IMF Working Paper

Can the Natural Resource Curse Be
Turned Into a Blessing?
The Role of Trade Policies and
Institutions

Rabah Arezki and Frederick van der Ploeg

INTERNATIONAL MONETARY FUND

IMF Working Paper

Middle East and Central Asia Department

Can the Natural Resource Curse Be Turned Into a Blessing?
The Role of Trade Policies and Institutions

Prepared by Rabah Arezki and Frederick van der Ploeg[1]

Authorized for distribution by Ahsan Mansur

March 2007

Abstract

We criticize existing empirical results on the detrimental effects of natural resource dependence on the rate of economic growth after controlling for institutional quality, openness, and initial income. These results do not survive once we use instrumental variables techniques to correct for the endogenous nature of the explanatory variables. Furthermore, they suffer from omitted variables bias as they overestimate the effect of initial income per capita and thus underestimate the speed of conditional convergence. Instead, we provide new evidence for the impact of natural resource dependence on income per capita in a systematic empirical cross-country framework. In addition to a significant negative direct impact of natural resources on income per capita, we find a significant indirect effect of natural resources on institutions. We allow for interaction effects and provide evidence that the natural resource curse is particularly severe for economic performance in countries with a low degree of trade openness. Adopting policies directed toward more trade openness may thus soften the impact of a resource curse. We also check the robustness of our results by using a variety of instruments and also employing the ratio of natural capital rather than natural resource exports to national income as an explanatory variable. We find evidence that resource abundance, measured by the stock of natural capital, also induces a resource curse, but less severely for countries that are relatively open.

Contents   Page

I. INTRODUCTION

Anecdotal evidence in the press and elsewhere suggests that natural resource-rich countries often fall victim to a 'resource curse. Resource-rich countries such as Congo, Nigeria, Bolivia, Sierra Leone, and Venezuela 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. For example, Fasano (2002) documents that the United Arab Emirates have turned the resource curse into a blessing by investing massively in modern infrastructure and education. Also, Acemoglu, Johnson, and Robinson (2003) argue that ethnically homogenous and diamond-rich Botswana is a success story as it also uses resource revenues to invest in education and growth. Still, there is a wealth of systematic cross-country evidence suggesting that countries with large exports of natural resources have a worse growth performance than countries with little or no natural resources after correcting for the investment-GDP ratio, openness, and institutional quality as well as the initial level of income per capita. Most of these studies are based on the seminal work of Sachs and Warner (1995, 1997, 2001). An interesting extension is provided by Mehlum, Moene, and Torvik (2005).[2] They argue and provide some evidence that resource dependence only affects growth performance adversely in countries with bad institutions (e.g., a poorly defined legal system or a high risk of expropriation), but may even boost growth in countries with good institutions. This literature is very interesting and potentially relevant from a policy point of view, but nevertheless suffers from a number of very serious shortcomings.

First, in their seminal work Sachs and Warner argue that resource dependence induces an appreciation of the real exchange rate which leads to a decline in the traded sector. If the traded sector enjoys more learning by doing than the sheltered sector, resource dependence harms growth.[3] The problem is that the evidence for this interpretation of the resource curse is at best mixed and ignores other potentially more promising political economy explanations of the resource curse. The main ones that are offered in the literature are that substantial natural resource exports may worsen institutional quality and thus harm growth prospects and that resource dependence may aggravate the adverse effects of bad institutions on growth performance. For example, Lane and Tornell (1996) and Tornell and Lane (1999) highlight the voracity effect. In the absence of well-defined property rights, natural resources introduce a common pool problem and elicit rapacious rent seeking. As a result, a wealth of natural

---

[2] Other examples are Mansano and Rigobon (2001) and Sala-i-Martin and Subramanian (2003). Isham et al. (2003), Murshed (2004) and Bulte, Damania, and Deacon (2005) provide evidence that point-based (geographically more clustered) resources harm growth more than diffuse natural resources.

[3] These arguments were based on van Wijnbergen (1984) and Krugman (1987). Earlier work on Dutch Disease by Forsyth and Kay (1980), Bruno and Sachs (1982), Neary and Purvis (1982), and Corden (1984) also discuss the decline of the traded sector, but learning by doing externalities are needed to have a rationale for government intervention.

resources can hamper economic growth. Ross (1999), Baland and Francois (2000), Auty (2001), Busby et al. (2002), Isham et al. (2003), Torvik (2002), Mehlum, Moene, and Torvik (2005), Robinson, Torvik, and Verdier (2006), Wick and Bulte (2006), Caselli (2006) and many others also put forward political economy explanations of how natural resource dependence invites rent seeking and corruption and thus harms the economy.[4]

Other explanations of the resource curse highlight that resource abundance erodes the critical faculties of politicians and tends to keep bad policies in place. For example, Mansoorian (1991) and Mansano and Rigobon (2001) argue that countries rich in natural resources have a tendency to borrow excessively, especially if resources fetch a high price on international markets. However, once resources run out or if resource prices fall, they end up with financial crises that have dire consequences for economic growth. Countries rich in natural resources may also make the mistake of building a generous welfare state, which is not sustainable when natural resources run out.[5] Perhaps the most relevant example of natural resources engendering bad policies is when they generate political pressure to protect non-resource export sectors from the vigor of international competition, especially if they are hurt by the real appreciation of the exchange rate caused by substantial natural resource exports. Natural resource dependence may thus play a role in keeping restrictive trade policies in place, which in turn may harm growth prospects. The empirical resource curse literature thus suffers from the problem that it makes no serious attempt to disentangle what the main channels are by which substantial natural resource exports may harm economic growth.

There is ample evidence that resource dependence hurts growth prospects, but it is unclear whether this is due to forsaking learning by doing, worsening institutions, or keeping bad policies in place. It is also unclear whether natural resources are the root cause of bad institutions and bad policies or whether they aggravate the adverse effects of bad institutions and bad policies on economic growth. Without more information on the channels by which resources affect growth, the empirical evidence will be of limited use to policy makers.

Second, from an econometric point of view, the empirical evidence for the resource curse is flawed as no allowance is made for the endogenous character of explanatory variables such as the quality of institutions or the degree of the economy's openness.[6] This is in sharp

---

[4] Some of these are based on the seminal work on the productive and unproductive use of talent by Murphy, Schleifer, and Vishny (1993) and on earlier work on corruption and growth by Mauro (1995) and Bardhan (1997). The pioneering work of North (1990) on the importance of good institutions for good growth has been a significant source of inspiration as well.

[5] It is often argued that the Netherlands used the revenues from the Slochteren gas source to build up an unsustainable welfare state during the 1970s and 1980s, which has taken many administrations to turn back.

[6] Lederman and Maloney (2002) allow for endogeneity and different time periods and cannot reproduce the results of Sachs and Warner (1995, 1997). However, they only have a sample of 19 to 37 countries.

contrast to the ever-growing literature on explaining differences in countries' income per capita, where the main effort lies in the search for good instruments in order to disentangle the direction of causation and correct for endogenous explanatory variables. For example, Acemoglu and others (2001) stress the usefulness of colonial origins and settler mortality rates as instruments that affect institutional quality but not differences in income per capital directly. A much larger sample is possible if institutional quality is instrumented by the fraction of the population speaking English or Western European languages as a first language as in Hall and Jones (1999). Frankel and Romer (1999) use gravity equations for bilateral trade flows as instruments for international trade. Using this diverse set of instruments, Rodrik, Subramanian, and Trebbi (2004) conduct a 'horse race.' They find 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.[7]

It is a serious defect of the empirical literature on the resource curse that it does not use instruments for institutions and trade and thus ends up with biased and misleading estimates. Furthermore, the existing literature on the resource curse does not distinguish between, on the one hand, the effect of resource dependence on institutional quality, and, on the other hand, the interaction effect of resource dependence and institutional quality. Of course, this is related to the problem of not being able to address the question of what the channel is by which substantial natural resources affect cross-country differences in income per capita. Furthermore, there is no evidence to explain the various channels by which substantial natural resource revenues may affect growth.

Third, as Islam (1995) has argued convincingly, cross-country regressions suffer from omitted variable bias. They do not allow for a correlation between the initial level of productivity and past income per capita. Since the correlation with past income per capita is likely to be positive, the coefficient on lagged income per capita is likely to be overestimated. As a result, cross-country regressions yield an underestimate of the speed of adjustment and an overestimate of the share of capital. As also pointed out by Parente and Prescott (1994), cross-country regressions can thus not explain 'growth miracles' as the high capital share implies slow adjustment speeds. One way out is to drop lagged income per capita and focus on explaining income per capita. A better solution is perhaps to use a panel regression in order to avoid these biases.

---

[7] 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.

The purpose of this paper is to remedy, with the limited macro data we have at our disposal, some of the shortcomings mentioned above. We thus re-examine the cross-country evidence based on the seminal work of Sachs and Warner with an extended dataset.

Section 2 provides the ordinary least square (OLS) estimates of the original Sachs and Warner result that natural resources negatively affect growth even after allowing for the positive growth effects of the investment-GDP ratio, institutional quality, and openness. Section 2 confirms Mehlum, Moene, and Torvik (2005) and finds empirical evidence that resource dependence only negatively affects growth performance in countries where institutional quality is worse than a critical value. However, we also find support for the idea that the natural resource curse is less severe in countries with less restrictive trade policies. Interestingly, if we extend the sample period, the interaction term with institutional quality becomes insignificant while the interaction term with trade openness remains significant at the 5 percent level. The natural resource curse may even become a blessing for very open economies.

In section 3 we re-estimate these equations where we instrument institutional quality and openness with bilateral trade shares, distance to the equator, settler mortality rates, legal origin, and fraction of the population speaking English. We find that the results of section 2 do not stand up to such scrutiny for a wide variety of instruments. Furthermore, we find that the conditional speed of convergence implied by the estimates is unrealistically small.

Section 4 therefore chooses a different tack. It takes as a 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 evidence of a negative effect of resource exports on income per capita. We also find evidence of interaction terms, which imply 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 stand up although the estimates are less precisely determined.

Section 5 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 natural resource *abundance* rather than *dependence*. We find that resource abundance depresses income per capita, but less severely for countries that are relatively open. Section 6 checks robustness with respect to alternative measures of institutional quality. Section 7 concludes.

II. EFFECTS OF RESOURCE DEPENDENCE ON GROWTH PERFORMANCE: OLS ESTIMATES

The identification of which policies matter most in turning natural resource dependence into a blessing is a key empirical question. Institutional quality and trade openness have been put forward as fundamental factors in driving income per capita differences. The presence of

substantial natural resource exports is likely to affect both these factors. Indeed, the presence of natural resources is likely to generate corruption, poor rule of law, and conflicts (both internal and external). On the impact of natural resources on trade, one needs to investigate both the static impact of the presence of natural resources on the openness of a country and its feedback effect on trade policies. The presence of natural resources is also likely to have a differentiated impact on growth, which depends on pre-existing conditions such as the quality of institutions or the economy's degree of openness. One also needs to investigate whether the presence of natural resources is also likely to have an impact on the most proximate sources of growth, such as education and infrastructure, that could help explain the relationship between natural resources and growth.

Table 1 presents the OLS regressions for growth in income per capita over the period 1965 to 1990 (i.e., GrowthGDP6590 in Appendix A). This sample period allows us to make a comparison with earlier tests of the natural resource curse done by Sachs and Warner (1995, 1997) and Mehlum, Moene, and Torvik (2005). Regression (1) confirms the classic result of Sachs and Warner (1995, 1997). It shows that conditional growth performance is better for poor countries than rich countries, since growth depends negatively on initial income per capita. This is, of course, a direct result of the assumption of decreasing returns to capital in production. The time it takes to reduce a given income gap by 50 percent is 84 years (see Appendix B).[8] This seems implausibly large and may be the result of omitted variable bias arising from the positive correlation between the initial level of productivity and past income per capita as suggested by Islam (1995). More interestingly, growth performance depends also positively on the de jure openness of the economy and negatively on the share of natural resources in exports. This has become known in the literature as the 'natural resource curse.'

It may be that natural resource dependence is a proxy for bad institutions. However, regression (2) indicates that if we also allow for institutional quality as an explanatory variable, we find that growth performance is also positively affected by the quality of institutions. Furthermore, we find that the natural resource curse survives. This suggests that natural resource dependence is associated with factors not captured by the other explanatory variables. For example, resource dependence may lead to low human capital accumulation or less learning by doing in the non-resource export sectors resulting from a fall in competitiveness as suggested by the standard Dutch disease story (e.g., van Wijnbergen, 1984; Krugman, 1987). Interestingly, regression (3) shows that once cross-country differences in ratios of investment to national income are taken into account, institutional quality is no longer significant. Still, the natural resource curse survives and investment is an important driver of growth performance. Clearly, poorer countries have to make ends meet to survive, and thus are less able to save and have to cope with a miserable growth performance. The half time to close a given income gap is 44 years, which seems more plausible.

---

[8] $\kappa=0.744$, $t_2 - t_1 = 25$, so $\theta = 1 - 25 \times 0.744/100 = 0.814$ and $T = -25 \log(2)/\log(0.814) = 84.2$ years.

Regression (4) confirms the results of Mehlum, Moene, and Torvik (2005). The interactive effect with institutional quality is significant at the 5 percent level, albeit that institutional quality itself has the right sign but is significant at the 5 percent level. This finding suggests that good institutions can turn the natural resource curse into a blessing. The net effect of natural resource exports on growth performance is given by $-14.361 + 1.540$ x InstQual80. Hence, in countries with a high level of institutional quality (i.e., InstQual80 > 9.325), substantial natural resource exports enhance growth performance. This is the case for the following countries: Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Finland, United Kingdom, Japan, Netherlands, Norway, New Zealand, Sweden, and the United States. However, if institutional quality is poor (InstQual80 < 9.325), natural resources are a curse for economic growth. Most of the natural resource rents are then likely to corrupt officials and rent seekers instead of being put to good use by productive entrepreneurs. Regression (4) also indicates that growth performance is better for more open economies with a low initial income per capita and a high investment rate.

Table 1. OLS Regression for Growth in Income Per Capita Over the Period 1965–90

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
logGDP/cap65	-0.733	-1.028	-1.284	-1.259	-1.277	-1.258	-1.209
	(3.62)**	(4.39)**	(6.68)**	(6.73)**	(6.70)**	(6.68)**	(6.93)**
OPEN6590	3.217	2.492	1.451	1.654	0.906	1.706	1.160
	(7.75)**	(4.99)**	(3.37)**	(3.88)**	(1.64)	(2.44)*	(2.23)*
PrimExp/GNP	-5.470	-5.755	-6.692	-14.361	-7.907	-14.540	-7.766
	(3.76)**	(3.80)**	(5.44)**	(4.24)**	(5.46)**	(3.72)**	(5.49)**
InstQual80		0.223	0.059	-0.134	0.073	-0.142	
		(2.05)*	(0.65)	(1.12)	(0.81)	(0.96)	
InvRate7089			0.150	0.156	0.153	0.156	0.154
			(6.73)**	(7.16)**	(6.90)**	(7.11)**	(7.46)**
Interact OPEN6590					5.089	-0.413	7.210
					(1.55)	(0.09)	(2.36)*
Constant	7.172	8.674	9.603	10.302	9.610	10.327	9.259
	(4.52)**	(5.25)**	(7.17)**	(7.73)**	(7.24)**	(7.56)**	(7.17)**
Interact InstQual80				1.540		1.596	
				(2.42)*		(1.82)	
Observations	96	87	87	87	87	87	96
R-squared	0.50	0.55	0.71	0.73	0.72	0.73	0.69

Absolute value of t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.

However, it is not unreasonable to conjecture that a trade policy aimed at more exposure to foreign competition and transfer of technology, managerial skills, and know how from abroad might turn the natural resource curse into a blessing as well. Regression (6) indicates that if we extend regression (4) and also allow for an interaction term of natural resource openness with de jure openness, it is not significant. However, regression (5) suggests that there might be such an interaction term with de jure openness if the interaction term with institutional quality is dropped, but then the effect of institutional quality on growth performance becomes even more poorly determined. Institutional quality and de jure openness may proxy similar things. The resulting collinearity can explain why the interaction

terms are not statistically significant in regression (6). We therefore decided to drop institutional quality and its interactions term with natural resource exports altogether.

The resulting regression (7) suggests that growth performance is positively affected by openness and investment rates, but negatively affected by the initial income per capita. The net effect of natural resource exports on growth performance is $-7.766 + 7.210$ OPEN6590, which is always negative as OPEN6590 never exceeds 1.00. This indicates that the natural resource curse is less severe for countries with de jure more open economies. Hence, countries that have state monopolies of major exports, black market exchange rate premiums higher than 20 percent, average tariff rates higher than 40 percent, and quotas covering more than 40 percent of imports suffer much more from the natural resource curse than countries with less restrictive trade policies.[9] Resource dependence may elicit a strong lobby from the non-resource export sectors for protection from competition from imports. In that case, the interaction term suggests that resource dependence indicates the extent to which this happens and hampers growth performance.

It is of some interest to examine how the results in Table 1 stand up to an extension of the sample period. Table 2 therefore presents the OLS regressions for growth in income per capita over the period 1965 to 2000 (i.e., GrowthGDP19652000 in Appendix A). The basic regression (1) again confirms the results in Sachs and Warner (1995, 1997) that the share of natural resources in exports and the initial level of income per capita have a negative effect on growth performance while openness has a positive effect on growth performance. Regression (2) adds institutional quality as an explanatory variable, which is of the right sign but no longer statistically significant. Furthermore, regression (3) indicates again that institutional quality drops out completely once we add the investment rate as an explanatory variable. Regression (4) shows that the interaction term of the share of natural resources in exports with institutional quality is no longer significant at the 5 percent level. Hence, the results of Mehlum, Moene, and Torvik (2005) are not robust to extending the sample period. Perhaps the reason is that rising natural resource prices during the 1990s have provided a surplus that made up for bad institutions in some resource-rich countries. Alternatively, the 1990s may have seen improvements in the institutional quality of resource-rich countries that have been relatively open to trade, enjoy high levels of press freedom and high levels of education, and do not receive much foreign aid as argued by the IMF (2005).

Regressions (5) and (6) indicate that the interaction term with de jure openness may be more promising. Indeed, regression (7) which drops institutional quality and its interaction term with natural resources, shows that the interaction term of the share of natural resources in exports with de jure openness has the right sign and is significant at the 5 percent level. The effect of natural resources on the average growth in income per capita equals $-4.4 + 7.2$

---

[9] The Sachs and Warner (1997) openness indicator, OPEN6590, is constructed using those variables as subcomponents.

OPEN6590, so that the natural resource curse is less severe for countries that do not have restrictive trade policies or extractive state monopolies on major exports. In fact, for relatively open economies with OPEN6590 larger than 0.61, the resource curse is turned into a blessing. This is the case for the rich OECD countries, but also for Bolivia, Indonesia, Jordan, Ecuador, Thailand, South Korea, and Malaysia. Alas, it is not the case for most resource-rich countries on the African continent.

Summing up, we cast doubt on the evidence put forward by Mehlum, Moene, and Torvik (2005) for the hypothesis that the natural resource curse can be turned into a blessing for countries with high institutional quality. Regression (4) indicates that their results do not stand up to extending the sample period. Institutional quality and its interaction with natural resource exports are no longer statistically significant. In any case, it has been argued by Glaeser and others (2004) that the available indicators of institutional quality may not be appropriate. They relate more to outcomes than true exogenous de jure measures of institutional quality. Dropping institutional quality avoids endogeneity bias arising from the measurement of institutional quality. We therefore prefer to use de jure openness as an explanatory variable. Regression (7) provides new evidence that the natural resource curse is less severe in countries that are more open to international trade. Also, growth performance is higher for countries that start with a low level of income per capita and invest a lot.

Table 2. OLS Regressions for Growth in Income Per Capita Over the Period 1965–2000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
logGDP/worker65	-0.356	-0.542	-0.607	-0.605	-0.605	-0.606	-0.545
	(1.92)	(2.61)*	(3.22)**	(3.20)**	(3.24)**	(3.22)**	(3.23)**
OPEN6590	2.572	2.064	1.109	1.195	0.431	0.316	0.544
	(5.96)**	(3.74)**	(2.04)*	(2.15)*	(0.61)	(0.35)	(0.87)
PrimExp/GNP	-3.690	-4.245	-3.697	-7.145	-5.115	-4.157	-4.389
	(2.40)*	(2.54)*	(2.44)*	(1.66)	(2.89)**	(0.85)	(2.69)**
InstQual80		0.129	0.017	-0.070	0.033	0.063	
		(1.14)	(0.16)	(0.48)	(0.31)	(0.35)	
InvShare19702000			0.120	0.123	0.125	0.125	0.132
			(4.32)**	(4.38)**	(4.51)**	(4.47)**	(5.17)**
Interact OPEN6590					6.159	6.942	7.193
					(1.51)	(1.25)	(2.02)*
Constant	4.489	5.712	5.277	5.650	5.303	5.183	4.671
	(2.83)**	(3.42)**	(3.49)**	(3.59)**	(3.54)**	(3.21)**	(3.35)**
Interact InstQual80				0.699		-0.231	
				(0.86)		(0.21)	
Observations	92	83	83	83	83	83	92
R-squared	0.38	0.39	0.51	0.51	0.52	0.52	0.53

Absolute value of t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.

Natural resources potentially affect growth performance through at least five channels: (i) directly through the Dutch disease channel; (ii) indirectly in the longer term through a worsening of institutional quality (e.g., war, internal conflict, deterioration of institutions after the discovery of natural resources); (iii) indirectly through a more restrictive trade policy in response to a decline in the non-resource export sectors; (iv) through an interaction

term with institutional quality; and (v) through an interaction term with de jure openness. Indeed, Sachs and Warner (1997) argue that the Dutch disease effect corresponds to the residual effect of natural resource exports (i) once the indirect effect of natural resources on de jure openness is taken into account (iii). In fact, we find that there is evidence of a direct Dutch disease channel (i) and (v) in the explanation of cross-country differences in growth performance, even after allowing for channels (ii), (iii), and (iv).

The results obtained in Tables 1 and 2 underestimate the speed of conditional convergence. Furthermore, these results can be criticised as some of the explanatory variables are clearly endogenous. We therefore turn to IV estimates of the effects of the natural resource curse on growth performance.

III. EFFECTS OF RESOURCE DEPENDENCE ON GROWTH PERFORMANCE: IV ESTIMATES

Rodrik, Subramanian, and Trebbi (2004) use IV regressions to explain cross-country variations in income per capita rather than growth performance. They find that institutions are more important in explaining income per capita than geography/climate and openness. It is therefore of interest to reconsider our OLS estimates of the natural resource curse presented in section 2 and to examine how they stand up under IV estimation. In this way we try to correct for the endogenous nature of explanatory variables such as institutional quality and openness.

We use the gravity equations of Frankel and Romer (1999) to instrument openness. We employ the colonial settler mortality data used by Acemoglu and others (2001) as an instrument for institutional quality. Colonial empires robbed states of their natural resources in which indigenous diseases were rife and survival prospects 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.

The IV approach requires that the instruments be valid, but it may be quite hard to come up with truly exogenous instruments that also 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 very 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 almost impossible 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 does not seem available.[10]

Despite all these problems, Table 3a provides IV regressions for the growth in income per capita from 1965 to 2000 (i.e., GrowthGDP19652000) where institutional quality is instrumented by the logarithm of colonial settler mortality, legal origin, and the fraction of the population speaking English. Illustrative cross-country regressions provided by the IMF (2005) indicate that institutional quality is higher for countries that are more open to international trade, have a greater accountability of the political executive and perhaps also have fewer natural resources, so it makes sense to include openness and natural resource dependence as instruments for institutional quality as well. Clearly, including these explanatory variables that are supposed to be exogenous also improves the statistical efficiency of the IV estimates.

The most striking result is that the direct effect of the share of natural resources in exports on growth performance initially found by Sachs and Warner (1995, 1997) is no longer statistically significant. Hence, if we use the standard instruments from the empirical literature on explaining cross-country variations in national income, the direct natural resource curse effect does not survive. The Mehlum, Moene, and Torvik (2005) result on the interaction term of natural resources with institutional quality did not hold up with a longer sample period, so we should not be too surprised that it does not appear in the IV regressions with the longer sample period either. However, IV regressions (11) and (12) do yield an estimate of the interaction effect of natural resources with de jure openness with the correct sign, but it is not statistically significant. One reason may be that the investment share is endogenous but is used de facto as an instrument for institutional quality. This certainly worsens the treatment for endogeneity bias. Thus another specification for the growth in income per capita regressions could help to alleviate that problem.

Table 3b presents the IV estimates if both institutional quality (i.e., InstQual80) and openness (OPEN6590) are instrumented, where the log of a gravity estimate (lnfrinstex, see Appendix A) is used as an instrument for openness. These estimates are qualitatively similar to those in Table 3a.

---

[10] 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.

Table 3: IV Regressions for Growth in Income Over the Period 1965–2000

(a) Using Specific Instruments for Institutional Quality

Second Stage for grgdpch19652000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
InstQual80	6.515	0.380	0.384	0.051	-0.257	0.381	0.138	0.334	1.492	0.125	0.019	0.293			0.304	0.181
	(0.32)	(0.87)	(0.73)	(0.15)	(0.56)	(0.93)	(0.41)	(0.69)	(0.68)	(0.35)	(0.06)	(0.77)			(1.00)	(1.12)
logGDP/worker65	-3.786	-0.829	-0.832	-0.289	-0.122	-0.830	-0.282	-0.621	-0.262	-0.258	-0.255	-0.286	-0.545	-0.564	-0.342	-0.309
	(0.36)	(2.52)*	(2.10)*	(0.93)	(0.32)	(2.57)*	(0.98)	(1.97)	(0.46)	(0.88)	(0.81)	(0.98)	(2.86)**	(2.81)**	(1.10)	(0.97)
OPEN6590	-8.941	0.344	0.335	1.221	1.705	0.342	1.174	0.789	0.314	1.224	0.716	-0.240	0.544	1.259		
	(0.27)	(0.32)	(0.26)	(1.34)	(1.57)	(0.33)	(1.35)	(0.80)	(0.13)	(1.34)	(0.58)	(0.16)	(0.85)	(1.99)*		
PrimExp/GNP	8.842	-3.078	-3.071	-1.624	-2.123	-3.076	2.320	8.642	58.507	3.544	-2.705	3.416	-4.389		2.288	
	(0.24)	(1.39)	(1.30)	(0.94)	(1.38)	(1.38)	(0.35)	(0.99)	(0.48)	(0.53)	(1.30)	(0.59)	(2.59)*		(0.28)	
InvShare19702000	-0.327	0.096	0.096	0.114	0.135	0.096	0.112	0.108	0.084	0.115	0.119	0.113	0.132	0.133	0.126	0.135
	(0.25)	(2.41)*	(2.19)*	(3.02)**	(2.89)**	(2.49)*	(2.98)**	(2.82)**	(0.97)	(2.95)**	(3.19)**	(3.26)**	(4.68)**	(4.53)**	(3.38)**	(4.19)**
Interact InstQual80							-0.818	-2.500	-12.421	-1.085		-1.493			-0.744	-0.139
							(0.52)	(1.35)	(0.52)	(0.68)		(0.90)			(0.40)	(0.41)
Interact OPEN6590											4.190	9.371	7.193	2.027		
											(1.12)	(1.25)	(2.45)*	(0.86)		
Constant	6.342	5.744	5.750	2.076	1.873	5.746	1.616	3.953	-4.831	1.438	2.011	1.193	4.671	4.186	1.326	1.447
	(0.43)	(3.12)**	(2.94)**	(1.03)	(0.89)	(3.10)**	(0.76)	(2.15)*	(0.33)	(0.69)	(0.98)	(0.63)	(2.94)**	(2.60)**	(0.55)	(0.63)
Observations	54	83	83	54	54	83	54	83	54	54	54	54	92	92	55	55
overid pvalue				0.01	0.01	0.99	0.02	0.54	0.40	0.01	0.03	0.03			0.01	0.04

First Stage for icrge80

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
logGDP/worker65	0.489	0.710	0.502	0.767	0.316	0.642	0.628	0.642	0.767	0.316	0.606	0.606			0.621	0.575
	(2.08)*	(3.81)**	(2.74)**	(3.03)**	(1.28)	(2.92)**	(2.02)*	(2.92)**	(3.03)**	(1.28)	(1.88)	(1.88)			(1.91)	(2.30)*
OPEN6590	1.528	2.081	2.059	1.164	1.290	2.065	1.126	2.065	1.164	1.290	1.556	1.556				
	(1.53)	(3.32)**	(3.26)**	(1.38)	(1.37)	(3.30)**	(1.32)	(3.30)**	(1.38)	(1.37)	(1.52)	(1.52)				
PrimExp/GNP	-1.538	-2.592	-2.090	-2.515	-2.111	-2.565	-2.585	-2.565	-2.515	-2.111	-1.718	-1.718			-2.416	
	(0.67)	(1.56)	(1.25)	(1.05)	(0.76)	(1.47)	(0.98)	(1.47)	(1.05)	(0.76)	(0.49)	(0.49)			(0.82)	
Inv Share19702000	0.064	0.055	0.069	0.058	0.066	0.058	0.060	0.058	0.058	0.066	0.056	0.056			0.073	0.065
	(1.78)	(1.85)	(2.21)*	(1.90)	(1.99)	(1.85)	(1.94)	(1.85)	(1.90)	(1.99)	(1.74)	(1.74)			(3.00)**	(2.90)**
logsetmort	-0.077			0.124	-0.017		0.111		0.124	-0.017	0.078	0.078			0.008	-0.101
	(0.33)			(0.48)	(0.07)		(0.41)		(0.48)	(0.07)	(0.28)	(0.28)			(0.03)	(0.52)
legor_uk		0.714		1.174		0.560	0.931	0.560	1.174		0.935	0.935			1.111	1.108
		(2.18)*		(2.55)*		(1.33)	(1.74)	(1.33)	(2.55)*		(1.75)	(1.75)			(2.10)*	(2.69)**
engfrac			1.066		1.658	0.454	0.786	0.454		1.658	0.686	0.686			0.783	0.603
			(1.67)		(1.69)	(0.57)	(0.73)	(0.57)		(1.69)	(0.63)	(0.63)			(0.70)	(0.52)
Interact OPEN6590											-3.275	-3.275				
											(0.58)	(0.58)				
Constant	0.208	-2.127	-0.405	-3.333	1.342	-1.571	-2.064	-1.571	-3.333	1.342	-1.768	-1.768			-1.585	-0.823
	(0.08)	(1.26)	(0.26)	(1.03)	(0.47)	(0.84)	(0.57)	(0.84)	(1.03)	(0.47)	(0.48)	(0.48)			(0.43)	(0.29)
Observations	54	83	83	54	54	83	54	83	54	54	54	54	92	92	55	60
R-squared	0.45	0.65	0.65	0.52	0.50	0.65	0.53	0.65	0.52	0.50	0.54	0.54			0.49	0.47

Robust t statistics in parentheses

* significant at 5 percent; ** significant at 1 percent.

Table 3: IV Regressions for Growth in Income Over the Period 1965–2000 (concluded)

(b) Using Specific Instruments for Both Institutional Quality and Openness

Second Stage for grgdpch19652000

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
InstQual80	-159.150	0.281	0.139	-0.584	-0.617	0.250	-0.337	0.137	1.089	-0.170	0.243	0.318			0.304	0.181
	(0.02)	(0.46)	(0.17)	(0.62)	(0.55)	(0.43)	(0.57)	(0.26)	(0.31)	(0.30)	(0.41)	(0.76)			(1.00)	(1.12)
OPEN6590	462.576	4.690	4.912	5.987	6.068	4.479	6.041	2.550	1.143	4.020	-4.015	-0.150	0.544	1.259		
	(0.02)	(1.31)	(1.23)	(0.76)	(0.74)	(1.40)	(1.13)	(1.18)	(0.09)	(0.75)	(0.57)	(0.04)	(0.85)	(1.99)*		
logGDP/worker65	77.485	-1.229	-1.133	-0.094	-0.077	-1.179	-0.094	-0.702	-0.126	-0.145	-0.228	-0.277	-0.545	-0.564	-0.342	-0.309
	(0.02)	(2.24)*	(2.07)*	(0.25)	(0.17)	(2.41)*	(0.27)	(2.26)*	(0.21)	(0.47)	(0.63)	(1.01)	(2.86)**	(2.81)**	(1.10)	(0.97)
PrimExp/GNP	-274.160	-1.523	-1.800	-2.916	-2.972	-1.691	7.638	6.101	52.814	5.968	-6.916	5.328	-4.389		2.288	
	(0.02)	(0.53)	(0.66)	(0.99)	(0.99)	(0.62)	(0.57)	(0.64)	(0.38)	(0.55)	(1.87)	(0.75)	(2.59)*		(0.28)	
Inv Share19702000	5.378	-0.026	-0.014	0.057	0.059	-0.015	0.047	0.074	0.098	0.079	0.169	0.112	0.132	0.133	0.126	0.135
	(0.02)	(0.22)	(0.13)	(0.43)	(0.43)	(0.15)	(0.48)	(1.32)	(0.50)	(0.83)	(1.47)	(1.67)	(4.68)**	(4.53)**	(3.38)**	(4.19)**
Interact InstQual80							-2.185	-1.907	-11.342	-1.743		-1.883			-0.744	-0.139
							(0.72)	(0.96)	(0.41)	(0.68)		(1.03)			(0.40)	(0.41)
Interact OPEN6590											23.356	9.115	7.193	2.027		
											(1.50)	(1.24)	(2.45)*	(0.86)		
Constant	0.955	9.989	9.721	3.512	3.505	9.656	2.392	5.618	-4.261	1.940	1.055	0.992	4.671	4.186	1.326	1.447
	(0.00)	(2.64)*	(2.86)**	(0.94)	(0.92)	(2.91)**	(0.94)	(2.77)**	(0.22)	(0.87)	(0.28)	(0.44)	(2.94)**	(2.60)*	(0.55)	(0.63)
Observations	54	83	83	54	54	83	54	83	54	54	54	54	92	92	55	55
overid pvalue				0.02	0.03	0.82	0.12	0.16	0.06	0.01	0.03	0.01			0.01	0.04
R-squared																

IV. CROSS-COUNTRY VARIATIONS IN INCOME PER CAPITA AND NATURAL RESOURCE DEPENDENCE

The empirical evidence for the negative effect of natural resource exports on growth performance is mixed. 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, the 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 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, we suspect that the data are simply not good enough yet to obtain satisfactory results. We therefore take a more modest approach and 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 income.

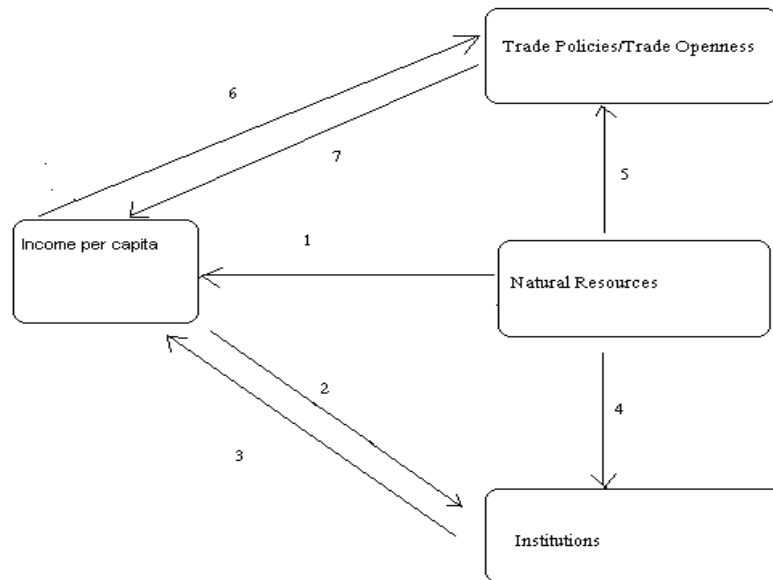**Figure 1. Direct and Indirect Effects of Natural Resources on Income Per Capita**

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 provide an open invitation to rapacious rent seeking. The resulting voracity effect lowers income per capita. The second one (arrows 4 and 3) is that natural resources worsen the adverse impact of bad institutions 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. 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). However, income per capita might also affect trade openness and institutional quality (arrows 6 and 2) and therefore it is important to look for good instruments (including natural resource dependence) to correct for the endogenous nature of these explanatory variables.

A. OLS Estimates

Table 4 presents some OLS regressions that attempt to explain cross-country variations in income per capita in the year 1995 (i.e., logGDP/cap95 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 1965 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. To avoid problems arising from collinearity 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. The preferred regression of Table 4 is thus (3). If the Democratic Republic of Congo and Nigeria had the same degree of resource dependence as Japan, they would suffer less from a resource curse.[11] In that case, regression (3) implies that their income per capita would, respectively, be 372 percent and 205 percent higher, everything else being equal.

---

[11] In the sample of 98 countries used in regression (5) in Table 4, Japan has the lowest share of exports of primary products in GNP in 1970.

Table 4. OLS Regressions for Income Per Capita 1995 with Log of Natural Resource Exports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DISTEQ	0.015	0.013	0.011	0.011	0.011	0.012	0.027
	(4.02)**	(3.60)**	(1.91)	(1.90)	(1.83)	(2.05)*	(5.19)**
RL01	0.823	0.635	0.535	0.506	0.419	0.591	
	(12.08)**	(8.00)**	(4.66)**	(2.35)*	(1.70)	(2.60)*	
LNOPEN		0.348	0.455	0.450	0.629		0.879
		(4.31)**	(4.26)**	(4.05)**	(2.32)*		(3.34)**
ln PrimExp/GNP			-0.218	-0.212	-0.126	-0.069	-0.220
			(2.81)**	(2.45)*	(0.86)	(0.84)	(1.81)
Interact LNOPEN					0.066		0.050
					(0.73)		(0.60)
Constant	7.916	8.344	8.081	8.084	8.310	7.842	8.109
	(73.00)**	(55.66)**	(40.51)**	(40.20)**	(22.39)**	(39.09)**	(22.80)**
Interact RL01				-0.013	-0.048	-0.095	
				(0.16)	(0.53)	(1.19)	
Observations	139	131	98	98	98	101	99
R-squared	0.71	0.74	0.76	0.76	0.76	0.73	0.71

Absolute value of t statistics in parentheses.

* significant at 5 percent; ** significant at 1 percent.

B.   IV Estimates

Rule of law and de facto openness suffer from endogeneity bias. Hence, we instrument them with combinations of UK legal origin, log of settler mortality, fraction of population speaking English, and a bilateral gravity estimate of openness. 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. 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.

Table 5 presents the IV regressions for cross-country variations in income per capita in 1995 (i.e., logGDP/cap95). 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 possibly de facto openness and a resource curse. Regressions (4)-(6) indicate there is no evidence for interaction effects of natural resource exports with institutional quality and de facto openness.

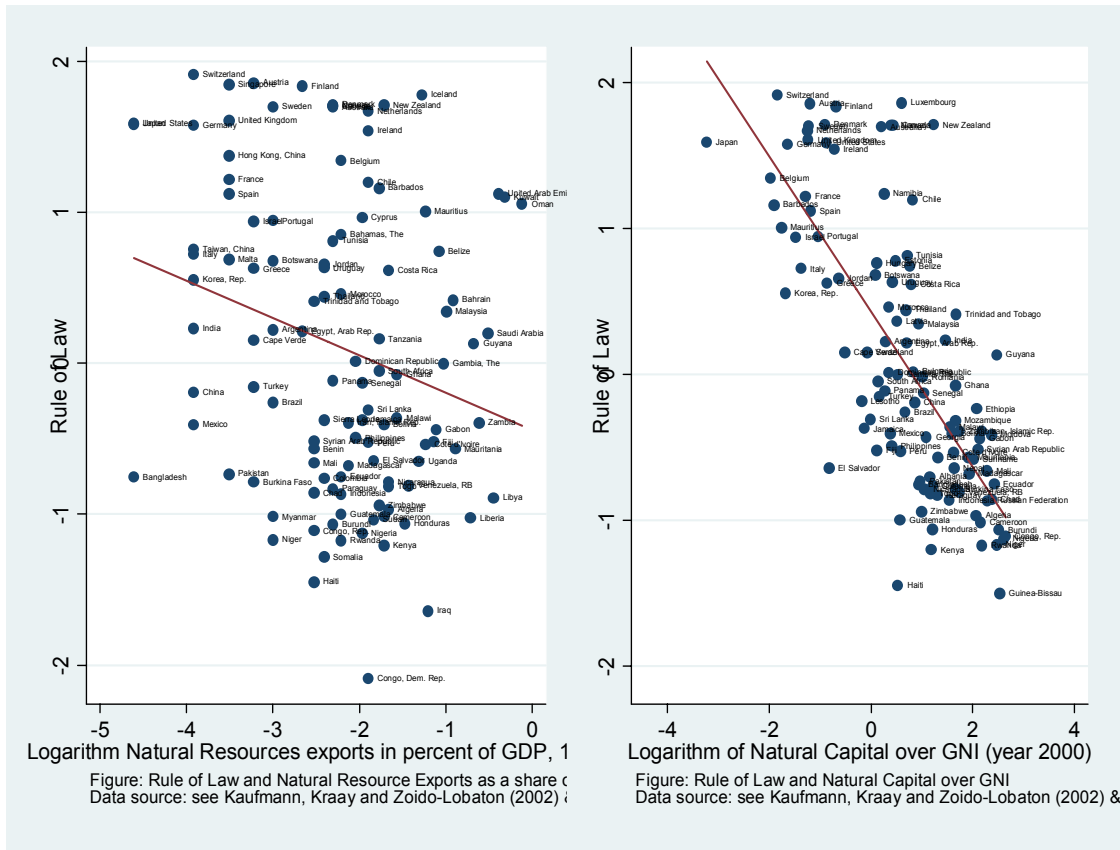**Figure 2: Correlation Between Rule of Law and Natural Resource Exports**

Figure: Rule of Law and Natural Resource Exports as a share of GDP
Data source: see Kaufmann, Kraay and Zoido-Lobaton (2002)

Figure: Rule of Law and Natural Capital over GNI
Data source: see Kaufmann, Kraay and Zoido-Lobaton (2002) & World Bank (2006)

Table 5. IV Income Per Capita 1995 Regressions Using Log of Natural Resource Exports

	(1)	(2)	(3)	(4)	(5)	(6)
RL01	0.222	0.226	0.458	-0.323	0.481	20.894
	(0.64)	(0.69)	(1.69)	(0.55)	(1.38)	(0.28)
DISTEQ	0.027	0.017	0.013	0.020	0.014	-0.354
	(2.18)*	(1.28)	(1.60)	(1.42)	(1.77)	(0.28)
ln PrimExp/GNP	-0.193	-0.504	-0.232	-0.474	-0.209	-4.407
	(1.86)	(2.27)*	(2.39)*	(2.09)*	(1.76)	(0.24)
LNOPEN	0.408	1.329	0.518	1.292	0.431	-18.368
	(1.28)	(3.28)**	(1.83)	(3.33)**	(1.72)	(0.24)
Interact LNOPEN						-4.118
						(0.24)
Constant	7.755	8.573	8.089	8.512	8.012	-5.159
	(21.05)**	(30.21)**	(31.52)**	(29.50)**	(30.78)**	(0.09)
Interact RL01				-0.220	-0.002	3.767
				(1.40)	(0.01)	(0.26)
Observations	98	65	98	65	98	65
overid pvalue		0.00	0.01	0.01	0.05	
Instruments 1/						
RL01	legor_uk	logsetmort, legor_uk, engfrac	legor_uk, engfrac	logsetmort, legor_uk, engfrac	legor_uk, engfrac	logsetmort
LNOPEN	Infrinstex	Infrinstex	Infrinstex	Infrinstex	Infrinstex	Infrinstex

Robust t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.
 1/ Interactive variables are instrumented using ln PrimExp/GNP time the instruments used for the individual variables.

V. Natural Capital as an Explanatory Variable

Given the disappointing results of our IV estimates of the negative effect of natural resource exports on income per capita, it may be worthwhile to use the estimates of natural capital for 2000 developed by the World Bank (2006b) to explain income per capita in 1995. 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 (2006) argue that natural resource exports indicators often used in the resource curse literature capture resource *dependence* rather than resource *abundance*. A stock variable 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. Using natural capital as an explanatory variable also has the advantage that it is available for a larger number of countries.[12]

A. OLS Regressions with De Facto Openness

Table 6 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).[13] 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 on and a significant interaction term with openness. The results

---

[12] 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.

[13] This is in contrast to Brunnschweiler and Bulte (2006), who find a direct positive effect of resource *abundance* and an indirect effect of resource *dependence* (through worsening of institutional quality) on growth performance.

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.

Table 6. OLS Income Per Capita 1995 Regressions Using Log of Natural Capital

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DISTEQ	0.015	0.013	0.012	0.012	0.013	0.012	0.024
	(4.02)**	(3.60)**	(2.69)**	(2.72)**	(3.01)**	(2.55)*	(6.27)**
RL01	0.823	0.635	0.456	0.437	0.511	0.580	
	(12.08)**	(8.00)**	(4.10)**	(3.77)**	(4.38)**	(5.32)**	
LNOPEN		0.348	0.276	0.277	0.101		0.313
		(4.31)**	(2.92)**	(2.93)**	(0.88)		(3.17)**
lnNatCapital/GNI			-0.198	-0.209	0.018	-0.234	-0.168
			(3.10)**	(3.14)**	(0.17)	(3.42)**	(2.49)*
interact LNOPEN					0.201		0.149
					(2.56)*		(2.60)*
Constant	7.916	8.344	8.476	8.505	8.309	8.184	8.442
	(73.00)**	(55.66)**	(49.42)**	(47.51)**	(43.65)**	(55.75)**	(53.75)**
Interact RL01				0.031	-0.066	0.026	
				(0.60)	(1.06)	(0.50)	
Observations	139	131	106	106	106	106	112
R-squared	0.71	0.74	0.74	0.74	0.76	0.72	0.71

Absolute value of t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.

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 7 corrects for the endogenous nature 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 impact is significant in regressions (1) and (2). There is no evidence of an interaction effect of natural capital with institutional quality. Furthermore, although the interaction effect of natural capital with de facto openness has the right sign in regressions (4) and (7), it is not significant at the 5 percent level.

Table 7. IV Income Per Capita Regressions 1995 Using Log of Natural Capital

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RL01	0.116	0.201	1.278	0.861	1.092	1.064	
	(0.25)	(0.37)	(2.89)**	(2.11)*	(4.75)**	(4.95)**	
DISTEQ	0.023	0.025	-0.015	0.010	-0.007	-0.008	0.029
	(2.05)*	(1.81)	(0.78)	(0.94)	(0.63)	(0.67)	(4.43)**
lnNatCapital/GNI	-0.404	-0.475	-0.163	0.769	-0.166	-0.159	-0.381
	(2.29)*	(2.00)*	(1.60)	(1.66)	(1.65)	(1.65)	(1.56)
LNOPEN		-0.358	-0.262	0.046			-0.329
		(0.77)	(0.55)	(0.13)			(0.76)
Interact LNOPEN				0.685			0.133
				(1.93)			(1.00)
Constant	8.033	7.598	8.394	8.076	8.584	8.610	7.663
	(42.29)**	(11.93)**	(18.68)**	(17.05)**	(35.42)**	(36.11)**	(11.97)**
Interact RL01			0.010	-0.561	-0.016	0.029	
			(0.08)	(1.78)	(0.14)	(0.28)	
Observations	106	106	62	106	62	62	112
overid pvalue			0.15	0.36	0.15	0.08	
Instruments 1/							
RL01	legor_uk	legor_uk	logsetmort, legor_uk, engfrac	legor_uk, engfrac	logsetmort, legor_uk, engfrac	logsetmort, engfrac	
LNOPEN		Infrinstex	Infrinstex	Infrinstex			Infrinstex

Robust t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.
 1/ Interactive variables are instrumented using lnNatCapital/GNI time the instruments used for the individual variables.

C. Natural Capital and De Jure Trade Openness

To enable comparison with Sachs and Warner (1995, 1997), we check the robustness of our results to using de jure rather than de facto openness as an explanatory variable. Table 8 presents the resulting OLS regressions. All regressions show evidence of a significant negative effect at the 5 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 weak evidence at the 10 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 multi-collinearity, 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.[14]

---

[14] Indeed regression (7) in Table 8 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.

Table 8. OLS Income Per Capita Regressions with Natural Capital and De Jure Openness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
DISTEQ	0.027	0.012	0.014	0.016	0.016	0.012	0.025
	(6.65)**	(2.53)*	(3.01)**	(3.26)**	(3.32)**	(2.55)*	(5.91)**
lnNatCapital/GNI	-0.416	-0.224	-0.178	-0.201	-0.317	-0.234	-0.420
	(8.26)**	(3.43)**	(2.55)*	(2.86)**	(2.99)**	(3.42)**	(4.61)**
RL01		0.596	0.435	0.326	0.397	0.580	
		(5.74)**	(3.64)**	(2.46)*	(2.83)**	(5.32)**	
OPEN6590			0.529	0.694	0.511		0.839
			(2.43)*	(2.97)**	(1.94)		(4.21)**
Interact OPEN6590					0.291		0.352
					(1.45)		(2.64)**
Constant	7.941	8.160	7.910	7.940	8.029	8.184	7.809
	(60.51)**	(59.07)**	(45.44)**	(45.95)**	(44.02)**	(55.75)**	(44.74)**
Interact RL01				0.103	0.005	0.026	
				(1.81)	(0.05)	(0.50)	
Observations	113	106	100	100	100	106	100
R-squared	0.63	0.72	0.75	0.76	0.77	0.72	0.74

Absolute value of t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.

To correct for the possible endogenous character of de jure openness and rule of law, Table 9 presents some IV regressions. There is always a negative effect of the log of the ratio of natural capital to national income, but it is only significant at the 5 percent level in regressions (1), (3), and (4). Regressions in Table 9 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 some evidence of a significant interaction term of natural capital with de jure openness. Trade policies directed toward more exposure to foreign competition and transfer of technology and 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.[15]

---

[15] In fact, regressions (3) and (4) of Table 9 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.

Table 9: IV Income Per Capita Regressions with Natural Capital and De Jure Openness

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
RL01	0.116	0.242	3.207	2.572	2.470	1.092	
	(0.25)	(0.35)	(1.98)	(1.10)	(1.21)	(4.75)**	
DISTEQ	0.023	0.010	-0.045	-0.028	-0.031	-0.007	0.026
	(2.05)*	(0.54)	(1.14)	(0.50)	(0.69)	(0.63)	(1.85)
lnNatCapital/GNI	-0.404	0.005	-1.234	-1.337	-1.025	-0.166	-1.171
	(2.29)*	(0.04)	(2.05)*	(2.08)*	(1.40)	(1.65)	(1.46)
OPEN6590		2.150	-3.147	-2.394	-1.696		1.644
		(1.59)	(1.13)	(0.61)	(0.45)		(0.30)
Interact OPEN6590			3.110	3.274	2.722		2.588
			(2.12)*	(2.00)	(1.60)		(0.80)
Constant	8.033	7.672	10.440	10.010	9.793	8.584	8.381
	(42.29)**	(11.89)**	(6.70)**	(4.79)**	(5.02)**	(35.42)**	(5.97)**
Interact RL01		0.289	-1.201	-1.118	-0.857	-0.016	
		(1.36)	(1.60)	(1.24)	(0.92)	(0.14)	
Observations	106	59	59	59	59	62	100
overid pvalue		0.19	0.85	0.58	0.83	0.15	
Instruments 1/							
RL01	legor_uk	logsetmort, legor_uk, engfrac	logsetmort, legor_uk, engfrac	logsetmort, legor_uk	logsetmort, engfrac	logsetmort, legor_uk, engfrac	
OPEN6590		Infrinstex	Infrinstex	Infrinstex	Infrinstex		Infrinstex

Robust t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.
 1/ Interactive variables are instrumented using lnNatCapital/GNI time the instruments used for the individual variables.

VI. ROBUSTNESS: DIFFERENT MEASURES OF INSTITUTIONAL QUALITY

Tables 10 and 11 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.[16] Interestingly, the results also suggest a natural resource curse as there is some evidence for a significant negative effect at the 5 percent level 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, 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 cross-country correlation between natural resource abundance and inflation.[17] 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

---

[16] 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.

[17] The cross-correlations between inflation over the period 1970 to 1990 and the logarithm of natural resource exports over GNI in 1965 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.

directly a nation's incentives to improve economic performance) and through damaging institutions and not necessarily through the so-called Dutch disease channel. The regressions in Tables 10 and 11 again provide mixed 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.

Table 10: IV Income Per Capita Regressions Using Expropriation Risk Index

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
EXPRORISK	0.075	0.565	0.129	0.510	0.349	0.608	0.368	
	(0.26)	(4.38)**	(0.40)	(4.16)**	(3.32)**	(3.49)**	(3.71)**	
DISTEQ	0.024	0.006	0.025	0.010	0.016	0.006	0.013	0.029
	(1.71)	(0.82)	(1.44)	(1.73)	(2.30)*	(0.79)	(1.74)	(4.43)**
lnNatCapital/GNI	-0.369	-0.241	-0.442	-0.197	-0.503	0.458	-0.631	-0.381
	(2.54)*	(1.78)	(1.99)*	(1.58)	(1.31)	(0.56)	(1.37)	(1.56)
LNOPEN			-0.339	0.393	0.589	-0.652		-0.329
			(0.75)	(1.59)	(2.64)*	(1.43)		(0.76)
Interact LNOPEN						0.537		0.133
						(2.19)*		(1.00)
Constant	7.511	4.492	6.746	5.319	6.577	3.324	5.742	7.663
	(4.19)**	(4.68)**	(3.18)**	(4.93)**	(8.57)**	(1.91)	(8.06)**	(11.97)**
Interact EXPRORISK					0.048	0.012	0.054	
					(0.80)	(0.13)	(0.70)	
Observations	91	53	91	53	53	53	53	112
overid pvalue		0.06		0.11	0.11	0.31	0.14	
Instruments 1/								
RL01	legor_uk	logsetmort, legor_uk, engfrac	legor_uk	logsetmort, legor_uk, engfrac	logsetmort, legor_uk, engfrac	logsetmort, engfrac	logsetmort, legor_uk	
OPEN6590			Infrinstex	Infrinstex	Infrinstex	Infrinstex		Infrinstex

Robust t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.
1/ Interactive variables are instrumented using lnNatCapital/GNI time the instruments used for the individual variables.

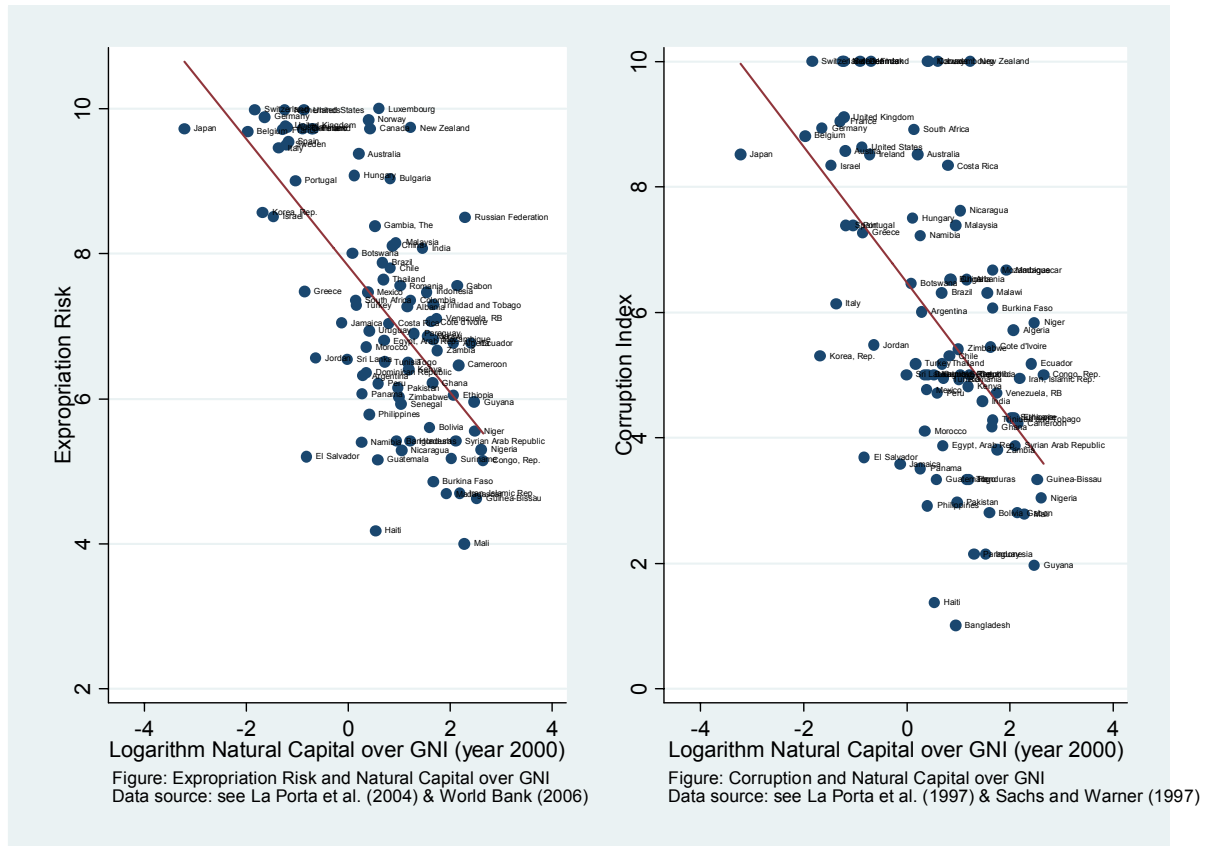**Table 11. IV Income Per Capita Regressions Using Corruption Index**

	(1)	(2)	(3)	(4)	(5)	(6)
CORRUPT	0.082	0.128	0.418	0.208	0.354	
	(0.28)	(0.43)	(3.61)**	(0.77)	(2.90)**	
DISTEQ	0.021	0.020	0.003	0.017	0.004	0.029
	(0.94)	(0.81)	(0.19)	(1.04)	(0.32)	(4.43)**
lnNatCapital/GNI	-0.378	-0.437	1.363	0.374	-0.737	-0.381
	(2.64)**	(1.90)	(1.10)	(0.28)	(1.13)	(1.56)
LNOPEN		-0.270	-1.895	0.194		-0.329
		(0.59)	(1.01)	(0.55)		(0.76)
Interact LNOPEN			1.759	0.471		0.133
			(1.92)	(2.69)**		(1.00)
Constant	7.666	7.141	3.793	7.434	6.657	7.663
	(6.21)**	(5.83)**	(1.45)	(3.94)**	(10.47)**	(11.97)**
Interact CORRUPT			0.189	-0.006	0.091	
			(0.82)	(0.03)	(0.63)	
Observations	90	90	53	90	53	112
overid pvalue			0.74	0.16	0.10	
Instruments 1/						
RL01	legor_uk	legor_uk	logsetmort, legor_uk	legor_uk, engfrac	logsetmort, legor_uk	
OPEN6590		Infrinstex	Infrinstex	Infrinstex		Infrinstex

Robust t statistics in parentheses.
* significant at 5 percent; ** significant at 1 percent.
1/ Interactive variables are instrumented using lnNatCapital/GNI time the instruments used for the individual variables.

Figure 3: Corruption/Expropriation Risk and Log of Natural Capital

Figure: Expropriation Risk and Natural Capital over GNI
Data source: see La Porta et al. (2004) & World Bank (2006)

Figure: Corruption and Natural Capital over GNI
Data source: see La Porta et al. (1997) & Sachs and Warner (1997)

VII. CONCLUDING REMARKS

In our empirical work we focussed on the effects of natural resources on growth performance and cross-country variations in income per capita and paid particular attention to how natural resources might hamper economic performance through institutions and bad policies. We have four main findings. First, we find that the evidence of a resource curse based on OLS growth regressions used in the resource curse literature does not survive the use of instrumental variables techniques. Second, using income per capita-type regressions and instrumenting for institutional quality and openness, we find evidence of a negative direct effect of natural resource exports on income per capita even after controlling for geography, openness, and institutional quality. Third, we find that the conclusion of Mehlum, Moene, and Torvik (2005) that the natural resource curse can be turned into a blessing for countries with good institutions is not robust to the use of instrumental variables techniques. We do find that trade policies directed toward more openness can make the resource curse less severe and may even turn it into a blessing. Fourth, our results are robust to the use of various indicators of institutional quality such as the risk of expropriation or the degree of corruption.

If we use natural resource *abundance* rather than *dependence*, we also find evidence of a natural resource curse after controlling for geography, institutions, and openness. Furthermore, we find that this resource curse is attenuated if countries pursue more liberal trade policies.

Bad trade policies are highly correlated with bad fiscal policies. Resource booms may make it easier to boost public sector employment and investment and subsidies geared towards import substitution in order to win votes and satisfy befriended interest groups. This undoubtedly harms economic performance. It is therefore likely that bad policies in general are likely to aggravate a resource curse and good policies may turn a resource boom into a blessing. In future work it will be important to distinguish between *point-based* and *diffuse* natural resources. The former are typically associated with capital-intensive extraction and concentrated ownership while the rents associated with the latter are more widely dispersed. The idea is that point-based resources are more prone to rapacious rent seeking and the resource curse (e.g., Auty, 2001; Isham et al., 2003; Sala-i-Martin and Subramanian, 2003; Murshed, 2004; and Lay and Mahmoud, 2004). In future work it will also be interesting to investigate further whether and through which channels the notorious volatility of natural resource prices harms economic growth. One way this might occur is that the resulting volatility in real exchange rates has an adverse effect on investment, learning, and growth, but Gylfason, Herbertsson, and Zoega (1999) find no evidence for this. However, Ramey and Ramey (1995) do provide cross-country evidence that volatility harms growth. The underlying cause being that poor countries engaged in excessive borrowing when resource prices were low and suffered from a financial crisis when resource prices rose again. In future work it will also be important to pay more attention to how natural resources induce war and strife, as documented by Collier and Hoeffler (2004),[18] and thus frustrate growth.

---

[18] Also, see Skaperdas (2002), Murshed (2002), Fearon and Laitin (2003), and Ross (2004).

References

Acemoglu, D., S. Johnson, and J.A. Robinson, 2001, "The colonial origins of comparative development: an empirical investigation," *American Economic Review*, Vol. 91, pp. 1369–1401.

Acemoglu, D., S. Johnson, and J.A. Robinson, 2003, "An African Success: Botswana," in *In Search of Prosperity,* ed. by D. Rodrik. Analytic Narratives in Economic Growth (Princeton: Princeton University Press).

Auty, R.M., 2001, "The political economy of resource-driven growth," *European Economic Review*, Vol. 46, pp. 839–46.

Baland, J.-M. and P. Francois, 2000, "Rent-seeking and resource booms," *Journal of Development Economics*, Vol. 61, 527–42.

Barro, R.J. and J.-W. Lee, 1999, "International comparisons of educational attainment," *Journal of Monetary Economics*, Vol. 32, pp. 363–94.

Bardhan, P., 1997, "Corruption and development: a review of the issues," *Journal of Economic Literature* Vol. 35, pp. 1320–1346.

Bruno, M. and J. Sachs, 1982, "Energy and resource allocation: A dynamic model of the 'Dutch Disease'," NBER Working Paper 852, *Review of Economic Studies,* Vol. 49, pp. 845–859.

Brunnschweiler, C., N. and Bulte, E.H., 2006, "Reverse Causality and the Resource Curse: Paradoxes and Red Herrings," Tilburg, mimeo.

Bulte, E., R. Damania, and R. Deacon, 2005, "Resource intensity, institutions and development," *World Development,*Vol. 33(7), pp. 1029–1044.

Busby, G., J. Isham, L. Pritchett, and M. Woolcock, 2002, "The varieties of rentier experience: how natural resource export structures affect the political economy of economic growth," mimeo (Washington: World Bank).

Caselli, F., 2006, "Power struggles and the natural resource curse," mimeo (London: London School of Economics).

Collier, P. and A. Hoeffler, 2004, "Greed and grievance in civil wars," *Oxford Economic Papers,* vol. 56, pp. 663–695.

Corden, W.M., 1984, "Booming sector and Dutch Disease economics: Survey and consolidation," *Oxford Economic Papers,* vol. 36, pp. 359–380.

Dollar, D. and A. Kraay, 2002, "Growth is good for the poor," *Journal of Economic Growth,* vol. 7 (3), pp. 119–225.

Easterly, W. and R. Levine, 2003, "Tropics, germs and crops: how endowments influence economic development," *Journal of Monetary Economics,* vol. 50 (1), pp. 3-39.

Fasano, U, 2002, "With open economy and sound policies, U.A.E. has turned oil "curse" into a blessing," *IMF Survey,* October 21, pp. 330–332.

Fearon, J.D. and D.D. Laitin, 2003, "Ethnicity, insurgency, and civil war," *American Political Science Review,* vol. 97, pp. 75–90.

Forsyth, P.J. and J.A. Kay, 1980, "The economic implications of North Sea oil revenues," *Fiscal Studies,* vol. 1, pp. 1–28.

Frankel, J. and D. Romer, 1999, "Does trade cause growth?" *American Economic Review,* vol. 89, pp. 379–399.

Glaeser, E.L., R. La Porta, F. Lopez-De-Silanes, and A. Schleifer, 2004, "Do institutions cause growth?" *Journal of Economic Growth,* vol. 9, no. 3, pp. 271–303.

Gylfason, T., T.T. Herbertsson, and G. Zoega, 1999, "A mixed blessing: natural resources and economic growth," *Macroeconomic Dynamics,* vol. 3, pp. 204–225.

Hall, R. and C.I. Jones, 1999, "Why do some countries produce so much more output per worker than others?" *Quarterly Journal of Economics,* vol. 114, pp. 83–116.

Heston, A., R. Summers, and B. Aten, 2002, Penn World Table Version 6.1, Centre for International Comparisons (Philadelphia: University of Pennsylvania).

International Monetary Fund, 2005, *World Economic Outlook, September 2005: Building Institutions*, , World Economic and Financial Surveys, Chapter 3, pp. 125-160 (Washington).

Isham, J., L. Pritchett, M. Woolcock, and G. Busby, 2003, "The varieties of the resource experience: How natural resource export structures affect the political economy of economic growth," (Washington: World Bank).

Islam, N., 1995, "Growth empirics: a panel data approach," *Quarterly Journal of Economics,* vol. 110, no. 4, pp. 1127–1170.

Kaufmann, D., A. Kraay, and P. Zoido-Lobaton, 2002, "Governance matters II: updated indicators for 2000/01," Policy Research Department (Washington: World Bank).

Knack, S. and P. Keefer, 1995, "Institutions and economic performance: cross-country tests using alternative institutional measures," *Economics and Politics,* vol. 7, pp. 207–227.

Krugman, P., 1987, "The narrow moving band, the Dutch Disease and the competitive consequences of Mrs. Thatcher on trade in the presence of dynamic scale economies," *Journal of Development Economics,* vol. 27, pp. 41–55.

Lane, P.R. and A. Tornell, 1996, "Power, growth and the voracity effect," *Journal of Economic Growth,* vol. 1 (2), pp. 213–241.

LaPorta, R., F. Lopez-de-Silanes, A. Schleifer, and R.W. Vishny, 1999 "The quality of government," *Journal of Law, Economics and Organization,* vol. 15, pp. 222–279.

LaPorta R., F. Lopez-de-Silanes, C. Pop-Eleches, and A. Schleifer, 2004 "The guarantees of freedom," *Working Paper,* (New Haven: Yale School of Management).

Lay, J. and T.O. Mahmoud, 2004, "Bananas, oil and development: examining the resource curse and its transmission channels by resource type," *Kiel Institute for World Economics*, *Working Paper* No. 1218.

Lederman, D. and W. Maloney, 2002, "Open questions about the link between natural resources and economic growth: Sachs and Warner revisited," *Working Paper* No. 141, Central Bank of Chile.

Mankiw, N.G., D. Romer, and D. Weil, 1992, "A contribution to empirics of economic growth," *Quarterly Journal of Economics,* vol. 107, pp. 407–437.

Mansoorian, A., 1991, "Resource discoveries and 'excessive' external borrowing," *Economic Journal,* vol 101, pp. 1497–1509.

Mansano, O. and R. Ribogon, 2001, ":Resource curse or debt overhang?" *Working Paper* 8390, NBER, Cambridge, Mass.

Mauro, P., 1995, "Corruption and growth," *Quarterly Journal of Economics,* vol 90, pp. 681–712.

Mehlum, H., K. Moene, and R. Torvik, 2005, "Institutions and the resource curse," *Economic Journal,* vol. 116, pp. 1–20.

Murphy, K., A. Schleifer, and R. Vishny, 1993 "Why is rent-seeking so costly to growth?" *American Economic Review,* Papers and Proceeding, pp. 409–414.

Murshed, S.M., 2002, "Civil war, conflict and underdevelopment," *Journal of Peace Research,* vol. 39, pp. 387–393.

Murshed, S.M., 2004 "When does natural resource abundance lead to a resource curse?" mimeo (The Hague: Institute for Social Studies).

Neary, J.P. and D.D. Purvis, 1982, "Sectoral shocks in a dependent economy: long-run adjustment and short-run accommodation," *Scandinavian Journal of Economics,* vol. 84, no. 2, pp. 229–253.

North, D.C., 1990, *Institutions, Institutional Change and Economic Performance*, (New York: Cambridge University Press).

Parente, S.L. and E.C. Prescott, 1994, "Barriers to technology adoption and development," *Journal of Political Economy,* vol. 102, no. 2, pp. 298–321.

Ramey, G. and V.A. Ramey, 1995, "Cross-country evidence on the link between volatility and growth," *American Economic Review,* vol. 85, pp. 1138–1151.

Rigobon, R. and D. Rodrik, 2004, "Rule of law, democracy, openness, and income: estimating the interrelationships," *Working Paper* 10750, NBER, Cambridge, Mass.

Robinson, J.A., R. Torvik, and T. Verdier, 2006, "Political foundations of the resource curse," *Journal of Development Economics,* vol. 79, pp. 447–468.

Rodrick, D., A. Subramanian, and F. Trebbi, 2004, "Institutions rule: the primacy of institutions over geography and integration in economic development," *Journal of Economic Growth,* vol. 9, pp. 131–165.

Ross, M.L., 1999, "The political economy of the resource curse," World Politics, vol. 51, pp. 297-322.

Ross, M.L., 2004, "What do we know about natural resources and civil war?" *Journal of Peace Research**, vol. 41, pp. 337–356.

Sachs, J.D., 2003, "Institutions don't rule: direct effects of geography on per capita income," *Working Paper* 9490, NBER, Cambridge, Mass.

Sachs, J.D. and A.M. Warner, 1995 and revised 1997, "Natural resource abundance and economic growth," in *Leading Issues in Economic Development,* ed. by G. Meier and J. Rauch (Oxford: Oxford University Press).

Sachs, J.D. and A.M. Warner, 2001, "The curse of national resources," *European Economic Review,* vol. 45, pp. 827–838.

Sala-i-Martin, X. and A. Subramanian, 2003, "Addressing the natural resource curse: An illustration from Nigeria," NBER *Working Paper* 9804, Cambridge, Mass.

Skaperdas, S., 2002, "War lord competition," *Journal of Peace Research,* vol. 39, pp. 435–446.

Solow, R.M., 1956, "A contribution to the theory of economic growth," *Quarterly Journal of Economics,* vol. 70, pp. 65–94.

Stijns, J.-C., 2005, "Natural resource abundance and economic growth," mimeo. (Boston: Northeastern University).

Tornell, A. and P.R. Lane, 1999, "The voracity effect," *American Economic Review,* vol. 89 (1), pp. 22–46.

Torvik, R., 2002, "Natural resources, rent seeking and welfare," *Journal of Development Economics,* vol. 67, pp. 455–470.

Wick, K. and E. Bulte, 2006, "Contesting resources—rent seeking, conflict and the natural resource curse," *Public Choice,* vol. 128, no. 3, pp. 457–476.

Wijnbergen, S. van, 1984, "The Dutch Disease: A disease after all?" *Economic Journal,* vol. 94 (373), pp. 41–55.

World Bank, 2006a, *World Development Indicators,* (Washington).

World Bank, 2006b, "Where is the Wealth of Nations? Measuring Capital for the 21st Century," International Bank for Reconstruction and Development/World Bank (Washington).

Appendix A: Data

Category	Variable	Mnemonic	Source
Growth of income per capita	average annual percentage growth rate of real GDP per capita between 1965 and 2000 (constant prices: chain series).	GrowthGDP19652000	Heston Summers and Aten PWT 6.1 (2002)
	average annual percentage growth rate in real GDP per person between 1965 and 1990.	GrowthGDP6590	Sachs and Warner (1997)
Initial income	log of real gross domestic product per capita (international $ in current prices) in 1995.	logGDP/cap95	Heston Summers and Aten PWT 6.1 (2002)
	log of real GDP chain per worker in 1965 (in I$ worker in 1996 constant prices).	logGDP/worker65	Heston Summers and Aten PWT 6.1 (2002)
	log of GDP per capita in 1965.	logGDP/cap65	Sachs and Warner (1997)
Investment share	percentage investment share of RGDPL averaged over 1970–2000 (in 1996 constant prices).	InvShare19702000	Heston Summers and Aten PWT 6.1 (2002)
	ratio of real gross investment to real GDP over 1970 to 1989.	InvRate7089	Sachs and Warner (1997)
Openness	fraction of years during 1965–90 in which country is rated open (de jure measure).	OPEN6590	Sachs and Warner (1997)
	log of average (exports+imports)/GDP, measured in constant 1985 US dollars.	LNOPEN	Dollar and Kraay (2002)
	average de facto openness in constant prices during the period 1965–2000 (in percent in 1996 constant prices).	openk6500	Heston Summers and Aten PWT 6.1 (2002)
	log of extended version of Frankel and Romer (1999) instrument.	lnfrinstex	Dollar and Kraay (2002)
Resource abundance	share of exports of primary products in GNP in 1970.	PrimExp/GNP	Sachs and Warner (1997)
	average natural resource exports over GDP.	Natrsgdpav	World Bank (2006a)
	natural logarithm of natural capital 2000, in thousand of US $ over GNI (in current US$ 2000).	lnNatCapital/GNI	World Bank (2006b)
Institutions	rule of law 2000/01.	RL01	Kaufmann, Kraay, and Zoido-Lobaton (2002)
	institutional quality index (rule of law, level of bureaucracy, risk of expropriation, government repudiation).	InstQual80	ICRG, Sachs and Warner (1997)
	log settler mortality.	logsetmort	La Porta et al. (2004)
	expropriation risk.	EXPRORISK	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: Estimation of Effects of Natural Resources on Economic Growth

Following Solow (1956), we postulate a Cobb-Douglas production function

$$Y = K^\alpha (AL)^{1-\alpha} \quad \text{with} \quad \dot{L}/L = n \quad \text{and} \quad \dot{A}/A = \gamma,$$

where Y, K, L and A indicate output, capital, labour supply and efficiency of labour, respectively, and a constant savings rate s. Hence, capital accumulation is given by:

$$\dot{\hat{K}} = s\hat{Y} - (n + \gamma + \delta)\hat{K} = s\hat{K}^\alpha - (n + \gamma + \delta)\hat{K} \quad \text{with} \quad \hat{K} \equiv K/AL \text{ etc.}$$

Rewriting in terms of the logarithm of national income in efficiency units, we obtain:

$$d\hat{y}(t)/dt = \lambda[\hat{y}^* - \hat{y}(t)] \quad \text{with} \quad \hat{y} \equiv \log(\hat{Y}) = \alpha \log(\hat{K}),$$

$$\hat{Y}^* \equiv \left(\frac{s}{n+\gamma+\delta}\right)^{\alpha/(1-\alpha)} \quad \text{and} \quad \lambda \equiv \hat{Y}^{1-1/\alpha} s(1-\alpha) = (n+\gamma+\delta)(1-\alpha) > 0.$$

The adjustment speed λ is high if the share of capital α is low and the rates of population growth n and labour-augmenting technical progress γ are high. The time to close half the gap is $T = \log(2)/\lambda$. Steady-state income per capita is high if the savings rate s is high and the population growth rate n small, and grows at the rate of technical progress γ.

$$\log(Y(t)/L(t))^* = \log(A_0) + \gamma t + \left(\frac{\alpha}{1-\alpha}\right)[\log(s) - \log(n+\gamma+\delta)].$$

This expression explains cross-country variations in per capita income. To avoid too much noise, assume γ is the same for all countries. The term a_0 reflects technology, resource endowments, climate, geography, and institutional quality, among others and differs across countries. With a constant steady-state level of output in efficiency units, we have:

$$y(t_2) = \theta y(t_1) + (1-\theta)\left[\log(A(t_1)) + \left(\frac{\alpha}{1-\alpha}\right)\{\log(s) - \log(n+\gamma+\delta)\}\right] + \gamma(t_2 - t_1) \text{ or}$$

$$\hat{y}(t_2) = \theta\hat{y}(t_1) + (1-\theta)\hat{y}^* \quad \text{with} \quad 0 < \theta \equiv \exp(-\lambda(t_2 - t_1)) < 1.$$

We can also estimate a regression for the average percentage growth rate:

$$100[y(t_2) - y(t_1)]/(t_2 - t_1) = -\kappa y(t_1) + \kappa_1[\log(s) - \log(n+\gamma+\delta)] + \kappa_2 \log(A(t_1)) + 100\gamma$$

$$\text{with} \quad \kappa \equiv 100[1 - \exp(-\lambda(t_2 - t_1)]/(t_2 - t_1), \quad \kappa_1 \equiv \left(\frac{\alpha}{1-\alpha}\right)\kappa_2 \text{ and } \kappa_2 \equiv 100\left(\frac{1-\theta}{t_2 - t_1}\right) > 0.$$

Growth performance thus rises one for one with the rate of labour-augmenting technical progress, depends negatively on initial income per capita and population growth, and positively on the savings rate. Growth also depends through $a(t_1)$ on technology, resource endowments, climate, geography, and institutional quality, among others. One can then calculate $0 < \theta = 1 - (t_2 - t_1)\kappa/100 < 1$ and $0 < \alpha = \kappa_1/(\kappa_1 + \kappa) < 1$. This implies $0 < \kappa < 100/(t_2 - t_1)$. Also, $\lambda = -\log(\theta)/(t_2 - t_1)$ and $T = \log(2)/\lambda$.

Cross-country regressions yield biased estimates of θ, since they ignore the correlation of the initial level of productivity with past income per capita. This correlation is likely to be positive, so the omitted variable bias will be positive. Hence, cross-country regressions overestimate θ, underestimate κ and underestimate the speed of adjustment λ. They also overestimate α. Following Islam (1995), one could estimate the logarithm of income/capita at time 2 as a panel regression with a lagged dependent variable:

$$y_{it} = \theta y_{it-1} + \theta_1 x_{it}^{1} + \theta_2 x_{it}^{2} + \mu_i + v_t + \varepsilon_{it}$$

where $y_{it} \equiv \log(Y_i(t_2)/L_i(t_2)) = \hat{y}_{it} + \log(A(t_2)), y_{it-1} \equiv \hat{y}_{it-1} + \log(A(t_1)),$

$$x_{it}^{1} \equiv \log(s) - \log(n + \gamma + \delta), \quad v_t \equiv \gamma(t_2 - \theta t_1), \quad \mu_i \equiv (1-\theta)\log(A(0)),$$

and the coefficients are $0 < \theta \equiv \exp(-\lambda(t_2 - t_1)) < 1, \quad \theta_1 \equiv (1-\theta)\left(\dfrac{\alpha}{1-\alpha}\right) > 0.$

Following Mankiw, Romer, and Weil (1992), Barro and Lee (1993), and Hall and Jones (1999), one can avoid a too high estimate of α and also put in (steady-state) human capital h by setting $x_{it}^{2} \equiv \log(h)$ and $\theta_2 \equiv \omega\theta_1/\alpha$ where ω is the share of human capital in value added. Unscrambling the speed of adjustment and the shares of physical capital and human capital:

$$\lambda = \left(\frac{1}{t_2 - t_1}\right)\log(\theta), \quad \alpha = \left(\frac{\theta_1}{1-\theta+\theta_1}\right) \quad \text{and} \quad \omega = \left(\frac{\theta_2}{1-\theta+\theta_1}\right).$$

One can use least squares regression with dummies for the country effects if one assumes that these individual country effects do not change with time. In that case, resource abundance is typically no longer statistically significant. An alternative is to use a minimum distance estimator after specifying the fixed country effects μ_i as a function of the variables to which it is thought to be correlated. For example, the fixed country effects may depend on the vector x_i^{3} which may include the quality of institutions (such as corruption or rule of law), geography/climate, and resource abundance. We can thus estimate the panel:

$$y_{it} = \theta y_{it-1} + \theta_1 x_{it}^{1} + \theta_2 x_{it}^{2} + \theta_3 \hat{x}_i^{3} + v_t + \varepsilon_{it},$$

where the hat indicates the predicted value of the vector x_i^{3} from regressions with appropriate instruments. Since Easterly and Levine (2005) suggest that geography and climate mainly affect the country fixed effects through institutions, one could include an interaction term of those variables with institutions. We leave panel data estimation for further research.