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Development outcomes, resource abundance, and the transmission through inequality

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Abstract

The paper studies the effect of resource abundance on human development. A simple theory is presented to show that resource abundance negatively affects human development through its effect on inequality. The prediction of the theory is then tested using a system of three equations. Estimates indicate that the transmission channel through inequality is statistically significant and economically relevant even after controlling for per-capita income, institutional quality, and other determinants of both human development and inequality.

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1 Introduction

This paper documents the adverse effect that resource abundance has on human development through the dynamics of income inequality. In a simple theoretical model, capitalists allocate their wealth between resource-seeking and physical capital investment. A resource boom implies that less wealth is allocated to investment. This in turn reduces the marginal productivity of labour and drives the wage of workers in the productive sector down, while the rents of capitalists increase. Growing inequalities between capitalists and workers have an ambiguous effect on average per-capita income in the economy. However, a mean-preserving increase in income inequality unambiguously worsens human development, which is formally defined as a concave function of individual income. The econometric analysis tests the predictions of the theoretical model within the framework of a system of three equations. Estimates suggest that (i) resource abundance increases inequality after controlling for per-capita income, (ii) higher inequality reduces the average level of human development in the population, and (iii) resource abundance worsens institutional quality, but the effect of institutional quality on human development is not always significant once per-capita income and income inequality are controlled for.

The conventional wisdom holds that resource abundance is bad for economic growth. Gylfason et al. (1999), Gylfason (2001a) and Sachs and Warner (1999 and 2001) document a statistically significant inverse relationship between the size of the resource sector and economic growth in large cross-sections of countries. Work by Leite and Weidmann (1999), Ross (2001), Sala-i-Martin and Subramanian (2003), Isham et al. (2005) indicates that a large natural resource sector lowers the quality of governance and weakens state's capacity to deliver dynamically efficient policies. This negative institutional effect then results in slower growth.

Recent research provides some interesting challanges to the conventional wisdom. Stijns (2005), Gylfason and Zoega (2006), Brunnschweiler (2008), Brunnschweiler and Bulte (2008), and Alexeev and Conrad (2009) emphasize that empirical results are sensitive to the way in which natural resources are measured. Earlier papers typically employed the GDP share of the primary commodity sector and/or the total exports share of primary commodity exports as empirical proxies for resource abundance. However, these are indicators of resource dependence, rather than abundance, and they are likely to be endogenous with the dependent variable in income or growth regressions. When more specific measures of resource abundance, based on the estimated stock of natural capital and mineral assets per individual (see below for further discussion), are used, then results are reversed and resources are found to be positive for growth and, possibly, for institutional development as well.

A related strand of research argues that resources are not good or bad *per se,* but that their effects depend on some underlying structural conditions. In this sense, the findings reported by Gylfason (2001b), Mehlum et al. (2006), and Snyder (2006) suggest that what seems to matter for economic growth is the quality of resource management and of economic management and institutions in general. Hodler (2006) develops a theoretical model where resources are a curse only in ethnically fractionalised countries, while they are a blessing in homogenous countries. He then provides empirical evidence in support of this theoretical prediction. Collier and Hoeffler (2009) find that democratization of resource-rich countries can reduce growth unless the democratic process involves stronger checks and balances in policymaking. Finally, in Bhattacharyya and Hodler (2010) the effect of resource abundance on the quality of governance (i.e. the level of corruption) is conditional on the strength of democratic institutions.

While there is a voluminous literature on the growth and institutional effects of natural resources, only a few papers look at the impact of resource abundance on other aspects of the development process. Bulte et al. (2005) study the effect of resource intensity on different measures of human welfare. They conclude that any significant effect operates indirectly through institutional quality. Costantini and Monni (2008) analyse the interrelations between growth, institutional quality, human development, and resource . They find that more abundant natural resource endowments cause worse development outcomes by lowering the growth rate of the economy and by worsening the average quality of institutions. Gylfason (2008) discusses crowding out effects between natural capital and social capital, thus providing evidence of an adverse effect of natural resources on social development.

The purpose of this paper is to better understand the effects of natural resources on human development, whereby human development is defined by a combination of different social outcomes. This seems to be an important issue in view of the growing interest of the international community towards non-income dimensions of development. Given the state of the art in the literature, the analysis will investigate whether or not natural resources affect development *beyond* any effect they might have on per-capita income and institutional quality. In so doing, the paper considers a channel of transmission that previous literature has neglected: income inequality. In fact, the idea that natural resources cause inequality is not new (see Gylfason and Zoega, 2003). What is new is the theoretical and empirical investigation of how this inequality effect matters for human development. In other words, the paper argues, and demonstrates, that even if resources did not adversely affect per-capita income and institutional quality, their effect on inequality would still produce what can be regarded as a development curse.[1]

The rest of the paper is organised as follows. Section 2 presents a simple theoretical argument. Section 3 introduces the empirical analysis, with specifica attention to the issue of measuring resource abundance and instrumenting endogenous variables. Results are discussed in Section 4. Section 5 concludes. The appendix contains some proofs, statistical diagnostics, and the description of variables and data sources.

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[1] The medical literature on the effects of income inequality on population helath is also relevant to the topic of this paper. Wilkinson and Pickett (2006) conduct a meta-analysis of published work and conclude that, while the issue is still controversial, about 70% of the papers they surveyed suggest that health is less good in societies where income differences are bigger.

2 A simple theory

To provide some theoretical fundations to the econometric analysis, a simple two-sector model is presented in this section.

2.1 The economy

The economy consists of two sectors: natural reosurce and final good. In the natural resource sector, individuals make an initial investment and employ some search technology in order to appropriate (i.e. discover) new bundles of resources. Let r be the value of the resources discovered by a generic individual and s her initial investment. Then $r - s$ is the resource rent and it is expressed as follows:

$$r - s = \gamma f(s) \tag{1}$$

where $\gamma \geq 0$ and $f'(s) > 0$ and $f''(s) < 0$

The intution underlying (1) is that discovering new bundles is a stochastic process (very much in line with the formalization of Gylfason and Zoega, 2003). How many bundles, and of which value, are discovered will depend on (i) the initial investment in the search process, (ii) the producitivity of the search technology, and (iii) country's endowment of natural resources. The effect of initial investment and search technology are captured by the term $f(s)$. The assumptions concerning the sign of the first and second derivative of the f function imply that investment in the resource sector is characterized by diminishing marginal products. The parameter γ instead captures the effect of country's endowment. Intuitively, if a country has no resources to start with, or if its resources have no market value, so that $\gamma = 0$, then an individual can invest all of her wealth and emply the best possible search technology and still her rent will be zero simply because there are no resources to discover and appropriate. Conversely, if the country is well endowed with valuable natural resources, and hence γ is large, then the number of bundles discovered for any given investment and technology is higher and the rent will also be higher.

In the final good sector, a large number of perfectly competitive firms produce a homogenous good that can be consumed or invested. The production function of the generic firm i is a Cobb-Douglas with labour augmenting technological progress:

$$Y_i = (AL_i)^{1-\beta} K_i^{\beta} \tag{2}$$

where Y denotes firm's output, L and K are firm's inputs of labour and capital, A is the aggregate stock of ideas, and $0 < \beta < 1$.

Following Romer (1986), learning-by-doing and perfect knowledge spillovers imply that $A = \sum_i K_i = K$. The aggregate production function is then obtained by aggregating equation (2) over all is:

$$Y = KL^{1-\beta} \tag{3}$$

where $Y = \sum_i Y_i$ and $L = \sum_i L_i$. In the absence of population growth, equation (3) belongs with the class of AK production functions.

The eocnomy is populated by individuals of two types: capitalists (P) and workers (W). There are no demographic dynamics, meaning that the number of both capitalists and workers is constant and the ratio of capitalists to workers is equal to v, with $v < 1$. The generic individual in each group lives for two periods. In the first period she earns an income a, either by working or by investing. In the second period she spends all of her income to consume the homogenous good produced by the competitive firms. Through consumption, the individual achieves a given level of human development h. The relationship between human development and consumption is given by:

$$h_j = c_j^{\epsilon} \tag{4}$$

where h_j denotes the level of human development of an individual of type j ($j = P, W$), c_j is consumption of the individual of type j, and $0 < \epsilon < 1$.

To simplify the discussion, it will be assumed that one unit of the income earned in period 1 buys one unit of consumption in period 2, so that in the end human development in the second period is a concave function of the income earned in the first period. The objective of the individuals is therefore to maximise first period earnings as this will imply the highest possible level of human development in the second period.

The representative capitalist is initially endowed with one divisible unit of wealth. This unit of wealth can be invested in the discovery of new resources or rented to firms as physical capital. The representative worker is endowed with one unit of labour that she inelastically supplies to the perfectly competitive firms in the final good sector. If workers cannot borrow against their future labour income, then they cannot afford the initial investment in the natural resource sector. Therefore, only capitalists populate the natural resource sector.

2.2 Allocative choices and equilibrium

This subsection studies the equilibrium choices of the representative individuals and how these choices are affected by changes in country's resource endowment γ. The function $f(s)$ in equation (1) is assumed to take the form s^{α}, with $0 < \alpha < 1$. The resource rent earned by the capitalist is therefore:

$$r - s = \gamma s^{\alpha} \tag{5}$$

It is worth stressing that s represents the proportion of initial wealth that the capitalists allocates to the discovery of natural resources. Therefore, $s < 1$ and s^{α} is decreasing in α.[2] In this sense, lower values of α denote a more efficient

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[2] The margina product of s is instead a non-linear function of α and has a maximum at $\alpha = -\frac{1}{\ln(s)}$

technology; that is, a technology that allows to earn higher rents for any given s and γ.

Letting ρ denote the rental price of physical capital, the maximization problem of the representative capitalist is :

$$\max_{s} a_P = (r - s) + \rho(1 - s) \tag{6}$$

subject to (5) and to the first order condition for the maximization of firm's profit $\rho = L^{1-\beta}$.

For $0 < \gamma < \frac{\rho}{\alpha}$, the problem has an internal solution given by[3]:

$$s = \left(\frac{\alpha\gamma}{\rho}\right)^{\frac{1}{1-\alpha}} \tag{7}$$

Equation (7) then implies that the income earned by the representative capitalist in equilibrium is:

$$a_p = \gamma^{\frac{1}{1-\alpha}} \left(\frac{\alpha}{\rho}\right)^{\frac{\alpha}{1-\alpha}} (1 - \alpha) + \rho \tag{8}$$

Equation (7) suggests that the proportion of wealth allocated by the capitalist to the resource sector is higher the more resource abundant the country is. Moreover, from equation (8) it can be seen that $\frac{\partial a_P}{\partial \gamma} = \left(\frac{\alpha\gamma}{\rho}\right)^{\frac{\alpha}{1-\alpha}}$ is strictly positive, meaning that the capitalist earns a higher income the more resource abundant the country is. It is also worth stressing the that capitalist's income in equilibrium declines as α grows; that is, a less efficient search technology reduces the earnings of the capitalist for any given level of country's resource abundance.

The representative worker does not have much of a choice in this model. She can only supply her unit of labour to firms in the final good sector and earn a the market clearing wage. Her income in the first period is therefore:

$$a_W = K(1 - \beta)L^{-\beta} \tag{9}$$

The stock of physical capital K is determined by the allocative decision of the capitalists. Letting N be the total number of capitalists in the economy, equation (7) implies:

$$K = N \left[1 - \left(\frac{\alpha\gamma}{L^{1-\beta}}\right)^{\frac{1}{1-\alpha}}\right] \tag{10}$$

Given that L is equal to the number of workers and that the ratio of capitalists to workers is assumed to be constant and equal to υ, then $N/L = \upsilon$ and equation (10) can substituted into equation (9) to obtain:

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[3] For $\gamma > \frac{\rho}{\alpha}$ profit maximization yields the corner solution $s = 1$. For $\gamma < 0$, the corner solution would be $s = 0$.

$$a_W = (1-\beta)vL^{1-\beta}\left[1-\left(\frac{\alpha\gamma}{L^{1-\beta}}\right)^{\frac{1}{1-\alpha}}\right] \tag{11}$$

Equation (11) has a very intuitive meaning: workers earn a lower income in resource-richer countries. This is because of the crowding-out effect between the natural resource sector and the final good sector. In resource-richer economies, the capitalist invests more of her initial wealth in searching for new bundles, thus leaving less wealth available for investment in physical capital. In turn, a lower level of physical capital reduces the marginal producitivity of labour in the final good sector and therefore results in a lower market clearing wage. Formally, $\frac{\partial a_W}{\partial \gamma} = -\frac{(1-\beta)}{(1-\alpha)}vL^{1-\beta}\left(\frac{\alpha}{L^{1-\beta}}\right)^{\frac{1}{1=\alpha}}\gamma^{\frac{\alpha}{1-\alpha}}$ is negative.

With $\rho = L^{1-\beta}$, comparison between equation (8) and equation (11) immediately reveals that a_P is always larger than a_W and that the gap between the income of the two representative individuals widens as γ grows. This is obvious since the derivatives $\frac{\partial a_P}{\partial \gamma}$ and $\frac{\partial a_W}{\partial \gamma}$ are of opposite sign. Under the assumption that the relative size of the two groups of workers is constant, both the standard deviation of per-capita incomes around the mean and the Gini coefficient are proportional to the gap between a_P and a_W.This implies that income inequality is higher the more resource abundant the country is.

2.3 Closure

Average human development, $\bar{h}$, and average income, $\bar{a}$, are formally equal to:

$$\bar{h} = v\left(a_P\right)^{\epsilon} + (1-v)\left(a_W\right)^{\epsilon} \tag{12}$$

$$\bar{a} = va_P + (1-v)a_W \tag{13}$$

The effect of resource abundance is therefore captured by the derivatives $\frac{\partial \bar{h}}{\partial \gamma}$ and $\frac{\partial \bar{a}}{\partial \gamma}$. As shown in the Appendix, neither of the two can be signed with certainty. However:

Proposition 1 $\frac{\partial \bar{h}}{\partial \gamma}$ *is certainly negative for* $\frac{\partial \bar{a}}{\partial \gamma} = 0$.

Proof. See Appendix.

Proposition 2 *The likelihood of* $\frac{\partial \bar{h}}{\partial \gamma}$ *being negative is higher the wider the gap between* a_P *and* a_W.

Proof. See Appendix.

These two simple propositions summarize the theoretical effect of country's resource abundance on average human development and average income. Of particular interest for empirical purposes is proposition 1. This proposition implies that an increase in γ that leaves $\bar{a}$ unchanged unambigously reduces $\bar{h}$. That is, holding per-capita income constant, higher resource abundance reduces average human development by raising income inequality in the economy. The intuition underlying this result is that as natural resources crowd out the final good sector, capitalists receive a higher income and therefore improve their human development while the opposite happens with workers. However, because of the concavity in the relationship between human development and income, the increase in human development of the capitalits is relatively weaker than the decrease in human development of the workers. Average human development is therefore reduced for any increase in resource abundance that preserves mean income. In fact, proposition 2 suggests that even without holding mean income constant, a wider gap between income of capitalists and income of workers is likely to determine an overall decrease in average human development in response to an increase in resource abundance.

3 Empirical model and data

3.1 Specification and estimation method

The prediction of the theoretical model is that resource abundance lowers human development, after controlling for the level of per-capita income, through its effect on the inequality of income distribution in the economy. The empirical test of this prediction involves the estimation of two structural relations:

$$Inequality_{c,t} = \eta_0 + \eta_1 natural\_resources_{c,t} + HZ_{c,t} + \varepsilon_{c,t} \tag{14}$$

$$Human\_devolpment_{c,t} = \kappa_0 + \kappa_1 Inequality_{c,t} + KW_{c,t} + \upsilon_{it} \tag{15}$$

where Z and W are vectors of controls, c denotes a generic country, t is time, ε and υ are error terms, and ηs, κs, H, and K are the parameters to be estimated.

Equation (14) captures the inequality effect of resource abundance while equation (15) accounts for the transmission channel of the effect of natural resources on human development through the dynamics of inequality. Based on the theoretical model, the expectation is that $\eta_1 > 0$ and $\kappa_1 > 0$.

In order to allow for possible correlation in the residuals across equations, and hence achieve some gain in efficiency, the two equations should be estimated together as a system. However, system estimation is not immune from shortcomings. In particular, if one of the equations were misspecified, then the estimates of the other equation would be affected too. The practical solution to this stalmate is to estimate first the two equations individually, using standard two stage least squares (2SLS) to account for the possible endogeneity of some of the regressors. Then, the equations are jointly estimated as a system using a GMM estimator. System and single equation estimates can thus be compared in order to detect any significant differences in the results.[4]

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[4] See Wooldrdige (2002) for a discussion of the GMM estimator. It is worth stressing that the more traditional three stage least squares estimator (3SLS) is a special case of the GMM estimator. As further discussed below, system estimates obtained with 3SLS are not significantly different from those obtained with the GMM estimator.

3.2 Choice of variables

Income inequality is measured by the Gini index. Resource abundance is measured by the log of subsoil assets in US$ per capita, using data provided by World Bank (1997). This choice is in line with the most recent literature (see for instance Brunnschweiler and Bulte, 2008 and Alexeev and Conrad, 2009) and addresses some of the shortcomings associated with the traditional approach of measuring dependence as the GDP or total exports share of primary commodity exports (see Sachs and Warner, 1999 and 2001). Subsoil wealth rather than total natural capital (which would include land, forests, and timber resources in additional to subsoil assets) is used because it appears to be closer to the notion of resource abundance portrayed in the theoretical model. In fact, one should note that the correlation between subsoil assets and total natural capital is high (0.55) and statistically significant at the 1% confidence level.[5]

The main limitation of the subsoil assets data is that they are not available on a time-series dimension and therefore, in a panel regression, they work as time-invariant country-specific effect. For this reason, other recent papers (i.e. Collier and Hoeffler, 2008 and Bhattacharyya and Holder, 2010) employ the adjusted net savings dataset described by Hamilton and Clemens (1999) and available through the World Bank Development Indicators. Once again, correlations between these data and subsoil assets data are very high (around 0.4) and significant. All of the regressions reported in the next subsection have been re-estimated using the adjust net savings dataset and results appear to be robust.

The empirical measurement of human development is also a controversial issue. Previous literature makes use of several dissagregate indicators of social outcomes (i.e. child mortatlity rate, primary or secondary enrollment rate, life expectancy, etc...). However, if one is interested in the joint evolution of different development dimensions, then some sort of aggregate measure ought to be employed. Constantini and Monni (2008) for instance use the Human Development Index (HDI) of the United Nations Development Programme (UNDP, 1990), which however is obtained from an arbitrary choice of weights in the aggregation of the individual components.

In this paper, human development is defined as the first princinpal component of life expectancy at birth, rate of children immunization against diphteria, pertussis, and tetanus, and averge years of education in the population. While principal components guarantees that weights are not chosen ad-hoc, one has to recognize that the selection of the individual components to be included in the aggregate measure is still arbitrary and therefore open to criticism. In defense of this choice it can be said that (i) adding more individual components does not seem to change the dynamics of the aggregate measure by much and (ii) data on life expectancy, immunization rates, and schooling are available for

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[5] World Bank (2005) reports other natural capital data that could be used to proxy for resource abundance. The correlation between the 1997 and 2005 data is very high. For subsoil assets, the correlation coefficient is 0.95 and for total natural capital it is 0.86. Not surprisingly, estimates obtained using the 2005 data are qualitatively identical to estimates obtained from the 1997 data.

most countries over sufficiently long time-series (the same is not necessarily true for other measures of human development).

The vector of controls H includes: the log of per-capita GDP, a measure of institutional quality, and a measure of ethnic fragmentation. The role of per-capita income and institutional quality in determining income inequality is discussed in Carmignani (2009). Istitutional quality is measured by one minus the ratio of currency in circulation to M2 (see Clague et al. 1999 and Dollar and Kraay, 2004). This variable measures the extent to which property rights are sufficiently secure that individuals are willing to hold liquid assets via financial intermediaires. It has at least two relevant advantages over other measures of institutional quality: (i) it is objective and (ii) it is available on an annual basis for many countries.[6] Ethnic fragmentation is likely to matter because it affects public goods provision and redistribution (see for instance Alesina et al. 1999 and 2000).

The vector K includes log per-capita income and institutional quality, in line with Bulte et al. (2005). In addition, two country-fixed effects are controlled for: distance from the equator and settler's mortality rate. Distance from the equator is intended as a rough proxy for the incidence of fatal diseases such as malaria and yellow fever. The inclusion of the settler's mortality rate as a regressor instead follows the argument put forward by Glaeser et al. 2004. They suggest that what European settlers brought to colonies was not just a new institutional setting, but also human capital. They then show that the correlation between educational outcomes and settler's mortality is in fact generally high. Therefore, settler's mortality is likely to be a relevant determinant of human development, when this latter is broadly defined to include health and education.

3.3 Choice of instruments

A key problem in estimating equations (14) and (15) is that some of the regressors might be endogenous to the dependent variables and therefore need to be instrumented. While subsoil assets is likely to be an exogenous variable (see Brunnschweiler and Bulte, 2008), per-capita income and institutional quality might be affected by inequality and/or human development. To identify appropriate instruments, one shuld then look at the literature on the long-term determinants of income and institutional quality and see which variables are generally used as controls.[7] One such variables is distance from the equator. However, this can be used as an excluded instrument only in equation (14) as it is already included as a regressor in equation (15). Settler's mortality is a popular instrument for institutional quality, but again it appears as a regressor in equation (15) and therefore it can work as an excluded instrument only in

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[6] Regressions were also estimated using an alternative definition of institutional quality: the index of quality of the legal system of Economic Freedom of the World (see Gwartney and Lawson, 2009). Results do not change to any significant extent.

[7] Determinants of institutions and income are often studied together, see for instance Acemogu et al. 2001 and Glaeser et al. 2004. Other well known studies of the determinants of income include Nunn, 2008 and Alexeev and Conrad, 2009. On the determinants of institutional quality see the seminal paper by La Porta et al. 1999.

equation (14). Other excluded instruments to be used in both equations would be desirable in order to increase the number of overidentfying restrictions. Regional dummies and dummies for legal origin can serve this purpose. Indeed, regional effects are often found to be relevant in explaining long-term differences in income levels across countries. Regional dummies might therefore instrument for per-capita GDP. Legal origins are instead identifed as key determinants of institutional quality. Dummy variables for English, Scandinavian, German, and Socialist legal origins are therefore used as instruments for institutional quality.

Furthermore, when the equations are not estimated as a system, the likely endogeneity of inequality and human development in equation (15) should also be addressed through the choice of an instrument for inequality. In fact, the specification of equation (14) immediately suggests using ethnic fragmentation as an instrument for inequality.

All of these instruments are time-invariant and should therefore be predetermined relative to income and institutional quality. The J-test confirms that the overindifying restrictions implied by the choice of instruments are valid. Measures of goodness of fit of the first stage regression in the 2SLS also indicate that the chosen instruments are likely to be relevant.[8]

4 Results

The equations are estimated on data for 65 countries for the period 1980-2005. Data are averaged over sub-periods of five year so that at most five observations per country are available. This implies a total of 325 potential observations. In fact, due to missing data, the panel is unbalanced and the effective number of observations available for estimation is considerably smaller than the potential.

Table 1 reports 2SLS estimates of equations (14) and (15). Starting with equation (14), the coefficients in column I indicate that resource abundance increases inequality after controlling for the effect of per-capita GDP. The inequality-reducing effect of institutional quality is in line with previous research (see Carmignani, 2009) while the negative coefficient of ethnic fragmentation is in line with the "disguised" redistributive policy hypothesis of Alesina et al. 2000. The lack of significance of the coefficient of per-capita GDP might be due to multicollinearity between per-capita GDP and institutional quality.

As discussed in the previous section, several different measures of resource abundance have been used in the literature. When resource dependence is measured by the total natural capital or resource rents measured from the adjusted saving datasets, estimated coefficients are virtually equal to those reported in column I. Some changes are instead observed when a measure of resource dependence (exports of fuels and metals in percent of total merchandise export) replaces the measure of resource abundance. Estimated coefficients in column II show that in this case resources appear to play no role in determining in-

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[8] The J-statistic is reported at the bottom of the tables in the next section. The associated p-value is always larger than 0.1, suggesting that the null hypothesis cannot be rejected at usual confidence levels. The first stage diagnostics are instead provided in the Appendix.

equality. However, the resource dependence measure is likely to be endogenous with income inequality.[9] Following Brunnschweiler (2008), resource dependence is instrumented by two indicators of constitutional arrangements: the type of regime (i.e. presidential, parliamentary, or assembly elected) and the type of electoral rule (proportional vs. majoritarian). The regression with resource dependence treated as an endogenous variable are shown in column III. The inequality-increasing effect of natural resources returns to be significant, but the coefficient of institutional quality is no longer different from zero.

Turning to equation (15), estimates in column IV indicate that higher inequality worsens human development. Combined with the result that resource abundance increases inequality, this finding provide support to the theoretical prediction: resource abundance negatively affects human development through its effect on income inequality. Interestingly, estimates also suggest that after controlling for the level of per-capita income, institutional quality does not determine human development. This finding however changes when the two equations are estimated as a system (see below). Looking at the other controls, settler's mortality is largely insignificant while distance from the equator appears to reduce human development. This latter result is counter-intuitive and might be due to the fact that latitude is a poor proxy the incidence of diseases.

The specification presented in column V accounts for the possibility that there is a residual direct effect of resource abundance on human development after controlling for inequality, institutions, and per-capita income. The estimated coefficient of the natural resource variable suggests that this residul effect is significant and has the same sign as the indirect effect operating through inequality. The mechanics of this residual effect should be investigated in future work.

INSERT TABLE 1 ABOUT HERE

System estimates are reported in table 2. In general, it appears that estimates are more precise. This gain in efficiency results from the fact that the system estimator allows for non-zero correlations between the error terms of the two equations. The core of the findings is confirmed. In column I, resource abundance is still a significant determinant of inequality. In column II, higher inequality reduces human development and there is again evidence of a significant direct effect of resource abundance. There is however an important new finding: the coefficient of institutional quality is now significant, even if only at the 10% confidence level. Therefore, there is evidence of a positive effect of good institutions on human development.

The last three columns of table 2 report estimates from an extended system of equation. In addition to equations (14) and (15), the system now includes an equation for the determinantion of institutional quality:

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[9] The p-value associated with the J-statistic in column II is actually 0.11. Therefore, the null hypothesis that the overidenfying restrictions are valid can still be rejected, but at a rather low confidence level.

$$Institutional\_quality_{c,t} = \varpi_0 + \varpi_1 natural\_resources_{c,t} + \Omega S_{c,t} + \xi_{c,t} \quad (16)$$

where S is a vector of controls, ξ is the error term, and ϖs and Ω are the parameters to be estimated.

With equation (16), the empirical model integrates two channels of transmission from resource abundance to human development: the inequality channel theorized in this paper and the institutional channel studied by Bulte et al. (2005) and Costantini and Monni (2008). The choice of controls for equation (16) draws on La Porta et al. (1999), but with a major modification: the inclusion of the settler's mortality rate (in line with Acemoglu et al. 2001). The estimated coefficients of equations (14) and (15) are qualitatively the same as those reported in column II and III. Therefore the key findings concerning the role of resource abundance and the transmission via income inequality survive. The coefficients reported in column V however indicate that resource abundance worsens institutional quality and therefore affects human development also through this negative institutional effect. In other words, the effect through inequality does not eliminate the effect through inequality that has been identified by Bulte et al. (2005). The two effects operate together and in the same direction: higher resource abundance results in lower human development.

INSERT TABLE 2 ABOUT HERE

5 Conclusion

The paper uses a simple theoretical framework to investigate the effect of resource abundance on human development. The theory predicts that higher resource abundance worsens average human development through its effect on the inequality of income distribution in the economy. This prediction is then empirically tested using a system of three equations. Estimates indicate that resource-rich countries do tend to experience higher inequality and that higher inequality reduces human development. This effect via inequality adds to the effect that natural resources have on human development through the quality of institutions. Therefore, the inequality channel and the institutional channel co-exist and operate in the same direction. However, estimates also suggest that a third channel of transmission is at work. An hypothesis to be tested in future work is that this third channel operates through the volatility of growth. In a nutshell, resource-rich economies would experience greater volatility because they are exposed to changes in international commodity prices. If volatility has asymmetric effects; that is, if recession hurt the poor more than the rich and expansions benefit the rich more than the poor, then higher volatility would reduce human development.

From a policymaking perspective, the results of this paper assign a critical role to redistribution in buffering the adverse effects of resource abundance on development prospect. Of course, redistribution is not meant to substitute for institutional reforms, which are desirable not just to avoid the resource curse, but also to promote growth and improve economic outcomes. However, tackling the inequalities associated with resource abundance will help transform the curse into a potential blessing.

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6 Appendix

6.1 Proof of proposition 1

From equation (12) the derivative of $\bar{h}$ w.r.t. γ is:

$$\frac{\partial \bar{h}}{\partial \gamma} = v\epsilon(a_P)^{\epsilon-1}\frac{\partial a_P}{\partial \gamma} + (1-v)(a_W)^{\epsilon-1}\frac{\partial a_W}{\partial \gamma} \tag{17}$$

From equation (13) the derivative of $\bar{a}$ w.r.t. γ is

$$\frac{\partial \bar{a}}{\partial \gamma} = v\frac{\partial a_P}{\partial \gamma} + (1-v)\frac{\partial a_W}{\partial \gamma} \tag{18}$$

To be mean-preserving, a chance in γ must be such that $\frac{\partial \bar{a}}{\partial \gamma} = 0$; that is:

$$\frac{\partial a_P}{\partial \gamma} = -\frac{(1-v)}{v}\frac{\partial a_W}{\partial \gamma} \tag{19}$$

Substituting (19) into (17) and rearranging terms:

$$\frac{\partial \bar{h}}{\partial \gamma} = \epsilon(1-v)\frac{\partial a_W}{\partial \gamma}\left[(a_W)^{\epsilon-1} - (a_P)^{\epsilon-1}\right] \tag{20}$$

In equation (20), ϵ is positive and $1-v$. As shown in the text, $\frac{\partial a_W}{\partial \gamma}$ is negative and $a_P > a_W$. This latter inequality implies that the term in square brackets is positive, so that in the end $\frac{\partial \bar{h}}{\partial \gamma}$ must be negative. Therefore, for $\frac{\partial \bar{a}}{\partial \gamma} = 0$, $\frac{\partial \bar{h}}{\partial \gamma}$ is negative.

6.2 Proof of proposition 2

From equation (8) the derivative of a_P w.r.t. γ is:

$$\frac{\partial a_P}{\partial \gamma} = \left(\frac{\alpha\gamma}{\rho}\right)^{\frac{\alpha}{1-\alpha}} \tag{21}$$

From equation (11) the derivatve of a_W w.r.t. γ is:

$$\frac{\partial a_W}{\partial \gamma} = -\frac{(1-\beta)}{(1-\alpha)} v\rho \left(\frac{\alpha}{\rho}\right)^{\frac{1}{1=\alpha}} \gamma^{\frac{\alpha}{1-\alpha}} \tag{22}$$

where is use made of the fact that in equilibrium $\rho = L^{1-\beta}$

Substituting (21) and (22) into both (17) and (18), closed forms of $\frac{\partial \bar{h}}{\partial \gamma}$ and $\frac{\partial \bar{a}}{\partial \gamma}$ are obtained:

$$\frac{\partial \bar{h}}{\partial \gamma} = \epsilon \left(\frac{\alpha\gamma}{\rho}\right)^{\frac{\alpha}{1-\alpha}} v \left[(a_P)^{\epsilon-1} - (1-v)\frac{\alpha(1-\beta)}{1-\alpha}(a_W)^{\epsilon-1}\right] \tag{23}$$

$$\frac{\partial \bar{a}}{\partial \gamma} = \left(\frac{\alpha\gamma}{\rho}\right)^{\frac{\alpha}{1-\alpha}} v \left[1 - (1-v)\frac{\alpha(1-\beta)}{1-\alpha}\right] \tag{24}$$

The sign of both derivatives is uncertain and depends on the relative size of model parameters. Focusing on equation (23), the term $\epsilon \left(\frac{\alpha\gamma}{\rho}\right)^{\frac{\alpha}{1-\alpha}} v$ is positive, so that the sign of the derivative is determined by the sign of the expression in square brackets. While this expression cannot be signed unambiguously, an increase in a_P and a contemporaneous decrease in a_W (that is, a wider gap between a_P and a_W) increase the likelihood that it is negative and therefore that $\frac{\partial \bar{h}}{\partial \gamma} < 0$.

6.3 First stage diagnostics

To be valid, instruments must be exogenous and relevant. The J-test reported at the bottom of tables 1 and 2 indicates that the overidentfying restrictions implied by the choice of instruments cannot be rejected, thus providing some evidence that the instruments are likely to be exogenous. To assess relevance, instead, various measures of goodness of fit of the first stage regression in the 2SLS procedure are reported in Table 3. For each endogenous regressor, the table gives the R^2, partial R^2 and associated $F-$statistic, and the Shea (partial) R^2. The traditional R^2 is not particularly informative in this context. More interesting are the other two R^2, which are computed by partialling out included instruments. In particular, the Shea's R^2 takes into account interrelations between excluded instruments when there are two or more endogenous variables. As can be seen from the table, the F-test associated with the partial R^2 always rejects the null hypothesis that the excluded instrument are not significant in the first stage regression. At the same time, Shea R^2 is numerically very close to the partial R^2. As discussed for instance in Baum et al. (2003) this suggests that the chosen instruments are effectively relavant.

INSERT TABLE 3 ABOUT HERE

6.4 List of variables and data sources

- Human development: principal component of (i) life expectancy at birth, (ii) percentage of children ages 12-23 months who recieved vaccination against diphteria, pertussis, and tetanus, (iii) average number of years of schooling in the population. Source: life expectancy and immunization data are taken from the World Development Indicators, education data are from Barro and Lee (2001) and updates from ILo and UNESCO.

- Inequality: Gini coefficient of income distribution. Source: United Nations University - WIDER database.

- Per-capita GDP: log or GDP per-capita in constant US dollars. Source: World Development Indicators

- Natural resources: the main reference variable is the log of subsoil assets per-individual in US dollars from World Bank (1997). The following other variables are used in some regressions: log of natural capital per-individual in US dollars (World Bank, 1997), ratio of exports of fuels and metals to total merchandise exports (World Development Indicators), and log of per-capita rent from energy, minerals, and forestry (World Development Indicators)

- Institutional quality: the main reference variable is 1 minus the ratio of currency in circulation to M2. This is constructed following the deifnition in Clague et al. (1999) and using data in the Internaitonal Financial Statistics of the IMF. For the sensitivity analysis, the index of quality of the legal environment provided by the Economic Freedom of the World is used.

- Ethnic fragmentation: probability that two randomly selected individuals do not belong to the same ethnic group (La Porta et al. 1999)

- Latitude: countr's latitude, measured at the capital city (La Porta et al. 1999)

- Legal origin: dummy variables taking value 1 if the countr's legal system originates from the UK common law, the French civil code, the German commercial code, the Scandinavian commercial code, or the Socialist legal framework (La Porta et al. 1999)

- Settler's mortality: mortality rate of European settlers (Acemoglu et al. 2001)

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Tables

Table 1: Single equation estimates

	I	II	III	IV	V
	Inequality	Inequality	Inequality	Human dev.	Human dev.
Constant	63.094***	72.898***	72.121***	-6.827***	-6.145
Natural resources	0.756**	0.004	0.392***	..	-0.068***
Institutional quality	-5.092**	-5.005**	-1.764	0.139	0.124
Ethnic fragment.	-9.746**	-11.971***	-12.505**	..	
Per-capita GDP	-0.545	-1.351	-3.609	0.985***	0.988***
Inequality	..	..	..	-0.018***	-0.025**
Latitude	..	..	..	-1.387***	-1.413*
Settler's mortality	..	..	..	0.001	0.001
N.Obs	147	156	150	139	134
J-statistic	10.47	20.89	11.03	1.89	4.17

Notes: Estimation is by 2SLS. Instrumented variables are institutional quality and per-capita GDP in all columns plus natural resources in column III and inequality in columns IV and V. In columns I and II the excluded instruments are: latitude, settler's mortality, regional dummies, and legal origin dummies. In column III the excluded instruments are as in columns I and II plus the constitutional variables for type of regime and type of electoral rule. In column IV and V excluded instruments are: ethnic fragmentation, regional dummies and legal origin dummies. The J-statistic is the statistic of the test of overidentifying restrictions. The associated p-value is always smaller than 0.1, implying that the null hypothesis that overidentfying restrictions are valid cannot be rejected. *, **, *** denote statistical significance of estimated coefficients at the 1%, 5%, and 10% confidence level repsectively.

Table 2: System estimates

	I Inequality	II Human dev.	III Inequality	IV Human dev	V Inst. quality
constant	53.314	-6.496**	56.331***	-6.593***	-3.967***
natural resources	0.721**	-0.075***	0.747**	-0.076***	-0.075***
Institutional quality	-8.876***	0.246*	-8.728***	0.269**	..
Ethnic fragment.	-11.581***	..	-12.667***	..	..
per-capita GDP	2.415	1.011***	2.046	1.016***	0.873***
Inequality	..	-0.027***	..	-0.027***	..
Latitude	..	-1.726**	..	-1.8**	0.882*
settler's mortality	..	0.001	..	0.001	0.001
Legal origin UK	..	..	..	..	1.021***
N. Obs	291		653		
J-statistic	14.82		7.23		

Notes: Estimation is by GMM. Instrumented variables are institutional quality and per-capita GDP. Excluded instruments are: latitude, settler's mortality, regional dummies, and legal origin dummies (with the exception of dummy for UK legal origin in columns II, IV, and V). The J-statistic is the statistic of the test of overidentifying restrictions. The associated p-value is always smaller than 0.1, implying that the null hypothesis that overidentfying restrictions are valid cannot be rejected. *, **, *** denote statistical significance of estimated coefficients at the 1%, 5%, and 10% confidence level repsectively.

Table 3: Goodness of fit of first stage regression in 2SLS estimation

	R^2	Partial R^2	F-stat	Shea R^2
Column I				
Institutional quality	0.26	0.19	4.66***	0.21
Per-capita GDP	0.58	0.34	10.53***	0.38
Column II				
Institutional quality	0.26	0.19	4.91***	0.18
Per-capita GDP	0.53	0.38	12.95***	0.37
Column III				
Institutional quality	0.25	0.21	4.01***	0.19
Per-capita GDP	0.49	0.36	8.54***	0.36
Natural resources	0.15	0.15	2.72***	0.13
Column IV				
Institutional quality	0.22	0.11	3.35***	0.13
Per-capita GDP	0.47	0.26	9.40***	0.37
Inequality	0.43	0.36	14.54***	0.35
Column V				
Institutional quality	0.24	0.10	2.81***	0.13
Per-capita GDP	0.57	0.31	11.09***	0.42
Inequality	0.46	0.37	14.89***	0.40