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Natural Resources and Economic Growth: A Meta-Analysis

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Abstract

An important question in development studies is how abundance of natural resources affects long-term economic growth. No consensus answer, however, has yet emerged, with approximately 40% of empirical papers finding a negative effect, 40% finding no effect, and 20% finding a positive effect. Does the literature taken together imply the existence of the so-called natural resource curse? In a quantitative survey of 402 estimates reported in 33 studies, we find that overall support for the resource course hypothesis is weak when potential publication bias and method heterogeneity are taken into account. Our results also suggest that three aspects of study design are especially effective in explaining the differences in results across studies: 1) including an interaction of natural resources with institutional quality, 2) controlling for the level of investment activity, and 3) distinguishing between different types of natural resources.

JEL-Classification: Q30, O13, C51
Keywords: Natural resources, economic growth, institutions, publication selection bias, meta-analysis

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An online appendix with data and code is available at meta-analysis.cz/resource_curse

1 Introduction

Little consensus exists on the effect of natural resource richness on economic growth and the mechanism underlying the effect. An influential article by Sachs and Warner (1995) argues that the impact of natural resources on growth is negative, and the finding has been labeled the "natural resource curse." More specifically, this stream of literature asserts that point-source non-renewable resources, such as minerals and fuels, can hamper growth.[1] Mehlum et al. (2006) put forward that the natural resource curse only occurs in countries with low institutional quality and that with a sufficient quality of institutions natural resources can foster long-term development. Other researchers emphasize that the natural resource curse is more likely to occur for certain types of natural resources (Isham et al., 2005), because point natural resources such as oil are for economic and technical reasons more prone to stir rent-seeking and conflict (Boschini et al., 2007).

Atkinson and Hamilton (2003) and Gylfason and Zoega (2006) propose a different transmission channel and stress the role of investment. They find that natural resources crowd out physical capital and consequently have a negative effect on economic growth. Brunnschweiler and Bulte (2008) show that the quality of institutions is endogenous to natural resource richness and discriminate between natural resource dependence (flows) and natural resource abundance (stocks). They conclude that while resource dependence does not affect growth, resource abundance is growth-enhancing. Alexeev and Conrad (2009) also find very little evidence in support of the natural resource curse. To the contrary, examining countries with large oil endowments, they find that these countries exhibit higher income growth. In addition, Smith (2015) examines the impact of major natural resource discoveries since 1950 on GDP per capita and, applying various quasi-experimental methods such as the synthetic control method, he finds that these discoveries are associated with high growth in the long run.

According to the data we collect in this paper, the last two decades of empirical research on the effect of natural resources on economic growth have produced 33 econometric studies reporting 402 regression estimates of the effect. Approximately 40% of these estimates are negative and statistically significant, 40% of the estimates are insignificant, and approximately 20% of the estimates are positive and statistically significant (based on the conventional 5% significance level). Given this heterogeneity in results, our ambition is to conduct a meta-analysis of the literature in order to shed light on two key questions: Does the natural resource curse exist in general? Can we explain why different studies come to so different conclusions? The use of meta-analysis is vital here because the method provides rigorous techniques of quantitative surveys and is able to disentangle different factors driving the estimated effect (Stanley, 2001).

[1] Note that given our focus on the natural resource curse, we examine the literature primarily examining the point-source non-renewable resources—those extracted from a narrow geographic or economic base—rather than agriculture or other resources such as water or wind.

While meta-analysis methods have been applied within economics in numerous fields such as labor economics (Card and Krueger, 1995; Card et al., 2010; Chetty et al., 2011), development economics (Askarov and Doucouliagos, 2015; Benos and Zotou, 2014; Doucouliagos and Paldam, 2010), and international economics (Bumann et al., 2013; Havranek and Irsova, 2011; Irsova and Havranek, 2013), there has been no meta-analysis examining the effect of natural resources on economic growth.

Our results suggest that, taken together, the previous empirical studies on the topic imply a negligible effect of natural resources on economic growth on average. Therefore, the literature suggests that the natural resource curse is not inevitable. In addition, we find that the heterogeneity in the estimated effect of natural resources on economic growth can be explained by whether the studies control for the following three relevant factors: 1) the interaction effect of institutional quality and natural resource richness, 2) investment level, and 3) the type of natural resources under examination. We find that sufficient institutional quality decreases the likelihood of the natural resource curse, which complies with the results presented in Mehlum et al. (2006), who stress the importance of institutional quality in driving the natural resources-economic growth nexus, rather than with Sachs and Warner (1995), who find institutions largely irrelevant in this respect.

Our findings also provide certain support to the literature demonstrating that natural resources tend to crowd out investment activity (Atkinson and Hamilton, 2003; Gylfason and Zoega, 2006). Finally, our results indicate that oil is less prone to the natural resource curse than other substances such as diamonds or precious metals, which is consistent with the results of Boschini et al. (2007), who argue that especially diamonds and precious metals are subject to the so-called technical appropriability (for economic or technical reasons more prone to rent-seeking and conflict) and therefore more likely to contribute to the natural resource curse. The result also broadly corresponds to several recent studies showing that large oil discoveries have been associated with sustained economic growth (Alexeev and Conrad, 2009; Smith, 2015).

The paper is organized as follows. Section 2 discusses some of the primary studies on the resource-growth nexus. Section 3 describes the meta-regression framework. Section 4 describes the data set that we collect for this paper. Section 5 presents the empirical results on potential publication bias, while Section 6 focuses on the explanation of the differences in results across studies. We provide concluding remarks in Section 7. Robustness checks and a list of studies included in the meta-analysis are available in the Appendix.

2 Related Literature

In this section we briefly discuss the relevant literature that focuses on the relation between natural resources and economic growth. For more comprehensive narrative surveys we refer the interested reader to Frankel (2012) and van der Ploeg (2011).

Sachs and Warner (1995) examine the effect of natural resources on long-term economic growth and find that resource-rich countries tend to grow more slowly than resource-scarce countries, which has become known under the label of the natural resource curse. The literature published after Sachs and Warner (1995) primarily investigates different transmission mechanisms of how natural resources affect growth, assessing whether it is possible to avoid the natural resource curse by improving the quality of institutions, or whether the existence of the natural resource curse depends on the means of measurement and the type of natural resources.

Several studies investigate the role of institutional quality and find that the natural resource curse can be avoided if institutional quality is sufficiently high (Isham et al., 2005; Mehlum et al., 2006; Arezki and van der Ploeg, 2007; Boschini et al., 2007; Horvath and Zeynalov, 2014). Brunnschweiler and Bulte (2008) make a distinction between resource dependence (a degree of to what extent countries depend on natural resource exports) and resource abundance (a stock measure of resource wealth) and, unlike many other studies, they treat institutions as endogenous. While they fail to find a link between resource dependence and growth, they show that resource abundance is associated with better institutions and more growth. As a consequence, their results do not provide support for the existence of the natural resource curse.

Sala-i-Martin and Subramanian (2013) document that new oil discoveries tend to cause real exchange rate appreciation and harm other export sectors of the economy. Gylfason and Zoega (2006) examine a different channel and finds that natural resource richness crowds out human and physical capital, which leads to slower growth in the long-term. Another stream of the literature examines the impact of natural resources on variables other than economic growth. Natural resource richness might induce more corruption, increase political instability and the likelihood of conflict, and hinder the functioning of democratic institutions (Tella and Ades, 1999; Barro, 1999; Ross, 2001; Jensen and Wantchekon, 2004; Collier and Hoeffler, 2005).

In our meta-analysis we examine not only real factors, such as the role of institutional quality for the occurrence of the natural resource curse, but also the role of study design for the estimated effect of natural resource richness on growth. Researchers often employ cross-sectional data to investigate the long-term effect of natural resources on growth (Sachs and Warner, 1995; Leite and Weidmann, 1999; Tella and Ades, 1999; Lederman and Maloney, 2003; Boschini et al., 2007; Sala-i-Martin and Subramanian, 2013; Ding and Field, 2005; Mehlum et al., 2006; Brunnschweiler and Bulte, 2008; Arezki and van der Ploeg, 2007). van der Ploeg (2011) notes that the application of cross-sectional data in growth regressions suffers from omitted variable bias because of the correlation between initial income and the omitted initial level of productivity. Lederman and Maloney (2003) estimate cross-sectional as well as panel regressions and find that the results differ.

Panel regressions provide a significantly positive effect of natural resources on economic growth, while cross-sectional regressions result in negative but insignificant estimates. Tella and Ades (1999) also use both cross-sectional and panel data and find that the impact of natural resources on economic growth becomes insignificant when using panel data. Panel data has been also applied by Jensen and Wantchekon (2004); Ilmi (2007); Horvath and Zeynalov (2014).

The primary studies also differ with respect to the measurement of natural resource richness. Sachs and Warner (1995) measure natural resource richness as the share of primary exports (agriculture, fuels, and minerals) to GDP. Boschini et al. (2007); Lederman and Maloney (2003); Isham et al. (2005); Brunnschweiler and Bulte (2008) also apply this measure. Leite and Weidmann (1999) and Mehlum et al. (2006) use the share of exports of primary products to GNP. Sala-i-Martin and Subramanian (2013) and Jensen and Wantchekon (2004) use the percentage of fuel, mineral, and metal exports on merchandise exports. Collier and Hoeffler (2005) employ the sum of resource rents as a percentage of GDP. Papyrakis and Gerlagh (2004) use the share of mineral production in GDP and Gylfason and Zoega (2006) employs the share of natural resource capital as a percentage of total capital.

3 Methodology

Following the approach described in the guidelines for conducting meta-analyses in economics (Stanley et al., 2013), we search for potentially relevant studies in the databases Scopus, Google Scholar, and RePEc. We use the following combinations of keywords: "natural resource + economic growth," "natural resource + economic development" and "Dutch disease." We identify more than 300 journal articles and working papers, including 33 econometric studies examining the effect of natural resources on economic growth. These 33 studies report 402 different regression specifications, which enter as observations into our meta-analysis. The number of reported regressions per study ranges from one (Papyrakis and Gerlagh, 2004) to fifty two (Brunnschweiler and Bulte, 2008) with a mean of 11. We report the full list of studies included in our meta-analysis in the Appendix; all data and codes we use in the paper are available in the online appendix. In this section we briefly describe the meta-analysis methods that we use in this paper, and we refer readers interested in more detailed treatment to Stanley and Doucouliagos (2012).

In general, researchers interested in the effect of natural resources on economic growth estimate a variant of the following model:

$$G_{it} = \alpha + \beta NAT_{it} + \gamma NAT_{it} * INS_{it} + \theta X_{it} + \epsilon_{it}, \quad (1)$$

where i and t denote country and time subscripts; G represents a measure of economic growth; *NAT* represents a measure of natural resource richness; *INS* represents institutional quality of a country, and *NAT*INS* is an interaction term between natural resource and institutional quality; X is a vector of control variables, such as macroeconomic conditions; and ϵ denotes an error term. Eq. (1) describes a general panel data setting, which encompasses both cross-sectional and time-series studies, differences among which we also investigate in our meta-regression analysis. We only include studies that use economic growth as the dependent variable. Other studies investigating, for example, the effect on human capital, physical capital, democracy, institutions or GDP level, are excluded to ensure a basic level of homogeneity in our data sample.

Following several previous meta-analyses (Doucouliagos, 2005; Efendic et al., 2011; Valickova et al., 2015), for the summary statistic we use the partial correlation coefficient (PCC), which can be derived as:

$$PCC_{is} = \frac{t_{is}}{\sqrt{t_{is}^2 + df_{is}}}, \quad (2)$$

where $i = 1, \ldots, m$ denotes primary study; $s = 1, \ldots, n$ denotes the regression specification in each primary study; t_{is} is the associated t-statistics; and df_{is} is the corresponding number of degrees of freedom. PCC_{is} represents the partial correlation coefficient between natural resource and economic growth and measures the statistical strength of the relationship.

We have to resort to calculating the PCC because primary studies differ in terms of proxies for natural resources and economic growth, so that standardization is necessary to make the estimated effect of resources on growth comparable across studies.

It is important to note that approximately one fifth of primary studies include an interaction effect of natural resources and institutional quality in addition to the measure of natural resources. For these studies, we consider the average marginal effect of natural resources on economic growth and use the delta method to approximate the corresponding standard error. (In principle, one could also conduct separate meta-analyses of the linear and interaction terms. In our case, however, the percentage of studies using the interaction term is relatively low and would not allow for a proper meta-analysis.)

To investigate and correct for potential publication selection bias (the preference of authors, referees, or editors for certain type of results, which will be discussed in more details later in the paper), we use the following simple meta-regression model and examine the effect of the standard error of PCC_{is} $(SEpcc_{is})$ on the summary statistic, PCC_{is}, itself:

$$PCC_{is} = \beta_0 + \beta_1 * SEpcc_{is} + \epsilon_{is}, \quad (3)$$

where $SEpcc_{is} = \frac{PCC_{is}}{TSTAT_{is}}$ and ϵ is the regression error term. This basic meta-regression model, based on Card and Krueger (1995) and Stanley (2005), has the following underlying intuition: in the absence of publication bias, the effect should be randomly distributed across studies (when we, for a moment, abstract from the use of different methodology in different studies and only consider the sampling error as the source of heterogeneity). If authors prefer statistically significant results, they need large estimates of the effect to offset their standard errors, which gives rise to a positive coefficient β_1 whenever the underlying true effect is different from zero. Similarly, if authors prefer a certain sign of their regression results, a correlation between the estimated effect and its standard error arises. For example, suppose that authors prefer to report negative estimates—that is, those consistent with the natural resource curse hypothesis. The heteroskedasticity of the equation ensures a negative coefficient β_1, because with low standard errors (high precision) the reported estimates will be negative and modest (close to the underlying effect), while with large standard errors the reported estimates will be both modest and large, while no large positive estimates will be reported.

The meta-analysis literature has not converged to a consensus on what is the best method to estimate Eq.(3). Because of the heteroskedasticity and likely within-study correlation of the reported results, most meta-analysts estimate standard errors clustered at the study level, which is an approach we also adopt. Apart from the basic OLS with clustered standard errors, however, we also report fixed effects estimation (OLS with study dummies), the so-called mixed effects (study-level random effects estimated by maximum likelihood methods to take into account the unbalancedness of the data), and instrumental variable estimates, which we describe below. All of these approaches have their pros and cons. For example, fixed effects control for unobservable study-level characteristics, but therefore the use of fixed effects does not allow us to investigate the impact of some important features of studies (such as the number of citations). Mixed effects are more flexible in this respect, but with many explanatory variables in the models the exogeneity conditions underlying mixed effects are unlikely to hold. Apart from different approaches to identification, we also use several different weighting schemes.

To reduce heteroskedasticity and obtain more efficient estimates, Stanley and Doucouliagos (2015) recommend using Eq.(3) weighted by the inverse variance of the estimated PCC_{is}, because the variance is a measure of heteroskedasticity in this case. Therefore, weighted least squared (WLS) version of Eq.(3) is obtained by dividing each variable by $SEpcc_{is}$:

$$TSTAT_{is} = \beta_0 \frac{1}{SEpcc_{is}} + \beta_1 + \epsilon_{is} \frac{1}{SEpcc_{is}}, \tag{4}$$

where $TSTAT_{is} = \frac{PCC_{is}}{SEpcc_{is}}$ measures the statistical significance of the partial correlation coefficient. The β_0 provides an estimate of the underlying effect of natural resources on economic growth corrected for any potential publication selection bias (or, alternatively, we can think of it as the effect conditional on maximum precision in the literature). The coefficient β_1 assesses the extent and direction of publication selection. As a robustness check, in the Appendix we also present nonweighted regressions and regressions weighted by the inverse of the number of estimates reported in each study—to give each study the same weight.

The univariate regression presented above may provide biased estimates if important moderator variables are omitted (Doucouliagos, 2011). Suppose, for example, that a specific method choice made by the authors of primary studies affects both the standard error and the reported point estimate in the same direction. Then the standard error variable will be correlated with the error term, and we obtain a biased estimate of β_1 (Havranek, 2015). A solution is to use an instrument for the standard error that is correlated with the standard error but not with method choices. Such an instrument can be based on the number of observations, because larger studies are, on average, more precise, and the number of observations is little correlated with method choices. We use the inverse of the square root of the number of degrees of freedom, as this number is directly proportional to the estimated standard error. An alternative is to add additional moderator variables to Eq.(4), after which we obtain the following model to examine the driving forces of heterogeneity in the estimated effect of natural resource richness on economic growth:

$$TSTAT_{is} = \beta_0 \frac{1}{SEpcc_{is}} + \beta_1 + \sum_{k=1}^{N} \lambda_k * \frac{1}{SEpcc_{is}} X_{kis} + u_{is} \frac{1}{SEpcc_{is}}, \tag{5}$$

where k represents the number of moderator variables weighted by $(1/SEpcc_{is})$, λ_k is the coefficient on the corresponding moderator variables, and u_{is} denotes the error term.

4 Data

The explanatory variables used in this meta-regression analysis are listed and defined in Table 1. These variables represent potential sources of heterogeneity in the results of primary studies. Table 1 classifies the characteristics of primary studies into several categories such as macroeconomic conditions, the choice of dependent and independent variables, and estimation methods.

Outcome characteristics: We observe that the typical estimate of the effect of natural resources on economic growth is negative (-2.14) but the standard error of this estimate is large (1.56)—since the reported estimates are not strictly comparable, however, it makes more sense to look at partial correlation coefficients. The mean PCC is -0.07, which would be classified as a small effect according to the guidelines by Doucouliagos (2011) for the interpretation of partial correlations in economics. The mean number of observations in primary studies is 165, and a typical study includes about 6 explanatory variables. The mean number of time periods is low (4.68) because most of the primary studies estimate cross-sectional regressions for a wide set of countries.

Publication characteristics: The empirical literature on the effect of natural resources on economic growth is alive and well with more and more studies published each year—the mean primary study in our sample was only published in 2006. The primary studies are mostly published in peer-reviewed journals (30 out of our 33 primary studies are published in a journal, 3 are working papers from institutions such as the National Bureau for Economic Research or International Monetary Fund). The primary outlet for this literature is World Development with 5 primary studies. We also control for journal quality by including the recursive impact factor from RePEc and the number of citations from Google Scholar. We argue that these measures capture aspects of study quality not covered by method characteristics: for example, some aspects of methodology are employed only in a single study, which does not allow us to include the corresponding control variable. We select the RePEc database for journal ranking because it covers virtually all journals and working paper series in economics; Google Scholar, on the other hand, is the richest database providing citation counts for each research item.

Institutional quality: As discussed in the related literature section, several articles have demonstrated that the quality of domestic institutions is likely to constitute an important factor influencing the magnitude as well as the direction of the effect of natural resources on economic growth. Nearly three fourths of primary studies control for institutional quality, and approximately one fifth additionally include an interaction effect of institutional quality and natural resources.

Macroeconomic conditions: The primary studies typically control for several macroeconomic characteristics such as the level of schooling, economic openness, and investment activity. It is striking that approximately one fourth of primary studies do not control for the initial level of GDP despite the voluminous theoretical and empirical research which suggests that initial GDP is one of the key factors driving subsequent economic growth, as poorer economies take the benefit of innovations already developed in advanced countries (Durlauf et al., 2008).

The choice of the dependent variable: While the primary studies commonly employ GDP growth as the dependent variable, non-resource GDP is also sometimes used. Approximately two thirds of studies use per capita measures, and we distinguish between these different approaches to the definition of the dependent variable.

The choice of the natural resource variable: Studies differ in the employed proxies for natural resources. The ratio of natural resource exports to GDP is often used as a measure of natural resource richness. Nearly all of the regression specifications in our data set include a measure of point-source natural resources. Approximately one fourth of primary studies narrow their focus on oil and do not take into account other fuels or minerals.

Dataset type: Despite the fact that van der Ploeg (2011) emphasizes that the application of cross-sectional data in growth regressions is likely to suffer from the omitted variable bias, approximately 80% of regression specifications in the primary studies on the resource-growth nexus are based on cross-sectional data. This is largely motivated by data availability. Panel structure is less common (less than 20%) and time series evidence is almost non-existent.

Estimation method: Approximately two thirds of the primary studies are based on OLS regressions. The remaining one third allows for the endogeneity of regressors by employing a type of the instrumental variable estimator or by using lagged measures of natural resources.

Dataset time period: Finally, we create dummy variables and classify whether the data for primary studies primarily come from the 1960, 1970s, 1980s, 1990s, or 2000s to control for potential time effects. An alternative is to include directly the mean year of data period, but we prefer to focus on decade dummies in order to control for potential time breaks in the effect of natural resources on growth.

Table 1: Description and summary statistics of collected variables

Variable	Definition	Mean	St.Dev.	Min	Max
Outcome characteristics					
TSTAT	The estimated t-statistics of the effect size	–0.32	3.07	–8.66	7.44
PCC	The partial correlation coefficient	–0.07	0.32	–0.91	0.77
INVSEpcc	The inverse standard error of the PCC	10.96	6.95	3.60	46.86
SXP	Natural resource effect size	–2.14	5.50	–26.90	36.92
SXPSE	Standard error of the effect size	1.56	2.07	0.01	11.21
DF	Logarithm of the number of degrees of freedom	4.43	0.91	2.40	7.69
NO.OBS	Logarithm of the number of observations	4.53	0.86	3.04	7.69
NO.EXPL.VARS	Number of explanatory variable included	6.38	2.69	1	16
NO.COUNTRY	Logarithm of the number of countries	4.01	0.94	0.69	5.04
NO.TIME	Logarithm of the number of years	1.13	0.91	0.69	3.81
Publication characteristics					
YEAR	Logarithm of publication year	7.60	0.002	7.599	7.608
IMPACT.FACTOR	Recursive impact factor of the journal from RePEc	0.18	0.27	0	0.87
CITATIONS	Logarithm of the number of Google Scholar citations	4.22	2.32	0	8.09

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Table 1 continued

Variable	Definition	Mean	St.Dev	Min	Max
REVIEWED	Dummy, 1 if published in peer-review journal, 0 otherwise	0.77	0.42		
Institutional quality					
INSTITUTION	Dummy, 1 if institutional variable is included, 0 otherwise	0.68	0.47		
INTERACTION	Dummy, 1 if interaction term is included, 0 otherwise	0.22	0.42		
Macroeconomic conditions					
TOT	Dummy, 1 if terms of trade is included, 0 otherwise	0.19	0.39		
OPENNESS	Dummy, 1 if trade openness is included, 0 otherwise	0.56	0.50		
INITIAL GDP	Dummy, 1 if initial GDP is included, 0 otherwise	0.75	0.43		
INVESTMENT	Dummy, 1 if investment is included, 0 otherwise	0.59	0.49		
SCHOOLING	Dummy, 1 if schooling is included, 0 otherwise	0.48	0.50		
Dependent variable choice					
GDP PER CAPITA	Dummy, 1 if dependent is measured with per capita level, 0 otherwise	0.69	0.46		
GDP GROWTH	Dummy, 1 if dependent is measured with growth, 0 otherwise	0.88	0.33		
NON-RESOURCE GDP	Dummy, 1 if dependent is measured with non-resource GDP, 0 otherwise	0.04	0.21		
Natural-resource variable choice					
NAT.RES.EXPORT	Dummy, 1 if effect size is measured with export, 0 otherwise	0.57	0.50		
POINT-RESOURCE	Dummy, 1 if effect size is measured with point resource, 0 otherwise	0.95	0.22		
OIL-RESOURCE	Dummy, 1 if effect size is measured with petroleum/fuel/oil, 0 otherwise	0.24	0.43		
Dataset type					
CROSS	Dummy, 1 if dataset type is cross-sectional, 0 otherwise	0.82	0.39		
PANEL	Dummy, 1 if dataset type is panel, 0 otherwise	0.17	0.38		
TIME.SERIES	Dummy, 1 if dataset type is time series, 0 otherwise	0.01	0.10		
REGION	Dummy, 1 if dataset includes all countries, 0 otherwise	0.79	0.41		
Estimation methods					
ENDOGENEITY	Dummy, 1 if endogeneity controlled, 0 otherwise	0.35	0.48		
OLS	Dummy, 1 if method type is OLS, 0 otherwise	0.66	0.47		
Dataset time period					
DUMMY60	Dummy, 1 if time period in 1960s, 0 otherwise	0.03	0.18		

Continued on next page

Table 1 continued

Variable	Definition	Mean	St.Dev	Min	Max
DUMMY70	Dummy, 1 if time period in 1970s, 0 otherwise	0.43	0.50		
DUMMY80	Dummy, 1 if time period in 1980s, 0 otherwise	0.19	0.39		
DUMMY90	Dummy, 1 if time period in 1990s, 0 otherwise	0.33	0.47		
DUMMY00	Dummy, 1 if time period in 2000s, 0 otherwise	0.02	0.14		

Notes: Method characteristics are collected from the studies estimating the effect of natural resources on economic growth. The list of studies is available in the Appendix; the complete data set is available in the online appendix.

Table 2 presents an initial analysis of the reported estimates of the natural resource curse. The arithmetic mean yields a partial correlation coefficient of -0.066 with a 95 % confidence interval $[-0.097, -0.035]$. The random-effects estimator (allowing for random differences across studies) estimates provide a similar picture suggesting that the effect of natural resources on growth is negative and statistically significant, although negligible to small according to the guidelines by Doucouliagos (2011). In contrast, the fixed-effects estimator (weighted by inverse variance) shows a positive effect, albeit very small. Nevertheless, these simple estimators do not account for potential publication selection and the influence of method choices, some of which may be considered misspecifications that have systematic effects on the results.

Table 2: Estimates of the overall partial correlation coefficient

Explanation	Estimate	Standard error	95% Confidence interval	
Simple average of PCC	–0.066	0.016	–0.097	–0.035
Fixed-effects average PCC	0.023	0.004	0.016	0.031
Random-effects average PCC	–0.059	0.013	–0.083	–0.034

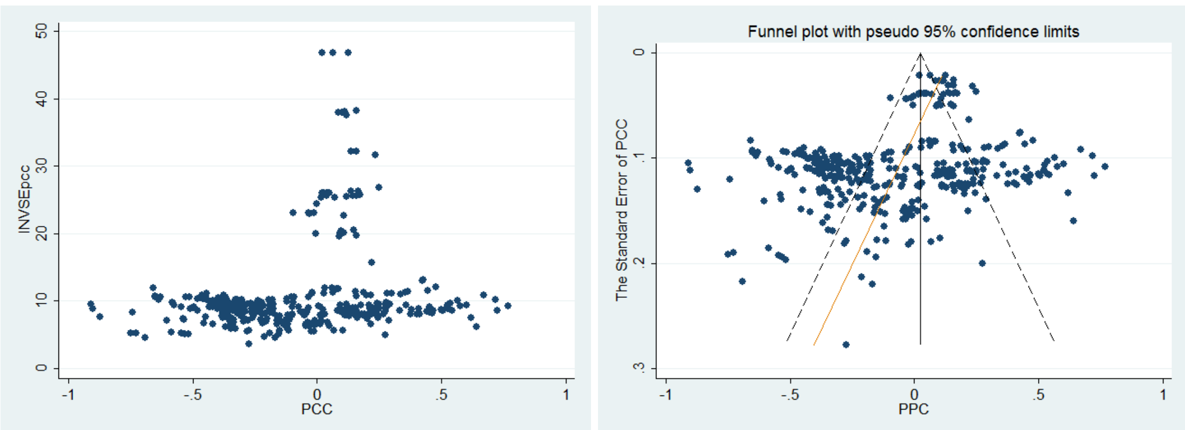
Notes: Simple average represents the arithmetic mean. The fixed-effect estimator uses the inverse of variance as the weight for PCC. The random-effect specification additionally considers between-study heterogeneity.

5 Publication Bias

Publication selection occurs when researchers, referees, or editors prefer certain types of estimates, typically statistically significant results or those that are in line with the prevailing theory (Stanley, 2005). If the literature on the natural resource curse suffers from some sort of publication selection, it is important to account for it in order to uncover the underlying effect of natural resources on economic growth. For example, if negative estimates of the relationship are reported preferentially, the small negative mean effect computed in the previous section may be entirely due to publication bias.

In line with the previous meta-analysis literature (Doucouliagos and Stanley, 2009), we first generate funnel plots to assess the degree of publication selection visually. The horizontal axis of the funnel plot displays the effect size (partial correlation coefficients) of natural resources on economic growth and the vertical axis displays precision (inverse standard errors) derived from the corresponding regression specification of a given primary study. The funnel plot is available in the left panel of Figure 1. In the absence of publication bias, the funnel plot should be symmetrical—the most precise estimates would be close to the underlying effect, less precise estimates would be more dispersed, and both negative and positive estimates with low precision (and thus low statistical significance) would be reported. In our case, the left-hand side of the funnel appears to be somewhat heavier than right-hand side. This finding suggests that negative estimates, i.e. those suggesting the natural resource curse, are slightly more preferred for reporting and publication.

Figure 1: A funnel plot of the effect of natural resources on economic growth



The right panel of Figure 1 presents a variant of the funnel plot resembling more closely the simple meta-regression model presented earlier in this paper. The vertical line denotes an estimate of the mean effect of natural resources on economic growth derived using fixed effects.

The two dashed lines that join the vertical line at the top of the funnel denote boundaries of conventional statistical significance at the 5% level: estimates outside these boundaries are statistically significantly different from the underlying effect as computed by fixed effects. These outlying estimates form, apparently, much more than 5% of the data, which could indicate publication bias in favor of statistically significant estimates, but also heterogeneity in data and methods. The remaining dashed line visualizes a regression line from our simple meta-regression model when the effect size is regressed on the standard error: the slope is negative, which suggests publication bias, and the intercept is slightly above zero, which indicates that publication bias is responsible for the mean reported negative relationship between natural resources and growth. In the next step we provide a formal test of publication selection bias.

Table 3: Tests of true effect and publication selection

Panel A	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**t-stat**	**p-value**
	Clustered OLS			IV Estimation		
SE (publication selection)	−2.008**	−2.49	0.013	−2.263**	−2.41	0.016
Constant (true effect)	0.154***	5.09	0.000	0.170***	4.50	0.000
Model Diagnostics						
	Number of observations=402 F-test: F(1,32)= 6.00 Ho: Precision=0, $Prob > F = 0.02$ Ramsey RESET test: F(3, 397)=0.80 Ho: No omitted variables, $Prob > F = 0.492$			Number of observations=402 F-test: F(1,32) = 7.62 Ho: Precision=0, $Prob > F = 0.00$ Underidentification test =1221.39 $Prob > \chi^2 = 0.000$		
Panel B	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**z-stat**	**p-value**
	Fixed effects			Mixed-effect ML regression		
SE (publication selection)	−0.012	−0.18	0.862	1.400	1.30	0.192
Constant (true effect)	−0.186	−0.24	0.810	−0.292**	−2.12	0.013
Model Diagnostics						
	Number of observations=402 Number of groups = 33 F(1,32)=0.03 $Prob > F = 0.86$			Number of observations = 402 Number of groups = 33 Wald test: $\chi^2(1)$= 1.70 $Prob > \chi^2 = 0.19$		

Notes: The dependent variable is PCC; the estimated equation is $PCC_{is} = \beta_0 + \beta_1 * SE + \epsilon_{is}$. All results are weighted by inverse variance. The standard errors of the regression parameters are clustered at the study level. Panel A, column (2)-(4) represent OLS with cluster-robust standard errors at the study level; columns (5)-(7) represent IV estimation, where the instrumental variable is the inverse of the square root of the number of degrees of freedom. Panel B, columns (2)-(4) represent fixed-effect estimation at the study level; column (5)-(7) represent Mixed-effects ML regression. Reported t-statistics are based on heteroskdasticity cluster-robust standard errors.

To asses the extent of publication bias, we estimate Eq.(3); that is, regress the partial correlation coefficient on its standard error using the so-called funnel asymmetry test (note the relation between these regressions and the right-hand panel of Figure 1). A negative coefficient attached to the standard error suggests there is some preference in the literature for results documenting the natural resource curse. The estimated constant provides the true (publication selection free) effect of natural resources on economic growth. For example, if the constant is negative, the coefficient suggests the existence of the natural resource curse in line with Sachs and Warner (1995).

We present the results in Table 3. We use four different econometric methods: ordinary least squares with clustered standard errors, instrumental variables estimation, fixed effects estimation, and mixed effects maximum likelihood estimation. The results vary across specifications. Although two methods give us evidence of publication selection, two others do not. The estimated constant is also not robust to different econometric methods.

In Table A.1 in the Appendix we present two robustness checks. In the first case, we run the specification without employing any weights. In the second case, we weight the observations by the inverse of the number of regressions reported per study to give each study the same weight. The results largely confirm our baseline results discussed in the previous paragraph. We hypothesize that the instability of these bivariate regressions results stems from the omission of some important moderator variables (Doucouliagos and Stanley, 2009), which we address in the following section. In any case, the visual and regression analyses taken together do not provide evidence for the natural resource course hypothesis, but also limited evidence for any substantial publication bias.

6 Explaining the Differences in Estimates

Table 4 presents the results of multivariate meta-regression, for which we employ four different estimation methods to explain the heterogeneity of the estimated effects of natural resources on economic growth reported in primary studies. Our results do not suggest evidence of publication selection bias once the characteristics of studies and estimates are taken into account. Therefore, it seems that the apparent (but slight) asymmetry of the funnel plot described in the previous section results from method heterogeneity across studies or individual estimates rather than from systematic publication selection.

We have discussed earlier that the mean effect of natural resources on growth is weak. Table 4 shows, however, that some of the method choices have a strong impact on the reported coefficient, so the underlying conclusion about the resources-growth nexus depends on what methodology one prefers. Because of the importance of the individual aspects of estimation design for the results, we discuss them in detail in the following paragraphs.

Table 4: What drives the heterogeneity in the results?

Variable	Clustered OLS	IV Regression	Fixed effects	Mixed-effect ML
NO.EXPL.VARS	–0.057	–0.049	0.001	–0.025
	(0.05)	(0.06)	(0.06)	(0.06)
NO.COUNTRY	0.015	–0.019	0.001	–0.062
	(0.04)	(0.06)	(0.07)	(0.06)
NO.TIME	–0.164**	–0.228**	0.100	–0.357***
	(0.07)	(0.09)	(0.11)	(0.11)
Publication characteristics				
YEAR	16.163	15.066		41.098
	(16.22)	(17.06)		(29.90)
IMPACT.FACTOR	0.317**	0.308**		0.180
	(0.14)	(0.14)		(0.29)
CITATIONS	0.005	0.005		–0.012
	(0.02)	(0.02)		(0.04)
REVIEWED	–0.258***	–0.296**		–0.475***
	(0.09)	(0.12)		(0.15)
Institutional quality				
INSTITUTION	0.073*	0.084*	–0.064**	–0.068**
	(0.04)	(0.04)	(0.03)	(0.03)
INTERACTION	0.113***	0.116***	0.085	0.088
	(0.04)	(0.04)	(0.06)	(0.06)

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Table 4 continued

Variable	Clustered OLS	IV Regression	Fixed effects	Mixed-effect ML
Macroeconomic conditions				
TOT	–0.019	–0.019	–0.020	0.006
	(0.04)	(0.05)	(0.05)	(0.05)
OPENNESS	0.053	0.065	0.061	0.027
	(0.05)	(0.04)	(0.04)	(0.3)
INITIAL GDP	–0.015	–0.003	–0.001	0.009**
	(0.05)	(0.04)	(0.04)	(0.03)
INVESTMENT	–0.216***	–0.245***	–0.072	–0.163***
	(0.06)	(0.07)	(0.09)	(0.03)
SCHOOLING	–0.131	–0.140		–0.077
	(0.09)	(0.10)		(0.15)
Dependent variable choice				
GDP PER CAPITA	–0.007	–0.005	0.131	0.275***
	(0.05)	(0.05)	(0.15)	(0.02)
GDP GROWTH	0.190**	0.219**	–0.004	–0.205***
	(0.09)	(0.10)	(0.14)	(0.02)
NON-RESOURCE GDP	0.072	0.068	–0.120	–0.212***
	(0.11)	(0.10)	(0.13)	(0.02)
Natural-resource variable choice				
NAT.RES.EXPORT	–0.246***	–0.209***	–0.042	0.067
	(0.08)	(0.07)	(0.07)	(0.06)
POINT-RESOURCE	0.118**	0.129**	0.042	0.019
	(0.06)	(0.07)	(0.05)	(0.03)
OIL-RESOURCE	0.186***	0.174***	0.215***	0.188***
	(0.06)	(0.06)	(0.05)	(0.05)
Dataset type				
CROSS	–0.515	–0.732**		–1.178**
	(0.36)	(0.32)		(0.50)
PANEL	0.129	–0.085		–0.546
	(0.36)	(0.28)		(0.37)
REGION	0.102	0.128		0.348*
	(0.09)	(0.10)		(0.18)
Estimation methods				
OLS	0.004	0.006	–0.019	0.003
	(0.06)	(0.06)	(0.04)	(0.03)
ENDOGENEITY	–0.003	0.011	0.006	0.046
	(0.07)	(0.08)	(0.06)	(0.05)
Dataset time period				
DUMMY60	–0.216*	–0.237*	–0.008	0.027
	(0.12)	(0.13)	(0.06)	(0.03)
DUMMY80	0.103	0.165	0.194**	0.130***

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Table 4 continued

Variable	Clustered OLS	IV Regression	Fixed effects	Mixed-effect ML
	(0.10)	(0.10	(0.09)	(0.04)
DUMMY90	0.152*	0.205***	0.295**	0.487***
	(0.09)	(0.07)	(0.11)	(0.08)
DUMMY00	−0.006	0.065		0.511**
	(0.24)	(0.20)		(0.02)
SE	0.902	−1.001	2.307	0.115
	(0.92)	(1.84)	(2.31)	(1.56)
CONSTANT	−122.543	−113.674	−0.645	−311.18
	(123.40)	(129.83)	(0.56)	(227.69)
NO.OBSERVATION	402	402	402	402
F/Wald-test	1324.14	1748.34	3.82	139.34
R-squared	0.66	0.66	0.52	0.57

Notes: The dependent variable is PCC; the estimated equation is $PCC_{is} = \beta_0 + \beta_1 * SE + \sum_{k=1}^{N} \lambda_k * X_{kis} + \epsilon_{is}$. All results are weighted by inverse variance. Column (2) represents OLS with cluster-robust standard errors at the study level. Column (3) represents IV estimation, where SE is instrumented with the inverse of the square root of the number of degrees of freedom. Column (4) represents fixed-effect estimation at the study level. Column (5) represents Mixed-effects ML regression. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level.

Concerning data characteristics, we find that the number of time periods in primary studies is negatively associated with the estimated effect of natural resources on economic growth. This result suggests that it might be worthwhile to focus on expanding the time dimension when examining the natural resource curse (we have noted that most of the primary studies are of cross-sectional nature), as it takes time until the negative effect of natural resources prevails and the potential Dutch disease develops.

Next, the inclusion of the interaction term of institutional quality and natural resources has a systematic effect on the reported results. The effect is positive, which means that studies which include the interaction between institutional quality and natural resources tend to find a less negative impact of resources on growth. To be more specific, our findings based on the OLS meta-regression (the first column of the table) suggest that studies controlling for the interaction between institutions and resources (holding other study and estimate characteristics fixed at sample means and computing the predicted PCC) typically find partial correlation coefficients of about 0.25, implying a moderate positive effect according to Doucouliagos's guidelines. This result gives some support to the hypothesis that once a country exhibits a sufficient level of institutional quality, natural resources contribute positively to economic growth, which is the case of, for instance, Norway (Mehlum et al., 2006).

Concerning the measurement of natural resources, the dummy variable for oil resources is systematically positive, supporting the notion that oil is less prone to the natural resource curse than other substances, such as precious metals or diamonds.

The OLS specification of our meta-regression analysis suggests that studies exploring the effect of oil tend to find partial correlation coefficients close to 0.3, which implies a moderate impact of natural resources on economic growth. Indeed, even the simple correlation coefficient between the oil dummy and the partial correlation coefficient in our sample is significantly positive with the value of 0.49. These results are in line with the literature showing that many countries with new oil discoveries exhibit higher growth for a sustained period of time (Alexeev and Conrad, 2009; Smith, 2015). Importantly, the result also complies with Boschini et al. (2007), who show that the degree of technical appropriability (i.e., that some substances such as precious metals or diamonds are for economic or technical reasons more prone to rent-seeking activities and conflict) matters for the occurrence of the natural resource curse.

Concerning controls for macroeconomic conditions, we find that the primary studies underestimate the importance of controlling for investment; approximately 40% of primary studies do not condition for investment activity, but we find that investment affects the resource-growth nexus significantly and negatively. According to our OLS meta-regression, a typical study that controls for investment finds a negative effect of natural resources on economic growth. The implied partial correlation coefficient, however, is only about -0.06, which in absolute value is less than the threshold recommended by Doucouliagos (2011) for interpretation as a small effect. In general, the result provides some support to the previous evidence showing that natural resources tend to crowd out investment activity (Gylfason and Zoega, 2006).

Next, we find that the dummy variable for the data from the 1990s is statistically significant and positive. The finding indicates that the literature which primarily uses the data for the 1990s finds a less negative effect (or a more positive effect, respectively) of natural resources on economic growth. Holding other estimate and study characteristics constant, using data for the 1990s implies partial correlations of about 0.3, suggesting a positive and moderately strong effect of resources on growth. Although it is far from easy to explain this finding, we hypothesize that it is a consequence of high real oil prices in the 1980s, which might have translated into higher growth in oil-exporting countries with a certain lag.

Moreover, our results suggest that articles published in journals are more likely to report negative effects of natural resources on economic growth (the difference in terms of the reported partial correlation coefficients is about 0.3), but we do not intend to overemphasize this finding given that very few of the studies in our sample are unpublished manuscripts. Moreover, our previous analysis indicates relatively little evidence for publication bias.

Other moderator variables are only significant in specific regressions and therefore their effect does not seem to be systematic. In addition, we conduct a number of robustness checks. In Table A.2 in the Appendix we present the results without weighting the estimates with the inverse of their estimated variance. In these robustness checks we run the same regressions with identical moderator variables and identical econometric methods.

Next, we also run the same four specifications in a setting where weighting is based on the inverse of the number of regression specifications per primary study instead of inverse variance of estimates to give each study the same importance in the analysis. The results are available in Table A.3 in the Appendix. All robustness checks are largely in line with our baseline findings presented in the main text. We have also experimented with Bayesian model averaging (for applications of the method in meta-analysis, see Havranek et al., 2015a,b), because our regressions include many explanatory variables, and are thus subject to model uncertainty. While we are not able to emulate the instrumental variable specification using BMA, the Bayesian analogy of our OLS specification gives results similar to our baseline.

7 Concluding Remarks

In this paper we take stock of two decades of empirical research examining the existence of the natural resource curse. The previous literature has documented a great deal of heterogeneity in the effect of (point-source non-renewable) natural resources on economic growth. We collect 33 studies providing 402 different regression specifications and find that approximately 40% of them report a negative and statistically significant effect, other 40% report no effect, and the remaining 20% report a positive and statistically significant effect of natural resources on economic growth.

After reviewing the apparently mixed results reported in the literature, we ask two principle questions. First, what is the mean effect of natural resources on economic growth? A lot of research work has been devoted to the topic, and the literature deserves more than a statement that the results are mixed. A quantitative synthesis of the literature can uncover economists' best guess concerning the resources-growth nexus, and support or reject the findings of Sachs and Warner (1995), the most influential study in this field, which finds evidence for the natural resource curse. Second, why do different researchers obtain so different results? Methods of systematic literature reviews allow us to formally trace the sources of heterogeneity to the data and methods used in estimations.

To summarize the literature quantitatively, we use meta-analysis techniques (Stanley, 2001) and find that the mean effect of natural resources on economic growth is negligible (negative or positive depending on the particular meta-analysis model). In addition, we find little evidence for publication selection: i.e., that the authors, referees or editors would prefer some types of the findings (such as statistically significant evidence in favor of the natural resource curse) at the expense of other results. Next, our meta-regression analysis also shows that several factors are systematically important for the estimated effect of natural resources on economic growth. We find that it matters for the results whether primary studies control for the investment level, include an interaction term between institutional quality and natural resource richness, and distinguish among different types of natural resources.

When primary studies explicitly consider the interaction of institutional quality and natural resources, they are less likely to find evidence consistent with the natural resource curse. Well-functioning institutions eliminate the potentially negative effect of natural resources, as they reduce the extent of rent-seeking activities often associated with point-resource natural resources (Mehlum et al., 2006; Boschini et al., 2007). Next, the primary studies that include investment as a control variable are more likely to find the natural resource curse. This result broadly corresponds to the available literature, which reports that natural resources crowd out physical capital (Atkinson and Hamilton, 2003; Gylfason and Zoega, 2006). Finally, we also find that when natural resource richness is only measured based on oil endowment (and not using other substances such as diamonds or precious metals), support for the natural resource curse is less common.

This result highlights the role of the measurement of natural resource richness, as different natural resources have a different degree of so-called technical appropriability (Boschini et al., 2007). Our results in this respect are consistent with several recent studies showing that large oil discoveries tend to be associated with sustained economic growth (Alexeev and Conrad, 2009; Smith, 2015).

In terms of policy implications, the focus on improving institutions in developing countries will not strike our readers as new, since it has represented a recurring theme in development studies, not only in relation to the effects of natural resources. Compared to individual empirical papers, though, our meta-analysis approach is more systematic and allows for robust inference based on a vast literature that lacks consensus on the importance of institutions. The approach also points to several method choices that have a strong and systematic effect on the reported results (data period under investigation, treatment of institutions, control for investment, definition of natural resources), and our recommendation to researchers is to report robustness checks with respect to these aspects of methodology.

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Appendix

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Table A1: The true effect and publication selection—a robustness check

Unweighted results						
Panel A	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**t-stat**	**p-value**
	Clustered OLS			IV Estimation		
SE (publication selection)	–1.748***	–2.71	0.007	–2.609**	–2.19	0.028
Constant (true effect)	0.127*	1.67	0.094	0.223*	1.85	0.065
Model Diagnostics						
	Number of observations=402 F-test: F(1,32)= 7.12 Ho: Precision=0, Prob>F=0.01 Ramsey RESET test: F(3,393)= 1.70 Ho: No omitted variables, Prob>F=0.17			Number of observations=402 F-test: F(1,32) = 4.66 Ho: Precision=0, Prob>F=0.03 Underidentification test = 792.711 Prob > $\chi^2 = 0.00$		
Panel B	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**z-stat**	**p-value**
	Fixed effects			Mixed-effect ML regression		
SE (publication bias)	1.064	0.90	0.375	0.697	1.36	0.174
Constant (effect beyond bias)	–0.183	–1.40	0.171	–0.206***	–2.77	0.006
Model Diagnostics						
	Number of observations=402 Number of groups = 33 F(1,32)=0.81 Prob > F=0.38			Number of observations = 402 Number of groups = 33 Wald test: $\chi^2(1) = 1.85$ Prob > $\chi^2 = 0.17$		
Weighted with the inverse of the number of regressions per study						
Panel C	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**t-stat**	**p-value**
	Clustered OLS			IV Estimation		
SE (publication bias)	–0.490	–0.39	0.699	–1.545	–0.92	0.358
Constant (effect beyond bias)	–0.085	–0.62	0.532	0.038	0.21	0.830
Model Diagnostics						
	Number of observations=402 F-test: F(1,32)= 0.14 Ho: Precision=0, Prob>F=0.71 Ramsey RESET test: F(3,397)= 3.95 Ho: No omitted variables, Prob>F=0.01			Number of observations = 402 F-test: F(1,32) = 0.82 Ho: Precision=0, Prob>F=0.37 Underidentification test = 747.02 Prob > $\chi^2 = 0.00$		
Panel D	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**z-stat**	**p-value**
	Fixed effects			Mixed-effect ML regression		
SE (publication bias)	1.220	0.94	0.355	–0.460	–0.38	0.704
Constant (effect beyond bias)	–0.277*	–1.87	0.071	–0.086	–0.62	0.538
Model Diagnostics						
	Number of observations=402 Number of groups = 33 F(1,32)=0.80 Prob > F=0.36			Number of observations = 402 Number of groups = 33 Wald test: $\chi^2(1) = 0.14$ Prob > $\chi^2 = 0.70$		

Notes: The dependent variable is PCC. The equation $PCC_{is} = \beta_0 + \beta_1 * SE + \epsilon_{is}$ used. The standard errors of the regression parameters are clustered at the study level. Panel (A) and Panel (B) represents unweighted results. Panel A, columns (2)-(4) represent OLS with cluster-robust standard errors at the study level; columns (5)-(7) represent IV estimation, instrumented variable is the inverse of the square root of the number of degrees of freedom. Panel B, columns (2)-(4) represent fixed-effect estimation at the study level; columns (5)-(7) represent Mixed-effects ML regression. Reported t-statistics are based on heteroskdasticity cluster-robust standard errors. Panel (C) and Panel (D) results are weighted with the inverse of the number of regression specifications per study.

Table A2: What drives the heterogeneity in the results? Unweighted regressions

Variable	Clustered OLS	IV Regression	Fixed effects	Mixed-effect ML
NO.EXPL.VARS	–0.064	–0.046	–0.007	–0.007
	(0.05)	(0.06)	(0.05)	(0.04)
NO.COUNTRY	–0.032	–0.089	–0.008	–0.003
	(0.04)	(0.06)	(0.13)	(0.04)
NO.TIME	–0.257***	–0.336***	–0.025	–0.206**
	(0.07)	(0.07)	(0.09)	(0.10)
Publication characteristics				
YEAR	10.778	9.753		50.415
	(16.51)	(16.33)		(33.00)
IMPACT.FACTOR	0.304**	0.280*		0.284
	(0.14)	(0.14)		(0.26)
CITATIONS	–0.001	0.000		0.024
	(0.02)	(0.02)		(0.04)
REVIEWED	–0.299***	–0.350***		–0.326**
	(0.08)	(0.10)		(0.13)
Institutional quality				
INSTITUTION	0.102**	0.108**	–0.055*	–0.038
	(0.05)	(0.04)	(0.03)	(0.03)
INTERACTION	0.126	0.143*	0.067	0.071**
	(0.08)	(0.08)	(0.13)	(0.03)
Macroeconomic conditions				
TOT	–0.008	–0.005	0.019	0.013
	(0.06)	(0.06)	(0.05)	(0.05)
OPENNESS	0.043	0.055	0.049	0.055
	(0.04)	(0.04)	(0.03)	(0.04)
INITIAL GDP	–0.022	–0.003	0.020	0.030
	(0.04)	(0.03)	(0.03)	(0.05)
INVESTMENT	–0.222***	–0.257***	–0.177***	–0.130*
	(0.06)	(0.07)	(0.04)	(0.08)
SCHOOLING	–0.174**	–0.193**		–0.079
	(0.08)	(0.09)		(0.11)
Dependent variable choice				
GDP PER CAPITA	0.008	0.009	0.263***	0.102
	(0.05)	(0.05)	(0.03)	(0.08)
GDP GROWTH	0.205**	0.245***	–0.204***	–0.013
	(0.08)	(0.08)	(0.02)	(0.11)
NON-RESOURCE GDP	0.050	0.038	–0.217***	–0.061
	(0.10)	(0.09)	(0.02)	(0.09)
Natural-resource choice				
NAT.RES.EXPORT	–0.247***	–0.195***	0.078	–0.003
	(0.09)	(0.07)	(0.06)	(0.05)
POINT-RESOURCE	0.125**	0.155**	0.018	0.030

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Table A2 continued

Variable	Clustered OLS	IV Regression	Fixed effects	Mixed-effect ML
	(0.06)	(0.07)	(0.04)	(0.06)
OIL-RESOURCE	0.178***	0.169***	0.190***	0.179***
	(0.06)	(0.06)	(0.05)	(0.04)
Dataset type				
CROSS	–0.855***	–1.032***		–0.802**
	(0.27)	(0.20)		(0.40)
PANEL	–0.078	–0.232		–0.235
	(0.30)	(0.22)		(0.31)
REGION	0.175*	0.214**		0.136
	(0.10)	(0.11)		(0.13)
Estimation methods				
OLS	0.108	0.115	–0.002	–0.026
	(0.09)	(0.10)	(0.04)	(0.10)
ENDOGENEITY	0.099	0.105	0.021	–0.002
	(0.09)	(0.11)	(0.07)	(0.11)
Dataset time period				
DUMMY60	–0.284***	–0.256**	0.041	–0.139
	(0.10)	(0.10)	(0.03)	(0.14)
DUMMY80	0.119	0.188**	0.140***	0.146*
	(0.08)	(0.08)	(0.04)	(0.08)
DUMMY90	0.164*	0.254***	0.493***	0.293***
	(0.10)	(0.07)	(0.09)	(0.09)
DUMMY00	–0.041	0.039		0.290
	(0.20)	(0.16)		(0.27)
SE	–0.163	–2.467*	0.561	0.581
	(1.01)	(1.39)	(2.01)	(0.62)
CONSTANT	–80.973	–72.603	–0.268	–382.780
	(125.63)	(124.20)	(0.75)	(251.09)
NO.OBSERVATION	402	402	402	402
F/Wald-test	1262.20	1061.91	NA	98.23
R-squared	0.64	0.62	0.23	0.54

Notes: The dependent variable is PCC; the estimated equation is $PCC_{is} = \beta_0 + \beta_1 * SE + \sum_{k=1}^{N} \lambda_k * X_{kis} + \epsilon_{is}$. The results correspond to unweighted regressions. Column (2) represents OLS with cluster-robust standard errors at the study level. Column (3) represents IV estimation, where SE is instrumented with the inverse of the square root of the number of degrees of freedom. Column (4) represents fixed-effect estimation at the study level. Column (5) represents Mixed-effects ML regression. ***, ** and * denote statistical significance at the 1%, 5%, and 10% level.

Table A3: What drives the heterogeneity in the results? Weighted by the inverse of number of regressions per study

Variable	Clustered OLS	IV Regression	Fixed effects	Mixed-effect ML
NO.EXP	–0.001	0.021	0.016	–0.001
	(0.06)	(0.06)	(0.07)	(0.06)
NO.COUNTRY	–0.002	–0.036	0.083	–0.002
	(0.04)	(0.05)	(0.16)	(0.04)
NO.TIME	–0.242***	–0.316***	–0.010	–0.242***
	(0.08)	(0.08)	(0.09)	(0.08)
Publication characteristics				
YEAR	9.797	4.971		9.831
	(20.61)	(23.53)		(20.93)
IMPACT.FACTOR	0.386***	0.389***		0.386***
	(0.13)	(0.13)		(0.13)
CITATIONS	–0.015	–0.016		–0.015
	(0.02)	(0.02)		(0.02)
REVIEWED	–0.297***	–0.327***		–0.297***
	(0.07)	(0.09)		(0.07)
Institutional quality				
INSTITUTION	0.052	0.065	–0.054	0.052
	(0.05)	(0.05)	(0.03)	(0.05)
INTERACTION	0.194**	0.217**	0.205	0.194**
	(0.09)	(0.09)	(0.17)	(0.09)
Macroeconomic conditions				
TOT	0.023	0.021	0.021	0.023
	(0.06)	(0.06)	(0.06)	(0.06)
OPENNESS	0.022	0.037	0.061*	0.022
	(0.05)	(0.05)	(0.04)	(0.05)
INITIAL GDP	–0.046	–0.031	0.044*	–0.046
	(0.06)	(0.06)	(0.02)	(0.06)
INVESTMENT	–0.244***	–0.313***	–0.178***	–0.244***
	(0.07)	(0.08)	(0.04)	(0.07)
SCHOOLING	–0.159*	–0.152		–0.158
	(0.10)	(0.10)		(0.10)
Dependent variable choice				
GDP PER CAPITA	0.028	0.028	0.264***	0.028
	(0.06)	(0.06)	(0.03)	(0.06)
GDP GROWTH	0.200*	0.271**	–0.197***	0.200*
	(0.12)	(0.13)	(0.02)	(0.12)
NON-RESOURCE GDP	–0.045	–0.045	–0.213***	–0.045
	(0.13)	(0.14)	(0.03)	(0.13)
Natural-resource choice				
NAT.RES.EXPORT	–0.306***	–0.274***	0.081	–0.306***
	(0.08)	(0.08)	(0.05)	(0.08)

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Table A3 continued

Variable	Clustered OLS	IV Regression	Fixed effects	Mixed-effect ML
POINT-RESOURCE	0.024	0.036	0.005	0.024
	(0.08)	(0.08)	(0.05)	(0.08)
OIL-RESOURCE	0.178**	0.150*	0.165**	0.178**
	(0.09)	(0.08)	(0.07)	(0.09)
Dataset type				
CROSS	–0.795***	–0.996***		–0.795**
	(0.31)	(0.25)		(0.31)
PANEL	0.059	–0.117		0.059
	(0.31)	(0.26)		(0.31)
REGION	0.175*	0.202**		0.175*
	(0.09)	(0.10)		(0.10)
Estimation methods				
OLS	0.139**	0.147**	0.021	0.139**
	(0.07)	(0.07)	(0.02)	(0.07)
ENDOGENEITY	0.066	0.054	–0.011	0.066
	(0.08)	(0.08)	(0.08)	(0.08)
Dataset time period				
DUMMY60	–0.333***	–0.282***	0.029	–0.333***
	(0.10)	(0.10)	(0.03)	(0.11)
DUMMY80	–0.005	0.053	0.159***	–0.004
	(0.09)	(0.09)	(0.04)	(0.09)
DUMMY90	0.015	0.080	0.606***	0.015
	(0.11)	(0.10)	(0.11)	(0.12)
DUMMY00	–0.120	0.012		–0.120
	(0.22)	(0.18)		(0.23)
SE	1.189	–0.801	0.807	1.189
	(1.01)	(1.15)	(2.11)	(1.02)
CONSTANT	–73.736	–36.556	–0.808	–1.625***
	(156.87)	(179.12)	(0.81)	(0.09)
NO.OBSERVATION	402	402	402	402
F/Wald-test	146.82	129.85	NA	4606.16
R-squared	0.68	0.67	0.23	0.58

Notes: The dependent variable is PCC; the estimated equation is $PCC_{is} = \beta_0 + \beta_1 * SE + \sum_{k=1}^{N} \lambda_k * X_{kis} + \epsilon_{is}$. All the regressions are weighted by the inverse number of estimates reported per study. Column (2) represents OLS with cluster-robust standard errors at the study level. Column (3) represents IV estimation, where SE is instrumented with the inverse of the square root of the number of degrees of freedom. Column (4) represents fixed-effect estimation at the study level. Column (5) represents Mixed-effects ML regression. ***, ** and * denote statistical significance at the 1%, 5%, and 10% level.