The Natural Resource Curse and Fiscal Decentralization

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Abstract

Natural resource abundance is a blessing for some countries, but a curse for others. We show that differences across countries in the degree of fiscal decentralization can contribute to this divergent outcome. Using a large panel of countries, covering several decades and various fiscal decentralization and natural resource measures, we provide empirical support for the novel hypothesis. We also study a model that combines political and market mechanisms, under a unified framework, to illustrate how natural resource booms may create negative effects in fiscally decentralized nations.

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Since the influential works of Sachs and Warner (1997, 1999, 2001) the so-called *resource curse puzzle*, describing an inverse relationship between resource abundance and economic growth, has attracted considerable attention. Albeit facing criticism (e.g., Brunnschweiler and Bulte 2008), further studies have provided additional empirical evidence of this phenomenon as well as various potential explanations for its occurrence. Among these explanations (see van der Ploeg 2011 for a survey of the literature), authors have emphasized political factors, corruption, underdeveloped legal and financial systems, Dutch Disease mechanisms, or human-capital inhibiting institutions.

This article contributes to this strand of the literature by further examining the type of institutions that can contribute to the above result. More specifically, we focus on the level of fiscal decentralization, a novel explanation. Fiscal decentralization comprises the financial aspects of devolution to regional and local governments, and it covers two main interrelated issues. The first is the division of spending responsibilities and revenue sources between levels of government. The second is the amount of discretion given to regional and local governments to determine their expenditure and revenues. The definition that we adopt concerns both issues, yet emphasizes the latter. Our main hypothesis is that fiscally decentralized economies are more vulnerable to the growth curse of natural resources than fiscally centralized ones.

Consider, for example, the case of Venezuela versus Botswana. Both are heavily endowed with natural resources, yet the former experienced negative growth rates in the period of 1970-1990, while the latter presented one of the highest positive growth rates during that time. According to the Fiscal Decentralization Indicators of the World Bank, the economy of Venezuela is highly fiscally decentralized whereas that of Botswana is the most centralized in the sample. Let us consider other resource abundant countries with an average share of mineral output in total GDP greater than

10 percent over the said period. Some of the most fiscally centralized ones include Azerbaijan, Chile, Indonesia, Malaysia and Norway; all of which performed (growth-wise) remarkably well in the periods investigated in our samples. Conversely, some of those that are most fiscally decentralized include Ecuador, Ethiopia, Iran, Mexico, and Zambia; all of which performed rather poorly during the same time frames.

We offer a theory that combines political and market mechanisms, under a unified analytical framework, to illustrate possible income-reducing effects that operate when natural resource booms hit fiscally decentralized nations. The political aspect builds on the notion that local governments, especially if poorer and in distant regions, can be less efficient at providing public goods and fall more easily prey of corruption (e.g., see Rodriquez-Pose and Ezcurra 2011).[1] If this is the case, resource windfalls will incentivize rent-seeking behavior of local, fiscally-autonomous, governments. In addition, the model also considers a market mechanism: a natural resource boom gives resource rich regions an advantage in the inter-regional fiscal competition over factors (borne by fiscal decentralization) which they exploit to attract capital from the rest of the economy. This leads to a capital movement towards areas that are less productive because, as we show later, they benefit less from agglomeration externalities (e.g., see Marshall 1920; Ciccone and Hall 1996) and public infrastructure.[2] These two channels contribute to the potential drop in the nation's total output level. Raveh (2013) studies a similar market mechanism, termed the *Alberta Effect*; however, he focuses on within-region effects, and does not consider agglomeration economies or public goods as inputs.

The article provides empirical evidence for the main hypothesis and key predictions of the model. We adopt the World Bank's Fiscal Decentralization Indicators to add a fiscal decentralization measure together with its interaction with resource share measures to the regressions. The analysis is performed under a cross-country

framework which enables studying the full extent of the variation in fiscal decentralization. For the natural endowment, we employ a variety of aggregate measures such as primary rents, natural capital stock, as well as price-based measures, and also look at the individual effects of cropland, forest, pastureland, protected areas and sub-soil assets.

We start with Sachs and Warner's (1997) data and methodology. The time period is 1970-1990 over a sample of 51 countries. Results confirm the main hypothesis and show that the growth curse of natural resource amplifies in fiscally decentralized economies, and is mainly driven by sub-soil assets. These results hold when controlling for investment, openness, institutional quality, ethnicity, terms of trade, education, and interaction terms of ethnicity and institutional quality with the resource share proxy.

Departing from Sachs and Warner, we thereafter employ an extended sample of 73 countries over the period of 1972-2008 to test the same hypothesis through panel estimations, having largely the same controls as in the cross-sectional version, but in addition controlling for country and time fixed effects. The main result remains. By undertaking further checks, we conclude that the confirmation of our hypothesis is robust to using various fiscal decentralization and resource share measures, as well as to different estimation methods and time periods.

Several papers within the natural resource curse literature have investigated the institutional link. Lane and Tornell (1996) suggest that the existence of powerful groups in conjunction with weak institutions provide an explanation for the curse. Mehlum *et al.* (2006) provide additional evidence that the quality of institutions matter. Other authors like Caselli and Michaels (2013) and Brollo *et al.* (2013) offer empirical evidence indicating that the quality of institutions deteriorate as a response to oil windfalls; in particular, they show that local corruption levels increase.

In addition, some papers looked into the type of institutions that matter for the said curse. Andersen and Aslaksen (2008) provide empirical evidence that point at the importance of constitutional arrangements. Hodler (2006) argues that natural resources cause conflict in ethnic fragmented societies that, in turn, weakens property rights. We contribute to this literature by studying an additional related institutional aspect: fiscal decentralization; to the best of our knowledge, this article is the first to do so.

Our article also relates to the debate on the effect of fiscal decentralization on economic growth. Since the seminal work of Tiebout (1956), a literature has emerged stressing the benefits of fiscal decentralization. For example, Oates (1972) and Qian and Roland (1998) argue that this can occur through a higher degree of discipline on local governments and more efficient resource allocation. Other authors, however, argue against those benefits. Fiscal decentralization may introduce harming distortions related to fiscal competition that can prompt a race-to-the-bottom in local taxes and welfare provision – Zodrow and Mieszkowski (1986) – or produce overinvestment in infrastructure – Keen and Marchand (1997). As Martinez-Vazquez and McNab (2003) conclude in their survey of the literature, the effect still remains an open question. We contribute to this ongoing debate by emphasizing the potential adverse effects of fiscal decentralization on welfare manifested through natural resource abundance; a channel that, to our best knowledge, has not been considered previously in this context.

Analytical Framework

To help organize the discussion, we now construct a simple framework that illustrates how fiscal decentralization can interact with natural resources to affect income. Specifically, we consider two potential channels that operate under a unified setting;

one related to political factors, and another to the optimal choice of taxation across fiscally decentralized regions.

Regions and consumers

Assume that there are N small regions in a closed and fiscally decentralized economy, each with its own government, competing for the nation's capital stock. Regions possess the same production and preference structure. They can differ in the endowment of natural riches, capacity to generate public goods, and population density – characteristics that are taken as given. Region i's fixed population is denoted by L_i.

These assumptions deserve some comment. First, foreign capital inflows are potentially important for natural resource exploitation. Multinational firms, for example, finance their own activities, and are in charge of the exploitation of oil fields in many countries. This is, nevertheless, consistent with our closed-economy model because it treats income from natural riches as exogenous, as in for instance Caselli and Cunningham (2009).

Second, we abstract from the existence of a central government. As long as resource abundant regions benefit more from their natural resources compared to the resource poor ones, our results would go through. This has the underlying implication that resource abundant regions have some fiscal advantage due to the resources located in their territories, irrespective of any existing equalization payment schemes. This may happen directly due to the control of the tax base, or indirectly through revenue sharing and grants from the central government. In the former case, decentralization directly provides the regions some fiscal ownership over its resources; examples include Argentina, Canada, the United Arab Emirates and the United States, where subnational ownership over resources is constitutionally entrenched. Under revenue sharing and grants arrangements, on the other hand, the central government

owns the natural riches, yet it may redistribute greater proportions of the revenues to natural-resource rich areas; examples now include Bolivia, Brazil, Colombia, Ecuador, Indonesia, Nigeria and Russia (see Brosio and Jimenez 2012 for Latin America; and Ahmad and Mottu 2002 for nations worldwide). In addition, notice that even in the most equalized federations some significant fiscal imbalance remains regardless of the equalization schemes (see Boadway 2006 for the case of Canada).

Third, as Oates (1993), Prud'homme (1995) and Rodríguez-Pose and Gill (2005), among others, argue, differences in the capacity to generate public goods can be a consequence of economies of scale in production, administration or even negotiation, so that a central government or bigger/richer regions might be more efficient at the provision of public goods. Inman and Rubinfeld (2000), and Storper (2005) also emphasize that local governments may fall more easily prey of elites or special-interest groups, and suffer from greater corruption.

Finally, the fixed-population assumption is made for simplicity. What is essentially required for the model results to hold is that labor is sufficiently less mobile than capital; specifically, when moving towards less agglomerated areas where natural resources are located. We further discuss and present supporting evidence for these latter claims regarding the lack of factor co-movement and systematic differences in agglomeration levels in Appendices A and B.[3]

Each individual is endowed with one unit of labor and one unit of capital that are inelastically supplied to the production sector. As return from the use of these inputs, the consumer obtains a wage payment (w_i) and an interest rate (r_i) that are allocated to the consumption of a private good (c_i) and to pay taxes levied on capital at rate τ_i. A representative individual derives utility (U_{pi}) from the consumption of

this private good and from a public good G_i supplied by the government:

$$U_{pi} = \ln(c_i) + \ln(G_i/L_i), \tag{1}$$

where

$$c_i = w_i + r_i - \tau_i. \tag{2}$$

Governments

Regional governments are rent-seekers and fiscally autonomous. Region i's authorities tax capital (K_i) and use the region's natural input endowment (Z_i) to obtain rents (R_i) and finance the public good. The emphasis on capital taxation is made because of its relative importance in fiscally decentralized scenarios (see Newman and Sullivan 1988, and Wilson and Wildasin 2004), and is more specifically motivated by our focus on capital mobility.

The problem reduces to choosing τ_i, G_i and R_i to maximize their current utility (U_{gi}) that depends on the rents and the representative consumer's utility. For ease of exposition, policymakers take as given all variables that are not directly under their control. More specifically, the government in region i solves:

$$\max_{\{\tau_i, G_i, R_i\}} \left\{U_{gi} = \mu_i \ln R_i + (1-\mu_i)U_{pi}\right\}, \quad \mu_i \in [0,1], \tag{3}$$

subject to

$$Z_i + \tau_i K_i = R_i + G_i, \tag{4}$$

$$U_{pi} \text{ given by (1)},$$

$$K_i, L_i, Z_i, w_i, r_i \text{ taken as given.}$$

The weighting coefficient μ_i can be interpreted as a region-specific rent-seeking parameter; we also use it to capture possible heterogeneity in the capacity of regions to provide the public good G_i. A higher value of μ_i implies that the government is more interested in its own consumption, either because of corruption or because of an inability to provide better public services. Expression (4) is a feasibility constraint that equates public revenues to public expenditures.

The first order conditions to this problem imply the following optimal choices:

$$\tau_i = \frac{1}{2-\mu_i}\left[w_i + r_i - (1-\mu_i)\frac{Z_i}{K_i}\right], \tag{5}$$

and

$$G_i = (1-\mu_i)(Z_i + \tau_i K_i). \tag{6}$$

The tax rate then falls with the natural endowment, and increases with income and μ_i. Government spending G_i, on the other hand, rises with tax revenues and natural resources, and falls with the intensity of the rent-seeking behavior of politicians μ_i. Another interesting implication of expression (5) is that for a sufficiently large value of the natural endowment, the region can fully finance public goods using natural riches, and then the optimal tax rate becomes a subsidy to private-goods consumption.

Production and equilibrium outcomes

Expressions (5) and (6) determine the control variables as implicit functions, because K_i depends on equilibrium prices and taxes. In order to know how tax rates and government spending reacts to changes in exogenous variables and parameters, we need to specify the production side of the model. We assume that there exist a large number of profit-maximizing firms of mass one that produce in region i's non-

resource-extractive sector using labor and capital as inputs according to

$$Y_i = A_i K_i^{\alpha} L_i^{1-\alpha}; \tag{7}$$

where $\alpha \in (0,1)$; and A_i is the region-specific technology level which we discuss later.

Unlike labor, capital moves perfectly across regions until the rental price net of taxes (ρ_i) is equalized and the capital market clears. Market clearing requires that

$$\sum_{j=1}^{N} K_j = K; \tag{8}$$

where K is the nation's capital stock, taken as given.

To see how the region's capital stock reacts to changes in exogenous variables and parameters, we compute the tax rate, τ_i, and the net return to capital, ρ_i. Assuming that firms take prices as given, the first order conditions to the firms' profit maximization problem deliver

$$\tau_i = \frac{A_i}{2-\mu_i}\left(\frac{K_i}{L_i}\right)^{\alpha}\left(1-\alpha+\alpha\frac{L_i}{K_i}\right) - \left(\frac{1-\mu_i}{2-\mu_i}\right)\frac{Z_i}{K_i} \tag{9}$$

and

$$\rho_i = \frac{A_i}{2-\mu_i}\left(\frac{K_i}{L_i}\right)^{\alpha}\left[(1-\mu_i)\,\alpha\frac{L_i}{K_i} - (1-\alpha)\right] + \left(\frac{1-\mu_i}{2-\mu_i}\right)\frac{Z_i}{K_i}. \tag{10}$$

The last two equalities imply that, other things constant, both τ_i and ρ_i rise with A_i. The impact of μ_i, on the other hand, is positive on τ_i but negative on ρ_i. In addition, the RHS of expression (10) declines with K_i. Hence, because net returns are equalized across areas, a region with a higher μ_i or a lower A_i will attract less capital – the former effect is due to the larger tax rate charged, and the latter one to the smaller input productivity.

To see how the provision of public goods is affected, combine (6), (7), and the fact that inputs are paid their marginal productivity to get:

$$G_i = \frac{1-\mu_i}{2-\mu_i}\left\{A_i\left(\frac{K_i}{L_i}\right)^{\alpha}\left[(1-\alpha)K_i + \alpha L_i\right] + Z_i\right\}. \tag{11}$$

Government spending then falls with the intensity of politicians' rent-seeking, and increases with the productivity parameter – notice that this remains true even when taking into account equilibrium effects on capital.

Fiscal decentralization and the natural resource curse

A natural resource curse occurs if a resource windfall in one of the regions induces an economy-wide decrease in the output produced by the non-resource sector that more than offsets the gains that the newly discovered natural riches bring to the nation. In our model, this means that

$$\frac{\partial}{\partial Z_i}\sum_{j=1}^{N}\left(Y_j + Z_j\right) < 0. \tag{12}$$

Looking at expression (7) that gives non-resource sector output Y_i, the curse in our model can be seen as a consequence of a sufficiently large decrease in the weighted average of A_i across regions.

Let us consider that

$$A_i = AY_i^{\lambda}G_i^{\beta}; \tag{13}$$

where β, λ are strictly positive. The effect of the output level Y_i on the region-specific productivity captures agglomeration externalities of the type emphasized by Ciccone and Hall (1996). The effect of G_i, in turn, reflects the contribution of public goods as inputs, either directly as infrastructure, or indirectly through their role, for example,

in the human capital accumulation process. Both of these effects in expression (13) are potentially important for our analysis: natural resources are located in relatively low agglomerated areas (see online appendix A for evidence), and the impact of fiscal decentralization on growth is related to the capacity of regions to provide public goods.

Coming back to the question of when inequality (12) may hold, a region that enjoys a resource windfall will in principle tend to have a larger G_i – by (11) – and therefore a larger A_i. However, there are at least two channels in the model that can contribute to diminish A_i and deliver the negative sign in (12): one related to politics, and the other to the reallocation of capital among regions.

The political channel is related to forces that directly generate a lower provision of public goods. This could be the case if

$$\mu_i = \mu_i(Z_i), \tag{14}$$

and $\partial \mu_i / \partial Z_i > 0$; put differently, if a resource windfall intensifies the rent-seeking behavior of politicians. By expression (11), a higher rent-seeking parameter implies a lower G_i, leading to lower productivity (A_i) and output levels. If the reduction is sufficient, it will produce a natural resource curse.

This effect can be present, to some extent, regardless of the degree of fiscal decentralization. However, as discussed earlier a higher degree of fiscal independence contributes to making the curse more pronounced if local governments, specifically in poorer and less agglomerated regions, fall more easily prey of elites, special-interest groups, and corruption. Indeed, supporting empirical evidence are obtained by Brollo *et al.* (2013) and Caselli and Michaels (2013) who find that in Brazil, a fiscally decentralized nation, municipalities that enjoy resource windfalls become more corrupted,

and do not increase the supply of public goods.

The second channel is a market mechanism. Expression (13) implies that multifactor productivity is a function of the regional level of economic activity and the supply of public goods. Therefore, the reallocation of capital towards geographical areas with weaker agglomeration externalities and, as a consequence, less government spending will contribute to generate the curse. This originates directly from fiscal decentralization. In particular, it is a consequence of the lower tax rate chosen by regions that enjoy the resource windfall, as seen through condition (9).

In this respect, it is important to mention that there is evidence that supports that better-endowed areas compete more aggressively and drain capital from their poorly endowed counterparts. For example, Cai and Treisman (2005) provides evidence for post-communist Russia, Raveh (2013) for U.S. states, and Yao and Zhang (2008) for a less developed nation like China. For general discussions on the importance, and occurence, of competition for production factors in fiscally decentralized nations see, for example, Qian and Roland (1998) and Li *et al.* (2000).

Another factor that can contribute to the negative effect is the input misallocation generated by the constant population assumption, which increases the disparity in capital-labor ratios across regions. In online appendix B, we carry out a calibration exercise that shows that the market mechanism is quantitatively able to cause the curse.

Empirical Evidence

This section provides empirical support for the main hypothesis of the article; namely, that fiscally decentralized economies are more vulnerable to the growth curse of natural resources. It also tests the amplification mechanisms to which the theory has pointed out. Given that the fundamental findings on the curse are rooted in the sem-

inal work of Sachs and Warner (1997), subsection tests our hypothesis using their database and cross-sectional methodology. Later, subsection departs from Sachs and Warner and undertakes panel estimations using an extended sample of countries and years covered. Finally, in subsection , we undertake various robustness checks.

A detailed description of all variables, their definitions, and sources, are given in online appendix C. Online appendix D provides the nations included in each of the samples. Table 1 presents descriptive statistics for all variables employed in the article.

Cross-section tests

We first employ Sachs and Warner's (1997) data, variables, and cross-sectional estimation methodology. Because of limitations in the fiscal decentralization data, the original sample reduces to a cross-section of 51 countries that covers the period of 1970-1990. Employing those numbers, we test the following model:

$$\hat{y}_i = \alpha_0 + \alpha_1 X_i + \varepsilon_i; \tag{15}$$

where i represents the country; $\hat{y}$ is average annual growth in real per capita GDP during the interval 1970-1990; X is a vector of controls that includes resource share, initial income, openness, investment, institutional quality, ethnicity, terms of trade, education, fiscal decentralization, interactions terms of the natural resource share with ethnicity, institutional quality, and fiscal decentralization, and a dummy for landlocked economies; ε_i is the disturbance. Our focus will be on the latter interaction term, which puts our hypothesis to test.

In their analysis, Sachs and Warner (1997) measured resource abundance as the GDP share of mineral output in 1970. One key concern in the resource curse literature

is the potential endogeneity of this measure (van der Ploeg 2011). Therefore, in the benchmark cross-sectional framework, we follow Brunnschweiler and Bulte (2008) and Arezki and van der Ploeg (2011), and use the World Bank's (2006) measure of natural capital: the total stock of sub-soil assets, timber, non-timber forest resources, protected areas, cropland, and pastureland. This stock variable is arguably more exogenous to growth than Sachs and Warner's flow variables, because it captures an economy's amount of proven natural reserves rather than its capacity to produce or export them. Hence, in the analysis to follow to we use the GDP share of natural capital in 2000 as the resource share proxy.[4]

As for the fiscal decentralization measure, we follow Davoodi and Zou (1998), Oates (1985, 1993) and Zhang and Zou (1998), and employ the World Bank's *Fiscal Decentralization Indicators*, which are based on data from the International Monetary Fund's *Government Finance Statistics*.[5] Since the World Bank provides several of those measures, we use the one that most closely resembles the model's notion of fiscal decentralization, which is the degree to which sub-national governments fund their expenditures through their own revenue sources (*Vertical Imbalance*). The higher the indicator, the more independent sub-national governments are, implying that the country as a whole is more fiscally decentralized.[6]

Results appear in table 2. Regression 1 replicates Brunnschweiler and Bulte's (2008) analysis with the addition of Mehlum *et al.*'s (2006) interaction term of institutional quality and resources, Hodler's (2004) interaction term of fractionalization and resources, and our proposed interaction term of fiscal decentralization and the resource share proxy (along with the fiscal decentralization variable). Results on the various controls replicate those presented in previous studies in terms of signs and occasionally significance, including those on the non-fiscal-decentralization interaction terms, which replicate Hodler's (2004) and Mehlum *et al.*'s (2006). Regression

1 confirms our main hypothesis: the estimated coefficient on the interaction of fiscal decentralization and resources is negative and significant, confirming our main hypothesis by showing that the negative growth effect of resources is transmitted through the decentralization channel.[7]

Given that the natural capital measure is an aggregation of various types of natural resources, we disaggregate it to its various components (namely, cropland, forest, pastureland, protected areas, subsoil assets) to better understand the source of this. Results appear in Regressions 2 to 6 in table 2, where we use the GDP share of each component. In these cases interactions of the resource proxy with ethnicity and institutional quality are excluded to minimize multicollinearity. The main result holds only under the subsoil assets, being the triggering group for the overall average effect. Indeed, this is consistent with the focus minerals have taken in previous studies on the natural resource curse (e.g. Sachs and Warner 1997, Ross 2001).

To further strengthen our claim let us try to offer additional evidence in favor of the mechanisms that drive the model prediction that fiscally decentralized nations may not benefit from resource windfalls: inter-regional differences in agglomeration levels. In particular, smaller isolated areas can be less efficient in the production and provision of public goods, and subject to stronger corruption problems. This is the main source in the model of the negative effects induced by a resource windfall.

More specifically, we construct an agglomeration index based only on population density vis-a-vis urbanization levels. This measure divides each country's total non-urbanized area by its total area (both in square kilometers); where the calculation of non-urbanized areas follows the definition of non-urbanization provided by the United Nations, on per-country basis.[8] A higher value is interpreted as an indication of greater agglomeration differences. Importantly, the sample shows virtually zero correlation between this agglomeration measure and economic growth, which

mitigates endogeneity related concerns.

The model prediction is that decentralized economies with a higher index are more vulnerable to the growth curse. We multiply the fiscal decentralization measure and the above index, and refer to the updated index as *potential vulnerability*. Results appear in Regression 9, and confirm those presented in Regression 1. This provides some validation to the underlying forces, implying that resource endowments may be hurting fiscally decentralized economies through the proposed channels.

Fiscal decentralization can also suffer from endogeneity problems. Previous studies show that fiscal decentralization has several determinants, the key ones being land area, level of democracy, and level of income, each affecting fiscal decentralization positively – see Arzaghi and Henderson (2005), Oates (1972), Panizza (1999), and Treisman (2006). Thus fiscal decentralization may in fact be endogenous to growth through an unobserved development factor; consequently, the positive association between income and fiscal decentralization could be creating an upward bias. We address this concern by taking an IV approach. In particular, we use the abovementioned determinant, land area, as instrument for fiscal decentralization. Consistent with the findings of previous studies, the logarithm of land area is positively correlated with our measure of fiscal decentralization ($\rho = 0.51$), as depicted in figure 1. As for the exclusion restriction, some authors such as Alesina *et al.* (2005) discuss the potential endogenous nature of a country's land area and its influence on economic growth. Their work suggests that controlling for the degree of openness can minimize this influence; this is what we do. Our identification assumption is that, once controlling for the level of openness, land area affects growth solely through the fiscal decentralization channel.[9]

We follow Wooldridge's (2002) approach to instrumentation of endogenous interaction terms. In the first stage, we predict fiscal decentralization using the instrument

and the exogenous explanatory variables of the regression. We then interact the predicted variable with the natural resource share proxy and use it in the second stage of the TSLS estimation. Results appear in Regressions 7 and 10. First stage results confirm the validity of the instrument, through the F-statistic and the coefficient of interest (being positive and significant). Second stage estimations, in turn, show that the key result remains: the coefficient on the interaction term of decentralization and resources is negative and significant in all cases.

Panel data analyses

The previous cross-sectional analyses, a-la Sachs and Warner, raise several concerns. First, the time period covered is limited (1970-1990). Second, the sample covers merely 51 countries. Last, the cross-sectional estimation methodology potentially gives rise to both omitted variable and endogeneity biases (van der Ploeg 2011). Departing from Sachs and Warner, we now employ an extended panel that covers the period 1972-2008 (in 9-year intervals) for 73 countries; the maximum number provided by the World Bank's Fiscal Decentralization Indicators.[10] The use of this panel allows addressing the above concerns.

We estimate the following model:

$$\hat{y}_{it} = \beta_0 + \beta_1 X_{it} + \varphi_i + \varepsilon_{it}. \tag{16}$$

The variables $\hat{y}_{it}$, X_{it} and ε_{it} are the same ones as in specification (15), for country i at date t, with the difference of excluding ethnicity and terms of trade as controls due to lack of data, as well as some additional measurement differences outlined below. Because the Hausman test strongly rejects (at the 1% level) the null hypothesis of an efficient random effects model, we take a fixed effects approach and include

φ_i, denoting country fixed effects. This approach also mitigates potential omitted variable bias, alleviates concerns regarding potential multicollinearity by centering variables, and helps control for unobserved within-country constant phenomena, being a standard concern under the given framework. All variables are measured in the initial year of the corresponding time interval to reduce endogeneity concerns,[11] and are expressed in deviations from period means so that time fixed effects are also implicitly controlled for in all the corresponding regressions (e.g., see Caselli *et al.* 1996).

Not all the explanatory variables employed in these panel estimations are measured in the same way as in the cross-sectional analysis due to data limitations, though all our measures are standard in the economic growth literature (see online appendix B). Specifically, given its greater coverage, institutional quality is now measured by the Civil Liberties Index, which is commonly used as a proxy for institutional quality. Civil liberties, however, do not capture corruption levels that are essential for our analysis. Therefore, as a separate control, we follow Andersen and Aslaksen (2008) and consider the level of democracy as a proxy for corruption, using data from the Polity-IV project dataset.[12] We include as well its interaction with the resource proxy to control for the heterogeneous effects across levels of corruption (but excluding the interaction with institutional quality, due to multicollinearity).

As for resource abundance, we also use a different measure, in an attempt to capture exogenous variations in resource shocks over time. This measure is constructed as follows: for each country, we take the GDP share of mineral rents in the earliest year available, and multiply it by the average international price index of mineral goods (normalized to 2005) at time t.[13] Put differently, we keep the initial share of mineral production in GDP constant, but we weigh the share at each point in time with the corresponding level of mineral prices.

As presented in figure 2, the relative international ranking in the GDP share of mineral output (having nations with no mineral output assigned a rank of 1) has changed little over time: countries that were largely mineral abundant at the beginning of the period (1972) appear to hold their relative ranking 36 years later ($\rho = 0.81$). Keeping the share of mineral production in GDP constant, hence, can still capture accurately the countries' relative position with respect to their mineral abundance over time. To the extent that changes in international mineral prices are exogenously driven and that initial mineral output is pre-determined, we argue that the variation we investigate is indeed exogenous since it is entirely triggered by changes in the international price of minerals.

Results appear in Regression 1 of table 3. Results on convergence, openness, investment, institutional quality, democracy, education, decentralization and the interaction of resources with institutional quality are similar in sign, and occasionally in significance, to previous findings in the cross-section tests. Interestingly, the regression shows that our main result – a negative and significant coefficient on the interaction term between fiscal decentralization and resource share – holds in this case as well.

There is a debate in the literature on the nature of the link between fiscal decentralization and internal conflicts (Siegle and O'Mahony 2006). To the extent that fiscal decentralization may induce internal conflicts, the observed effect on growth may be driven through that channel. We test this hypothesis by adding an indicator for whether an internal armed conflict has taken place in the investigated time interval; this measure is retrieved from the Uppsala Conflict Data Program.[14] This exercise is undertaken in Regression 2 which shows that our main result on the interaction term of interest remains.

Additional robustness checks

Regressions 3 to 5 in table 3 contain further robustness tests of our main hypothesis. Using the panel data, we begin by considering an output-based resource measure, which allows us to examine variations in resource discoveries and technology improvements (on top of price variations, as was done initially): the GDP share of primary rents. Regression 4 reproduces Regression 1 using this output-based measure. Results on all variables, including our interaction term, are similar in sign and significance.

Nevertheless, as was mentioned previously, this measure is potentially endogenous (motivating our use of the price-based measure in the baseline specification); thus, we take an IV approach and instrument it with the GDP share of mineral rents in $t-1$. We view this measure as a suitable IV, because it is highly correlated with our proxy ($\rho = 0.9$), and relatively exogenous to growth. Its exogeneity can be justified as follows: first, mineral rents are not dependent on an economy's capability to export, thus making it less correlated with development and growth; second, mineral rents in developing economies are usually extracted by multi-national firms that bring their own technology and production factors, making these rents relatively independent of unobserved development indicators; last, the lagged value is arguably more exogenous to growth in the following period. Estimation of the endogenous interaction term is carried out using the previously described procedure. Results are reported in Regression 5 of table 3. First stage results validate the instrument, and the second stage ones confirm our main result.

Let us now test the hypothesis using a different fiscal decentralization measure, and in particular, the Kearney Decentralization Index (Arzaghi and Henderson 2005). Although there are several available decentralization indices, we adopt this one because of its larger time and country coverage: the index is available for 43 devel-

oping and developed countries over the years 1965-1995. The Kearney measure is a comprehensive index that covers nine distinct dimensions of fiscal decentralization. We adopt one of them: the Revenue Raising Authority dimension; it measures sub-national governments' formal authority to raise their own revenue through taxation, which resembles the model's notion of decentralization more closely.[15] Regression 3 of table 3 replicates Regression 1 using the Kearney measure, the previously described price-based resource measure, and a panel that covers the period of 1965-2000 with 5-year intervals.[16] Results under these measure are similar to previous estimations; our main result, therefore, is robust to different decentralization variables.

We realize that throughout the panel analyses the fiscal decentralization measure remains potentially endogenous. Adopting a suitable IV with sufficient time variation is not straightforward. As an alternative, we turn to test the cross-sectional version of our panel employing the logarithm of land area as an instrument for fiscal decentralization. More specifically, we extend the previously used Sachs and Warner's cross-sectional sample to 2008, use the logarithm of land area as IV for fiscal decentralization, and employ the previously discussed natural capital measure as the resource share proxy. Regression 8 of table 2 gives the outcome of this exercise for the period 1970-2008. Our main finding is once again confirmed. Although not presented, similar results arise when the time interval from 1990 to 2008 is used instead.

To this point we considered maximized cross-country samples that include both developed and developing economies. Often times, however, the natural resource curse hypothesis refers specifically to developing economies (Auty 1993). Let us test, therefore, whether our result holds for developing economies. Hence, we divide our samples into high and non-high income economies based on the earliest available classification provided by the World Bank starting at 1989, and estimate the basic specifications as in Regression 1 of table 2 and Regressions 1 and 3 of table 3, for each

group separately.[17] Due to multicollinearity concerns when the sample is split, we exclude the interaction terms of the resource share measure with fractionalization and rule of law in the cross-sectional case, and the measure of democracy together with its interaction with the price-based resource measure in the panel cases. Results appear in table 4. As can be seen, the main result is strongly apparent in the developing economies group, and weakly so in the developed one. This result also lends support to the political angle of the model, and its potential significance in the overall mechanism, given that corruption levels are higher and markets more imperfect in developing economies.

Given our empirical setting, using various standard country-level controls and interaction terms, one concern is that our main results may be plagued by multicollinearity. In the panel analyses this is addressed through the usage of a fixed effects framework that centers the variables. However, to address this further we estimate the benchmark regressions, namely Regression 1 of table 2, and Regressions 1, 3 and 4 of table 3, with the non-fiscal-decentralization related interactions excluded. Results appear in table A2 in the online appendix. The highest Variance Inflation Factor (uncentered) in all cases is 6.58, indicating multicollinearity levels are sufficiently low. In all regressions the main result remains to hold in sign, significance, and magnitude, hence alleviating related concerns.

Conclusion

The question of why resource endowments lead to divergent outcomes continues to attract much interest among economists. This article presented a novel answer to that question: countries with a high degree of fiscal decentralization are more vulnerable to the negative effects of natural resource windfalls. The new hypothesis also contributes to understanding the effects of fiscal decentralization on economic growth.

We explored a model that suggests possible channels through which fiscal decentralization and natural resource booms can interact to increase the probability of a natural resource curse. To support the theory, we have shown that natural resources are located in less agglomerated, sparsely-populated regions; areas in which we have argued that agglomeration externalities are weaker, and the growth-harming effects emphasized by the fiscal decentralization literature are more likely to arise. If this is the case, resource windfalls may incentivize rent-seeking behavior of local, fiscally-autonomous, governments – the political channel. In addition, natural riches can lead less agglomerated and efficient regions to cut taxes and attract capital from more productive areas – the market mechanism. These two channels can contribute to drop total output in the nation, following a natural resource boom.

The main hypothesis – that countries with a high degree of fiscal decentralization are more vulnerable to the natural resource curse – has been empirically tested and confirmed. First, we used the original Sachs and Warner's (1997) data set and method; then, an extended panel, in conjunction with the World Bank's Fiscal Decentralization Indicators. Finally, we have shown that results are robust to different resource abundance and fiscal decentralization measures, as well as to different estimation techniques and time periods.

The article has, in general, remained agnostic about the contribution of each of the two mechanisms to our estimations – whether one is more important than the other. Yet results have shown that the interaction between fiscal decentralization and natural resources is driven mainly by developing nations. This suggests that political channels might be more significant than market mechanisms. Nevertheless, assessing more accurately the relative importance of each of them represents a promising avenue for future research. In addition, results may be sensitive to the specific periods and countries investigated. Future work should further test the results and analyze the

suggested mechanisms using different data sets and case studies, as they become available

Supplementary Material

Supplementary online appendix is available at http://oxfordjournals.org/our_journals/ajae/online

References

Alesina, A., E. Spolaore, and R. Wacziarg. 2005. Trade, Growth and the Size of Countries. In *Handbook of Economic Growth*, Vol. 1B, ed. P. Aghion and S.N. Durlauf. Elsevier.

Andersen, J., and S. Aslaksen. 2008. Constitutions and the Resource Curse. *Journal of Development Economics* 87 (2), 227-246.

Arezki, R., and F. van der Ploeg. 2011. Do Natural Resources Depress Income per Capita? *Review of Development Economics* 15, 504-521.

Arzaghi, M., and J. Henderson. 2005. Why Countries Are Fiscally Decentralizing? *Journal of Public Economics* 89, 1157-1199.

Auty, R. M. 1993. *Sustaining Development in Mineral Economies*. Routledge, London.

Boadway, R. 2006. Natural Resource Shocks and the Federal System: Boon and Curse? *Fiscal Federalism and the Future of Canada Conference Proceedings*, Institute of Intergovernmental Relations.

Brollo, F., T. Nannicini, R. Perotti, and G. Tabellini. 2013. The Political Resource Curse. *American Economic Review* 103 (5), 1759-1796.

Brunnschweiler, C. N., and E. H. Bulte. 2008. The Natural Resource Curse Revised and Revisited: A Tale of Paradoxes and Red Herrings. *Journal of Environmental Economics and Management* 55 (3), 248-264.

Cai, H. and D. Treisman. 2005. Does Competition for Capital Discipline Governments? Decentralization, Globalization, and Public Policy. *American Economic Review* 95 (3), 817-830.

Caselli, F., and T. Cunningham. 2009. Leader Behavior and the Natural Resource Curse. *Oxford Economic Papers* 61, 628-650.

Caselli, F., G. Esquivel, and F. Lefort. 1996. Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics. *Journal of Economic Growth* 1 (3), 363-389.

Caselli, F., and G. Michaels. 2013. Do Oil Windfalls Improve Living Standards? Evidence from Brazil. *American Economic Journal: Applied Economics* 5 (1), 208-38.

Ciccone, A., and R. Hall. 1996. Productivity and the Density of Economic Activity. *American Economic Review* 86 (1), 54-70.

Davoodi, H., and H. Zou. 1998. Fiscal Decentralization and Economic Growth: A Cross Country Study. *Journal of Urban Economics* 43, 244-257.

Hodler, R. 2006. The Curse of Natural Resource in Fractionalized Countries. *European Economic Review* 50 (6), 1367-1386.

Inman, R. P., and D. L. Rubinfeld. 2000. Federalism. In *The Encyclopedia of Law and Economics*, Volume V.

Keen, M., and M. Marchand. 1997. Fiscal Competition and the Pattern of Public Spending. *Journal of Public Economics* 66 (1), 33-53.

Lane, P. R., and A. Tornell. 1996. Power, Growth and the Voracity Effect. *Journal of Economic Growth* 1, 213–41.

Li, S., S. Li, and W. Zhang. 2000. The Road to Capitalism: Competition and Institutional Change in China. *Journal of Comparative Economics* 28 (2), 269-292.

Marshall, A. 1920. *Principles of Economics*, 8th ed., London, Macmillan and Company.

Martinez-Vazquez, J., and R. McNab. 2003. Fiscal Decentralization and Economic Growth. *World Development* 31 (9), 1597-1616.

Mehlum, H., K. Moene, and R. Torvik. 2006. Institutions and the Resource Curse. *The Economic Journal* 116, 1-20.

Newman, R. J., D. H. and Sullivan. 1988. Econometric Analysis of Business Tax Impacts on Industrial Location: What Do We Know, and How Do We Know It? *Journal of Urban Economics* 23, 215-234.

Oates, W. 1972. *Fiscal Federalism*. New York, Harcourt Brace Jovanovich, Academic Press.

Oates, W. 1985. Searching for Leviathan: An Empirical Analysis. *American Economic Review* 75, 748-757.

Oates, W. 1993. Fiscal Decentralization and Economic Development. *National Tax Journal* XLVI, 237-243.

Panizza, U. 1999. On the Determinants of Fiscal Centralization: Theory and Evidence. *Journal of Public Economics* 74, 97-139.

Prud'homme, R. 1995. The Dangers of Decentralization. *World Bank Research Observer* 10, 201-220.

Qian, Y., and G. Roland. 1998. Federalism and the Soft Budget Constraint. *American Economic Review* 88 (5), 1143-1162.

Raveh, O. 2013. Dutch Disease, Factor Mobility, and the Alberta Effect – The Case of Federations. *Canadian Journal of Economics*, 46 (4), 1317-1350.

Rodriguez-Pose, A., and R. Ezcurra. 2011. Is Fiscal Decentralization Harmful for Economic Growth? Evidence from the OECD Countries. *Journal of Economic Geography* 11, 619-643.

Rodríguez-Pose, A., and N. Gill. 2005. On the "Economic Dividend" of Devolution. *Regional Studies* 39, 405-420.

Ross, M. 2001. Does Oil Hinder Democracy? *World Politics* 53 (1), 297-322.

Sachs, J.D., and A. M. Warner. 1997. Natural Resource Abundance and Economic Growth. *Mimeo*, Center for International Development and Harvard Institute for International Development.

Sachs, J.D., and A. M. Warner. 1999. The Big Push, Natural Resource Booms and Growth. *Journal of Development Economics* 59, 43-76.

Sachs, J.D., and A. M. Warner. 2001. Natural Resources and Economic Development: The Curse of Natural Resources. *European Economic Review* 45, 827-838.

Siegle, J., and P. O'Mahony. 2006. Assessing the Merits of Decentralization as a Conflict Mitigation Strategy. *Mimeo*, prepared for the USAID's Office of Democracy and Governance.

Storper, M. 2005. Society, Community and Economic Development. *Studies in Comparative International Development* 39, 30-57.

Tiebout, C. 1956. A Pure Theory of Local Expenditures. *Journal of Political Economy* 64, 416-24.

Treisman, D. 2006. Explaining Fiscal Decentralization: Geography, Colonial History, Economic Development, and Political Institutions. *Journal of Commonwealth and Comparative Politics* 44 (3), 289-325.

van der Ploeg, F. 2011. Natural Resources: Curse or Blessing? *Journal of Economic Literature* 49 (2), 366-420.

Wilson, J. D., and D. E. Wildasin. 2004. Capital Tax Competition: Bane or Boon. *Journal of Public Economics* 88 (6), 1065-1091.

Wooldridge, J. M. 2002. *Econometric Analysis of Cross Section and Panel Data*. MIT Press.

Yao, Y., and X. Zhang. 2008. Race to the Top and Race to the Bottom: Tax Competition in Rural China. *Discussion paper* 799, International Food Policy Research Institute (Washington, D.C.).

Zhang, T., and H. Zou. 1998. Fiscal Decentralization, Public Spending, and Economic Growth in China. *Journal of Public Economics* 67, 221-240.

Zodrow, G., and Z. Mieszkowski. 1986. Pigou, Tiebout, Property Taxation, and the Underprovision of Local Public Goods. *Journal of Urban Economics* 19, 356-370.

Notes

[1]This does not mean that fiscal decentralization increases corruption nation-wide. What it implies is that corruption rises in fiscally autonomous regions where resource booms occur. We later reference papers that support this role.

[2]The concept of agglomeration economies refers to the positive externalities of economic integration at the local level, especially with respect to increased labor market pooling, shared inputs, and knowledge spillovers.

[3]Implicit in this is the assumption that capital is relatively highly mobile across regions within the same nation. Previous studies support this notion.

[4]Year 2000 is preferred because it gives the largest sample size, 51 countries. Results do not change qualitatively in case the numbers provided by the World Bank for 1995 and 2005 are employed instead. Results do not change either if we use Sachs and Warner's measure – the mineral output GDP share in 1970; estimates using this last proxy are provided in table A1 in the online appendix.

[5]In terms of coverage, indicators are only provided for countries that report expenditures at both the national and sub-national levels. Nonetheless, as reported by the World Bank, this coverage reflects a lack of reported data rather than few countries with local and provincial governments; also, this should not necessarily reflect differences in the degree of fiscal decentralization between countries included in the sample and those that are not – the sample ranges from highly decentralized countries to highly centralized ones.

[6]Given that the seminal Sachs and Warner's analysis starts at 1970, the fiscal decentralization measure collected for each country is the one closest to 1970, up to 1975 (to mitigate endogeneity concerns), so that countries that do not have such a measure available up to 1975 are not included in the sample. This limits the coverage of our cross-sectional sample to 51 countries.

[7]For all cases reported in tables we have also estimated the regressions without incorporating any of the fiscal decentralization related variables, and with fiscal decentralization but without its interaction term. Results were similar for all variables.

[8]For detailed definitions see the Gridded Population of the World database of the Center for International Earth Science Information Network at Columbia University.

[9]Regardless of any arguments over exogeneity, there were very little changes in the land area of the countries in our sample throughout the investigated period. In fact, the only countries in our sample that experienced such a change are Denmark, Philippines, and Spain, with the largest change being at a rate of only 0.07 percent over the period.

[10]This is an unbalanced panel, limited by data availability of the World Bank's Fiscal Decentralization Indicators. We use 9-year intervals to maximize sample size, while maintaining a relatively long time interval, consistent with the resource curse hypothesis; longer time intervals decrease sample size significantly.

[11]Nonetheless, we note that results are not sensitive to the alternative usage of average values.

[12]Note that the correlation between our proxies for corruption and institutional quality stands at approximately 0.5, affirming to some extent their distinct definitions, and motivating their concurrent inclusion in the regressions. Nonetheless, we note that all results hold if only one of them is included. In addition, we discuss multicollinearity related concerns separately in a later section.

[13]Data retrieved from the World Bank. Mineral resources include: oil, natural gas, minerals, and coal. Rents are computed as unit rents times production, where a unit rent is the unit price less unit cost. The price measure is a general index that does not account for the different mineral shares of each country; prices of different minerals, however, exhibit strong co-movement.

[14]An internal armed conflict is defined as a contested incompatibility that concerns government and/or territory where the use of armed force between two parties, of which at least one is the government of a state, results in at least 25 battle-related deaths. The internal armed conflict occurs between the government of a state and one or more internal opposition group(s), without intervention from other states.

[15]This component of the index assigns each country a number between zero and four, with four having the highest level of revenue raising autonomy and zero the least.

[16]We adopt 5-year intervals in this case, again, to maximize the sample size (notice that the index is available in 5-year intervals as well). Nonetheless, results do not change qualitatively if 10-year intervals are adopted instead.

[17]See online appendix D for a list of economies included in each group. We note that results hold as well if the developed-economies group includes also the middle-income countries, leaving the developing-economies group with the low-income ones only.

Table 1. Descriptive Statistics

A. Cross-sectional analysis

	Mean	Std. Dev.	Min.	Max.		Mean	Std. Dev.	Min.	Max.
Growth, 1970-1990	1.3	1.6	-3.09	5.7	Ethnicity	36.89	28.35	0	89
Growth, 1970-2008	3.4	3.1	-1.2	17.77	Terms of trade	-0.41	2.32	-4.69	7.38
GDP share of mineral output	0.04	0.08	0	0.37	Education	0.17	0.14	0.005	0.54
GDP share of natural capital	0.02	0.05	0.0001	0.38	Landlocked economies	0.13	0.34	0	1
Logarithm of initial income	8.65	0.86	6.76	9.95	Vertical Imbalance	67.15	23.94	7.02	99.8
Openness	0.5	0.45	0	1	Potential Vulnerability	62.47	24.75	3.96	99
GDP share of cropland	0.02	0.02	0.0001	0.104	GDP share of pastureland	0.006	0.008	0.0002	0.04
GDP share of forest	0.006	0.01	1E-05	0.06	GDP share of protected areas	0.006	0.01	3E-05	0.09
Investment	2.86	0.49	1.33	3.61	Modified Potential Vulnerability	9.63	4.31	0.97	20.6
Institutional quality	3.56	2.005	1	6	Logarithm of land area	12.65	1.97	6.54	16
GDP share of subsoil assets	0.005	0.01	0	0.05					

B. Panel analysis

Regressions 1, 2, 4, and 5; Table 3					Regression 3; Table 3				
	Mean	Std. Dev.	Min.	Max.		Mean	Std. Dev.	Min.	Max.
Growth, 1972-2008	2.13	2.75	-8.06	12.98	Growth, 1965-2000	2.14	2.98	-11.39	22.4
Price-based resource measure	1.81	8.48	0	120.4	Price-based resource measure	4.42	7.61	0	61.7
GDP share of primary rents	0.05	0.09	0	0.78	Logarithm of initial income	7.49	1.57	4.43	10.5
GDP share of mineral rents	0.03	0.08	0	0.78	Openness	0.39	0.24	0.05	1.92
Logarithm of initial income	8.75	1.25	4.91	11.4	Investment	24.75	8.81	1.34	58.3
Openness	0.71	0.42	0.02	3.24	Institutional quality	4.31	2.19	1	7
Investment	24.4	9.23	5.17	70.31	Education	5.45	2.95	0.13	12.7
Institutional quality	4.86	1.83	1	7	Kearney Decentralization Index	1.18	1.06	0	3.56
Education	7.17	2.82	0.57	12.7	Democracy	4.66	4.19	0	10
Democracy	5.93	4.11	0	10					
Vertical Imbalance	45.72	21.25	0.91	97.38					

Note: Further descriptions and sources of all variables are outlined in the Appendix.

Table 2. Cross-Country Growth Regressions, Cross-Section [Sachs and Warner (1997) database, period: 1970-1990, unless specified otherwise]

Panel A: Main and second stage results	Fiscal decentralization is 'Vertical Imbalance'								Fiscal decentralization is 'Potential Vulnerability'	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variable: Average annual growthin real per capita GDP, 1970-1990	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)	(OLS)	(TSLS)	(TSLS, extending to 2008)	(OLS)	(TSLS)
Natural capital	10.72						17.27	6.23	7 .67	14.34
	(27.01)						(27.47)	(54.59)	(27.29)	(27.56)
Cropland		-6.68								
		(22.01)								
Forest			-30.37							
			(46.53)							
Pastureland				-150.36						
				(132.22)						
Protected areas					-1.5					
					(52.78)					
Subsoil assets						37.54				
						(30.89)				
Logarithm of initial income	-2.02***	-2.15***	-2.04***	-1.89***	-2.02***	-1.54***	-1.94***	-2.22***	-1.99***	-1.94***
	(0.38)	(0.41)	(0.38)	(0.38)	(0.39)	(0.36)	(0.34)	(0.45)	(0.37)	(0.34)
Openness	2.81***	2.12***	2.32***	2.22***	2.27***	1.99***	2.75***	5.09***	2.81***	2.75***
	(0.49)	(0.49)	(0.41)	(0.53)	(0.48)	(0.51)	(0.49)	(1.45)	(0.49)	(0.49)
Investment	0.07	0.02	0.17	0.21	0.24	1.05*	-0.26	1.16	-0.05	-0.22
	(0.45)	(0.48)	(0.49)	(0.56)	(0.55)	(0.53)	(0.39)	(0.85)	(0.42)	(0.39)
Rule of law	0.04	0.24	0.27	0.27	0.29	0.13	0.05	-0.43	0.05	0.05
	(0.21)	(0.19)	(0.19)	(0.19)	(0.21)	(0.18)	(0.19)	(0.44)	(0.2)	(0.19)
Ethnicity	-0.01	-0.009	-0.007	-0.01**	-0.01**	-0.01	-0.01	-0.04	-0.01	-0.01
	(0.007)	(0.006)	(0.006)	(0.01)	(0.01)	(0.006)	(0.007)	(0.03)	(0.007)	(0.007)
Terms of trade	0.16**	0.13*	0.13	0.13	0.18**	0.31***	0.16**	0.05	0.16**	0.16**
	(0.06)	(0.07)	(0.08)	(0.08)	(0.08)	(0.08)	(0.07)	(0.11)	(0.06)	(0.07)
Education	2.85**	2.06*	2.22*	2.54*	2.68**	1.99*	2.68**	4.43*	2.72**	2.69**
	(1.29)	(1.19)	(1.25)	(1.36)	(1.28)	(1.13)	(1.28)	(2.49)	(1.23)	(1.28)
Landlocked economies	0.22	-0.63	-0.29	-0.99**	-0.99*	-1.11**	0.41	0.19	0.28	0.39
	(0.45)	(0.59)	(0.38)	(0.49)	(0.54)	(0.43)	(0.51)	(0.91)	(0.45)	(0.49)
Ethnicity x Resource share	-0.62**						-0.71**	-1.06	-0.61**	-0.66**
	(0.27)						(0.26)	(0.68)	(0.27)	(0.29)
Rule of law x Resource share	7.84**						8.14**	18.32**	7.97**	7.89**
	(3.67)						(3.77)	(7.2)	(3.74)	(3.81)
Fiscal decentralization	0.008						0.002	-0.001	0.004	-0.001
	(0.01)						(0.01)	(0.03)	(0.01)	(0.01)
Fiscal decentralization x Resource type share	**-0.39*** **	**-0.34**	**-0.31**	**1.77**	**-0.25**	**-1.19*** **	**-0.46*** **	**-0.71****	**-0.37*** **	**-0.43*** **
	(0.08)	**(0.33)**	**(0.53)**	**(1.37)**	**(0.6)**	**(0.38)**	**(0.1)**	**(0.27)**	**(0.09)**	**(0.09)**
Adjusted R-squared	0.7853	0.7238	0.7513	0.6956	0.708	0.7532	0.7733	0.6517	0.7827	0.7695
Observations	51	51	51	51	51	51	51	51	51	51

Panel B: First stage results		
Regressions:	(7), (8)	(10)
Dependent variable:	Fiscal decentralization	Fiscal decentralization
Logarithm of land area	3.59***	4.93***
	(0.99)	(0.91)
Adjusted R-squared	0.7823	0.8146
F-statistic	17.2	21.16

Note: Standard errors are robust and appear in parentheses for independent variables. Superscripts *,**, *** correspond to a 10, 5 and 1% level of significance, respectively. First stage regressions include all relevant variables. All regressions include an intercept. 'Resource type' refers to the specific type o natural resource examined in the regression. All resource-type variables are measured as GDP shares (source: World Bank 2006). For description and sources of variables, as well as a list of economies included in each regression, see Appendix.

Table 3. Cross-Country Growth Regressions, Panel Data (OLS estimations, unless specified otherwise]

Panel A: Main and second stage results	Using the price-based measure as the resource share proxy			Using GDP share of primary rents as the	
Dependent variable: Average annual growthin real per capita GDP for sample period	(1)	(2)	(3) Kearney	(4)	(5) [TSLS]
Resource share	0.47	0.46	0.003	10.41	6.78
	(0.44)	(0.43)	(0.05)	(8.3)	(10.44)
Logarithm of initial income	-3.46***	-3.48***	-2.2*	-4.18***	-4.36***
	(1.23)	(1.23)	(1.2)	(1.24)	(1.28)
Openness	1.26	1.22	1.1	1.14	1.19
	(1.26)	(1.34)	(1.94)	(1.13)	(1.22)
Investment	0.38	0.39	2.32***	0.71	0.81
	1.2	(1.19)	(0.62)	(1.09)	(1.16)
Civil liberties	-0.58***	-0.58***	-0.22	-0.63***	-0.56***
	(0.18)	(0.19)	(0.19)	(0.18)	(0.19)
Democracy	-0.12	-0.12	-0.03	0.01	0.21
	(0.09)	(0.09)	(0.03)	(0.04)	(0.04)
Democracy x Resource share	-0.09	-0.09	-0.004	1.64	-0.59
	(0.06)	(0.06)	(0.01)	(1.24)	(0.89)
Education	0.39	0.34	0.85***	0.34	0.24
	(0.24)	(0.24)	(0.25)	(0.23)	(0.23)
Fiscal decentralization	-0.02	-0.02	-0.05	-0.002	-0.002
	(0.01)	(0.01)	(0.29)	(0.01)	(0.01)
Fiscal decentralization x Resource share	**-0.01*** **	**-0.01** **	**-0.05** **	**-0.4** **	**-0.4** **
	(0.006)	**(0.007)**	**(0.02)**	**(0.19)**	**(0.19)**
Internal armed conflicts		**-0.11**			
		(0.62)			
Adjusted R-squared	0.8034	0.8035	0.5859	0.7982	0.7987
Observations	207	207	232	207	207
Country fixed effects	Yes	Yes	Yes	Yes	Yes
Number of economies included	73	73	43	73	73

Panel B: First stage results	
Regressions:	(5)
Dependent variable:	GDP share of primary rents
GDP share of mineral rents in t-1	0.99***
	(0.06)
Adjusted R-squared	0.8877
F-statistic	71.04

Note: Standard errors are robust, clustered by country, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance, respectively. In Regressions 1, 2, 4, and 5 the period covered is 1972-2008 in 9-year intervals, with the fiscal decentralization measure being 'Vertical Imbalance'; In Regression 3 the period covered is 1965-2000, in 5-year intervals, with the fiscal decentralization measure being the Revenue Raising Authority component of the Kearney Decentralization Index. First stage regressions include all relevant variables. All regressions include an intercept. All variables are expressed as deviations from period means so that time fixed effects are controlled for in all regressions. For description and sources of variables, as well as a list of economies included in each regression, see Appendix.

Table 4. Revisitng Main Results Using Restricted Samples of Developing and Developed Economies [OLS estimations]

Dependent variable: Average annual growth in real per capita GDP	Developing economies			Developed economies		
	Cross section (Table 2, Regression 1)	Panel (Table 3, Regression 1)	Panel (Table 3, Regression 3)	Cross section (Table 2, Regression 1)	Panel (Table 3, Regression 1)	Panel (Table 3, Regression 3)
	(1)	(2)	(3)	(4)	(5)	(6)
Resource share	11.82**	0.54	-0.03	-9.77	0.26	0.21**
	(4.24)	(0.74)	(0.05)	(107.337)	(0.32)	(0.08)
Logarithm of initial income	-2.48***	-2.95***	-1.94	-1.05*	-4.11***	-4.68***
	(0.33)	(1.39)	(1.22)	(0.57)	(1.16)	(1.31)
Openness	3.43***	0.001	1.21	2.21	3.88***	3.14
	(0.71)	(1.33)	(2.64)	(1.72)	(1.22)	(1.87)
Investment	-0.02	1.16	2.23***	0.63	-1.72	-0.59
	(0.67)	(1.56)	(0.62)	(0.69)	(1.29)	(1.37)
Rule of law	0.25			-0.28		
	(0.25)			(0.28)		
Ethnicity	-0.03***			0.01		
	(0.01)			(0.01)		
Terms of trade	0.16**			0.91		
	(0.07)			(0.35)		
Landlocked economies	-0.49			-0.46		
	(0.89)			(0.35)		
Education	-0.19	0.79*	1.14***	2.51*	-0.21	0.31
	(2.66)	(0.42)	(0.29)	(1.23)	(0.24)	(0.52)
Civil liberties		-0.69**	-0.14		-0.23	-0.43**
		(0.29)	(0.21)		(0.19)	(0.14)
Fiscal decentralization	0.02	-0.02*	0.01	0.02*	-0.01	-0.31
	(0.01)	(0.01)	(0.37)	(0.01)	(0.02)	(0.27)
Fiscal decentralization x Resource share	**-0.48*** **	**-0.01** **	**-0.04** **	**0.01**	**-0.02***	**-0.04**
	(0.13)	**(0.005)**	**(0.02)**	**(1.31)**	**(0.01)**	**(0.04)**
Adjusted R-squared	0.8272	0.7128	0.6417	0.8421	0.3802	0.358
Observations	30	120	161	21	94	74
Number of economies included	30	48	29	21	27	14

Note: Standard errors are robust, clustered by country in Regressions 2, 3, 5, 6, and appear in parentheses for independent variables. Superscripts *, **, *** correspond to a 10, 5 and 1% level of significance, respectively. Regressions 1, 2, 3 (4, 5, 6) replicate Regression 1 of Table 2 and Regressions 1 and 3 of Table 3, respectively, using a restricted sample of developing (developed) economies; unlike the benchmark specifications, the interaction terms of the resource share measure with fractionalization and rule of law in the cross-sectional cases, and the measure of democracy together with its interaction with the price-based resource measure in the panel cases, are excluded, to avoid multicollinearity; this increases the sample in the panel cases, compared to that in the benchmark specifications. For description and sources of variables, as well as a list of economies included in each regression, see Appendix.

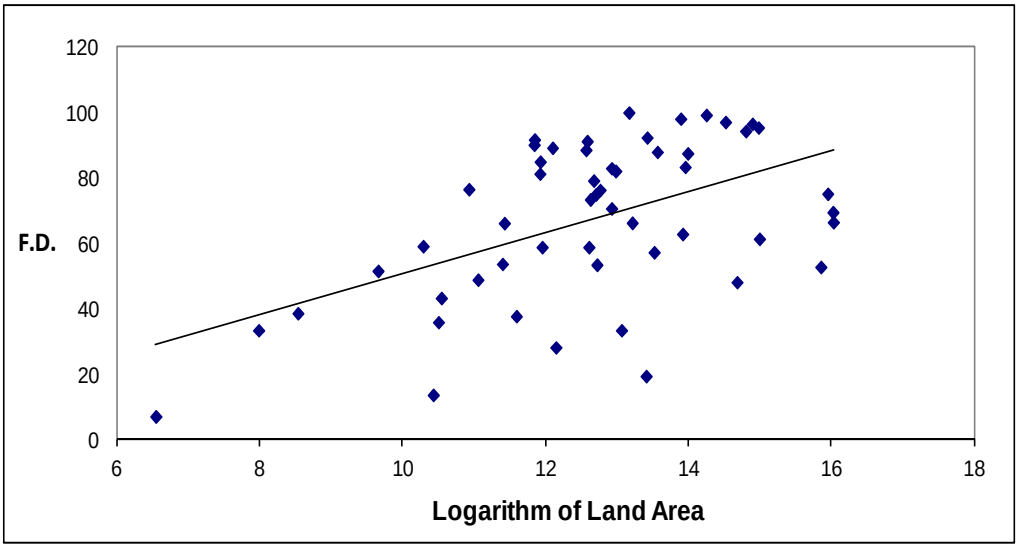

Figure 1. Fiscal decentralization and land area

Note: Figure presents the correlation between the logarithm of land area (source: World Bank Indicators) and the cross-sectional fiscal decentralization measure ('Vertical Imbalance'; source: World Bank Fiscal Decentralization Indicators).

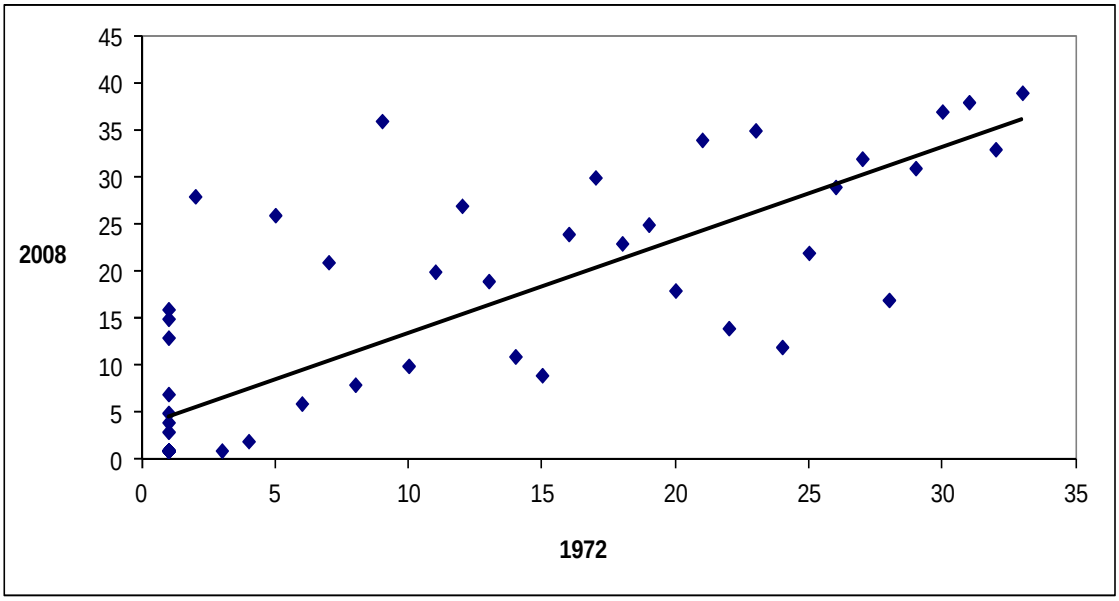

Figure 2. Relative rank of resource dependence: 1972 VS. 2008

Note: Figure presents the Spearman Correlation between the GDP share of mineral output in 1972 and that in 2008 (source: World Bank Indicators); ρ=0.81.