proposed by Gylfason, measure (i) appears to be most commonly used to study natural resources and economic growth. In their influential paper, Sachs and Warner (1995) measure natural resource abundance using the ratio of primary product exports to GDP, finding a negative relationship between natural resources and economic growth. However, the use of this measure to model economic growth rates leads to endogeneity problems. Suppose that the secondary and tertiary sectors of economies grow faster than the primary sector. In these economies, the share of primary exports in GDP will decline over time, even if the primary sector contributes positively to economic growth. Thus, economic growth is correlated with a declining share of primary exports in GDP, leading to the conclusion that the primary sector is negatively related to economic growth. Nonetheless, as long as the primary sector is growing, the primary sector is actually contributing positively to economic growth. This is where the distinction between natural resource abundance and natural resource dependence becomes very clear. An abundance of natural resources may lead to positive economic growth, but if this comes at the expense of the secondary and tertiary sectors of the economy, this natural resource dependence may decrease economic growth.

Others have also pointed out various problems associated with measuring resource abundance by the share of primary commodity exports to GDP (Lujala et al., 2005; de Soysa, 2002). De Soysa (2002) measures resource abundance in terms of available natural resources per capita, similar to what is done in this study. We estimate available resource rents using per capita measures of resource exports and resource production. The transformation of resource exports and production into per capita terms is crucial in determining the extent to which resource rents have the potential to increase average living standards in a given country. If resource exports and/or production were measured in aggregate terms, then large countries with large populations would appear resource rich, when, in fact, the potential for resource rents to impact overall standards of living could be quite small. Similarly, small countries with modest populations would appear resource poor, even if the available natural resources per capita were substantial. Transforming aggregate natural resource exports and production into per capita terms creates a measure of resource abundance that more accurately reflects the potential for resource rents to impact average overall standards of living.

In this study, we consider only natural resources that are openly traded in the global market economy, namely, agricultural resources (e.g., grain, coffee, tea, beef), forest resources (e.g., pulp, lumber), fuel resources (e.g., coal, natural gas, crude oil), and ores and mineral resources (e.g., gold, tungsten, diamonds). As noted in the foregoing discussion, early studies treated all natural resources as relatively homogenous, whereas more recent studies indicate that the validity of the natural resource curse clearly depends on how natural resources are delineated (Sala-i-Martin and Subramanian, 2003; Collier and Hoeffler, 2004, 2005).

4. Framework for Evaluating the Natural Resource Curse

Discussions of the natural resource curse must begin by considering natural resource rent. Resource rents consist of scarcity rents plus differential (or Ricardian) rents (van Kooten and Folmer, 2004, pp.41-44). Scarcity rent refers to the difference between marginal revenue and marginal production cost that can only come about as a result of the natural or policy-induced scarcity of a resource. Differential rent, on the other hand, refers to the excess of the market value of non-marginal units of *in situ* resources over and above current scarcity rents. Differential rents are given by the area above the all factors variable resource supply curve and below the cost of providing the marginal unit. Scarcity rent is then the difference between output price and the marginal cost of providing the last unit multiplied by the amount of the resource provided. Resource rents are greater for some natural resources than others. Agriculture is unlikely to result in significant rents (with some exceptions), because agriculture is an annual activity that requires inputs of labor and capital each year to extract any rent, and rent is mainly of a Ricardian nature. There is a risk that output prices fall between the time of planting and harvest, or that adverse weather leads to low yields or crop failure. Further, while the surplus from agriculture can be a driver of economic development, rents in agriculture are generally too small or spread over too many landowners, or both, to attract the attention of rent seekers. It is not surprising, therefore, that the resource curse literature finds that “the inclusion or exclusion of agriculture does not much alter the basic results" (Sachs and Warner, 2001, p.831).

Forest resources offer a potentially much more valuable surplus to rent seekers than is generally available from agriculture. Large forest rents are feasible on some valuable sites of mature standing timber. However, forests rents are very much smaller or insignificant if the costs of tree planting and waiting for trees to mature are properly taken into account, as is the case with plantation forests. In many regions where deforestation takes place, it occurs because, after rents are captured through harvest, the land is more valuable in agriculture than growing trees. In some countries, forestlands are publicly owned with governments having some success in collecting related rents. Nonetheless, there are situations where illegal logging is rampant (e.g., Ukraine, Malaysia, Indonesia), because of the lucrative windfalls. In the resource curse literature, forestry is generally included with all other resources, ignored entirely, or no distinction is made between types of forest resources – natural forests that can generate large rents upon being logged and plantation forests that generally support processing and manufacturing activities.

The extraction of fossil fuels (especially crude oil), copper, uranium, and other valuable metals and minerals (especially diamonds and gold) has much greater potential to incite rent seeking behavior. The reason is that extraction activities are spatially much more concentrated than in forestry and agriculture, these activities generate much higher rents, and rent capture is generally easier. Without proper property rights, enforcement of property rights and independent courts, rent seeking leads to lawlessness and corruption to the detriment of the economy (De Soto, 2000; Anderson and Hill, 2004). Resource rents are dissipated in a variety of ways that include bribery in its various forms, spending on militias to protect the beneficiaries from other rent seekers, transfer of wealth to private overseas bank accounts, investments in overseas stock markets to the benefit of the ruling elite, and so on. The point is: The existence of resource rents encourages rent seeking, corruption and behavior that are ultimately detrimental to economic growth and development (Ades and Di Tella, 1999; Azfar, Young and Swamy, 2001). It is not the natural resources that are the curse, but government failure that is the problem. Governments do not define and enforce property rights, nor do they protect citizens from theft, which is commonly carried out by agents of government. The literature on the resource curse often hints at all this, but fails to expand on it in any formal way.[1]

If social institutions such as civil law and property rights exist, rent seeking and corruption may not occur to the same degree. However, the relationship between rent seeking and corruption and institutional quality is bi-directional. While well developed institutions may reduce corruption, corruption may also reduce the quality of institutions.

Econometric Specification

To overcome problems associated with endogeneity between institutions and corruption/ rent seeking, we employ a systems regression model:

(1) $y_{it} = \alpha_{it} + \beta_1 x_{1i} + \beta_2 x_{2it} + ... + \beta_K x_{Kit} + \varepsilon_{it} \quad , i= 1, ...,N; t= 1, ...,T_i,$

(2) $c_{it} = \delta_{it} + \gamma_1 z_{1it} + + \gamma_2 z_{2it} + ... + \gamma_M z_{Mit} + \xi_{it} \quad , i= 1, ...,N; t= 1, ...,T_i.$

Here y_{it} is a measure of economic wellbeing (HDI or per capita GDP) of country *i* in period *t*; x_{kit} (k=1, …, K) are characteristics of country *i* that influence wellbeing; c_{it} is control of corruption; and z_{mit} (m=1, …, M) are country- and time-specific factors that affect corruption. Our dataset is an unbalanced panel, allowing for countries to contribute observations for different time periods;

[1] Thus, Sachs and Warner (2001, p.48) state: "There is an inverse association between natural resource abundance and several measures of institutional quality". But they make no effort to explain why, other than to point out that quality of institutional measures is less than desirable.

the total number of observations is denoted by $n = \sum_{i=1}^{N} T_i$. Regressors were chosen on the basis of theory, empirical results from the literature, data availability and preliminary data analysis. These are discussed further below. Regressor parameters, β_k and γ_m, are assumed not to vary by country or time period, whereas, in this general model, the intercept terms (α_{it} and δ_{it}) are permitted to change with both country and time. Specific assumptions for these intercept terms are given below. The model's errors, ε_{it} and ξ_{it}, are assumed to have mean zero with possible heteroskedasticity of unknown form over *i* and *t*.

Our data are compiled from a variety of sources, although most indicators come directly or indirectly from the World Bank. (Detailed definitions of the variables and data sources are provided in Appendix A.) We have 366 (=*n*) observations covering 102 (=*N*) countries at possibly four points in time – 1998, 2000, 2002 and 2004. A list of countries is provided in Appendix B, while descriptive statistics for the variables are provided in Table 1. Monetary values are in constant 2000 US$. Forest output is measured in cubic meters of roundwood.

As a dependent variable in equation (1), we employ the HDI, which is a weighted index comprised of income (measured by purchasing power parity GDP per capita), health (measured by life expectancy at birth), and education (measured by adult literacy and gross school enrolment rate). As an alternative measure of wellbeing, we use per capita GDP in order to better place our analysis in the existing literature.

Table 1: Descriptive statistics of variables included in the model (n=366 observations)

Variable	Mean	Median	Minimum	Maximum	Std. Dev.
Human Development Index	0.718	0.753	0.302	0.965	0.163
Investment per capita	$1,205	$402	$16	$9,901	$1,835
Openness (trade as % of GDP)	78.5	70.5	17.2	228.9	38.7
Number of languages	6.7	3.0	1.0	46.0	7.6
Latitude	29.138	31.950	0.217	60.167	17.357
Control of corruption	-0.030	-0.323	-1.324	2.535	0.945
GDP per capita (2000 US$)	$5,527	$1,809	$126	$39,353	$8,687
Fuel exports per capita	$229	$24	$0	$8,611	$856
Ores & minerals exports per capita	$69	$17	$0	$1,010	$145
Forest production per capita	1.021	0.574	0.000	10.483	1.663
Regulatory quality	0.152	0.047	-2.569	1.990	0.821
Largest ethnic group	0.669	0.691	0.120	0.998	0.234
Civil war dummy[+]	0.221	0.000	0.000	1.000	0.416

Note: [+] For completeness, we report the standard deviation of the binary civil war dummy.

As to regressors in equation (1), Sachs and Warner (2001) include investment and degree of openness in their cross-country growth rates of income, and we expect that these would also influence cross-country differences in levels of income and wellbeing. However, we employ a nonlinear rather than linear specification between economic wellbeing and investment, because countries can expect decreasing returns to investment. Further, given that the HDI ranges from 0 to 1 while investment per capita has a very broad range of values, a nonlinear relation between HDI and investment per capita (measured in constant dollars) seems appropriate, as indicated in Figure 1 (*n*=366 observations). We use the inverse of investment rather than the log of investment, because it allows the marginal effect of investment on the HDI to decrease at a faster rate than would occur with the log of investment.

The number of languages in a country could negatively impact both the income and education components of the HDI. If the number of languages spoken in a country is large, it will be more difficult to conduct business (higher transaction costs), and the income indicator may be adversely affected. In addition, greater diversity of languages makes it more difficult for governments to deliver educational services, and the education indicators may also be affected.

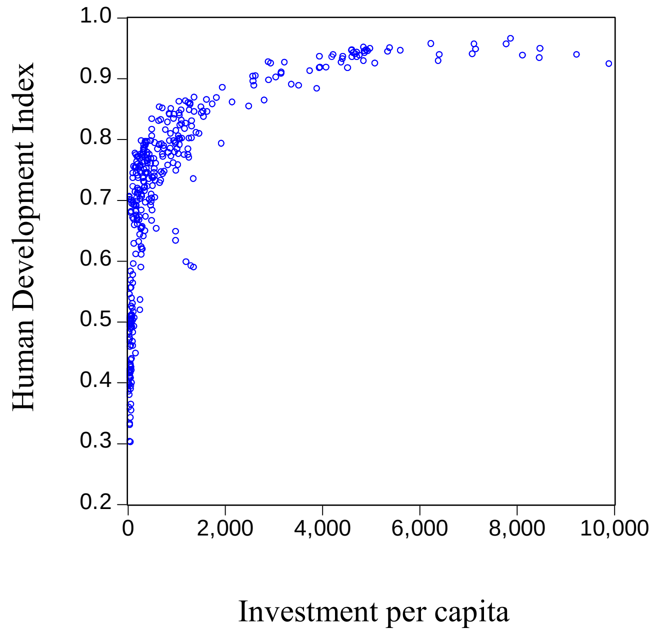

Figure 1: The Human Development Index vs. Investment Per Capita

Latitude is included in the HDI equation to capture other unobservable cross-country differences, such as geography and climate, which may affect the overall standard of living. It may also be a strong indicator of other important but otherwise unobservable differences across countries. Theil and Chen (1995), and Theil and Galvez (1995), show that differences in latitude can explain up to 70% of the variation in cross-country levels of income. Brunnshweiler and Bulte (2007) use latitude as an instrument for institutional quality in their estimation of the resource curse. In our data, the relationship between latitude and overall standards of living is quite clear as indicated in Figure 2 (*n*=366); the correlation between the HDI and latitude is 0.61. Countries farther from the equator (whether north or south) tend to have higher overall standards of living, while those near the equator have lower overall standards of living.

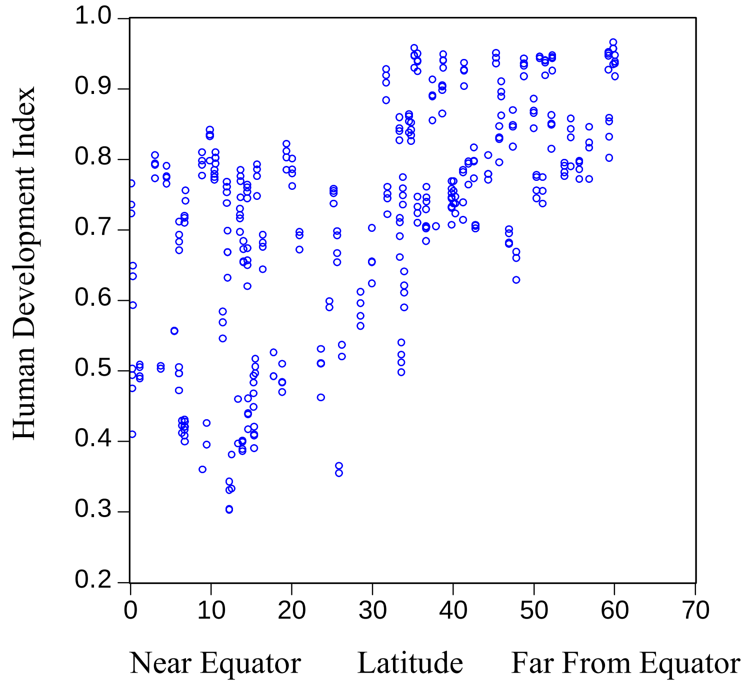

Figure 2: Human Development Index vs. Latitude

Finally, control of corruption is included in equation (1) because, as discussed above, it is through rent seeking and corruption that natural resources may lower overall levels of wellbeing. The relationship between the control of corruption variable and the HDI is shown in Figure 3 (*n*=366). It appears that the data support the hypothesis that higher levels of corruption are associated with lower levels of wellbeing. This general finding holds if we consider simple linear or nonlinear relationships between the HDI and control of corruption.

In the control of corruption equation (2), exports and production of resources per capita are used as proxies for resource rents. Potential rents from fuel resources and ores and mineral resources are measured in terms of dollar exports per capita, while those from forest resources are measured by the per capita volume of forestry production. In order to interpret the resulting coefficients on resource rents appropriately, per capita GDP is included in the regression. If per capita GDP were not included, the values of the resource variables would be a simple indicator of a country's level of income, which is highly correlated with control of corruption.

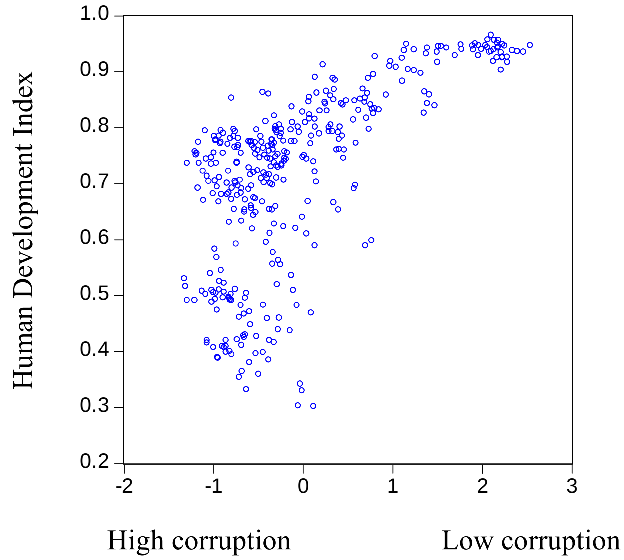

Figure 3: Human Development Index vs. Control of Corruption

The control of corruption equation also includes indicators of regulatory quality, ethnic diversity, and a dummy for recent civil war. Regulatory quality measures the quality of institutions, which may play an important role in mitigating the effect of resource rents on corruption activities. If the resource curse does exist, countries with well-developed institutions should be able to overcome it.

The largest ethnic group variable measures the country's largest ethnic group as a share of that country's total population. In general, where the largest ethnic group constitutes a smaller proportion of the population, there is more likely to be sizeable secondary and other ethnic groups. In our data, the correlation between the share of the population accounted for by the largest ethnic group and the share accounted for by the second largest ethnic group is –0.61. Countries with a smaller share of the population accounted for by the largest ethnic group are more likely to have secondary or tertiary ethnic groups of considerable size, which may lead to ethnic tensions. These in turn may be associated with a greater risk of internal conflict, and hence increased rent seeking. Internal conflict can lead to rent seeking and corruption as different groups try to achieve political and economic power. Further, if there is civil war, looting of natural resources may be more prevalent, increasing opportunities for bribery and corruption.

5. Empirical Results

The dollar value of fuel exports per capita is plotted against the dollar value of ores and mineral exports per capita in Figure 4. There are four clear points in the figure that are strong outliers, with very high levels of natural resource exports per capita. The four outliers are for Norway, thus providing evidence against the resource curse since Norway has a high HDI. Including this country might bias the results in favour of rejecting the resource curse claim. Upon estimating the model with and without this outlier, we found little impact on the results, indicating that our conclusions would not be sensitive to the inclusion of Norway. Given there is no reason to doubt the quality of data for this country, we chose to keep observations for Norway in the analysis.

As a validity test and before estimating our model, we decided to find out how well our data replicate those of Sachs and Warner (1995, Equation 1.4, Table 1, p.24). The dependent variable we use in this case is the growth rate of real GDP per capita between 1998 and 2004. Following Sachs and Warner (1995), we included estimates of initial income, investment, openness and rule of law. Investment, openness and rule of law were measured in the same manner as in our core model. The share of natural resource exports in GDP was derived from the shares of agricultural, fuel, and ores and mineral exports in total merchandise exports. With the exception of initial income, the average value of each variable was for the period 1998–2004.

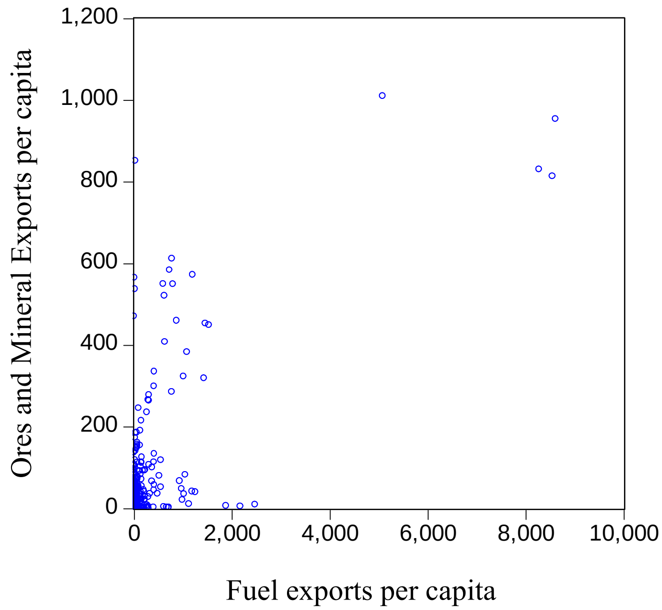

Figure 4: Ores and Mineral Exports Per Capita vs. Fuel Exports Per Capita

Sachs and Warner also measure openness and investment as averages over time. They measure openness by the fraction of years during the period that the country met certain 'openness' criteria, and they measure investment by the average investment to GDP ratio. One noticeable difference is that Sachs and Warner measure natural resource abundance as the share of primary exports in GDP at the start of the time period, while we chose to average the share of natural resources in GDP over time. The reason is that Sachs and Warner consider a relatively long time horizon (1970-1989), while we consider a period of only seven years (1998-2004). We used the average share of natural resource exports in GDP to minimize the possibility of getting erratic data for a particular country (e.g., due to an exogenous shock such as weather). Sachs and Warner measured resource exports at the beginning of the time period because their investigation period was much longer.

Sachs and Warner (1995) include 62 countries, but they do not provide a list of which ones, although they (1997b) do discuss a number of African countries that are missing from their analysis and make reasonable predictions of growth for those missing countries. With the exception of Mauritius and Togo, the same countries are missing from our data as well. As discussed in Appendix B, our data include 88 countries that represent a wide range of economies. Consistent with Sachs and Warner, we do not allow for individual country effects. The estimation results are provided in Table 2.[2] They confirm our prior expectations: Consistent with economic theory, the signs on initial income and the inverse of investment are negative, while those on openness and rule of law are positive, and all are statistically significant. Note that we are unable to reproduce Sachs and Warner's finding regarding the natural resource curse – the coefficient on natural resource dependence is insignificant. For comparison, Sachs and Warner's (1995) results are provided in Table 3. Their general conclusion regarding the resource curse does not appear to be robust. We investigate this further using our two-equation model.

Table 2: OLS estimation using a traditional model of the resource curse (n=88)

Dependent Variable: Growth Rate of Real GDP Per Capita, 1998-2004		
	Coefficient	St. Error
Constant	110.818	23.115***
Log GDP per capita, 1998	-12.173	2.761***
Inverse of investment per capita	-1383.082	381.682***
Openness	0.090	0.027***
Rule of law	9.368	3.228***
Share of natural resource exports in GDP	0.051	0.231
Adjusted R^2	0.208	

Note: Estimated standard errors are heteroskedasticity consistent. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

[2] All estimation is undertaken using EViews 6.

Table 3: Results from Sachs & Warner (1995) (n=62)

Dependent Variable: Annual Growth Rate of Real GDP Per Capita		
	Coefficient	St. Error
Constant	12.472	1.978***
Log GDP per capita, 1970	-1.921	0.308***
Average investment to GDP ratio, 1970-89	9.085	3.391***
Openness	2.167	0.564***
Quality of bureaucracy	0.370	0.117***
Share of natural resource exports in GDP	-7.806	2.653***
Adjusted R^2	0.597	

Note: ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Regression equations (1) and (2) were estimated jointly using a systems generalized method of moments (GMM) estimator allowing for the endogeneity issues identified earlier and heteroskedasticity of unknown form. The GMM estimator, obtained from minimizing a weighted quadratic objective function, is obtained from the moment conditions that the instruments are uncorrelated with the error terms; see, e.g., Greene (2008, Chapter 15). All exogenous variables are used to form the systems instrument matrix and we use a weighting matrix that is robust to heteroskedasticity and contemporaneous correlation of unknown form.

Specification of the intercept terms, α_{it} and δ_{it}, requires assumptions on unobserved heterogeneity; i.e., the time-invariant differences across countries and the country-invariant differences across time periods. Possible structures include pooled estimation, fixed effects and random effects. As our model includes important time-invariant regressors (e.g., latitude, ethnicity and number of languages), modelling the unobserved unit heterogeneity with fixed country effects would not enable parameter estimation for these time-invariant covariates. Accordingly, we estimated with fixed period effects and no unobserved country heterogeneity. The impact of any possible inconsistency is explored below.

The regression results are provided in Table 4. Hypothesis testing revealed that period effects are jointly insignificant in the corruption equation, but statistically significant in the wellbeing (HDI or per capita GDP) equation. Accordingly, we report results with fixed period effects in the wellbeing equation but not in the control of corruption equation.[3]

Table 4: Core empirical results (*n*=366)

	Wellbeing = HDI		*Wellbeing = Per Capita GDP*	
	Coefficient	Std. Error	Coefficient	Std. Error
Dependent Variable: Wellbeing				
Constant	0.730	0.014***	7440.165	615.301***
Inverse of Investment per capita	-10.029	0.978***	-1.283E05	2.111E04***
Openness	2.04E-04	9.33E-05**	-11.607	4.727***
Number of Languages	-0.004	7.12E-04***	-7.676	15.591
Latitude	0.002	2.07E-04***	60.280	8.508***
Control of Corruption	0.057	0.004***	6.793E03	278.488***
Year 2000 Dummy	0.011	0.010	563.928	410.748
Year 2002 Dummy	0.017	0.009*	1.036E03	403.728***
Year 2004 Dummy	0.032	0.010***	1.454E03	421.323***
Adjusted R^2	0.797		0.820	
Dependent Variable: Control of Corruption				
Constant	-0.555	0.054***	-0.546	0.046***
GDP per capita	5.16E-05	8.63E-06***	5.13E-05	8.40E-06***
Fuel Exports per capita	-1.29E-04	2.78E-05***	-1.40E-04	2.76E-05***
Ores/Mineral Exports per capita	9.07E-04	1.68E-04***	0.001	1.53E-04***
Forestry Production per capita	0.032	0.010***	0.028	0.009***
Regulatory Quality	0.533	0.048***	0.516	0.048***
Largest Ethnic Group	0.199	0.090**	0.184	0.080**
Civil War Dummy	-0.110	0.040***	-0.134	0.036***
Adjusted R^2	0.865		0.864	

Note: Estimated by GMM allowing for unknown heteroskedasticity. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

[3] Interestingly, whether we estimated models with or without fixed period effects had little impact on the overall conclusions. We also estimated our model using ordinary least squares, finding the single-equation OLS results to be quite similar to those of Table 4; the standard errors produced by OLS led to similar conclusions about the significance of the coefficient estimates.

Discussion

We first examine the results with wellbeing measured by the HDI index. As expected, the sign on the inverse of investment per capita in the HDI equation was negative, suggesting that higher levels of investment are associated with higher levels of the HDI. This result is statistically significant at the 99% confidence level. The coefficient on the openness variable also has the expected sign (positive), indicating that more open countries have higher standards of living, which accords with Sachs and Warner's model of economic growth. However, sensitivity analysis (not reported here but available upon request) indicates that the sign and statistical significance of the openness variable is not robust to econometric methodology.

The sign on the number of languages coefficient was negative, confirming the expectation that an increase in number of languages is associated with decreased levels of income and education. An increase in the number of languages in a given country should make it more difficult to conduct economic transactions and deliver educational services, thereby decreasing income, literacy rates and educational enrolment. Together these three indicators form two-thirds of the Human Development Index.

The coefficient on latitude was positive and significant, implying that countries farther away from the equator tend to have higher standards of living. Control of corruption was positively associated with the HDI, suggesting that countries with more corruption tend to have lower levels of wellbeing. This finding confirms the first part of the transmission mechanism through which we expect the resource curse (if it exists) to operate.

In comparison to the HDI results, when the dependent variable is PPP-adjusted GDP per capita the openness variable has an unexpected sign and the number of languages variable is no longer significant. In the control of corruption equation, the coefficients on each of the resource rent variables are significant, although the signs vary. The coefficients on ores and mineral exports and forestry production per capita are positive, while the coefficient on fuel exports is negative. Regulatory quality is positively associated with control over corruption, and the result is significant, indicating that, even if resources are a curse, improved institutional quality can help overcome this obstacle. Countries with better institutions tend to have more control over corruption and rent seeking. Finally, countries with a larger share of their population accounted for by the largest ethnic group (less ethnic diversity) experienced less corruption, and countries that experienced civil war experienced more corruption. These findings confirm our hypothesis that increased ethnic diversity and civil war provide opportunities for rent seeking and corruption as different groups try to gain political power. Overall, however, our finding that rents from fuel resources are an important part of the resource curse continues to hold.

To determine the relative importance of our explanatory variables with HDI as the measure of standard of living, we report standardized regression coefficients (beta coefficients) in Table 5. Such coefficients are also used by Bulte, Damania and Deacon (2005), for example. We computed beta coefficients for each of the variables of interest by multiplying each coefficient estimate from the core model (Table 4) by each variable's standard deviation (Table 1), and then dividing by the standard deviation of the associated dependent variable.[4] The reported beta coefficients measure the magnitude of each variable in terms of standard deviations, providing one way of ascertaining the relative contribution of the variable to the prediction of the dependent variable. For example, a one standard deviation increase in numbers of languages variable is associated with a 0.21 standard deviations decrease in the HDI, ceteris

[4] The standard deviation of the inverse of investment per capita is not provided in Table 1. This standard deviation was computed separately as equal to 8.164E-03.

paribus. From the table, investment and control of corruption are the two most important indicators of a country's standard of living, while openness appears to be less important.

Table 5: Standardized regression coefficients (beta coefficients) from the core model

Human Development Index	*beta coefficient*	*Control of Corruption*	*beta coefficient*
Inverse of Investment per capita	-0.50	GDP per capita	0.47
Openness	0.05	Fuel Exports per capita	-0.12
Number of Languages	-0.21	Ores/Mineral Exports per capita	0.14
Latitude	0.16	Forestry Production per capita	0.06
Control of Corruption	0.33	Regulatory Quality	0.46
		Largest Ethnic Group	0.05
		Civil War Dummy[+]	-0.05

Note: [+]Although it is meaningless to consider the standard deviation of a dummy variable, we report the civil war dummy variable's beta coefficient for completeness.

In the control of corruption equation, per capita GDP and regulatory quality appear to be the most important indicators of the dependent variable. Although the coefficients on resource exports per capita are smaller, they all appear to contribute more to the prediction of control of corruption than the ethnicity and civil war variables. The beta coefficient on fuel exports per capita is -0.14, and the beta coefficient on ores and mineral exports per capita is 0.15. Bulte, Damania and Deacon (2005) estimated the impact of point resources (resources concentrated in a narrow geographic region, including oil, minerals, and plantations) on two measures of institutional quality: rule of law and government effectiveness. In the rule of law equation, they obtained a beta coefficient of -0.21 on point resources, and in the government effectiveness equation, they obtained a beta coefficient of -0.27 on point resources. In comparison, the beta coefficients we obtain on fuel exports and ores and mineral exports seem reasonable.

The results suggest that in determining whether or not natural resources are a curse or a blessing, individual types of natural resources must be considered separately. If all types of resources are aggregated into one measure, the positive and negative impacts of different resource types would offset each other, resulting in insignificant results and misleading conclusions. Our results suggest that fuel resources can be considered a curse, because large rents available from exploitation of fuel resources are associated with increased levels of rent seeking and corruption that lead, in turn, to lower standards of living. A similar conclusion was reached by Fearon (2005), who demonstrates that oil exports are positively associated with increased risk of internal conflict. In our analyses, institutional quality can offset the impact of the fuel resource curse. As indicated in Table 5, the magnitude of the regulatory quality variable is much greater than that of the fuel exports per capita variable. This suggests that improvements in institutional quality can more than offset the curse of fuel resources. This might explain why some countries, such as Norway, have both high levels of fuel exports per capita and high standards of living. On the other hand, availability of ores and minerals, and to a lesser extent forest resources, might be a blessing rather than a curse.

Sensitivity Analysis

OLS is used to estimate each of the model equations separately, using a pooled estimator and, to allow for individual country unobserved heterogeneity, by fixed-effects and random-effects estimation. For the fixed effects case, we had to drop the time-invariant variables. Regression results are provided in Table 6. In each case, we continue to allow for period fixed effects in the HDI equation but not in the control of corruption equation. We observe that the pooled estimates using the independent equations are quite similar to those obtained with our systems GMM estimator (Table 4), although the latter is more appropriate because it explicitly allows for endogeneity of some of the regressors.

Table 6: Estimation of the system using separate equations

	Pooled		*Fixed effects*		*Random effects*	
	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Human Development Index						
Constant	0.728	0.015 ***	0.693	0.008 ***	0.658	0.019 ***
Inverse of Investment per capita	-9.277	0.570 ***	-0.158	0.468	-1.890	0.425 ***
Openness	1.47E-04	1.02E-04 *	1.14E-04	9.04E-05	8.84E-05	8.08E-05
Number of Languages	-0.005	0.001 ***	n/i	n/i	-0.008	0.001 ***
Latitude	0.002	2.72E-04 ***	n/i	n/i	0.003	4.46E-04 ***
Control of Corruption	0.053	0.005 ***	0.015	0.006 ***	0.030	0.005 ***
Year 2000 Dummy	0.009	0.011	0.019	0.002 ***	0.019	0.002 ***
Year 2002 Dummy	0.014	0.011	0.020	0.002 ***	0.020	0.002 ***
Year 2004 Dummy	0.029	0.011 ***	0.033	0.002 ***	0.032	0.002 ***
Adjusted R^2	0.797		0.995		0.602	
Control of Corruption						
Constant	-0.571	0.058 ***	-0.129	0.085 *	-0.673	0.100 ***
GDP per capita	4.49E-05	3.32E-06 ***	1.30E-05	1.71E-05	6.08E-05	5.25E-06 ***
Fuel Exports per capita	-1.17E-06	2.95E-07 ***	-8.37E-07	4.41E-07 **	-1.02E-06	3.06E-07 ***
Ores/Mineral Exports per capita	1.14E-05	1.99E-06 ***	-3.51E-06	3.07E-06	4.32E-06	2.13E-06 **
Forestry Production per capita	0.042	0.012 ***	0.050	0.034 *	0.069	0.019 ***
Regulatory Quality	0.520	0.034 ***	0.139	0.035 ***	0.240	0.031 ***
Largest Ethnic Group	0.209	0.082 ***	n/i	n/i	0.341	0.145 ***
Civil War Dummy	-0.110	0.045 ***	n/i	n/i	-0.189	0.080 ***
Adjusted R^2	0.868		0.982		0.607	

Note: n/i = not included as these are time-invariant regressors. ***, **, * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Many of the qualitative conclusions from the model are the same regardless of which estimator is employed. One notable exception is the effect of ores and mineral resources on control of corruption. In the pooled and random-effects models, this variable has a significant positive impact on control of corruption, but is insignificant in the fixed-effects model.

The estimates reported in Table 6 provide a means of examining whether there is unmodelled country specific heterogeneity. In the core model, the time-invariant variables (latitude, number of languages, ethnicity and civil war dummy) allow for some country specific differences but other unobserved heterogeneity may remain. Because these time-invariant variables are dropped from the fixed-effects equations, the resulting country specific constant terms (not reported in Table 6) capture the differences across countries from these observable variables included in the core model and any other relevant unspecified time-invariant covariates. To test for unobserved heterogeneity, we compare the sum of squared residuals from each pooled equation to those from each fixed-effects equation using an F-test. Results in Table 7 clearly indicate that further (unobserved) country-specific heterogeneity exists.

We also compare the fixed-effects and random-effects estimates using a Hausmann (1978) test. The outcome supports the use of fixed effects over random effects, and it implies that the unobserved heterogeneous effects are correlated with other variables in the model, so that the pooled estimator is also likely inconsistent.

Table 7: Panel methods: Hypothesis tests results

Equation	Pooled Estimator vs. Fixed Effects Estimator (F-test)	Random-Effects Estimator vs. Fixed-Effects Estimator (Hausmann test)
Human Development Index	F-statistic: 135.77 Degrees of freedom: 258, 99 Reject H_0	Chi-square statistic: 132.86 Degrees of freedom: 6 Reject H_0
Control of Corruption	F-statistic: 23.38 Degrees of freedom: 259, 99 Reject H_0	Chi-square statistic: 81.64 Degrees of freedom: 5 Reject H_0
Null Hypothesis (H_0)	Unobserved heterogeneity does not exist	Unobserved heterogeneity is uncorrelated with other variables in the model

Table 7 results indicate that the fixed-effects estimator is the most appropriate. Despite this, we chose to use a pooled estimator because, if the fixed-effects estimator is used, it would not be possible to estimate coefficients on the time-invariant variables. Recognizing that the pooled estimates may be inconsistent, we re-estimated the original model using fixed effects in order to judge the degree to which the inconsistency might affect the results. Although not shown here, we find there is little difference between the estimates, which suggests that the impact of the asymptotic bias on the pooled estimator is small. However, the coefficient obtained on the ores and minerals variable appears to be highly sensitive to the panel estimation technique that is employed. This highlights the need for further research on the resource curse using panel data.

To ensure that the results are not affected by the use of an unbalanced panel, the model was also re-estimated using the original data, but only for countries for which the data are available for all four years (see Appendix B). This reduced the total number of countries to 74 (*n*=296) from 102. Although not shown here, the results using a balanced panel are very similar to those in Table 4 obtained using an unbalanced panel. The reason is that there appears to be no systematic bias in dropping observations as both developed countries (e.g., Canada and Belgium) and developing countries (e.g., Cambodia and Ecuador) are dropped. The coefficient on the openness variable doubled, but all other coefficient estimates were remarkably similar. The coefficient on largest ethnic group was no longer significant, but this could be a direct result of the decrease in the available number of observations. Thus, we continue to rely on the results in Table 4, because, as Baltagi and Chang (2000) show, using an unbalanced panel is preferable to dropping observations just to balance the panel.

To determine how sensitive the results are to the specification of resource abundance, the core model was also re-estimated using the more conventional measure of resource abundance, the share of natural resource exports in GDP. In this case, the coefficient on resource abundance in the corruption equation is negative (-0.001), suggesting that resource abundance is indeed a curse, but the estimate is statistically insignificant (standard error = 0.002). This again highlights the need to specify an appropriate transmission mechanism between resources and wellbeing, and the importance of providing an appropriate measure of natural resource abundance.

7. Concluding Remarks

We evaluated the natural resource curse by considering the potential for resource rents to lead to corruption and rent seeking, which in turn affect standards of living or wellbeing. This is in contrast to traditional models of the natural resource curse that have focussed on using the share of primary product exports in GDP to explain differences in growth rates of GDP across countries. We also measured resource abundance in per capita terms, rather than as the relative share of resources in GDP. Finally, we examined the effect of natural resource abundance on the overall standard of living as measured by the Human Development Index rather than GDP, although results for PPP-adjusted per capita GDP are similar to those using the HDI.

Our findings indicate that it is important to treat different types of natural resources separately when addressing the validity of the resource curse hypothesis. Fuel resources are associated with increased rent seeking and potential corruption, suggesting that fuel resources may be considered a ‘curse’. Forest resources on the other hand appear to be associated with decreased rent seeking and corruption, indicating that forest resources may be a blessing rather than a curse. However, we did not distinguish between pristine and plantation forests, with the former capable of generating much greater rents than the latter. The relationship between ores and mineral resources appears to be positive, also suggesting that these resources are a blessing, although this result is sensitive to panel data estimation techniques and warrants further investigation. Through their impact on rent seeking and corruption, rents from fuel resources negatively impact overall standards of living across countries, as measured by both HDI and per capita GDP. This effect can be mitigated, however, by improving institutional quality in many countries so that rent seeking is minimized.

While our research focussed on a relatively short time horizon, it would be interesting to study how natural resource abundance impacts long-term changes in countries’ standards of living as more data become available. This could be done by using panel data that span a longer time horizon with longer intervals between periods.

Finally, natural resources provide a valuable flow of income to various countries. Throughout history, some resource-rich countries have grown rapidly and achieved high standards of living, while others have experienced corruption, civil war and widespread poverty. The relationship between natural resource abundance and overall standards of living is extremely complicated, and, before making any general claim about whether or not natural resources are a curse or a blessing, researchers should spend more time considering the mechanisms through which resource rents may help or hinder economic development. If resource rents are invested in infrastructure and social programs that increase long-term economic growth and distribute wealth to those in need, resource rents have the potential to increase overall standards of living. But if resource rents are captured by special interest groups and dissipated through corruption and rent-seeking behavior, resource rents may lead to lower overall standards of living and higher income inequality within countries. The capacity for resource rents to improve, rather than inhibit, economic development depends in large part on the role of government institutions and the nature of the resources generating the rents.

References

Ades, Alberto and Di Tella, Rafael. 1999. "Rents, Competition, and Corruption." *American Economic Review,* 89(4), pp.982-993.

Anderson, T.L., and Hill, P.J. 2004. *The Not So Wild, Wild West. Property Rights on the Frontier*. Stanford University Press, Stanford, CA

Auty, Richard M. 1993. *Sustaining Development in Mineral Economies: The Resource Curse Thesis.* London and New York: Routledge.

Azfar, Omar, Young, Lee, and Swamy, Anand. 2001. "The Causes and Consequences of Corruption." *Annals of the American Academy of Political and Social Science,* Vol. 573, Culture and Development: International Perspectives, pp.42-56.

Baltagi, Badi H., and Chang, Young-Jae. 2000. "Simultaneous Equations with Incomplete Panels." *Econometric Theory*, 16(2), pp.269-279.

Barbier, Edward B. 2003. "The Role of Natural Resources in Economic Development." *Australian Economic Papers,* 42(2), pp.253-272.

Brunnshweiler, Christa N., and Bulte, Erwin H. 2006. "The Resource Curse Revisited and Revised: A Tale of Paradoxes and Red Herrings." *Center of Economic Research at ETH Zurich Working Paper*, No. 06/61, Zurich, Switzerland.

Bulte, Erwin H., Damania, Richard, and Deacon, Robert T. 2005. "Resource Intensity, Institutions, and Development." *World Development*, 33(7), pp.1029-1044.

CIA (Central Intelligence Agency). 2007. *The World Factbook.* https://www.cia.gov/library/publications/the-world-factbook/index.html

Collier, Paul, and Goderis, Benedikt. 2007. "Commodity Prices, Growth, and the Natural Resource Curse: Reconciling a Conundrum." CSAE Working Paper: CSAE WPS/2007-15. http://www.csae.ox.ac.uk/workingpapers/pdfs/2007-15text.pdf

Collier, Paul, and Hoeffler, Anke. 2004. "Greed and Grievance in Civil War." *Oxford Economic Papers,* 56(4), pp.563-96.

—. 2005. "Resource Rents, Governance, and Conflict." *Journal of Conflict Resolution,* 49(4), pp.625-632.

De Soto, Hernando. 2000. *The Mystery of Capital. Why Capitalism Triumphs in the West and Fails Everywhere Else*. New York, NY: Basic Books.

de Soysa, Indra. 2002. "Paradise Is a Bazaar? Greed, Creed, and Governance in Civil War, 1989-99." *Journal of Peace Research,* 39(4), pp.395-416.

Deaton, Angus. 1999. "Commodity Prices and Growth in Africa." *Journal of Economic Perspectives,* 13(3), pp.23-40.

Fearon, James D. 2005. "Primary Commodity Exports and Civil War." *Journal of Conflict Resolution,* 49(4), pp.483-507.

Fearon, James D. and Laitin, David D. 2003. "Ethnicity, Insurgency, and Civil War." *American Political Science Review,* 97(1), pp.75-90.

Folmer, Henk and G. Cornelis van Kooten. 2007. "Deforestation." Chapter 7 in *Solutions for the World's Biggest Problems: Costs and Benefits* edited by Bjorn Lomborg. Cambridge, UK: Cambridge University Press.

Gelb, Alan H. 1988. *Oil Windfalls: Blessing or Curse?* Oxford: Oxford University Press.

Greene, William H. 2008. *Econometric Analysis, 6th Edition*. Upper Saddle River, NJ: Pearson-Prentice Hall.

Gylfason, Thorvaldur. 2001. "Natural Resources and Economic Growth: What is the Connection?" *Center for Economic Studies & Ifo Institute for Economic Research Working Paper,* No. 530, Munich, Germany.

Gylfason, Thorvaldur. 2002. "Mother Earth: Ally or Adversary?" *World Economics,* 3(1), pp.7-24.

Hausmann, Jerry A. 1978. "Specification Tests in Econometrics." *Econometrica*, 46(6), pp. 1251-1271.

Huntington, Samuel P. 1968. *Political Order in Changing Societies.* New Haven, CT: Yale University Press.

Kaufmann, Daniel, Kraay, Aart, and Mastruzzi, Massimo. 2007. "Governance Matters VI: Governance Indicators for 1996-2006." *World Bank Policy Research Working Paper, No. 4280*. Data: http://info.worldbank.org/governance/wgi2007/

Kronenberg, Tobias. 2004. "The Curse of Natural Resources in the Transition Economies." *Economics of Transition,* 12(3), pp.399-426.

Leff, Nathaniel. 1964. "Economic Development through Bureaucratic Corruption." *American Behavioral Scientist,* 8(3), pp.8-14.

Lewis, W. Arthur. 1954. "Economic Development with Unlimited Supplies of Labour." *The Manchester School,* 28(2), pp.139-191.

Lujala, Päivi, Gleditsch, Nils Petter, and Gilmore, Elisabeth. 2005. "A Diamond Curse?: Civil War and a Lootable Resource." *Journal of Conflict Resolution,* 49(4), pp.538-562.

Manzano, Osmel and Rigobon, Roberto. 2001. "Resource Curse or Debt Overhang?" *National Bureau of Economic Research Working Paper,* No. 8390, Cambridge, MA.

Mauro, Paolo. 1995. "Corruption and Growth." *Quarterly Journal of Economics*, 110(3), pp.681-712.

Montenegro, Alvaro. 2004. "An Economic Development Index." *Econ WPA Working Paper, Development and Comp Systems Series,* No. 0404010. Available at: http://ideas.repec.org/p/wpa/wuwpdc/0404010.html

Murphy Kevin M., Shleifer, Andrei, and Vishny, Robert W. 1989. "Industrialization and the Big Push." *Journal of Political Economy*, 97(5), pp.1003-1026.

Naidoo, Robin. 2004. "Economic Growth and Liquidation of Natural Capital: The Case of Forest Clearance." *Land Economics,* 80(2), pp.194-208.

Papyrakis, Ellissaios and Gerlagh, Reyer. 2004. "The Resource Curse Hypothesis and its Transmission Channels." *Journal of Comparative Economics*, 32(1), pp.181-193.

Sachs, Jeffrey D. and Warner, Andrew M. 1995. "Natural Resource Abundance and Economic Growth." *National Bureau of Economic Research Working Paper*, No. 5398, Cambridge, MA.

—. 1997a. "Natural Resource Abundance and Economic Growth ." Revised version. Unpublished manuscript. Harvard Institute for International Development, Cambridge, MA.

—. 1997b. "Sources of Slow Growth in African Economies." *Journal of African Economies*. 6(3), pp.335-376.

—. 1999. "The Big Push, Natural Resource Booms and Growth." *Journal of Development Economies*. 59(1), pp.43-76.

—. 2001. "The Curse of Natural Resources." *European Economic Review,* 45(4-6), pp.827-838.

Sala-i-Martin, Xavier. 1997. "I Just Ran Two Million Regressions." *American Economic Review*, 87(2), pp.178-183.

Sala-i-Martin, Xavier, Doppelhofer, Gernot, and Miller, Ronald. 2003. "Determinants of Long-Term Growth: A Bayesian Averaging of Classical Estimates (BACE) Approach." *American Economic Review,* 94(4), pp.813-835.

Sala-i-Martin, Xavier and Subramanian, Arvind. 2003. "Addressing the Natural Resource Curse: An Illustration from Nigeria." *National Bureau of Economic Research Working Paper,* No. 9804, Cambridge, MA.

Theil, Henri and Chen, Dongling. 1995. "The Equatorial Grand Canyon." *De Economist*, 143(3), pp.317-327.

Theil, Henri and Galvez, Janet. 1995. "On Latitude and Affluence: The Equatorial Grand Canyon." *Empirical Economics*, 20(1), pp.163-166.

Todaro, Michael P., and Smith, Stephen C. 2002. *Economic Development*. Eight Ed. New York: Addison-Wesley.

UNCDB (United Nations Common Database). 2007. http://unstats.un.org/unsd/cdb/cdb_help/cdb_quick_start.asp

UNDP (United Nations Development Programme). 2000, 2002, 2004, & 2006. *Human Development Reports, selected years.* Available at: http://hdr.undp.org/en/reports/

van Kooten, G. Cornelis and Folmer, Henk. 2004. *Land and Forest Economics*. Cheltenham, UK: Edward Elgar.

Weil, David N. 2005. *Economic Growth*. Boston, MA: Addison-Wesley.

World Bank. 2007. World Development Indicators 2007. http://www.worldbank.org/ .

Appendix A: Data Definitions

Human Development Index

- Weighted index comprised of GDP per capita (purchasing power parity), adult life expectancy at birth, adult literacy rate, and combined gross school enrolment rate
- Source: United Nations Human Development Reports, selected years

Investment per capita

- Gross capital formation (constant 2000 US$) per capita
- Source: World Bank Development Indicators

Openness

- Trade volume expressed as a percentage of GDP
- Source: World Bank Development Indicators

Number of Languages

- Number of languages in Ethnologue that exceed minimum threshold (1% of population or 1 million speakers)
- Country observations are time invariant
- Data available at: http://www.stanford.edu/~jfearon/
- Source: Fearon and Laitin (2003)

Control of Corruption

- Measures the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interest

- Ranges from about -2.5 to +2.5 (higher values are associated with less corruption)
- Source: World Bank Governance Indicators

Latitude

- Latitude of the country's capital city
- Seconds of latitude were converted into fractions of a minute and expressed as decimal values
- Source: CIA World Factbook

GDP per capita

- GDP per capita (constant 2000 US$)
- Source: World Bank Development Indicators

Fuel Exports per capita

- Measures the relative abundance of resource rents from petroleum
- Measured in constant 2000 US $
- Derived from % of fuel exports in merchandise exports, merchandise exports (current $), population, and export deflator[5]
- Source: Derived from variables available from World Bank Development Indicators

Ores and Minerals Exports per capita

- Measures the relative abundance of resource rents from minerals and metals
- Measured in constant 2000 US $
- Derived from % of ores and minerals exports in merchandise exports, merchandise

[5] Export deflator was derived by dividing a country's current $ value of total exports by the constant 2000 US$ value of total exports.

exports (current $), population, and export deflator

- Source: Derived from variables available from World Bank Development Indicators

Forestry Production per capita

- Measures the relative abundance of resource rents from forestry
- Measured by cubic meters of roundwood produced per capita
- Derived from roundwood production (millions of cubic meters) and population
- Source: Derived from variables available from United Nations Common Database and World Bank Development Indicators

Largest Ethnic Group

- Measures the size of a country's largest ethnic group, as a share of the country's total population
- Data available at: http://www.stanford.edu/~jfearon/
- Country observations are time invariant
- Source: Fearon and Laitin (2003)

Regulatory Quality

- Measures the ability of government to formulate and implement sound policies and regulations that permit and promote private sector development
- Ranges from about -2.5 to +2.5 (higher values are associated with better regulatory quality)
- Source: World Bank Governance Indicators

Civil War Dummy

- Indicates whether or not a country had a civil war (internal conflict with at least 1,000 combat-related deaths per year) during the period 1980-1999
- Data available at: http://www.stanford.edu/~jfearon/
- Source: Derived from Fearon (2005) dataset

Appendix B: Countries Included in the New Framework

The sample in Table B1 below includes 102 countries and 366 observations. These are included in our core regression model (Table 4). Note that some countries do not have observations on all of the variables in the model for each of the four years (e.g., Canada). Only countries with observations for all of the four time periods were included in the balanced panel estimation (not shown), of 74 countries. Finally, we duplicate the regression model of Sachs and Warner (1995) in Table 2. In this case, observations are required on the relevant variables indicated in Table 2 with growth calculated using information for 1998 and 2004 (as discussed in the text). The necessary information is available for countries in Table B1 denoted with a *, plus Georgia, Grenada, Hong Kong, Iceland, Oman, Serbia & Montenegro, and the Slovak Republic, or a total of 88 countries. Note that, in this case for example, information on the required variables is available for Canada, while Canada is not included in the balanced panel as some information is missing for one of the four years.

Table B1: List of countries included in various regression models and number of years for which information on all variables in the core model are available

Albania*	4	Ghana	2	Pakistan*	4
Algeria*	4	Guatemala*	4	Panama*	4
Argentina*	4	Guinea	2	Paraguay*	4
Armenia	3	Guyana	3	Peru*	4
Australia*	4	Honduras*	4	Philippines*	4
Azerbaijan*	3	Hungary*	4	Poland*	4
Bangladesh*	4	India*	4	Portugal*	4
Belarus*	4	Indonesia*	4	Romania*	4
Belgium*	3	Iran*	4	Russian Federation*	4
Benin	3	Israel*	4	Senegal*	4
Bolivia*	4	Japan*	4	Slovenia*	4
Botswana	2	Jordan*	4	South Africa*	4
Brazil*	4	Kazakhstan	3	Sri Lanka	2
Bulgaria*	4	Kenya*	4	Sudan	2
Burkina Faso*	4	Korea, Rep. *	4	Swaziland	2
Cambodia	3	Kyrgyz Rep*	3	Sweden*	4
Cameroon	2	Latvia*	4	Syrian Arab Rep*	4
Canada*	3	Lebanon*	4	Tanzania*	4
Chile*	4	Lithuania*	4	Thailand*	4
China*	4	Macedonia*	3	Togo*	4
Colombia*	4	Madagascar*	4	Trinidad & Tobago*	4
Costa Rica*	4	Malawi*	4	Tunisia*	4
Cote d'Ivoire	3	Malaysia*	4	Turkey*	4
Croatia*	4	Mali	2	Turkmenistan	1
Czech Rep*	4	Mauritius*	4	Uganda*	4
Ecuador*	3	Mexico*	4	Ukraine*	4
Egypt*	4	Moldova*	4	United Kingdom*	4
El Salvador*	4	Mongolia	3	United States*	4
Estonia*	4	Morocco*	4	Uruguay*	4
Ethiopia	1	Mozambique	2	Venezuela*	4
Finland*	4	Netherlands*	4	Vietnam	3
France*	4	New Zealand*	4	Yemen*	4
Gabon*	3	Nicaragua*	4	Zambia*	4
Gambia	2	Norway*	4	Zimbabwe	3