# Department of Economics

## Working Paper

**The Development Effects of Natural Resources: A Geographical Dimension**

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# The Development Effects of Natural Resources: A Geographical Dimension

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**Abstract**

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. 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.

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## I. 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) find 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 Africa’s 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 find 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; and Boschini *et al*., 2007), increase the risk of civil war (Collier and Hoeffler, 2005), crowd-out other forms of capital (Gylfason, 2001) and/or other sectors of the economy (Sachs and Warner, 2001), and expose the economy to a secular decline in the terms of trade (Harvey et al. 2010). The conventional wisdom has, however, been challenged on several grounds. Mehlum *et al*. 2006, Snyder, 2006, and Hodler, 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) finds 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 find 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 accumulation, 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 Section 2. Then we discuss the results in Section 3. In Section 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 provides a set of robustness checks as well as first stage estimates and diagnostics.

## 1. Econometric set-up

### 1.1. Income equation

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

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

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, **X** is a set of control variables (eventually including a constant term), ε is a residual, and α, β, γ, and δ 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 and 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 α. 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 20-25 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 2, we show that results do not qualitatively change when we estimate equation (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 define three regional dummies: $d_{1(\mathrm{SSA})}$ equals 1 if country $i$ is located in the SSA region and 0 otherwise, $d_{2(\mathrm{ASIA})}$ equals 1 if country $i$ is located in Asia and 0 otherwise, and $d_{3(\mathrm{LATAM})}$ 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 **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 progressively enrich it to account for the impact of institutions, schooling, and some policy variables. The 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 equation (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 GDP levels (and hence excluded 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 most 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, equation (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.

### 1.2. 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):

$$(2)\quad q_t = \theta r_t + \sum_{j=1}^{N} \vartheta_j r_t d_{(t)j} + \sum_{j=1}^{N} \pi_j d_{(t)j} + \lambda \mathbf{Z}_t + \mu_t$$

$$(3)\quad h_t = \varphi r_t + \sum_{j=1}^{N} \omega_j r_t d_{(t)j} + \sum_{j=1}^{N} \eta_j d_{(t)j} + \xi \mathbf{W}_t + \upsilon_t$$

Where $q$ is a measure of institutional quality, $h$ is an indicator of education (schooling), **Z** and **W** are set of controls, μ and υ are error terms, $r$ and $d$ are the same as in equation (1), and the

$\theta$, $\vartheta$, $\pi$, $\varphi$, $\omega$, $\eta$, $\xi$, $\lambda$ are the coefficients to be estimated. Similarly to equation (1), the interaction terms $r_i d_{(i)j}$ in equations (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 equation (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 equations (2) and (3). The alternative would be to use the 2000 or 2005 values to measure the dependent variables in equations (2) and (3), while using averages over 1985-1995 to measure the regressors in equation (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 equations (1), (2), and (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 equations (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 and 2000, and Alesina *et al*. 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 equation (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 equation (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 today's differences in educational outcomes across developing countries. Accordingly, we single out British colonization using a dummy variable.[9] Coastal population captures the influence that international trade and other forms of economic/cultural exchange might have had on individual's incentive to accumulate human capital.

## 2. Results

We present our core results in three steps. First we document the existence of cross-regional differences in the effect of natural resources on income levels. Second, we document that the effects of natural resources on institutional quality and schooling also differ across regions.

Third, we consider the interactions between institutional quality, schooling, and per-capita income.

## 2.1. The effect of natural resources on income

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

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.[11]

INSERT TABLE 1 ABOUT HERE

## 2.2. The effect of natural resources on institutional quality and schooling

The remaining columns of Table 1 report estimates of equations (2) and (3). 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%.

Columns VI and VII reproduce the previous two columns, but using a 2SLS instrumental variable estimator to account for the possible endogeneity of per-capita GDP. The estimates in columns II and III indicate that coastal population and latitude are both significantly correlated with per-capita GDP and hence they might be useful instruments. However, coastal population is included as a regressor in equation (3) while latitude is a regressor in equation (2), meaning that they cannot be jointly used as instrument in both equations. Therefore, we use coastal population as an instrument in equation (2) and latitude as an instrument in equation (3).[12] With respect to the effect of natural resources, the 2SLS are qualitatively very similar to the GLS results. The only difference is that in the schooling equation, the regional effect in Asia is no longer significant, which leaves SSA as the only region that does not behave the same as the baseline group.

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 finding 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 equation (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 equation (3).

### 2.3. The interactions between institutional quality, schooling, and per-capita income

The results in Table 1 suggest that institutional quality and schooling might be the two channels through which the effect of natural resources is transmitted to per-capita GDP. In particular, the finding that natural resources increase per-capita GDP everywhere but not in SSA (columns I, II, and III of Table 1) is consistent with the finding that natural resources negatively affect institutional development and schooling in SSA, but not elsewhere (columns IV, V, VI, and VIII of Table 1).

To shed light on the transmission mechanisms we start by adding institutional quality and schooling as regressors in equation (1). Even if they are measured as averages over the period 1985-1995, 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 2 and indicate that the model is neither underidentified nor weakly identified. Additional diagnostics and the first stage results are provided in Appendix 2. The 2SLS estimates reported in column I of Table 2 indicate that neither institutions nor schooling are significant. All of the interaction terms also become insignificant, while the baseline effect of natural resources remains positive and significant at the 10% confidence level. These findings are to be expected: if natural resources affect per-capita income mainly through institutions and schooling, then institutions, schooling and natural resources (including the interaction terms) are likely to be collinear and hence their coefficients are less precisely estimated.

The next step is to estimate equations (1), (2), and (3) 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 that 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 and use the same instruments as in columns VI and VII of Table 1.[14] Results are reported in columns II (equation (1)), III (equation (2)), and IV (equation (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 equation (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.

Given that the coefficients of the interaction terms are not significant in equation (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 collinearity in equation (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 V, VI, and VII 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 equations (2) and (3) are similar to those reported in columns III and IV. 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.

INSERT TABLE 2 ABOUT HERE

## 3. 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.

### 3.1. 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.

## 3.2. Some historical evidence

Our hypothesis is rooted in historical trends and facts that are well documented in the literature and which we briefly summarize in this subsection. To start with, there is ample evidence that mercantilist and business interests oriented colonization towards the extraction and exploitation of natural (as well as human) resources in the colonies. Davis and Huttenback (1987) and Cain and Hopkins (1993) document how British governments diverted resources and designed policies to help the growing financial sector of the City exploit opportunities for profits in the colonies. Similar mercantilist interests also prevailed in European countries that did not have such an influential business community as Britain. For instance, Gann and Duignan (1979) and Jewsiewicky (1983) report that the massive, and often violent, exploitation of natural and human resources carried out by the Belgian King Leopold in Congo resulted in the destruction of local socioeconomic life and political structures. Young (1994) writes that in Africa, French colonization typically took the form of regulations, limitation of individual liberties, and tax collection to appropriate the rents arising from colony's natural wealth. Lang (1975) and Lockhart and Schwartz (1983) argue that the main goal of Spain and Portugal in the colonization of Central and Latin America was to extract resources and monopolize the trade of valuable commodities, gold in particular. Interestingly, exploitation did not just take the form of extractive trade and commercial policies or institutions, but also of distorted education policies which severely affected the subsequent development of human capital in the colonies. Examples are provided, among others, by Bush and Saltarelli (2000).

The presence of European settlers in the colonies seems to have been one of the few factors that somewhat limited the extent of extraction. This is because, animated by capitalist interests, settlers demanded their political and economic rights to be recognized by the metropolis and they were prepared to fight for that (see Denoon, 1993 and Acemoglu et al. 2001). Settlers' colonies therefore developed social, institutional, and economic arrangements that quite closely resembled those of the home country, thus giving rise to the so-called Neo-Europes (Crosby, 1986). The presence of settlers also had an important impact on human capital and schooling policies. Not only they brought their human capital and technological knowledge with them; they also established the means and structures to proliferate the education component of that human capital through their schooling system (Llyod et al. 2000 and Whitehead, 2007). But not all colonies eventually evolved into settlers' colonies and Europeans generally did not settle down in territories where the disease environment was too hazardous.[15] For instance, Diamond (1997) argues that colonization of various inland territories in Latin America was made possible by the resistance of Spanish settlers to the Eurasian disease. On the contrary, the inability of white populations to resist to tropical diseases, such as malaria and yellow fever, prevented the colonization of inland Africa and also severely limited the incentives to settle along African coasts (see Curtin, 1961 and Robinson and Gallagher, 1961)

Differences in institutional, economic, and socio-political arrangements that arose from different types of colonization have eventually persisted until modern times (see Wittfogel, 1957; La Porta et al. 1999; Young, 1994; Acemoglu et al. 2001). Despite the desire to break with the colonial past, most government officials trained and installed during the colonial period remained in office once independence was obtained. At the same time, the local elites that had flourished under the colonial regime became the critical supporting constituencies of the new independent governments. The extractive policies and institutions set-up by the colonizers presented these elites and governments with an opportunity to strengthen their power and increase their profits. It is therefore not surprising that the newly independent states often reverted to the same type of policies, institutions, and arrangements of the colonial nations. In the specific case of education policies and goals, these dynamics are discussed by Blakemore and Cooksey (1980), Nitri (1993) and Brown (2000).

As a practical example of the historical trends that underlie our working hypothesis, one can compare the British colonization of British West Africa (BWA[16]) and Australia. The control and appropriation of valuable commodities was the main reason of British presence in West Africa. As Crowder (1986) puts it, for Britain "flag followed trade" and it was therefore not a case that colonization focused on resource rich coastal areas in the region. However, BWA was equipped with a full range of tropical diseases to which Europeans had very little resistance. The two principal killers were, of course, malaria and yellow fever. 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. It was this high mortality that caused the failure of important expeditions such as the British colonization of Bulama Island in 1792-1793, the Sierra Leone Company in the 1820s, and the Niger expedition of 1841-1842. Facing this extremely tough disease environment, surviving settlers were certainly not encouraged to stay and new settlers were not willing to come.

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 (see, inter alia, 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[17], in Australia institutions and policies were designed to reproduce those that progressively emerged from the changes (constitutional and political) taking place in Britain (see also 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, in spite of the incentive of governments and capitalists back home to extract rents from resource wealth, the presence of settlers implied 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 gave Australia better long-term development prospects. To sum up, the incentive to implement some sort of extractive strategy existed in both BWA and Australia. But different disease environments in the two territories led to different settlement patterns, which eventually resulted in sharply different types of colonization. These differences have then persisted in the post-independence era.

### 3.3. 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. In order to make the test more powerful, we do not include schooling and institutions in equation (1).[18] We apply GLS throughout, but results do not change when we use 2SLS for equations (2) and (3) or when we estimate the set of three equations jointly as a system.

Results are reported 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.[19] 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 coefficient. 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. All in all, while we suggest that more research is needed in the future, the evidence presented in Table 3 goes some distance towards supporting our explanation: SSA is different from the other regions because in SSA much more than anywhere else large endowments of natural resources are combined with a very unfavourable disease environment.

INSERT TABLE 3 ABOUT HERE

## 4. 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 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.

Our findings support the general 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. However, improving health conditions today will not change the type of colonization experienced by a country in the past. So, for a resource rich economy that suffered some form of extractive colonization, the extant challenge is to identify a set of policies that can somehow offset the negative legacy of unfavourable "initial conditions" arising from colonization. In this respect, if we were to advice SSA countries on a course of action, we would recommend them to use revenues from the commercialization of natural resources to create infrastructures to improve physical connectivity and reduce non-tariff barriers to international trade. More generally, public investment financed via revenues from natural resources is likely to crowd-in private investment. This would boost capital accumulation and growth. Finally, we would also recommend SSA countries to use the revenues from natural resources counter-cyclically. At times of buoyant international commodity prices, resource rich countries in SSA should try and accumulate public savings, which can then be used to boost the economy at times of recession. In this sense, resource abundance would help create enough policy space to implement effective stabilization policies.

## Endnotes

[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 characterized by resource abundance and a bad disease environment.
[4] All the results discussed in Sections 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 effectively 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] 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 we re-estimate all regressions after dropping latitude and results are qualitatively unchanged.
[12] The tests of weak identification and under-identification reported at the bottom of Table 1 provide some support to this choice of instruments. Additional diagnostics and the full set of first stage results are reported in Appendix 2. In Appendix 2 we also re-estimate equations (2) and (3) after dropping coastal population from equation (3) and latitude from equation (2). In this way, we can use both variables jointly as instruments for per capita GDP. Results are qualitatively similar to those presented in columns VI and VII of Table 1.

[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] In system estimation, the validity of instruments is assessed by looking at the first stage diagnostics of the 2SLS applied equation-by-equation. Therefore, the specification tests and statistics reported in Table 1 (columns VI and VII) still apply here. In addition, we report at the bottom of Table 2 the Hansen test of validity of the overidentifying restrictions. The null hypothesis of the test is rejected, which provides further support to the choice of instruments.

[15] There is a voluminous tradition of historical and medical research on the impact of disease on colonization patterns and the evolution of societies (see, inter alia, Cartwright and Biddiss, 1972, Kiple, 1993, Hays 1998, and Spilelman and d'Antonio, 2001).

[16] 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).

[17] 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.

[18] This is because, as shown in Table 2, when including schooling and institutions are regressors, multicollinearity implies that the regional effects of natural resources are imprecisely estimated.

[19] Interestingly, in the 2SLS estimates of equations (2) and (3), the interaction term is significant at the 5% confidence level rather than the 10% level.

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

| | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|
| | GLS | GLS | GLS | GLS | GLS | 2SLS | 2SLS |
| | **The dependent variable is:** | | | | | | |
| | Log per-capita income | Log per-capita income | Log per-capita income | Inst. quality | Schooling | Inst. quality | Schooling |
| Log natural capital | 0.429*** | 0.274*** | 0.018 | 0.056 | 1.209*** | 0.023 | 0.946*** |
| | (0.160) | (0.092) | (0.050) | (0.153) | (0.314) | (0.258) | (0.333) |
| SSAfrica*log natural capital | -0.410** | -0.241* | -0.075 | -0.543* | -1.275*** | -0.525* | -1.257*** |
| | (0.204) | (0.117) | (0.082) | (0.311) | (0.355) | (0.319) | (0.396) |
| Asia*Log natural capital | -0.168 | 0.044 | 0.259*** | 0.546*** | -0.962** | 0.561*** | -0.644 |
| | (0.172) | (0.147) | (0.086) | (0.189) | (0.400) | (0.207) | (0.449) |
| Latin A.*log natural capital | 0.129 | 0.327 | 0.276** | 0.653*** | -0.342 | 0.629** | -0.512 |
| | (0.211) | (0.187) | (0.106) | (0.194) | (0.518) | (0.271) | (0.670) |
| Malaria ecology | .. | -0.024** | -0.007 | 0.006 | -0.052 | 0.011 | -0.016 |
| | | (0.011) | (0.009) | (0.027) | (0.035) | (0.041) | (0.045) |
| Costal population | .. | 0.638** | 0.286** | ... | 0.809 | ... | 0.154 |
| | | (0.263) | (0.126) | | (0.609) | | (0.923) |
| Latitude | .. | 2.976*** | 1.428*** | 2.353** | .. | 2.080 | .. |
| | | (0.327) | (0.431) | (0.939) | | (2.001) | |
| Log per capita income 1970 | .. | .. | 0.777*** | 0.686*** | 1.180** | 0.837 | 2.029** |
| | | | (0.080) | (0.154) | (0.516) | (0.994) | (1.042) |
| Legal origin France | .. | .. | .. | -0.592** | .. | -0.584** | .. |
| | | | | (0.270) | | (0.284) | |
| Ethnic fractionalization | .. | .. | .. | -0.043 | 0.452 | -0.015 | 0.277 |
| | | | | (0.564) | (1.179) | (0.639) | (1.475) |
| UK colony dummy | .. | .. | .. | .. | 0.718* | .. | 0.836** |
| | | | | | (0.404) | | (0.417) |
| | **Diagnostics** | | | | | | |
| Number of observations | 91 | 89 | 89 | 78 | 83 | 78 | 83 |
| R2 | 0.66 | 0.78 | 0.90 | 0.81 | 0.75 | 0.80 | 0.72 |
| K-P LM statistics | .. | .. | .. | .. | .. | 7.94** | 9.58*** |
| K-P Wald F statistics | .. | .. | .. | .. | .. | 16.54 | 19.32 |
| (Stock-Yogo critical values) | .. | .. | .. | .. | .. | (16.38) | (16.38) |

Notes: 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 first stage diagnostics reported are: (i) the Kleibergen-Paap (K-P) LM statistic for underidentification test (under the null hypothesis, the equation is underidentified) and (ii) the Kleibergen-Paap (K-P) Wald F statistic for weak identification test with Stock and Yogo (2005) 10% critical value (higher value of the statistic indicate the model is not weakly identified). Both of these statistics refer to the instrumentation of log per-capita income (which is the only endogenous variable in the model). *, **, *** denote statistical significance at the 10%, 5%, and 1% confidence level respectively

Table 2: Interactions between institutions, schooling, and natural resources

| | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|
| | 2SLS | | System (GMM) | | | System (GMM) | |
| | Log p.c income | Log p.c income | Inst. Quality | Schooling | Log p.c income | Inst. quality | Schooling |
| Log natural capital | 0.244* (0.129) | 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 | 0.386 (0.263) | 0.452 (0.375) | -0.481* (0.264) | -1.416*** (0.347) | .. | -0.397 (0.271) | -1.405*** (0.340) |
| Asia*Log natural capital | -0.129 (0.291) | -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 | 0.064 (0.291) | -0.156 (0.297) | 0.770*** (0.230) | -1.062** (0.465) | .. | 0.790*** (0.231) | -0.824* (0.452) |
| Malaria ecology | -0.052** (0.021) | -0.053* (0.029) | 0.002 (0.035) | 0.008 (0.037) | -0.041** (0.021) | 0.003 (0.034) | -0.001 (0.037) |
| Costal population | 0.565** (0.237) | 0.623*** (0.231) | .. | -0.526 (0.773) | 0.464** (0.194) | .. | -0.418 (0.755) |
| Latitude | 1.411 (1.433) | 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 | -0.105 (0.154) | -0.224 (0.148) | .. | .. | 0.121* (0.07) | .. | .. |
| Inst. Quality | 0.344 (0.388) | 0.646* (0.354) | .. | .. | 0.264** (0.134) | .. | .. |
| Number of observations | 75 | | 234 | | | 234 | |
| J-stat (p-value) | .. | | 3.698 (0.29) | | | 2.124 (0.18) | |

Notes: 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 underidentification and weak identification diagnostics for the equation shown in column 1 are as follows Kleibergen-Paap LM statistics for underidentification: 13.012*** (null hypothesis is that the model is underidentified); Kleibergen-Paap 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. For the system estimates, the number of observations reported is the total for the entire system. * . *, **, *** denote statistical significance at the 10%, 5%, and 1% confidence level respectively

Table 3. The interaction between natural resources and disease environment

| | I<br>GLS | II<br>GLS | III<br>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) |
| SSAfrica*log 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) |
| Costal 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 |

Notes: 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. *, **, *** denote statistical significance at the 10%, 5%, and 1% confidence level respectively.

**Appendix 1.**

| Variable | Description | Source | Mean | St. Dev. |
|---|---|---|---|---|
| Natural capital | Natural capital wealth in per-capita US$ | World Bank (1997) | 7693.077 | 10604.26 |
| 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 | 12261.78 | 13377.76 |
| Malaria ecology | Index of Malaria ecology | Sachs (2003) | 3.688 | 6.468 |
| Costal 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 UK colony | Sala-i-Martin (2004) | 0.384 | 0.488 |

**List of countries (92 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 d'Ivoire, 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.

## Appendix 2: Additional results

*Sensitivity checks*

In Table A1 we provide a number of sensitivity checks. Column I extends the core specification of equation (1) (see column II of Table 1) to include a set of policy variables: years of openness to international trade, volatility of inflation, and financial development[20]. All of these variables are measured over the period 1970-2000 so to make them pre-determined relative to per-capita GDP in 2005. The central result of the paper is confirmed. The baseline effect of natural resources is positive and significant while the region-specific effect is significantly negative in SSA only. At the same time, there is evidence that policies do matter. Particularly, more years of openness to trade and deeper financial development tend to increase per-capita GDP. The negative effect of inflation volatility is instead negligible in statistical terms.

Next we re-estimate equations (2) and (3) by allowing log-per capita GDP in 1970 to be instrumented by both costal population and latitude. As a matter of fact, the results in column II of Table 1 of the paper suggest that both these variables might be useful instruments. However, latitude is included as a regressor in equation (2) and hence it cannot be used as an instrument for per-capita GDP in that equation. Similarly, costal population is included as a regressor in equation (3) and hence cannot be used as an instrument. Therefore, log per-capita GDP in 1970 is instrumented by costal population in equation (2) and by latitude in equation (3). The results obtained from this choice of instruments are those shown in columns VI and VII of Table 1 of the paper. As can be seen, the estimated coefficients of latitude in equation (2) and costal population in equation (3) are insignificant. This suggests that they could be dropped as regressors, which in turn would make it possible to use both of them jointly as instruments for log per-capita GDP. The results from the 2SLS procedure with both instruments are reported in Columns II and III of Table A1. Qualitatively, the results are very similar to those discussed in the paper. Natural resources promote better institutions in Latin America and Asia, but not in Africa. Moreover, natural resources have a positive baseline effect on schooling while the region-specific effect is negative in Africa only. The coefficient of log per-capita GDP in 1970 is now more precisely estimated. The statistics of the underidentification and weak identification tests also somewhat improve. The LM statistic for underidentification is now 9.856 (p-value 0.0072) for the regression in column II and 10.545

for the regression in column III. The Wald F statistic for weak identification is 24.773 and 23.627 respectivaly. Having two instruments for one endogenous regressor it is also possible to test for the validity of overidentifying restrictions using the Hansen test. The relevant J-statistic is 0.774 (p-value 0.3789) in Column II and 0.32 (p-value 0.8582) in Column III. The overidentifying restrictions are therefore valid.

In the remaining columns of Table A1 re-estimate all of the equations of the paper after dropping latitude from any specification that also includes malaria ecology as regressor. Malaria ecology and latitude might capture different factors, but they are also quite highly correlated. Their bilateral correlation coefficient is -0.5 and this might cause a problem of collinearity, even though both variables appear to be significant in the basic income regression (see for instance column II of Table 1). As a robustness check, we re-estimate all the equations after dropping one of the two. Given the important role that malaria ecology has in the punch-line of the paper, we choose to drop latitude. Columns IV through to X reproduce the equations presented in columns II, III, IV, and VI of Table 1, column I of Table 2, and columns I and II of Table 3 of the paper. The results are again very similar to those discussed in the paper.

INSERT TABLE A1 ABOUT HERE

*First stage regressions*

The paper includes three 2SLS regressions (see columns VI and VII of Table 1 and column I of Table 2). For each of these three, Table A2 shows the corresponding first stage regression in the 2SLS procedure. To assess the validity and relevance of the instruments, the table also reports three statistics in addition to those already discussed in the paper. These additional statistics are the partial R2, which is obtained by partialling out the included instruments, and the Angrist and Pischke (2009) version of the chi-squared and F statistics as tests of underidentification and weak identification, respectively, of individual regressors (see also notes at the bottom of Table A2). For the F statistic, critical values are not available. Therefore, for comparison purposes, we report the critical values of Stock and Yogo (2005).

The first stage regression in column I of Table A2 refers to the 2SLS regression shown in column VI of Table 1. The endogenous regressor is log per capita income in 1970 and it is instrumented by costal population. In the first stage regression, costal population is highly significant and the null hypothesis that the regressor is underidentified is rejected. The F statistic for weak identification is also quite high. Column II shows the first stage regression of the 2SLS model reported in column VII of Table 2. The endogenous regressor is still log per capita in 1970, but it is now instrumented by latitude. Again, this instrument is highly significant in the first stage regression and the chi squared and F statistics seem to indicate that the endogenous regressor is neither unidentified nor weakly identified. Column III presents the two first stage regressions associated with the 2SLS model in column I of Table 2 of the paper. Both institutional quality and schooling are endogenous regressors and they are instrumented, respectively, by French legal origin and the UK colonial dummy variable. Both instruments are highly significant in the first stage regressions. The null hypothesis of underidentification is largely rejected for both regressors. The F statistic is marginally lower than the critical values of Stock and Yogo, but still well above 10 (which is generally indicated as a threshold for weak identification not to be a problem).

INSERT TABLE A2 ABOUT HERE

*Panel estimates*

In Table A3 we present a set of panel estimates of equation (1). The data set consists of five year averages taken over the period 1960-2005, so that for each country the maximum number of observations on the time dimension is T = 9 (results using ten year averages are also available upon request). The panel is however unbalanced as data are not available for several countries in the early quinquennia of the sample. As a time varying measure of resource intensity we use the log of primary commodity exports per capita.

Column I reports GLS random effects estimates of the parsimonious specification corresponding to the model in Column I of Table 1 of the paper. The evidence concerning region-specific effects is particularly strong: on top of a positive baseline effect, natural resources tend to increase per-capita income in Asia and Latin America and reduce income in Africa. Column II estimates a fixed effects version of the same equation. The fixed effects now capture time invariant factors, such as malaria ecology and latitude. This specification can therefore be interpreted as the counterpart of the model in column II of Table 1 of the paper. As can be seen, results are again very similar to those obtained from the random effects model.

In column III we introduce a lagged dependent variable, so that the specification now corresponds to the one estimated in column III of Table 1 of the paper. The estimated coefficient of lagged per-capita income is positive and highly significant, but rather low. However, as it is well known, the inclusion of a lagged dependent variable in a panel model with fixed effects makes standard least square estimators biased (Arellano and Bond, 1991; Caselli et al. 1996). Therefore, in Column IV we re-estimate the model using the sys-GMM estimator discussed in Arellano and Bover (1995) and Blundell and Bond (1998). The estimated coefficient of the lagged dependent variable is now much higher (and certainly more in line with previous estimates from the growth literature). At the same time, there is still evidence of a negative region-specific effect of natural resources in Africa, and in Africa only. The baseline effect of resources is instead positive.

Column V shows a specification that is equivalent to that in column I of Table 2 of the paper. The time varying institutional variable is the index of economic freedom of the World provided by the Fraser Institute. Education is instead measured by the average number of years of schooling in adult population. In the cross-sectional framework, these two variables are instrumented by the dummies for French legal origin and UK colonization. In a panel setting, these two time-invariant instruments turn out to be quite weak. We therefore use the lagged values of the first differences of the two variables as instrument. These correspond to the GMM-type instruments used in dynamic panel estimation. The panel estimates are qualitatively similar to the cross-section estimates, therefore confirming that differences in the regional effect of natural resources on per-capita GDP are largely explained by cross-regional differences in the effect of resources on institutional quality and schooling. The remaining two columns of Table A3 re-estimate the model allowing for a lagged dependent variable (column VI) and extending the set of regressors to include two standard "Solow" factors, namely investment in physical capital and population growth (column VII). The baseline effect of natural resources is once again positive, but the region-specific effect in Africa is negative and almost of the same size as the baseline effect.

Finally, we run two diagnostic tests to assess the validity of the identifying assumptions underlying the sys-GMM procedure. First, we tested for autocorrelation in first differenced errors and in all cases the null hypothesis of no autocorrelation cannot be rejected at order one, but it is rejected at order 2. This suggests that the errors in levels are serially uncorrelated. Second, we performed the Hansen test of overidentifying restrictions. The null hypothesis of this test is that the overidentifying restrictions are valid and it can never be rejected at usual confidence level. We also run a Hansen-in-difference test for the joint validity of the GMM-style instruments for the levels equation in the sys-GMM procedure. These instruments turn out to be valid.

INSERT TABLE A3 ABOUT HERE

**References for Appendix A2**

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Table A1 – Sensitivity analysis

| | I | II | III | IV | V |
|---|---|---|---|---|---|
| | GLS | 2SLS | 2SLS | GLS | GLS |
| | **The dependent variable is** | | | | |
| | Log pc income | Inst. quality | Schooling | Log pc income | Log pc income |
| Log natural capital | .298*** | .261 | .921*** | .379*** | .030 |
| | (.097) | (.228) | (.298) | (.144) | (.074) |
| SSAfrica*log natural capital | -.235** | -.064 | -1.265*** | -.299* | -.078 |
| | (.101) | (.085) | (.355) | (.184) | (.099) |
| Asia*log natural capital | -.182 | .725** | -.602 | -.191 | .187** |
| | (.287) | (.313) | (.388) | (.165) | (.080) |
| Latin A*log natural capital | .331** | .581** | -.548 | .258 | .241** |
| | (.137) | (.201) | (.525) | (.203) | (.122) |
| Malaria ecology | -.009 | .038 | -.010 | -.037** | -.009 |
| | (.011) | (.031) | (.034) | (.015) | (.011) |
| Log pc income 1970 | | 1.713*** | 2.131*** | .. | .874*** |
| | | (.518) | (.633) | | (.072) |
| Legal origin France | .. | -.667*** | .. | .. | .. |
| | | (.274) | | | |
| UK colony dummy | .. | .. | .853** | .. | .. |
| | | | (.402) | | |
| Ethnic fractionalization | .. | .091 | .229 | .. | .. |
| | | (.631) | (1.293) | | |
| Costal population | .537*** | .. | .. | .657** | .250* |
| | (.188) | | | (.303) | (.151) |
| Latitude | 1.501** | .. | .. | .. | .. |

| | | | | | |
|---|---|---|---|---|---|
| | (.670) | | | | |
| Years of openness | .854*** | .. | .. | .. | .. |
| | (.317) | | | | |
| Inflation volatility | -.001 | .. | .. | .. | .. |
| | (.025) | | | | |
| Financial development | .014*** | .. | .. | .. | .. |
| | (.004) | | | | |
| Institutions | .. | .. | .. | .. | .. |
| Schooling | .. | .. | .. | .. | .. |
| Log natural capital*malaria ecology | .. | .. | .. | .. | .. |
| N. Obs | 79 | 78 | 83 | 89 | 89 |
| R2 | 0.86 | 0.69 | 0.72 | 0.71 | 0.89 |

Table continues next page

Table A1 – Sensitivity analysis (continued)

| | VI | VII | VIII | IX | X |
|---|---|---|---|---|---|
| | GLS | 2SLS | 2SLS | GLS | GLS |
| | **The dependent variable is** | | | | |
| | Inst. quality | Inst. quality | Log pc income | Log pc income | Inst. Quality |
| Log natural capital | .135 | .251 | .259** | .393*** | .477*** |
| | (.170) | (.400) | (.132) | (.115) | (.139) |
| SSAfrica*log natural capital | -.572* | -.631** | .027 | -.052 | -.123 |
| | (.337) | (.318) | (.071) | (.162) | (.109) |
| Asia*log natural capital | .400** | .314 | -.069 | .114 | -.009 |
| | (.205) | (.332) | (.051) | (.145) | (.051) |
| Latin A*log natural capital | .550*** | .582*** | .008 | .368 | -.201*** |
| | (.208) | (.232) | (.199) | (.188) | (.031) |
| Malaria ecology | .003 | -.011 | -.056* | -.023* | -.312* |
| | (.025) | (.051) | (.036) | (.013) | (.173) |
| Log pc income 1970 | .806*** | .434 | .. | .. | .837*** |
| | (.163) | (1.180) | | | (.178) |
| Legal origin France | -.625** | -.655*** | .. | .. | -.461* |
| | (.287) | (.278) | | | (.266) |
| UK colony dummy | .. | .. | .. | .. | .. |
| Ethnic fractionalization | -.393 | -.581 | .. | .. | -.029 |
| | (.534) | (.842) | | | (.581) |
| Costal population | | .. | .621* | .608** | .. |

| | | | | | |
|---|---|---|---|---|---|
| | | | (.339) | (.265) | |
| Latitude | .. | .. | .. | .. | .. |
| Years of openness | .. | .. | .. | .. | .. |
| Inflation volatility | .. | .. | .. | .. | .. |
| Financial development | .. | .. | .. | .. | .. |
| Institutions | .. | .. | .577** | .. | .. |
| | | | (.239) | | |
| Schooling | .. | .. | -.230 | .. | .. |
| | | | (.171) | | |
| Log natural capital*malaria ecology | .. | .. | .. | -.291*** | -.038** |
| | | | | (.079) | (.021) |
| N. Obs | 78 | 78 | 75 | 89 | 78 |
| R2 | 0.79 | 0.77 | 0.67 | 0.75 | 0.76 |

Notes: All equations include a constant term and regional dummies for Sub-Saharan Africa, Asia, and Latin America. Estimates coefficients of these variables are not reported, but are available upon request. Heteroskedasticity consistent standard errors are reported in brackets. *, **, *** denote statistical significance at the 10%, 5%, and 1% confidence level respectively.

[20] Years of openness to international trade is measured as the proportion of total sample period that a country has been open to trade and is taken from Sala-i-Martin et al. 2004. Inflation volatility is defined as the sample period standard deviation of annual inflation rates and is computed from data in the World Development Indicators. Financial development is defined as the difference between M2 and currency in circulation outside banks in proportion of M2 (see Clague et al. 1999 and Dollar and Kraay, 2004).

Table A2 – First stage regressions

| | I | II | III | |
|---|---|---|---|---|
| | **The dependent variable in the first stage regression is** | | | |
| | Log pc income 1970 | Log pc income 1970 | Inst. quality | Schooling |
| Log natural capital | .170* | .164** | .041 | .507* |
| | (.091) | (.073) | (.167) | (.319) |
| SSAfrica*log natural capital | -.064 | .094 | -.288 | .107 |
| | (.313) | (.164) | (.295) | (.601) |
| Asia*log natural capital | -.089 | -.136 | .585*** | .022 |
| | (.152) | (.143) | (.211) | (.607) |
| Latam*log natural capital | .264** | .324** | .999*** | .922* |
| | (.103) | (.112) | (.251) | (.555) |
| Malaria ecology | -.028** | -.031*** | -.015 | -.026 |
| | (.015) | (.009) | (.036) | (.041) |
| Latitude | 1.973** | 2.197*** | 3.743*** | 4.463* |
| | (.797) | (.697) | (1.081) | (2.401) |
| Legal origin France | -.102 | .. | -0.834*** | -1.610** |
| | (.231) | | (.221) | (.811) |
| Ethnic fractionalization | .011 | .354 | .. | .. |
| | (.549) | (.391) | | |
| Costal population | .394*** | .802*** | .526 | 1.898*** |
| | (.115) | (.219) | (.345) | (.666) |
| UK colony dummy | .. | .004 | .798** | 1.311*** |
| | | (.014) | (.307) | (.417) |

| | | | | |
|---|---|---|---|---|
| N. Obs. | 78 | 83 | 75 | |
| Partial R2 | 0.27 | 0.34 | 0.39 | |
| Angrist-Pischke chi-sq | 16.87*** | 21.13*** | 18.49*** | 18.73** |
| Angrist-Pischke F test | 16.54 | 19.32 | 15.87 | 16.09 |
| (critical value) | (16.38) | (16.38) | (16.38) | (16.38) |

Notes: All equations are first stage OLS regressions in the 2SLS procedure. Column I is the first stage regression of the equation reported in column VI of table 1. Column II is the first stage regression of the equation reported in column VI of table 1. Column III shows the two first stage regressions of the equation reported in Column I of Table 2. The Partial R2 is the squared partial correlation. The Shea partial R2 is by definition identical to the reported partial R2 when there is only one endogenous regressor. In the case of Column III, with two endogenous regressors, the Shea partial R2 is 0.32. The statistics at the bottom of the table are the Angrist and Pischke (2009) chi squared and F statistics for the null hypothesis that individual endogenous regressors are, respectively, unidentified or weakly identified. Critical values for the T statistic are not available. Stock and Yogo (2005) are reported for comparison. *, **, *** denote statistical significance at the 10%, 5%, and 1% confidence level respectively.

Table A3: Sensitivity analysis – Panel estimates

| | I | II | III | IV | V | VI | VII |
|---|---|---|---|---|---|---|---|
| | random effects, GLS | fixed effects, GLS | fixed effects, GLS | Sys-GMM | fixed effect, 2SLS | Sys-GMM | Sys-GMM |
| Resource dep. | .548*** | .471*** | .377*** | .092*** | .123*** | .111*** | .053*** |
| | (.029) | (.032) | (.032) | (.013) | (.044) | (.016) | (.018) |
| SSAfrica*resource dep. | -.166*** | -.196*** | -.091* | -.039* | .135 | -.092*** | -.041*** |
| | (.054) | (.061) | (.043) | (.021) | (.093) | (.015) | (.015) |
| Asia*resource dep. | .162*** | .303*** | .273*** | .051*** | .429 | .011 | .004 |
| | (.055) | (.062) | (.067) | (.016) | (.067) | (.011) | (.011) |
| Latin A.*resource dep. | .362*** | .317*** | -.236 | -.022 | .069*** | -.045 | -.041 |
| | (.051) | (.052) | (.457) | (.104) | (.068) | (.137) | (.139) |
| Inst. Quality | .. | .. | .. | .. | .132*** | .036*** | .037 |
| | | | | | (.025) | (.007) | (.007) |
| Schooling | .. | .. | .. | .. | .085*** | .015* | .007 |
| | | | | | (.018) | (.009) | (.009) |
| Log pc income lag | .. | .. | .114*** | .817*** | .. | .683*** | .832*** |
| | | | (.013) | (.019) | | (.041) | (.042) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Investment ratio | .. | .. | .. | .. | .. | .. | .009*** |
| | | | | | | | (.001) |
| Population | .. | .. | .. | .. | .. | .. | -.006 |
| | | | | | | | (.024) |
| N.obs | 1006 | 1006 | 900 | 790 | 515 | 519 | 514 |

Notes: The dependent variable is log per capita income in all columns. The measure of resource dependence is the log of exports of natural resources per capita. Data are in panel format, averaged over five year period. Robust standard errors in brackets. Sys-GMM refers to the dynamic panel GMM estimator of Arellano and Bover (1995) and Blundell and Bond (1998). *, **, *** denote statistical significance at the 10%, 5%, and 1% confidence level respectively.

## Endnotes for Appendix 2

[1] Years of openness to international trade is measured as the proportion of total sample period that a country has been open to trade and is taken from Sala-i-Martin et al. 2004. Inflation volatility is defined as the sample period standard deviation of annual inflation rates and is computed from data in the World Development Indicators. Financial development is defined as the difference between M2 and currency in circulation outside banks in proportion of M2 (see Clague et al. 1999 and Dollar and Kraay, 2004).