8-2012

# The Geographical Dimension of the Development Effects of Natural Resources

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*Environmental and Resource Economics*, Vol. 52, No. 4 (August 2012): 479-498. DOI. 

# The Geographical Dimension of the Development Effects of Natural Resources

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## Abstract
We study the contribution of natural resource intensity to long-term development along different dimensions: per-capita income, institutional quality, and education. We allow natural resources to affect these dimensions differently in different regions of the world. The evidence suggests that natural resources are generally a positive driver of development, but in Sub-Saharan Africa (SSA) their contribution is almost negligible, if not even negative. We explain these cross-regional differences with the fact that in SSA more than anywhere else large resource endowments are combined with a particularly bad disease environment. Some historical evidence and formal econometric results support this hypothesis.

## Keywords
Natural resources, Development, Institutions, Schooling

# 1 Introduction

Despite the recent growth resurgence, Sub-Saharan Africa (SSA) remains the poorest region in the world. At the same time, it is a region that heavily relies on natural resources.[1]

In this paper we investigate the extent to which the second fact helps explain the first one. The distinctive feature of our study is that we take a geographical perspective and allow the effect of natural resources to differ across regions of the world. Our findings suggest that (i) the effect of natural resource intensity on per-capita income is positive and significant in general, but almost negligible and possibly negative in SSA, (ii) natural resources have a negative effect on institutional quality in SSA only, (iii) natural resources hinder human capital accumulation in SSA much more than anywhere else, and (iv) the combination of bad disease environments and large resource endowments accounts for most of the observed cross-regional differences in the effect of natural resources.

Understanding the causes of slow economic progress in SSA is a challenge that has spurred a lively debate in the academic literature. While the potentially adverse role of resource intensity has received some attention (Deaton and Miller 1996; Sachs and Warner 1997; Temple 1998; Sala-i-Martin and Subramanian 2003; Beny and Cook 2010), recent contributions tend to focus on other explanations. For instance, Collier and Gunning (1999a,b) emphasize bad policies, poor public services delivery, cumbersome bureaucracy, and generally dysfunctional governments arising from a lack of social capital. Bertocchi and Canova (2002) nd that colonial indicators (such as the identity of the colonial ruler) correlate with economic and socio-political variables that explain a significant part of the heterogeneity of growth performances in Africa. Nunn (2008) documents a significant causal relationship between Africas slave trades and current economic performance. Bhattacharyya (2009) reports that malaria prevalence is the most powerful explanatory of long-run development in Africa and that after controlling for malaria, other factors do not seem to play a statistically significant effect. Bleaney and Dimico (2010) confirm the critical role of malaria risk, but also nd that other geographical factors (such as coastline length) are important.

Beyond the analysis of the African case, the macroeconomic effects of resource abundance have been widely investigated. Most of this research revolves around the test of the resource curse hypothesis as initially put forward by Gelb (1988) and Auty (1993). The conventional wisdom holds that natural resources are bad for economic growth because they reduce the quality of institutions (see, inter alia, Leite and Weidmann 1999; Ross 2001; Isham et al. 2005; Boschini et al. 2007), increase the risk of civil war (Collier and Hoefer 2005), crowd-out other forms of capital (Gylfason 2001; Papyrakis and Gerlagh 2004) and/or other sectors of the economy (Sachs and Warner 2001), expose the economy to a secular decline in the terms of trade (Harvey et al. 2010), and retard its integration into the world economy (Papyrakis and Gerlagh 2004). This conventional wisdom has, however, been challenged on several grounds. Hodler (2006), Mehlum et al. (2006), and Snyder (2006) provide evidence that natural resources are not necessarily bad per-se, but that their effect depends on some underlying conditioning factors, such as the quality of institutions or the degree of ethnic fragmentation of a country. Stijns (2005) nds that the negative effect of resources on growth is not robust to changes in the specification of the regression model. Brunnschweiler (2008) and Brunnschweiler and Bulte (2008) also show that econometric results significantly change depending on the specific measure of resource intensity adopted.

Alexeev and Conrad (2009) point out that a growth regression where the dependent variable is measured over the last few decades (i.e. three or four) might be misleading: if resources historically promote growth, but for some reason this positive effect has weakened (or reverted) in the last few decades, then the regression will

return a negative correlation which is not representative of the true effect of resources. They therefore estimate a regression where the dependent variable is the level of per-capita GDP rather than its growth rate. They measure natural wealth by country's oil endowments and nd that the effect is generally positive.[2] Conversely, Arezki and van der Ploeg (2011) report that resource endowments tend to depress income per-capita. They consider two different measures of natural resources: the primary products exports to GNI ratio and the stock of natural assets. Both measures display a negative coefficient in the income regression, but this effect appears to be attenuated in countries with better institutions and/or greater openness to international trade.

Within the context of this literature, our paper studies whether there are any differences across geographical regions in the effect of natural resources on per-capita income levels, institutional quality, and schooling. We are not aware of any previous paper that takes a similar geographical perspective in studying the development effects of resource abundance. Our results, therefore, contribute to the understanding of both the long-term macroeconomic effects of natural resources and the causes of SSA underdevelopment. More specifically, we provide evidence that, on balance, natural resources seem to boost long-term development. However, SSA does not benefit from this positive effect: the contribution of natural resources to development in SSA is much less strong than elsewhere, and possibly even negative.

Why is then SSA different? We argue that the answer to this question lies in the combination of resource endowments and disease environment. Neither large endowments of resources nor exposure to fatal illnesses are exclusive to SSA. However, in no other continent such large resource endowments are combined with such an unfavourable disease environment. Our hypothesis is that because of this unique combination, SSA more than any other region of the world suffered from a particularly unfavourable type of colonization. For one thing, European colonizers tried to exploit the large resource wealth of the continent through intensively extractive institutions and policies. For another, the high prevalence of mortal diseases reduced the presence of European settlers who elsewhere played an important role in limiting the extent of extraction and contributed to re-creating institutional, economic, and social arrangements similar to those in the metropolis. The consequence was that the evolution path of important drivers of development, such as institutions and human capital, significantly differed between SSA and other colonies. These differences have persisted over time and contribute to explaining SSA backwardness today.[3] We support our argument with some historical evidence as well as more formal econometric analysis. In particular, the econometric analysis indicates that (i) natural resources in SSA do not affect per-capita income beyond their effect on institutional quality and schooling and (ii) differences across regions in the effect of natural resources disappear when the interaction between resource endowments and disease environment is taken into account.

The rest of the paper is organised as follows. We review our econometric methodology in Sect. 2. Then we discuss the results in Sect. 3. In Sect. 4 we present the historical and empirical evidence in support of our explanation of why SSA is different. Section 5 concludes the paper. Variables definition, data sources, and a list of countries included in the sample are provided in Appendix 1. Appendix 2 (separately available on-line) provides a set of robustness checks as well as first stage estimates and diagnostics.

# 2 Econometric Set-up

## 2.1 Income Equation

First, we estimate the effect of resource intensity on the level of per-capita GDP using the following regression model:

$$y_{2005,i} = \alpha r_i + \sum_{j=1}^{N} \beta_j r_i d_{(i)j} + \sum_{j=1}^{N} \gamma_j d_{(i)j} + \delta \mathbf{X}_i + \varepsilon_i$$

(1)

where $y$ is the log of real per-capita GDP in 2005 in country $i$, $r$ is a measure of natural resource abundance, $d$ is a regional dummy that takes value 1 if country $i$ is located in the geographical region $j$ and zero otherwise, $N$ is the total number of geographical regions, $\mathbf{X}$ is a set of control variables (eventually including a constant term), $\varepsilon$ is a residual, and α, β, γ, and $\boldsymbol{\delta}$ are the coefficients to be estimated.

Equation (1) differs from other models previously used to study the impact of natural resources on per-capita GDP (see for instance Alexeev and Conrad 2009; Arezki and van der Ploeg 2011) because it accounts for the interaction between natural resources and geographical location through the term $r_i d_{(i)j}$. This allows for the slope of the relationship between natural resources and income to differ across regions. The marginal effect of natural resources on income is then given by the combination of (i) a *baseline effect*, captured by the coefficient $\alpha$, and (ii) a *region-specific effect* (or, for brevity, *regional effect*) captured by the coefficient $\beta_j$. For a country that is not located in any of the $N$ regions, the marginal effect is simply equal to $\alpha$. For a country located in the generic region $j$, the marginal effect is instead equal to $\alpha + \beta_j$. It is worth noting that by including the regional dummies separately from the interaction terms, equation (1) also accounts for differences in the level of income across regions.

Resource abundance is measured by the log of per-capita natural wealth. Data are taken from World Bank (1997) and include five categories of resources: pastureland, cropland, timber and other forest resources, subsoil assets, and protected areas (i.e. areas that are set aside to protect biodiversity).[4] An alternative measure that has been widely used in the literature is the ratio of primary commodity exports to GDP. We prefer the World Bank natural wealth data because the primary commodity exports ratio is likely to be endogenous to the dependent variable. Conversely, the estimates of natural wealth provided by the World Bank are based on valuations of the net present value of benefits over a time horizon of 2025 years and in this respect appear to be less prone to the endogeneity issue (see also the discussion and evidence reported by Brunnschweiler and Bulte 2008). Moreover, the primary commodity exports ratio is more a measure of resource *dependence*, while instead we are interested in capturing the effect of resource *abundance*.[5] In Appendix 2supplementary material, we show that results do not qualitatively change when we estimate Eq. (1) in a panel set-up and measure resource intensity by the log of primary commodity exports per-capita.

The World Bank data are available for 92 countries. These countries (see list in the Appendix 1) are mostly located in one of the following regions: SSA, Asia, Latin America, Western Europe, and North America. Accordingly, we dene three regional dummies: $d_{1(SSA)}$ equals 1 if country $i$ is located in the SSA region and 0 otherwise, $d_{2(ASI\ A)}$ equals 1 if country *i* is located in Asia and 0 otherwise, and $d_{3(L\ AT\ AM)}$ equals 1 if a country $i$ is located in Latin America. The baseline group then consists of mostly developed countries in Europe, North America, and Oceania. Ideally, one might want to split the Asian group into East Asia and South Asia. However, the natural wealth data are available for only a handful of South Asian countries. Hence, the dummy for South Asia would have too many zeros and too few ones. All in all, we contend that a comparison among Africa, Asia, and Latin American (with developed countries as the baseline) is the most relevant one in a development perspective.

The selection of control variables to be included in $\mathbf{X}$ follows previous empirical studies on the long-term determinants of development.[6] We start with a parsimonious specification that only controls for geographical

factors and the quality of the disease environment. We then enrich it to account for the impact of institutions and schooling (in Appendix 2 supplementary material we extend it further to include some policy variables). A critical choice in this regard is whether or not to include the value of per-capita GDP at the beginning of the sample period as a regressor. If it were included, then Eq. (1) would become a standard growth regression of the type generally estimated in the resource curse literature. However, as previously noted, Alexeev and Conrad (2009) argue that the estimated coefficient of the natural resource variable in a growth regression might not capture the true impact of initial resource endowments on overall growth. More generally, since the seminal contribution of Hall and Jones (1999), most papers focus on per-capita GDP levels (hence excluding initial GDP from the set of regressors) because levels more than growth rates capture the differences in long-run economic performance that are most directly relevant to welfare. We take a pragmatic approach to this issue: our core results concern the effect of resources on long-term income levels, but we also estimate a model with initial income as a regressor for the purpose of comparison and sensitivity check.

Estimation is performed using cross-sectional data for the period 1970-2005. The parsimonious specifications are estimated by GLS, as the r.h.s. variables can be safely regarded as exogenous to the dependent variable. When additional controls, like institutional quality and schooling, are added, then 2SLS instrumental variables (IV) are employed to account for possible endogeneity. In Appendix 2 supplementary material, Eq. (1) is re-estimated using panel data and the sys-GMM estimator of Arellano and Bover (1995) and Blundell and Bond (1998). Our main conclusions about the role of natural resources do not change when we change specification and estimators.

## 2.2 Institutions and Educational Outcomes

Our analysis of the effects of natural resources is not limited to income levels, but extends to institutional quality and education. This extension is motivated on two grounds. First, development is a multidimensional concept that should not be restricted to economic and monetary aspects. In this regard, achieving good institutions and improving educational outcomes are desirable development objectives per-se. Second, to the extent that institutional quality and education are important determinants of income, studying how they are affected by natural resources will shed some light on the transmission channels that link resources to per-capita income.[7]

The econometric framework in this case is a straightforward extension of model (1):

$$q_i = \theta r_i + \sum_{j=1}^{N} \vartheta_j r_i d_{(i)j} + \sum_{j=1}^{N} \pi_j d_{(i)j} + \lambda \mathbf{Z}_i + \mu_i$$

(2)

$$h_i = \varphi r_i + \sum_{j=1}^{N} \omega_j r_i d_{(i)j} + \sum_{j=1}^{N} \eta_j d_{(i)j} + \xi \mathbf{W}_i + \upsilon_i$$

(3)

where $q$ is a measure of institutional quality, $h$ is an indicator of education (schooling), $\mathbf{Z}$ and $\mathbf{W}$ are set of controls, $\mu$ and $\upsilon$ are error terms, $r$ and $d$ are the same as in Eq. (1), and the $\theta$, $\vartheta$, $\pi$, $\varphi$, $\omega$, $\eta$, $\boldsymbol{\xi}$, $\boldsymbol{\lambda}$ are the coefficients to be estimated. Similarly to Eq. (1), the interaction terms $r_i d_{(i)j}$ in Eqs. (2) and (3) allow for natural resources to affect institutional quality and schooling differently in different regions of the world.

Institutional quality is measured by an index of protection against expropriation risk and h is measured by the average years of schooling in population ages above 15 years. There are indeed many possible indicators of institutional quality. We focus on protection against expropriation risk because this is the type of institutional arrangement that natural resources are most likely to affect.[8] Schooling can also be measured in different ways and enrolment (or completion) rates are often used in the literature. However, we are reluctant to use enrolment rates because we would have to choose the level of schooling (i.e. primary, secondary, or tertiary) and this choice is not without consequences. Primary and secondary enrolment rates probably underestimate the difference in education between developed and developing countries, while tertiary enrolment rates overestimate it. We therefore settle for an indicator of the number of years of formal education of the average individual in the population.

The variables $q$ and $h$ will eventually enter Eq. (1) as regressors and will be measured by their average value over the period 1985-1995. This will make them pre-determined relative to the dependent variable and reduce the risk of reverse causality. We then use the same average values over the period 1985-1995 to measure $h$ and $q$ as dependent variables in Eqs. (2) and (3). The alternative would be to use the 2000 or 2005 values to measure the dependent variables in Eq. (2) and (3), while using averages over 1985-1995 to measure the regressors in Eq. (1). We think that using the same 1985-1995 averages in all the three equations is a better solution. One of the strength of our econometric set-up is that Eqs. (1)(3) constitute a system where institutional quality and schooling work as the transmission channels of the effect of natural resources on income. If the measures of $q$ and $h$ were taken at different times in different equations, then this interpretation would be lost (if not entirely, at least to some extent). Moreover, as institutional quality and schooling are relatively persistent over time, results would not be much different if we used the 2000 or 2005 values in Eqs. (2) and (3).

In both equations we control for the degree of ethnic fragmentation, the quality of the disease environment, and the initial level of per-capita GDP. Various political economy arguments suggest that ethnic fractionalization should adversely affect both institutional quality and schooling. This is because more fragmented societies tend to be more prone to rent-seeking and less likely to agree on the supply of public goods (see for instance, Easterly and Levine 1997; Alesina et al. 1999, 2000, 2003). The quality of the disease environment is also expected to matter for both institutional and educational outcomes. In fact, a worse disease environment reduced colonizers incentive to settle down, thus resulting in more extractive institutions (Acemoglu et al. 2001) and/or a weaker endowment of human capital (Glaeser et al. 2004). Finally, richer countries can usually afford better institutions as well as a greater investment in public education, which implies that a higher initial per-capita income should be associated with better institutions and educational outcomes.

In addition, each equation includes two controls that do not appear in the other equation. The regressors specific to Eq. (2) are country's legal origin and distance from the Equator. La Porta et al. (1999) compare different legal traditions and conclude that the civil legal tradition, which aimed at strengthening the power of the State against the individuals, produced worse institutions than the common law tradition, which instead was developed as a tool of protection of the rights of Parliament and citizens against the interference of the Crown. Distance from the Equator accounts for the possibility that faster agricultural productivity growth in temperate zones might have facilitated both economic transformation and institutional development. The regressors specific to Eq. (3) are the identity of the colonizer and the proportion of country's population residing nearby the coast. Among other things, colonizers differed in terms of their philosophies of education. Grier (1999) and Brown (2000) show that those different philosophies, especially between France and Britain, contribute to explaining todays differences in educational outcomes across developing countries. Accordingly, we single out British colonization using a dummy variable.[9] Coastal population captures the inuence that international trade and other forms of economic/cultural exchange might have had on individuals incentive to accumulate human capital.

## 3 Results

We present our core results in two steps. First we document the existence of cross-regional differences in the effect of natural resources on income levels, institutions, and education. Second, we look at the interactions between institutional quality, schooling, and per-capita income.

### 3.1 The Effect of Natural Resources on Income, Institutions, and Education

Columns I, II, and III in Table 1 report the estimates of Eq. (1). The specification in column I is very parsimonious and only includes the log of natural capital, the regional dummies[10],

Table 1 Regional effects of natural resources on per-capita income, institutional quality, and schooling

| | I GLS | II GLS | III GLS | IV GLS | V GLS | VI GLS |
|---|---|---|---|---|---|---|
| | Log percapita income | Log percapita income | Log percapita income | Inst. quality | Schooling | Log percapita income |
| Log natural capital | 0.429*** (0.160) | 0.274*** (0.092) | 0.018 (0.050) | 0.056 (0.153) | 1.209*** (0.314) | 0.244* (0.129) |
| SSAfrica∗log natural capital | −0.410** (0.204) | −0.241* (0.117) | −0.075 (0.082) | −0.543* (0.311) | −1.275*** (0.355) | 0.386 ( 0.263) |
| Asia∗log natural capital | −0.168 (0.172) | 0.044 (0.147) | 0.259*** (0.086) | 0.546*** (0.189) | −0.962** (0.400) | −0.129 (0.291) |
| Latin A.∗log natural capital | 0.129 (0.211) | 0.327 (0.187) | 0.276** (0.106) | 0.653*** (0.194) | −0.342 (0.518) | 0.064 (0.291) |
| Malaria ecology | – | −0.024** (0.011) | −0.007 (0.009) | 0.006 (0.027) | −0.052 (0.035) | −0.052** (0.021) |
| Coastal population | – | 0.638** (0.263) | 0.286** (0.126) | – | 0.809 (0.609) | 0.565** (0.237) |
| Latitude | – | 2.976*** (0.327) | 1.428*** (0.431) | 2.353** (0.939) | – | 1.411 (1.433) |
| Log per capita income 1970 | – | – | 0.777*** (0.080) | 0.686*** (0.154) | 1.180** (0.516) | – |
| Legal origin France | – | – | – | −0.592** (0.270) | – | – |
| Ethnic fractionalization | – | – | – | −0.043 (0.564) | 0.452 (1.179) | – |
| UK colony dummy | – | – | – | – | 0.718* (0.404) | – |
| Schooling | – | – | – | – | – | −0.105 (0.154) |
| Inst. quality | – | – | – | – | – | 0.344 (0.388) |
| Number of observations | 91 | 89 | 89 | 78 | 83 | 75 |
| R2 | 0.66 | .078 | 0.90 | 1.81 | 0.75 | 0.71 |

All equations include a constant term and regional dummies for Sub Saharan Africa, Asia, and Latin America. Estimated coefficients of these variables are not reported, but they are available upon request. Heteroskedasticity consistent standard errors are reported in brackets. The under identification and weak identification diagnostics for the equation shown in column VI are as follows: KleibergenPaap LM statistics for under identification: 13.012*** (null hypothesis is that the model is under identified); KleibergenPaap Wald F statistic for weak identification: 7.12 (higher values indicate that the model is not weakly identified; the Stock and Yogo (2005) 10% critical value is 7.03

*, **, *** Statistical significance at the 10, 5, and 1% confidence level respectively

and the interaction terms. In column II, we introduce three variables to control for geography and disease environment. Latitude and coastal population (defined as the share of country's population living within 100 km from the coastline) proxy for location. Malaria ecology is an index that combines temperature, mosquito abundance, and mosquito vectors into an ecologically-based measure of malaria risk (see Sachs 2003). These three variables are all exogenous and time invariant. In column III we extend the specification by including the log level of per-capita income in 1970 as a regressor. As already noted, the specification in column III is in fact a regression of the rate of growth between 1970 and 2005 on the initial level of per-capita GDP and the time invariant variables (natural resources, geography, and interaction terms). Estimates are by GLS with heteroskedasticity consistent standard errors.

The estimated coefficients in columns I and II imply that for the average country in the baseline group, the elasticity of per-capita GDP with respect to resource abundance is positive and statistically significant, even though the two specifications yield different point estimates. According to the model in column I, a 10% increase in natural resources per-capita increases per-capita GDP by approximately 4.3%. The model in column II instead suggests that a 10% increase in resource abundance results in a 2.7% increase in per-capita GDP in 2005. The coefficients of the interaction terms for Asia and Latin America are not significant. Therefore, the effect of natural resources on income in the average country in these two regions is not different from the baseline. On the contrary, in SSA the regional effect of resources is significant and negative. Given the positive baseline effect, the net effect of natural resources on per-capita income in the average SSA country turns out to be very close to zero: a 10% increase in resource abundance would increase per-capita GDP by something between 0.2 and 0.3% (depending on whether we use the estimates in column I or those in column II). Statistically, the linear restriction that the algebraic sum of the baseline effect and the SSA regional effect is equal to zero is not rejected in a standard Wald test. Thus, the elasticity of per-capita GDP with respect to resource abundance in SSA is negligible both economically and statistically. In other words, natural resources increase per-capita GDP in the baseline group, in Asia, and in Latin America, but not in SSA.

From a development economics perspective, the implications of this nding can be understood with a simple example. Consider Nicaragua and Ivory Coast. These two countries have similar levels of natural resources (USD 3690 Nicaragua and USD 3790 Ivory Coast) and per-capita GDP in 2005 (USD 2112 Nicaragua and USD 2315 Ivory Coast). Doubling their resource endowments (so that they would achieve approximately the same level of resource abundance of a country like Indonesia) would then generate sharply different income effects. Using the point estimates of columns I and II to generate upper and lower bounds, the GDP per-capita of Nicaragua would increase to somewhere between USD 2682 and USD 3151. This is the same income range of countries like Vietnam, Micronesia, and Tajikistan. Per-capita GDP in Ivory Coast would instead remain within a range of USD 2358 to USD 2391. So, even if the natural resource endowment doubled, the average individual in Ivory Coast would be no more than 75 dollars richer.

The inclusion of initial per-capita GDP in column III produces some interesting results. The baseline effect of natural resources is still positive, but no longer significant. Of the three region-specific effects, those for Latin America and Asia are positive and different from zero while the one for SSA is not significant. Therefore, SSA again appears to behave differently, if not from the baseline, at least from the other two developing regions. In this respect, the overall story from columns I and II is confirmed here: natural resources increase per-capita income in the average Latin American or Asian country, but not in the average SSA country. In fact, the net effect of resources on per-capita GDP in SSA is negative, albeit not significant. The estimated elasticities for the other two regions are of a comparable size to those reported in column II: an increase of 10% in natural resource abundance produces an increase in per-capita GDP of 2.5% in Asia and 2.7% in Latin America. It is also interesting to note that the estimated coefficient of initial per-capita GDP provides support to the conditional convergence hypothesis: countries grow faster the lower their per-capita GDP in 1970.[11]

The estimated coefficients of the other control variables in columns II and III are of the expected sign and confirm previous empirical findings. Countries that are located further away from the Equator and that enjoy better access to the sea tend to have higher incomes. Conversely, warmer temperatures combined with adequate conditions for mosquito breeding and a more abundant presence of the anopheles genus (all factors that are captured by the malaria ecology index) reduce per-capita income. However, the role of malaria ecology becomes statistically irrelevant in the specification that controls for initial per-capita GDP.[12]

GLS estimates of Eqs. (2) and (3) are reported in columns IV and V of Table 1. If anything, the differences between SSA and other developing regions are now even more striking. Starting with column IV, the estimated coefficients indicate that the effect of resource abundance on institutional development is positive in Asia and Latin America, but negative in SSA. The elasticities implied by the point estimates are however not very large: doubling the endowment of natural resources in the average Asian or Latin American country would increase the institutional quality index by approximately 0.6 units (the effect is a bit stronger in Latin American and a bit weaker in Asia). This corresponds to the difference in institutional quality between China and the Republic of Korea. In SSA, the effect is of comparable strength, but with a reversed sign: if natural resources in South Africa were doubled, then institutional quality in that country would decline to the level of Ghana. Turning to column V, there is evidence of a positive baseline effect of natural resources on schooling: a 10% increase in natural resources is associated with an additional 0.12 year of schooling in the population. The region-specific effect is instead negative in both SSA and Asia. In fact, in SSA the negative regional effect is sufficiently strong to offset the positive baseline effect. The net effect is therefore negative, but very small and the elasticity of schooling with respect to natural resources evaluated at the mean of schooling (6.4 years) is just 0.04%. The overall picture does not change when the two equations are estimated using 2SLS to account for the potential endogeneity of initial per-capita GDP. The results are reported in Appendix 2supplementary material and indicate that SSA is the only region where natural resources do not increase institutional quality and also the only region where natural resources decrease schooling.

The estimated coefficients of the other control variables confirm previous findings in the literature. In particular, there is a clear negative effect of French civil legal origins on institutional quality while British colonization tends to be associated with a higher level of schooling. Perhaps, the only really surprising nding is the lack of statistical significance of the coefficient of ethnic fractionalization in both equations. A possible explanation is that the ethnic variable is collinear with some other regressor(s) in the two equations. A simple covariance analysis indicates that the bilateral correlation coefficient between ethnic fragmentation and malaria ecology is effectively very large (0.74) and highly significant. When dropping malaria ecology, ethnic fragmentation becomes significant in Eq. (2) at the 10% confidence level. At the same time, when the two equations are re-estimated without the index of ethnic fragmentation, then malaria ecology becomes significant at the 5% confidence level in Eq. (3).

In the last column of Table 1 we use institutional quality and schooling as regressors in an extended specification of Eq. (1). Even if they are measured as averages over the period 19851995, and hence pre-determined relative to per-capita GDP in 2005, institutions and schooling might still be endogenous. Therefore, they need to be instrumented. As instruments, we choose the dummy variables for French legal origin and British colonization. French legal origin is a significant determinant of institutional quality and it is most likely exogenous to per-capita GDP in 2005. Similarly, British colonization is a significant determinant of schooling and again exogenous to per-capita GDP. Two tests of the validity of instruments are reported in the notes to Table 1 and indicate that the model is neither under-identified nor weakly identified. Additional diagnostics and the first stage results are provided in Appendix 2supplementary material. The 2SLS estimates reported in column VI indicate that the baseline effect of natural resources remains positive and significant at the 10% confidence level. However, institutions, schooling and the interaction terms are insignificant. This might be a sign of multicollinearity, which

might indeed occur if institutional quality and schooling were the two channels of transmission of the effect of natural resources on per-capita GDP.

## 3.2 The Transmission of the Effects of Natural Resources

The estimates of Eq. (1) are coherent with those from Eqs. (2) and (3) in showing that SSA is the only region where the effect of natural resources on development is not positive, if not outright negative. Moreover, as just observed, there is evidence of multicollinearity in the extended specification that includes institutional quality and schooling in addition to natural resources and the interaction effects. All this suggests that the transmission of the effect of natural resources on income might occur through institutions and education.

To shed light on the transmission mechanisms, Eqs. (1)(3) are jointly estimated as a system in order to account for possible correlations of the error terms across equations.[13] The traditional method of system estimation is a 3SLS. However, this is inconsistent when errors are heterosckedastic. We therefore prefer a GMM estimator that allows for heteroskedasticity and encompasses the 3SLS as a special case (see Wooldridge 2010). In addition to the three dependent variables (which are endogenous by construction), we also treat initial per-capita GDP as endogenous, using coastal population and latitude as instruments.[14]

Results are reported in columns I (Eq. 1), II (Eq. 2), and III (Eq. 3) of Table 2 and they are generally consistent with those reported in Table 1. Three main findings on the role of natural resources emerge. First, there are significant region-specific effects of natural resources on institutional quality: in Asia and Latin America, resource abundance promotes institutional development, while in Africa the effect is negative. These region-specific effects are then transmitted to per-capita GDP via the positive impact that good institutions have on it. Second, there are significant baseline and region-specific effects of natural resources on schooling. In this regards, natural resources positively affect schooling in the baseline group and in Asia, but their net effect is negative in Latin America and SSA. Nevertheless, while this net effect is quite small in Latin America, in SSA it is larger and statistically significant (the linear restriction that baseline plus regional effect in SSA is equal to zero is rejected at the 5% confidence level). To what extent these regional effects on schooling are passed through to per-capita GDP is however unclear as the estimated coefficient of the schooling variable in Eq. (1) remains insignificant, possible because of collinearity with the interaction terms. Third, after controlling for the indirect effects via institutions and schooling, there is a positive baseline residual direct effect of resource abundance on income. The residual regional effects are instead largely insignificant. All in all, the system estimates confirm that on balance natural resources are likely to have positive rather than negative effects on long-term development. However, in the specific case of SSA, the opposite seems to be true.

Table 2 Interactions between institutions, schooling, and natural resources

| | System (GMM) | | | | | |
|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI |
| | Log p.c income | Inst. Quality | Schooling | Log p.c income | Inst. quality | Schooling |
| Log natural capital | 0.322* (0.183) | 0.007 (0.201) | 0.898*** (0.283) | 0.304*** (0.008) | −0.040 (0.201) | 0.929*** (0.271) |
| SSAfrica∗log natural capital | 0.452 (0.375) | −0.481* (0.264) | −1.416*** (0.347) | – | −0.397 (0.271) | −1.405*** (0.340) |
| Asia∗Log natural capital | −0.381 (0.312) | 0.679*** (0.117) | −0.434 (0.410) | – | 0.684*** (0.131) | −0.545 (0.385) |
| Latin A.∗log natural capital | −0.156 (0.297) | 0.770*** (0.230) | −1.062** (0.465) | – | 0.790*** (0.231) | −0.824* (0.452) |
| Malaria ecology | −0.053* (0.029) | 0.002 (0.035) | 0.008 (0.037) | −0.041** (0.021) | 0.003 (0.034) | −0.001 (0.037) |
| Coastal population | 0.623*** (0.231) | – | −0.526 (0.773) | 0.464** (0.194) | – | −0.418 (0.755) |
| Latitude | 0.358 (1.278) | 2.956* (1.621) | – | 1.631*** (0.634) | 2.699* (1.568) | – |
| Log per capita income 1970 | – | 0.505 (0.924) | 2.929*** (0.719) | – | 0.559 (0.898) | 2.741*** (0.691) |
| Legal origin France | – | −0.674*** (0.212) | – | – | −0.689*** (0.228) | – |
| Ethnic fractionaliz. | – | −0.264 (0.679) | −0.905 (1.046) | – | −0.200 (0.679) | −0.533 (1.044) |
| UK colony | – | – | 0.859*** (0.237) | – | – | 0.921*** (0.347) |
| Schooling | −0.224 (0.148) | – | – | 0.121* (0.07) | – | – |
| Inst. Quality | 0.646* (0.354) | – | – | 0.264** (0.134) | – | – |
| Number of observations | | 234 | | | 234 | |
| J-stat (*p* value) | | 3.698 (0.29) | | | 2.124 (0.18) | |

All equations include a constant term and regional dummies for Sub Saharan Africa, Asia, and Latin America. Estimated coefficients of these variables are not reported, but they are available upon request. Heteroskedasticity consistent standard errors are reported in brackets. The J-statistics reported at the bottom refer to the null hypothesis that the overidentifying restrictions in the system are valid (the p value is reported in brackets). The number of observations reported is the total for the entire system*, **, *** Statistical significance at the 10, 5, and 1% confidence level respectively

Given that the coefficients of the interaction terms are not significant in Eq. (1) when institutional quality and schooling are included as regressors, we re-estimate the system by explicitly imposing the restriction that $\beta_j = 0$ for every $j$. This should solve the problem of multicollinearity in Eq. (1) and hence facilitate the assessment of the transmission mechanism of the regional effects of natural resources on income. Results from this restricted model are presented in columns IV, V, and VI of Table 2. Both institutional quality and schooling are now positive and significant in the income equation. At the same time, the estimated coefficients of the interaction terms in Eqs. (2) and (3) are similar to those reported in columns II and III. Overall, these results confirm that the regional specific effects of natural resources are likely to be channelled to per-capita income through the quality of institutions and educational outcomes.

# 4 The Interaction Between Natural Resources and Disease Environment

According to our evidence, the effect of natural resource abundance in SSA is significantly less favourable than in other developing or emerging regions like Asia and Latin America. Why then is SSA different? We suggest that the answer to this question lies in how the interaction between resource endowments and disease environment affected the patterns of colonization and the evolution of societies.

## 4.1 A Working Hypothesis

Our argument draws on the theory of colonial origins of comparative development of Acemoglu et al. (2001). In particular, from this theory we take the view that European states pursued two broad types of colonization. One mainly aimed at extracting valuables from the colony. The other, while still driven by economic and mercantilist interests, also aspired to recreating the conditions of life that existed in the home country. The resulting differences in factors like institutional quality, schooling policy, and human capital have then led to diverging post-independence development paths across colonies, with colonies that fell under the more extractive type of colonization being particularly disadvantaged.

Which type of colonization prevailed in a colony certainly depended on several circumstances, but two in particular appear to have been important: the intensity of the resource endowments in the colony and the quality of its disease environment. Larger and more valuable endowments made extraction more attractive and profitable. A worse disease environment limited the presence of European settlers and hence released home governments from the pressure to provide conditions similar to those prevailing in the *metropolis*. Therefore, the extractive type of colonization was more likely to occur in countries with large endowments of resources *and* a bad disease environment. This combination of large endowments and bad environments can be found in SSA more than anywhere else, so that in the end SSA more than any other region experienced the adverse long-term development effects of extractive colonization. In other words, the combination of resource intensity and bad disease environment should explain why SSA is different from Asia and Latin America.

## 4.2 Some Historical Evidence

Our hypothesis is rooted in historical trends and facts that are well documented in the literature. Lang (1975), Gann and Duignan (1979), Jewsiewicky (1983), Lockhart and Schwartz (1983), Davis and Huttenback (1987), Cain and Hopkins (1993), and Young (1994) discuss how mercantilist and business interests in European countries oriented colonization towards the extraction and exploitation of natural (as well as human) resources in the colonies. Exploitation did not just take the form of extractive trade and commercial policies or institutions, but also of distorted education policies (Bush and Saltarelli 2000). The crucial role of settlers in limiting the extent of extraction and ensuring that institutions and policies similar to those of the home country were established in the colonies is documented by Crosby (1986), Denoon (1993), Acemoglu et al. (2001), Llyod et al. (2000), and Whitehead (2007). Curtin (1961); Robinson and Gallagher (1961), and Diamond (1997) provide evidence of the impact that the disease environment had on settlement patterns and hence on the type of colonization (i.e.

more or less extractive) to which different colonies were subjected. Finally, Wittfogel (1957), La Porta et al. (1999) and Engerman and Sokoloff (2000) argue that the different institutional, economic, and social arrangements arising from different types of colonization persisted after independence, and until the present days, because (i) most of the officials of the newly independent states had been trained and installed during the colonial period and (ii) the local elites that had emerged under the colonial regime opposed changes to policies and institutions that would reduce their profits and power (see also Blakemore and Cooksey 1980; Nitri 1993; Brown 2000 for a specific discussion of the persistence of education policies and goals).

As a practical example of these historical trends, we can compare the British colonization of British West Africa (BWA[15]) and Australia. The control and appropriation of valuable commodities was the main reason of British presence in West Africa (Crowder 1968). However, BWA was equipped with various tropical diseases (including malaria and yellow fever) to which Europeans had very little resistance. According to Curtin (1961), mortality within any group of European newcomers to the African coast was somewhere between 30 and 70% a year. After the first shock, mortality of the survivors could decrease to somewhat between 8 and 12%, which was still higher than mortality in tropical Asia and America. This clearly discouraged surviving settlers from staying and new settlers from coming.

Australia instead offered less harsh health conditions. Certainly, the tropical climate made the northern territories as threatening as Africa. But, the relatively low death rate in the penal colonies down south and reports of fertile soil and mild climate eventually led to several waves of free settlers in the 1820s. These settlers sought the opportunity to own land, engage in trade, and ultimately prosper. Hence, they demanded the same rights as the citizens in the home country (Hughes 1987). So, while in BWA the British government was unconstrained in carrying out its extractive strategy based on trade monopolies and distorted social policies[16],

in Australia institutions and policies were designed to reproduce those that progressively emerged from the changes (constitutional and political) taking place in Britain (Cain and Hopkins 1993). This does not mean that there was no extraction. In fact, as documented by Butlin (1993), extraction of natural resources, maritime resources before the 1840s and gold and other minerals subsequently, was important and the opportunities for large profits in mining did attract considerable amounts of British capital. However, the presence of settlers meant that economic and political rights were recognized and enforced, good schools were established, and large public investments in transport, communication, and urban infrastructures were realized. This ultimately gave Australia better long-term development prospects than BWA.

## 4.3 Some Econometric Evidence

In simple econometric terms, our hypothesis implies that once controlling for the interaction between natural resources and disease environment, the regional effects of natural resources on per-capita GDP, institutions, and schooling should be no longer significant. In what follows, we provide evidence that this is indeed the case.

To capture the interaction between natural resources and disease environment, we multiply our resource variable $(r)$ by the index of malaria ecology. This interaction term has a sample mean of 35.97; the mean is 95.26 in SSA, 14.93 in Asia, and 5.18 in Latin America. As suspected, large endowments of resources are not an exclusive of SSA, but it is only in SSA that such large endowments are combined with such a risky disease environment. We then use the interaction term as a regressor in each of our three equations. If our hypothesis is correct, then this interaction term should be significant and negative, while the region-specific effects of natural resources should become insignificant. We apply GLS throughout, but results do not change when we use 2SLS for Eqs. (2) and (3).

Results are shown in Table 3. They provide some considerable support to our hypothesis. The interaction term between resources and malaria ecology is significant and negative in all the three equations. At the same time,

the regional effects of resources become irrelevant, the only exception being a negative effect of resources on institutions in Latin America. Malaria ecology retains its negative and generally significant coefcient. The baseline effect of resources is still positive and significant, thus providing further evidence that in general natural resources are not harmful to long-term development prospects. The estimated coefficients on the other controls are again in line with the findings reported in the previous two tables.

We also estimated the three equations jointly as a system. The only noticeable difference is that the interaction between resources and disease environment becomes significant at the 1% confidence level in the income equation. The other results are similar to those obtained from the GLS estimator. All in all, while we suggest that more research is needed in the future, the evidence in Table 3 goes some distance towards supporting our explanation: SSA is different from the other regions because in SSA much more than elsewhere large endowments of natural resources are combined with a very unfavourable disease environment.

Table 3 The interaction between natural resources and disease environment

| | I | II | III |
|---|---|---|---|
| | GLS | GLS | GLS |
| | Dependent variable is | | |
| | Log per-capita GDP | Institutional quality | Schooling |
| Log natural capital | 0.338***<br>(0.075) | 0.454***<br>(0.136) | 0.907***<br>(0.305) |
| SS*Africalog natural capital | 0.067<br>(0.053) | 0.089<br>(0.065) | 0.144<br>(0.158) |
| Asia*log natural capital | 0.021<br>(0.035) | 0.028<br>(0.056) | 0.043<br>(0.153) |
| Latin A.*log natural capital | 0.009<br>(0.030) | 0.142***<br>(0.044) | 0.176<br>(0.211) |
| Malaria ecology | 0.082*<br>(0.048) | 0.342*<br>(0.175) | 0.339*<br>(0.181) |
| Coastal population | 0.520**<br>(0.260) | - | 0.661<br>(0.536) |
| Latitude | 2.789***<br>(0.651) | 2.025**<br>(0.978) | - |
| Log per capita income 1970 | - | 0.730***<br>(0.176) | 1.165***<br>(0.459) |
| Legal origin France | - | 0.399*<br>(0.207) | - |
| Ethnic fractionalization | - | 0.322<br>(0.636) | 0.137<br>(1.151) |
| UK colony dummy | - | - | 0.883**<br>(0.402) |
| Log natural capital malaria ecology | 0.012**<br>(0.006) | 0.042**<br>(0.021) | 0.047***<br>(0.017) |
| Number of observations | 89 | 78 | 83 |
| $R^2$ | 0.754 | 0.769 | 0.689 |

All equations include a constant term and regional dummies for Sub Saharan Africa, Asia, and Latin America. Estimated coefficients of these variables are not reported, but they are available upon request. Heteroskedasticity consistent standard errors are reported in brackets

*, **, *** Statistical significance at the 10, 5, and 1% confidence level respectively

# 5 Conclusions

In this paper we provide evidence that the effect of natural resources on income, institutional quality, and schooling is different across different regions. In general, natural resource abundance appears to be positive, or at least not negative, for development. However, in SSA its impact is much less favourable and often negative. Why then is SSA different? We argue that the combined effect of resources and disease environment is what explains the difference between SSA and other regions. We provide some historical and econometric evidence in support of our hypothesis. One way to rationalize our findings is to think that natural resource abundance can trigger both positive and negative development effects. The balance between these effects of opposite sign depends on the disease environment: the worse the environment is, the stronger the negative effects are. With this perspective, the disease environment determines a non-linearity in the relationship between natural resources and development. A more explicit test of this non-linearity is certainly an avenue of interesting future research.

From a development perspective, our analysis suggests two considerations. First, on a general ground, our findings support the argument that developing countries and the international community ought to invest in disease prevention and control not just because better health is desirable per se, but also because it can accelerate economic development. Second, in the logic of our paper, the development gap suffered by resource-rich countries with a bad disease environment arises from the type of colonization they experienced. However, this does not necessarily mean that the gap must be permanent. In fact, while the type of colonization cannot be changed, its adverse effects pertain to factors, like institutional quality and schooling, which can evolve and improve. Here therefore lie an opportunity and a challenge for the countries that were subjected to extractive colonization. The opportunity is that through policy change and reforms, these countries can offset the negative impact of colonization on the drivers of development. The challenge is that extractive colonization not only caused bad institutions and inadequate schooling, but also created conditions that have made change and reforms difficult to undertake.

# Acknowledgments

We would like to thank Sambit Bhattacharyya, the editor Daan van Soest, and three anonymous referees for very helpful comments. We are solely responsible for any remaining errors and inconsistencies.

# Appendix 1

Table 4 Variables description and sources

| Variable | Description | Source | Mean | SD |
|---|---|---|---|---|
| Natural capital | Natural capital wealth in per-capita US$ | World Bank (1997) | 7,693.077 | 10,604.26 |
| Institutional quality | Average protection against expropriation risk | Acemoglu et al. (2001) | 4.572 | 3.672 |
| Schooling | Average years of schooling in population ages 15+ | Barro and Lee (2010) | 6.417 | 2.673 |
| Per-capita GDP | Real per-capita GDP | Penn World Tables | 12,261.78 | 13,377.76 |
| Malaria ecology | Index of Malaria ecology | Sachs (2003) | 3.688 | 6.468 |
| Coastal population | Proportion of population living within 100 km from the coast | Sachs (2003) | 0.434 | 0.366 |
| Latitude | Absolute geographical latitude of capital city | La Porta et al. (1999) | 0.283 | 0.190 |

| | | | | |
|---|---|---|---|---|
| Legal origin France | Legal origin French | La Porta et al. (1999) | 0.435 | 0.497 |
| Ethnic fraction. | Probability that two randomly selected individuals do not belong to the same ethnic group | Easterly and Levine (1997) | 0.338 | 0.303 |
| UK colony dummy | Dummy variable taking value 1 if country was colonized by the UK | Sala-i-Martin (2004) | 0.384 | 0.488 |

List of countries: Argentina, Australia, Austria, Bangladesh, Belgium, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Congo, Costa Rica, Cote dIvoire, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Finland, France, Gambia, Germany, Ghana, Greece, Guatemala, Guinea-Bissau, Haiti, Honduras, India, Indonesia, Ireland, Italy, Jamaica, Japan, Jordan, Kenya, Republic of Korea, Lesotho, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Morocco, Mozambique, Namibia, Nepal, The Netherlands, New Zealand, Nicaragua, Niger, Norway, Pakistan, Panama, Papua New guinea, Paraguay, Peru, Philippines, Portugal, Rwanda, Saudi Arabia, Senegal, Sierra Leone, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Kingdom, United States, Uruguay, Venezuela, Vietnam, Zambia, Zimbabwe

# References

Acemoglu D, Johnson S, Robinson J (2001) The colonial origins of comparative development: an empirical investigation. Am Econ Rev 91(5):1369-1401

Alexeev M, Conrad R (2009) The elusive curse of oil. Rev Econ Stat 91(3):568-598

Alesina A, Baquir R, Easterly W (1999) Public goods and ethnic divisions. Q J Econ 114(4):1243-12894

Alesina A, Baquir R, Easterly W (2000) Redistributive public employment. J Urban Econ 48(2):219-241

Alesina A, Devleeschauwer A, Easterly W, Kurlat S, Wacziarg R (2003) Fractionalization. J Econ Growth 8:155-194

Arellano M, Bover O (1995) Another look at the instrumental variable estimation of error-components models. J Econom 68(1):29-51

Arezki R, Ploeg Fvan der (2011) Do natural resources depress income per capita. Rev Dev Econ 15(3):504-521

Auty R (1993) Sustaining development in mineral economies: the resource curse thesis. Routledge, London

Barro J, Lee W (2010) A new data set of educational attainment in the world, 19502010. NBER working paper no 15902

Bhattacharyya S (2009) Root causes of African underdevelopment. J Afr Econ 18(5):745-780

Beny L, Cook L (2010) Metals or management? Explaining Africas recent economic growth performance. Am Econ Rev 99(2):268-274

Bertocchi G, Canova F (2002) Did colonization matter for growth? An empirical exploration into the historical causes of Africas underdevelopment. Eur Econ Rev 46:1851-1871

Blakemore K, Cooksey B (1980) A sociology of education for Africa. George Allen and Unwin, London

Bleaney M, Dimico A (2010) Geographical inuences on long-run development. J Afr Econ. doi:10.1093/jae/ejq014 (forthcoming, on-line)

Blundell R, Bond S (1998) Initial conditions and moment restrictions in dynamic panel data model. J Econom87(1):115-143

Boschini A, Petterson J, Roine J (2007) Resource curse or not: a question of appropriability. Scand J Econ109:593-671

Brown D (2000) Democracy, colonization, and human capital in Sub-Saharan Africa. Stud Comput Int Dev35(1):20-40

Brunnschweiler C (2008) Cursing the blessings? Natural resource abundance, institutions, and economic growth. World Dev 36(3):399-419

Brunnschweiler C, Bulte E (2008) The resource curse revisited and revised: a tale of paradoxes and red herrings. J Environ Econ Manage 55:248-264

Bush K, Saltarelli D (2000) The two faces of education in ethnic conict. UNICEF Innocenti Research Centre, Florence

Butlin N (1993) Economics and the dreamtime, a hypothetical history. Cambridge University Press, Cambridge

Cain P, Hopkins A (1993) British imperialism: innovation and expansion 16881914. Longman, New York
Carmignani F, Avom D (2010) The social development effects of primary commodity export dependence. Ecolog Econ. doi:10.1016/j.ecolecon2010.09.003 (Forthcoming, on-line)
Collier P, Gunning J (1999) Explaining African economic performance. J Econ Lit 37(1):64-111
Collier P, Gunning J (1999) Why has Africa grown so slowly. J Econ Perspect 13(3):3-22
Collier P, Hoefer A (2005) Resource rents, governance and conict. J Conf Resol 49(4):625-633
Collier P, Hoefer A, Rohner D (2009) Beyond greed and greviances: feasibility and civil war. Oxford Econ Pap 61(1):1-27
Crowder M (1968) West Africa under colonial rule. Northwestern University Press, Chicago
Crosby A (1986) Ecological imperialism: the biological expansion of Europe 900-1900. Cambridge University Press, New York
Curtin P (1961) The white mans grave: image and reality, 17801850. J Br Stud 1(1):94-110
Davis G (1995) Learning to love the Dutch disease: evidence from the mineral economies. World Dev 23(10):1765-1779
Davis L, Huttenback R (1987) Mammon and the pursuit of empire: the political economy of British imperialism, 18601912. Cambridge University Press, Cambridge
Deaton A, Miller R (1996) International commodity prices, macroeconomic performance and politics in Sub-Saharan Africa. J Afr Econ 5(3):99-191
Denoon D (1993) Settler capitalism: the dynamics of dependent development in the southern emisphere. Claredon Press, Oxford
Diamond J (1997) Guns, germs and steel: the fate of human societies. Norton, New York
Easterly W, Levine R (1997) Africas growth tragedy: policies and ethnic divisions. Q J Econ 112:12031250
Engerman S, Sokoloff K (2000) Institutions, factor endowments, and paths of development in the new world. J Econ Perspect 14(3):217-232
Gann L, Duignan P (1979) White settlers in tropical Africa. Penguin, Baltimore
Gelb A (1988) Oil windfalls: blessing or curse?. Oxford University Press, New York
Glaeser E, La Porta R, Lopez-de-Silanes F, Shleifer A (2004) Do institutions cause growth. J Econ Growth 9:271-303
Grier R (1999) Colonial legacies and economic growth. Public Choice 98(2):317-335
Gylfason T (2001) Natural resources, education and economic development. Eur Econ Rev 45(5):847859
Hall R, Jones C (1999) Why do some countries produce so much more output per worker than others. Q J Econ 114(1):83-116
Harvey D, Kellard N, Madsen B, Wohar M (2010) The Prebisch-Singer hypothesis: four centuries of evidence.Rev Econ Stat 92(2):367-377
Hodler R (2006) The curse of natural resources in fractionalized countries. Eur Econ Rev 50:1367-1386
Hughes R (1987) The fatal shore. Collins Harvill, London
Isham J, Woolock M, Pritchett L, Busby G (2005) The variety of resource experience: natural resource export structure and the political economy of economic growth. World Bank Econ Rev 15(2):222-279
Jewsiewicky B (1983) Rural society and the Belgian colonial economy. In: Birmingham D, Martin P (eds) The history of Central Africa. Longman, New York
Lang J (1975) Conquest and commerce: Spain and England in the Americas. Academic Press, New York
La Porta R, Lopez-de-Silanes F, Shleifer A, Vishny R (1999) The quality of government. J Law Econ Organ 15(1):222-279
Leite C, Weidmann J (1999) Does mother nature corrupt? Natural resources, corruption, and economic growth. IMF working paper 99/85
Llyod C, Kaufman C, Hewett P (2000) The spread of primary schooling in Sub-Saharan Africa: implication for fertility change. Popul Dev Rev 26(3):483-515
Lockhart J, Schwartz S (1983) Early Latin America. Cambridge University Press, New York
Mehlum H, Moene K, Torvik R (2006) Institutions and the resource curse. Econ J 116(1):1-20

Nitri D (1993) Africas educational dilemma: Roadblocks to universal literacy for social integration and change. Int Rev Educ 39(5):357-372
Nunn N (2008) The long-term effects of Africas slave trades. Q J Econ 123(1):139-176
Papyrakis E, Gerlagh R (2004) The resource curse hypothesis and its transmission channels. J Compar Econ 32(1):181-193
Robinson R, Gallagher J (1961) Africa and the Victorians: the ofcial mind of imperialism. MacMillan,London
Ross M (2001) Does oil hinder democracy. World Polit 53(3):325-361
Rodrik D, Subramanian A, Trebbi F (2004) Institutions rule: the primacy of institutions over geography and integration in economic development. J Econ Growth 9:131-165
Sachs J (2003) Institutions dont rule: direct effects of geography on per capita income. NBER working paper 9490, http://www.nber.org/papers/w9490
Sachs J, Warner A (1997) Sources of slow growth in Africa. J Afr Econ 6(3):335-376
Sachs J, Warner A (2001) The curse of natural resources. Eur Econ Rev 45:827-838
Sala-i-Martin X, Subramanian A (2003) Addressing the natural resource curse: an illustration from Nigeria. IMF working paper 03/139
Snyder R (2006) Does lootable wealth breed disorder. Comp Pol Stud 39:943968
Stijns J (2005) Natural resource abundance and economic growth revisited. Resour Pol 30:107-130
Stock J, Yogo M (2005) Testing for weak instruments in linear IV regression. In: Andrews DWK, Stock JH (eds) Identication and inference for econometric models: essays in honor of Thomas Rothenberg. Cambridge University Press, Cambridge
Temple J (1998) Initial conditions, social capital and growth in Africa. J Afr Econ 7(3):309-347
Whitehead C (2007) The concept of British education policy in the colonies 18501960. J Educ Admin Hist 39(2):161-173
Wittfogel K (1957) Oriental despotism: a comparative study of total power. Yale University Press, New Heaven
Wooldridge J (2010) Econometric analysis of cross-section and panel data. The MIT Press, Boston
World Bank (1997) Expanding the measure of wealth: indicators of environmentally sustainable development. Environ Sustain Dev Stud Monogr Ser N 17:34-38
Young C (1994) The African colonial state in comparative perspective. Yale University Press, New Heaven

# Notes

1 Measured in constant 2005 PPP US dollars, per-capita GDP in 2010 was US$ 2041 in SSA, US$ 2941 in South Asia, US$ 5991 in East Asia and the Pacific (excluding industrial economies), US$ 9131 in Middle East (including North Africa), and US$ 10117 in Latin American and the Caribbean. Since 1980, per-capita GDP in SSA has grown at an annual average rate of 0.4%. This compares to an average annual growth rate of 0.9% in the Middle East, 1% in Latin America, 3.7% in South Asia, and 6.5% in East Asia. Finally, with the exception of the Middle East, SSA has the highest ratio of fuel exports to total merchandise exports (37% in 2009) and the highest ratio of primary commodity exports to total merchandise exports (61% in 2009).

2 Davis (1995) also provides some informal evidence that resource abundance is not associated with lower levels of per-capita GDP.

3 Our hypothesis has its premises in the theory of colonial origins of development that goes back to Acemoglu et al. (2001). We also stress that our hypothesis does not mean that European-like institutions, policies, and human capital were the only possible way to develop. Several Asian countries have achieved high levels of development without ever benefiting from European colonization and human capital. What is central to our hypothesis is that European colonization was particularly disruptive in colonies with abundant natural resources and a bad disease environment.

4 All the results discussed in Sects. 3 and 4 do not qualitatively change if we use only the category “subsoil” assets instead of the total of the five categories.

5 To exemplify the difference between dependence and abundance, consider a resource-abundant developed economy like Germany that uses most of its resources domestically: the ratio of primary commodity exports to GDP in this country is relatively low even though its endowment of natural resources is relatively large. Therefore, this country would be abundant in natural resources, but not much dependent on their exports.

6 See, among others, Hall and Jones (1999), Acemoglu et al. (2001), Sachs (2003), Rodrik et al. (2004), Glaeser et al. (2004), Bhattacharyya (2009), and Bleaney and Dimico (2010).

7 There are other non-monetary dimensions of development which might be affected by natural resources, see for instance Carmignani and Avom (2010). In the same vein, the effect of natural resources on per-capita income might be transmitted through factors other than institutional quality and education. One such factor, which could be particularly relevant in the context of SSA, is civil conflict or war (see for instance Collier et al. 2009). While future work should certainly consider these other dimensions and mechanisms, our results indicate that cross-regional differences in the effect of resources on institutions and schooling already explain most of the observed cross-regional differences in the effect of resources on per-capita GDP.

8 Consider for instance the case of a ruler or a colonizer who wants to appropriate as much as possible of a large endowment of natural resources. Then this ruler would set up institutional arrangements that make it easier for him to obtain natural capital, mineral wealth, and the rest of country's valuables. These types of institutional arrangements would be reflected in low protection of private property rights and therefore low protection against expropriation risk. This is in fact the notion of extractive state portrayed by Acemoglu et al. (2001).

9 The identity of the colonizer is different from country's legal origin. Statistically, the correlation between the colonizer identity dummy (=1 if a country was colonized by Britain) and the legal origin dummy (=1 if the law of a country originates from the French civil law tradition) is −0.56, significantly smaller than −1, and hence far from perfect. More substantially, there are several countries that have not been colonized by the United Kingdom and that, at the same time, do not have French legal origins. This is for instance the case of several former Spanish colonies or the socialist countries in Eastern Europe.

10 To save space, estimated coefficients on the regional dummies are not reported. They tend to be negative for the SSA dummy and positive for the other two dummies. However, they are generally insignificant. We also stress that the number of observations is smaller than the total number of countries for which we have natural wealth data (92). As a matter of fact, for some of these countries, data on some of the controls are not available.

11 The coefficient is positive, but significantly smaller than one. Then, subtracting initial per-capita GDP from both sides of the equation yields growth on the l.h.s. and a negative coefficient (−0.23) for initial GDP on the r.h.s.

12 There might some collinearity between malaria ecology and latitude, at least to the extent that they both pick factors like temperature and general climatic conditions. Their simple bilateral coefficient is −0.51 and statistically significant. However, the fact that both variables are strongly significant when simultaneously included in the model without initial per-capita GDP (column II) suggests that this collinearity might not be too strong. In any event, in Appendix 2—supplementary material we re-estimate all regressions after dropping latitude and results are qualitatively unchanged.

13 We are aware of the potential drawbacks of the simultaneous approach. In particular, if one of the three equations is mis-specified, then the estimates of the other two equations will be affected. This is why we have first reported equation-by-equation estimates. In other words, we are once again pragmatic. Given the relative merits and costs of the two approaches, we apply both of them and we show that are our story is always valid.

14 See Appendix 2 in supplementary material for further discussion on the instrumentation of initial per-capita GDP in the institutional quality and schooling equations. At the bottom of Table 2 we report the Hansen test of validity of the overidentifying restrictions. The null hypothesis of the test is rejected, which provides support to the choice of instruments.

15 British West Africa is the collective name of British colonies in West Africa, which included modern Sierra Leone, Gambia, Ghana, and a large part of Nigeria (the so-called Lagos Territory).

16 Crowder (1968) notes that in the West African region, the basic objectives of the educational polices of Britain (but also France) was the training of Africans for participation in the bureaucratic administration of the colonies. This limited objective implied that very few children got even to primary school under the colonial regime.