WPS7831

Policy Research Working Paper 7831

Nonrenewable resources, Income Inequality and per Capita GDP

An Empirical Analysis

Antonio Scognamillo
Gianluca Mele
Luca Sensini

WORLD BANK GROUP
Macroeconomics and Fiscal Management Global Practice Group
September 2016

Policy Research Working Paper 7831

Abstract

This analysis examines the relationship between nonrenewable resource dependence, economic growth and income inequality. It uses a two-equation system in which the Gini index and GDP per capita are the dependent variables and the stock of nonrenewable resources as a share of national wealth—i.e. resource dependence—is the independent variable. Using a dataset that includes information on 43 countries from 1980 to 2012, this paper estimates several model specifications in order to check the robustness of the results under different assumptions and to account for income-group-related heterogeneity among countries. The baseline model provides strong evidence that natural resource dependence is negatively correlated with both per capita GDP and the Gini index; in other words, resource dependence is associated with lower income levels, but also with a more equal distribution of income. Interestingly, however, after controlling for country income group, the sign and magnitude of these relationships appear to become dependent on national-level structural characteristics. Among higher-income countries, greater nonrenewable natural resource dependence is associated with lower income inequality, while there is no statistically significant correlation with GDP per capita. Among the lower-income group, greater dependence on nonrenewable natural resources is associated with both higher levels of income inequality and lower per capita GDP. Further analysis focusing on a subsample of nonrenewable resource rich countries confirms these findings.

This paper is a product of the Macroeconomics and Fiscal Management Global Practice Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at gmele@worldbank.org.

Nonrenewable resources, Income Inequality and per Capita GDP: An Empirical Analysis

Antonio Scognamillo[1]; Gianluca Mele[2]; Luca Sensini[3]

Keywords: Natural Capital, Economic Growth, Income Inequality

JEL codes: C01, C13, C3, E01, D31, D63, O11, O43, Q32

[1] Food and Agriculture Organization of the United Nations (FAO), antonio.scognamillo@fao.org
[2] The World Bank; gmele@worldbank.org
[3] University of Salerno; lsensini@unisa.it

1. Introduction and Literature Review

A large body of literature has examined the relationship between natural resources, economic growth, and income inequality, revealing a set of complex and often ambiguous associations. The relationship between natural resources and economic growth is especially controversial. On the one hand, general economic theory suggests that a booming natural resource sector will boost economic growth, and that it will facilitate—though not necessarily cause—improvements in poverty and shared-prosperity indicators. Ideally, rising natural resource output would increase public revenues, enabling greater public investment in physical and human capital, while the private returns to resource production would encourage greater private investment (both domestic and external), as well as higher rates of household savings. On the other hand, the substantial literature on the so-called "Dutch disease" finds that a resources boom can divert resources away from the non-resource tradable sectors (especially manufacturing), distort the growth of nontradables (especially services), and put upward pressure on the exchange rate. These effects erode the competitiveness of exports and give imports an advantage over domestic production, undermining long-term growth (Sachs and Warner 1999).

The World Bank (2012) analyzed the impact of natural capital[4] on income by examining the adjusted net savings of resource-rich countries. It found that the sustainable management of natural resources has a positive and significant correlation with economic resilience and welfare gains. The World Bank analysis underscored that the elements of natural capital cannot be managed in isolation, but require an integrated approach to "regulating" and "provisioning" natural resource exploitation in order to preserve the underlying stock of natural capital.

Other studies have focused on the depletion of natural resources. Dasgupta (2010) concludes that GDP per capita and the Human Development Index (HDI) should not be regarded as comprehensive indicators of economic and social welfare, as they do not reflect the depletion of the natural capital stock, and that more sophisticated forms of wealth accounting that include produced, human and natural capital are more appropriate measures of inclusive and sustainable development. The World Bank has long been a major advocate for integrating the sustainable management of natural capital into growth strategies. Cleveland et al. (1996) analyzed the relationship between natural capital, ecosystem services and economic growth, highlighting that economic growth models tend not to account for either the degradation of critical, non-replaceable ecosystem services or the depletion of natural capital. The study concludes that these elements should be taken into account in future analyses of the link between natural capital and growth.

In recent years increased attention to the issue of income inequality has added a new dimension to the debate over the role of the depletion of natural capital in economic growth and development. Barbier (2014) argues that understanding the depletion of natural capital is crucial to assessing both the extent to which natural capital will

[4] Natural capital includes both nonrenewable resources such as oil and minerals and renewable resources such as arable land, forests and fisheries, as well as environmental quality.

contribute to future economic growth and the pace at which inequality has increased over time. According to Barbier (2015), environmental degradation and the widening gap between the world's rich and poor are symptomatic of gradually intensifying structural imbalances in how natural capital is used to create economic wealth and how that wealth is distributed. On the one hand, natural capital is undervalued and thus overexploited, while on the other hand the human capital stock is insufficient to meet demand, which drives rising income inequality. This structural imbalance between natural and human capital creates obstacles to innovation, growth and prosperity.

Gill et al. (2014) focus on the use of natural resources in Eurasia, demonstrating that the region has benefited from its natural wealth through rising income levels and improvements in living standards. Inequality, however, has also increased over time and across countries, yet it remains lower than in most parts of the developing world, especially Latin America. Alessandrini and Buccellato (2009) find a significant positive relationship between income inequality and economic dependence on natural resources. This link is especially strong for mining commodities and exports that are not used in domestic value chains. These conditions are associated with a dramatic increase in household-level inequality, since only a few households typically control resource revenues.

Fum and Hodler (2010) focus on the political-economy aspects of resource management and income inequality. They present empirical evidence that ethnic polarization increases the probability that a large stock of natural resources will correlate with inequality. Bourguignon and Morrisson (1990) find that mineral resource endowments, rather than other variables such as GDP, are an important determinant of the income distribution. Taking a microeconomic perspective, Loayza, Teran and Rigolini (2013) find strong evidence of spatially dependent inequality outcomes. Households located in physical proximity to mining districts in Peru tend to experience the largest gains in living standards, consumptions and literacy, while consumption inequality increases in all districts of a resource-producing province.

Although many empirical studies have investigated the link between natural capital, growth and inequality, very limited research is available on how all three factors interact. Moreover, much of the existing literature on the subject fails to adequately account for the role of wealth stocks. A thorough review of the literature would seem to indicate that the quantitative relationship between the exploitation of natural resources, economic growth and income inequality has been studied only by Gylfason and Zoega (2002) and Alessandrini and Buccellato (2009).

The following analysis tests the existence of a relationship between the dependence on nonrenewable natural resources (hereafter dependence) and per capita income and income inequality. The analysis is conducted in the spirit of Sachs and Warner (1995; 2001) and uses panel data for 43 countries for which data is available from 1980 to 2012 to examine, under different specifications, a system of two equations in which the dependent variables are per capita GDP and the Gini index and the independent variable is the dependence on nonrenewable natural resources. While Gylfason and Zoega (2002) and Alessandrini and Buccellato (2009) use a recursive model and focus on cross-sectional data, this analysis attempts to account for the endogeneity problem generated by feedback effects across variables and control for the presence of unobserved country heterogeneity.

The empirical results from the baseline model provide evidence of a negative association between resource dependence and GDP per capita, which is consistent with the existing literature on the Dutch disease effect. However, the empirical evidence shows that Dutch disease is not consistent or inevitable, as it is influenced by the institutional heterogeneity across countries (Bunte 2011). For example, a given country's institutional framework and the relative effectiveness of its policy interventions can either mitigate or magnify the effect on income distribution. The intensity of Dutch disease effects depends in large part on whether and how natural resource revenues are used to promote social equity through investment in human capital, public goods and services, and targeted poverty-reduction programs.

Robust public investment and redistributive fiscal policies could more than compensate for the increase in income inequality due to the inter-sectorial wage differential caused from the reallocation of the workers, as the resource sector develops. In order to explore the implications of the national policy framework, an analytical specification was devised to account for the heterogeneity of country income groups. This specification uses a dummy variable to assess the correlation between resource dependence, economic growth and income inequality among both lower-income countries and higher-income countries. The findings show that among higher-income countries a greater degree of resource dependence is associated with an *improvement* in the income distribution and has no statistically significant correlation with economic growth. Conversely, greater resource dependence among lower-income countries is associated with widening income inequality and lower economic growth.

These findings imply that the relationship between natural resource dependence and economic growth and income inequality hinges on a given country's income level. Replicating the analysis on a subsample of resource-rich countries confirms the robustness of these findings. The findings are also consistent with previous studies that have argued that the "resource curse" is not caused by natural resource endowments per se, but rather by country-level characteristics such as the quality of natural resource management or the nature of the fiscal policies financed by resource revenues (see, e.g. Gylfason, 2001; Robinson, Torvik, and Verdier 2006).

Following this introductory section, the paper is structured as follows: Section 2 describes the study's methodology and clarifies the empirical strategy for obtaining consistent parameter estimates under the specific assumptions imposed on the model; Section 3 discusses the dataset constructed for this analysis and provides some descriptive statistics; Section 4 presents the results of the analysis; and Section 5 draws policy implications and conclusions.

2. Methodology

This study uses a broad set of specifications and estimation techniques to explore the relationship between nonrenewable resource dependence and income inequality and economic growth. As the observed results are comparable with previous studies, it is necessary to add further controls and assumptions to the model. Moreover, adding further controls and altering certain assumptions enables a more comprehensive evaluation of the overall robustness of the results and enriches the analysis by considering changes in magnitude and the significance of the estimated coefficients on the dependent variable.

The baseline model is a system of two equations that does not consider the heterogeneity among groups of countries. Both a recursive model and a non-recursive model are estimated. The recursive model is based on the existing literature and innovates it, by exploiting the panel structure of the database to control for the presence of unobservable country-level heterogeneity, as in Equation 1:

Equation 1: Recursive Model Specification

$$GINI_{i,t} = \beta_0 + \beta_1 NKD_{i,t} + \beta_2 X_{i,t} + a_i + u_{1\ i,t}$$
$$GDP_{i,t} = \beta_3 + \beta_4 NKD_{i,t} + \beta_5 Y_{i,t} + a_i + u_{2\ i,t}$$

where the two dependent variables are the country's GINI index and its GDP per capita, NKD is its nonrenewable resources dependence index, X and Y are two vectors of control variables, ai represents the country time invariant unobservable effect, and $u1$ and $u2$ are the equation error terms.

Assuming that the error terms in the two equations are not correlated, each equation is estimated separately using a fixed-effect estimator (FE).[5] However, relaxing this assumption by allowing for a correlation among the equation's error terms and making a simultaneous estimate of the two equations via a seemingly unrelated regression estimator (SURE) increases the efficiency of the results. This non-recursive model accounts for the endogeneity problem arising from feedback effects across equations in a panel environment. Consequently, the dependent variable in Equation 1 is an independent variable in Equation 2:

Equation 2: Non-Recursive Model Specification

$$GINI_{i,t} = \beta_0 + \beta_1 NKD_{i,t} + \beta_2 GDP_{i,t} + \beta_3 X_{i,t} + a_i + u_{1\ i,t}$$
$$GDP_{i,t} = \beta_4 + \beta_5 NKD_{i,t} + \beta_6 GINI_{i,t} + \beta_7 Y_{i,t} + a_i + u_{2\ i,t}$$

[5] The presence of unobserved country heterogeneity has been tested using a Breusch-Pagan Lagrange multiplier test for random effects, while the Hausman test has enabled the use of a fixed-effects estimator rather than a random-effects estimator.

where a consistent estimate of the model relies on a set of instrumental variables (IV) that are correlated with the endogenous variable but are correctly excluded (as exogenous) from the main equation.

Again assuming that the error terms of the two equations are not correlated, an instrumental variable fixed-effect estimator (IVFE) consistently estimates each equation separately while accounting for both the endogeneity issues and the unobservable heterogeneity across countries.[6] Finally, allowing for a correlation between the equation's error terms using a Three Stage Least Square estimator (3SLS),[7] which estimates the coefficient of the two equations simultaneously, further increases the efficiency of the estimates.

The same estimation procedure is applied to the subsequent model specifications, and for the sake of brevity each equation is not formalized. The second model specification accounts for heterogeneity related to country income group by adding a dummy variable to each equation that identifies lower-income countries. The interaction of this variable with the nonrenewable resource dependence index distinguishes the results for higher-income and lower-income countries. Finally, a third model specification is restricted to a subsample of non-renewable resources rich countries.

3. Data

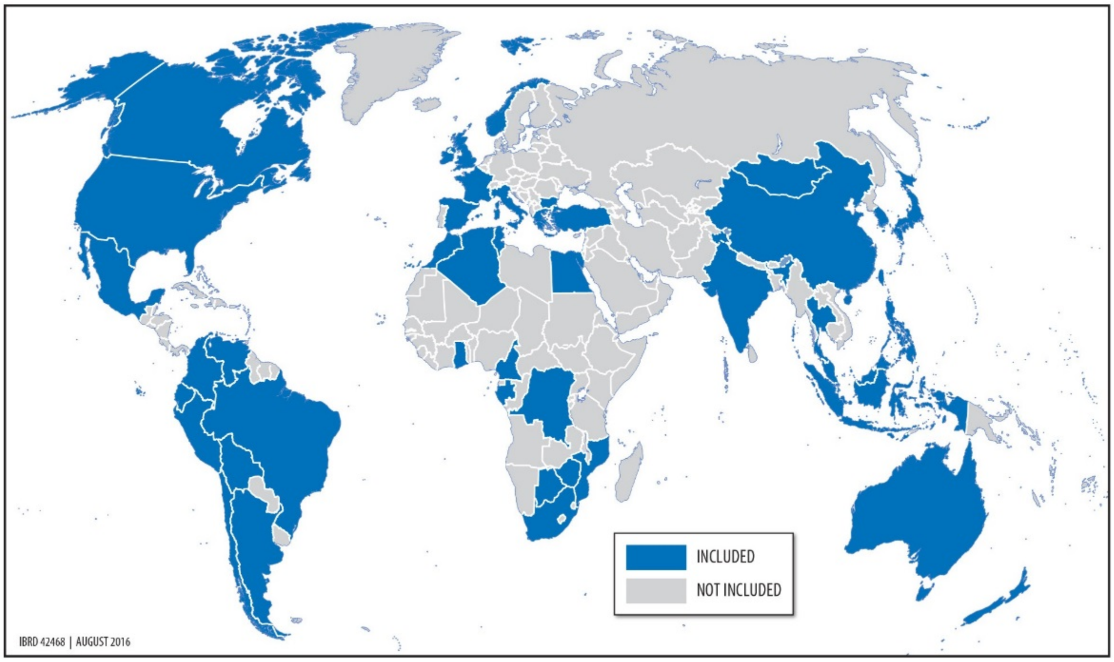
The dataset comprises 43 countries from five continents and covers the period from 1980 to 2012. It includes all countries for which complete data on nonrenewable resources are available and nonzero. Using the World Bank classification system, the information contained in the dataset can be divided into four groups, as shown in Table 1: 13 high-income countries, 14 upper-middle-income countries, 12 lower-middle-income countries and 4 low-income countries. Figure 1 illustrates the geographic coverage of the dataset. The countries included on our dataset are: Algeria, Argentina, Australia, Bolivia, Botswana, Brazil, Bulgaria, Cameroon, Canada, Chile, China, Colombia, Democratic Republic of Congo, Ecuador, Egypt, France, Gabon, Ghana, Greece, India, Indonesia, Ireland, Italy, Japan, Republic of Korea, Malaysia, Mexico, Mongolia, Morocco, Mozambique, New Zealand, Norway, Peru, Philippines, South Africa, Spain, Thailand, Tunisia, Turkey, United Kingdom, United States, Venezuela and Zimbabwe.

Table 1: Countries in Dataset, Classified by Income Groups

Income group Frequency:	Absolute	Relative	Cumulative
High income: OECD	13	30%	30%
Upper middle income	14	33%	63%
Lower middle income	12	28%	91%
Low income	4	9%	100%
Total	43	100%	

[6] The exogeneity of the instruments was successfully verified by a Sargan/Hansen-J test.
[7] The simultaneous equation models include country dummies in order to control for unobserved country heterogeneity.

Figure 1: Map of Countries Included in the Empirical Analysis



Data on natural capital is sourced from a World Bank dataset on national wealth. The dataset disaggregates the three components of national wealth—produced capital, intangible capital and natural capital—and it decomposes the natural wealth stock into renewable and nonrenewable resources.

This analysis focuses on nonrenewable resources due to the methodological soundness of their estimation. Current techniques for estimating the stock of renewable resources are limited, and their core methodological assumptions may compromise the reliability of the data. The literature uses two different methods for defining the economic importance of nonrenewable resources: "resource abundance," which is the per capita value of the stock of nonrenewable resources, and "resource dependence," which is the value of nonrenewable resources as a share of total national wealth. As noted by Gylfason and Zoega (2002), resource dependence is a measure of the current economic relevance of natural resources, while resource abundance reflects the estimated value of the natural resource stock.

Examining the distribution of resource dependence and abundance across countries at different stages of development reveals that the two measures do not evolve according to the same pattern. Table 2 shows that average resource dependence is least prevalent among high-income countries (2.1 percent), most prevalent among upper-middle-income countries (15.1 percent) and moderate among both lower-middle-income countries (8.3 percent) and low-income countries (10.8 percent). Meanwhile, resource abundance is also most prevalent among upper-middle-income countries but is more common among high-income countries than it is among lower-middle-income and low-income countries. This is likely due to high-income countries having larger stocks of produced and intangible capital, which offset the economic importance of natural resources. This analysis focuses on resource dependence rather than resource abundance, as the former is more immediately relevant to economic growth and income inequality.

Table 2: Average Nonrenewable Resource Dependence and Abundance by Income Group (1980-2012)

	Dependence	Log_Abundance
High income	2%	7.8
Upper middle income	15%	8.6
Lower middle income	8%	7.3
Low income	11%	6.6

The data on income inequality is sourced from the World Bank's "All-the-Ginis Database," which was last updated in 2014.[8] The database collects Gini indexes from multiple sources into long time series. The data has been standardized for this analysis via the so-called "choice-by-precedence approach," which reflects each dataset's reliability, degree of variable standardization, and consistency of geographical coverage. GDP and population figures have been collected from the United Nation's UNCTAD-STAT database. Table 2 presents the descriptive statistics for per capita GDP and the Gini index by country income group. The Gini index peaks among the upper-middle-income group, falls among the lower-middle-income and low-income groups and is lowest among the high-income group. These data are consistent with the relationship between inequality and GDP described by Kuznets (1955).

Table 3: GDP per capita and Gini index for Countries in Dataset, classified by Income Group (1980-2012)

	GDP per capita (US$ thous)	Gini index
High income	34.5	33.9
Upper middle income	8.4	49.1
Lower middle income	2.8	40.5
Low income	1.4	42.7

The data for control variables was collected from different sources. Data on the structural and cyclical characteristics of national economies comes from the World Bank's World Development Indicator Database[9] and UNCTAD-STAT;[10] the figures on education are sourced from Barro & Lee (2013);[11] those on the real effective exchange rate (REER) are taken from Darvas (2012);[12] and metal- and oil-price figures are sourced from the IMF's Primary Commodity Prices database.[13] Referring to the original datasets will provide further details on the methodology and sources used. Table 4 shows income-level-related heterogeneity across countries for the specified variables.

[8] Available at http://econ.worldbank.org/projects/inequality
[9] Available at http://data.worldbank.org
[10] Available at http://unctadstat.unctad.org
[11] Available at http://www.barrolee.com
[12] Available at http://bruegel.org
[13] Available at http://www.imf.org

Table 4. Indicators of Heterogeneity across Countries in the Dataset, for Control Variables

Panel A: Variable included in the GINI equation

	Education ratio[14]	CPI	Services value added (% of GDP at market prices)	Manufacturing value added (% GDP at m. prices)	Agriculture value added (% of GDP at m. prices)
High income	4.6	80.9	66.3	17.6	3.9
Upper middle income	0.9	65.3	52.3	17.1	7.9
Lower middle income	0.7	75.7	48.5	18.6	18.1
Low income	0.4	63.7	45.4	14.6	29.4
Average	1.9	73.2	54.8	17.4	11.5

Panel B: Variables included in the GDP equation

	(log)Labor Force	(log)Gross fixed capital formation	(log)Export	(log)REER	World oil price index	World metal price index
High income	9.5	11.7	11.8	4.5	73.0	91.9
Upper middle income	9.0	9.7	9.9	4.6	73.0	91.9
Lower middle income	9.8	9.4	9.4	4.7	73.0	91.9
Low income	9.0	6.7	7.4	4.8	73.0	91.9
Average	9.4	9.9	10.1	4.6	73.0	91.9

Finally, to introduce the empirical analysis Table 5 summarizes the pairwise correlations between the most relevant variables. As shown in the table, resource dependence is positively associated with the Gini index and negatively associated with GDP per capita at a significance level greater than 1 percent. In other words, the simple correlations show that the more dependent a country is on nonrenewable resources, the higher its Gini coefficient and the lower its GDP per capita.

Table 5: Correlation Matrix for the Main Variables

	Resource Dependence	Gini index	Log GDP
Resource Dependence	1		
Gini index	0.242***	1	
GDP per capita	-0.142***	-0.350***	1

Note: * ** and *** denote significance at the 10% 5% and 1% levels, respectively.

[14] Education ratio is the ratio between the share of the population with secondary and tertiary education and the share of population with primary or no education.

4. Empirical Analysis

This section summarizes the results of the analytical methodology described above. The specifications and the estimation techniques have been systematically adapted according to the different assumptions characterizing each model. The baseline model estimates the average empirical associations for all the countries included in the dataset, and is then adjusted to assess heterogeneity between country income groups. Finally, the model was tested on a sub-sample of resource-rich countries[15], with a view to test the robustness of the empirical association.

4.1 The Baseline Model: Pooling All Countries

Table 6 presents the results from the recursive baseline model. The two equations have been estimated separately using a fixed-effect estimator and simultaneously using SURE plus country-level dummy variables. We find that, on average, nonrenewable resource dependence is negatively associated with both income inequality and GDP per capita. In the simultaneous estimation both coefficients increased because of the correlation between the error terms of the two equations.

Table 6: Estimated Results from the Recursive Model Specification (baseline model)

	Fixed Effect		SURE	
	Gini index	**GDP_c**	**Gini index**	**GDP_c**
Non Renewable resource dependence	-0.059**	-0.087**	-0.149***	-0.132**
High-low education ratio	-0.639***	-	-0.203	-
High-low education ratio square	0.021***	-	0.010**	-
Consumer price index (2005)	-0.001	-	0.002	-
Services value added share	0.078*	-	0.071	-
Manufacturing value added share	-0.047	-	0.069	-
Agriculture value added share	-0.091*	-	-0.112**	-
Log labor force	-	-7.916***	-	-17.991***
Log gross fixed capital formation	-	3.802***	-	7.472***
Log exports of goods and services	-	2.422**	-	3.422***
Log REER	-	5.082***	-	1.353
World oil price index	-	0.067***	-	0.067***
World Metal price index	-	0.013	-	0.006
Observations	1015	1034	873	873
R2	0.058	0.383	0.910	0.858

Note: * ** and *** denote significance at the 10% 5% and 1% levels, respectively.

Table 7 shows the results of the non-recursive baseline model specification estimation—that is, the results obtained once the endogeneity related to the feedback effect of including the Gini in the GDP equation, and vice versa, has been accounted for. The estimation results confirm the previous findings from the recursive model, though the

[15] Based on an IMF definition of 'resource-rich' countries.

magnitude of the coefficient generally increases after the feedback effect has been taken into account.

Table 7: Estimated Results from the Non-Recursive Model Specification (baseline model)

	IV Fixed Effect		3SLS	
	Gini index	GDP_c	Gini index	GDP_c
Non Renewable resource dependence	-0.149***	-0.443***	-0.151***	-0.467***
High-low education ratio	-0.082	-	-1.110***	-
High-low education ratio square	0.008	-	0.025***	-
Consumer price index (2005)	0.005	-	0.027***	-
Services value added share	0.072	-	0.035	-
Manufacturing value added share	0.055	-	0.145**	-
Agriculture value added share	-0.124**	-	-0.105**	-
GDP	-0.040	-	-0.005	-
Log labor force	-	-11.564**	-	-9.069**
Log gross fixed capital formation	-	9.842***	-	7.658***
Log exports of goods and services	-	1.344	-	3.123**
Log REER	-	0.764	-	1.458
World oil price index	-	0.078***	-	0.055***
World metal price index	-	-0.015	-	0.003
Gini index	-	-1.877***	-	-2.073***
Observations	873	873	873	873
R2	0.113	0.245	0.901	0.799

Note: * ** and *** denote significance at the 10% 5% and 1% levels, respectively.

Overall, these results indicate that a positive variation in the dependencies is empirically associated with a negative variation in both GDP per capita and the Gini index. In other words, resource dependence is associated with lower levels of GDP per capita, but also with lower income inequality. These results are consistent with the literature on Dutch disease, which explains them as an effect of the diversion of labor and capital from the industrial sector to the natural resource sector, combined with the negative effect of real exchange-rate appreciation on the tradable sector. However, the model's findings suggest that, on average, the inter-sectoral shift in labor patterns—which affects the distribution of income through rising wage differentials between sectors—is offset by the investment of additional fiscal revenue in pro-poor policy interventions. The literature highlights that the sign of the relationship between resource dependence and inequality is likely to depend on each country's institutional framework and the quality of its policy interventions. These factors determine whether—and how—natural resource revenues support rising productivity and consumption among lower-income households. The model's findings suggest that, on the whole, policies designed to promote shared prosperity more than offset the increase in inequality caused by the inter-sectoral wage differential.

However, pooling such a heterogeneous mix of countries may undermine the reliability of the model's conclusions. The next section explores the issue of country-level heterogeneity by adding dummy variables to the baseline specification. The objective is to disentangle the influence of specific countries or groups of countries by disaggregating the dataset based on a likely explanatory variable, which in this case is country income level.

4.2 Controlling for Heterogeneity between Income Groups

The model specification presented below attempts to differentiate the impact of resource dependence on higher- and lower-income countries. The model has been adjusted to include a dummy variable equal to 1 for low- and lower-middle-income countries and to 0 for high- and upper-middle-income countries. Within this framework, the coefficient associated with the interaction variable will measure the association between resource dependence, GDP per capita and the Gini index among lower-income countries, while the coefficient associated with the non-interaction variables permits to isolate the average relationship for higher-income countries. Table 8 summarizes the results obtained from the recursive model.

Table 8: Estimated Results from the Recursive Model Specification (income-group heterogeneity)

	Fixed Effect		SURE	
	Gini index	**GDP_c**	**Gini index**	**GDP_c**
Nonrenewable resource dependence	-0.082***	-0.006	-0.190***	0.124
Lower income	dropped	dropped	4.386*	47.628***
Lower income* Nonrenewable resource dependence	0.068	-0.370***	0.115**	-0.720***
High-low education ratio	-0.622***	-	-0.179	-
High-low education ratio square	0.021***	-	0.010**	-
Consumer price index (2005)	-0.002	-	0.000	-
Services value added share	0.081*	-	0.071	-
Manufacturing value added share	-0.043	-	0.068	-
Agriculture value added share	-0.087	-	-0.110**	-
Log labor force	-	-6.538**	-	-17.058***
Log gross fixed capital formation	-	3.433***	-	7.237***
Log exports of goods and services	-	2.348**	-	3.519***
Log REER	-	5.852***	-	2.742
World oil price index	-	0.068***	-	0.066***
World metal price index	-	0.016	-	0.010
Observations	1015	1034	873	873
R2	0.060	0.392	0.911	0.863

Note: * ** and *** denote significance at the 10% 5% and 1% levels, respectively.

The results show that higher levels of resource dependence are associated with lower levels of income inequality among countries in the higher-income group, with no negative effect on GDP per capita. Conversely, higher levels of resource dependence are associated with greater income inequality and lower GDP per capita in lower-income countries. Again, the estimated results of the non-recursive model, summarized in Table 9, confirm those of the recursive model.

Table 9: Estimated Results from the Non-Recursive Model Specification (income-group heterogeneity)

	IV Fixed Effect		3SLS	
	Gini index	GDP_c	Gini index	GDP_c
Nonrenewable resource dependence	-0.185***	-0.008	-0.173***	-0.007
Lower income	dropped	dropped	5.637**	49.933***
Lower income* Nonrenewable resource dependence	0.100**	-0.638***	0.070	-0.640***
High-low education ratio	-0.000	-	-0.440*	-
High-low education ratio square	0.006	-	0.014**	-
Consumer price index (2005)	0.004	-	0.012**	-
Services value added share	0.072	-	0.063	-
Manufacturing value added share	0.047	-	0.086	-
Agriculture value added share	-0.123**	-	-0.123**	-
GDP_c	-0.046	-	-0.032	-
Log Labor Force	-	-15.487***	-	-15.901***
Log gross fixed capital formation	-	7.880***	-	7.164***
Log exports of goods and services	-	3.043**	-	3.765***
Log REER	-	2.477	-	2.754
World oil price index	-	0.069***	-	0.064***
World metal price index	-	0.004	-	0.009
Gini index	-	-0.616	-	-0.616
Observations	873	873	873	873
R2	0.119	0.445	0.911	0.863

Note: * ** and *** denote significance at the 10% 5% and 1% levels, respectively.

Accounting for the heterogeneity between country income groups yields a very different picture than that shown in the baseline models. From a methodological perspective, this heterogeneity affirms the importance of considering structural differences between countries at different stages of development. From a macroeconomic perspective, it lends credibility to the idea that the "resource curse" is a function of country-level structural characteristics, such as the management of natural resources rents, the sophistication of public financial management systems and the impartiality of policy processes.

4.3 Analyzing a Subsample of Resource-Rich Countries

The model presented below focuses on a subset of countries defined as nonrenewable resource rich according to the IMF's 2013 Resource Governance Index Report.[16] The full sample included countries in which nonrenewable natural resources played a relatively modest economic role. Excluding these countries can shed light on the possibility that the empirical associations between resource dependence and the Gini index and GDP per capita are affected by the relative economic importance of natural resources. Focusing on a subsample of resource-rich countries also tests the robustness of the estimated relationships by reducing the original sample by one-third[17]. Table 10 summarizes the subsample's composition by income group of the resulting restricted panel.

[16] Available at http://www.resourcegovernance.org/resource-governance-index/report

[17] Based on the IMF classification of resource-rich countries (see note 16), thirteen countries are dropped from our original dataset: Argentina, Bulgaria, France, Greece, Ireland, Italy, Japan, Republic of Korea, New Zealand, Spain, Thailand, Tunisia, and Turkey. The resulting sub-group thus comprises the remaining 30 countries.

Table 10: Countries included in Resource-rich Sub-group, classified by Income Groups

	Absolute	Relative
High income	5	16.7%
Upper middle income	11	36.7%
Lower middle income	10	33.3%
Low income	4	13.3%
Total	30	100%

According to the IMF report, "nations [rich in nonrenewable natural resources] produce 85% of the world's petroleum, 90% of its diamonds and 80% of its copper, generating trillions of dollars in annual profits." Table 11 summarizes the empirical results of the recursive model estimated for the subsample of resource-rich countries. These figures confirm the results of the full-sample model. The magnitude of the coefficient, as expected, slightly increases relative to the full-sample model, but the sign of the associations and their economic implications remain unchanged.

Table 11. Estimated Results from the Recursive Model Specification (resource-rich subsample)

	Fixed Effect		SURE	
	Gini index	GDP	Gini index	GDP
Nonrenewable resource dependence	-0.067**	0.008	-0.177***	0.122
Lower Income	dropped	dropped	6.090**	57.336***
Lower income * Nonrenewable resource Dependence	0.078	-0.362***	0.129**	-0.756***
High-Low education ratio	-0.418***	-	-0.159	-
High-Low education ratio square	0.015***	-	0.008*	-
Consumer Price Index (2005)	-0.010*	-	-0.003	-
Services value added share	0.130***	-	0.117**	-
Manufacturing value added share	-0.006	-	0.064	-
Agriculture value added share	-0.175***	-	-0.154**	-
Log Labour Force	-	-8.651***	-	-26.131***
Log Gross fixed capital formation	-	0.975	-	5.280***
Log Exports of goods and services	-	2.663**	-	6.042***
Log REER	-	5.057***	-	3.325
World Oil price index	-	0.081***	-	0.091***
World Metal price index	-	0.018	-	-0.001
Observations	667	707	580	580
R2	0.096	0.311	0.911	0.864

Note: * ** and *** denote significance at the 10% 5% and 1% levels, respectively.

These findings are further confirmed and indeed reinforced in the non-recursive model results summarized in Table 12. In this case, resource dependence among higher-income countries is *positively* associated with GDP per capita, suggesting that in wealthier countries natural resources are a blessing rather than a curse. In fact, greater resource dependence in higher-income countries is associated with lower levels of income inequality and greater GDP per capita. However, the opposite is true for lower-income countries, in which an increase in resource dependence is associated with higher rates of income inequality and lower GDP per capita.

Table 12: Estimated Results from the Non-Recursive Model Specification (resource-rich subsample)

	IV Fixed Effect		3SLS	
	Gini index	**GDP_c**	**Gini index**	**GDP**
Nonrenewable resource dependence	-0.175***	0.385**	-0.194***	0.355**
Lower income	dropped	dropped	-12.765***	51.841***
Lower income* nonrenewable resource dependence	0.121**	-0.960***	0.167***	-0.925***
High-low education ratio	0.337	-	1.754***	-
High-low education ratio square	-0.001	-	-0.030***	-
Consumer price index (2005)	-0.001	-	-0.009	-
Services value added share	0.114**	-	0.132***	-
Manufacturing value added share	0.002	-	-0.078	-
Agriculture value added share	-0.157**	-	-0.093	-
GDP_c	-0.085	-	-0.195***	-
Log labor force	-	-30.421***	-	-27.100***
Log gross fixed capital formation	-	0.548	-	4.939*
Log exports of goods and services	-	9.189***	-	5.571**
Log REER	-	4.338*	-	3.613
World oil price index	-	0.084***	-	0.088***
World metal price index	-	0.027	-	0.011
Gini index	-	1.337**	-	1.096*
Observations	580	580	580	580
R2	0.162	0.229	0.903	0.835

Note: * ** and *** denote significance at the 10% 5% and 1% levels, respectively.

The subsample analysis appears to confirm the robustness of the full-sample results. Restricting the analysis to resource-rich countries also supports the conclusion that the impact of resource dependence on income inequality and economic growth is determined by country-level characteristics that affect the management of natural resources. The overall conclusions of the analysis are presented in the following section.

5. Conclusions

This study was designed to investigate the empirical relationships between dependence on nonrenewable natural resources and income inequality and economic growth. The baseline model was recursive, with a fixed-effect estimator. It regarded GDP per capita and the Gini index as dependent variables. A non-recursive model was then used to address the endogeneity problem arising from the feedback effects across equations in a panel environment, which included a set of instrumental variables and an instrumental variable fixed-effect estimator. Finally, two previous models were estimated jointly by accounting for the potential correlation among the error terms of the equations via the use of a seemingly unrelated regression estimator (SURE) for the first model, and a three-stage least square estimator (3SLS) for the second.

The results of the baseline model showed that an increase in resource dependence is associated with lower GDP per capita but a more equal income distribution. A subsequent specification tried to address the problem of heterogeneity between countries at different income levels, since the descriptive statistics clearly pointed to substantial variations between country income groups. Controlling for the heterogeneity between higher-and lower-income countries reveals dramatically different effects for each of these two groups. Among higher-income countries resource dependence is associated with lower levels of income inequality, and there is no statistically significant correlation between resource dependence and GDP per capita. However, among lower-income countries greater resource dependence is associated with greater income inequality and lower per capita GDP.

A third specification restricted the analysis to a subsample of resource-rich countries, which included about two-thirds of the countries included in the original full sample. The objective of this third specification was to increase the robustness of the findings by accounting for the unequal distribution of natural resources across countries. Its results largely corroborate those of the other models. Moreover, the non-recursive model estimation reveals a positive association between resource dependence and GDP per capita among resource-rich higher-income countries, further supporting the idea that whether natural resources are a blessing or a curse depends on each country's specific political-economic and public administrative characteristics.

Taken together, these findings point to a number of important policy implications. While resource dependence initially appears to correlate with lower per capita income, this association is nullified or even reversed among high-income countries. One prospective explanation for this finding is that wealthier countries are systematically more likely to manage resource revenues effectively, and that they are more capable of mitigating their exposure to the inherent multidimensional volatility of the resource sector. By contrast, poorer countries are more likely to experience boom-and-bust economic cycles driven by unmediated external shocks and pro-cyclical expenditure policies, and due to weaker public financial and administrative systems, they may be less able to use resource revenues to promote broad-based improvements in productivity. These findings appear to confirm the results of previous analyses, and they further underscore the importance of both reinforcing macroeconomic resilience and investing resource revenues in physical and human capital in order to facilitate the growth of the non-resource economy.

Fiscal stabilization and public expenditure policies involve complex issues that extend well beyond the scope of this paper. However, the heterogeneous results obtained by distinguishing between higher- and lower-income countries strongly suggest that the policy framework plays a decisive role in determining whether natural resources are a blessing or a curse.

The fact that, within our group of “lower income” countries, the positive relationship between dependence and income polarization is so strong (contrary to what this analysis finds in the higher income group) speaks volumes about the governance problems of most natural resource rich developing countries. These findings reaffirm the critical importance of effectively managing resource revenues in order to build a more prosperous and equitable economy.

6. References

Alessandrini, Michele and Tullio Buccellato. 2009. "Natural Resources: A Blessing or a Curse? The Role of Inequality." *Discussion Paper 98* 2009(October).

Barbier, Edward B. 2014. "Account for Depreciation of Natural Capital." *Nature* 515:32–33.

Barbier, Edward B. 2015. "Wealth Inequality." Pp. 1–30 in *Nature and Wealth*, vol. 1, edited by Intergovernmental Panel on Climate Change. Cambridge: Palgrave Macmillan. Retrieved (http://ebooks.cambridge.org/ref/id/CBO9781107415324A009).

Barro, Robert J. and Jong Wha Lee. 2013. "A New Data Set of Educational Attainment in the World, 1950–2010." *Journal of Development Economics* 104:184–98. Retrieved (http://dx.doi.org/10.1016/j.jdeveco.2012.10.001).

Bourguignon, Francois and Christian Morrisson. 1990. "Income Distribution, Development and Foreign Trade." *European Economic Review* 34(6):1113–32. Retrieved (http://linkinghub.elsevier.com/retrieve/pii/0014292190900716).

Bunte, Jonas. 2011. "Why Does the Severity of the Dutch Disease Vary across Countries ?" Pp. 1–29 in *International Political Economy Society Conference Paper*. Retrieved (https://ncgg.princeton.edu/IPES/2011/papers/S900_rm2.pdf).

Cleveland, Cutler J. et al. 1996. "Natural Capital , Human-Made Capital , Economic Growth , and Sustainability." 1–24.

Darvas, Zsolt. 2012. *Real Effective Exchange Rates for 178 Countries: A New Database*.

Dasgupta, Partha. 2010. "The Place of Nature in Economic Development." Pp. 4977–5046 in *Handbook of Development Economics*, vol. 5, *Handbook of Development Economics*. Elsevier. Retrieved March 23, 2016 (http://www.sciencedirect.com/science/article/pii/B9780444529442000124).

Fum, Ruikang Marcus and Roland Hodler. 2010. "Natural Resources and Income Inequality: The Role of Ethnic Divisions." *Economics Letters* 107(3):360–63. Retrieved (http://dx.doi.org/10.1016/j.econlet.2010.03.008).

Gill, Indermit S., Ivailo Izvorski, Willem van Eeghen, and Donato De Rosa. 2014. *Diversified Development: Making the Most of Natural Resources in Eurasia*. Washington, DC 20433, USA: The World Bank. Retrieved (http://elibrary.worldbank.org/doi/book/10.1596/978-1-4648-0119-8).

Gylfason, Thorvaldur. 2001. "Nature, Power and Growth." *Scottish Journal of Political Economy* 48(5):558–88. Retrieved (http://doi.wiley.com/10.1111/1467-9485.00215).

Gylfason, Thorvaldur and Gylfi Zoega. 2002. *Inequality and Economic Growth: Do Natural Resources Matter ?*

Loayza, Norman, Alfredo Mier y Teran, and Jamele Rigolini. 2013. *Poverty, Inequality, and the Local Natural Resource Curse*. The World Bank. Retrieved (http://elibrary.worldbank.org/doi/book/10.1596/1813-9450-6366).

Robinson, James A., Ragnar Torvik, and Thierry Verdier. 2006. "Political Foundations of the Resource Curse." *Journal of Development Economics* 79(2):447–68. Retrieved (http://linkinghub.elsevier.com/retrieve/pii/S0304387806000137).

Sachs, Jeffrey D. and Andrew Warner. 1995. *Natural Resource Abundance and Economic Growth*. Cambridge, MA. Retrieved (http://www.nber.org/papers/w5398.pdf).

Sachs, Jeffrey D. and Andrew M. Warner. 1999. "The Big Push, Natural Resource Booms and Growth." *Journal of Development Economics* 59(1):43–76. Retrieved (http://linkinghub.elsevier.com/retrieve/pii/S030438789900005X).

Sachs, Jeffrey D. and Andrew M. Warner. 2001. "The Curse of Natural Resources." *European Economic Review* 45(4-6):827–38. Retrieved (http://linkinghub.elsevier.com/retrieve/pii/S0014292101001258).

The World Bank. 2012. *Inclusive Green Growth*. The World Bank. Retrieved (http://elibrary.worldbank.org/doi/book/10.1596/978-0-8213-9551-6).