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**OxCarre Research Paper 1**

**Do Natural Resources Depress Income Per Capita?**

*Revised, April 2010*

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# Do Natural Resources Depress Income Per Capita?

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## Abstract

Most evidence for the resource curse comes from cross-country growth regressions suffers from a bias originating from the high and ever-evolving volatility in commodity prices. This paper addresses these issues by providing new cross-country empirical evidence for the effect of resources in income per capita. Natural resource dependence (resource exports) has a significant negative effect on income per capita, especially in countries with bad rule of law or bad policies, but these results weaken substantially once we allow for endogeneity. However, the more exogenous measure of resource abundance (stock of natural capital) has a significant negative effect on income per capita even after controlling for geography, rule of law and *de facto* or *de jure* trade openness. Furthermore, this effect is more severe for countries that have little *de jure* trade openness. These results are robust to using alternative measures of institutional quality (expropriation and corruption instead of rule of law).

JEL Classification Numbers: C21, C82, O11, O41, Q30

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## I. INTRODUCTION

Resource-rich countries such as Congo, Nigeria, Bolivia, Sierra Leone, and Venezuela often fall victim to a ‘resource curse’. They have fared much worse than resource-poor countries like the Asian Tigers. Countries with a large share of natural resource exports typically have a relatively low income per capita, but there are notable exceptions such as Norway or Botswana. Countries with large exports of natural resources have worse growth performance than those with little or no natural resources (Sachs and Warner, 1997), especially if they are point-source resources (Isham et al., 2005). This curse can be turned into a blessing in countries with institutions that are of sufficiently high quality (Mehlum et al., 2006; Boschini, et al., 2007). Using growth regressions to investigate the impact of resources on growth can be misleading. Depending on whether the beginning and end year period is a peak or trough can bias the estimate of the effect of resources on growth. If volatility changes over time due to say boom-bust cycles as has been the case during the last decade, this can further bias this estimate. Furthermore, the cited evidence typically uses the ratio of exports of natural resources to GDP evaluated at the beginning of the sample period to explain growth during the following three decades. But this is a measure of resource dependence, not abundance (Brunnschweiler and Bulte, 2008)<sup>2</sup>. Resource dependence is problematic, because it is associated with little economic diversification and thus high dependence is associated with worse economic performance. Given the inherent volatility of commodity prices, valuation effects can bias estimation of the effect of resources on growth depending on the choice of the start and end date of the sample period. We therefore depart from the literature by using a stock measure of resource *abundance* (natural capital) rather than dependence (resource exports) to explain cross-country differences in *income* rather than growth. This ensures that both measures are valued at the same stage of the commodity price cycle. The prevailing literature on the resource curse suffers from some other shortcomings as well.

First, the implied Dutch disease story is that resource exports induce appreciation of the real exchange rate and decline of the traded sector. Growth falls if learning by doing externalities occur mainly in the traded sector. But political economy explanations of the resource curse (via worsening of institutions and rapacious rent seeking) may be relevant as well, since governments are involved in the natural resource sector through taxation, sale of licenses to foreign companies, state companies, thus inviting rent seeking. Others highlight that resources erode the critical faculties of politicians and keeps bad policies (a too generous welfare state, import substitution, restrictive trade policy, excessive borrowing, etc.) in place. The empirical resource curse literature makes no serious attempt to disentangle whether the adverse effect of resources on growth is due to loss of learning by doing, worsening institutions, or keeping bad policies in place. It is also unclear whether resources are the cause of bad institutions and bad policies or whether they aggravate the adverse effects of bad institutions and bad policies on growth.

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<sup>2</sup> Examples of resource-scarce but resource-dependent countries are most Sub-Saharan African countries. Resource-abundant and non-dependent-resource countries include Australia, Canada.

Second, the empirical evidence for the resource curse is flawed as often no allowance is made for endogeneity of, say, quality of institutions or degree of trade openness.<sup>3</sup> In contrast, the literature on explaining cross-country differences in income per capita stresses the search for good instruments to disentangle direction of causation and correct for endogeneity. For example, the instruments colonial origins and settler mortality rates affect institutional quality but not differences in income per capital directly (Acemoglu et al., 2001). A much larger sample is possible if institutions are instrumented by the fraction of the population speaking English or Western European languages as first language (Hall and Jones, 1999). Gravity equations for bilateral trade flows give instruments for international trade (Frankel and Romer, 1999). Using this diverse set of instruments, a ‘horse race’ finds that institutions trump geography/climate and openness in explaining cross-country variations in income per capita, but geography/climate may affect income per capita indirectly through the quality of institutions (Rodrik et al., 2004).<sup>4</sup> Although some deal with endogeneity of natural resource export revenues (Ding and Field, 2005; Brunnschweiler and Bulte, 2008), much of the empirical literature on the resource curse does not use instruments for investment, institutions and trade and thus ends up with biased estimates. Furthermore, apart from Mehlum et al. (2006) and Boschini et al. (2007), this literature does not distinguish between the effect of resource dependence on institutional quality and the interaction effect of resource dependence and institutional quality. Also, there is no attempt to identify the channel by which substantial natural resources might affect cross-country differences in growth.

Third, empirical evidence for the resource curse may not be robust. Natural resource endowment (measured by, respectively the World Bank (2006b) data on natural wealth and hydrocarbon deposits) has a *positive* effect while resource dependence (measured by natural resource exports) has a *negative* or even no effect on growth performance (Ding and Field, 2005; Alexeev and Conrad, 2005; Brunnschweiler and Bulte, 2008).

Finally, cross-country regressions suffer from omitted variable bias as they do not allow for correlation between initial level of productivity and past income (Islam, 2005). If this correlation is positive, the coefficient on lagged income is overestimated.. One way out is to drop lagged income per capita and focus on explaining income per capita.

Since the estimated effects of resources on growth fail to disentangle the various transmission channels, often ignore endogeneity issues, suffer from omitted variable bias, and lead to results that are not robust, we prefer to explain cross-country variations in income

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<sup>3</sup> Lederman and Maloney (2006) allow for endogeneity and different time periods and cannot reproduce Sachs and Warner (1997). They find that resource dependence has a *positive* effect on growth, whereas export concentration hampers growth, even after controlling for physical and human capital accumulation variables.

<sup>4</sup> Sachs (2003) disagrees and demonstrates that malaria transmission, strongly affected by ecological conditions, directly affects the level of income per capita after controlling for the quality of institutions. Malaria risk is instrumented by an index of malaria ecology (based on temperature, species abundance, etc.), which predicts malaria risk well.

rather than in growth in income per capita. The income-per-capita literature has a much richer tradition in allowing for endogeneity and instruments for institutions and trade openness. Our objective is to econometrically test whether there is *robust* evidence for a resource curse for income per capita, and to test whether such a curse if it exists is especially severe in countries with poor institutions and lack of openness to international trade.

We find limited support for the hypothesis that resource endowments have a *negative* effect on *income per capita*, and find that this curse is more severe in countries with little trade openness. Once we allow for endogeneity of the explanatory variables in our income-per-capita regressions, we find that empirical support for a curse of resources on income per capita is weak. Cross-country variations in economic growth are unlikely to be explained by resource stocks as natural resource stocks under the ground change very little over time (except in the rare case of large discoveries) compared to economic growth. This is why we offer resource curse results for income rather than growth in income per capita.

Section 2 takes as starting point the literature that explains cross-country variations in income per capita in terms of institutions, openness, and geography. Adding natural resource exports as an additional explanatory variable, we find a significant negative effect of resource exports on income per capita. We also find evidence of interaction terms suggesting that the natural resource curse particularly harms income per capita in countries with bad institutions or bad policies. When we estimate with instrumental variables techniques (IV) rather than OLS, we find that the results do not stand up very well as the estimates are less precisely determined and support for the curse is much weaker. Section 3 replaces the traditional *flow* measure of resource dependence (i.e., share of exports of natural resources in GNI) by the World Bank's recent *stock* estimates of natural capital (World Bank, 2006b). This allows one to study the effects of resource *abundance* rather than *dependence*. We find that resource abundance depresses income per capita, but less severely for countries that are *de jure* relatively open.<sup>5</sup> Appendix B demonstrates the robustness of our income per capita regressions to alternative measures of institutional quality (namely, expropriation and corruption). Section 4 concludes.

## II. INCOME PER CAPITA AND NATURAL RESOURCE DEPENDENCE

The empirical evidence for the negative effect of natural resource exports on growth performance is mixed (Arezki and van der Ploeg, 2009). The OLS regressions suggest that growth is higher in countries that have good institutions, invest a lot, are open to international trade, and have a low initial level of income per capita. Furthermore, OLS estimates suggest that growth is lower in countries that are rich in natural resources, especially if they restrict international trade and the quality of institutions is poor. Unfortunately, these results do not

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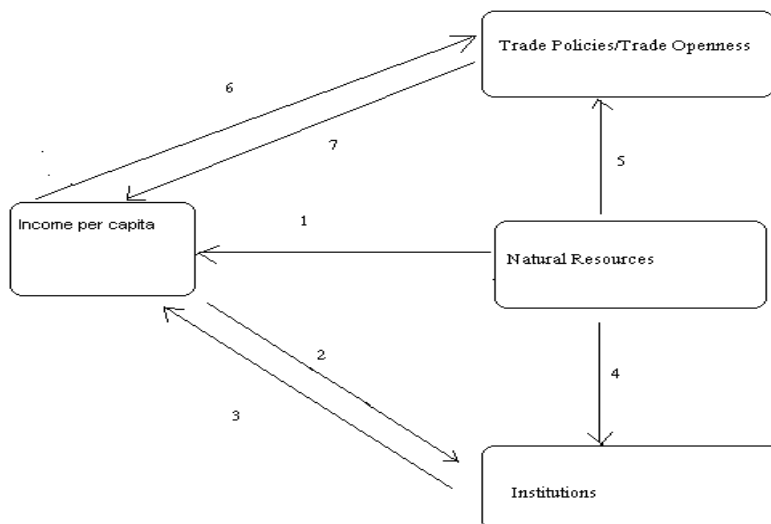
<sup>5</sup> We also estimated using the ratio of natural capital over produced capital and the ratio of natural capital to total wealth. Our results are qualitatively similar when using those alternative measures.

really stand up if institutional quality is instrumented by the logarithm of colonial settler mortality, legal origin, and the fraction of the population speaking English. Furthermore, the estimates suggest an implausibly slow speed of conditional convergence. To remedy this latter problem, it would help to estimate a dynamic panel. However, it is hard to identify valid instruments for endogenous variables that vary both across time and space. We therefore attempt to assess whether there is evidence that natural resources have additional explanatory power in addition to geography, openness, and institutional quality in explaining cross-country variations in the *level* rather than the *growth* of income per capita, using instruments available from the literature to address endogeneity issues.

Figure 1 indicates that there are various direct and indirect ways by which resource dependence can make a country poorer. The first one (arrow 1) is that natural resources through government involvement in the resource sector provide an open invitation to rapacious rent seeking. Unleashing rent seeking behavior is likely to lead to unproductive government spending, largely benefiting political elites. The resulting voracity effect lowers income per capita. It is an important reason why natural resources should be an important explanatory variable in any explanation of income per capita.

The second one (arrows 4 and 3) is that natural resources erode the quality of institutions (e.g., the rule of law) and via this channel lower income per capita. Indeed, political elites have no incentive to reinforce institutions such as the implementation of checks and balances and thus pave the way to “grabber friendly” institutions; talented individuals as a result engage in activities that are socially unproductive such as rent seeking (Mehlum, et al., 2006). Hence, resource-rich countries perform poorly compared to resource-poor countries.

**Figure 1: Direct and Indirect Effects of Natural Resources on Income Per Capita**



The third one (arrows 5 and 7) argues that the appreciation of the real exchange rate and the decline of the non-resource exposed sectors may induce a lobby for more restrictive trade policies (import substitution, subsidies for pet manufacturing companies, etc.) and in this way lower income per capita. Indeed, in countries that have adopted import substitution policies, entrepreneurs have little incentive to seek productivity gains. Also, import substitution has led to misallocation of factors in the form of the emergence of capital-intensive industries despite capital scarcity in those countries. All these inefficiencies have in turn led to low economic performance in those countries. Empirical evidence suggests that country with policies tilted towards more open trade regimes are less distortive and achieve a higher level of income per capita (Dollar, 1992; Sachs and Warner, 1995). One of the explanations put forward to explain such results is that adopting more outer-oriented trade regime prevents the government's temptation to put in place counterproductive policies such as import substitution policies. Of course, just like geography, trade policies/trade openness and the quality of institutions also have a direct effect on income per capita (arrows 7 and 3). Most prominently, North (1990) highlighted the the role institutions play in shaping economic performance by enabling private investment to thrive. Rodrik, et al. (2004) provide more systematic evidence for the role of institutions. However, income per capita might also affect trade openness and institutional quality (arrows 6 and 2). Indeed, richer countries would also certainly be in a better position to trade with other countries through the more sophisticated products they have to offer and achieve a better quality of institution through the availability of resources to the public brought about by higher income. From a statistical standpoint, it is thus important to look for good instruments (including natural resource dependence) to correct for the endogenous nature of these explanatory variables.

### A. OLS Estimates

Before we do that, Table 1 presents OLS regressions that explain cross-country variations in income per capita in the year 2003 (i.e.,  $\ln\text{GDP}/\text{cap}03$  in Appendix A). Regression (2) confirms the empirical results of a large number of empirical studies. Cross-country variations in income per capita are well explained by geography, institutions, and *de facto* openness. If a country is close to the equator, has limited rule of law, and is not much exposed to international trade, it is more likely to have low income per capita. In line with the horse race conducted by Rodrik, Subramanian, and Trebbi (2004) we find that institutional quality is the most important explanation of income per capita. However, regression (3) indicates that, even once we control for geography, institutions, and openness, natural resource exports in 1970 have a strong additional negative impact on income per capita. This gives empirical support for a significant natural resource curse effect at the 5 percent significance level.

Regressions (4) and (5) suggest that there is no evidence of significant interaction terms of natural resources with rule of law or openness.<sup>6</sup> To avoid problems arising from collinearity

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<sup>6</sup> When the non-resource exports openness indicator is used, it leads to qualitatively similar results. However, the variance of the coefficient associated with the non-resource trade openness indicator is now smaller,

(continued...)

of openness and institutional quality, regressions (6) and (7) try them one at a time. Regression (6) indicates that there is no evidence for a significant interaction term of the rule of law with natural resource dependence. If we drop the rule of law as an explanatory variable, regression (7) suggests that there is still no evidence of a significant interaction term of openness with natural resource dependence. Our preferred regression of Table 1 is thus (3). If the Liberia and Zambia had the same degree of resource dependence as Japan, they would suffer less from a resource curse.<sup>7</sup> In that case, regression (3) implies that their income per capita would, respectively, be 387 percent and 427 percent higher, everything else being equal.

**Table 1: OLS Regressions for Income Per Capita 2003 with Log of Natural Resource Exports**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
disteq	0.014*** [0.004]	0.016*** [0.004]	0.007 [0.006]	0.007 [0.006]	0.006 [0.006]	0.008 [0.006]	0.027*** [0.006]
rl01	0.906*** [0.066]	0.581*** [0.087]	0.652*** [0.118]	0.711*** [0.216]	0.576** [0.247]	1.065*** [0.190]	
lnopen		0.413*** [0.088]	0.417*** [0.107]	0.427*** [0.112]	0.716** [0.283]		1.012*** [0.287]
lnsxpr			-0.216*** [0.078]	-0.228** [0.087]	-0.088 [0.153]	-0.054 [0.076]	-0.187 [0.132]
interactrl01				0.025 [0.078]	-0.032 [0.093]	0.036 [0.071]	
interactlnopen					0.105 [0.095]		0.091 [0.091]
Constant	8.253*** [0.110]	8.686*** [0.163]	8.402*** [0.207]	8.398*** [0.209]	8.778*** [0.400]	8.272*** [0.189]	8.524*** [0.397]
Observations	162	130	96	96	96	109	97
R-squared	0.679	0.734	0.774	0.774	0.777	0.747	0.701

Standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

## B. IV Estimates

Rule of law and *de facto* openness suffer from endogeneity bias. Hence, we instrument rule of law with combinations of United Kingdom legal origin, log of settler mortality and fraction of population speaking English. We employ the colonial settler mortality data used by Acemoglu et al. (2001) as instrument for institutional quality. Colonial empires robbed states of their natural resources in which indigenous diseases were rife and survival prospects

reflecting the reduced colinearity with the natural resource indicator. Despite the variance associated with the interaction term between the corrected openness indicator and the natural resource indicator being smaller, it remains statistically insignificant.

<sup>7</sup> In the sample of 96 countries used in regression (5) in Table 1, Japan has the lowest share of exports of primary products in GNP in 1970.



were poor, and thus did not invest in good institutions. We separately use data on the fraction of the population speaking English or Western European languages as a first language used by Hall and Jones (1999) to instrument institutional quality. This has the advantage that it permits a much larger sample. We use an instrument based on a gravity model suggested by Frankel and Romer (1999) to instrument openness to international trade.

The IV approach requires that the instruments be valid, but it is hard to come up with truly exogenous instruments that satisfy the exclusion restriction (i.e., that do not affect the dependent variable directly, but only through the explanatory variables they are being used to instrument). Since there are few potential instruments, one may end up with just-identified specifications so that only a limited number of issues can be resolved. For example, there may be problems in using the two instruments for institutions and openness simultaneously. The reason is that the predicted values of the explanatory variables are typically very collinear, so that inference is unreliable. Also, these instruments for institutions and openness are strongly correlated with geography/climate and human capital variables, so that it is unclear what is being identified and there is thus plenty of room for disagreement about interpretation. For example, on the basis of Sachs (2003) one may argue that settler mortality rates capture the historical impact of geography/climate rather than of institutional quality installed by colonial settlers. Alternatively, Glaeser and others (2004) argue that settler mortality captures the human capital of European settlers rather than institutional quality. Similarly, the gravity instruments for international trade may simply capture the effects of geography on income per capita. Finally, it is difficult to resolve the issue of reverse causality. An instrument that strongly predicts the determinants of income per capita but has no correlation with income per capita itself is hard to find.<sup>8</sup>

Explanatory variables that do not suffer from endogeneity bias are also included in the set of instruments. Hence, natural resource exports are also an instrument for openness and rule of law.<sup>9</sup> This is important for obtaining consistent estimates, since Figure 2 suggests that rule of law and the ratio of natural resource exports (or natural capital) to national income are highly negatively correlated.

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<sup>8</sup> Rigobon and Rodrick (2004) split their sample into two sub-samples (colonies versus non-colonies and continents aligned along an East-West axis versus those aligned on a North-South axis) and exploit the differences in structural variance in these sub-samples to identify parameters. They find that democracy and especially the rule of law boost income per capita, but openness negatively affects income per capita and democracy and positively affects the rule of law.

<sup>9</sup> During the colonial era, resource-rich countries have been encouraged to export cheap natural resources (the “plunder” effect) but were not encouraged to set up democratic institutions since democratization could weaken the ability of colonial powers to plunder those natural resources. Thus, openness can have a negative effect on per capita income both because of a direct “plunder” effect and indirectly by its effect on the quality of institutions.

Figure 2: Correlation Between Rule of Law and Natural Resource Exports

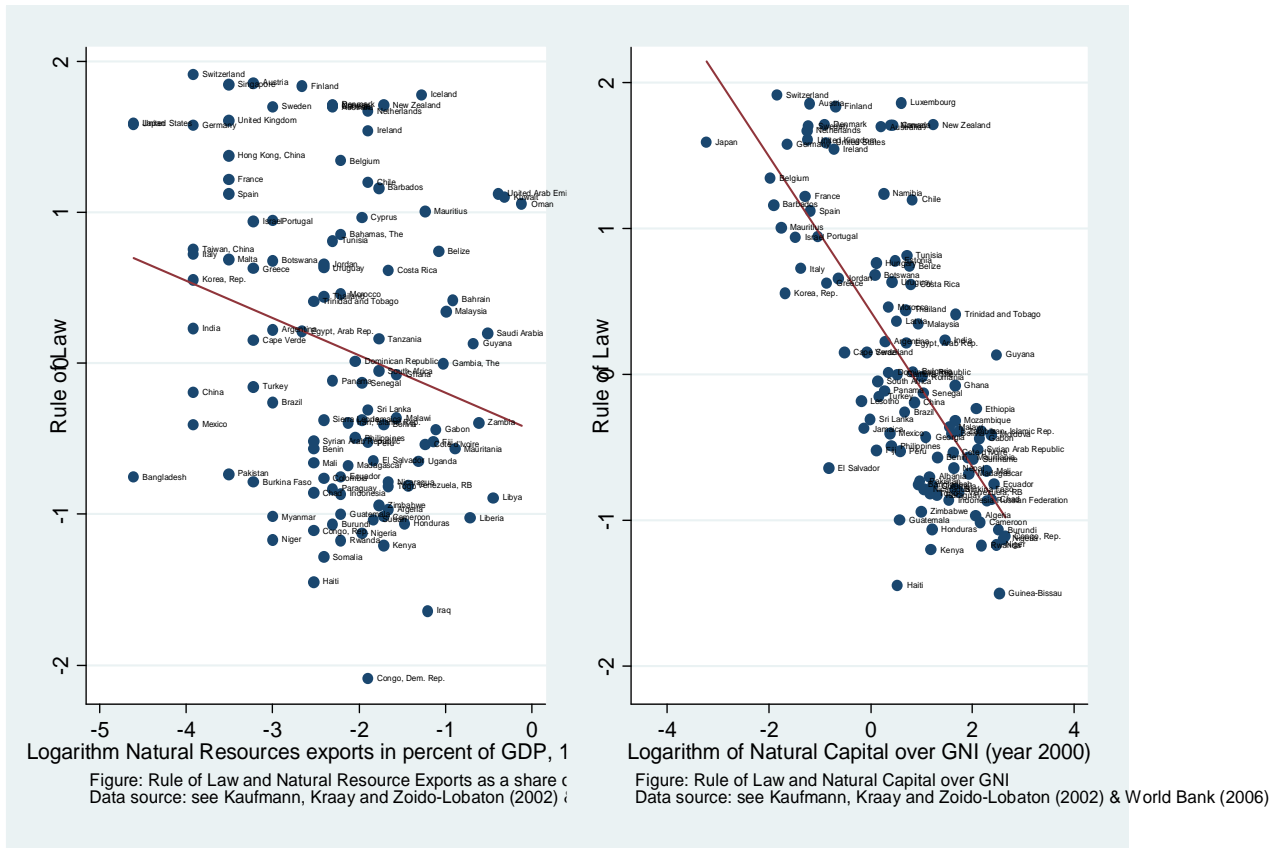


Table 2 presents the IV regressions for cross-country variations in income per capita in 2003 (i.e.,  $\ln \text{GDP}/\text{cap}03$ ). Although the core regression that explains cross-country variations in income by geography, institutions, and openness survives in the IV estimates, there appears to be a significant additional negative effect of natural resource exports in regressions (2) and (3) at the 5 percent level. However, rule of law is no longer statistically significant at the 5 percent level, while openness is at least significant in regression (2) and distance to the equator is of the right sign albeit statistically insignificant. Also, when using more instruments than endogenous variables, the over-identification tests suggest that we cannot rely on regressions (2) or (3). Regression (1) suggests that cross-country variations in income are explained by distance to the equator and a resource curse. Regressions (4)-(6) indicate that there is no evidence for interactive effects of natural resource exports with *de facto* openness, but there is some evidence of interactive effect with institutional quality, despite the over-identification tests suggesting that over-identifying restrictions are not valid.

Table 2: IV Income Per Capita 2003 Regressions Using Log of Natural Resource Exports

	(1)	(2)	(3)	(4)	(5)	(6)
rl01	0.337 [0.367]	0.391 [0.363]	0.656** [0.267]	0.980** [0.442]	0.485 [0.306]	0.488 [0.302]
interactrl01				0.177 [0.128]	0.235** [0.107]	0.214* [0.112]
lnopen	0.325 [0.306]	1.316*** [0.440]	0.407 [0.265]	0.470 [0.515]	0.718** [0.290]	0.528 [0.387]
interactlnopen						0.096 [0.099]
disteq	0.024* [0.014]	0.010 [0.015]	0.007 [0.009]	-0.016 [0.018]	0.001 [0.010]	0.003 [0.011]
lnsxp	-0.187* [0.100]	-0.512** [0.250]	-0.213** [0.093]	-0.326 [0.250]	-0.406*** [0.142]	-0.331* [0.178]
Constant	8.003*** [0.405]	8.990*** [0.312]	8.393*** [0.289]	8.936*** [0.272]	8.702*** [0.271]	8.731*** [0.266]
Instruments for:1/						
rl01	legor_uk	logsetmort, legor_uk, engfrac	legor_uk, engfrac	logsetmort, legor_uk, engfrac	legor_uk, engfrac	legor_uk, engfrac
lnopen	Infrinstex	Infrinstex	Infrinstex	Infrinstex	Infrinstex	Infrinstex
Observations	96	63	96	58	89	89
R-squared	0.736	0.506	0.774	0.611	0.748	0.76
overid pvalue	...	0.002	0.009	0.01	0.034	0.042

Robust standard errors in brackets

\*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

1/ Interactive variables are instrumented using lnsxp time the instruments used for the individual variables

### III. NATURAL CAPITAL AS EXPLANATORY VARIABLE

Our IV estimates indicate a negative effect of natural resource exports on income per capita. Here we use the estimates of natural capital for 2000 developed by the World Bank (2006b) to explain income per capita in 2003. Natural capital effectively corresponds to an estimate of the total stock of sub-soil assets, timber, non-timber forest resources, protected areas, cropland, and pastureland corrected for the renewable nature of resources when relevant. One might argue that natural capital over gross national income (GNI) better captures natural resource abundance than natural resource exports as a share of GNI, which may suffer from endogeneity bias. Brunnschweiler and Bulte (2008) argue that natural resource exports indicators often used in the resource curse literature capture resource *dependence* rather than resource *abundance*. A *stock* variable like natural capital may be more appropriate for explaining income per capita than a *flow* variable like natural resource exports, since it can capture forward-looking expectations of government and the private sector about future natural resource revenues. Indeed, if demand is iso-elastic and marginal extraction costs are zero, the Hotelling rule implies that resource prices grow at the market rate of interest and natural capital is then exactly equal to the discounted stream of resource revenues. More generally, one might expect natural capital to be closely related to the discounted value of natural resource rents. We thus wish to test the hypothesis that the discounted stream of all future resource rents proxied by natural capital rather than simply the current natural resource exports invites voracious rent seeking and thus harms income per capita. Using natural

capital as an explanatory variable also has the advantage that it is available for a larger number of countries.<sup>10</sup>

### A. OLS Regressions with *De Facto* Openness

Table 3 first presents the results from the OLS regressions. Interestingly, the log of natural capital always has a negative impact on income per capita and is significant at the 5 percent level in all regressions except (5).<sup>11</sup> Regressions (1) and especially (2) are again the core regression results that confirm that institutions, openness, and geography determine cross-country variations in income. Regression (3) indicates that the log of natural capital depresses income per capita even after allowing for the effects of distance to the equator, rule of law, and *de facto* openness. Regression (4) shows that there is no evidence of an interaction effect of natural capital with rule of law and regression (6) indicates that this is the case even if openness is dropped. This suggests that the disastrous consequences of rapacious rent seeking on growth are mainly elicited through natural resource export revenues rather than by how much oil, gas, or other resources are underground. However, regression (5) shows that the interaction term of natural capital with openness is significant at the 5 percent level. To avoid collinearity of rule of law and *de facto* openness, regression (7) drops the rule of law as an explanatory variable and now finds that at the 5 percent level natural capital has a significant negative effect and its interaction term with openness is now significant at 1 percent. The results thus suggest that income per capita is high for countries that are far from the equator and relatively open. There is evidence for a resource curse in the sense that natural resource abundance harms income per capita. Furthermore, this resource curse is less severe for more open economies. However, even for the most open countries in our sample, openness does not turn resource abundance into a blessing.

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<sup>10</sup> Stijns (2005) uses the reserves of oil, gas, coal, minerals, and land to test for the adverse effect of resource abundance on growth. He finds this is only the case for land, which correlates (in contrast to oil, gas, and minerals) with bad institutions and bad policies. He also stresses that the ability to turn the curse into a blessing depends on the nature of the learning process. Unfortunately, Stijns (2005) does not control for investment rates or the initial level of GDP per capita.

<sup>11</sup> This is in contrast to Brunnschweiler and Bulte (2008), who find a direct *positive* effect of resource abundance and an indirect *negative* effect of resource dependence (through worsening of institutional quality) on growth performance. It is also in contrast to earlier evidence using natural wealth data for a resource blessing for growth performance by Ding and Field (2005) and Alexeev and Conrad (2005).

**Table 3: OLS Income Per Capita 2003 Regressions Using Log of Natural Capital**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
disteq	0.014*** [0.004]	0.016*** [0.004]	0.013*** [0.005]	0.014*** [0.005]	0.014*** [0.004]	0.012*** [0.005]	0.026*** [0.004]
rl01	0.906*** [0.066]	0.581*** [0.087]	0.523*** [0.114]	0.480*** [0.118]	0.552*** [0.120]	0.624*** [0.115]	
Inopen		0.413*** [0.088]	0.254*** [0.095]	0.257*** [0.095]	0.101 [0.114]		0.291*** [0.102]
Innatcapitalovergni			-0.174** [0.067]	-0.198*** [0.069]	0.019 [0.114]	-0.213*** [0.071]	-0.168** [0.071]
interactrl01				0.068 [0.051]	-0.021 [0.063]	0.057 [0.054]	
interactInopen					0.187** [0.079]		0.157*** [0.059]
Constant	8.253*** [0.110]	8.686*** [0.163]	8.701*** [0.173]	8.768*** [0.179]	8.603*** [0.189]	8.492*** [0.148]	8.671*** [0.162]
Observations	162	130	106	106	106	107	112
R-squared	0.679	0.734	0.755	0.759	0.772	0.728	0.714

Standard errors in brackets  
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Table 4: IV Income Per Capita Regressions 2003 Using Log of Natural Capital**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
rl01	0.098 [0.594]	0.241 [0.654]	1.566*** [0.543]	1.123*** [0.347]	1.365*** [0.332]	1.293*** [0.295]	
Inopen		-0.433 [0.550]	-0.364 [0.554]	0.245 [0.382]			-0.442 [0.542]
interactrl01			0.044 [0.141]	-0.445 [0.328]	0.055 [0.134]	0.100 [0.119]	
interactInopen				0.662* [0.389]			0.077 [0.164]
disteq	0.025* [0.014]	0.027 [0.018]	-0.025 [0.023]	0.003 [0.009]	-0.019 [0.015]	-0.018 [0.014]	0.033*** [0.008]
Innatcapitalovergni	-0.413* [0.236]	-0.497 [0.342]	-0.081 [0.141]	0.910 [0.576]	-0.034 [0.136]	-0.041 [0.126]	-0.487 [0.328]
Constant	8.307*** [0.214]	7.763*** [0.796]	8.683*** [0.576]	8.752*** [0.491]	9.037*** [0.294]	9.047*** [0.286]	7.721*** [0.818]
Instruments for:1/							
rl01	legor_uk	legor_uk	logsetmort, legor_uk, engfrac	legor_uk, engfrac	logsetmort, legor_uk, engfrac	logsetmort, engfrac	...
Inopen	...	Infrinstex	Infrinstex	Infrinstex	...		Infrinstex
Observations	107	106	60	106	61	61	112
R-squared	0.656	0.548	0.387	0.513	0.502	0.514	0.503
overid pvalue	...	...	0.349	0.424	0.250	0.0885	...

Robust standard errors in brackets  
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1  
1/ Interactive variables are instrumented using Insxpr time the instruments used for the individual variables

## B. IV Regressions with *De Facto* Openness

In order to make inferences about the causality of the relationship between natural capital and income per capita, Table 4 corrects for the endogeneity of *de facto* openness and institutional quality and presents the resulting IV estimates. Apart from regression (4), the log of natural

capital has a negative impact on income per capita. This individual impact is significant in regression (1). There is no evidence of an interaction effect of natural capital with institutional quality. Furthermore, the interaction effect of natural capital with *de facto* openness has the right sign in regressions (4) and (7). It is significant at the 10 percent level in regressions (4) and the over-identification test suggests that the overidentification restrictions are valid.

### C. Natural Capital and *De Jure* Trade Openness

To enable comparison with Sachs and Warner (1997), we check the robustness of our results when using *de jure* openness (number of years that a country is rated open to trade) rather than *de facto* openness (sum of exports and imports as fraction of GD) as explanatory variable. The advantage of this measure is that it is more exogenous. Table 5 presents the resulting OLS regressions. All regressions show evidence of a significant negative effect at the 1 percent level of the log of the ratio of natural capital to GNI on income per capita. Income per capita clearly rises with distance from the equator, the rule of law, and *de jure* openness, but regression (3) shows that there is in addition a strong and significant resource curse effect at the 5 percent level even after controlling for these standard explanations of income per capita. Regression (4) gives evidence at the 5 percent level for a significant interaction effect of natural capital with rule of law, which suggests that the resource curse is less severe for countries with good institutions. Both institutional quality and trade policy indicators may reflect the willingness of the government to adopt good policies toward domestic and foreign investors and trade partners. Indeed, to avoid issues of multicollinearity, regression (7) drops the rule of law and its interaction with natural capital. There is then evidence of a significant interaction term of natural capital with *de jure* openness. Hence, if a country abandons trade restrictions, the resource curse seems to be less severe.<sup>12</sup>

To correct for the possible endogenous character of *de jure* openness and rule of law, Table 6 presents some IV regressions. There is almost always a negative individual effect of the log of the ratio of natural capital to national income, but it is only significant at the 10 percent level in regressions (1). Regressions in Table 6 indicate that there is no evidence of a significant interaction term of natural capital with institutional quality. Furthermore, in regressions (3)-(6) this term has the wrong sign. However, there is evidence of a significant interaction term of natural capital with *de jure* openness in regressions (3) and (4) where the interaction term is significant at the 10 percent level. The over-identification tests in regressions (3) and (4) also suggest that the overidentifying restrictions are valid. Trade policies directed toward more exposure to foreign competition and transfer of technology and

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<sup>12</sup> Indeed regression (7) in Table 5 indicates that the resource curse is attenuated by a higher degree of *de jure* openness. However, according to that regression, the curse can not be turned into a blessing.

managerial skills can thus weaken the resource curse and even transform it into a blessing for those countries with a sufficiently high degree of *de jure* openness.<sup>13</sup>

**Table 5: OLS Income Per Capita Regressions with Natural Capital and *De Jure* Openness**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
disteq	0.029*** [0.004]	0.012** [0.005]	0.015*** [0.005]	0.017*** [0.005]	0.017*** [0.005]	0.012*** [0.005]	0.027*** [0.004]
Innatcapitalovergni	-0.425*** [0.053]	-0.193*** [0.069]	-0.169** [0.074]	-0.199*** [0.073]	-0.312*** [0.110]	-0.213*** [0.071]	-0.474*** [0.094]
rl01		0.658*** [0.110]	0.533*** [0.128]	0.392*** [0.140]	0.454*** [0.147]	0.624*** [0.115]	
open6590			0.375* [0.220]	0.583** [0.235]	0.414 [0.265]		0.730*** [0.204]
interactrl01				0.127** [0.058]	0.032 [0.091]	0.057 [0.054]	
interactopen6590					0.281 [0.205]		0.417*** [0.137]
Constant	8.208*** [0.138]	8.439*** [0.139]	8.219*** [0.177]	8.256*** [0.174]	8.332*** [0.182]	8.492*** [0.148]	8.109*** [0.179]
Observations	114	107	100	100	100	107	100
R-squared	0.621	0.725	0.755	0.767	0.771	0.728	0.735

Standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

**Table 6: IV Income Per Capita Regressions with Natural Capital and *De Jure* Openness**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
rl01	0.098 [0.594]	0.694 [0.763]	3.148* [1.720]	2.561 [2.486]	2.270 [1.963]	1.365*** [0.332]	
open6590		1.706 [1.361]	-2.598 [2.675]	-1.930 [3.644]	-1.013 [3.452]		2.402 [5.144]
interactrl01		0.286 [0.197]	-1.059 [0.843]	-0.988 [0.875]	-0.649 [0.916]	0.055 [0.134]	
interactopen6590			2.793* [1.642]	2.813* [1.635]	2.214 [1.646]		2.762 [3.353]
disteq	0.025* [0.014]	-0.003 [0.024]	-0.045 [0.042]	-0.029 [0.066]	-0.029 [0.045]	-0.019 [0.015]	0.027** [0.013]
Innatcapitalovergni	-0.413* [0.236]	0.083 [0.174]	-1.021 [0.637]	-1.101 [0.659]	-0.766 [0.708]	-0.034 [0.136]	-1.084 [0.873]
Constant	8.307*** [0.214]	8.290*** [0.725]	10.454*** [1.477]	10.042*** [2.041]	9.723*** [1.778]	9.037*** [0.294]	8.356*** [1.357]
Instruments for:1/		logsetmort, legor_uk, engfrac	logsetmort, legor_uk, engfrac	logsetmort, legor_uk, engfrac	logsetmort, legor_uk, engfrac	logsetmort, legor_uk, engfrac	
rl01	legor_uk						
Inopen		Infrinstex	Infrinstex	Infrinstex	Infrinstex		Infrinstex
Observations	107	57	57	57	57	61	100
R-squared	0.656	0.525	0.096	0.229	0.244	0.502	-0.372
overid pvalue	...	0.390	0.877	0.502	0.542	0.250	...

Robust standard errors in brackets

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

1/ Interactive variables are instrumented using Insxpr time the instruments used for the individual variables

<sup>13</sup> In fact, regressions (3) and (4) of Table 6 imply that the resource curse is turned into a blessing thanks to a high degree of *de jure* openness for the following countries: Australia, Bolivia, Barbados, Canada, Chile, Ecuador, Indonesia, Mauritius, Malaysia, and the United States.

#### IV. CONCLUDING REMARKS

We show that there is a direct negative effect of natural resources on income per capita. Support for such a curse is found regardless of whether we use resource abundance (natural resource stocks) or resource dependence (resource exports) as an explanatory variable. Given that natural capital is more exogenous than natural resource exports, there may be a casual negative relationship between resource abundance and economic performance. We also find strong evidence that *de facto* trade openness (the sum of exports and imports as fraction of GDP) attenuates this curse. We also find that the more exogenous measure of *de jure* openness (the number of years that a country is rated open to international trade) weakens this curse provided that institutional quality is removed as determinant of income per capita (which is likely to be collinear with trade policies). Those results offer a different perspective on the natural resource curse literature, which has hitherto focused on the effect of resources on growth in income per capita rather than on income per capita.

In future work it is important to distinguish between *point-source* and *diffuse* natural resources. The former are typically associated with capital-intensive extraction and concentrated ownership while rents associated with the latter are more widely dispersed, hence point-source resources are more prone to rapacious rent seeking and lead to a more severe curse (Isham et al., 2005; Sala-i-Martin and Subramanian, 2003; Lay and Mahmoud, 2004; Bosschini et al., 2007). Building on cross-country evidence that volatility harms growth provided by Ramey and Ramey (1995), it is important to investigate whether and through which channels the notorious *volatility* of natural resource prices induces real exchange rate volatility and harms economic performance.

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## Appendix A: Data

Category	Variable	Mnemonic	Source
Initial income	log of real gross domestic product per capita (international \$ in current prices) in 2003.	lnGDP/cap03	Heston Summers and Aten PWT 6.2 (2006)
Openness	fraction of years during 1965–90 in which country is rated open ( <i>de jure</i> measure).	open6590	Sachs and Warner (1997)
	Log of average (exports+imports)/GDP, measured in constant 1985 US dollars.	lnopen	Dollar and Kraay (2002)
	log of extended version of Frankel and Romer (1999) instrument ( <i>de facto</i> measure).	Lnfrinstex	Dollar and Kraay (2002)
Resource dependence	share of exports of primary products in GNP in 1970.	lnsxpr	Sachs and Warner (1997)
Resource abundance	natural logarithm of natural capital 2000, in thousand of US \$ over GNI (in current US\$ 2000).	Innatcapitalovergni	World Bank (2006)
Institutions	rule of law 2000/01.	rl01	Kaufmann, Kraay, and Zoido-Lobaton (2002)
	log settler mortality.	logsetmort	La Porta et al. (2004)
	expropriation risk.	exproprisk	La Porta et al. (2004)
	corruption index (ICRG).	corrupt	La Porta et al. (1999)
	fraction of population speaking English.	engfrac	Hall and Jones (1999).
	legal origin—British.	legor_uk	La Porta et al. (1999)
Geography	distance from equator, measured as absolute value of latitude of capital city.	disteq	Sachs and Warner (1997)

## Appendix B: Robustness

Tables 7 and 8 present the IV regressions that explain income per capita in terms of distance to the equator, *de facto* trade openness, and expropriation risk or corruption (both obtained from the International Country Risk Guide) as alternative measures of institutional quality to rule of law.<sup>14</sup> Interestingly, the results also suggest a natural resource curse as there is a negative effect of the log of the ratio of natural capital over gross national income on income per capita even after controlling for the effects of geography and these alternative measures of institutional quality. However, this results is significant at the 5 percent level in regressions in Tables 7 and 8. However, Figure 3 displays a strong correlation between expropriation risk/corruption and natural capital. This suggests that natural resources have an adverse effect on income per capita through a worsening of institutional quality as illustrated by arrow 4 combined with arrow 3 in Figure 1. Furthermore, we find weak evidence of

<sup>14</sup> Knack and Keefer (1995) also use a variety of alternative measures of institutional quality to empirically examine the relationship between institutions and growth using cross-country data.

cross-country correlation between natural resource abundance and inflation.<sup>15</sup> One reason might be that averaging over a long period might smooth out the variation. Thus, further investigation of the empirical relationship between inflation and resource abundance using time series variation is needed. However, the high correlation (in absolute terms) between institutional quality and resource abundance suggests that resource abundance affects income per capita directly (affecting directly a nation's incentives to improve economic performance) and through damaging institutions and not necessarily through the so-called Dutch disease channel. Regressions Tables 7 and 8 again provide no evidence of an interaction effect of natural resources with expropriation risk or corruption. However, there is again evidence for an interaction effect of natural capital with openness in regression (4) in Tables 7 and 8.

**Table 7: IV Income Per Capita Regressions Using Expropriation Risk Index**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
exprop risk	0.085 [0.328]	0.634*** [0.174]	0.157 [0.383]	0.575*** [0.160]	0.360*** [0.132]	0.556*** [0.176]	0.415*** [0.126]	
interactexprop risk					0.088 [0.089]	0.037 [0.081]	0.055 [0.088]	
lnopen			-0.432 [0.567]	0.390 [0.360]	0.682* [0.380]	-0.487 [0.453]		-0.442 [0.542]
interactlnopen					0.722* [0.396]			0.077 [0.164]
disting	0.025 [0.016]	0.003 [0.010]	0.026 [0.021]	0.009 [0.007]	0.017** [0.008]	0.011 [0.008]	0.011 [0.009]	0.033*** [0.008]
lnnatcapitalovergni	-0.355** [0.172]	-0.203 [0.175]	-0.462 [0.307]	-0.177 [0.178]	-0.719 [0.519]	0.641 [0.916]	-0.618 [0.517]	-0.487 [0.328]
Constant	7.712*** [2.089]	4.337*** [1.265]	6.672*** [2.394]	5.145*** [1.320]	6.859*** [1.014]	4.055** [1.815]	5.751*** [0.914]	7.721*** [0.818]
Instruments for:1/								
rl01	legor_uk	logsetmort, legor_uk, engfrac	legor_uk	logsetmort, legor_uk, engfrac	logsetmort, legor_uk, engfrac	logsetmort, engfrac	logsetmort, legor_uk	...
lnopen	...	lnfrinstex	lnfrinstex	lnfrinstex	lnfrinstex	lnfrinstex	...	lnfrinstex
Observations	90	52	89	51	51	51	52	112
R-squared	0.655	0.508	0.534	0.607	0.619	0.622	0.572	0.503
overid pvalue	...	0.138	...	0.306	0.327	0.235	0.198	...

Robust standard errors in bracket  
\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>15</sup> The cross-correlations between inflation over the period 1970 to 1990 and the logarithm of natural resource exports over GNP in 1970 or the logarithm of natural capital over GNI in 2000 equal 6 percent and 9 percent, respectively. In future work we will investigate the empirical relationship between volatility in the real exchange rate and resource abundance.

