The Pungent Smell of "Red Herrings":
Subsoil Assets, Rents, Volatility and the Resource Curse

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Abstract

Brunnschweiler and Bulte (2008) provide cross-country evidence that the resource curse is a "red herring" once one corrects for endogeneity of resource exports and allows resource abundance affect growth. Their results show that resource exports are no longer significant while the value of subsoil assets has a significant positive effect on growth. But the World Bank measure of subsoil assets is proportional to current rents, and thus also endogenous. Furthermore, their results suffer from an unfortunate data mishap, omitted variables bias, weakness of the instruments, violation of exclusion restrictions and misspecification error. Correcting for these issues and instrumenting resource exports with values of proven reserves at the beginning of the sample period; there is no evidence for the resource curse either and subsoil assets are no longer significant. However, the same evidence suggests that resource exports or rents boost growth in stable countries, but also make especially already volatile countries more volatile and thus indirectly worsen growth prospects. Ignoring the volatility channel, may lead one to erroneously conclude that there is no effect of resources on growth.

JEL-Code: C12, C21, C82, F43, O11, O41, Q32.

Keywords: resource curse, resource exports, resource rents, natural capital, subsoil assets, reserves, instrumental variables, volatility.

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1. Introduction

Brunnschweiler and Bulte (2008ab), from now on referred to as BB, argue that the resource curse popularized by the cross-country study of Sachs and Warner (1997)[1] is a “red herring”.[2] [3] This is a bold claim given the huge literature on the potential adverse effects of natural resources on growth. Interestingly, BB base their critique on the endogeneity of resource dependency, measured by resource exports. It is, after all, reasonable to conjecture that resource exports themselves may be affected by the growth rate of the economy. To overcome the problem, trade openness and a presidential system dummy are put forward as instruments for resource exports. Natural capital as estimated by World Bank (2006a) is used to give the value of subsoil assets. Re-estimation then shows that resource dependence has no significant effect on growth whereas resource abundance, measured by subsoil assets, has a significant positive effect on the growth rate. Hence, BB conjecture in their influential study that the curse is a “red herring”.

However, examining the data for the value of subsoil assets that have been used to shed doubt on the resource curse[4], it becomes apparent that these data are proportional to resource rents. Although the factor of proportionality varies with the ratio of reserves to current production, this is not the case for those resources for which reserves data are missing. World Bank (2006a) made the strong assumption for their 1994 data that natural resources for which reserves data are missing – regardless of where they are, what type they are and what date it is –

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[1] See also Mehlum et al. (2006), Boschini et al. (2007) and van der Ploeg and Poelhekke (2009) for empirical evidence on the natural resource curse.

[2] A “red herring”, often used in mystery novels, diverts attention from the truth about, say, the identity of the guilty party. The “red herring” is a preserved fish with brownish color and pungent smell. One etymology is that it was used in the training of scent hounds and also to deflect attention from the smell of a fox or badger. Another (unlikely) reading is that escaped convicts would throw “red herrings” to confuse the dogs chasing them. (http://en.wikipedia.org/)

[3] Brunnschweiler and Bulte (2009) also argue that the detrimental effect of natural resources on war and conflict established and further evaluated by Collier and Hoeffler (1998, 2004, 2005), Reynal-Querol (2002), Ross (2004), Ron(2005) and Fearon (2005) among others, is also a “red herring”.

[4] Ding and Field (2005) and Alexeev and Conrad (2009) also find that, if natural resource abundance is used rather than natural resource dependence, a positive effect on growth is found. These studies also seem to appear to confuse natural resource abundance with natural resource rents.

last a further 20 years. For their 2000 data the World Bank assumed *all* reserves last 20 years. This may make sense to get a one-off cross-country estimate of natural capital and net adjusted saving, but not to get a cross-country or panel dataset of subsoil wealth. If the effect of resource exports on growth is insignificant and that of subsoil assets is positive and significant, one might conclude that there is no curse

To tackle the intricate issue of endogeneity of natural resource exports and the quality of institutions, BB instrument natural resource exports with average openness and a presidential system dummy and instrument the quality of institutions with latitude. However, their analysis is based on too stringent assumptions that preclude direct interpretation of the results. One problem is that BB accidentally used GDP per capita based on current rather than constant (1996) international dollars. Although BB include all exogenous variables in both stages of IV regressions for economic growth in preliminary regressions instrumenting one endogenous variable at a time (presented in their Table 4), they omit several exogenous variables in the first stages of their more important robustness exercises when all endogenous variables are instrumented at once (presented in their Table 5). The latter generally yield inconsistent estimates. Openness and a presidential system dummy as (weak) instruments for natural resource exports give noisy estimates of resource exports and an insignificant coefficient on the predicted value of resource exports in the second stage. BB also use institutional quality in both the first- and the second-stage IV regressions, which leads to misspecification of the IV regressions if institutional quality is endogenous. Furthermore, weakness of the instruments leads to biased estimates (i.e., a bias towards the OLS estimates). Apart from these issues with appropriate use of instrumental variables, the second-stage regressions may suffer from omitted variables bias as average saving or investment rates, schooling, openness, and population growth do not feature in the second stage. The assumption that the effect of several standard growth determinants is neglible is very restrictive a priori.[5] The standard errors which they report for the second stage may be too small, so that natural resource exports may be more significant than is suggested. Also, the estimated value of subsoil assets is closely related to resource rents and thus is thus also endogenous. This begs the question why subsoil assets themselves are not instrumented.

The objective of this comment is twofold. First, we highlight the strong assumptions behind the World Bank (2006a) measures of natural capital. Second, we examine whether the resource curse is indeed a “red herring” and whether the value of subsoil assets is a blessing for growth as suggested by BB. We therefore re-estimate their IV regressions while relaxing several assumptions. We make sure to use the full range of exogenous variables, obey the exclusion restriction, avoid omitted variables bias in the second stage, and correct the standard errors. We believe openness and a presidential system dummy are weak instruments for natural resource exports (or rents), hence we use not yet extracted reserves per capita from Norman (2009) as an alternative instrument that should not affect growth directly. These data are more exogenous than natural capital data, but relate to economically recoverable reserves and depend on the price of resources and the state of technology. Although they are not completely exogenous, it is random whether a country has resource in the ground or not and this should not affect the rate of economic growth directly. Openness can then also be a potential determinant of growth in the second stage.

We confirm that there is no negative significant effect of initial resource exports on growth. We offer weak evidence that the long-run average of resource exports and rents have negative effects on growth, but these effects are not robust. When using Norman’s (2009) direct

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[5] Although BB argue that their results are robust to including some of these additional regressors, it may still be the case that the results are inconsistent if these are also left out of the first stages.

measure of reserves as an alternative instrument instead of openness and the residential dummy, we find no evidence for either a curse or blessing.

Section 2 describes how the World Bank calculates its estimates of the value of subsoil assets and demonstrates that these data are closely related to resource rents. Section 3 criticizes the use of these data as an explanatory variable. Section 4 re-estimates the effect of resources on growth paying careful attention to the econometric specification, using reserves as instrument for resource exports and the value of subsoil assets, and using data from more recent Penn World Tables. The results confirm there is no evidence neither for a curse or blessing of resource exports, nor of subsoil assets. However, section 5 offers evidence that the negative indirect effect via volatility seems to wipe out the direct effect of resource dependence. Section 6 concludes.

2. How is the World Bank measure of natural capital constructed?

It is hard to estimate the value of energy and mineral resources. First, the importance of the value of resources in national accounting has only recently been recognized, and most efforts to estimate these values are undertaken by international organizations rather than countries themselves. Second, there are no private markets for subsoil resource deposits which can convey information on the value of reserves. Third, reserves are only those that are economically viable to produce and thus depend on the prevalent price of resources and cost of extraction. Still, World Bank (2006a) assigns dollar values to stocks of hydrocarbon energy using data from the BP Statistical Review of World Energy and stocks of bauxite, copper, gold, iron, ore, lead, nickel, phosphate rock, silver, tin and zinc where production figures are available.

For a particular country and resource, we define the value of assets as present value of rents $V_t \equiv \sum_{i=t}^{t+T_t-1} \pi_i q_i (1+r^*)^{-(i-t)}$, where π_i is rent per unit of resource production and q_i production at time i, r^* the growth-corrected social discount rate, and T_t remaining lifetime of the resource measured from time t. Since future rents are unknown, World Bank (2006a) assumes that unit resource rents grow at rate $g \equiv \dot{\pi} / \pi = r / \left[1+(\varepsilon-1)(1+r)^{T_t}\right]$, where $\varepsilon = 1.15$ is the elasticity of the cost function, as in Vincent (1997), and r is the social discount rate. Appendix 1 explains the necessary assumptions. With a growth-corrected discount rate $r^* = (r-g)/(1+g)$, resource wealth at any point of time is proportional to resource rents $V_t = \pi_t q_t \left(\frac{1+r}{r-g}\right)\left[1-(1+r^*)^{-T_t}\right]$. The factor of proportionality is smaller if the remaining lifetime of the resource is less, the growth rate of natural resource rents is smaller or the social discount rate is bigger.

Lifetime years of a resource can be calculated as the ratio of reserves to current production. World Bank (2006a, appendix 1) reports median lifetime years for oil, gas, hard coal and soft coal of 17, 36, 122 and 192 years, respectively, and for bauxite, copper, gold, iron ore, lead, nickel, phosphate, tin, silver and zinc of 178, 38, 16, 133, 18, 27, 28, 28, 22 and 17 years, respectively.[6] With the exception of coal, bauxite and iron which are very abundant, the median reserves-to-production ratios are around 20 to 30 years. To overcome the practical problem of missing data, World Bank (2006a) takes a pragmatic approach and chooses a smaller value of $T = 20$ for all resources and all countries despite lifetime years differing by resource, country, and date, even though a gold mine may have only 15 years left in 2000 and thus only 10 years left in 2005. And no allowance is made for very large lifetimes of coal, bauxite and iron and for the specifics of some countries and some resources. World Bank (2006a) argues that extending the lifetime beyond 20 years should not matter that much, as future rents are more heavily

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[6] Estimates of natural capital for timber resources, non-timber forest resources, cropland, pastureland and protected areas are also given, but as the resource curse is often said to be especially acute for point-based resources (e.g., Boschini, et al., 2007), we focus on the subcategory subsoil wealth.

discounted. Furthermore, uncertainty increases with longer lifetimes and it may be prudent not to weigh distant rents too much.

With a lifetime of 20 years and a social discount rate of $r = 0.04$, we have $T = 20$, $g = 0.03$, $(1+r)/(r-g) = 104$ and $V_t = 18.3\ \pi_t\ q_t$. The value of sub-soil assets for 2000 calculated by World Bank (2006a) is thus simply 18.3 times current natural resource rents.[7] This ratio is relatively constant as the time horizon of the resource is changed. It increases from 14 times natural resource rents for a lifetime of 15 years to 32.3 for a lifetime of 58 years, and thereafter the ratio of sub-soil asset value to current rents gradually declines to 26 (i.e., $(1+r)/r$). With a lifetime more relevant for coal or bauxite, say 175 years, we have a ratio of 26.2 (which is unrealistically low). Doubling the life to 40 years increases the ratio of the value of subsoil assets to 31.9, which is less than double. With a longer lifespan of the resource, costs of extraction rise substantially and so the growth rate of resource rents falls (and tapers off to zero for extremely long lifetimes). Consequently, the growth-corrected social discount rate is higher which reduces the value of sub-soil assets. The other effect is due to the truncation term $\left[1-(1+r^*)^{-T_t}\right]$, which rises as the lifetime T_t increases. If the escalation-of-cost effect dominates the truncation effect, higher lifetimes lower the ratio of value of subsoil assets to current rents. This occurs for $T_t > 58$.

The ratio of sub-soil asset value to current rents is quite sensitive to the choice of social discount rate; the ratio being higher for higher real interest rates. The well-known Keynes-Ramsey rule suggests to use a social discount rate given by $r = \rho + \eta\, g_C$, where g_C denotes growth of consumption, ρ the rate of time preference, and η the coefficient of relative risk aversion or the inverse of the elasticity of intertemporal substitution. With $\rho = 0.02$, $\eta = 2/3$ and

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[7] World Bank (1997) calculates the value of subsoil assets for 1994 in a similar way using average resource rents for the period 1990-94 with again the assumption of a social discount rate of 4 percent per annum and a common lifetime of 20 years for all natural resources for which reserves and production data is missing.

$g_C = 0.03$, we obtain $r = 0.04$. More realistic is to give fast-growing developing economies a higher social discount rate and declining economies a lower social rate of discount, but that has not been done. Resource exporters typically experience low long-run growth rates, which suggests that a low social discount rate of 2 rather than, say, 6 percent is more realistic. The ratio of subsoil assets to current rents is then about three times as high. Furthermore, we note that a smaller curvature of the cost function (lower ε) leads to a higher ratio of the value of subsoil assets to rents across the range of lifetimes, especially in the range 50-90 years.

3. Can natural capital and subsoil assets be viewed as exogenous?

Section 2 and appendix 1 indicate that it is hazardous to use the natural capital data of the World Bank as a cross-country or panel data set. These measures of natural capital assume the same social discount rate of 4 percent per annum independent of whether a country grows fast or slow. Our discussion in section 2 suggests that resource-rich fragile states with low or even negative rates of growth should employ a lower discount rate and thus a higher ratio of subsoil wealth to resource rents, but this only holds on optimal consumption-saving paths. In practice, politicians in such countries tend to be shortsighted, suggesting a lower ratio. For fast-growing countries like China the ratio would be lower. Furthermore, the 2000 measures of natural capital and the 1994 measures only for those cases where reserve data are missing assume the same remaining lifetime of the resource of 20 years and the same elasticity of the cost of extraction, regardless of type of resource, country concerned and calendar date. Appendix 1 points out that calculations of current rents in World Bank (2006a) are based on a dated estimate of the cost function for Malaysian oil fields in World Bank (1992) and used by Vincent (1997). These calculations are an approximation and tend to over-estimate marginal costs of extraction and thus under-estimate resource rents and reserves. The same curvature of the cost function and erroneous calculation is applied to all energy and mineral resources regardless of where production takes place.

For those resources for which data are missing, the World Bank measures of natural capital are 18.3 times resource rents, regardless of the type of the resource, the country concerned and the date. Also, the price of natural resources is assumed to be exogenous, so no allowance is made for market power. Since measures of subsoil wealth are proportional or closely related to resource rents and rents depend on growth in income per capita and are thus endogenous, subsoil wealth is endogenous as well and should thus be instrumented.

We thus re-examine the evidence for the resource curse using Norman's (2009) reserves data. The index of reserves measures the 1970 value of 35 commodities using reserves data from a combination of reports by the US Geological Survey and the US Energy Information Agency.[8] Reserves are measured as the latest (2002) observed level of reserves[9] plus total production during the years preceding the estimate of reserves to capture as closely as possible actual subsoil stocks, even if they are partly discovered in later years or only deemed profitably extractable in later years. This yields the broadest available measure of reserves. Taking only 1970 reserves would have underestimated actual and reasonably expected reserves and limited country coverage. Even though fast-growing countries may have relatively more reserves due to better discovery and extraction technology, it is still essentially random whether a country has resources in the ground. Furthermore, in the ground reserves should not affect growth directly.

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[8] These are: antimony, barite, aluminum, bismuth, boron, chromium, cobalt, columbium, copper, industrial diamond, fluorspar, gold, graphite, iodine, iron, lead, lithium, manganese, mercury, molybdenum, nickel, perlite, phosphate rock, platinum group metals, potash, silver, talc/pyrophyllite, tantalum, tin, titanium concentrate (ilmanite), titanium concentrate (rutile), tungsten, vanadium, zinc and zirconium.

[9] Including deposits considered worth extracting at current prices and extraction costs, and reserves that have potential to become economically available within planning horizons.

Although this measure is somewhat endogenous, we suspect it is much less so than resource rents or the World Bank measures of the value of subsoil assets.

4. Re-examining the natural resource curse with data on subsoil assets

The BB data are described in Appendix 2. One problem, as pointed out in detail in sections 2 and 3, is that their proposed measure of resource abundance, log subsoil 2000 taken from World Bank (2006a), is not exogenous. In any case, they do not use it as an exogenous instrument but as an additional exogenous regressor in the growth regression. They use average openness for the period 1950-60 and a presidential system dummy for 1970 as instruments for mineral exports and use latitude as instrument for institutional quality (rule of law or government effectiveness). They also use the log of hydrocarbon reserves per capita for 1993 taken from Sala-i-Martin and Subramanian (2003)[10] and also the log fuel and non-fuel mineral per-capita stocks taken from Norman (2009). If the latter data are the best reserves variable in the sense of suffering least from the problem of endogeneity, then their regressions 5 and 6 of Table 5 are their best estimates. Their data allows us to exactly reproduce their results.[11] However, regression 1 in Table 1 below reproduces their regression 5 with GDP per capita based on constant (1996) rather than current international dollars.[12] On the basis of these 3SLS estimates, it seems at first blush that the resource curse is a “red herring” and that, if anything, non-fuel mineral per capita stocks have a positive effect on growth, although the equation is unable to explain growth overall.

However, one can also comment on these 3SLS estimates. First, the 3SLS growth regressions suffer from omitted variables bias as usual determinants of growth (average saving or investment

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[10] These are the log of total BTUs per person of proven crude oil and natural gas reserves in 1993 in WRI (1996).

[11] The data was kindly provided to us by the authors.

[12] Using the Penn World Tables 6.1 series *rgdpch* instead of *cgdp*. We will use *rgdpch* throughout this paper. For the Penn World Tables 6.2 the base year is 2000. Over the sample period 1970-2000 the annual growth rates in *rgdpch* and *cgdp* are, respectively, 5.8% and 1.5% per annum.

rates, schooling, openness, or population growth) do not feature in these regressions. Our estimates yield a rate of convergence of –ln(0.647)/30 = 1.45% per year, but the standard error is large.

Openness could not be used as a determinant of growth, since it was already used as an instrument for mineral exports. This issue may be particularly troublesome for 3SLS estimation, because 3SLS is sensitive to the assumed exclusion restrictions in each equation. If only one is invalid (i.e., if initial income does affect the rule of law) then all other parameters in each equation are generally inconsistent. In addition, their 3SLS regressions assume homoskedastic errors. We believe that the robustness of 2SLS estimation is more important for achieving consistent results than the possible efficiency gains of 3SLS in a cross-country growth setting. Second, the variable lgdp70, which is assumed to be exogenous in the second-stage growth regressions, is not included in the first-stages of the 3SLS regressions. This omission will generally lead to inconsistent results due to correlation between the first stage error and the omitted variable. Third, 2SLS first-stage excluded F-tests suggest that the instruments underidentify the instrumented variables, which leads to biased estimates (i.e., a bias towards the OLS estimates). Actual proven reserves rather than the value of subsoil wealth based on rents ought to be a good instrument for resource exports whereas it should not have a direct effect on growth performance. Fourth, the Shea's partial R2 is reported to be 0.43 which implies noisy 2SLS first-stage estimates, leading to inflation of the second-stage standard errors by $0.43^{-0.5}$ = 1.5 (Shea, 1997). This may mean that the mineral exports variable *minxp7080s* is much more significant than is suggested. Fifth, in the 2SLS regressions institutions are included in the second stage but are also included in the first-stage regressions for resource dependence. However, if institutions are endogenous and some assumed exclusion restrictions are violated, than the first-stage regressions for resource dependence are misspecified.

We therefore re-estimate the IV regressions with the following changes:

- To avoid misspecification, institutional quality and openness are not used as instruments in the first stage of the IV regressions as they are potential determinants of growth performance in the second stage. This also helps to avoid the pitfall of omitted variables bias in the second-stage IV regressions. We focus on 2SLS results, rather than 3SLS regressions. The latter are less robust to misspecification of the first stages which may be more important than possible potential efficiency gains from 3SLS regression.
- To further avoid omitted variables bias, population growth, average saving or investment rates and schooling levels are added to institutional quality and initial GDP per capita as potential determinants of economic growth in the second-stage IV regressions.
- Resource exports (minxp) are instrumented with reserves, and a presidential system dummy.[13] Institutional quality is still instrumented with latitude. To avoid inconsistent estimates, we also include all the other exogenous variables in the second stage (i.e., openness, lgdp70, population growth, average investment rates and schooling levels. We thus project each of the potentially endogenous regressors on the full set of exogenous variables and use this as the regressor for the second stage. Additionally, we update the data with a more recent version (6.2) of the Penn World Tables.

As discussed at the end of section 3, reserves are measured at the beginning of the sample period in 1970 to avoid the problem of endogeneity of reserves. Table 1 reports the results of our IV regressions.

Regressions 1 reproduce the 3SLS specification of BB, their Table 5, column 5, which

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[13] Minxp refers to the variable used by BB, which is defined as average resource exports over GDP between 1970 and 1989. When we change the period we also change the name to natpoint in order to clearly distinguish new variables from variables used in BB.

has non-robust standard errors.[14] This specification suggests an insignificant but positive effect of mineral exports on the growth rate of the economy.

Table 1: IV estimates for the effect of natural resources on growth

	(1): BB, with constant (1996) I$			**(2): PWT6.1**			**(3): PWT6.2**		**(4): PWT6.2**	
	1st stage for:	1st stage for:	**3SLS**	1st stage for:	1st stage for:	**2SLS 2nd stage**	1st stage for:	**2SLS 2nd stage**	1st stage for:	**2SLS 2nd stage**
dependent variable	**minxp 7080s**	rule 1996	**g7000**	**natpoint 70**	rule 1996	**g7000**	**natpoint 7000**	**g7000**	**lsubsoil 1994**	**g7000**
Instrumented resource dependence *(definition changes)*			0.998			**1.400**		**-0.933**		
			(0.916)			**(0.947)**		**(1.115)**		
Instrumented resource stock based on rents										**-0.008**
										(0.035)
rule 1996	-0.010		0.554*			**0.421**				
	(0.017)		(0.283)			**(0.270)**				
rule 1984							0.003	**0.064**	0.450***	**0.123****
							(0.006)	**(0.044)**	(0.136)	**(0.058)**
open5060s	0.209***			0.233***	0.046	**-0.253**	0.159***	**0.041**	0.186	**-0.390**
	(0.033)			(0.077)	(0.273)	**(0.243)**	(0.034)	**(0.150)**	(0.832)	**(0.264)**
lgdp70			-0.353	0.042	0.267	**-0.628*****	-0.004	**-0.499*****	-0.051	**-0.525*****
			(0.215)	(0.033)	(0.201)	**(0.183)**	(0.014)	**(0.084)**	(0.267)	**(0.093)**
invgdp7000				-0.000	0.012	**0.030*****	-0.001	**0.036*****	-0.011	**0.023****
				(0.002)	(0.009)	**(0.010)**	(0.002)	**(0.008)**	(0.030)	**(0.011)**
human70				-0.027***	0.111*	**-0.005**	-0.006	**0.027**	-0.092	**0.014**
				(0.010)	(0.065)	**(0.057)**	(0.005)	**(0.025)**	(0.108)	**(0.025)**
gpop7000				-0.064	-0.128	**-0.437***	-0.048	**-0.720*****	-0.350	**-0.856*****
				(0.039)	(0.246)	**(0.250)**	(0.056)	**(0.213)**	(1.151)	**(0.291)**
Instruments:										
pres70s	0.066***			0.010	-0.016		0.046***		0.431	
	(0.024)			(0.035)	(0.184)		(0.015)		(0.370)	
lallminpc	0.016***	0.034	0.004	0.019***	-0.009		0.014***		0.753***	
('mineral abundance')	(0.003)	(0.023)	(0.022)	(0.005)	(0.030)		(0.004)		(0.107)	
latitude		2.449***		0.014	1.544**					
		(0.552)		(0.083)	(0.581)					
Constant	0.023	0.620	2.994*	-0.097	-2.849*	**5.596*****	0.135	**4.172*****	9.836***	**4.726*****
	(0.062)	(0.521)	(1.757)	(0.213)	(1.521)	**(1.412)**	(0.119)	**(0.624)**	(2.579)	**(0.601)**
Observations/Countries	82	82	82	61	61	**61**	66	**66**	50	**50**
R-squared	0.541	0.685	0.327	0.516	0.871	**0.746**	0.59	**0.60**	0.69	**0.61**
Hansen J overidentification test, p-value						**0.497**		**0.537**		**0.862**
Kleibergen-Paap F-test statistic (robust)						**2.413**	**9.185**		**25.083**	
Shea's Partial R2				0.271	0.124		**0.368**		**0.598**	
1st stage excluded F-test (non-robust)				5.986	2.888					

Standard errors in parentheses, robust to heteroskedasticity in regressions (2), (3) and (4). Regressions (1) and (2) include BB regional dummies, but they were excluded in regressions (3) and (4) because they were jointly insignificant. *** p<0.01, ** p<0.05, * p<0.1

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[14] For reasons of space and clarity, we only use rule of law as a proxy of institutions and not also government effectiveness. The core 3SLS estimates of the core regression of BB with real GDP per capita growth evaluated at current rather than constant international dollars are 3.666 Instrumented Resource dependence + 2.774** rule 1996 – 1.604* lgdp70 + 0.055 lalmincp + 15.786** constant, 84 Observations/countries, R-Squared = 0.333.

2SLS regressions 2 incorporate several improvements to the specification. First of all, average natural resource exports between 1970 and 1989 (minxp) is replaced with resource exports in 1970 (natpoint70) because initial period characteristics suffer less from reverse causality concerns than average period resource dependence, and mineral abundance (lallminpc) as captured by the 1970 stock of reserves per capita is now used as an excluded instrument along with the presidential dummy (pres70s) and latitude. Moreover, we include several previously omitted variables such as the average investment intensity between 1970 and 2000 (invgdp7000), initial schooling (human70) and average population growth between 1970 and 2000 (gpop7000) and we let openness (open5060s) affect growth directly. Also rule of law in 1996 (rule) no longer enters the first stage for resource exports because it is endogenous.

Even though the instruments are exogenous (see the high p-value of the Hansen J test statistic which is robust to heteroskedasticity), we still see that the first stages are underidentified. The Kleibergen-Paap (2006) F-statistic is far below 10, which means that the IV estimates have a bias of over 30% towards the corresponding OLS coefficient (Stock and Yogo, 2005).[15] Even the F-test by first stage on the excluded instruments are very small (unlike the Kleibergen-Paap statistic they are not robust to heteroskedasticity and do not take into account the correlation among instruments across the first stages) and suggest that especially latitude as an instrument for rule of law performs poorly. We therefore gain little from instrumenting, yielding the inconsistent result that resource exports have a weakly significant positive effect on growth.[16]

In regressions 3 we also update the data with more recent Penn World Tables 6.2 (Heston et al., 2006) and replace initial resource exports with the average over 30 years (natpoint7000). For

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[15] The Kleibergen-Paap statistic is uses the same critical values as the Cragg-Donald (1993) statistic. The latter assumes i.i.d. errors, while the former is more general.

[16] The effect, if taken at face value, is rather large: a one standard deviation increase in resource dependence (9.8%) supposedly leads to a bonus of 0.46% additional annual growth.

lack of a good instrument for rule of law, we replace rule of law in 1996 with rule of law in 1984 to limit reverse causality as much as possible. Latitude is consequently no longer included in the first stage for resource exports. The diagnostic statistics are now much more favorable. The instruments are exogenous according to the Hansen test and although the instruments are not perfect, they predict resource exports much better as suggested by the Kleibergen-Paap statistics, which means that the bias has halved with respect to regressions 2 and 3 in BB table 4.[17] Population growth is now also significant. We estimate a convergence rate of –ln(0.501)/30 = 2.30% per year, which implies 30 years to halve the gap. Resource exports do not significantly affect growth. The sign points in the direction of a curse, but the standard error is large.[18]

Regressions 4 also look at subsoil assets (based on rents, from BB) as a measure of a country's endowment of natural resources. This time we assume that it is endogenous for reasons explained before and instrument it with reserves. The model works rather well judging from the very good Kleibergen-Paap F statistic[19] and the overidentification test. We can therefore safely conclude that subsoil assets have no effect on growth.

5. Unscrambling the “red herring”: Volatility and the resource curse

In van der Ploeg and Poelhekke (2009) we offer support for an indirect effect of natural resources on growth via the volatility channel. To put this thesis to the test whilst allowing for endogeneity of mineral resource exports taking account of the critiques discussed above, we estimate IV regressions for yearly growth in GDP per capita and volatility of unanticipated

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[17] The critical value above which the bias towards the OLS equivalent is less than 10% is for this case 19.93, and 11.59 for 15% bias (Stock and Yogo, 2005).

[18] If the effect were significant, a one standard deviation increase in resource dependence (7.7%) would lead to a cut of 0.24% growth per annum.

[19] The critical value above which the bias is less than 10% is 19.93 for this case.

output growth. Using a dataset with N countries and a sample of T years, we estimate a three-equation econometric model for growth in GDP per capita:

$$(1) \qquad \Delta \log(y_{it}) = \lambda \sigma_i + \mathbf{X}_{i70}\boldsymbol{\theta} + \mathbf{Z}_{i70}\boldsymbol{\beta} + \mu \hat{r}_{i70} + \varepsilon_{it}, \quad \varepsilon_{it} \sim N(0, \sigma_i^2), \quad i = 1,..,N, \quad t = 1,..,T.$$

$$(2) \qquad \sigma_i^2 = \exp(\mathbf{Z}_{i70}\boldsymbol{\gamma} + \nu \hat{r}_{i70} + c) \text{ and}$$

$$(3) \qquad r_{i70} = \xi a_{i'70} + \omega X_{i70} + \chi Z_{i70} + \theta_i, \quad \theta_i \sim \mathrm{N}(0, \tau^2),$$

where y_{it} is GDP per capita in country i for year t, σ_i is the standard deviation for country i of the innovation terms ε_{it}, $\mathbf{X}_{\mathbf{i70}}$ are the controls for country i in 1970, r_{i70} is mineral resource exports (dependence) for country i, and a_{i70} measures resource reserves (abundance). Equation (1) explains growth, (2) explains volatility of unanticipated output growth, and (3) is the first-stage regression for resource dependence, where $\hat{r}_{i70}$ indicates the predicted instrumented values. We suppose average volatility σ_i is constant over time, but differs depending on the initial country characteristics captured in $\mathbf{Z}_{\mathrm{i70}}$. We also allow for *direct* effects of these variables on growth ($\boldsymbol{\beta}$). We suppose error terms are uncorrelated across countries, but allow for correlation of errors within countries over time. The parameters λ, μ, ν, c and vectors $\boldsymbol{\theta}$, $\boldsymbol{\beta}$, $\boldsymbol{\gamma}$, $\boldsymbol{\omega}$ and $\boldsymbol{\chi}$ are supposed to be constant across countries. We estimate these coefficients by maximizing the corresponding log-likelihood function.

We extend van der Ploeg and Poelhekke (2009) by instrumenting resource exports. The traditional view ignores the volatility channel and interprets a significant negative estimate of μ as evidence for the natural resource curse. Our evidence presented in table 1 based on BB suggests, in fact, that μ is insignificantly different from zero and possibly even positive, which undermines the case for the traditional resource curse. However, the total effect of resource dependence on unanticipated output growth is given by $\partial \Delta \log(y_{it}) / \partial r_{i70} = \mu + \frac{1}{2} \lambda \nu \sigma_i$. Hence, if resource dependence exerts a positive influence on volatility (positive ν) and volatility exerts a negative influence on growth in unanticipated output (negative λ), there may be a resource curse even if μ is positive provided that λ, ν and σ_i are big enough. Another way of saying this is that if a positive direct effect of resources on growth (μ) is cancelled by the indirect negative effect via volatility ($\lambda \nu \sigma_i/2$), one could erroneously conclude from table 1 there is no effect of resources on growth. Note that our specification implies that a curse is more likely to occur in more volatile countries. Descriptive statistics of the variables used in the regressions are reported in table 2.

Table 2: Descriptive statistics

	regression 5		regression 6	
Variable	mean	sd	mean	sd
d_gdppc	0.016	0.046	0.015	0.046
invgdp70	0.202	0.133		
invgdp7003			0.169	0.070
gpop7003	0.017	0.010	0.017	0.010
log_gdppc70	8.418	0.947	8.361	0.947
human70	4.238	2.753	4.102	2.673
volatility	0.039	0.021	0.040	0.020
findev70	0.298	0.231	0.292	0.227
open70	0.386	0.487	0.341	0.474
lallminpc	-6.830	2.565	-6.891	2.884
Resource dependence (point-source) 1970	0.043	0.096		
Resource dependence (point-source) 1970-2003			0.052	0.075
Resource dependence (diffuse) 1970	0.072	0.059		
Resource dependence (diffuse) 1970-2003			0.067	0.051
distcr	259.567	319.801	262.313	317.122

Countries (with * included in regression 6, but not in regression 5 due to data availability constraints): Algeria, Argentina, Australia, Austria, Belgium, Benin, Bolivia, Brazil, Cameroon, Canada, Central African Republic, Chile, Colombia, Congo, Rep., Costa Rica, Denmark, Dominican Republic*, Ecuador, Egypt, Arab Rep., El Salvador, Finland, France, Ghana, Greece, Guatemala, Honduras, Iceland*, India, Ireland, Israel, Italy, Jamaica*, Japan, Jordan, Kenya*, Korea, Rep., Malaysia, Mali, Mexico, Netherlands, New Zealand, Nicaragua, Niger, Norway, Pakistan, Panama, Paraguay*, Peru, Philippines, Portugal, Senegal, South Africa*, Spain, Sri Lanka, Sweden, Switzerland, Syrian Arab Republic*, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda*, United Kingdom, United States, Uruguay, Venezuela, Zambia.

Natural resource export intensity enters both **X** and **Z**, but we assume it is endogenous and instrument it with reserves in 1970. Table 3 therefore reports a first stage with lallminpc as the excluded instrument.[20] We did not use the presidential dummy as instrument, since it had no predictive power for resource exports. Omitting it improves the first stage F-statistics even though we sacrifice the Hansen test because the model is just identified.

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[20] We report panel robust sandwich standard errors, which are asymptotically equivalent to block bootstrapping.

Table 3: IV estimates for the effect of natural resources on volatility and growth

dependent variable: d_gdppc	(5)		(6)	
	1st stage for:	**2nd stage**	1st stage for:	**2nd stage**
Mean equation:	**natpoint70**		**natpoint7003**	
Resource dependence (point-source)		**0.123*****		**0.057**
		(0.037)		**(0.043)**
ld_gdppc	-0.020	0.224***	-0.020	0.230***
	(0.033)	(0.026)	(0.031)	(0.028)
invgdp70	0.392**	-0.032**		
	(0.150)	(0.016)		
invgdp7003			0.362**	0.057**
			(0.181)	(0.026)
gpop7003	-3.070	-0.517***	-0.678	-0.345**
	(3.496)	(0.152)	(1.656)	(0.148)
lgdppc70	0.025	-0.020***	0.014	-0.011***
	(0.018)	(0.003)	(0.017)	(0.002)
human70	-0.014*	0.003***	-0.006	0.001**
	(0.007)	(0.001)	(0.005)	(0.001)
Volatility (σ_i)	0.769	**-1.208****	1.798***	**-0.394****
	(1.182)	**(0.471)**	(0.508)	**(0.187)**
findev70	-0.059	-0.014*	-0.046	-0.007
	(0.045)	(0.008)	(0.028)	(0.005)
open70	-0.058*	-0.004	-0.033	0.001
	(0.035)	(0.006)	(0.026)	(0.004)
Constant		0.236***		0.114***
		(0.040)		(0.019)
Instrument:				
lallminpc ('mineral abundance')	0.013**		0.009***	
	(0.006)		(0.003)	
Variance equation:				
Resource dependence (point-source)		**2.664*****		**11.803*****
		(0.908)		**(0.662)**
Resource dependence (diffuse)	0.139	1.085**	-0.148	5.320***
	(0.173)	(0.486)	(0.145)	(0.584)
findev70		-1.645***		-0.532***
		(0.085)		(0.115)
open70		-0.717***		-0.652***
		(0.176)		(0.151)
distcr	0.000	0.001***	0.000	0.000**
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	-0.044	-6.126***	-0.074	-7.382***
	(0.160)	(0.035)	(0.149)	(0.040)
Observations	2016	2016	2282	2282
Countries	60	60	68	68
year dummies in mean eq.	yes	yes	yes	yes
R-squared	0.514	.	0.548	.
Log likelihood	2595	3759	3573	4389
Kleibergen-Paap F-test statistic (robust)		8.393		4.702
Shea's Partial R2		0.145		0.140

Robust and clustered (by country) standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

However, from previous regressions we feel confident that reserves are exogenous. We also exclude rule of law in 1984 because it was never significant and limits the sample. Instead we use openness in 1970 (open70) and financial development (private credit as percentage of GDP, findev70). We also control for one lag of per capita GDP growth (ld_gdppc) and barriers to trade (distance to the nearest coast or navigable river, distcr) and initial investment intensity (invgdp70). We distinguish between point-source resources (such as metals, natpoint70) and diffuse resources (such as agriculture, natnonpoint70). Also openness and financial development may have direct and indirect effects.

The diagnostic statistics of regression 5 are favorable and we find significant positive effects of resource exports on growth at the 1% significance level. However, we also find that volatility affects growth negatively, which itself is heavily increased by dependence on natural resource exports! Van der Ploeg and Poelhekke (2009) show that the indirect effect through volatility is more robust than the direct effect. In regressions 6 we use averages over time for resource and investment intensity instead of initial levels.[21] The direct positive effect of exported raw mineral and fuel resources becomes insignificant and the net effect of resource dependence predicts a negative effect of resource on growth. The idea is that volatile swings of world resource prices translate into severe shocks to GDP in countries that depend on natural resource exports. We use regression 6 to calculate $\partial \Delta \log(y_{it}) / \partial r_{i70} = 0.057 - 0.394 \times 11.803 \times \sigma_i / 2$, so there is a resource curse for countries with growth volatility above 2.45%.[22] This is the case for say Bolivia, but not for Norway with its strong institutions and financial development.[23] Both

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[21] Averages are taken between 1970 and 2003, since we have GDP per capita growth data up to and including 2003.

[22] Similarly, for average variable values, a one standard deviation increase in resource dependence (7.5%) has a direct positive effect of 0.43%-points additional growth, but also decreases annual growth by 0.7%-points.

[23] Out of 68 countries in the sample of regression (6), only 20 (mostly OECD countries) have growth volatility below 2.45%.

average about 15% point-source resource dependence between 1970 and 2003. We thus believe that an indirect curse exists, through volatility. For countries that are relatively stable, natural resource dependence may be a blessing rather than a curse.

6. Conclusion

The natural resource curse has rarely been questioned. BB therefore deserve credit for questioning the exogeneity of natural resource dependence and therefore questioning the validity of the curse itself. They find that, once resource dependence is instrumented with natural resource abundance, the curse as popularized by Sachs and Warner (1997) turns out to be a “red herring”; resource dependence has no significant effect on growth. Our comments on BB are directed at a better understanding of the data used to measure subsoil assets, the econometric methodology, and the specification of the resource curse.

Care is needed in using World Bank (1997, 2006a) estimates of the value of natural resources in cross-country and panel studies, since these data use the same social discount rate of 4 percent per annum regardless of whether a country grows fast or slow, and the same remaining lifetime of 20 years and the same elasticity of the cost of extraction regardless of the type of resource, the country concerned and the date. Furthermore, they over-estimate marginal extraction costs and under-estimate resource rents and reserves and they do not allow for monopoly power on the resource market. The rents data are based on dated estimates of the cost function for Malaysian oil fields. The measures of subsoil wealth are endogenous, since they are a multiple of endogenous resource rents. Hence, the econometric tests using these data reported in BB can be criticized as subsoil wealth cannot be used as an instrument for resource exports.

This is why we focus on the specifications that use fuel and non-fuel mineral per-capita stocks from Norman (2009), which is a more exogenous measure of resource abundance.

We improve on the econometric methodology of Brunnschweiler and Bulte (2008ab) by using GDP based on constant rather than current international dollars, introducing omitted variables such as schooling, investment and population growth in the growth equation, excluding institutional quality and openness as instruments as they are potential determinants of growth, including all other exogenous variables in the set of instruments, and also using the latest version of the Penn World Tables. We concur with BB that there is no evidence for a traditional resource curse and there may even be a small positive direct effect of resource dependence on growth. However, this may be due to the fact that the direct positive effect on growth of the level of resource dependence and the indirect negative effect via volatility more or less wipe each other out. If we instrument resource dependence with resource abundance and use the data of this comment, we indeed find in line with van der Ploeg and Poelhekke (2009) evidence for this. This suggests that the total effect of resource dependence on growth is negative in highly volatile countries and positive in stable countries, so that the quintessence of the resource curse appears to be the notorious volatility of commodity prices.

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Appendix 1: Extraction costs and sustainability of natural resources

We sketch the ingenious arguments of Vincent (1997). The Hartwick rule ensures that a country sustains a constant level of consumption by maintaining a constant broad stock of capital, including physical, human, and natural resource capital, and environmental quality. Hartwick (1977, 1990) shows that a country then needs to deplete its non-renewable resource at a rate equal to the Hotelling rents $\pi(t)q(t)$, where $q(t)$ denotes the level of natural resource production, unit rents are defined by $\pi(t) \equiv p(t) - c'(q(t))$ and $c(q(t))$ denotes the cost function for producing natural resources, all at time t. Unit rents are the exogenous price of natural resources minus marginal extraction cost. The required rate of depletion is thus less than resource rents $p(t)q(t) - c(q(t))$. When resource extraction begins, marginal rent is low and Hotelling rents are low compared to total rents. As extraction continues, the logic of the Hotelling rule demands that marginal rents rise and thus that Hotelling rents grow more in line with rents. Just before the resource is exhausted, Hotelling rents reach rents. Hartwick and Hagemann (1993) suggest a sinking-fund interpretation: investing the Hotelling rents in an interest-bearing account each year implies that, by the time the well or mine reaches exhaustion, there are sufficient funds to buy an equally valuable well or mine and sustain business. Over time, a growing proportion of resource rents need to be invested in the sinking fund as the time that is available to earn interest before exhaustion shrinks. If each period actual rents rather than Hotelling rents are consumed, the economy is unable to sustain constant consumption.

Since data on marginal extraction costs and Hotelling rents are unavailable, Vincent (1997) obtains Hotelling rents by using estimates of the elasticity of the marginal cost curve and the number of years before the well or mine is exhausted. He adopts an aggregate approach for a wide range of minerals in Malaysia produced at hundreds of sites with varying resource quality and extraction costs. Suppose extraction costs for producing $q(t)$ barrels, m3s or tons of the resource are $\mathrm{c}(q(t)) = \Xi\, q(t)^{\varepsilon}$ with $\varepsilon > 1$ to ensure $\mathrm{c}''(q(t)) > 0$. Since at the time of exhaustion T marginal cost $\varepsilon\, \Xi\, q(T)^{\varepsilon-1}$ must equal average cost of extraction $\Xi\, q(T)^{\varepsilon-1}$ in an optimal program, we have $q(T)=0$ and marginal rents at time T equal p. Vincent (1997) applies Hotelling's (1931) rule, namely that growth of marginal rents equals the rate of discount, to get marginal rent at terminal date T as $p = [p - \mathrm{c}'(q(\mathrm{t}))]\,(1+r)^{T-t}$ and thus marginal extraction cost at time t equals:

(A1) $$\mathrm{c}'(q(t)) = p\,[1 - (1+r)^{-(T-t)}] \quad \text{and} \quad \mathrm{c}(q(t)) = \mathrm{c}'(q(t))q(t)/\varepsilon.$$

This expression is not quite correct, since it erroneously assumes that resource production levels are constant for the remaining life of the resource (i.e., assumes $q(s)=q(t)$ for $t \le s < T$ and $q(T) = 0$) whereas the Hotelling rule suggests that resource production levels and marginal extraction costs gradually diminish over the life of the resource until they become zero at the date of exhaustion. Correct application of Hotelling's rule gives the permanent value of marginal extraction costs at time t as:

(A1′) $$p[1-(1+r)^{-(T-t)}] = \overline{\mathrm{c}'(q(t))} \equiv (1+r)^{T-t}\sum_{s=t}^{T}\mathrm{c}'(q(s))(1+r)^{-(s-t)} < \mathrm{c}'(q(t)).$$

The erroneous assumption used in Vincent (1997) and World Bank (2006a) thus leads to an over-estimate of current marginal costs of extraction and an under-estimate of resource rents. Working with the approximation of Vincent (2007) and making use of (A1), we see that the ratio of Hotelling rents to rents can be written as:

(A2) $$\Theta(t) \equiv \frac{pq(t) - \mathrm{c}'(q(t))q(t)}{pq(t) - \mathrm{c}(q(t))} = \frac{pq(t)(1+r)^{-(T-t)}}{pq(t) - \varepsilon^{-1}pq(t)\left[1-(1+r)^{-(T-t)}\right]} = \frac{\varepsilon}{1+(\varepsilon-1)(1+r)^{(T-t)}} \cong \frac{\varepsilon}{1+(\varepsilon-1)(1+r)^{S(t)/q(t)-1}} \le 1,$$

where $S(t)$ is the stock of in-situ reserves time t and $S(t)/q(t)-1$ a proxy for the remaining years of the resource. Note that $\Theta(T) = 1$. The value of ε chosen by Vincent (1997) is 1.15, which comes from the development cost function for Malaysian oil fields reported in World Bank (1992).

Total development costs corresponding to an oil field of size Z equals $c_D(Z) = 40\, Z^{0.85}$, so the development costs of a marginal field are $c_D'(Z) = 34\, Z^{-0.15}$ and decline with the size of an oil field. If largest fields are put into production first, increases in production are associated with declining marginal field size and thus rising marginal development costs. Since operating costs do not vary with field size, the overall marginal cost elasticity equals the marginal development cost elasticity:

$$\text{(A3)} \qquad \varepsilon-1 = [\mathrm{d}c_D'(Z)/\mathrm{d}Z]\,(\mathrm{d}Z/\mathrm{d}q)\,[q/c_D'(Z)] = -0.15\,(\mathrm{d}Z/\mathrm{d}q)\,q/Z = 0.15 \;\text{ and }\; \varepsilon = 1.15,$$

where Z is inversely proportional to q to capture that the number of large fields is smaller than the number of smaller fields. It follows from (A2), Hotelling's rule (marginal unit rents, $p - c'(q(t))$ must grow at the rate of discount), and the approximation $\ln(1+r) \cong r$ that unit rents $\pi(t) \equiv p - c(q(t))/q(t) = \Theta(t)\,[p - c'(q(t))]$ must grow at the rate that is used in the calculations of natural capital in World Bank (2006a):

$$\text{(A4)} \qquad g(t) \equiv \dot{\pi}(t)/\pi(t) = r - \dot{\Theta}(t)/\Theta(t) = r \Big/ \left[1+(\varepsilon-1)(1+r)^{T-t}\right].$$

Appendix 2: Description of data

	Data taken from Brunnschweiler and Bulte (2008)	
minxp7080s	GDP share of total yearly mineral exports, defined as the sum of fuel minerals, ores and metal exports, averaged over 1970–1989. Fuels comprise SITC section 3 (fuel minerals); ores and metals comprise the commodities in SITC sections 27 (crude fertilizer, minerals not elsewhere specified (n.e.s.)), 28 (metalliferous ores, scrap), and 68 (non-ferrous metals).	World Development Indicators and PWT 6.1
lsubsoil_1994	Ln of subsoil assets, estimated in US$ per capita. The measures include energy resources (oil, natural gas, hard coal, lignite) and other mineral resources (bauxite, copper, iron, lead, nickel, phosphate, tin, zinc). Based on rents averaged between 1990 and 1994. T=20 only for those resources where reserves data was not available. Does not include gold and silver.	World Bank (1997)
lsubsoil_2000	as in lsubsoil_1994, but includes gold and silver and refers to year 2000 only. T=20 for all resources and countries.	World Bank (2006a)
Lallminpc	Ln of fuel and 35 non-fuel mineral stocks estimated for 1970 at market prices, in US$ per capita.	Norman (2009)
Latitude	Absolute value of latitude of a country on a scale of 0–1.	La Porta et al. (1999)
open5060s	Measure of trade openness (in nominal terms), defined as the sum of imports and exports over GDP. Average between 1950 and 1969.	PWT 6.1

pres70s	Binary indicator for form of government, coded 1 if the chief executive is directly presidential or a strong president elected by an assembly. Coded 0 if parliamentary. Value for early 1970s.	Beck et al. (2005), Persson and Tabellini (2004)
rule 1996	Measures quality of contract enforcement, police and courts, and likelihood of crime and violence in 1996. Calibrated with values between 0 (worst) and 5 (best).	Kaufmann et al. (2005)
	Additional data	
g7000	Ln difference of real GDP per capita between 1970 and 2000, in constant international dollars (1996 for PWT 6.1, and 2000 for PWT 6.2).	PWT 6.1 and 6.2 (rgdpch)
lgdp70	Ln of real GDP per capita in 1970, in constant international dollars (1996 for PWT 6.1, and 2000 for PWT 6.2).	PWT 6.1 and 6.2 (rgdpch)
Gpop	Ln difference in total population. Averages are taken by country across the given period	PWT 6.1 and 6.2
Human	Average schooling years in the population (age 25+)	Barro & Lee(2000)
Invgdp	Gross fixed capital formation as % of GDP. Averages are taken by country across the given period	PWT 6.1 and 6.2
Natpoint	F.o.b. value of exported fuels + ores & metals as percentage of GDP. Averages taken by country across given period	World Bank (2006b)
rule 1984	Country's score on law and order index in 1984 (first year available)	PRS Group (2006)
	Additional data for table 3	
d_gdppc	Annual ln difference in real GDP per capita, Laspeyres	PWT 6.1 and 6.2
ld_gdppc	One year lag of annual ln difference in real GDP per capita, Laspeyres	idem
open	dummy: open to trade = 1	Wacziarg and Welch (2008)
distcr	minimum distance in km to nearest navigable river or coast	CID, General Measures of Geography, 2007
findev	Domestic credit to private sector (% of GDP)	World Bank (2006)
natnonpoint	idem, but foods and agricultural raw materials. Averages are taken by country across the given period	World Bank (2006b)

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