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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 curse 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 between natural resources and institutional quality, 2) controlling for the level of investment activity, and 3) distinguishing between different types of natural resources.

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

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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 & 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 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 rent-seeking and conflicts (Boschini *et al.*, 2007).

Atkinson & Hamilton (2003) and Gylfason & 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 & 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 & Conrad (2009) also find very little evidence in support of the natural resource curse. On 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% are insignificant, and approximately 20% are positive

[1] Note that given our focus on the natural resource curse, we study the literature primarily examining 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.

and statistically significant (based on the conventional 5% significance level). Given this heterogeneity in the 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 such different conclusions? The use of meta-analysis is vital here because the method provides rigorous quantitative survey techniques and is able to disentangle the different factors driving the estimated effect (Stanley, 2001). While meta-analysis methods have been applied within economics in numerous fields, such as labor economics (Card & Krueger, 1995; Card *et al.*, 2010; Chetty *et al.*, 2011), development economics (Askarov & Doucouliagos, 2015; Benos & Zotou, 2014; Doucouliagos & Paldam, 2010), and international economics (Bumann *et al.*, 2013; Havranek & Irsova, 2011; Irsova & Havranek, 2013; Iwasaki & Tokunaga, 2014), 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 reduces the likelihood of the natural resource curse, in line 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 & Warner (1995), who find institutions to be 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 & Hamilton, 2003; Gylfason & Zoega, 2006). Finally, our results indicate that oil is less prone to the natural resource curse than other substances, such as diamonds and precious metals. This is consistent with the results of Boschini *et al.* (2007), who argue that diamonds and precious metals in particular are subject to "technical appropriability" (for economic or technical reasons they are more prone to rent-seeking and conflicts) and are 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 & 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 explaining the differences in the results across studies. We provide concluding remarks in Section 7. Robustness checks and a list of the 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 & 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. This has become known as the natural resource curse. The literature published after Sachs & 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 & van der Ploeg, 2007; Boschini *et al.*, 2007; Horvath & Zeynalov, 2014). Brunnschweiler & Bulte (2008) make a distinction between resource dependence (the degree to which 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 & Subramanian (2013) document that new oil discoveries tend to cause real exchange rate appreciation and harm other export sectors of the economy. Gylfason & Zoega (2006) examine a different channel and find that natural resource richness crowds out human and physical capital, leading to slower growth in the long term. Another stream of 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 conflicts, and hinder the functioning of democratic institutions (Tella & Ades, 1999; Barro, 1999; Ross, 2001; Jensen & Wantchekon, 2004; Collier & Hoeffler, 2005).

In our meta-analysis we examine not only real factors, such as the role of institutional quality in the occurrence of the natural resource curse, but also the role of study design in 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 & Warner, 1995; Leite & Weidmann, 1999; Tella & Ades, 1999; Lederman & Maloney, 2003; Boschini *et al.*, 2007; Sala-i-Martin & Subramanian, 2013; Ding & Field, 2005; Mehlum *et al.*, 2006; Brunnschweiler & Bulte, 2008; Arezki & van der Ploeg, 2007). But 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 & 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 & 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 also been applied by Jensen & Wantchekon (2004), Ilmi (2007), and Horvath & Zeynalov (2014).

The primary studies also differ with respect to the measurement of natural resource richness. Sachs & Warner (1995) measure natural resource richness as the share of primary exports (agriculture, fuels, and minerals) in GDP. Boschini *et al.* (2007), Lederman & Maloney (2003), Isham *et al.* (2005), and Brunnschweiler & Bulte (2008) also apply this measure. Leite & Weidmann (1999) and Mehlum *et al.* (2006) use the share of exports of primary products in GNP. Sala-i-Martin & Subramanian (2013) and Jensen & Wantchekon (2004) use the percentage share of fuel, mineral, and metal exports in merchandise exports. Collier & Hoeffler (2005) employ the sum of resource rents as a percentage of GDP. Papyrakis & Gerlagh (2004) use the share of mineral production in GDP and Gylfason & Zoega (2006) employ 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 Scopus, Google Scholar, and RePEc databases. 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 regressions reported per study ranges from one (Papyrakis & Gerlagh, 2004) to 52 (Brunnschweiler & 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 & Doucouliagos (2012).

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

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

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 the institutional quality of a country and NAT*INS is an interaction term between natural resources 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 between 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:

$$PCC_{is} = \frac{t_{is}}{\sqrt{t_{is}^2 + df_{is}}}, \tag{2}$$

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-statistic; and df_{is} is the corresponding number of degrees of freedom. PCC_{is} represents the partial correlation coefficient between natural resources and economic growth and measures the statistical strength of the relationship.

We have to resort to calculating the PCC because the 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 the primary studies include the 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 a certain type of result, which will be discussed in more detail 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:

$$PCC_{is} = \beta_0 + \beta_1 * SEpcc_{is} + \epsilon_{is}, \tag{3}$$

where $SEpcc_{is} = \frac{PCC_{is}}{TSTAT_{is}}$ and ϵ is the regression error term. This basic meta-regression model, based on Card & 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, for a moment, we abstract from the use of different methodologies 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. Each of these approaches has its pros and cons. For example, fixed effects control for unobservable study-level characteristics, but the use of fixed effects therefore 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 & 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, a weighted least squares (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. 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 non-weighted 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 the 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 six 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 literature on the effect of natural resources on 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 studies are mostly published in peer-reviewed journals (30 out of our 33 primary studies are published in a journal, and the other three are working papers from institutions such as the National Bureau for Economic Research and International Monetary Fund). The primary outlet for this literature is World Development, with five 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: 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 be an important factor influencing the magnitude as well as the direction of the effect of natural resources on economic growth. Nearly three quarters of the primary studies control for institutional quality, and approximately one fifth additionally include the 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 quarter of the 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 the 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: The studies differ in the proxies they employ 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 quarter of the primary studies 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 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 structures are 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 allow for endogeneity of regressors by employing a type of 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 1960s, 1970s, 1980s, 1990s, or 2000s to control for potential time effects. An alternative is to include directly the mean year of the 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	Estimated t-statistics of effect size	−0.32	3.07	−8.66	7.44
PCC	Partial correlation coefficient	−0.07	0.32	−0.91	0.77
INVSEpcc	Inverse standard error of 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 effect size	1.56	2.07	0.01	11.21
DF	Logarithm of number of degrees of freedom	4.43	0.91	2.40	7.69
NO.OBS	Logarithm of number of observations	4.53	0.86	3.04	7.69
NO.EXPL.VARS	Number of explanatory variables included	6.38	2.69	1	16
NO.COUNTRY	Logarithm of number of countries	4.01	0.94	0.69	5.04
NO.TIME	Logarithm of 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 journal from RePEc	0.18	0.27	0	0.87
CITATIONS	Logarithm of number of Google Scholar citations	4.22	2.32	0	8.09
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 are 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 exports, 0 otherwise	0.57	0.50		
POINT-RESOURCE	Dummy, 1 if effect size is measured with point resource, 0 otherwise	0.95	0.22		

Continued on next page

Table 1: **Description and summary statistics of collected variables (continued)**

Variable	Definition	Mean	St.Dev	Min	Max
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 is controlled for, 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		
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 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 the inverse variance) shows a positive effect, albeit a very small one. 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

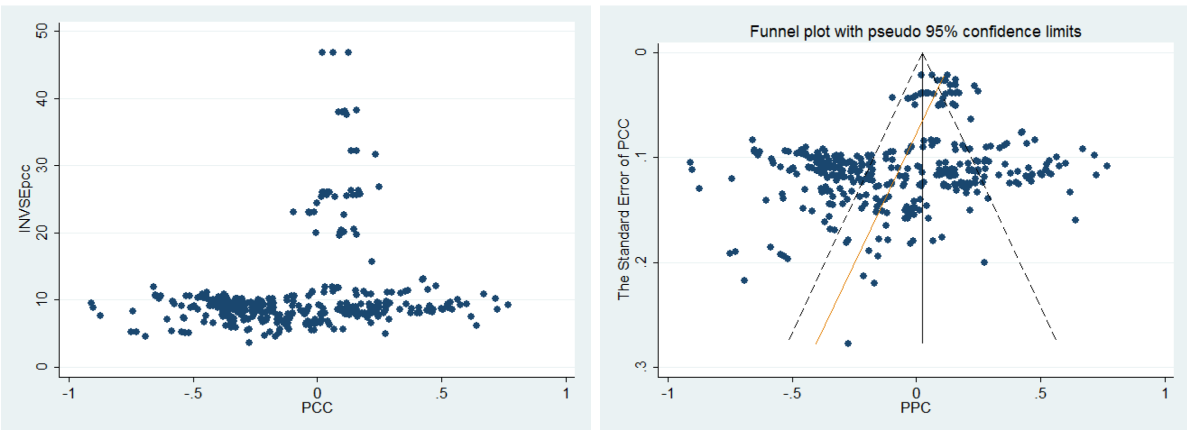
Notes: Simple average represents the arithmetic mean. The fixed-effects estimator uses the inverse of the variance as the weight for the PCC. The random-effects specification additionally considers between-study heterogeneity.

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 & Stanley, 2009), we first generate funnel plots to assess the degree of publication selection visually. The horizontal axis of the funnel plot displays the size of the effect (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 will be close to the underlying effect, less precise estimates will be more dispersed, and both negative and positive estimates with low precision (and thus low statistical significance) will be reported. In our case, the left-hand side of the funnel appears to be somewhat heavier than the right-hand side. This finding suggests that negative estimates, i.e., those suggesting the natural resource curse, are slightly preferred for reporting and publication.

Figure 1: **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 the 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. This 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 the 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			Number of observations = 402		
	F-test: F(1, 32) = 6.00			F-test: F(1, 32) = 7.62		
	Ho: Precision = 0, $Prob > F = 0.02$			Ho: Precision = 0, $Prob > F = 0.00$		
	Ramsey RESET test: F(3, 397) = 0.80			Under-identification test = 1221.39		
	Ho: No omitted variables, $Prob > F = 0.492$			$Prob > \chi^2 = 0.000$		
Panel B	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**z-stat**	**p-value**
	Fixed effects			Mixed-effects 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 observations = 402		
	Number of groups = 33			Number of groups = 33		
	F(1, 32) = 0.03			Wald test: $\chi^2(1) = 1.70$		
	$Prob > F = 0.86$			$Prob > \chi^2 = 0.19$		

Notes: The dependent variable is PCC; the estimated equation is $PCC_{is} = \beta_0 + \beta_1 * SE + \epsilon_{is}$. All results are weighted by the inverse variance. The standard errors of the regression parameters are clustered at the study level. Panel A, columns (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-effects estimation at the study level; columns (5)–(7) represent mixed-effects ML regression. The reported t-statistics are based on heteroskedasticity cluster-robust standard errors.

To assess the extent of publication bias, we estimate Eq. (3); that is, we 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 & 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, the 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 regression results stems from the omission of some important moderator variables (Doucouliagos & 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 curse hypothesis, and also offer only 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 any 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 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-effects 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)
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)

Continued on next page

Table 4: **What drives the heterogeneity in the results? (continued)**

Variable	Clustered OLS	IV regression	Fixed effects	Mixed-effects ML
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^{***}
	(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 the 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-effects 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 a cross-sectional nature), as it takes time for the negative effect of natural resources to prevail and the potential Dutch disease to develop.

Next, the inclusion of an interaction term between 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 the 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, for instance, of 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 a 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 & Conrad, 2009; Smith, 2015). Importantly, the result is also consistent with Boschini *et al.* (2007), who show that the degree of technical appropriability (i.e., that some substances, such as precious metals and diamonds, are, for economic or technical reasons, more prone to rent-seeking and conflicts) 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 & 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 (or more positive) effect 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 by 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 the weighting is based on the inverse of the number of regression specifications per primary study instead of the inverse variance of the 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 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, another 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 & Warner (1995), the most influential study in this field, which finds evidence for the natural resource curse. Second, why do different researchers obtain such different results? Systematic literature review methods 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 authors, referees, or editors prefer some types of 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 between different types of natural resources.

When primary studies explicitly consider the interaction between 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-source natural resources (Mehlum *et al.*, 2006; Boschini *et al.*, 2007). Next, primary studies that include investment as a control variable are more likely to find the natural resource curse. This result is broadly consistent with the available literature, which reports that natural resources crowd out physical capital (Atkinson & Hamilton, 2003; Gylfason & Zoega, 2006). Finally, we also find that when natural resource richness is measured solely on the basis of 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 different degrees of "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 & 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 been a recurring theme in development studies, and 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 A

Studies Included in the Meta-Analysis (sorted by publication year)

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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, $Prob > F = 0.03$ Under-identification test = 792.711 $Prob > \chi^2 = 0.00$		
Panel B	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**z-stat**	**p-value**
	Fixed effects			Mixed-effects 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 by 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, $Prob > F = 0.37$ Under-identification test = 747.02 $Prob > \chi^2 = 0.00$		
Panel D	**Coefficient**	**t-stat**	**p-value**	**Coefficient**	**z-stat**	**p-value**
	Fixed effects			Mixed-effects 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) represent unweighted results. Panel A, columns (2)–(4) represent OLS with cluster-robust standard errors at the study level; columns (5)–(7) represent IV estimation, where the instrumented variable is the inverse of the square root of the number of degrees of freedom. Panel B, columns (2)–(4) represent fixed-effects estimation at the study level; columns (5)–(7) represent mixed-effects ML regression. The reported t-statistics are based on heteroskedasticity cluster-robust standard errors. Panel (C) and Panel (D) results are weighted by 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-effects 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
	(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)

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Table A2: **What drives the heterogeneity in the results? Unweighted regressions (continued)**

Variable	**Clustered OLS**	**IV regression**	**Fixed effects**	**Mixed-effects ML**
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-effects 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-effects 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)
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**

Continued on next page

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

Variable	**Clustered OLS**	**IV regression**	**Fixed effects**	**Mixed-effects ML**
	(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-effects estimation at the study level. Column (5) represents mixed-effects ML regression. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level.

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