Does Inequality Drive the Dutch Disease? Theory and Evidence*

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Abstract

In this paper we show that the Dutch disease can arise solely from inequality in the distribution of natural resource rents. Given two otherwise identical countries that differ only in the ownership shares of the natural resource rents, the country with the less equal distribution will have less production of manufacturing goods and less development of learning-by-doing in this sector. As opposed to conventional models, where income distribution has no effect on economic outcomes, an unequal distribution of the resource wealth can generate the Dutch disease dynamics even in countries with an initial comparative advantage in manufacturing. We also provide a range of empirical tests of our model, including both difference and system GMM estimators in a dynamic panel. To disentangle the effects of inequality and institutional quality we purge our inequality measure of any linear or higher order correlations with institutional quality and repeat our system and difference GMM estimations. Our empirical analysis supports the hypothesis that inequality indeed plays a significant role in whether being resource-rich is a blessing or a curse for a country. The more unequal is the distribution of natural resource rents, the stronger is the disease.

JELClassification: F11, D31, Q32

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1 Introduction

The Dutch disease is an old, well-known, and still relevant paradox in economics. It describes how the initial good fortune of an exhaustible natural resource find (or a commodity price boom, or a foreign transfer) can turn sour in the long run. In this paper we show that this phenomenon can arise solely because of the unequal distribution of the natural resource rents. In particular, we demonstrate that a mean-preserving increase in the inequality of the natural resource rent distribution can generate manufacturing sector stagnation and lower long-run growth, even in a country with a smaller resource base and (initially) higher manufacturing productivity than its trading partners.

In our framework the Dutch disease stems from a shift in demand, without a production movement or increased wage effect. With a new-found wealth from the resource discovery, the demand for non-tradable luxury consumption services increases.[1] Consequently, labor that could be used to develop the manufacturing sector is pulled into the service sector and manufactured goods become more likely to be imported. Although the economy may develop increased expertise in the service sector, most of these luxury services are targeted at domestic consumption and not easily exportable. Moreover, because manufacturing is more prone to learning and production process improvements, the potential gains in productivity accrue to foreign exporters. As a result, once the resource is diminished, there is less income to purchase the services and, thus, the resource find can generate economic stagnation.

The key to our model is an increase in the share of income spent on luxury services that accompanies the new-found resource wealth. The marginal (and average) propensities to consume are commonly assumed to be independent of income in the literature. These constant income share assumptions, which rely on homothetic preferences, however, have two limitations. First, they are repeatedly contradicted by empirical evidence.[2] Second, aggregate demand is not affected by income distribution under the assumption of homothetic preferences. As the distribution of natural

[1]We use the term "luxury" to indicate an income elasticity greater than one. Thus "luxury services" pertain to services whose demand increases with income, such as housekeepers, nannies, butlers, private pilots, or personal security forces.

[2]From Stone's (1954) seminal work on expenditures through Hunter and Markusen's (1988) groundbreaking work that demonstrates its importance in explaining the pattern of trade, the data continually confirm that preferences are non-homothetic and consumption bundles do change with income.

resource wealth is often unequal, it is necessary to consider how changes in the distribution of this wealth affects the prevalence of the Dutch disease. In our framework, we, thus, consider not only per capita income but also changes in the distribution of income.

Our main result, that the Dutch disease is more likely to arise when the resource rent distribution is less equal, is intuitive. A natural resource find is like finding money. By itself, it should not generate lower long-run welfare unless it creates expenditure distortions. If the resource wealth is narrowly distributed, then, as will be shown below, the distortions are greater. In particular, as a result of the assumed non-homotheticity of preferences, wealthier agents have a greater marginal propensity to consume services. We then show that a mean preserving spread of the natural resource rent distribution shifts more income to the wealthier agents and generates an increase in the total purchase of services. Crucially in this case, the increase in the purchases of services is of larger magnitude than the decrease in the purchase of manufactured goods, so that the country with a less equal distribution becomes a net importer of manufactured goods. As a result, given two countries with identical technologies, labor supplies, skill development, and natural resources, but differences in income distribution (solely as a result of ownership of the rents generated by the resources), the country with the less equal distribution will have less production of manufacturing goods and less development of learning-by-doing in this sector.

We next take our model to the data. In order to isolate country heterogeneity, capture annual changes, and deal with the possible endogeneity of the regressors, we utilize a dynamic panel analysis with Arellano-Bond and Blundell-Bond general method of moments (GMM) estimators. In addition, we consider the relationship between institutional quality and income inequality and we show that our results are robust to a similar regression where inequality is replaced by the residuals of a regression of inequality on institutional quality and its squared term. Our empirical findings in all of our estimation procedures support our hypothesis that the Dutch disease is directly linked with how well the natural resource rents are distributed. Natural resource rents by themselves positively impact growth, however, the interaction of rents with their distribution shows that there is a critical level of our inequality measure. Whether inequality is above or below this level plays a significant role in whether being resource-rich is a blessing or a curse for a country.

Our results build on and contribute to a large literature. The original use of the term "Dutch disease" (in the Economist magazine, 1977) referred to an appreciation of the Dutch guilder after oil was found in the North Sea. This currency appreciation rendered Dutch manufactured goods uncompetitive in world markets and generated a long-run export illness. Recognizing the limitation of a purely nominal exchange-rate explanation of the Dutch disease, several economists have developed models that provide additional non-monetary explanations of this malady. Starting with Corden and Neary (1982) economists have recognized a factor of production movement effect and a spending effect as elements of the Dutch disease. [3] Krugman (1987), Matsuyama (1992), Torvik (2001) and Goderis and Malone (2011) all introduce learning-by-doing and dynamic effects into models of the Dutch disease.[4]

An interesting difference between our model and the above mentioned papers (as well as Neary (1988), van der Ploeg and Venables (2013), and Beine, Coulombe and Vermeulen (2015)) is that the wage in the country that has the resource boom (or less equal distribution) does not increase relative to that of the other country even under full employment. In fact, it can even decline over time without changing our results. This is possible because there is two way trade in the manufacturing sector and all manufacturing goods have the same initial labor productivity. Therefore, unlike traditional Dutch disease models, manufacturing production does not need to be more costly in the resource abundant country. It is simply not a priority in the short run.

Although we are the first to consider the effect of the distribution of natural resource rents as generating the Dutch disease, the question of distribution comes up in other papers. Goderis and Malone (2011) also consider the relationship between natural resources and income distribution. Their concern, however, is with the effect of the resource find and the resulting reallocation of skilled and unskilled labor (along with changes in learning-by-doing) on the level of inequality between skilled and unskilled workers. In Corden's (1984) survey, he suggests (in footnote 5) that changes in factor prices in a Heckscher-Ohlin framework could actually overturn the spending effect found in Corden and Neary (1982). His suggestion is very different from our result which

[3]The basic premise of production factors shifting to the sector with increased productivity follows from standard textbook models of comparative advantage (Ricardo, Ricardo-Viner, and the Rybczynski effect) and by itself, without a consequent loss of learning-by-doing or external economies of scale, would not generate lower long-run growth.

[4]Matsuyama (1992) not only provides an explanation of the Dutch disease, but, more importantly, shows how an increase in agricultural productivity can generate long-run growth in a closed but not an open economy.

shows how the spending effect can be magnified (and not overturned) if the distribution of the resource rents is less equal.

Our emphasis on the importance of resource rent distribution in creating Dutch disease effects resonates with the resource curse literature which conditions the curse on poor political governance (see, for example, the literature cited in van der Ploeg (2011) and Acemoglu and Robinson (2012)). Although our framework emphasizes the Dutch disease aspects (a production shift that eventually generates manufacturing stagnation) of natural resource abundance, it develops a bridge to the natural resource curse literature (that emphasizes the consequent decline in institutions) by emphasizing the role of resource rents distribution.[5]As much as institutional quality is related to income and natural resource rent distribution, then our model suggests that the effect may exist at a more primitive distributional level.

We also provide a new explanation for the observation that point-source natural resource finds (such as diamonds, gold, or oil) are more likely to reduce long-run growth than are dispersed-source resource finds (such as timber, fisheries, or many non-precious metals). The prevailing school of thought (see the literature cited in van der Ploeg (2011) and Acemoglu and Robinson (2012)) from the resource curse literature suggests that point-source resources are more valuable for expropriation, and therefore, generate unstable, kleptocratic societies plagued by bad institutions. Our model, on the other hand, implies that because diffuse source resources are naturally distributed in a diffuse manner they do not engender the same spending effects as do point-source (and point-distributed) resources. In this way we tie together the natural resource curse and Dutch disease explanations.[6]

The empirical literature on estimation of the Dutch disease and the resource curse begins with Sachs and Warner (1997a, 1997b, 2001) who find strong evidence of the Dutch disease. Mehlum, Moene and Torvik (2006) extend their analysis to consider the interaction between institutional quality and natural resource abundance. We replace their resource abundance measure (which

[5]It may be said that whereas the Dutch disease is primarily an international economics phenomenon, the resource curse does not require an international or interregional economics framework. Neary (1988) succinctly summarizes the Dutch disease as an appreciation of the real exchange rate of non-traded for traded goods which is generated by the change in an exogenous variable that pushes up the demand for traded versus non-traded goods. Although his observation is stated for an economically small country the same result holds in large economy Dutch disease models such as the one in this paper.

[6]In addition to the Dutch disease and resource curse theories as to the negative effect of natural resources on growth there is a crowding-out of education effect as demonstrated by Gylfason (2001).

includes food, beverages, animal and plant products, as well as energy and precious metals) with natural resource rents (which only includes energy, precious metals, and forestry products). This narrower measure of natural resources refutes the hypothesis that natural resources by themselves can cause the Dutch disease. It is only when interacted with inequality that the effect can be negative. Brunnschweiler and Bulte (2008), van der Ploeg and Poelhekke (2010), and Collier and Goderis (2012) also propose different measures of natural resources that should not suffer the same endogeneity problems as that used by Sachs and Warner and Mehlum et al. and, like us, they find that natural resources by themselves do not cause a disease. In addition to our narrower measure of natural resources which does not include agriculture (a large source of the endogeneity, since poor countries are always dependent on agriculture) we treat the possible endogeneity of each of the dependent variables through the use of Arellano-Bond (1991) and Blundell-Bond (1998) estimation techniques. An important contribution to this literature is our test of the relationship between natural resource rent distribution and the Dutch disease. A nice overview of the empirical literature on the Dutch disease and the resource curse is provided by van der Ploeg (2011).

In the next section we describe the economy of each country. In the third section we characterize the international trade equilibrium between two countries. The fourth section contains our main results on natural resource rent distribution. We describe our data in the fifth section and conduct empirical estimations of our model in the sixth section. Our conclusions are in the seventh section. All necessary proofs are provided in the appendices.

2 Economic Environment

In this section we develop the simplest possible model that can capture our main points. Following Corden and Neary's (1982) seminal work, we consider two tradable sectors in each country – natural resources (which they call energy and we will call oil) and manufacturing goods – and a non-tradable luxury consumption services sector (which we call services). The manufacturing goods include manufacturing services as well as sales and infrastructure services for the manufactured goods. Items in the services sector are non-tradable and include items such as construction, entertainment, household services (from childcare to chauffeurs), and maintenance of imported

Rolls-Royce automobiles. Manufacturing and services are both produced with a constant returns to scale technology using labor, the only factor of production. There is learning-by-doing in the manufacturing sector so more production in the current period boosts labor productivity in later periods.

Each agent is endowed with the same amount of labor, which she supplies inelastically in the domestic market, and the size of the identical labor force in each country is normalized to one. In addition to their labor endowment agents may also be endowed with oil. Oil can be consumed domestically or exported. In this simple model oil is not produced with labor but is realized as an endowment, which then allows us to demonstrate the Dutch disease without a resource movement effect. The price of oil is set on world markets and is normalized to unity.

Formally, one unit of labor produces M_t, (M_t^*) units of the manufacturing good in the home (foreign) country. Similarly, $A = A^*$ are the identical labor productivities in the services sectors in both countries. The labor productivity in manufacturing is a function of the entire past output. In particular, the labor productivity at time t increases with past output as a result of the learning and refinement of the production process in previous periods. The output of manufactured goods in the home country at time t can be represented as

$$Q_{Mt} = \ell_t M_t = \ell_t \int_0^t \delta Q_{M\tau} d\tau, \tag{1}$$

where $\delta < 1$ and ℓ_t is the quantity of labor supplied to the manufacturing sector in period t. Foreign learning obeys the same process with the same δ, however, there are no international learning spillovers. Of course, ℓ_t^* and Q_{Mt}^* may differ. From this point on we will not separately describe the foreign variables when the distinction is obvious. The instantaneous rate of change in labor productivity in the manufacturing sector is $\dot{M}_\tau = \delta Q_{M\tau}$. At times we will be interested in describing the labor productivity at time 0 before any learning has occurred (M_0).

Agents earn income from their labor and oil endowments. Each agent in the home and foreign countries has the same identical labor supply. There is a unit mass of agents in each country and the unit supply of labor in each country earns a wage w_t (w_t^*). The oil endowment in each country is given as θ_t (θ_t^*). In the foreign country each agent is endowed with the same amount of oil. The measure of home country agents who are endowed with oil is κ, where $0 < \kappa \leq 1$. We will refer to the κ agents as rich and to the $1-\kappa$ as poor.[7] Each of the rich agents owns θ_t^R units of oil and $\kappa\theta_t^R = \theta_t$. Hence, if $\kappa < 1$, then each of the rich agents owns more than the average so that $\theta_t^R > \theta_t$. The measure of rich agents indexes the natural resource (and income) distribution in the home country. Note that a reduction in κ generates a mean-preserving spread in the natural resource rent distribution. Hence, inequality is decreasing in κ and the distribution is equal when κ approaches one. We will, therefore, refer to decreases (increases) in κ as a worsening (improvement) of the natural resource rent distribution.

Per-period preferences in the home and foreign country over the three goods are of the same Stone-Geary variety.

$$u_t\left(d_{St}, d_{Mt}, d_{Ot}\right) = (d_{St} + \gamma)^{\alpha}(d_{Mt})^{\beta}(d_{Ot})^{1-\alpha-\beta} \tag{2}$$

where d_{jt} is the consumption of good j in period t and $\gamma > 0$ is the amount of services that can be enjoyed without being purchased in the market. These services may consist of socializing with friends or family, household chores, playing sports, reading, or taking walks. If $\gamma = 0$, then these preferences would be Cobb-Douglas and agents would spend a constant income share $(\alpha, \beta, 1 - \alpha - \beta)$ on each of the goods. As will be seen below, with $\gamma > 0$ services become a luxury good so that the marginal propensity to consume services is increasing in income. Stone-Geary preferences are more commonly depicted with $\gamma < 0$ so that it determines a subsistence level of the good. This more common depiction does not allow for a consideration of within country income distribution because all agents must achieve the subsistence level of the good and, therefore, purchase all three goods. In this case they are all on the same segment of the income expansion path and have the same marginal propensity to consume all three goods. Our luxury good version, with $\gamma > 0$ allows some agents to purchase no services in the market and allows us to make meaningful statements about within country income distribution.[8]

[7]Note that we consider our measure of distribution as time invariant. We make this assumption for several reasons. First, resource rent distribution policy usually does not change much over time unless it is accompanied by a complete change of government (or a revolution) and even in that case the change is typically a substitution of one connected group of recipients for another. Second, although point and diffuse source resources suggest different patterns of distribution, a country rarely, if ever, changes from being, say, predominantly exporting oil to mostly exporting timber. Third, our data set exhibit negligible intertemporal variation in inequality regardless of the chosen measure.

[8]Markusen (2013) makes use of a similar utility function with two goods and also shows that increased income inequality can increase demand for the luxury good. He uses this result to provide an explanation for the home bias effect in trade.

The discounted sum of utility can be represented by

$$U = \int_{0}^{\infty} e^{-\rho t} u_t \left(d_{St}, d_{Mt}, d_{Ot} \right) dt \tag{3}$$

where $\rho > 0$ is the common rate of time preference. There is no uncertainty and no possibility for international or intertemporal borrowing and lending. Hence, maximization of the above utility function subject to the per period income constraint $P_{St}d_{St} + P_{Mt}d_{Mt} + d_{Ot} = I_t$, where P_j is the price of good j and I is income, yields the following demand functions.

$$d_S = Max\{0, \frac{\alpha I - P_S\gamma(1-\alpha)}{P_S}\}$$

$$d_M = Min\{\frac{\beta I}{(1-\alpha)P_M}, \frac{\beta(I + P_S\gamma)}{P_M}\} \tag{4}$$

$$d_O = Min\{\frac{I(1-\alpha-\beta)}{(1-\alpha)}, (I + P_S\gamma)(1-\alpha-\beta)\}.$$

From this point onward, we will suppress the time subscript when it is not necessary for the exposition. The foreign country demand functions are similar. The income, I, consists of wages and oil endowment. When oil is equally distributed, we can treat the individual demand functions as the aggregate demand with income $I^E = w + \theta$. When it is not equally distributed, income for the rich agents is $I^R = w + \kappa\theta^R$ and for the poor agents is $I^P = w$. In the foreign country, where the oil endowment is equally distributed, $I^{E*} = w^* + \theta^*$. In order to consider the effects of income distribution, we assume that only rich people can purchase services. Our key assumption is, therefore,

Assumption 1:

$$A < \frac{\gamma(1-\alpha)}{\alpha} < A + \frac{\theta}{\theta+\theta^*}\frac{(1-\alpha-\beta)g(\kappa)}{(\alpha+\beta)(1-\alpha)} \tag{5}$$

where $g(\kappa) = A(1-\alpha\kappa) + \gamma(1-\alpha)\kappa$. As will be seen below, after the equilibrium goods and factor prices are derived (in equations 7 and 11), equation (5) is sufficient for

$$w < \frac{P_S \gamma (1-\alpha)}{\alpha} = I^0 < w + \theta \tag{6}$$

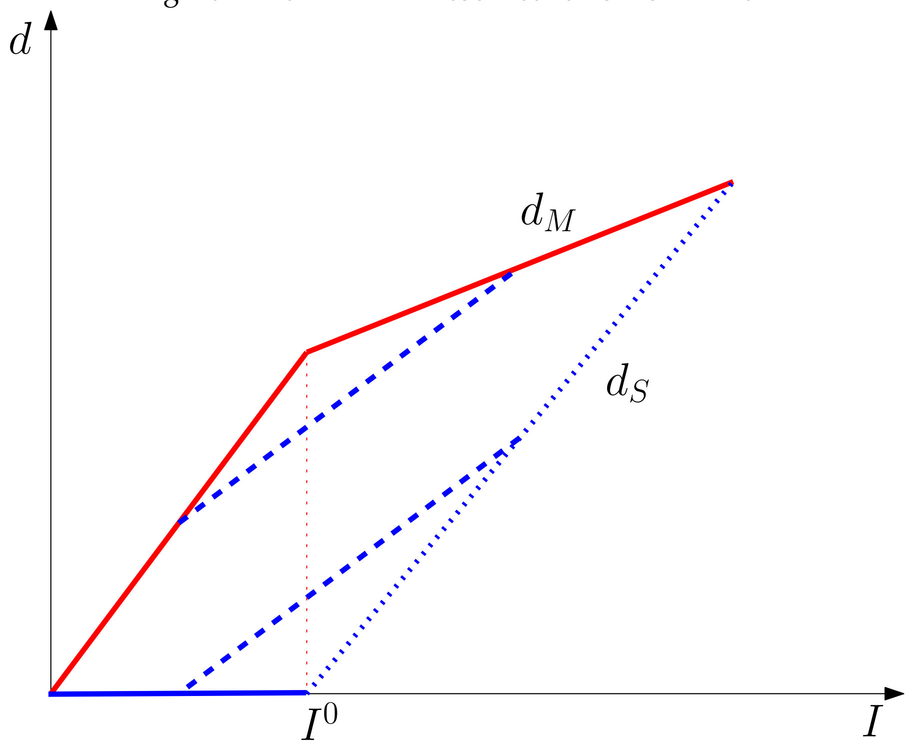
so that when oil income is equally distributed there is positive demand for services by all agents (see equation (4)). There are two parts to assumption 1.[9] The first inequality states that without oil income an agent will not purchase services in the market. It clearly requires non-homotheticity of preferences ($\gamma > 0$) and it is more likely to be satisfied if services are more of a luxury good (larger γ), if they comprise a smaller share of total expenditure (smaller α) or if labor productivity in services (A) is not too large. The second inequality will be satisfied if the oil endowment (θ) is sufficiently large.

Inspection of the demand functions in equation (4) also reveals that rich and poor home country agents consume differing amounts of manufactured goods and oil. Although less people purchase services when income is not equally distributed, those who purchase them purchase relatively more of them (as a result of the positive income effect given by the non-homotheticity of preferences). An important determinant of our results is that the larger purchases dominates the fewer purchasers so that total purchases of services are larger when income is less equally distributed. In figure 1, we graph the demand for services and manufactured goods as a function of income.

The per-period utility function given in equation (2) allows the demand for services (manufactured goods) to be a strictly convex (concave) function of income. As seen in figure 1 a worsening of the resource rent distribution generates a mean preserving spread so that the quantity demanded of services (the convex function) increases and the quantity demanded of manufactured goods decreases. It will be seen below that these differences play an important part in explaining the pattern of trade and learning-by-doing in otherwise similar economies.

[9]Equation 6 is equivalent to $A < \frac{\gamma(1-\alpha)}{\alpha} < A + \frac{\theta}{\theta+\theta^*} \frac{(1-\alpha-\beta)[g(\kappa)M_0+(A+\gamma)(1-\alpha)M_0^*]}{(\alpha+\beta)(1-\alpha)M_0}$. Hence, the first inequality in assumption 1 is identical to the first inequality in equation 6. Evaluating the second inequality when $M^* = 0$ yields the sufficient condition given in the second inequality in assumption 1.

Figure 1: Demand and resource rents distribution



3 International trade

We now consider international trade between the home and foreign countries. The price of the non-traded services can differ across countries, but the price of the freely-traded manufactured goods and oil are equalized across countries in the free trade equilibrium. Given the above described technologies, we then have the following four equilibrium prices

$$P_M = \frac{w}{M} = \frac{w^*}{M^*}, \; P_S = \frac{w}{A}, \; P_S^* = \frac{w^*}{A}, \; P_O = 1. \tag{7}$$

Oil can be traded, but is not produced, therefore, the total world demand must equal the total world endowment. The demand for the non-traded services must equal its supply in each country. The labor, services, and (by Walras' law) the goods markets equilibrium is given by these equilibrium conditions.

$$d_O + d_O^* = \theta + \theta^*, \; d_S = A(1-\ell), \; d_S^* = A(1-\ell^*). \tag{8}$$

From the equality of world demand and supply for oil and the pricing equation for services we have

$$\left[w(1-\kappa) + (1-\alpha)w\kappa + (1-\alpha)w^* + (1-\alpha)\frac{w\kappa + w^*}{A}\gamma\right][1-\alpha-\beta] = (1-\alpha)(\alpha+\beta)(\theta+\theta^*). \tag{9}$$

which uses the observations that $\kappa < 1$ of the home agents have income $w + \theta^R$ and the remaining $1-\kappa$ have income w.

Combining the separate zero excess demand conditions for services in each country along with the pricing equation for services yields the following two wage equations for home and foreign.

$$w = \frac{A\alpha\theta}{A(1-\ell-\alpha\kappa) + \gamma(1-\alpha)\kappa}, \ w^* = \frac{A\alpha\theta^*}{A(1-\ell^*-\alpha) + \gamma(1-\alpha)}. \tag{10}$$

Combining equations (9) and (10) along with the pricing equation for manufactured goods given in equation (7) completely describes the international trading equilibrium. The price of the manufacturing good, the measure of labor in the manufacturing sector in each country and the equilibrium home and foreign wage are then given by

$$P_M = \frac{A(\alpha+\beta)(\theta+\theta^*)(1-\alpha)}{[(M\kappa+M^*)(A+\gamma)(1-\alpha) + MA(1-\kappa)][1-\alpha-\beta]},$$

$$\ell = \frac{[\theta\beta + (\alpha+\beta)(1-\alpha)\theta^*]g(\kappa)M - \alpha(1-\alpha-\beta)\theta g(1)M^*}{AM(\alpha+\beta)(1-\alpha)(\theta+\theta^*)}, \tag{11}$$

$$\ell^* = \frac{[\theta^*\beta + (\alpha+\beta)(1-\alpha)\theta]g(1)M^* - \alpha(1-\alpha-\beta)\theta^* g(\kappa)M}{AM^*(\alpha+\beta)(1-\alpha)(\theta+\theta^*)}$$

$$w = \frac{AM(\alpha+\beta)(1-\alpha)(\theta+\theta^*)}{(1-\alpha-\beta)[g(\kappa)M + g(1)M^*]}, \quad w^* = \frac{AM^*(\alpha+\beta)(1-\alpha)(\theta+\theta^*)}{(1-\alpha-\beta)[g(\kappa)M + g(1)M^*]}$$

where $g(1) = (A+\gamma)(1-\alpha)$, which is $g(\kappa)$ evaluated at $\kappa = 1$. Note that these equilibrium conditions are derived for the case where the distribution of the home oil rents are unequal.

4 Resource Rent Distribution and the Dutch Disease

In this section we analyze how the home country's resource rent distribution affects the pattern of trade and the possibility of suffering a Dutch disease. From equation (11) we can see how the distribution of the resource rents affects the pattern of comparative advantage. In particular, we can characterize the ratio of the home to foreign labor share in manufacturing. If we then evaluate it when manufacturing productivity and resource endowments are the same, so that $M = M^*$ and $\theta = \theta^*$, this ratio can be written as

$$\frac{\ell}{\ell^*} = \frac{[2\beta + \alpha(1-\alpha-\beta)]g(\kappa) - \alpha(1-\alpha-\beta)g(1)}{[2\beta + \alpha(1-\alpha-\beta)]g(1) - \alpha(1-\alpha-\beta)g(\kappa)}. \tag{12}$$

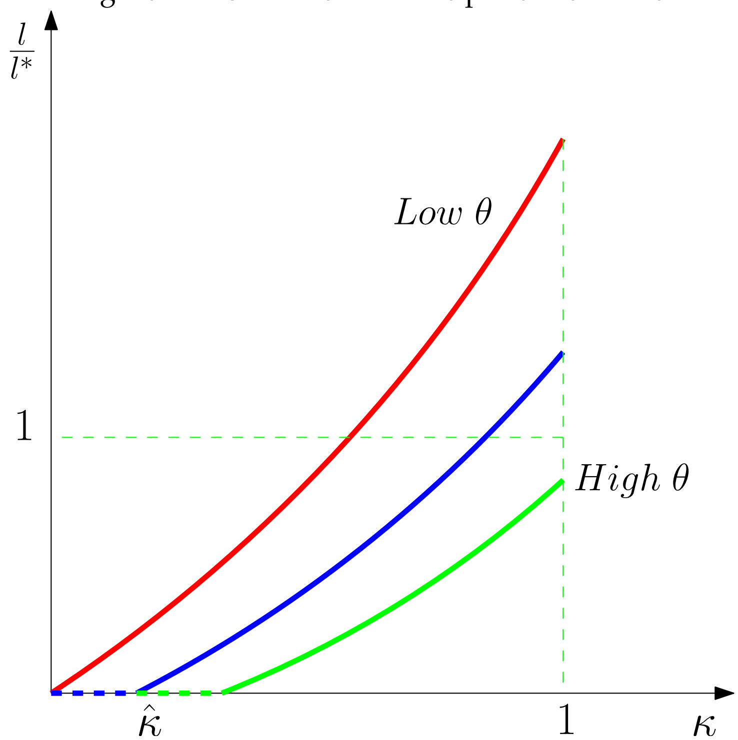
The ratio in equation (12) is equal to unity when $\kappa = 1$. To evaluate this ratio when $\kappa < 1$, note that the derivative of $g(\kappa)$ with respect to κ is $\gamma(1-\alpha) - \alpha A$ which is positive by assumption (1).[10] Hence, $g(\kappa) < g(1)$ for all $\kappa < 1$, and the ratio in equation (12) is, therefore, less than one for all $\kappa < 1$. Furthermore, as the home resource rent distribution becomes more unequal (κ decreases) the ratio becomes smaller and the home country falls further behind the foreign country in manufacturing production.

Equation (12) shows that the distribution of the resource rents can be a source of comparative advantage even when resource rents are equal. It provides a possible answer as to why some countries suffer a Dutch disease after finding a natural resource. Of course, equation (12) is a special case. To better see the effect of the natural resource distribution on manufacturing and service production we now consider the marginal effect of resource rents distribution after any history.

It is possible that after some histories, the manufacturing output in the country with unequal distribution of rents may be zero. As we show in proposition 1 if manufacturing output is positive in both countries, then worse home country distribution reduces home manufacturing output and increases that in foreign. The proposition also shows that the home country distribution (as well as manufacturing productivity and resource rents) determines whether manufacturing output is

[10] The result that $g(\kappa)$ is increasing in κ (which follows from assumption 1) is used throughout the remainder of the analysis.

Figure 2: Distribution and the pattern of trade



greater than zero or not.

Proposition 1. *There exists a $\hat{\kappa}(\theta, \theta^*, M_t, M_t^*)$ and a $\hat{\kappa}^*(\theta, \theta^*, M_t, M_t^*)$ such that home manufacturing output is positive only if $\kappa > \hat{\kappa}$ and foreign manufacturing is positive only if $\kappa < \hat{\kappa}^*$. If $\kappa \in (\hat{\kappa}, \hat{\kappa}^*)$, then an increase in the inequality of the home resource rent distribution reduces home manufacturing output and increases foreign output.*

Proposition 1 extends the result in equation (12) by showing that a worsening in the distribution of the natural resource endowment not only changes the ratio of home to foreign manufacturing, but also causes an absolute reduction of manufacturing at home and an increase abroad. This result holds regardless of the previous history and of the manufacturing productivity in period t. In fact, the proof of this proposition shows that the reduction in home manufacturing is independent of the home manufacturing technology. On the other hand, greater relative home technology ($\frac{M}{M^*}$) does reduce the foreign manufacturing growth that results from worse home resource rent distribution. Finally, note that the above result holds regardless of either country having a greater natural resource endowment. The results of proposition 1 are illustrated in figure 2.

In figure 2 we see that the relative level of home versus foreign manufacturing is a function not only of resource endowments and manufacturing productivity, but also the home country distribution of the resource rents. In particular, comparative advantage is also a function of the resource rent distribution. Even when the home country has better initial technology in manufacturing and a smaller natural resource endowment, it can still have a comparative disadvantage in manufacturing if it has worse natural resource rents distribution.

We now show that the Dutch disease can arise solely from less equal natural resource rents distribution. Furthermore, such an outcome is possible even in the absence of an increase in the relative wage of the country with worse resource rents distribution. In fact, as a result of the reduction in manufacturing output, the relative wage will decrease in the long run.

Proposition 2. *A worsening of the home country resource rent distribution can generate manufacturing stagnation. It does so without a change in the relative home to foreign wage in the short run and with a decrease in the long run.*

An interesting difference between our model and the models of the Dutch disease discussed in the introduction is that the wage in the country that has the resource boom (or the less equal income distribution) does not increase relative to that of the other country. In fact, it can decline over time. This result occurs mainly because international trade equalizes the domestic and foreign prices of manufactures, so that relative wages are given by Ricardian productivity differences across countries. In particular, there are constant returns to labor in the manufacturing sector in our model and all manufacturing goods have the same technology. In all but one of the previously mentioned Dutch disease models there are diminishing returns to labor so that as the wage rises, the labor demand adjusts, which in turn affects the marginal product of labor so that labor is still paid the value of its marginal product. In Krugman (1987) each of the manufacturing goods has a different labor productivity so that an increase in the relative wage corresponds to production of a set of goods with higher average labor productivity. In our model, on the other hand, each good in the manufacturing sector has the same Ricardian technology, therefore, no such adjustments are possible in the manufacturing sector and the relative wage does not rise in response to the change in the natural resource rents (or their distribution). Although it arises from a simplification designed so that we can more clearly present our main point about the distribution of the natural resource rents, our simple stylized model also shows that the Dutch disease can arise without an increase in the relative wage even when there is full employment.

If we were to consider two small countries (as in Corden and Neary (1982) or Matsuyama (1992)), then they would face a given price for the manufactured goods. In reassessing proposition 1 note that P_M is decreasing in κ so that a worsening of the home distribution raises the price of manufactured goods. This price increase somewhat attenuates the reduction in the home manufacturing sector but also generates an increase in the foreign manufacturing sector. In the case of two small economies there would be no change in P_M and the reduction of the home manufacturing sector would be larger, but there would be no increase in the size of the foreign manufacturing sector.[11] Given that many of the countries in our empirical sample could be considered as economically small it is important to see that our results are still valid for the case of a small country.

In our empirical analysis we will make use of annual changes in the resource rents, therefore, it is necessary to show that our results are robust to temporary changes in resource rents or their distribution. Our main concern is with the boom and bust cycle of a depletable natural resource find or the fluctuation in commodity prices. Furthermore, a temporary change in rent distribution can arise from a change in government policy.[12] It may be wondered if, after the resource rents or their distribution return to their previous equal level, the now lower relative home wage (given by the loss of learning-by-doing) could offset the technology difference and shift manufacturing production back to its earlier level. We answer this question in proposition 3.

Proposition 3. *If $M_t = M_t^*$, and from time t to a finite time $\tau > t$ either $\theta > \theta^*$ or $\kappa < 1$ or both, and after time τ, $\theta = \theta^*$ and $\kappa = 1$, then home will have lower manufacturing productivity, lower wages, and lower income for all time after τ.*

Hence, a temporary reduction in the equality of resource rent distribution or a temporary resource boom can generate permanent manufacturing stagnation. In addition, if home productivity drops enough so that $\hat{\kappa} \geq 1$, then home manufacturing could remain at zero even after the narrowly distributed resource boom is over.

[11] Treating P_M as an exogenous parameter allows us to write $\ell = \frac{A(1-\alpha\kappa)+\gamma(1-\alpha)\kappa}{A} - \frac{\alpha\theta}{MP_M}$ and $\ell^* = \frac{(1-\alpha)(A+\gamma)}{A} - \frac{\alpha\theta^*}{M^*P_M}$ so that $\frac{\partial \ell_t}{\partial \kappa} = \frac{\gamma(1-\alpha)-\alpha A}{A} > 0 = \frac{\partial \ell_t^*}{\partial \kappa}$.

[12] As noted in footnote 7, resource rent distribution is not expected to vary much over time, therefore, this second consideration is of less interest empirically.

5 Empirical Testing

In this section we test whether the predictions of our model are supported by the data. In particular, we test how changes in national income (or GDP) are affected by natural resource rents and their distribution. Using equation (11) and the fact that current manufacturing productivity is a function of some initial level as well as the past history of resource rents and their distribution, we can write the equation that forms the basis of our estimation strategy as:

$$GDP_t = I_t = w_t + \theta_t = f(M_t, M_t^*, \kappa, \theta_t, \theta_t^*) = f(M_0, M_0^*, \kappa, \{\theta_\tau\}_{\tau=0}^{t}, \{\theta_\tau^*\}_{\tau=0}^{t}) \quad (13)$$

From equation (11) we see that $\frac{\partial I_t}{\partial \theta_t} > 0 > \frac{\partial I_t^2}{\partial \theta_t \partial \kappa}$. The partial derivatives indicate that an increase in the current period natural resource rents should increase current GDP, however, this positive effect is mitigated by a less equal distribution. Given the reduction in learning by doing that it entails our theory predicts that the negative effect would be more evident for past period resource booms.

An OLS regression that *could* capture our coefficients of interest is given by equation (14).[13]

$$(logGDP_{it} - logGDP_{it-1}) = \beta_0 + (\beta_1 - 1)logGDP_{it-1} + \beta_2 Nr_{it} + \beta_3(Gini_i \centerdot Nr_{it}) + \beta_4 X_{it} + \delta_i + \delta_t + \varepsilon_{it} \quad (14)$$

The variable $logGDP_{it}$ has subscript i for country and t for year. Economic growth is measured by the annual changes in the log of GDP per capita and is expressed in percentages. $Gini_i$ is the reported Gini coefficient from the World Bank World Development Indicators (World Bank, 2013), which is averaged over 1965-2008 and indexed between 0 to 1. The data for natural resource rents, Nr_{it}, is also from the World Bank (2013). The interaction term of interest is $(Gini_i \centerdot Nr_{it})$ with β_3 as its coefficient, which we expect to be negative. Our theory also predicts that β_2 is positive. X_{it} is a vector of other explanatory variables that will be discussed below. Finally, δ_i and δ_t are country

[13] Our theory also supports an estimation where changes in the employment shares in manufacturing sector is used as the dependent variable. We prefer to use the GDP growth rate as the dependent variable for three reasons. First, the data on the employment share of manufacturing is noisy, and there is a lot of missing observations for the time period of our study. Second, the existing data indicates a continuous decline in employment shares in the manufacturing sector for almost all countries. This decline could be caused by other general factors such as non-uniform labor-saving technological change, which are less relevant for our purposes (i.e. income distribution and natural resources). Finally, since the majority of the previous empirical work on the Dutch disease and the resource curse makes use of a growth equation, employing the same approach enables us to compare our results with those.

and year fixed effects, respectively. We could also perform the same estimation with the lag of natural resource rents as well as its interaction with the Gini coefficient to test whether the effects appear after a year is passed.

This regression in equation (14), however, is inconsistent because the lag of GDP is used as a regressor both directly and indirectly as the denominator of the natural resource rents variable. In addition, many of the additional variables included in X_{it} could also be endogenously determined by the growth of GDP. Hence, in order to control for the potential endogeneity of the regressors, to isolate country heterogeneity, and to capture annual changes while dealing with possible inconsistencies associated with the fixed effects estimation we utilize dynamic panel analyses. We start first with Arellano-Bond estimators and then proceed to use Blundell-Bond estimators. For a dynamic growth panel such as ours, Bond, Hoeffler, and Temple (2001), show that the Blundell-Bond approach provides more reliable estimates. This result is confirmed in our analysis because the Blundell-Bond estimators in tables 3 and 4 do not suffer from the weak instruments that plague the Arellano-Bond estimators in column (1) of tables 1 and 2.

Before describing our estimation procedure, we define the rest of our explanatory variables that are included in X_{it}. These variables include the log of the fertility rate, government consumption as a share of GDP, inflation (annual percentage), investment, the annual growth rate of the terms of trade, and the log of initial per capita GDP squared. To be consistent with other cross sectional analyses, we also include institutional quality and its interaction with natural resource rents in our fixed effect model. This variable is an index between 0 and 1 with a higher value indicating better institutions. It is an average of 6 different variables (corruption in government, rule of law, bureaucratic quality, ethnic tensions, repudiation of contracts by government, risk of expropriation) compiled by Keefer and Knack (1998). The data for these six institutional quality variables is from the International Country Risk Guide (ICRG) database for the period 1982-1997 and the data for the other variables is from World Bank (2013). More details and definitions of the variables can be found in appendix Table A1. Appendix Table A2 contains summary statistics for these variables and the list of the countries in our data set can be found in Table A3.

There is no known empirical measure of the distribution of natural resource rents and we, therefore, use an average Gini coefficient during the above time period. There are three main reasons for our decision to use an average value of the Gini coefficient. First, our dataset does not cover every year in the sample; however, since the Gini coefficients do not appear to change much over time, we feel comfortable using the averages of the reported years. Second, if we were to use a panel, then we would have a very small one as the data is reported for a small subset of the total years in our sample. Third, we are not interested in annual changes in the inequality index per se, but rather the annual evolution of the natural resource rents interacted with some measure of their inequality of distribution for each country.[14] Finally, because the Gini coefficient is a time invariant average, it is isomorphic to the country effects and would be dropped from the panel regression if we tried to separately estimate its effect.

6 Dynamic Panel Analysis

Our estimation procedure needs to address issues of country heterogeneity, short run time effects, and any possible endogeneity between the dependent variable and the predictors of GDP growth. We, therefore, consider the effects of annual changes in the dependent variables on GDP growth, through dynamic panel data analyses.[15] We build on a regression introduced by Barro (2000) that was then modified by Banerjee and Duflo (2003) where they looked at the effect of inequality on growth. In turn, we extend these analyses to also estimate the impact of natural resource rents alone and interacted with inequality. In addition to the use of a differenced GMM estimation method introduced by Arellano and Bond (1991), to address potential inconsistency or endogeneity issues we also use a modified system GMM estimation technique introduced by Blundell and Bond (1998). Finally, we also consider the relationship between institutional quality and income inequality, and we show that our results are robust to a similar regression where inequality is replaced by the residuals of a regression of inequality on institutional quality.

We begin by using a first-differenced estimator and instrument the variables using further lags as

[14] The relationship between income inequality and growth over time is not straightforward. Theoretically, the Kuznets curve suggests that income inequality first increases and then declines as an economy develops. It has also been indicated empirically that this non-linearity generates ambiguous estimation of the effect of inequality on growth. There have been some attempts to pin down this relationship empirically through different methods of estimation, and generally the inverted-U shape Kuznets curve is confirmed in the data. In our panel data analysis, however, we are not concerned with the direct effect of inequality on growth or with its functional form.

[15] Our panel does not suffer a unit root problem and the variables are not necessarily integrated of order one. The results of the Im, Pesaran and Shin (2003) unit root tests are in Table A6 in the appendix.

suggested by Arellano and Bond, where the one period lagged GDP per capita is a predetermined variable.[16] [17] As a result, our main specification can be expressed as equation (15):

$$\Delta logGDP_{it} = \beta_1 \Delta logGDP_{it-1} + \beta_2 \Delta Nr_{it} + \beta_3 (Gini_i \,.\, \Delta Nr_{it}) + \beta_4 \Delta X_{it} + \Delta\delta_t + \Delta\varepsilon_{it} \qquad (15)$$

Where Δ stands for the annual changes. To deal with the contemporaneous correlation of the lagged GDP, as well as the endogeneity of all other variables, we use further lags of the variables (but not the first lag) as instruments.[18]

6.1 Difference GMM estimation

Note that using only one instrument for each variable in a difference GMM estimation leads to exact identification of the model and in this case we would be unable to verify the validity of instruments using an over-identification test. To overcome this issue, we increase the number of instruments by using one lag for the predetermined variable (i.e. the initial GDP) and two lags for the other endogenous variables.[19] Thus, Z_{it} represents our vector of instruments used in Arellano-Bond estimation

$$\mathbf{Z_{it}} = [\mathbf{logGDP_{it-2}},\ \mathbf{Nr_{it-2}},\ \mathbf{Nr_{it-3}},\ \mathbf{Gini_i \,.\, Nr_{it-2}},\ \mathbf{Gini_i \,.\, Nr_{it-3}},\ \mathbf{X_{it-2}},\ \mathbf{X_{it-3}}]$$

In order for the difference GMM and system GMM to be appropriate estimation methods, no serial correlation should exist in the first-differenced errors at orders 2 and above. A Sargan test

[16] Finding external (non-lagged) instruments that are exogenous to GDP growth is generally considered as impossible because almost everything is endogenous to growth. In dynamic growth panel analyses, therefore, the generalized method of moments (GMM) estimation of the first-differenced equations (Arellano-Bond (1991)) with lags are generally used as the best possible instruments (see Barro, 2000). Still, lagged variables are some times considered as weak instruments and the system GMM method of Blundell and Bond (1998) is considered to provide more reliable estimates in our type of analysis (see Bond, Hoeffler, and Temple (2001)). In fact, we do find that our results are more consistently significant across specifications when we use Blundell-Bond estimators in section 6.2.

[17] All results are computed using xtabond2 command in STATA with collapsed instruments in order to tackle the problem of too many instruments. See Roodman (2009).

[18] We do not use the first lag because $(logGDP_{it-1} - logGDP_{it-2})$ is correlated with $(\varepsilon_{it} - \varepsilon_{it-1})$. At the same time, under the crucial assumption of no serial correlation of the error terms (which we test later on), $\Delta\varepsilon_{it}$ is uncorrelated with $\Delta logGDP_{it-\tau}$ for $\tau \geq 2$ so that additional lags are valid to be used as instruments in an instrumental variable (IV) estimation.

[19] This exact identification problem is not the case in a system GMM estimation since the number of instruments that are generated is more than the number of endogenous variables. Thus, our Blundell-Bond estimator uses one lag for all the predetermined and endogenous variables.

constructs p-values such that the null hypothesis of $Cov(\Delta\varepsilon_{it}, \Delta\varepsilon_{it-\tau}) = 0$ for $\tau = 1, 2, 3$, is rejected at 5 percent level if $p < 0.05$. If ε_{it} are not serially correlated, then we expect to reject the null hypothesis at order 1, but not at higher orders. As shown in table A5 of the appendix the p-values indicate that we fail to reject the null hypothesis at orders 2 and above. Thus, there is no serial correlation in the error terms and two and three period lagged terms are valid instruments.

Table 1 – Arellano-Bond Estimation

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.360	0.141	-0.077	-0.060
	(0.455)	(0.463)	(0.378)	(0.229)
Log of GDP per capita (lagged one period) squared	0.026	-0.008	0.006	0.006
	(0.031)	(0.031)	(0.026)	(0.016)
Natural resource rents	-2.268		1.968	
	(3.153)		(1.186)	
Natural resource rents × Gini coefficient	7.583		-3.695	
	(7.250)		(2.822)	
Inflation	-0.002	-0.002*	-0.002	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	0.350	-0.403	0.036	-0.135
	(0.355)	(0.451)	(0.167)	(0.194)
Natural resource rents × Institutional quality	-1.845		-0.169	
	(1.517)		(1.423)	
Growth rate of terms of trade	0.007	0.028**	0.008	0.027**
	(0.014)	(0.012)	(0.011)	(0.010)
Log of fertility rate	0.149	-0.564	-0.139	-0.404
	(0.278)	(0.397)	(0.233)	(0.336)
Government consumption	0.125	-0.152	-0.149	-0.085
	(0.385)	(0.263)	(0.361)	(0.143)
Investments	0.180	0.244	0.205	0.157
	(0.194)	(0.235)	(0.172)	(0.192)
Natural resource rents (lagged one period)		2.570*		1.933***
		(1.488)		(0.609)
Natural resource rents (lagged one period) × Gini coefficient		-7.096		-4.358***
		(4.344)		(1.498)
Natural resource rents (lagged one period) × Institutional quality		2.904		1.388
		(2.369)		(1.078)
Hansen test	0.068	0.863	0.072	0.854
Number of observations	774	774	730	730
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($\log GDP_t - \log GDP_{t-1}$). Year fixed effects are included in all of the estimations. Arellano-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 1 further lag for the lagged GDP and 2 further lags for the rest of the variables. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $X^2(6)$. Total number of instruments is 33. Robust standard errors are reported in parentheses.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 1 reports the results of estimating equation (15) using the Arellano-Bond method.[20] In columns (1) and (3) the GMM estimation is performed on all variables including current natural resource rents. In columns (2) and (4) it is replaced by lagged natural resources.

There are four communist countries in our data set. Although low income inequality is a matter of ideology in communist countries, the same cannot be said for accurate reporting of economic statistics. We, therefore, create a restricted sample and exempt the communist countries from our analysis in columns (3) and (4) to test if the results are affected by the presence of these countries.[21] The results presented in this table suggest that when lagged natural resource rents are taken into account, the resource rents variable and its interaction with inequality have the expected signs. The interaction of lagged resource rents and the Gini coefficient has a significant negative impact on GDP growth when communist countries are excluded from the sample. From the results in column (4) natural resource rents will only increase the growth rate of GDP if the Gini is less than 0.44. In particular, from equation (15) we have that $\frac{\partial \Delta logGDP_{it}}{\partial Nr_{it}} = \beta_2 + \beta_3(Gini_i)$ which implies a critical gini coefficient of $\frac{-\beta_2}{\beta_3}$, which in the case of column (4) is 1.933/4.358.

One concern with our results is that although the estimated coefficient for lagged GDP is negative, it is insignificant so that conditional convergence appears to be absent in our results. It should be noted, however, that conditional convergence is more of a long term phenomenon than an annual one. Most of the panel studies which have found significant growth convergence (see Barro, 2000, Banerjee and Duflo, 2003, and the literature cited by them) have considered 5-year intervals for their sample, whereas in our analysis we are interested in year-on-year changes to take into account the annual fluctuations of natural resource rents. Still, our estimated coefficient has the correct sign, implying that conditional convergence may also have appeared in our analysis if we had considered longer time intervals.

A further concern is that the Gini coefficients and institutional quality could be correlated, in which case the Gini coefficients would capture the effects of institutional quality on growth rather

[20] Our results are robust to the use of additional lags used as instruments. These variations are contained in our online appendix, Behzadan et al (2016), which is located at https://ideas.repec.org/p/rye/wpaper/wp044.html.

[21] Although not significant, the coefficient of natural resource rents and its interaction term have the wrong sign in column (1). We note, however, that the Hansen test p-value is low for the instruments in column (1) so that this result may not be directly attributable to the data from the communist countries. A weak Hansen test p-value also plagues the results in column (1) of table 2. When we use the Blundell-Bond estimators to control for weak instruments, the Hansen test provides strong p-values for all 8 formulations and the coefficient on natural resources and its interaction have the expected sign in all 8 columns of tables 3 and 4.

than our postulated distributional effects. Although the correlation matrix in Table A4 shows a negligible linear correlation between these two variables, we would like to make sure that our results are not driven by any (either linear or non-linear) correlation between inequality and institutional quality. In order to remove such a possible multicollinearity problem, and check whether our results remain robust, we adapt the following procedure. We begin by regressing the Gini coefficient on institutional quality and the quadratic institutional quality term, then retrieve the residuals from this regression. We next use these residuals instead of the Gini coefficient so that we have a measure of income inequality purged from institutional quality.

Table 2 – Arellano-Bond Estimation (Robustness Check Using Residuals)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.196	0.099	-0.504	-0.074
	(0.355)	(0.423)	(0.762)	(0.224)
Log of GDP per capita (lagged one period) squared	0.014	-0.005	0.035	0.006
	(0.024)	(0.029)	(0.052)	(0.015)
Natural resource rents	0.776		0.861	
	(0.594)		(0.694)	
Natural resource rents × Residuals	1.088		-4.617	
	(9.762)		(4.021)	
Inflation	-0.002**	-0.002*	-0.001	-0.002**
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	0.208	-0.371	0.216	-0.126
	(0.296)	(0.429)	(0.301)	(0.191)
Natural resource rents × Institutional quality	-0.589		-2.132	
	(1.481)		(2.163)	
Growth rate of terms of trade	0.008	0.027**	0.019	0.026**
	(0.014)	(0.012)	(0.016)	(0.010)
Log of fertility rate	0.038	-0.561	-0.186	-0.409
	(0.276)	(0.388)	(0.320)	(0.333)
Government consumption	0.019	-0.144	-0.113	-0.081
	(0.156)	(0.238)	(0.393)	(0.138)
Investments	0.221	0.233	0.160	0.147
	(0.198)	(0.228)	(0.182)	(0.191)
Natural resource rents (lagged one period)		-0.170		0.243
		(0.642)		(0.357)
Natural resource rents (lagged one period) × Residuals		-6.868*		-4.249***
		(4.098)		(1.425)
Natural resource rents (lagged one period) × Institutional quality		1.947		0.819
		(1.991)		(0.969)
Hansen test	0.037	0.862	0.156	0.872
Number of observations	774	774	730	730
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($logGDP_t - logGDP_{t-1}$). In all estimations, the measure of inequality (Gini) is replaced by the residuals of regressing Gini on Institutional quality. Year fixed effects are included in all of the estimations. Arellano-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 1 further lag for the lagged GDP and 2 further lags for the rest of the variables. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $\chi^2(6)$. Total number of instruments is 33. Robust standard errors are reported in parentheses.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 2 presents the results of the same regressions as in Table 1 with these purged Gini coefficients. Our previous findings improve after this adjustment: in the non-restricted sample, we also find a significant estimated coefficient on the interaction term in the lagged regression (in column 2).

6.2 System GMM estimation

Although the Arellano-Bond estimator is dynamically consistent, it might suffer from finite sample biases in the presence of weak instruments. For example, lagged levels of the series may be weakly correlated with the subsequent first differences if there is either a unit root problem in the series or if the variance of the individual effects (δ_i) increases relative to variance of the error terms (ε_{it}). Although, as shown in our unit root test in Table A6 in the appendix, there is no non-stationarity problem in our panel, we cannot be certain that our lagged values are uniformly strong instruments. We, therefore, also perform a system GMM estimation introduced by Arellano and Bover (1995) and Blundell and Bond (1998, 2000) to examine whether our results are robust in the presence of these possible drawbacks. In particular, the Blundell-Bond system GMM estimator combines the set of first-differenced equations and lagged level instruments (as used in the Arellano-Bond difference GMM estimator), with an extra set of level equations and immediate lagged first differences as instruments. [22] The validity of these instruments are satisfied by the reported p-values of the Hansen over-identification test. In each case the Hansen test p-value is higher than 5 percent and ranges from around 20% to 80%. We report the results of the Blundell-Bond estimation below.

[22]See Blundell and Bond (1998) for the calculation of the system GMM estimator.

Table 3 – Blundell-Bond Estimation

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.287	-0.129	-0.338*	-0.140
	(0.182)	(0.122)	(0.171)	(0.152)
Log of GDP per capita (lagged one period) squared	0.020	0.009	0.023*	0.009
	(0.013)	(0.009)	(0.012)	(0.011)
Natural resource rents	1.471**		1.372***	
	(0.572)		(0.390)	
Natural resource rents × Gini coefficient	-1.971		-2.081**	
	(1.208)		(1.012)	
Inflation	-0.002*	-0.001	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	0.113	0.097	0.045	0.076
	(0.083)	(0.083)	(0.099)	(0.098)
Natural resource rents × Institutional quality	-1.031**		-0.871*	
	(0.430)		(0.517)	
Growth rate of terms of trade	0.018	0.020**	0.023**	0.019**
	(0.011)	(0.009)	(0.011)	(0.009)
Log of fertility rate	0.032	0.011	0.028	0.026
	(0.044)	(0.033)	(0.040)	(0.038)
Government consumption	0.083	0.013	0.052	0.114
	(0.277)	(0.156)	(0.166)	(0.147)
Investments	0.206**	0.184**	0.185*	0.141*
	(0.103)	(0.089)	(0.097)	(0.077)
Natural resource rents (lagged one period)		0.637*		0.618
		(0.371)		(0.391)
Natural resource rents (lagged one period) × Gini coefficient		-0.928**		-1.211***
		(0.390)		(0.440)
Natural resource rents (lagged one period) × Institutional quality		-0.302		-0.069
		(0.491)		(0.542)
Hansen test	0.487	0.334	0.416	0.201
Number of observations	836	836	788	788
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($\log GDP_t - \log GDP_{t-1}$). Year fixed effects are included in all of the estimations. Blundell-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 1 further lag. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $X^2(9)$. Total number of instruments is 36. Robust standard errors are reported in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

The results of the Blundell-Bond estimations are reported in Table 3 and the corresponding results of the robustness check, where we use the residuals of the regression of the Gini on institutional quality and its square, are presented in Table 4. Since the Blundell-Bond estimator generates more than one instrument for each variable there is no problem of exact identification and we use only one lag for each variable. Still, we report the results of using additional lags in our online appendix (Behzadan et al, 2016) and we note here that our results are robust to the inclusion of these additional lags.

Table 4 – Blundell-Bond Estimation (Robustness Check Using Residuals)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.095	-0.114	-0.156	-0.126
	(0.251)	(0.121)	(0.233)	(0.147)
Log of GDP per capita (lagged one period) squared	0.007	0.008	0.011	0.008
	(0.018)	(0.009)	(0.016)	(0.010)
Natural resource rents	0.490		0.498*	
	(0.300)		(0.264)	
Natural resource rents × Residuals	-1.412		-2.568*	
	(1.262)		(1.535)	
Inflation	-0.001	-0.001	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	0.143	0.109	0.079	0.082
	(0.092)	(0.084)	(0.108)	(0.090)
Natural resource rents × Institutional quality	-0.656		-0.777	
	(0.633)		(0.570)	
Growth rate of terms of trade	0.025**	0.020**	0.025**	0.021**
	(0.011)	(0.009)	(0.010)	(0.009)
Log of fertility rate	-0.012	0.005	0.010	0.020
	(0.034)	(0.035)	(0.049)	(0.037)
Government consumption	-0.015	-0.034	0.015	0.086
	(0.187)	(0.157)	(0.152)	(0.132)
Investments	0.179**	0.177**	0.176**	0.135*
	(0.073)	(0.085)	(0.072)	(0.071)
Natural resource rents (lagged one period)		0.315		0.177
		(0.247)		(0.232)
Natural resource rents (lagged one period) × Residuals		-1.008*		-1.381***
		(0.520)		(0.513)
Natural resource rents (lagged one period) × Institutional quality		-0.441		-0.238
		(0.491)		(0.501)
Hansen test	0.393	0.417	0.537	0.249
Number of observations	836	836	788	788
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($logGDP_t - logGDP_{t-1}$). In all estimations, the measure of inequality (Gini) is replaced by the residuals of regressing Gini on Institutional quality. Year fixed effects are included in all of the estimations. Blundell-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 1 further lag. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $\chi^2(9)$. Total number of instruments is 36. Robust standard errors are reported in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

As seen in Tables 3 and 4 the results from the Blundell-Bond estimation procedure establish the robustness of our results in Tables 1 and 2 and improve on those results in many respects. For example, in Table 3 natural resource rents is found to increase growth if the Gini coefficient is below a critical level in all four specifications. Furthermore, we find that investment, as expected, has a significant positive effect on growth. We also find some significant evidence of GDP growth convergence, however, as mentioned in the previous section we should not expect to find strong evidence of convergence when looking at annual changes. Most importantly, our coefficient of interest on the interaction term between the Gini coefficient (or the residuals) and natural resource rents (or its lagged value) is still negative and significant. The Blundell-Bond estimated coefficient on this interaction term, however, is smaller than that in the Arellano-Bond estimation, which suggests that in our case the difference GMM estimator is biased upwards. Although the Arellano-Bond estimators are consistent, and they provide results that support our theory, by tackling the issue of weak instruments Blundell-Bond estimation provides more reliable results for our analysis and ones that are even more supportive of our model.

7 Conclusion

In this paper we demonstrate that the Dutch disease effect may arise solely from the distribution of the natural resource rents. If the resource rents are less widely distributed, then the Dutch disease is more pronounced. In fact, the resource rents distribution can take precedence in determination of the Dutch disease. Our results suggest why some countries, therefore, have a greater chance of suffering this ailment.

We then take our theoretical model to the data and verify that inequality plays a significant role in whether being resource-rich generates sickness or health for an economy. Our empirical findings support our hypothesis that the Dutch disease is directly linked with how well the natural resource rents are distributed. The more unequal is this distribution, the stronger is the disease.

Apart from our focus on non-homothetic preferences our model is similar to that in Krugman (1987), Neary (1988), Torvik (2001), Goderis and Malone (2011), van der Ploeg and Venables (2013), and Beine, Coulombe and Vermeulen (2015) in that the natural resource sector does not use any labor (it is a pure economic windfall that is equivalent to a foreign transfer), however, it differs in that the natural resources are consumed and can be traded. In this way our framework is closer to Corden and Neary (1982), however, they also allow for their energy sector to employ factors of production (except when they turn off this possibility in order to concentrate solely on the spending effect). Although ignoring labor employment in the natural resource sector simplifies the exposition of our model (which works only through the spending effect), it also mirrors the empirical observation that in many countries a natural resource boom does not generate a large shift of labor towards the resource sector.[23]

Although there is no resource movement effect in our model, it does not mean that our results would be impervious to changes in the labor supply. As Beine, Coulombe and Vermeulen (2015) show, interprovincial and temporary worker immigration mitigate the Dutch disease effects of natural resource booms in western Canada. The results in our paper suggest that the mitigating effects of immigration may also depend on the share of the natural resource rents distributed to the economic migrants and may, therefore, be stronger in a more egalitarian country such as Canada.

Our analysis also relates to a recent debate evolving around the optimal use of resource revenues in developing countries (Collier, van der Ploeg, Spence, and Venables, 2010). Although we do not consider alternative distribution mechanisms to this effect, our main result demonstrates that equality in the distribution of natural resource rents could be an important factor to cope with Dutch disease dynamics. Future contributions to this discussion should explicitly consider the mechanisms through which natural resource rents are allocated.[24]

Our focus on the distribution of natural resource rents develops a relationship between Dutch disease effects and resource curse effects. Ideally one would like to more completely distinguish between, and isolate the effects of, institutions and resource rents distribution in explaining the growth of natural resource abundant countries. We leave these topics, as well as development of a more general understanding of the relationship between distribution and institutions, for further research.

[23]As noted by Brahmbhatt, Canuto, and Vostroknutova (2010) this resource movement effect is less prevalent in low-income countries. Furthermore, in many of the wealthy gulf oil states in the Middle East the workers are brought in from abroad. As shown by Kapiszewski (2006) the percentage of foreign-born workers in Kuwait, Qatar and the UAE (in 2004) are 64, 70, and 81 percent of the total population. A similar example is given by many South American countries where mining constitutes a large part of export revenues, but employs a very small part of the population. For example, mining made up 59 percent of Peru's exports in 2011 but employed only 1 percent of the labor force (Calfucura, Ortiz, Sanborn, and Dammert, 2013).

[24]An important observation here is that different allocation mechanisms may not be perfect substitutes. For example, remittances or foreign aid are conventionally considered to be analogous to natural resource finds in the literature. Although all these channels denote a windfall, the channels of injection to the economy could be different. Whereas the natural resource rents may be captured by the upper segments of the income distribution, remittances may be associated with poor or middle-class households on the receiver ends (see Behzadan and Chisik, 2016). Our framework, therefore, shows that natural resource finds and remittances may have different Dutch disease implications.

A Appendix

A.1 Proofs.

Proposition 1. *There exists a* $\hat{\kappa}(\theta, \theta^*, M_t, M_t^*)$ *and a* $\hat{\kappa}^*(\theta, \theta^*, M_t, M_t^*)$ *such that home manufacturing output is positive only if* $\kappa > \hat{\kappa}$ *and foreign manufacturing is positive only if* $\kappa < \hat{\kappa}^*$*. If* $\kappa \in (\hat{\kappa}, \hat{\kappa}^*)$*, then an increase in the inequality of the home resource rent distribution reduces home manufacturing output and increases foreign output.*

Proof. From equation (11) home manufacturing production is positive if

$$\frac{M_t}{M_t^*} > \frac{\alpha(1-\alpha-\beta)\theta g(1)}{[\theta\beta + (\alpha+\beta)(1-\alpha)\theta^*]g(\kappa)}. \tag{16}$$

Similarly foreign manufacturing is positive if

$$\frac{M_t^*}{M_t} > \frac{\alpha(1-\alpha-\beta)\theta^* g(\kappa)}{[\theta^*\beta + (\alpha+\beta)(1-\alpha)\theta]g(1)}. \tag{17}$$

The bounds given in equation (16) indicate that there exists a $\hat{\kappa}(\theta, \theta^*, M_t, M_t^*)$ such that home manufacturing is positive if and only if the equality of home resource rent distribution is above this critical level. Differentiation of both sides of equation (16) reveals that $\hat{\kappa}$ is increasing (decreasing) in the home (foreign) oil endowment and foreign (home) manufacturing productivity. Put succinctly, it is decreasing in θ^* and M_t and increasing in θ and ${M_t}^*$. Similarly, from equation (17) there exists a critical level of the home natural resource rent distribution $\hat{\kappa}^*(\theta, \theta^*, M_t, M_t^*)$ such that foreign manufacturing is positive if and only if κ is below this critical level and $\hat{\kappa}^*$ is decreasing in θ^* and M_t and increasing in θ and ${M_t}^*$. Of course, unless the foreign oil endowment is much larger, or their manufacturing productivity is much lower, this critical $\hat{\kappa}^*$ would be greater than one and not relevant in equilibrium.

If the bounds in equations (16) and (17) are satisfied, then it is straightforward to verify the effect of the home country's resource rent distribution on manufacturing output in home and foreign. In particular, from equation (11) we have that

$$\frac{\partial \ell_t}{\partial \kappa} = \frac{[\theta\beta + (\alpha+\beta)(1-\alpha)\theta^*][\gamma(1-\alpha) - \alpha A]}{A(\alpha+\beta)(1-\alpha)(\theta+\theta^*)} > 0$$

$$\frac{\partial \ell_t^*}{\partial \kappa} = -\frac{\alpha(1-\alpha-\beta)\theta^*[\gamma(1-\alpha) - \alpha A]M_t}{A(\alpha+\beta)(\theta+\theta^*)(1-\alpha)M_t^*} < 0. \tag{18}$$

In signing the above derivatives we again use assumption (1). □

Proposition 2. *A worsening of the home country resource rent distribution can generate manufacturing stagnation. It does so without a change in the relative home to foreign wage in the short run and with a decrease in the long run.*

Proof. From equation (11) the relative home wage is $\frac{w_t}{w_t^*} = \frac{M_t}{M_t^*}$ which does not depend on the current period values of κ, θ or θ^*. Hence, the relative wage does not change in the short run. After any change in the resource rent distribution of the home country, the total adjustment in the home manufacturing labor productivity at any time t is given by

$$dM_t = \int_0^t \delta \frac{\partial Q_{M\tau}}{\partial \ell_\tau} \frac{\partial \ell_t}{\partial \kappa} d\kappa d\tau = \int_0^t \delta M_\tau \frac{\partial \ell_t}{\partial \kappa} d\kappa d\tau \tag{19}$$

which, is strictly negative if $d\kappa < 0$ and $\kappa > \hat{\kappa}$ and is weakly negative if $d\kappa < 0$ and $\kappa \leq \hat{\kappa}$. Similarly, for $d\kappa < 0$ and $\kappa < \hat{\kappa}^*$ the total change in foreign manufacturing labor productivity is

$$dM_t^* = \int_0^t \delta \frac{\partial Q_{M\tau}^*}{\partial \ell_\tau^*} \frac{\partial \ell_t^*}{\partial \kappa} d\kappa d\tau = \int_0^t \delta M_\tau^* \frac{\partial \ell_t^*}{\partial \kappa} d\kappa d\tau > 0.$$

□

Proposition 3. *If $M_t = M_t^*$, and from time t to a finite time $\tau > t$ either $\theta > \theta^*$ or $\kappa < 1$ or both, and after time τ, $\theta = \theta^*$ and $\kappa = 1$, then home will have lower manufacturing productivity, lower wages, and lower income for all time after τ.*

Proof. We begin by writing the ratio of home to foreign labour in manufacturing at time t for the case when the resource rents and their distribution are equal in home and foreign.

$$\frac{\ell_t}{\ell_t^*} = \frac{M_t^* M_t[2\beta + \alpha(1-\alpha-\beta)] - M_t^* M_t^* \alpha(1-\alpha-\beta)}{M_t^* M_t[2\beta + \alpha(1-\alpha-\beta)] - M_t M_t \alpha(1-\alpha-\beta)} \tag{20}$$

Equation (20) shows that if $M_t < M_t^*$, then $\ell_t < \ell_t^*$ and foreign would have a comparative advantage in manufactured goods. Although $w_t < w_t^*$ (because $\frac{w_t^*}{w_t} = \frac{M_t^*}{M_t}$), this wage reduction will not be enough to offset the lower home manufacturing productivity. Wages cannot drop enough to reverse the pattern of trade given by comparative advantage. Furthermore, the reduction in the home wage will not change the measure of home agents that buy services, because the price of services is tied to the wage (see equations (6) and (7)). In equation (20) we only consider the case when manufacturing output is positive in home and foreign, however, the same result holds for the case when the home country does not produce manufactured goods. In particular, if the condition in equation (16) is not satisfied, then any further drop in the home relative wage would not bring back the manufacturing sector. □

A.2 Tables.

Table A1 – Definitions and Sources of the Variables

Variables	Definition and Comments	Source (World Bank, WDI (2013) for the period 1965-2008 unless specified)
Log of real GDP per capita	Measured in constant 2005 US$.	
Natural resource rents	Total natural resources rents (% of GDP). Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	
Gini coefficient (1965 – 2008)	Average of Gini index between the years 1965 – 2008. A Gini index of 0 represents perfect equality, while an index of 1 implies perfect inequality.	World Bank estimates (2013)
Institutional quality	Average of 6 variables; Corruption in government, Rule of law, Bureaucratic quality, Ethnic tensions, Repudiation of contracts by government, Risk of expropriation indexed between 0 and 10 (10 represents highest quality of institutions.) for the period 1982-1997.	Knack and Keefer (1998), ICRG data set
Log of fertility rate	Logarithm of the total fertility rate or births per woman; representing the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates.	
Government consumption	General government final consumption expenditure (% of GDP).	
Inflation	GDP implicit deflator (annual %) is the ratio of GDP in current local currency to GDP in constant local currency.	
Investments	Gross capital formation (% of GDP).	
Growth rate of terms of trade	Annual changes in the net barter terms of trade index calculated as the percentage ratio of the export unit value indexes to the import unit value indexes, measured relative to the base year 2000.	

Table A2 – Summary Statistics

Variables	Number of observations	Mean	Standard Deviation	Minimum	Maximum
Real GDP per capita Growth (annual rate)	959	0.00708	0.0489	-0.317	0.182
Gini coefficient	61	0.454	0.0831	0.299	0.691
Natural resource rents	963	0.0947	0.108	0.000337	0.677
Institutional quality	935	0.540	0.142	0.200	0.956
Log of fertility rate	976	1.510	0.374	0.464	2.051
Government consumption (share of GDP)	944	0.140	0.0615	0.0298	0.545
Inflation (annual %)	959	1.042	7.355	-0.292	136.1
Investment (% of GDP)	947	0.209	0.0762	0.0315	0.597
Growth rate of terms of trade	953	-0.0194	0.178	-1.460	1.057
Log of GDP per capita	1,081	7.113	1.152	4.717	10.56

Table A3 – List of the Countries

Countries with an asterisk are Communist countries and are excluded from the restricted sample.

Algeria	Ecuador	Malawi	South Africa
Angola*	Egypt, Arab Rep.	Malaysia	Sri Lanka
Argentina	El Salvador	Mali	Tanzania
Bangladesh	Ethiopia*	Mexico	Thailand
Bolivia	Gabon	Morocco	Togo
Botswana	Gambia, The	Mozambique*	Trinidad and Tobago
Brazil	Ghana	Namibia	Tunisia
Burkina Faso	Guatemala	Nicaragua	Turkey
Cameroon	Guinea	Niger	Uganda
Chile	Guinea-Bissau	Nigeria	United States
China*	Honduras	Pakistan	Uruguay
Colombia	India	Panama	Venezuela, RB
Congo, Rep.	Indonesia	Paraguay	Zambia
Costa Rica	Jordan	Peru	
Cote d'Ivoire	Kenya	Philippines	
Dominican Republic	Madagascar	Senegal	

Table A4 – Correlation Matrix

	Real GDP per capita growth	Gini coefficient	Natural resource rents	Institutional quality	Log of fertility rate	Government consumption	Inflation	Investments	Growth rate of terms of trade	Lagged log of GDP per capita	Lagged log of GDP per capita squared
Real GDP per capita growth	1.000										
Gini coefficient	-0.096	1.000									
Natural resource rents	-0.140	-0.055	1.000								
Institutional quality	0.254	0.159	-0.174	1.000							
Log of fertility rate	-0.293	-0.091	0.239	-0.566	1.000						
Government consumption	-0.222	0.232	0.077	0.068	0.177	1.000					
Inflation	-0.173	0.088	0.016	-0.070	-0.010	0.121	1.000				
Investments	0.299	-0.181	0.088	0.216	-0.322	0.098	-0.012	1.000			
Growth rate of terms of trade	0.117	0.021	-0.113	0.103	-0.076	-0.015	0.022	-0.052	1.000		
Lagged log of GDP per capita	-0.000	0.412	0.000	0.481	-0.643	0.136	0.022	0.194	-0.007	1.000	
Lagged log of GDP per capita squared	0.002	0.389	0.005	0.499	-0.642	0.128	0.016	0.185	-0.010	0.995	1.000

Table A5 – Test of Autocorrelation in the Error Terms

Orders	(Current Natural Resource Rents) z	(Current Natural Resource Rents) P-value	(Lagged Natural Resource Rents) z	(Lagged Natural Resource Rents) P-value	(Current Natural Resource Rents) z	(Current Natural Resource Rents) P-value	(Lagged Natural Resource Rents) z	(Lagged Natural Resource Rents) P-value
Panel A – Arellano-Bond Estimation (Table 1)								
1	-3.54	0.000	-3.37	0.001	-3.38	0.001	-3.10	0.002
2	-0.55	0.580	-0.85	0.393	0.31	0.758	-0.48	0.634
3	0.39	0.695	0.26	0.793	-0.18	0.854	-0.01	0.994
Panel B – Arellano-Bond Estimation Using the Residuals (Table 2)								
1	-3.58	0.000	-3.02	0.003	-3.15	0.002	-3.12	0.002
2	-0.32	0.747	-0.68	0.496	-0.33	0.739	-0.31	0.756
3	0.35	0.728	0.17	0.867	0.06	0.953	-0.03	0.979
Panel C – Blundell-Bond (Table 3)								
1	-3.85	0.000	-3.75	0.000	-3.38	0.001	-3.31	0.001
2	-0.25	0.801	-0.34	0.737	0.19	0.851	0.14	0.892
3	0.28	0.777	0.19	0.848	-0.13	0.896	-0.27	0.784
Panel D – Blundell-Bond Estimation Using the Residuals (Table 4)								
1	-3.81	0.000	-3.72	0.000	-3.45	0.001	-3.34	0.001
2	-0.17	0.865	-0.36	0.719	0.32	0.751	0.16	0.871
3	0.32	0.752	0.21	0.836	-0.14	0.892	-0.26	0.798
Communist Countries Excluded	NO		NO		YES		YES	

Notes: There is no autocorrelation in the error terms at orders 2 and above in all of the regressions. Thus using two further lags as instruments is appropriate.

Table A6 – Unitroot Test

	Statistic	P-value	Fixed-N Exact Critical Values 1%	5%	10%
t-bar	-3.4563		-1.820	-1.730	-1.690
$\tilde{t}$-bar	-2.4280				
Z-$\tilde{t}$-bar	-8.9583	0.0000			

Notes: Im-Pesaran-Shin (IPS) unit root test is performed for the unbalanced panel. The p-value is reported for the null hypothesis that all panels contain unit roots against the alternative that some panels are stationary. The zero p-value along with the t-bar statistic being less than its 1% critical value, imply that there is no integration of order one in the panel.

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Does Inequality Drive the Dutch Disease? Theory and Evidence (Online Appendix)

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1 Introduction

In this appendix we present the additional empirical sections in testing whether the Dutch disease arises in countries with less equal distribution of natural resource rents. Our empirical strategy as a whole consists of two parts. First, in order to draw comparisons with the seminal empirical papers on the Dutch disease and the resource curse (Sachs and Warner (1997a) and Mehlum, Moene, and Torvik (2006)) we employ a cross-sectional analysis of the data and look for the relationship between resource rent distribution and growth. The empirical literature on estimation of the Dutch disease and the resource curse begins with Sachs and Warner (1997a, 1997b) who find strong evidence of the Dutch disease. Mehlum et al. (2006) extend their analysis to consider the interaction between institutional quality and natural resource abundance. In addition to the extensions noted above we also replace their resource abundance measure (which includes food, beverages, animal and plant products, as well as energy and precious metals) with natural resource rents (which only includes energy, precious metals, and forestry products). This narrower measure of natural resources refutes the hypothesis that natural resources by themselves can cause the Dutch disease. It is only when interacted with inequality that the effect can be negative. Brunnschweiler and Bulte (2008), van der Ploeg and Poelhekke (2010), and Collier and Goderis (2012) also propose different measures of natural resources that should not suffer the same endogeneity problems as the measure used by Sachs and Warner and Mehlum et al and, like us, they find that natural resources by themselves do not cause a disease.

Although influential, it has been suggested that the results in these seminal papers may not be robust to better econometric specifications. In particular, cross-section growth equations may suffer from endogeneity of the supposed independent variables, effects driven by unobservable country heterogeneity, and the measure of natural resources. Hence, we extend our analysis in several dimensions. Since the old measure of natural resource that is used in these studies could most likely endogenous (as it includes agriculture), we introduce a more compelling measure of natural resource rents. We also consider the relationship between institutional quality and income inequality, and we show that our results are robust to a similar regression where inequality is replaced by the residuals of a regression of inequality on institutional quality. In fact, there is surprisingly little correlation between institutional quality and inequality. One possible explanation for this finding is that (as a matter of ideology) Muslim, communist, and former communist countries have low (reported) levels of inequality. Finally, in order to isolate country heterogeneity in capturing annual changes while dealing with the possible inconsistency of an OLS estimation, and especially any possible endogeneity of the regressors, we utilize a dynamic panel analysis with Arellano-Bond and Blundell-Bond general method of moments (GMM) estimators. This online appendix covers our examination of the measure of natural resources that we use throughout the paper and also provides further variations of the dynamic panel analysis which is discussed in more details in our original paper.

Our findings in this appendix (inline with the findings in our original paper) do not refute our hypothesis that the Dutch disease is directly linked with how well the natural resource rents are distributed. Natural resource rents by themselves positively impact growth, however, the interaction of rents with their distribution shows that there is a critical level of our inequality measure. Whether inequality is above or below this level plays a significant role in whether being resource-rich is a blessing or a curse for a country.[1]

In the next section we conduct a cross sectional analysis mainly to introduce the measure of natural

[1] Although our theory refers to distribution of the natural resource rents, there is no such known measure in the data. Hence, we use Gini coefficients as proxies for our desired measure. In all of our regression results, the critical level of the Gini coefficient (above which natural resource booms can cause the Dutch disease) is around the level for the USA (.41). Scandinavian countries are lower (.25-.29) and many African and Latin American countries have higher Gini coefficients (often above .5 and up to .7).

resources that we use throughout our study and compare its performance with the existing Dutch disease related studies. The third section serves as an appendix to the dynamic panel section in the original paper and provides various specifications for our main analysis.

2 Cross Sectional Analysis

We begin by following the growth and natural resource curse literature and examine this relationship in a cross-country experiment as introduced by Sachs and Warner (1997a). Starting by an ordinary least squares (OLS) estimation as given by equation (1), we replicate the cross-sectional results in Mehlum et al. (2006). In order to benchmark our results, we use a data set that originally comes from Sachs and Warner (1997a,b). This data set includes 87 countries for the years between 1965 and1990.

$$growth_i = \alpha_0 + \alpha_1 sxpr_i + \alpha_2 iq_i + \alpha_3 \left(sxpr_i \cdot iq_i\right) + \alpha_4 X_i + \alpha_5 \varepsilon_i \tag{1}$$

The dependent variable $growth_i$ is the average growth rate of real GDP per capita between 1965 and 1990. The variable $sxpr_i$ is the share of primary exports in GNP in 1970 and iq_i is the average institutional quality index in 1982-1997. This index takes values between zero and one (one indicating the best institutions). The variable X_i includes all other explanatory variables such as initial income level in 1965, openness, investments as a share of GDP. More details on, and the definitions of, the variables are presented in Table A1 in the appendix.

Table 1 shows the results of the above regression. The first column confirms the results of Mehlum et al. (2006) on convergence, openness, investments, natural resource abundance, institutional quality and the interaction of the last two variables. Natural resources (as measured by the share of exports of primary products in GNP) on average have a negative significant impact on GDP growth. In line with Sachs and Warner's results, institutional quality does not seem to alter growth significantly, however, the interaction of the two has a positive and strong impact on GDP growth. This implies that an increase in natural resource abundance increases GDP growth only if the institutional quality index is higher than 0.93. For a country with institutional quality index below this threshold, being resource rich is, on average, a curse.

Next, we present our cross-sectional regression in order to compare our results with Mehlum et al. (2006). As there is no direct measure of natural resource rent distribution at the time of this analysis, we use the average Gini coefficient in 1970-1990 from the Deininger and Squire (1996) high-quality data set to proxy for inequality. Also, we consider the interaction of the Gini coefficient and natural resources to examine how the results in Mehlum et al. (2006) are affected when income inequality and institutional quality coexist. Equation (2) indicates our cross-sectional OLS estimation where Nr_i is the measure of natural resource endowments (denoting either natural resource abundance as defined in Mehlum et al. (2006) or natural resource rents as we define it) and $Gini_i$ captures the income inequality:

$$growth_i = \alpha_0 + \alpha_1 Nr_i + \alpha_2 Gini_i + \alpha_3 (Nr_i \cdot Gini_i) + \alpha_4 iq_i + \alpha_5 (Nr_i \cdot iq_i) + \alpha_6 X_i + \alpha_7 \varepsilon_i \qquad (2)$$

Column (2) of table 1 summarizes the results of this regression. When inequality comes into the picture, neither natural resource abundance nor institutional quality have any significant effects on growth. Our coefficient of interest has the expected sign, however, it is not significant. Unfortunately of the 87 countries in the Sachs and Warner (1997a) and Mehlum et al. (2006) data set we only have a Gini coefficient for 36 countries during the same time frame. We utilize a different Gini below in order to increase the country coverage. Before augmenting our inequality measure, however, we address our concerns with the measure of natural resources in these previous studies.

Table 1 – Cross-Sectional Analysis

Variables	(1) Mehlum et al. (Natural resource abundance)	(2) OLS (Natural resource abundance & Average Gini 1970-1990)	(3) OLS (Average Gini 1970-1990)	(4) OLS (Average Gini 1965-2008)	(5) OLS (R/P 10% 2009)	(6) OLS (Average Gini 1965-2008)	(7) OLS (R/P 10% 2009)
Log GDP 1965	-1.260***	-1.391***	-1.257***	-0.794***	-1.234***	-0.785***	-1.213***
	(0.187)	(0.290)	(0.392)	(0.213)	(0.204)	(0.202)	(0.211)
Openness	1.653***	1.521**	1.182*	1.582***	1.826***	1.605***	1.854***
	(0.426)	(0.572)	(0.598)	(0.515)	(0.487)	(0.482)	(0.494)
Natural resource abundance	-14.265***	-6.430					
	(3.358)	(12.584)					
Institutional quality	-1.316	0.372	0.204	0.714	-0.010	-0.029	0.101
	(1.185)	(2.685)	(2.393)	(1.199)	(1.148)	(1.150)	(1.160)
Investments	0.156***	0.138***	0.144***	0.117***	0.159***	0.122***	0.150***
	(0.022)	(0.030)	(0.035)	(0.024)	(0.024)	(0.024)	(0.025)
Natural resource abundance × Institutional quality	15.252**	12.876					
	(6.317)	(15.020)					
Gini coefficient (1970 – 1990)		0.028	0.047				
		(0.037)	(0.035)				
Natural resource abundance × Gini coefficient (1970 – 1990)		-0.149					
		(0.268)					
Natural resource rents			0.168	0.500***	0.039	0.464***	0.042
			(0.169)	(0.149)	(0.074)	(0.138)	(0.074)
Natural resource rents × Institutional quality			0.295	0.017	0.035	0.136	0.031
			(0.217)	(0.106)	(0.115)	(0.105)	(0.116)
Natural resource rents × Gini coefficient (1970 – 1990)			-0.008*				
			(0.004)				
Gini coefficient (1965 – 2008)				6.606**		7.126***	
				(2.773)		(2.576)	
Natural resource rents × Gini coefficient (1965 – 2008				-1.204***		-1.304***	
				(0.310)		(0.289)	
R/P 10%					3.373		3.368
					(2.094)		(2.105)
Natural resource rents × R/P 10%					-0.493**		-0.497**
					(0.226)		(0.227)
Communist Countries Excluded	NO	NO	NO	NO	NO	YES	YES
Observations	87	36	36	80	79	77	77
R-squared	0.728	0.777	0.744	0.599	0.698	0.641	0.684

Notes: Robust standard errors are in parentheses. Dependent variable is the average growth rate of real GDP per capita between 1965 and 1990.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

From column (1) we see that the natural resource abundance measure used by Sachs and Warner (1997a) and Mehlum et al. (2006) shows a strong negative effect on growth. In both of these studies the coefficient on this variable is also negative and highly significant. We are, however, concerned with the excessively wide coverage of this variable. The sectors of the economy included in this variable are all of the industries under the following SITC (revision 1) codes: 0 (food and live animals), 1 (beverages and tobacco), 2 (crude materials, inedible, except fuels), 3 (mineral fuels, lubricants and related materials), 4 (animal and vegetable oils, fats and waxes), and 68 (manufactured non-ferrous metal). This variable has two potential problems. First, most of these items (except code 3, which includes mining and petroleum) take us far from the underlying presumption of the Dutch disease or the resource curse. Second, low income countries are much more likely to be highly dependent on food, beverage, animal, and vegetable products (codes 0, 1, 2, and 4). Hence, this variable is likely to be endogenous and it is, therefore, impossible to ascertain the direction of the causality between "natural resource abundance" and growth.

We propose instead to use what we call "natural resource rents" which includes only oil, natural gas, coal, mineral, and forest rents (codes 3 and 23-25) and we introduce it in column 3. Although we do not claim that the substitution of rents for abundance entirely solves the possible endogeneity problem (we attempt to control for that in a later section) it is interesting to note that the coefficient on rents in columns 3 through 7 is now positive. Hence, natural resource rents by themselves are correlated with faster growth. This finding reduces the concerns arising from the most important reason why natural resource rents could be endogenous: that low income countries are dependent on natural resources because that is all they have. Further note that natural resources by themselves do not appear to cause the Dutch disease.

More importantly, the results in column (3) show that inequality of the resource rent distribution can reverse the positive effects of resource rents on GDP growth. This implies that natural resource rents can only help the economy to grow if income inequality is lower than a threshold. In other words, what really matters for economic growth is how equally the natural resource rents are distributed. Note, however, that the coefficient on the interaction term of Gini and resource rents is rather small and significant only at the 10 percent level. We believe this is driven by the noisiness and sparseness of the Gini data for 1970-1990. The Gini coefficient is not reported for many countries in the Deininger and Squire data set in the period of 1970-1990 and the few number of countries can affect our results. In order to have a better country coverage, in column (4) we use the World Bank Gini coefficients averaged from 1965 to 2008. Although it includes many more countries, it still does not cover every year in the sample, however, Gini coefficients do not appear to change much over time and we feel comfortable using the average of the reported years. The inclusion of this additional data generates more pronounced results: both natural resource rents and inequality have positive significant effects and, crucially, when interacted they have a strong negative significant impact on real GDP growth. Furthermore, we note that the coefficient on institutional quality and on its interaction with natural resource rents have the expected signs, but they are not significant.

Column (5) reports the results of the same regression when the Gini coefficient is replaced by the ratio of the average income of the richest decile to the poorest decile as an alternative measure of income inequality. This index is from the United Nations Development Programme (UNDP) Human Development Report (2009) and has almost the same country coverage as the Gini coefficient between 1965 and 2008. Similar to the our previous findings, the interaction term has a significant negative impact on GDP growth and the effects of institutional quality are insignificant.

The relationship between income inequality and economic growth may differ for communist countries in the sense that these economies are generally known for low growth and bad institutions but also low income inequality. We, therefore, exempt them from our analysis to test if the results are affected by the presence of these countries. In columns (6) and (7), we test the same regression as in columns (4) and (5) while excluding communist countries from the analysis. As expected, the measured effects are more significant and more pronounced.

Intuitively, given the point estimates in column (4), we can express the total effect of natural resource rents on GDP growth as

$$\frac{\partial\ GDP\ Growth}{\partial\ Natural\ Resource\ Rents} = 0.5 - 1.204(Gini\ Coefficient) + .017(Institutional\ Quality). \tag{3}$$

Consequently, (ignoring the small effect of institutional quality) a country with a Gini coefficient higher than a threshold of 0.41 (i.e. $\frac{0.5}{1.204}$) experiences lower GDP growth when there is a natural resource boom. This is in line with our theoretical findings suggesting that the higher the inequality, the stronger the natural resource curse. As a point of reference, the reported Gini coefficient for the USA is between .39 and .41. Others are as follows: Norway .27, Egypt and Pakistan .32, China .35, Kenya .48, Bolivia .56, Brazil .58 and Namibia .69. The reported Gini coefficients in our data set are all between .25 and .7

Similarly, the effect of inequality on GDP growth is given by

$$\frac{\partial\ GDP\ Growth}{\partial\ Gini\ Coefficient} = 6.606 - 1.204(Natural\ Resource\ Rents)$$

In other words, for a country whose natural resource rents do not exceed 5.49 percent of its GDP, more inequality enhances economic growth. On the other hand, resource-rich countries do not benefit from higher inequality in terms of their GDP growth.

In order to test whether the point estimates given above are not affected by the additional explanatory variables, we examine the causal inference of our regression from column (4) of table 1. In table 2 we start in column (1) with a bare-bones regression of growth on natural resource rents, inequality, their interaction, and the initial GDP level. We successively add variables until in column (5) we reproduce the regression in column (4) of table 1. These results are presented in table 2. Our coefficient of interest always remains negative and significant suggesting that the effect of the distribution of natural resource rents are not altered by other growth related explanatory variables.

Table 2 – Cross-Sectional Causal Inference

Variables	(1)	(2)	(3)	(4)	(5)
Log GDP 1965	0.217	-0.331	-0.767***	-0.791***	-0.794***
	(0.212)	(0.212)	(0.201)	(0.210)	(0.213)
Openness		3.076***	1.874***	1.564***	1.582***
		(0.504)	(0.490)	(0.500)	(0.515)
Natural resource rents	0.280	0.494***	0.426***	0.511***	0.500***
	(0.170)	(0.154)	(0.134)	(0.134)	(0.149)
Investments			0.119***	0.117***	0.117***
			(0.022)	(0.024)	(0.024)
Institutional quality				0.831	0.714
				(0.959)	(1.199)
Natural resource rents ×					0.017
Institutional quality					(0.106)
Gini coefficient (1965 – 2008)	1.049	7.909**	6.043**	6.691**	6.606**
	(3.275)	(3.166)	(2.765)	(2.706)	(2.773)
Natural resource rents ×	-0.729*	-1.127***	-1.022***	-1.208***	-1.204***
Gini coefficient (1965 – 2008)	(0.394)	(0.357)	(0.310)	(0.307)	(0.310)
Observations	96	90	90	80	80
R-squared	0.123	0.399	0.554	0.598	0.599

Notes: Robust standard errors are in parentheses. Dependent variable is the average growth rate of real GDP per capita between 1965 and 1990.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

An additional concern is that the Gini coefficient and institutional quality could be correlated (either linearly or non-linearly) and, as a result, the Gini coefficient could only be capturing the effects of institutional quality on growth rather than the distributional effects. In order to remove such a possible multicollinearity problem, and check whether our results remain robust, we adopt the following procedure. We begin by regressing the Gini coefficient on institutional quality and institutional quality squared; then retrieve the residuals from this regression. We next use these residuals instead of the Gini coefficient so that we have a measure of income inequality purged from institutional quality. Table 3 presents the results of the same regressions as in table 2 with these purged Gini coefficients. Our previous findings remain robust after this alteration.

Despite the robust results in showing that our new measure of natural resource rents is legit for our purposes, we believe that this is not the preferred estimation method because it ignores country heterogeneity, time trends, more short run time effects, and any remaining possible endogeneity between the dependent variable and the predictors of GDP growth. Thus, in our main paper, we consider the time inference of the effects of annual changes in the resource rents on GDP growth in our estimations, through a dynamic panel data analysis. Accordingly, the following section provides more details and additional variations of our dynamic panel analysis which was not presented in the main paper.

Table 3 – Cross-Sectional Causal Inference Robustness Check

Variables	(1)	(2)	(3)	(4)	(5)
Log GDP 1965	0.359*	-0.410*	-0.769***	-0.821***	-0.827***
	(0.201)	(0.215)	(0.197)	(0.213)	(0.210)
Openness		2.680***	1.450***	1.338***	1.571***
		(0.460)	(0.459)	(0.492)	(0.508)
Natural resource rents	-0.033	0.001	-0.018	-0.016	-0.102*
	(0.020)	(0.019)	(0.016)	(0.017)	(0.056)
Investments			0.122***	0.119***	0.120***
			(0.023)	(0.024)	(0.024)
Institutional quality				0.615	-0.494
				(0.942)	(1.159)
Natural resource rents × Institutional quality					0.176
					(0.109)
Residuals	5.296	7.342**	5.143*	5.025*	5.866**
	(3.693)	(3.251)	(2.821)	(2.838)	(2.856)
Natural resource rents × Residuals	-1.227***	-1.190***	-1.030***	-1.019***	-1.174***
	(0.388)	(0.342)	(0.295)	(0.296)	(0.308)
Observations	83	80	80	80	80
R-squared	0.176	0.428	0.585	0.587	0.602

Notes: Robust standard errors are in parentheses. Dependent variable is the average growth rate of real GDP per capita between 1965 and 1990. Inequality is measured by the average Gini coefficient in 1965 – 2008. Residuals measure inequality purged from institutional quality.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

3 Dynamic Panel Analysis

In our growth regression, the contemporaneous correlation between the error terms and the initial GDP, would be generating an inconsistent fixed effects estimator. Hence, our dynamic panel analysis makes use of two estimators, namely difference GMM (Arellano-Bond) and system GMM (Blundell-Bond). Initially, Arellano and Bond proposed first differencing the level equation to purge out the individual effects, and simultaneously instrumenting the differenced variables using a panel GMM estimator to improve the efficiency of the estimation. In this case, the instruments are the deeper lags (starting from $t-2$) of each of the endogenous and predetermined variables assuming that the errors are serially uncorrelated.[2]

Although, Arellano-Bond estimator is consistent in dynamic panel, there are two issues with this instrumentation procedure; First, lagged variables are usually considered weak instruments in explaining the endogenous variables. This weak correlation can ultimately result in finite sample biases when we use the difference GMM.[3] To overcome this issue and make sure that our results are not reversed otherwise, as suggested by the existing studies on GMM estimation on growth models[4], we have also estimated our model using system GMM. Essentially, this estimator incorporates more informative moment conditions by using a set of instruments which includes first differences in addition to lagged levels, for a system of level equations along with first differenced equations.

Second, the number of instruments used in difference *and* system GMM estimations directly impacts the results. In fact, there is a trade off in choosing how many lags to use as instruments for each endogenous variable; Although in general, more instruments should better explain the model, too many instruments can also hurt the results. A large number of instruments might overfit the model and weakens the validity of the Hansen overidetification test. As a result and in order to obtain reliable Hansen tests, we have employed the method of collapsing the instruments as suggested by Roodman (2008) in both the difference and system GMM, in order to have as many instruments as possible that are still smaller than the number of countries. Ideally, we

[2] This assumption is tested by a test of autocorrelation in the error terms. The results presented in table A5 of the main text, suggest no serial correlation at order 2 and above.

[3] Blundell, and Bond (1998)

[4] Bond, Hoeffler, and Temple (2001)

would want to start with using 1 lag for each variable in the instrumentation process. However, in a difference GMM procedure, this will generate exact identification and we are unable to identify the validity of the instruments. Thus, as shown in the main paper, we have used one lag for the initial GDP and two further lags for the rest of the variables.

In sum, both of these types of estimators use a reasonable number of either the lagged variables alone or along with the lagged differenced-variables, as instruments for predetermined and endogenous regressors. As a result, the unobserved individual effects is properly eliminated in a dynamic panel setting such as the growth regressions (where the initial GDP is also a right hand side variable.).[5] Our results using both types of the estimations indicate that the inequality-resource threshold effect is present. In other words, natural resource rents have a negative impact on the growth when there is more inequality.

[5]See our main text for more details on the instrumentation procedure and the results.

Table 4 – Arellano-Bond Estimation (Two Lags)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.402	-0.079	-0.121	-0.161
	(0.511)	(0.252)	(0.375)	(0.233)
Log of GDP per capita (lagged one period) squared	0.029	0.007	0.009	0.013
	(0.035)	(0.017)	(0.026)	(0.016)
Natural resource rents	-1.293		1.874	
	(1.889)		(1.216)	
Natural resource rents × Gini coefficient	5.130		-3.424	
	(4.452)		(2.681)	
Inflation	-0.002	-0.002*	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	0.278	-0.084	0.039	-0.104
	(0.320)	(0.223)	(0.153)	(0.171)
Natural resource rents × Institutional quality	-1.540		-0.274	
	(1.507)		(1.265)	
Growth rate of terms of trade	0.009	0.028***	0.007	0.025**
	(0.014)	(0.009)	(0.013)	(0.010)
Log of fertility rate	0.057	-0.420	-0.145	-0.346
	(0.263)	(0.355)	(0.238)	(0.340)
Government consumption	0.047	-0.051	-0.119	-0.006
	(0.164)	(0.306)	(0.331)	(0.129)
Investments	0.221	0.256	0.193	0.198
	(0.209)	(0.186)	(0.158)	(0.173)
Natural resource rents (lagged one period)		2.162		1.628**
		(1.442)		(0.760)
Natural resource rents (lagged one period) × Gini coefficient		-5.104		-3.742**
		(3.813)		(1.791)
Natural resource rents (lagged one period) × Institutional quality		1.818		1.723*
		(1.248)		(0.922)
Hansen test	0.121	0.524	0.149	0.684
Number of observations	774	774	730	730
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($logGDP_t - logGDP_{t-1}$). Year fixed effects are included in all of the estimations. Arellano-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 2 further lags. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $X^2(8)$. Total number of instruments is 35. Robust standard errors are reported in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Given the 61 countries that we have in the sample, this seems to generate a moderate number of instruments that is not too small to have little explanatory power and at the same time not too large to overfit the variables or be more than 61.[6] However in what follows we present our results of the main GMM estimations using different numbers of instruments to assure the reader that our results are not solely driven by a specific number of instruments.

Table 4 and table 5 present the results of the Arellano-Bond estimation using 2 instruments for

[6]In this case, the difference GMM estimator generates 33 instruments.

both the predetermined and endogenous variables. The estimations in table 4 use the gini coefficient to measure inequality whereas the residuals of regressing gini on institutional quality and institutional quality squared are used instead of gini in table 5.

Table 5 – Arellano-Bond Estimation (Robustness Check Using Residuals – Two Lags)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.208	-0.033	-0.554	-0.113
	(0.359)	(0.268)	(0.640)	(0.226)
Log of GDP per capita (lagged one period) squared	0.015	0.004	0.038	0.009
	(0.024)	(0.018)	(0.044)	(0.015)
Natural resource rents	0.684		0.872	
	(0.583)		(0.655)	
Natural resource rents × Residuals	1.772		-4.465	
	(7.312)		(4.248)	
Inflation	-0.002*	-0.001	-0.001	-0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	0.189	-0.154	0.216	-0.165
	(0.277)	(0.231)	(0.265)	(0.195)
Natural resource rents × Institutional quality	-0.483		-2.225	
	(1.362)		(2.001)	
Growth rate of terms of trade	0.008	0.027**	0.020	0.026**
	(0.014)	(0.011)	(0.015)	(0.010)
Log of fertility rate	-0.003	-0.573*	-0.181	-0.514
	(0.258)	(0.336)	(0.325)	(0.400)
Government consumption	0.058	-0.062	-0.099	-0.033
	(0.135)	(0.353)	(0.363)	(0.122)
Investments	0.228	0.278	0.163	0.238
	(0.200)	(0.204)	(0.176)	(0.190)
Natural resource rents (lagged one period)		0.133		0.097
		(0.325)		(0.307)
Natural resource rents (lagged one period) × Residuals		-7.793*		-4.566**
		(4.582)		(1.791)
Natural resource rents (lagged one period) × Institutional quality		1.357		1.327
		(0.880)		(0.828)
Hansen test	0.088	0.704	0.279	0.870
Number of observations	774	774	730	730
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($logGDP_t - logGDP_{t-1}$). In all estimations, the measure of inequality (Gini) is replaced by the residuals of regressing Gini on Institutional quality. Year fixed effects are included in all of the estimations. Arellano-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 2 further lags. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $\chi^2(8)$. Total number of instruments is 35. Robust standard errors are reported in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

The results of the Blundell-Bond estimation using 2 lags are presented in table 6 and table 7 where gini and the residuals (correspondingly) are used in the estimations. These findings suggest that although adding more instruments improves the fit of the model, nothing else changes in terms of the presence of the threshold effect that we foundearlier, specially when the residuals are taken into account.

Table 6 – Blundell-Bond Estimation (Two lags)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.172	-0.132	-0.189	-0.102
	(0.120)	(0.125)	(0.141)	(0.120)
Log of GDP per capita (lagged one period) squared	0.012	0.009	0.013	0.007
	(0.009)	(0.009)	(0.010)	(0.008)
Natural resource rents	0.737		1.000**	
	(0.555)		(0.405)	
Natural resource rents × Gini coefficient	-0.696		-1.457	
	(1.088)		(0.943)	
Inflation	-0.001**	-0.001	-0.002**	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	0.145**	0.118**	0.098	0.097
	(0.072)	(0.055)	(0.072)	(0.066)
Natural resource rents × Institutional quality	-0.555		-0.497	
	(0.404)		(0.497)	
Growth rate of terms of trade	0.020**	0.024**	0.018	0.015
	(0.010)	(0.010)	(0.011)	(0.010)
Log of fertility rate	-0.001	0.011	0.013	0.022
	(0.034)	(0.030)	(0.027)	(0.030)
Government consumption	-0.063	-0.013	0.017	0.008
	(0.149)	(0.102)	(0.089)	(0.087)
Investments	0.204**	0.195**	0.137*	0.170***
	(0.092)	(0.083)	(0.075)	(0.063)
Natural resource rents (lagged one period)		0.535		0.353
		(0.373)		(0.353)
Natural resource rents (lagged one period) × Gini coefficient		-0.988**		-0.821*
		(0.464)		(0.444)
Natural resource rents (lagged one period) × Institutional quality		-0.082		0.100
		(0.457)		(0.400)
Hansen test	0.257	0.521	0.215	0.333
Number of observations	836	836	788	788
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($\log GDP_t - \log GDP_{t-1}$). Year fixed effects are included in all of the estimations. Blundell-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 2 further lags. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $\chi^2(19)$. Total number of instruments is 46. Robust standard errors are reported in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 7 – Blundell-Bond Estimation (Robustness Check Using Residuals – Two lags)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.063	-0.106	-0.123	-0.067
	(0.179)	(0.116)	(0.139)	(0.124)
Log of GDP per capita (lagged one period) squared	0.004	0.007	0.008	0.004
	(0.013)	(0.008)	(0.010)	(0.009)
Natural resource rents	0.344		0.475	
	(0.471)		(0.353)	
Natural resource rents × Residuals	-0.894		-2.925	
	(1.030)		(1.898)	
Inflation	-0.001**	-0.001*	-0.002***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Institutional quality	0.158**	0.135**	0.129**	0.122*
	(0.066)	(0.057)	(0.060)	(0.065)
Natural resource rents × Institutional quality	-0.267		-0.712	
	(0.944)		(0.712)	
Growth rate of terms of trade	0.022*	0.025**	0.025**	0.020*
	(0.011)	(0.010)	(0.012)	(0.011)
Log of fertility rate	0.004	0.001	0.013	0.021
	(0.037)	(0.036)	(0.038)	(0.033)
Government consumption	-0.098	0.016	-0.079	-0.001
	(0.134)	(0.097)	(0.135)	(0.086)
Investments	0.222**	0.191**	0.185**	0.178***
	(0.087)	(0.089)	(0.070)	(0.067)
Natural resource rents (lagged one period)		0.164		0.148
		(0.227)		(0.207)
Natural resource rents (lagged one period) × Residuals		-1.092**		-1.366**
		(0.525)		(0.642)
Natural resource rents (lagged one period) × Institutional quality		-0.158		-0.219
		(0.470)		(0.456)
Hansen test	0.366	0.511	0.396	0.317
Number of observations	836	836	788	788
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($logGDP_t$ – $logGDP_{t-1}$). In all estimations, the measure of inequality (Gini) is replaced by the residuals of regressing Gini on Institutional quality. Year fixed effects are included in all of the estimations. Blundell-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 2 further lags. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $X^2(19)$. Total number of instruments is 46. Robust standard errors are reported in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Next, we examine these estimations using the maximum number of instruments possible i.e. 3 instruments for each variable (3 lags for each endogenous and predetermined variable). Table 8 presents these results using the gini coefficient. In Table 9 the gini coefficient is replaced by the residuals in all regressions.

Table 8 – Arellano-Bond Estimation (Three Lags)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.596	-0.112	-0.705**	-0.319
	(0.384)	(0.240)	(0.345)	(0.193)
Log of GDP per capita (lagged one period) squared	0.041	0.009	0.049**	0.023*
	(0.027)	(0.017)	(0.024)	(0.013)
Natural resource rents	-0.879		0.924	
	(2.508)		(0.663)	
Natural resource rents × Gini coefficient	4.296		-0.449	
	(6.215)		(1.471)	
Inflation	-0.001	-0.001	-0.000	-0.001
	(0.001)	(0.001)	(0.001)	(0.000)
Institutional quality	0.386*	0.104	0.265**	0.144*
	(0.197)	(0.143)	(0.113)	(0.083)
Natural resource rents × Institutional quality	-2.203		-1.769*	
	(1.601)		(0.926)	
Growth rate of terms of trade	0.018	0.026	0.017	0.027***
	(0.013)	(0.016)	(0.012)	(0.010)
Log of fertility rate	0.162	-0.188	-0.110	-0.124
	(0.269)	(0.215)	(0.249)	(0.184)
Government consumption	-0.026	-0.245	0.032	0.054
	(0.273)	(0.318)	(0.208)	(0.166)
Investments	0.128	0.299	0.063	0.183
	(0.221)	(0.195)	(0.141)	(0.135)
Natural resource rents (lagged one period)		1.644*		1.124**
		(0.871)		(0.465)
Natural resource rents (lagged one period) × Gini coefficient		-3.676*		-2.109**
		(2.109)		(0.963)
Natural resource rents (lagged one period) × Institutional quality		0.673		0.582
		(0.767)		(0.546)
Hansen test	0.309	0.421	0.488	0.727
Number of observations	774	774	730	730
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($\log GDP_t - \log GDP_{t-1}$). Year fixed effects are included in all of the estimations. Arellano-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 3 further lags. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $X^2(18)$. Total number of instruments is 45. Robust standard errors are reported in parentheses.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 9 – Arellano-Bond Estimation (Robustness Check Using Residuals – Three Lags)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.505	-0.232	-0.688***	-0.321
	(0.304)	(0.238)	(0.253)	(0.225)
Log of GDP per capita (lagged one period) squared	0.035	0.017	0.048***	0.023
	(0.021)	(0.017)	(0.018)	(0.016)
Natural resource rents	0.855		1.101**	
	(0.548)		(0.506)	
Natural resource rents × Residuals	2.403		-4.962	
	(5.959)		(3.122)	
Inflation	-0.001	-0.001	-0.001	-0.000
	(0.000)	(0.001)	(0.000)	(0.001)
Institutional quality	0.342	0.122	0.282**	0.163*
	(0.216)	(0.141)	(0.108)	(0.085)
Natural resource rents × Institutional quality	-1.678		-2.494**	
	(1.434)		(1.127)	
Growth rate of terms of trade	0.013	0.027*	0.019*	0.024**
	(0.013)	(0.013)	(0.010)	(0.010)
Log of fertility rate	0.162	-0.279	-0.201	-0.132
	(0.225)	(0.184)	(0.233)	(0.207)
Government consumption	-0.084	-0.054	0.078	0.021
	(0.183)	(0.303)	(0.194)	(0.145)
Investments	0.186	0.338*	0.072	0.197
	(0.227)	(0.196)	(0.133)	(0.173)
Natural resource rents (lagged one period)		0.303		0.363
		(0.314)		(0.220)
Natural resource rents (lagged one period) × Residuals		-6.238**		-3.119**
		(2.643)		(1.512)
Natural resource rents (lagged one period) × Institutional quality		0.152		0.011
		(0.608)		(0.547)
Hansen test	0.326	0.791	0.693	0.672
Number of observations	774	774	730	730
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($\log GDP_t - \log GDP_{t-1}$). In all estimations, the measure of inequality (Gini) is replaced by the residuals of regressing Gini on Institutional quality. Year fixed effects are included in all of the estimations. Arellano-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 3 further lags. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $\chi^2(18)$. Total number of instruments is 45. Robust standard errors are reported in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Also, we perform system GMM using 3 lags and the results are presented in table 10 and table 11. Similar to previuos cases, our coefficinet of interest stays negative and significant throughout these estimations (specially when lagged natural resource rents are taken into account and also communist countries are excluded from the analysis).

Table 10 – Blundell-Bond Estimation (Three Lags)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.142	-0.100	-0.161	-0.094
	(0.090)	(0.104)	(0.110)	(0.107)
Log of GDP per capita (lagged one period) squared	0.009	0.007	0.011	0.006
	(0.006)	(0.007)	(0.008)	(0.008)
Natural resource rents	0.438		0.753	
	(0.376)		(0.534)	
Natural resource rents × Gini coefficient	-0.199		-0.876	
	(0.571)		(1.213)	
Inflation	-0.001**	-0.001	-0.001**	-0.001
	(0.000)	(0.000)	(0.001)	(0.001)
Institutional quality	0.180***	0.176***	0.157**	0.157***
	(0.051)	(0.051)	(0.066)	(0.053)
Natural resource rents × Institutional quality	-0.368		-0.581	
	(0.355)		(0.373)	
Growth rate of terms of trade	0.023**	0.025**	0.023*	0.021*
	(0.010)	(0.010)	(0.011)	(0.011)
Log of fertility rate	-0.015	0.008	0.015	0.027
	(0.029)	(0.029)	(0.021)	(0.023)
Government consumption	-0.072	-0.054	-0.079	-0.097
	(0.062)	(0.073)	(0.071)	(0.069)
Investments	0.201***	0.220***	0.182**	0.196***
	(0.075)	(0.078)	(0.071)	(0.056)
Natural resource rents (lagged one period)		0.330		0.415
		(0.351)		(0.342)
Natural resource rents (lagged one period) × Gini coefficient		-0.440		-0.751
		(0.492)		(0.602)
Natural resource rents (lagged one period) × Institutional quality		-0.090		-0.051
		(0.325)		(0.338)
Hansen test	0.537	0.533	0.249	0.384
Number of observations	836	836	788	788
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($\log GDP_t - \log GDP_{t-1}$). Year fixed effects are included in all of the estimations. Blundell-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 3 further lags. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $\chi^2(29)$. Total number of instruments is 56. Robust standard errors are reported in parentheses.

*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

Table 11 – Blundell-Bond Estimation (Robustness Check Using Residuals – Three Lags)

Variables	(1) (Current Natural Resource Rents)	(2) (Lagged Natural Resource Rents)	(3) (Current Natural Resource Rents)	(4) (Lagged Natural Resource Rents)
Log of GDP per capita (lagged one period)	-0.128	-0.085	-0.173	-0.089
	(0.129)	(0.095)	(0.108)	(0.099)
Log of GDP per capita (lagged one period) squared	0.009	0.006	0.012	0.006
	(0.009)	(0.007)	(0.008)	(0.007)
Natural resource rents	0.529		0.630**	
	(0.341)		(0.246)	
Natural resource rents × Residuals	-0.968		-3.431**	
	(0.739)		(1.671)	
Inflation	-0.001	-0.001	-0.001*	-0.001*
	(0.001)	(0.000)	(0.000)	(0.001)
Institutional quality	0.189***	0.179***	0.149***	0.160***
	(0.054)	(0.044)	(0.053)	(0.044)
Natural resource rents × Institutional quality	-0.643		-1.054**	
	(0.629)		(0.498)	
Growth rate of terms of trade	0.021*	0.023**	0.026**	0.024**
	(0.011)	(0.010)	(0.010)	(0.010)
Log of fertility rate	0.000	0.025	0.011	0.025
	(0.032)	(0.026)	(0.031)	(0.024)
Government consumption	-0.114	0.008	-0.126*	-0.077
	(0.074)	(0.106)	(0.070)	(0.070)
Investments	0.225***	0.226***	0.189**	0.182***
	(0.083)	(0.082)	(0.071)	(0.064)
Natural resource rents (lagged one period)		0.218		0.241
		(0.177)		(0.156)
Natural resource rents (lagged one period) × Residuals		-1.081**		-1.493*
		(0.476)		(0.752)
Natural resource rents (lagged one period) × Institutional quality		-0.273		-0.356
		(0.317)		(0.337)
Hansen test	0.526	0.577	0.438	0.467
Number of observations	836	836	788	788
Number of countries	61	61	57	57
Communist Countries Excluded	NO	NO	YES	YES

Notes: Dependent variable is real GDP per capita growth (annual percent) measured by ($\log GDP_t - \log GDP_{t-1}$). In all estimations, the measure of inequality (Gini) is replaced by the residuals of regressing Gini on Institutional quality. Year fixed effects are included in all of the estimations. Blundell-Bond estimation is by two-step GMM procedure. All variables, except growth of terms of trade and the year effects are instrumented with a maximum of 3 further lags. The figures reported for the Hansen overidentification test, are p-values for the null hypothesis of valid instruments with $X^2(29)$. Total number of instruments is 56. Robust standard errors are reported in parentheses.
*** Significant at the 1 percent level. ** Significant at the 5 percent level. * Significant at the 10 percent level.

All in all, these results suggest that our main finding (i.e. natural resource rents can hurt the GDP growth of a country if there is more inequality in thecountry), is not sensitive to the number of instruments that are used in the estimations and we almost always find this result especially after one period is passed. This points to the dynamic nature of the mentioned threshold effect, which is discussed in our theoretical framework.

4 Appendix

Table A1 – Definitions and Sources of the Variables

Variables	Definition and Comments	Source (Sachs and Warner (1997a,b) unless specified)
Growth rate of GDP per capita	Average annual growth in real GDP divided by the economically active population between the years 1965 – 1990.	
Log GDP 1965	Log of real GDP per capita in 1965.	
Openness	The fraction of years during the period 1965 – 1990 in which the country is rated as an open economy according to the criteria in Sachs and Warner (1995).	
Natural resource rents	Average total natural resources rents (% of GDP) between the years 1965 – 1990. Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	World Bank, WDI (2013)
Investments	Log of the ratio of real gross domestic investment (public and private) to real GDP, averaged over the period 1970 – 1989.	
Institutional quality	Average of 6 variables; Corruption in government, Rule of law, Bureaucratic quality, Ethnic tensions, Repudiation of contracts by government, Risk of expropriation indexed between 0 and 10 (10 represents highest quality of institutions.) Averaged over the period 1982-1997.	Knack and Keefer (1998), ICRG data set
Gini coefficient (1970 – 1990)	Average of Gini index between the years 1970 – 1990. A Gini index of 0 represents perfect equality, while an index of 1 implies perfect inequality.	Deininger and Squire (1996) high quality data set
Natural resource abundance	Share of exports of primary products in GNP in 1970. Primary products or natural resource exports are exports of "fuels" and "non-fuel primary products".	
Gini coefficient (1965 – 2008)	Average of Gini index between the years 1965 – 2008. A Gini index of 0 represents perfect equality, while an index of 1 implies perfect inequality.	World Bank estimates (2013)
R/P 10%	Share of income or expenditure of the richest 10 percent group to the poorest 10 percent group reported in 2009.	Human Development Report (2009), UNDP, World Bank (2009)