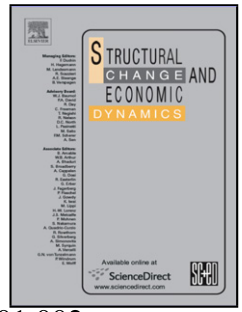
Accepted Manuscript



Title: Human Capital and Natural Resource Dependence

Authors: Dong-Hyeon Kim, Shu-Chin Lin

PII: S0954-349X(17)30007-3
DOI: http://dx.doi.org/doi:10.1016/j.strueco.2017.01.002
Reference: STRECO 649

To appear in: *Structural Change and Economic Dynamics*

Received date: 25-11-2015
Revised date: 31-5-2016
Accepted date: 5-1-2017

Please cite this article as: Kim, Dong-Hyeon, Lin, Shu-Chin, Human Capital and Natural Resource Dependence.Structural Change and Economic Dynamics http://dx.doi.org/10.1016/j.strueco.2017.01.002

Human Capital and Natural Resource Dependence

Reference: STRECO_649

Dong-Hyeon Kim
Department of Food and Resource Economics, Korea University
145, Anam-ro, Seongbuk-gu, Seoul 136-701, Korea. Phone +82-2-32903034
Fax +82-2-32903040, E-mail: dhk1015@korea.ac.kr

and

Shu-Chin Lin*
Department of Economics, SungKyunKwan University
25-2 Sungkyunkwan-ro, Jongno-gu, Seoul 110-745, Korea. Phone: +82-2-760-0410
Email: sclin@skku.edu

*Corresponding author: Department of Economics, SungKyunKwan University. 25-2 Sungkyunkwan-ro, Jongno-gu, Seoul 110-745, Korea. Phone: +82-2-760-0410, Email: sclin@skku.edu. We thank two anonymous reviewers for helpful comments and suggests. The usual disclaimer applies.

Highlights

- Study the impact of natural resource dependence to education and health capital.
- Natural resource dependence improves education but worsens health.
- Agricultural exports lower, but non-agricultural primary exports, promote education and health.
- The effects differ across countries, conditional on economic and sociopolitical institutions.

Human Capital and Natural Resource Dependence

Abstract

This paper offers an evaluation of the contribution of natural resource dependence to human capital. Two aspects of human capital are examined: education and health. Using a panel time series approach and a large cross-country dataset, it finds that natural resource dependence improves education but worsens health. It is also found that agricultural exports lower education and health whereas non-agricultural primary exports promote both. Finally, large differences in the relationships are detected across countries, depending upon a country's economic and sociopolitical institutions.

Keywords: Education, health, natural resource dependence, heterogeneous panels

JEL Classification: O13, O15, Q33

1 Introduction

The literature on the resource curse hypothesis focuses mostly on the influences of natural resource wealth on the levels or growth rates of real GDP per capita. Most of empirical findings in this context based on a time-series, cross-section or panel setting, point to mixed results (see van der Ploeg, 2011 for a detailed survey). In this paper, we ask whether natural resource dependence influences human capital accumulation. Two dimensions of human capital are investigated: education and health. We concentrate on education and health because of their importance as a driver of sustainable economic growth (Barro, 2001) and a potentially powerful equalizer (Aghion et al. 1999), and because both entails wide-ranging social implications and can be crucial in alleviating poverty (Gupta et al., 2003), which is especially important for poor countries (Bhargava et al., 2001; Krueger and Lindahl, 2001) featured by low human capital and abundant natural resources. The results of this paper therefore also constitute a test for the hypothesized adverse effects of natural resources on economic growth if human capital deteriorates due to greater dependence on natural resources. Besides, some argue that it is not natural resources but economic and socio-political environments that determine whether natural resources are a curse or blessing (Mehlum et al., 2006; Robinson et al., 2006; Boschini et al., 2013; Kim and Lin, 2015). Therefore, we also investigate whether and how a country's economic and political institutions, and culture influence the link between human capital and natural resource dependence.

Several studies have investigated the role of natural resources in determining human capital. Natural resource booms lead to a decline in the manufacturing sector for which human capital is an important production factor (Leamer et al. (1999). Also, an expanding primary sector does not need a high-skilled labor force. The need for high-quality education declines and, with it, the returns to education, thereby crowding out investment in schooling (Gylfason, 2001). Sachs and Warner (1995) claim that natural resource abundance creates over-confidence and a false sense of economic security, which leads to under-investment in human capital. In van der Ploeg and Poelhekke (2010), resource revenues are often highly volatile, which complicates longer term planning and leads to boom and bust in public spending. However, other studies such as Stijns (2006) and Kurtz and Brooks (2011) hold that countries that have successfully evaded the resource curse tend to have a higher level of human capital which makes possible the management of natural resources in ways that encourage the absorption of technology and development of valuable new economic sectors.

Political economy literature also provides some relevant insights into the nexus between resource abundance and human capital. Natural resource extraction enables governments to increase their autonomy (Ross, 2001). This disconnect could decrease the need to gain citizens' support, which consequently diminishes incentives to provide public goods such as health care and education. Resource-rich governments are most likely less dependent on tax revenues and politicians may therefore not feel the need to engage in public expenditures that justify taxes. In Acemoglu and Robinson (2006), governments of resource-rich countries may deliberately underinvest in human capital and block technological and institutional development to remain in power. In Rodriguez and Sachs (1999), large natural resource rents may tempt government officials into rent-seeking and possible corruption rather than pro-growth activities such as investment in education and health. Counter arguments also exist. In Tsui (2010), government's fiscal dependence on resource rents tends to displace government taxes, lowering the deadweight welfare costs of taxation, and hence those of public goods.

Therefore, resource-rich countries would be able to extend public goods (including education and health) at a lower social cost. In Ross (2001), oil-rich countries may overspend on the provision of public goods, including healthcare and education, to buy public cooperation and societal peace. Still, some argue nonlinearity. Cabrales and Hauk (2010) show, for instance, that for bad political institutions human capital, especially education, depends negatively on natural resources, while for high institutional quality the dependence is reversed.

Therefore, it is perhaps no coincidence that empirical investigations reach inconclusive results. Gylfason et al. (1999) find that school enrolment at all levels tends to be inversely related to natural resource abundance. Gylfason (2001), Papyrakis and Gerlagh (2004) and Birdsall et al. (2001) show that the negative growth effects of natural resources stem from lower education spending and less schooling in resource-rich countries. de Soyza and Gizelis (2013) demonstrate that oil wealth is associated with higher prevalence and mortality rates by HIV/AIDS. Likewise, Karl (2004) reports that minerals and oil dependence is associated with lower life expectancy and higher infant mortality rates. Cockx and Francken (2014) find a significant inverse relationship between natural resource dependence, and even abundance, and public health spending. However, Davis (1995) and Stijns (2006) find that resource-abundant economies tend to devote more resources to accumulate education capital. In Morrison (2009), oil windfalls lead to more social public spending and more stability in both democratic and non-democratic regimes. Cotet and Tsui (2013) find that oil wealth has led to better quality of life through significant reductions in infant mortality and gains in longevity, especially in less democratic oil-rich countries where the resource is concentrated in the hands of the ruling elite and initial health conditions were severely poor.

We confront several important challenges in conducting empirical analysis, however. First, there is an issue of endogeneity bias due to omitted-variable effects (the observed correlation between human capital and natural resource dependence reflects a common driven force as the incumbents prefer high resource revenue and low human capital investment) and reverse causation (the incumbent governments prefer not to enhance education, since education weakens their political position and it is easier for them to increase their income from natural resources than by taxing productive activity). Second, there is potential heterogeneity in the effect of natural resources on human capital across countries. On the one hand, in line with the new growth literature production technology may differ across countries, and thus also the relationship between natural resources and growth. On the other hand, each resource-rich country has its unique institutional and economic characteristics, and hence different degrees of market failures, policy distortions or institutional failures, that govern its development process. Therefore, pooling a number of heterogeneous countries with different economic and institutional frameworks as typical in the empirical literature may suffer from influential outliers and produce inconsistent and potentially misleading estimates (Pesaran and Smith, 1995). Nonlinearity may also spuriously appear if heterogeneous relationship is erroneously modelled as common across countries. Third, there is cross-section dependence as common global shocks—such as oil price disturbances and global technology shocks—affecting resource production and exploitation in one country are also likely to affect those of a related country, albeit to the varying degree, particularly in a global world with increasing trade and financial openness. The presence of these latent factors makes it difficult to argue for the validity of traditional approaches to causal interpretation of cross-country empirical results (Pesaran, 2006). Finally, there is a discrepancy between ex ante measures of resource abundance and ex post resource dependence and between point-source and diffuse resources. While ex post measures (e.g., trade intensities) capture resource dependence and are more subject to endogeneity, point-source measures are fundamentally affected by regulatory or political capture. The failure to address these differences may lead to measurement errors.

To address these concerns, we employ dynamic heterogeneous panel cointegration estimators. Such estimators are robust under cointegration to many of the problems inherent in cross-country and panel studies, including omitted variables, slope heterogeneity, and endogenous regressors (Pedroni, 2007). We find that natural resource dependence increases education but decreases health. We also find that agricultural exports lower education and health whereas non-agricultural primary exports promote both. Finally, it is found that the beneficial effect of resource dependence on education is more pronounced in countries at the later stages of economic development, better legal quality, higher levels of democratization, lower corruption, and a more homogeneous society. On the other hand, the detrimental effect of resource dependence on health is more evident in countries with the opposite attributes.

The remainder of the paper is composed of four sections. In Section 2 sets up the basic empirical model and describes the data. Section 3 presents the empirical results. Section 4 concludes.

2 Methodology and Data

2.1 Methodology

To examine the long-run relationship of natural resource dependence

$(natres\_dep)$ with human capital (*humcap*), we estimate the following regression:

$$humcap_{it} = \alpha_i + \beta_i natres\_dep_{it} + \theta_i X_{it} + \varepsilon_{it} \tag{1}$$

for $i = 1,2,...,N$ and $t = 1,2,...,T$, where *humcap* is either education or health, and X is a set of controls. Moreover, we include country-specific fixed effects, α_i, to control for country-specific omitted factors that are relatively stable over time.

In the presence of cointegration, the long-run effect of natural resource dependence on education and health can be estimated using a between-dimension group-mean panel dynamic OLS (DOLS) estimator that Pedroni (2001) argues has a number of advantages over the within-dimension approach. First, it allows for greater flexibility in the presence of heterogeneous cointegrating vectors, whereas under the within-dimension approach, the cointegrating vectors are constrained to be the same for each country. Clearly, this is an important advantage for applications such as the present one because there is no reason to assume that the effect of natural resources on human capital is the same across countries. Further, the point estimates provide a more useful interpretation in the case of heterogeneous cointegrating vectors, as they can be interpreted as the mean value of the cointegrating vectors, which does not apply to the within estimators. In addition, between-dimension estimators suffer from much lower small-sample size distortions than is the case with the within-dimension estimators.

The DOLS regression in our case is given by:

$$humcap_{it} = \alpha_i + \beta_i natres\_dep_{it} + \theta_i X_{it} + \sum_{j=-p_i}^{p_i} \phi_j \Delta natres\_dep_{it-j} + \sum_{j=-q_i}^{q_i} \varphi_j \Delta X_{it-j} + v_{it} \tag{2}$$

where ϕ_j and φ_j are coefficients of lead and lag differences, which accounts for possible serial correlation and endogeneity of the regressor(s), thus yielding unbiased estimates. Thus, an important feature of the DOLS procedure is that it generates unbiased estimates for variables that cointegrate even with endogenous regressors. Consequently, in contrast to cross-section and conventional panel approaches, the approach does not require exogeneity assumptions nor does it require the use of instruments. In addition, the DOLS estimator is super-consistent under cointegration, and it is also robust to the omission of variables that do not form part of the cointegrating relationship.

The mean-group DOLS estimator involves estimating separate regressions for each country and averaging the slope coefficients:

$$\hat{\beta} = N^{-1}\sum_{i=1}^{N}\hat{\beta}_i \text{ and } \hat{\theta} = N^{-1}\sum_{i=1}^{N}\hat{\theta}_i. \tag{3}$$

with the corresponding *t*-statistic as the sum of the individual *t*-statistics divided by the root of the number of cross-sectional units:

$$t_{\hat{\beta}} = \sum_{i=1}^{N}\frac{t_{\hat{\beta}_i}}{\sqrt{N}} \text{ and } t_{\hat{\theta}} = \sum_{i=1}^{N}\frac{t_{\hat{\theta}_i}}{\sqrt{N}}. \tag{4}$$

The DOLS estimator may be biased in the presence of cross-section dependence. We then eliminate cross-country common factors by demeaning the data using the corresponding cross-sectional means for every period to account for cross-section dependence. To verify if these suffice to remove unobserved common factors, we test cross-section dependence of the residuals using Pesaran’s (2004) cross-section dependence (CD) test. The use of demeaned data assumes that the cross-section dependence is due to a single common source and that the response to the common factor is the same for all countries. As a further check on our results we re-estimate equation (2) using the Chudik and Pesaran

(2015) Common Correlated Effects mean group (CCEMG) estimator. The CCEMG is well suited for situations in which the effects of the common factors differ among cross-sectional units. In essence, this amounts to augmenting equation (2) with (current and lagged) cross-sectional averages of the model's observable variables, allowing cross-country variation in the coefficients of the averages. Chudik and Pesaran (2015) show that in a dynamic setting the CCEMG procedure performs well with weakly exogenous regressors and a sufficient number of lagged cross-section averages.

Next we base the panel Granger causality (weak exogeneity) test on the panel vector error correction model (VECM) to check the direction of causality (weak exogeneity of regressors). We use a two-step procedure. In the first step, we employ the DOLS estimate of the long-run relationship to construct the disequilibrium term:

$$ec_{it} = humcap_{it} - (\hat{\alpha}_i + \hat{\beta}_i natres\_dep_{it} + \hat{\theta}_i X_{it}) \quad (5)$$

In the second step, we estimate the following specification of VECM:

$$\begin{pmatrix} \Delta humcap_{it} \\ \Delta natres\_dep_{it} \\ \Delta X_{it} \end{pmatrix} = \begin{pmatrix} \mu_{1i} \\ \mu_{2i} \\ \mu_{3i} \end{pmatrix} + \sum_{j=1}^{J} \Gamma_j \begin{pmatrix} \Delta humcap_{it-j} \\ \Delta natres\_dep_{it-j} \\ \Delta X_{it-j} \end{pmatrix} + \begin{pmatrix} c_1 \\ c_2 \\ c_3 \end{pmatrix} ec_{it-1} + \begin{pmatrix} \nu_{1i} \\ \nu_{2i} \\ \nu_{3i} \end{pmatrix} \quad (6)$$

where the error-correction term ec_{it-1} represents the deviation from the equilibrium and the adjustment coefficients c_1, c_2, and c_3 capture how $humcap_{it}$, $natres\_dep_{it}$, and X_{it} respond to deviations from the equilibrium relationship.

If a long-run relationship between the variables exists, according to the Granger representation theorem at least one of the adjustment coefficients must be nonzero. A significant error-correction term also suggests long-run Granger causality, and thus long-run endogeneity, whereas a non-significant adjustment coefficient implies weak exogeneity and no long-run Granger causality running from the independent to the dependent variable(s). We hence test for weak exogeneity of $humcap_{it}$, $natres\_dep_{it}$, and X_{it} and thus for long-run Granger non-causality between $humcap_{it}$, $natres\_dep_{it}$, and X_{it}. Since all variables in the model, including ec_{it-1}, are stationary, a conventional likelihood ratio test can be used to test the null hypothesis of weak exogeneity, $H_0 : c_{1,2,3} = 0.$

2.2 Data

Our dataset is mainly taken from the World Development Indicators (WDI, 2015) of the World Bank. We include all countries with complete time series, resulting in a balanced panel with 2310 observations and 55 developing and advanced countries for the period 1970-2011.[1] Table A1 in the Appendix lists the countries. Education is an index of human capital per person from Penn World Table and is calculated by using data on the average years of schooling from Barro and Lee (2010) and rates of return for completing different sets of years of education (Psacharopoulos, 1994). Specifically, human (education) capital is modeled as a function of the years of schooling, s_i :

$$H_i = e^{\phi(s_i)}$$

[1] The sample includes 19 OECD countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom, and United States; and 36 non-OECD countries: Argentina, Barbados, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Egypt, El Salvador, Fiji, Guatemala, Honduras, Hong Kong, India, Indonesia, Israel, South Korea, Malawi, Malaysia, Mexico, Morocco, Pakistan, Panama, Peru, Philippines, Saudi Arabia, and Senegal.

where $\phi(s_i)$ is specified as a piecewise linear function with coefficients 0.134 for the first four years of education, 0.101 for the next four years, and 0.068 for any value of $s_i > 8$. Health capital is proxied by life expectancy at birth, output of both mortality and morbidity, sourced from WDI.

As in Sachs and Warner (1995, 1999) and many others, we use the share of primary exports in GDP also from the WDI as our preferred resource measure. Primary exports include fuels, ores and metals, food and agricultural raw materials. This indicator measures importance of the natural resource exporting sector relative to other production activities and hence importance of natural resources to the economy. The share of primary exports in GDP is a measure of resource dependence/intensity and is vulnerable to claims of endogeneity as it may reflect not only the underlying sources of comparative advantage but also policy decisions affecting specific sectors, or trade-related macro variables such as exchange rates (Brunnschweiler and Bulte, 2008).

As a robustness check, we experiment with resource abundance measures. Abundance indicates the amount of natural resources that a country has at its disposal, while dependence measures the extent to which a country relies on natural resources for its livelihood. Natural resource dependence is of course predominantly determined by resource abundance, as this provides countries with a clear comparative advantage (Brunnschweiler and Bulte, 2008). However, resource abundance is large determined by geographic and technological reasons, and hence are less endogenous. We follow Bhattacharyya and Hodler (2010) and Boschini et al. (2013) to consider natural resource rents also from the WDI. Resource rents are measured as revenues from natural resources (including energy, minerals, and forestry) as a share of GDP. Specifically, total rents accruing from a variety of natural resources are calculated by the following procedure. First, calculate the unit rent as the difference between the unit price of a commodity and the unit cost of extraction/production. Second, multiply the natural resource rent per unit of output of a particular commodity by total extraction/production of that commodity. Third, aggregate them across commodities for a country and a particular year. Fourth, divide them by GDP. This measure captures the potential value of resource production to the country and hence is a good proxy for resource revenues that can potentially be appropriated by political leaders or weaken the political institutions.

The severity of the resource curse is argued to depend on the types of resources that are important in a country (Bulte et al., 2005; Boschini et al., 2013). In particular, point-source resources (such as ores, minerals and fuels) are argued more likely to cause the curse than diffuse resources (essentially agriculture). The basic argument is that point-source resources, characterized by being more capital-intensive, more geographically concentrated and almost always government-owned, generate rents that are more easily appropriable (Boschini et al., 2007), lead to more societal division and weaker institutions (Ishim et al., 2005), and increase the likelihood of causing conflict (Dal Bo and Dal Bo, 2011). On the other hand, diffuse resources tend to be labor-intensive and geographically diverse and hence ownership and control tend to be more diffuse. We then follow Isham et al. (2005) and Bulte et al. (2005) to examine whether there are differential impacts of these two types of resources on income per capita by disaggregating the primary export data into agricultural exports (i.e., diffuse resources, including food and agricultural raw materials) and non-agricultural primary exports (i.e., point resources, including fuels, ores and metals).

Two control variables are included. The first one is real GDP per capita to capture the impact of economic development on human capital. The second one is education (health) when health (education) is considered as the dependent variable to control for the potential complementarity between these two variables. As argued, increased education promotes health knowledge and technology and leads to better health outcomes (Pritchett and Summers, 1996; Brunello et al., 2015) and improved health expands education and leads to better education outcomes (Kremer and Miguel, 2004; Tamura, 2006). All variables are in natural logarithm except for education and health variables. Panel A of Table 1 reports summary statistics.

3 Empirical Results

As a first step, we examine the time series properties of the data. We use the panel unit root test of Im et al. (2003) (IPS) to investigate whether all variables are stationary. The IPS test allows for slope heterogeneity but can lead to spurious inferences in the presence of cross-section dependence. We therefore also consider the cross-sectionally augmented IPS test of Pesaran (2007) (CIPS). The results are reported in panels B and C of Table 1 for raw and demeaned data, respectively. The CD tests indicate the presence of cross-section dependence. The CIPS suggests that all variables follow I(1) processes, albeit some variables are I(0) according to the IPS. We then turn to examine the existence of a long-run relationship among variables. We use the standard panel cointegration test of Predroni (2004). A potential problem with this test is that it does not allow for cross-sectional dependence. We then test for cointegration in the presence of possible cross-section dependence by using a two-step residual based procedure. The first step is to employ the Pesaran (2006) CCEMG estimation procedure, i.e., by augmenting the cointegrating regression (1) with the cross-sectional averages of the dependent and independent variables as proxies for the unobserved factors.

The second step is to compute the residuals of the individual CCEMG long-run relations, and apply the CIPS test to the computed residuals, including an intercept. The results of the tests, which are reported at the bottom of Table 3-6, support the long-run cointegrating relationship among variables considered.

Table 2 reports the panel Granger causality (weak exogeneity) test results. Panels A and B report the results when education is considered as a dependent variable in the first step regression. According to the x^2 statistics of the error correction terms, natural resources, life expectancy and income can be regarded as weakly exogenous with respect to the cointegrating relationship, whereas the weak exogeneity hypothesis of education is overwhelmingly rejected. Hence, only education reacts to deviations from the long-run equilibrium relationship, implying that long-run causality runs unidirectional from natural resources, life expectancy and income to education. Likewise, when life expectancy is treated as a dependent variable in the first step regression shown in panels C and D, the x^2 statistics of the error correction terms indicate that natural resources, education and income can be considered as weakly exogenous regarding the cointegrating relationship, whereas the weak exogeneity hypothesis of life expectancy is decisively rejected. Thus, only life expectancy reacts to deviations from the long-run equilibrium relationship, indicating that long-run causality runs unidirectional from natural resources, education and income to life expectancy. Overall, the evidence suggests that all regressors are weakly exogenous.

3.1 Long-run Relationship

Having established a cointegration relationship, we then estimate the parameters of the cointegrating vector, which in principle might differ across countries. The estimation results are reported in Table 3 for alternative strategies to account for cross-section dependence: ignoring common factors or using cross-section demeaning. The first two columns report the group-mean DOLS estimates of Pedroni (2001) using our preferred measure of resource dependence, primary exports as a percentage of GDP. Focusing on education in Panel A, the coefficient estimate of resource exports is positive and statistically significant. Natural resource dependence improves education, which contradicts Stijns (2006) finding that resource exports reduce education. Concerning health in Panel B, the coefficient estimate of resource exports is negative and statistically significant. Consistent with Karl (2004), natural resource dependence worsens health status. However, demeaning leads to a relatively large effect for education and health. The estimate for education rises from 0.0237 to 0.0380 while that for health falls from -0.2440 to -0.4583. Demeaning also causes a drastic drop in the CD test statistic. While the cross-section dependence test shows considerable cross-section dependence for raw data, it yields some mild indication of cross-section dependence, but short of conventional significance levels, for demeaned data. Besides, we find that education and health are complements, and economic development promotes education and health. The estimates on health (education) and real GDP per capita are positive and significant in the education (health) regression.

Columns (4) and (5) confirm our finding with primary exports as a percentage of total exports again for raw and demeaned data, respectively. From panels A and B, the respective resource dependence estimate remains positive and negative for education and health, and both are of statistical significance. Demeaning leads to a drop in the size of estimates and CD test statistics such that there is no significant existence of cross-sectional dependence. Besides, all controls retain their signs and significance.

Thus far, the evidence indicates that using cross-sectionally demeaned data to account for common factors suffices to make the residuals cross-sectionally independent. As a further check, we experiment with the CCEMG approach of Chudik and Pesaran (2015) to deal with cross-section dependence. The results are reported in columns (3) and (6) of Table 4 for two different measures of resource dependence. We find qualitatively similar results as before. The respective estimated effect on education and on health remains positive and negative, and both are statistically significant, but with smaller magnitudes. Pesara's CD test suggests that there is no cross-section dependence for the education regression but borderline indication of cross-section dependence for the health regression.

The last two columns of Table 3 report estimates from the within-dimension DOLS estimator of Kao and Chiang (2000) assuming homogeneous slope coefficients for all countries, as a comparison. As illustrated, there is little change in the signs and significance of the estimates, but the cross-section dependence test overwhelmingly rejects the null of independence even for demeaned data. Given, however, that the effects of natural resource dependence on education and health differ across countries, the results of the pooled within-dimension estimator should be interpreted with caution.

Table 4 experiments with alternative estimators. We consider the group-mean fully modified OLS (FMOLS) estimator of Pedroni (2001) for non-transformed and demeaned data. The FMOLS estimator simultaneously corrects for serial correlation, endogeneity, and sample bias asymptotically via a non-parametric correction using ε_{it}, $\Delta natres\_dep_{it}$ and Δx_{it}. The estimation results for education are reported in columns (1)-(3) whereas those for health are in columns (4)-(6) with alternative strategies dealing with cross-section dependence. As indicated, there is little change in the sign and significance of the estimate. In addition, the CD test reveals no evidence against the null of independence at the conventional significance levels for demeaned data, but substantial cross-section dependence for raw data.

In Table 5 we consider natural resource rents to check whether there is a difference between resource dependence and abundance.[2] Despite deriving from abundance according to comparative advantage, it is argued that dependence might not share the same dynamics as abundance. The experience shows that resource-rich countries with good economic performance, such as Canada and Norway, are often not dependent on them. Furthermore, Ding and Field (2005) find that while natural resource dependence has a significantly negative effect on growth rates, abundance appears to have a positive impact. Daniele (2011) finds that human development, measured by the human development index, is negatively affected by resource dependence, but positively by abundance. Importantly, Stijns (2006) demonstrates that export intensity seems to have detrimental effects on education whereas resource rents tend to have beneficial impacts. However, our results show that there is no significant difference between these two measures. The respective estimate for education and health retains its sign and significance, albeit with a smaller magnitude. Moreover, under two alternative approaches to correct for common factors—cross-sectional demeaning and common correlated effects—there is no clear evidence of cross-section dependence at the conventional significance levels. The data also indicate that using resource rents per GDP or per capita are not decisive. Greater resource rents improve education but deteriorate health status.

[2] As in Stijns (2006), we divide resource rents by a country's population to yield resource rents per capita. We then multiply this number by the GDP deflator, also taken from WDI, to yield real rents per capita.

Table 6 looks at whether there is a difference between agricultural and non-agricultural primary exports, as a share of GDP or total exports. For both education and health indicators, the estimate of agricultural exports is negative and significant, meaning that agricultural dependence deteriorates education and health. On the other hand, the estimate of non-agricultural primary exports is positive and significant in both education and health regressions, implying that dependence on minerals and fuels improves education and health, supporting the finding of Stijns (2006) and Cotet and Tsui (2013). To check further whether there is a difference between fuel and mineral exports, we then divide the non-agricultural primary exports into fuel and mineral (including both ores and metal) components and re-do the DOLS and CCEMG estimation. The results are reported in Table A1 of the Appendix and suggest that fuel exports are beneficial for education expansion and health improvements, in line with Ross (2001). However, mineral exports expand education but lower life expectancy. Again, there is no clear evidence of cross-section dependence at the conventional significance levels for demeaned data and the CCE procedure.

Up till now, our data suggest that on average resource dependence leads to higher education but lower health status. The potential for the beneficial effect of resource dependence on education could arise, as suggested by Tsui (2010) and Ross (2001), because resource-dependent countries can escape from deadweight costs associated with distortionary taxation and hence are able to extend public goods at low social costs, and/or because governments in resource dependent countries have strong incentives to increase social spending in exchange for public cooperation and societal peace. On the other hand, one possibility for the adverse effect on health could be caused by pollution levels in the resource dependent country.[3] To check this potential, we first regress carbon (nitrous) emissions on resource dependence, log real GDP per capita and its quadratic term, FDI inflows (as a percentage of GDP), and education. The results using demeaned data and the DOLS estimator are reported in Tables A2-A3 of the Appendix and indicate that carbon (nitrous) emissions are higher for countries heavily dependent on primary exports (resources rents). It is also found that agricultural exports increase, but non-agricultural primary exports mitigate, carbon (nitrous) emissions. There is also difference between fuel and mineral exports. Mineral exports exert positive and statistically significant impacts on carbon (nitrous) emissions whereas fuel exports have a negative and significant effect.

We then investigate how health would respond to changes in resource dependence when controlling for emissions. This is performed by adding carbon emission into Eq. (1) and re-doing the DOLS estimation to demeaned data. The results are reported in Table A4 of the Appendix and show that primary exports now have a positive and significant effect on health. Likewise, both agricultural and non-agricultural primary exports exert positive and significant influence on health. Mineral exports have a negative but insignificant effect. Overall, the evidence indicates that once emissions are controlled for, there is either very little effect of natural resources on health or even a positive effect. Resource exports have no adverse effect on health. It implies that the adverse effect on health is mediated through pollutions.

3.2 Heterogeneity and Subsample Estimates

The results reported thus far are about the average effects of natural resources on human capital. In this subsection, we focus on country-specific

[3] We are grateful to one anonymous referee for pointing out this.

characteristics to address heterogeneity across countries. Specifically, we investigate whether countries with certain similar characteristics benefit (lose) more, on average, from natural resource dependence than others by presenting heterogeneous panel estimates of the education-resource and health-resource coefficients for certain country groups. A growing body of evidence suggests that resources are not necessarily good or bad, but that their effect depends on factors like the strength of domestic institutions and quality of economic policy management (Mehlum et al., 2006), the degree of ethnic or political fragmentation (Hodler, 2006; Bjorvatn et al., 2012), the extent of clientelism in the public sector (Robinson et al., 2006), the degree of political competition (Bulte and Damania, 2008), the effectiveness of checks and balances or the type of institutional arrangements (Andersen and Aslaksen, 2008; Collier and Hoeffler, 2009), and the extent of economic freedom (Farhadi et al., 2015; Kim and Lin, 2015). Table 7 reports the estimation results obtained from the DOLS estimator along these dimensions using cross-sectionally demeaned data.

Column (1) presents respective DOLS estimates for OECD and non-OECD countries. This exercise allows one to look at whether a country's economic development matters in shaping the link of resource dependence with education (Panel A) and health (Panel B). As illustrated, the impact of resource dependence on education tends to be more positive for OECD countries but less positive for non-OECD countries. The estimate on resource dependence is positive and significant in an OECD sample but insignificant in a non-OECD one. Note that the latter does not imply the absence of any significant effects, but rather highlights the heterogeneity across countries on average cancelling out. By contrast, the effect of resource dependence on health appears to be more negative for non-OECD countries. The estimate on resource dependence is negative and significant in a non-OECD sample but insignificant in an OECD one.

In Column (2) we split the sample into countries with high and low property right protection, based on the sample median of legal quality from the Fraser Institute's Economic Freedom of the World (2015). Legal quality measures the protection and respect for the rights of individuals to their own lives and rightfully acquired property. The legal quality index is composed of indicators of judicial independence, impartiality of the courts, protection of intellectual property rights, military interference in law and politics, and the integrity of the legal system. As expected, the impact of resource dependence on education tends to be more positive for countries with better property right protection while the influence of resource dependence on health seems to be more negative for countries with less protection. The estimate of resource dependence on education (health) is not significant in countries with lower (higher) legal quality.

In Column (3), we segregate the sample into high and low democratic countries, based on the sample median of the Polity2 index sourced from the Polity IV database. The Polity2 index is a measure of 10-point autocracy and 10-point democracy, with levels of democracy ranging from complete autarchy (-10) to complete democracy (10). This measure reflects the degree of competitiveness in political participation, the openness and competitiveness in the selection of the legislature, and the constitutional constraints on the executive. It also incorporates subjective information on checks and balances to executive powers, the degree of restrictions in electoral participation, and the extent to which the political participation is regulated. Because democracy is typically more responsive to the social concerns of civil society, more democratic countries are conducive to policies that generate growth-enhancing public goods and services such as education and health care (Kaufman and Segura-Ubiergo, 2001), rather than narrow redistribution of private goods to a few supporters (Acemoglu and Robinson, 2006). Evidence also shows that greater levels of democracy lead to lower infant and child mortality (Navia and Zweifel, 2003) and better education attainment (Tavares and Wacziarg, 2001). Not surprisingly, we find that the impact of resource dependence on education tends to be more positive for countries with higher levels of democratization while the influence of resource dependence on health seems to be more negative for countries with lower levels of democratization. The estimate of resource dependence on education (health) is not significant in a sample of less (more) democratic countries.

Column (4) reports a similar experiment distinguishing between countries with high and low corruption, with the sample median as the relevant dividing line. Corruption is obtained from ICRG with larger number indicating lower levels of corruption. Corruption proxies actual or potential corruption in the form of excessive patronage, nepotism, job reservations, 'favor-for-favors', secret party funding, and suspiciously close ties between politics and business. Several studies show that corruption has impacts on education and health outcomes. Corruption would reduce returns to education (Heyneman et al., 2008) and lead to a misallocation of skills away from productive activities (Fershtman et al., 1996). Corruption lowers the ability of the government to raise revenues and decreases the availability of public funds for education and health (Mauro, 1998). Evidence also shows that corruption leads to high child and infant mortality rates (Gupta et al., 2002), reduces adult literacy and average years of schooling (Kaufmann et al., 1999), and depresses investment in education (De La Croix and Delavallade, 2009). As indicated, the impact of resource dependence on education tends to be more positive for countries with lower corruption while the influence of resource dependence on health seems to be more negative for countries with higher corruption. The estimate of resource dependence on education (health) is negative (insignificant) in countries with higher (lower) corruption.

In circumstances of high fractionalization, elites or those in power may be less willing to invest in public goods such as education and health that benefit the entire population. Evidence also indicates that ethnically diverse countries have achieved lower rates of economic growth and worse educational and health outcomes as well as reduced investment in infrastructure when compared with countries that are ethnically homogenous (Easterly and Levine, 1997; La Porta et al., 1999). In Column (5) we group countries according to the level of ethnic fractionalization, again based on the sample median. The indicator of ethnic fractionalization is obtained from Alesina et al. (2003). As expected, countries with a more homogeneous society tend to have higher levels of education resulting from greater natural resource dependence, and countries with a more diverse society seem to have lower levels of health from greater natural resource dependence. The estimate of resource dependence on education (health) is not significant in more (less) ethnic-fractionalization countries.

4 Conclusion

This paper examines the effect of natural resources on education and health using dynamic panel cointegration techniques that are specifically designed to deal with the inability of previous studies to adequately account for the heterogeneity in the relationship across countries. Employing data for 55 developed and developing countries over the period from 1970 to 2011, we find that natural resource dependence has, on average, a statistically significant effect on education (health), with estimates between 0.0115 and 0.0380 (-0.2440 and -0.5187). Our results also indicate that there are, in fact, large cross-country differences in the response of education and health to natural resources. In particular, it is shown that the education-improving effect of resource dependence is more dominant in countries with higher income, better legal quality, higher democracy, lower corruption, and less ethnic diversity. By contrast, the health-decreasing effect of resource dependence is more prevailing in countries with opposite features. The evidence suggests that policy toward better economic and political institutions and reducing ethnic tension/conflicts would help resource-rich countries to accumulate more education and health capital.

References

Acemoglu, D. and J.A. Robinson (2006). *Economic Origins of Dictatorship and Democracy*. Cambridge, U.K.: Cambridge University Press.

Aghion, P., E. Caroli, and C. García-Peñalosa (1998) Inequality and economic growth: The perspective of the new growth theories. *Journal of Economic Literature* 37, 1615-60.

Andersen, J. and S. Aslaksen (2008). Constitutions and the resource curse. *Journal of Development Economics* 87, 227-246.

Alesina, A., A. Devleescha, W. Easterly, S. Kurlat, and R. Wacziarg (2003). Fractionalization. *Journal of Economic Growth* 8, 155-194.

Barro, R., (2001). Human capital and growth. *American Economic Review* 91, 12-17.

Barro, R. and J.W. Lee (2010). A new data set of educational attainment in the world, 1950-2010. *Journal of Development Economics* 104, 184-198.

Bhargava, A., D.T. Jamison, L.J. Lau, and C.J.L. Murray (2001). Modeling the effects of health on economic growth. *Journal of Health of Economics* 20, 423-440.

Birdsall, N., T. Pinckney, and R. Sabot (2001). Natural resources, human capital, and growth. In: Auty, R.M. (Ed.), *Resource Abundance and Economic Growth*. Oxford University Press, Oxford.

Bjorvatn, K., M.R. Farzanegan, and F. Schneider (2012). Resource curse and power balance: Evidence from oil-rich countries. *World Development* 40, 1308-1316.

Boschini, A., J. Pettersson, and J. Roine (2007). Resource curse or not: A Question of appropriability. *Scandinavian Journal of Economics* 109, 593-617.

Boschini, A., J. Pettersson, and J. Roine (2013).The resource curse and its potential reversal. *World Development* 43, 19-41.

Brunello, G., M. Fort, N. Schneeweis, and R. Winter-Ebmer (2015). The causal effect of education on health: What is the role of health behaviors? Forthcoming in *Health Economics*.

Brunnschweiler, C.N. and E.H. Bulte (2008). The resource curse revisited and revised: A tale of paradoxes and red herrings. *Journal of Environmental Economics and Management* 55, 248-264.

Bulte E.H. and R. Damania (2008). Resources for sale: corruption, democracy and the natural resource curse. *BE Journal of Economic Analysis & Policy* 8, 1-30.

Bulte, E.H., R. Damania, and R.T. Deacon (2005). Resource intensity, institutions, and development. *World Development* 33, 1029-1044.

Cabrales, A. and E. Hauk (2010) The quality of political institutions and the curse of natural resources. *Economic Journal* 121, 58-88.

Chudik, A. and M.H. Pesaran (2015). Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors. *Journal of Econometrics* 188, 393-420.

Cockx, L. and N. Frankcken (2014). Extending the concept of the resource curse: Natural resources and public spending on health. *Ecological Economics* 108, 136-149.

Collier, P. and A. Hoeffler (2009). Testing the neocon agenda: democracy in resource-rich societies. *European Economic Review* 53, 293-308.

Cotet, A. and K. Tsui (2013). Oil, growth, and health: What does the cross-country evidence really show? *Scandinavian Journal of Economics* 115, 1107-1137.

Dal Bo, E. and P. Dal Bo (2011). Workers, warriors, and criminals: Social conflict in general equilibrium. *Journal of the European Economic Association* 9, 646-677.

Daniele, V. (2011). Natural resources and the quality of development. *Journal of Development Studies* 47, 545-573.

Davis, G. (1995). Learning to love the Dutch disease: Evidence from the mineral economies. *World Development* 23, 1765-1779.

De la Croix, D. and Delavallade, C., (2009). Growth, public investment and corruption with failing institutions. *Economics of Governance* 10, 187-219.

De Soyza, I. and T.I., Gizelis (2013). The natural resource curse and the spread of HIV/AIDS, 1990-2008. *Social Science & Medicine* 77, 90-96.

Ding, N. and B.C. Field (2005). Natural resource abundance and economic growth. *Land Economics* 81, 496-502.

Easterly, W. and R. Levine (1997). Africa's growth tragedy: policies and ethnic divisions. *Quarterly Journal of Economics* 112, 1203-1250.

Farhadi, M., Md. R. Islam, and S. Moslehi (2015). Economic freedom and productivity growth in resource-rich economies. *World Development* 72, 109-126.

Fershtman, C., K.M. Murphy, and Y. Weiss (1996). Social status, education, and growth. *Journal of Political Economy* 104, 108-132.

Gupta, S., H.R. Davoodi, and E.R. Tiongson (2002). Corruption and the provision of health care and education services. In: Abed, G. T. and Gupta, S. (eds.), *Governance, Corruption and Economic Performance,* Washington, International Monetary Fund, 245-279.

Gupta, S., M. Verhoeven, and E. Tiongson (2003). Public spending on health care and the poor. *Health Economics* 12, 685-696.

Gylfason, T., T.T. Herbertsson, and G. Zoega (1999). A mixed blessing. *Macroeconomic Dynamics* 3, 204-225.

Gylfason, T. (2001). Natural resources, education, and economic development. *European Economic Review* 45, 847-859.

Heyneman, S.P., K.H. Anderson, and N. Nuraliyeva (2008). The cost of corruption in higher education. *Comparative Education Review* 52, 1-25.

Hodler, R. (2006). The curse of natural resources in fractionalized countries. *European Economic Review* 50, 1367-1386.

Im, K.S., M.H. Pesaran, and Y. Shin (2003). Testing for unit roots in heterogeneous panels. *Journal of Econometrics* 115, 53-74.

Isham, J., L. Pritchett, M. Woolcock, and G. Busby (2005). The varieties of resource experience: natural resource export structures and the political economy of economic growth. *World Bank Economic Review* 19, 141-174.

Kao, C. and M.H. Chiang (2000). On the estimation and inference of a cointegrated regression in panel data. *Advances in Econometrics* 15, 179-222.

Karl, T.L. (2004). Oil-led development: Social, political, and economic consequences. In: Cleveland, C.J. (Ed.), *Encyclopedia of Energy*, vol. 4. Elsevier, Amsterdam, 661-672.

Kaufman, D., A. Kraay, and P. Zoido-Lobaton (1999). Governance matters. World Bank Policy Research Working Paper No. 2196, Washington, D.C.

Kaufman, R.R. and A. Segura-Ubiergo (2001). Globalization, domestic politics, and social spending in Latin America. *World Politics* 53, 553-87.

Kim, D.H. and S.C. Lin (2015). Natural resources and economic development: New panel evidence. *Environmental and Resource Economics*, Doi 10.1007/s10640-015-9954-5.

Kremer, M. and E. Miguel (2004). Worms: Identifying impacts on education and health in the presence of treatment externalities? *Econometrica* 72, 159-217.

Krueger, A. and M. Lindahl (2001). Education for growth: why and for whom? *Journal of Economic Literature* 39, 1101-1136.

Kurtz, M.J. and S.M. Brooks (2011). Conditioning the resource curse: globalization, human capital, and growth in oil-rich nations. *Comparative Political Studies* 44,747-770.

La Porta, R., F. Lopez-de-Silanes, A. Shleifer, and R. Vishny (1999). The quality of government. *Journal of Law, Economics and Organization* 15, 222-279.

Leamer, E., H. Maul, S. Rodriguez, and P. Schott (1999). Does natural resource abundance increase Latin American income inequality? *Journal of Development Economics* 59, 3-42.

Mauro, P. (1998). Corruption and the composition of government expenditure. *Journal of Public Economics* 69, 263-279.

Mehlum, H., K. Moene, and R. Torvik (2006). Institutions and the resource curse. *Economic Journal* 116, 1-20.

Morrison, K. (2009). Oil, non-tax revenue, and the redistributional foundations of regime stability. *International Organization* 63, 107-38.

Navia, P. and T.D. Zweifel (2003). Democracy, dictatorship, and infant mortality revisited. *Journal of Democracy* 14, 90-103.

Papyrakis, E.E. and R. Gerlagh (2004). The resource curse hypothesis and its transmission channels. *Journal of Comparative Economics* 32, 181-193.

Pedroni, P. (2001). Fully modified OLS for heterogeneous cointegrated panels. *Advances in Econometrics* 15, 93-130.

Pedroni, P. (2004). Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis: new results. *Econometric Theory* 20, 597-627.

Pedroni, P. (2007). Social capital, barriers to production and capital shares: Implications for the importance of parameter heterogeneity from a nonstationary panel approach. *Journal of Applied Econometrics* 22, 429-451.

Pesaran, M.H. (2004). General diagnostic tests for cross section dependence in panels. University of Cambridge, Faculty of Economics, Cambridge Working Papers in Economics No. 0435.

Pesaran, M.H. (2006). Estimation and inference in large heterogeneous panels with a multifactor error structure. *Econometrica* 74, 967-1012.

Pesaran, M.H. (2007). A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Econometrics* 22, 265-312.

Pesaran, M.H. and R. Smith (1995). Estimating long-run relationships from dynamic heterogeneous panels. *Journal of Econometrics* 68, 79-113.

Pritchett, L. and L.H. Summers (1996). Wealthier is healthier. *Journal of Human Resources* 31, 841-868.

Psacharopoulos, G. (1994). Returns to investment in education: a global update. *World Development* 22, 1325-1343.

Robinson, J.A., R. Torvik, and T. Verdier (2006). Political foundations of the resource curse. *Journal of Development Economics* 79, 447-468.

Ross, M.L. (2001). Does oil hinder democracy? *World Politics* 53, 325-361.

Rodriguez, F. and J.D. Sachs (1999). Why do resource abundant economies grow more slowly? A new explanation and an application to Venezuela. *Journal of Economic Growth* 4, 277-303.

Sachs, J.D. and A.M. Warner (1995). Natural resource abundance and economic growth. National Bureau of Economic Research Working Paper 5398.

Sachs, J.D. and A.M. Warner (1999). The big push, natural resource booms and growth. *Journal of Development Economics* 59, 43-76.

Stijns, J.C., (2006). Natural resource abundance and human capital accumulation. *World Development* 34, 1060-1083.

Tamura, R., (2006). Human capital and economic development. *Journal of Development Journal* 79, 26-72.

Tavares, J., and R. Wacziarg (2001). How democracy affects growth? *European Economic Review* 45, 1341-1378.

Tsui, K.K. (2010). Resource curse, political entry, and deadweight costs. *Economics and Politics* 22, 471-497.

van der Ploeg, F. (2011). Natural resources: curse or blessing? *Journal of Economic Literature* 49, 366-420.

van der Ploeg, F. and S. Poelhekke (2010). The pungent smell of ‘‘red herrings’’: Subsoil assets, rents, volatility and the resource curse. *Journal of Environmental Economics and Management* 60, 44-55.

Table 1. Descriptive statistics and tests of cross-section dependence and unit root

	education	life expectancy	resource dependence (%GDP)	agricultural exports (%GDP)	non-agricultural primary exports (%GDP)	resource rents (%GDP)	GDP per capita
Panel A. Summary statistics							
mean	2.3685	69.7318	2.0300	1.3101	1.5977	0.5407	8.6256
median	2.4133	71.6601	2.1655	1.3571	1.6433	0.8960	8.6241
std.	0.5562	8.2418	0.9590	1.1345	1.0410	2.0664	1.4705
min.	1.1211	39.2205	-1.5825	-4.0249	-3.3349	-12.4045	5.1609
max.	3.6187	83.422	4.5493	8.1558	8.8489	4.3932	11.1243
Panel B. Cross-section dependence and unit root tests: raw data							
CD test statistics	239.70***	241.85***	46.70***	21.07***	31.27***	71.54***	168.39***
IPS: level	105.829	381.630***	111.405	128.979	102.230	195.025***	118.204
difference	133.348*	311.845***	717.919***	675.242***	751.661***	702.664***	447.709***
CIPS: level	2.523	-0.359	-1.023	-0.908	-0.702	-1.567	5.123
difference	-1.290*	-11.601***	-30.905***	-31.427***	-31.857***	-32.724***	-19.430***
Panel C. Cross-section dependence and unit root tests: demeaned data							
CD test statistics	-1.85*	11.1***	-3.52***	1.22	1.79*	-1.14	0.30
IPS: level	-4.7638***	-1.4186*	-0.9841	-1.8579**	-1.5525*	-1.0798	3.6652
difference	-1.9331**	-4.5292***	-15.0260***	-16.2313***	-16.6046***	-18.3427***	-9.1717***
CIPS: level	5.189	8.508	-0.569	-0.550	0.410	-0.055	4.743
difference	-2.446***	-4.396***	-21.951***	-23.413***	-23.425***	-24.525***	-13.924***

Note: All variables are in natural logarithms except for human capital. For unit rot tests, two lags and trend are included in ADF regressions. ***, ** and * denote significant at 1%, 5%, and 10% level, respectively.

Table 2. Weak exogeneity/Long-run causality tests

Panel A.

	weak exogeneity of				weak exogeneity of			
	education	life expectancy	GDP per capita	resource dependence	education	life expectancy	GDP per capita	resource rents
$\chi^2(1)$	19.63**	1.59	0.35	2.50	27.08***	0.50	1.60	2.06

Panel B.

	weak exogeneity of				weak exogeneity of			
	education	life expectancy	GDP per capita	agricultural exports	education	life expectancy	GDP per capita	non-agricultural exports
$\chi^2(1)$	17.60***	0.09	0.01	0.05	12.24***	0.01	0.01	0.44

Panel C.

	weak exogeneity of				weak exogeneity of			
	life expectancy	education	GDP per capita	resource dependence	life expectancy	education	GDP per capita	resource rents
$\chi^2(1)$	2.91**	0.84	0.03	2.13	3.04**	2.05	0.03	1.76

Panel D.

	weak exogeneity of				weak exogeneity of			
	life expectancy	education	GDP per capita	agricultural exports	life expectancy	education	GDP per capita	non-agricultural exports
$\chi^2(1)$	3.87**	1.19	1.02	4.09*	3.52**	1.01	0.07	2.23

Note: Demeaned data are used. The number of degrees of freedom v in the standard $\chi^2(v)$ tests correspond to the number of zero restrictions. The number of lags was determined by the general-to-specific procedure with a maximum of three lags. ** and * denote significance at the 1 % and 10% level, respectively.

Table 3. Natural resource dependence

	heterogeneous models						homogeneous models	
	primary export (% GDP)			primary export (% total exports)			primary export (% GDP)	
	DOLS raw data	DOLS demeaned data	CCEMG	DOLS raw data	DOLS demeaned data	CCEMG	DOLS raw data	DOLS demeaned data
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				Panel A. education capital				
resource dependence	0.0237**	0.0380***	0.0319***	0.0228***	0.0200***	0.0115***	0.0322**	0.0289**
	(2.084)	(2.484)	(3.8393)	(-9.522)	(2.8094)	(2.7650)	[0.0141]	[0.0128]
life expectancy	0.0499***	0.0108***	0.0461***	0.0619***	0.1464***	0.0363**	0.0348***	0.0254***
	(102.3)	(2.058)	(-4.9829)	(94.81)	(3.4032)	(1.9711)	[0.0032]	[0.0045]
GDP per capita	0.227***	0.0643***	0.0237***	1.738***	0.0962***	0.1898***	0.1076***	0.1446***
	(28.19)	(6.404)	(59.42)	(22.79)	(3.4070)	(2.8039)	[0.0402]	[0.0395]
CD test	8.01***	1.69*	1.26	2.19**	0.72	0.23	109.64***	38.03***
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
				Panel B. health capital				
resource dependence	-0.2440*	-0.4583***	-0.3995***	-0.5187***	-0.4954**	-0.4872***	-0.4992**	-0.3912*
	(-1.889)	(-4.1127)	(-3.7809)	(4.063)	(-2.1843)	(-2.5665)	[0.2284]	[0.2146]
education	9.1069***	4.335***	2.0410***	11.8***	1.9669***	3.5292**	5.5107***	3.4359***
	(23.92)	(25.13)	(-4.323)	(80.71)	(3.5851)	(2.0494)	[0.8737]	[1.2542]
GDP per capita	5.8687***	0.0564***	0.2620***	2.335***	1.5978***	1.0255***	2.8307***	3.2927***
	(51.783)	(2.47)	(-6.547)	(17.67)	(3.4740)	(3.5705)	[0.6719]	[0.6615]
CD test	6.79***	1.98*	1.84*	4.74***	-1.04	1.81*	237.97***	35.21***
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Note: For the first four columns resource dependence is proxied by primary exports as a percentage of GDP while for the last two columns resource dependence is primary exports as a share of total exports. The number of leads and lags in the individual DOLS regressions was determined by the Schwarz criterion with a maximum of three lags. The values in the parentheses (brackets) are the t-values (standard errors) of corresponding coefficient estimates. ***, ** and * denote significant at 1 %, 5%, and 10% level, respectively.

Table 4. Robustness checks with alternative methods

	primary exports			primary exports		
	%GDP		% total exports	%GDP		% total exports
	FMOLS raw data	FMOLS demeaned data	FMOLS demeaned data	FMOLS raw data	FMOLS demeaned data	FMOLS demeaned data
	(1)	(2)	(3)	(4)	(5)	(6)
	education capital			health capital		
resource dependence	0.0575** (6.1176)	0.0351*** (3.2616)	0.0342*** (2.8010)	-0.4670*** (-3.817)	-0.4356*** (-3.4685)	-0.4314** (-2.2145)
life expectancy	0.0456** (14.608)	0.0171*** (5.3251)	0.0196*** (5.9651)			
education				13.1653*** (4.9309)	3.0369*** (4.4969)	7.7971*** (6.9559)
GDP per capita	0.3933*** (9.7138)	0.1643*** (8.1965)	0.1262*** (6.7526)	0.9595** (2.4648)	0.6454*** (1.5207)	0.1582*** (3.4527)
CD test	9.56***	-1.61	1.27	14.35***	8.55***	1.20
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Note: In columns (1), (2), (4) and (5) resource dependence is proxied by primary exports as a percentage of GDP while in columns (3) and (6) resource dependence is primary exports as a share of total exports. The number of leads and lags in the individual DOLS regressions was adetermined by the Schwarz criterion with a maximum of three lags. The values in the parentheses are the t-values of corresponding coefficient estimates. ***, ** and * denote significant at 1 %, 5%, and 10% level, respectively.

Table 5. Natural resource rents

	resource rents				resource rents			
	% GDP		% population		% GDP		% population	
	DOLS demeaned data	CCEMG	DOLS demeaned data	CCEMG	DOLS demeaned data	CCEMG	DOLS demeaned data	CCEMG
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	education capital				health capital			
resource dependence	0.0380***	0.0220***	0.0130***	0.0117**	-0.2564***	-0.1982***	-0.191***	-0.1285***
	(4.312)	(4.287)	(-2.7682)	(-2.1976)	(-4.4779)	(6.698)	(-6.474)	(-4.0312)
life expectancy	0.0176***	0.0124***	0.0107*	0.0396***				
	(2.852)	(10.25)	(-1.7971)	(5.3113)				
education					12.12***	8.393***	1.306***	12.2107***
					(5.257)	(51.67)	(41.24)	(24.2887)
GDP per capita	0.1874***	0.256***	0.2995***	0.2299***	2.434***	3.486***	1.028***	1.7928***
	(7.204)	(23.14)	(7.4971)	(6.0571)	(17.85)	(-11.0)	(-10.3)	(3.4547)
CD test	-0.35	1.81*	0.93	1.25	1.58	1.49	1.70*	0.54
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Note: The number of leads and lags in the individual DOLS regressions was determined by the Schwarz criterion with a maximum of three lags. The values in the parentheses are the t-values of corresponding coefficient estimates. ***, ** and * denote significant at 1 %, 5%, and 10% level, respectively.

Table 6. Components

	agricultural exports				non-agricultural exports			
	% GDP		% total exports		% GDP		% total exports	
	DOLS demeaned data	CCEMG	DOLS demeaned data	CCEMG	DOLS demeaned data	CCEMG	DOLS demeaned data	CCEMG
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. education capital								
resource dependence	-0.0196***	-0.0170**	-0.0385***	-0.0319**	0.0351***	0.0225**	0.0448**	0.0402***
	(-2.6933)	(-2.2906)	(-3.0550)	(-3.0958)	(-2.6517)	(2.2134)	(2.2146)	(2.6607)
life expectancy	0.0323***	0.0489***	0.0188***	0.0145*	0.0168*	0.0609***	0.0279***	0.0710***
	(4.9301)	(-14.89)	(62790)	(-1.6693)	(1.7847)	(15.1616)	(3.0461)	(3.3564)
GDP per capita	0.0796***	0.0408**	0.0495*	0.0170***	0.2351***	0.1851***	0.1505***	0.1121**
	(2.8810)	(2.1429)	(1.6711)	(2.6515)	(7.0964)	(5.6523)	(3.8165)	(2.4953)
CD test	0.45	1.83*	-1.23	1.35	1.68*	1.49	1.24	0.88
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Panel B. health capital								
resource dependence	-0.5965***	-0.3184**	-0.4847***	-0.4614***	0.4589***	0.3024*	0.4403***	0.4298**
	(-3.1748)	(-2.3852)	(-2.8052)	(-2.9136)	(-4.0415)	(1.6770)	(3.3293)	(2.1023)
education	5.4574***	5.4405***	3.2993***	2.8838***	5.6269***	10.4046***	4.9459***	4.1913***
	(5.7490)	(-7.4824)	(4.5682)	(5.8666)	(5.6165)	(24.3522)	(3.5664)	(3.3741)
GDP per capita	3.0653***	1.1234***	2.8724***	1.3669***	3.08***	5.0309***	2.1555***	4.6036***
	(4.2834)	(11.03)	(-7.1108)	(-4.2820)	(4.154)	(23.2881)	(5.5503)	(22.2583)
CD test	-1.62	1.63	0.67	1.20	-0.51	-1.90*	0.89	1.44
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Note: The number of leads and lags in the individual DOLS regressions was determined by the Schwarz criterion with a maximum of three lags. The values in the parentheses are the t-values of corresponding coefficient estimates. ***, ** and * denote significant at 1 %, 5%, and 10% level, respectively.

Table 7. Subsamples

	(1)		(2)		(3)		(4)		(5)	
	OECD		property right protection		democracy		corruption		ethnic fractionalization	
	yes	no	high	low	high	low	low	high	low	high
					education capital					
resource dependence	0.1267***	0.0074	0.1095***	-0.0145	0.1117***	-0.0217	0.1346***	-0.0472***	0.0711***	0.0298
	(3.6735)	(0.6575)	(4.5399)	(-1.0543)	(4.7822)	(-1.5297)	(5.6575)	(-3.5620)	(3.6884)	(1.4878)
obs.	700 (19)	1311 (36)	1028 (28)	983 (27)	1064 (29)	947 (26)	1066 (29)	945 (26)	903 (25)	1108 (30)
					health capital					
resource dependence	0.3635	-0.8835***	0.0514	-0.9756***	0.1346	-1.1078***	0.1801	-1.1585***	0.7746**	-1.9255**
	(0.6319)	(-0.6859)	(0.1255)	(-2.3296)	(0.3396)	(-2.5506)	(0.4687)	(-2.5877)	(2.0832)	(-4.1395)
obs.	705 (19)	1313 (36)	1035 (28)	983 (27)	1074 (29)	944 (26)	1071 (29)	947 (26)	1104 (30)	914 (25)

Note: The number of leads and lags in the individual DOLS regressions was determined by the Schwarz criterion with a maximum of three lags. In columns (2)-(5) countries are divided into two different subsamples based on the sample median. *** indicates significance at the 1% level.

Appendix: Additional Robustness Checks

Table A1. Components of non-agricultural primary exports

	education capital				health capital			
	DOLS (demeaned data)		CCEMG		DOLS (demeaned data)		CCEMG	
	fuel exports (%GDP)	mineral exports (%GDP)	fuel exports (%GDP)	mineral exports (%GDP)	fuel exports (%GDP)	mineral exports (%GDP)	fuel exports (%GDP)	mineral exports (%GDP)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
resource dependence	0.0208***	0.0174*	0.0068*	0.0209**	1.5904***	-0.4683***	1.2010***	-0.9179***
	(0.0050)	(0.0101)	(0.0035)	(0.0105)	(0.5181)	(0.1084)	(0.5079)	(0.1005)
life expectancy	0.0249**	0.0170***	0.0231***	0.0114***				
	(0.0109)	(0.0050)	(0.0085)	(0.0042)				
education					4.8060***	2.3356***	4.6733***	4.4242***
					(0.8616)	(0.8240)	(0.9399)	(0.9637)
GDP per capita	0.3247***	0.1348***	0.3041***	0.1120**	0.7237	1.7040***	0.8435*	0.9144**
	(0.0492)	(0.0346)	(0.0338)	(0.0438)	(0.5286)	(0.3979)	(0.5104)	(0.3747)
CD test	0.18	0.32	0.54	1.51	0.46	1.26	0.78	-1.23
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)

Note: The number of leads and lags in the individual DOLS regressions was determined by the Schwarz criterion with a maximum of three lags. Standards errors are in the parentheses. ***, ** and * denote significant at 1 %, 5%, and 10% level, respectively.

Table A2: DOLS estimates on carbon emissions

dependent variable	carbon emissions (metric tons per capita)					
	primary exports (%GDP)	fuel exports (%GDP)	mineral exports (%GDP)	agricultural exports (%GDP)	non-agricultural exports (%GDP)	resource rents per capita
resource dependence	0.4489**	-0.6374***	0.3097**	0.8610***	-0.1404**	0.7780**
	(0.1847)	(0.0485)	(0.1308)	(0.3710)	(0.0657)	(0.3586)
log GDP per capita	9.3006***	-56.6439***	-42.6544***	6.3851***	46.6302***	7.1411***
	(2.7326)	(14.6808)	(7.0579)	(3.3922)	(7.9543)	(1.9184)
log GDP per capita ^{2}	0.3442**	3.2547***	2.5193***	-2.9029***	-2.9458***	-3.3328***
	(0.1408)	(0.7423)	(0.3757)	(0.1818)	(0.4494)	(1.0022)
log inflow FDI	-0.0740***	-0.0774	-0.1611***	-0.0774***	-0.0098	-0.1764***
	(0.0235)	(0.0481)	(0.0336)	(0.0428)	(0.0064)	(0.0543)
education	-2.1697**	-1.9361**	-3.2222***	-4.7870***	0.6525	4.4893
	(0.8820)	(0.8349)	(0.2520)	(1.4373)	(0.3054)	(4.1796)
CD test	1.25	0.69	-1.35	0.29	-1.73	0.54
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Obs.	1925(55)	1941(55)	1959(55)	1962(55)	1927(55)	1981(55)

Notes: All data are sourced from WDI (2016). The number of leads and lags in the individual DOLS regressions was determined by the Schwarz criterion with a maximum of three lags. Standards errors are in the parentheses. ***, ** and * denote significant at 1 %, 5%, and 10% level, respectively.

Table A3: DOLS estimates on nitrous emissions

dependent variable	log nitrous oxide emissions (thousand metric tons of CO2 equivalent)					
	primary exports (%GDP)	fuel exports (%GDP)	mineral exports (%GDP)	agricultural exports (%GDP)	non-agricultural exports (%GDP)	resource rents per capita
resource dependence	0.1458***	-0.1608**	0.0746**	1.9384***	-0.0843**	0.1071***
	(0.0527)	(0.0294)	(0.0436)	(0.0482)	(0.0349)	(0.0261)
log GDP per capita	0.0031	4.4335***	3.0368	5.0694***	7.2051	3.8298**
	(1.7919)	(1.5021)	(1.9248)	(0.8412)	(5.1203)	(1.5228)
log GDP per capita ^{2}	-0.0179	0.3730***	-0.1966*	-3.3222***	-0.3850	-0.2146***
	(0.1168)	(0.0885)	(0.1028)	(0.0397)	(0.3047)	(0.0784)
log inflow FDI	-0.0106*	-0.0897	-0.0145**	-0.0482***	-0.0136**	-0.1764***
	(0.0062)	(0.1157)	(0.0072)	(0.0103)	(0.0069)	(0.0543)
education	-6.0383***	-1.6470**	-6.0538***	-1.7982***	-3.0763***	4.4893
	(0.8897)	(0.7007)	(1.0047)	(0.5220)	(0.5602)	(4.1796)
CD test	0.46	0.72	-1.33	0.59	-1.06	0.91
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)	I(0)
Obs.	1948(55)	1945(55)	1927(55)	1927(55)	1957(55)	1946(55)

Notes: All data are sourced from WDI (2016). The number of leads and lags in the individual DOLS regressions was determined by the Schwarz criterion with a maximum of three lags. Standards errors are in the parentheses. ***, ** and * denote significant at 1 %, 5%, and 10% level, respectively.

Table A4. DOLS estimates controlling for carbon emissions

dependent variable	health capital				
	primary exports (%GDP)	agricultural exports (%GDP)	non-agricultural exports (%GDP)	fuel exports (%GDP)	mineral exports (%GDP)
	(1)	(2)	(3)	(4)	(5)
resource dependence	0.8126***	0.1969***	0.1939***	0.2713***	-0.0057
	(0.1027)	(0.0672)	(0.0534)	(0.0446)	(0.0346)
education	-1.1127**	-1.3912***	0.2327	-0.0422***	-0.9943***
	(0.3200)	(0.3150)	(0.3488)	(0.4077)	(0.3084)
GDP per capita	4.4558***	3.9055***	4.0989***	4.1200***	0.3695***
	(0.1420)	(0.1351)	(0.2710)	(0.3048)	(0.0338)
carbon emissions	-0.3444***	-0.1838***	-0.5400***	-0.5120***	-0.2207***
	(0.0302)	(0.0240)	(0.0431)	(0.0455)	(0.0219)
CD test	-1.36	0.23	0.93	0.52	-1.15
CIPS	I(0)	I(0)	I(0)	I(0)	I(0)
Pedroni (2004)	I(0)	I(0)	I(0)	I(0)	I(0)

Note: All data are sourced from WDI (2016). The number of leads and lags in the individual DOLS regressions was determined by the Schwarz criterion with a maximum of three lags. Standards errors are in the parentheses. ***, ** and * denote significant at 1 %, 5%, and 10% level, respectively.