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 provide empirical evidence that shows that differences across countries in the degree of fiscal decentralization can contribute to this divergent outcome. The paper first employs Sachs and Warner's cross-sectional data and finds support for the novel hypothesis. Then, it extends the sample, and presents IV and panel data robustness tests that confirm the results. We also offer a theory of inter-regional tax competition that rationalizes the findings. Under fiscal decentralization, a more resource abundant region charges lower taxes that attract capital from other parts of the country. If labor is not fully mobile, the gains generated by a resource windfall may not compensate for the efficiency losses caused by the tax competition, generating a loss in the country's aggregate income. This effect is amplified by the existence of differences in agglomeration between natural-resource rich and natural-resource poor areas.

Keywords: Natural resources, economic growth, resource curse, fiscal decentralization, agglomeration economies, tax competition

JEL classification: O13, O18, O40, Q32

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1 Introduction

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. Further studies have provided additional empirical evidence of this phenomenon as well as various potential explanations for its occurrence. Among these explanations, the literature has emphasized political factors, corruption, underdeveloped legal and financial systems, Dutch disease mechanisms, or human-capital inhibiting institutions.[1]

This paper contributes to this strand of the literature, presenting a novel explanation: the level of fiscal decentralization.[2] Our main hypothesis is that fiscally decentralized economies are more vulnerable to the growth curse of natural resources than fiscally centralized ones. Figure 1 illustrates the potential of this variable to explain the curse. The figure plots the average annual real per capita GDP growth from 1970 to 1990 versus the share of mineral output in total GDP in 1970.[3] Panel A is based on a sample of 52 countries, and provides a strong indication for an occurrence of a resource curse. In panels B and C, the sample is split into two equal sub-samples according to the degree of fiscal decentralization (a measure to be discussed in-detail in the empirical part) in 1970; results indicate that a resource curse appears in countries with a relatively higher degree of fiscal decentralization (panel B), yet it completely disappears in countries with a relatively lower degree of fiscal decentralization (panel C).[4]

A more specific example is Venezuela *versus* Botswana. Both are heavily endowed

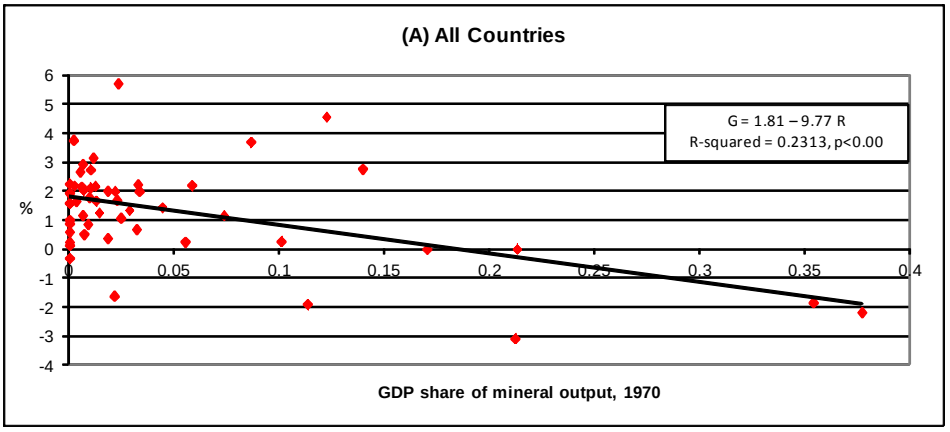
[1] For a detailed discussion see, for example, recent surveys by Frankel (2010) and van der Ploeg (2011). For a recent contribution, which finds evidence of the curse across US states, see Papyrakis and Gerlagh (2007).

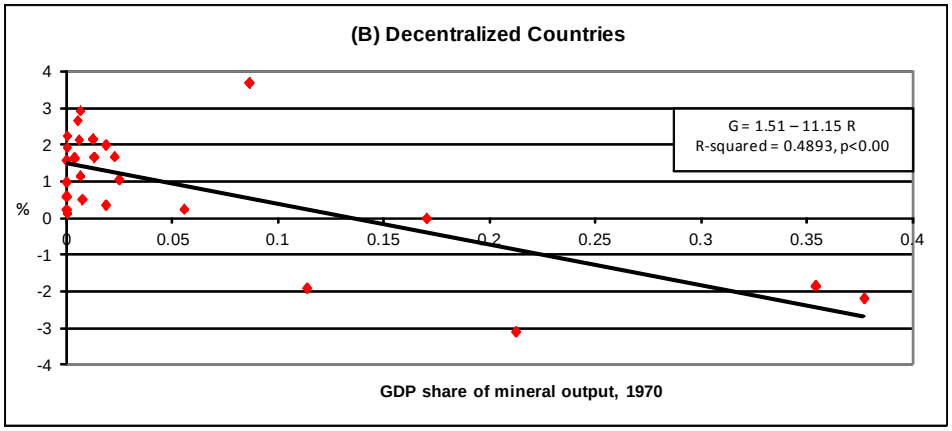
[2] Fiscal decentralization comprises the financial aspects of devolution to regional and local governments, and it covers two main interrelated issues. The first is the division of spending responsibilities and revenue sources between levels of government. The second is the amount of discretion given to regional and local governments to determine their expenditure and revenues. The definition adopted in this paper concerns both issues, yet emphasizes the latter.

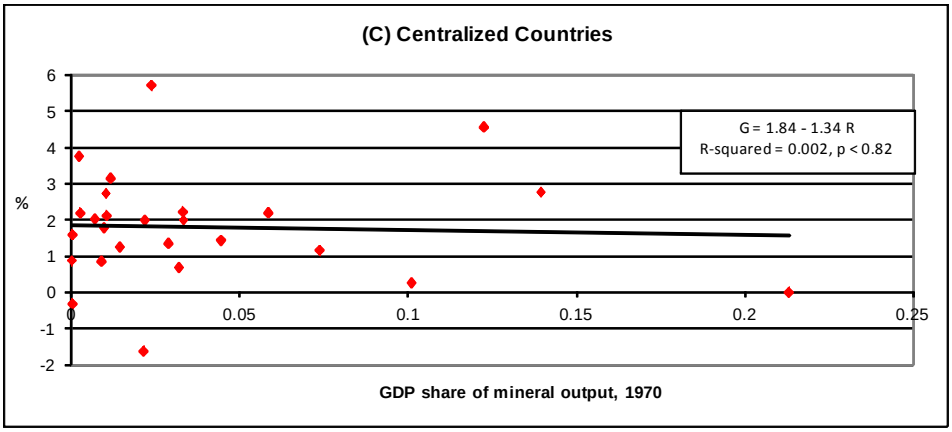
[3] Data on state-level primary output and GDP was retrieved from the US Bureau of Economic Analysis.

[4] The countries in panel B are: Austria, Bolivia, Brazil, Costa Rica, Ecuador, Finland, West Germany, Greece, Guatemala, Honduras, Iran, Kenya, Malaysia, Mexico, New Zealand, Nicaragua, Norway, Pakistan, Paraguay, Senegal, Sri Lanka, Sweden, Switzerland, Uruguay, Venezuela, and Zambia. The countries in panel C are: Australia, Belgium, Canada, Chile, Colombia, Denmark, Dominican Republic, France, India, Indonesia, Ireland, Israel, Italy, Korea Republic, Malawi, Netherlands, Peru, Philippines, Portugal, Spain, Sudan, Thailand, Trinidad and Tobago, Tunisia, United Kingdom, and United States.

Figure 1: Average Annual Growth in Real GDP per Capita (1970-1990) and Resource Abundance







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.[5] Some of the most fiscally centralized 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 the most fiscally decentralized nations include Ecuador, Ethiopia, Iran, Mexico, and Zambia; all of which performed rather poorly during the same time frames.

We present a model that postulates that this effect can be a consequence of tax competition and labor market rigidities, amplified by differences in the degree of agglomeration economies across a country's regions.[6] When labor is less mobile than capital, and inputs display diminishing marginal returns, capital reallocations can be welfare reducing. In particular, if a region that enjoys a resource windfall finds optimal to reduce taxes, it will attract capital from other parts of the country; but this can lead to a net loss in GDP for the country as a whole if the inefficiency effect offsets the increase in natural output.[7]

Agglomeration economies contribute to amplify the negative impact of the labor market inefficiency.[8] In addition, the model predicts that if resource-rich regions show lower agglomeration levels, the negative effect of a resource windfall on national income becomes larger. The last remark is important because as figure 2 illustrates for the

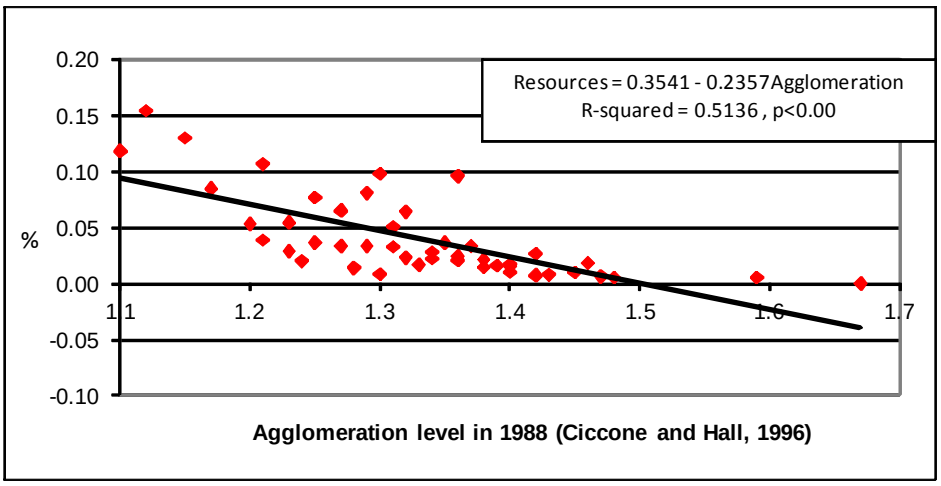
[5]For the purposes of the following examples, we consider a country to be resource abundant if it consistently has a share of mineral output in total GDP greater than 10 percent.

[6]Raveh (2011) studies a similar mechanism termed the *Alberta Effect*. It does not, however, consider agglomeration economies.

[7]Other models of tax competition include, for example, the seminal work of Zodrow and Mieszkowski (1986). In these models, the assumption of a relatively lower mobility of labor is not unusual, like in Mansoorian and Myers (1993). In terms of evidence, the degree of inter-regional labor mobility depends on the country being studied. Eichengreen (1993), for example, estimates an elasticity of inter-regional migration with respect to the ratio of local wages to the national average that is 25 times higher in the U.S. than in the U.K.; the difference with respect to Italy is even larger. As Decressin and Fatas (1995) argue, the result is that regional labor adjustments in Europe occur through a fall in the participation rate instead of through outwards migration. Evidence that supports that better-endowed areas compete more aggressively and drain capital from their poorly endowed counterparts is provided, for example, by Cai and Treisman (2005) for post-communist Russia.

[8]Introduced by Marshall (1920), 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.

Figure 2: GDP share of Primary Sector in 1988 Vs. Agglomeration in U.S. States



U.S. case, natural-resource rich regions actually enjoy lower agglomeration levels.[9]

The paper also presents empirical evidence for the main hypothesis. We start by testing it employing Sachs and Warner's (1997) data and methodology. We adopt the World Bank's Fiscal Decentralization Indicator, and add it together with its interaction with the resource share proxy to the regression; the time-period is 1970-1990 over a sample of 52 countries. Results confirm the main hypothesis and show that the growth curse of natural resource amplifies in fiscally decentralized economies. 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 75 countries over the period of 1972-2008 to test the same hypothesis through panel estimation; having the same controls as in the cross-sectional version together with 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.

[9]The agglomeration index comes from Ciccone and Hall (1996). The index, expressed as a number between one and two and measured for 1988, ranks U.S. states according to their agglomeration level. Appendix 1 presents similar state-level graphs for Australia, Brazil, Germany, Canada, Malaysia, Russia, India, and United Arab Emirates; all of them show similar negative relationships, implying that at regional levels resources indeed locate in non-agglomerated areas.

Other papers very close to our research are the following. Lane and Tornell (1996) suggest that the existence of powerful groups in conjunction with weak institutions provide an explanation for the natural resource curse. Mehlum *et al.* (2006) argue that the quality of institutions is what matters. Hodler (2004) provides a similar argument for the level of fractionalization. Andersen and Aslaksen (2008) point at constitutional arrangements as a viable determinant. Gylfason *et al.* (1999), and Gylfason (2001) suggest that natural riches may develop a false sense of security and harm human capital accumulation. Rodriquez and Sachs (1999) and Guillo and Perez-Sebastian (2012) show that the negative effect can be an artifact of the dynamics induced by resource windfalls in the economy.

The paper is structured as follows. Section 2 presents the model, and performs a calibration exercise. Section 3 provides the empirical evidence. Section 4 concludes.

2 The Model

In this section, we present a simple model that illustrates and evaluate mechanisms through which fiscal decentralization can interact with natural resources and affect income. More specifically, we explore two channels: lack of labor market mobility, and agglomeration economies.

2.1 Regions

Assume that there are N relatively small regions in a country. Out of them, we form two subsets. Within each subset, regions are identical in all aspects; and therefore, it is like if there were only two economies in the model, call them i and j. Areas i and j possess the same production and preference structure; they only differ in the endowment of natural riches and population density, characteristics that are taken as exogenous.

To formalize this last assumption, we can follow Ciccone and Hall (1996), and think that people have a preference for less agglomerated locations, and hence, are willing to accept lower wages there. We can also assume as in Mansoorian and Myers (1993) that individuals derive a non-pecuniary benefit from living in their home; that is, individuals have a preference for a particular region for cultural or nationalistic reasons. The lack of labor mobility is an extreme case scenario that we adopt for simplicity. However, as

will become clear later, the only thing that we need for the model results to go through is a sufficiently low degree of labor mobility.

2.2 Production

The production function is taken from Ciccone and Hall (1996). In each area, there exist a large number of profit-maximizing firms of mass one that rent capital (K) and labor (L) to produce output (Y). Focusing on area i, the production function is given by:

$$Y_i = a_i A \left[\left(\frac{L_i}{a_i} \right)^{\beta} \left(\frac{K_i}{a_i} \right)^{1-\beta} \right]^{\alpha} \left(\frac{Y_i}{a_i} \right)^{\frac{\lambda-1}{\lambda}}; \tag{1}$$

where the parameters $\alpha, \beta \in (0,1)$, and $\lambda > 1$; a_i is the land area of region i; and A is the Hicks neutral technology level of the nation. The variable L_i is exogenous, whereas K_i is endogenous. The elasticity α is less than one by the amount of the share of land on factor payments. The agglomeration externality is captured by the density measure output per hectare Y_i/a_i. The elasticity of output with respect to density is a constant and equal to $(\lambda - 1)/\lambda$.

From equation (1), once the externality is internalized, we obtain

$$\frac{Y_i}{a_i} = A^{\lambda} \left[\left(\frac{L_i}{a_i} \right)^{\beta} \left(\frac{K_i}{a_i} \right)^{1-\beta} \right]^{\alpha\lambda}. \tag{2}$$

The total output elasticity with respect to labor and capital depends on both the congestion parameter α and the agglomeration parameter λ. If $\alpha\lambda$ is greater than one, the agglomeration effect dominates congestion.

Unlike labor, capital perfectly moves across regions, so that its rental price (r) is equalized. We can use the first order condition of the firm's problem to get the following demand function for capital:

$$\frac{K_i}{a_i} = \frac{\alpha(1-\beta)}{r_t + \tau_i} \frac{Y_i}{a_i}; \tag{3}$$

where τ_i is the tax rate on capital in region i. And then

$$\frac{Y_i}{a_i} = \left[\frac{\alpha(1-\beta)}{r_t + \tau_i} \right]^{\frac{\alpha\lambda(1-\beta)}{1-\alpha\lambda(1-\beta)}} A^{\frac{\lambda}{1-(1-\beta)\alpha\lambda}} \left(\frac{L_i}{a_i} \right)^{\frac{\alpha\lambda\beta}{1-\alpha\lambda(1-\beta)}}. \tag{4}$$

2.3 Regional Governments

It is straightforward that, in our setup, a benevolent policymaker that chooses tax rates in a fiscally centralized nation will always generate gains in output as a consequence

of the discovery of natural resources. Given this, our analysis focus exclusively on the fiscal decentralization case.

The public sector taxes capital and uses the region's natural input endowment to provide a public consumption good to the economy. Its problem reduces to choosing the tax rate (τ_i) that maximizes the current utility level of a representative individual.

More specifically, the government in region i solves:

$$\max_{\tau_i} \left\{ U_i = \ln \frac{C_i}{L_i} + \gamma \ln \frac{G_i}{L_i} \right\}, \quad \gamma > 0, \tag{5}$$

subject to

$$Y_i + Z_i = C_i + G_i, \tag{6}$$

$$G_i = T_i K_i + Z_i; \tag{7}$$

where C_i and G_i are the amounts of the private and the public consumption goods, respectively; and Z_i is the value of natural riches net of extraction costs.

There are a number of implicit assumptions in expressions (6) and (7). In particular, we suppose that both consumption goods are produced with the same technology. Also, natural riches can be converted into the public good at zero cost.

The government takes as given the interest rate, the firms' demand function (3), and internalizes the external effect of agglomeration. As a consequence, output is given by equation (4) from the government's viewpoint. With those assumptions, the first order condition to the above problem obtains

$$\gamma \frac{C_i}{G_i} = \left[1 + \frac{\lambda}{1 - \alpha\lambda(1-\beta)} \right]. \tag{8}$$

Equation (8) is a Ramsey-Keynes condition, the marginal rate of substitution (LHS) is equalized to the marginal rate of transformation (RHS). It says that the optimal relative allocation to the private good increases with the size of the agglomeration externality. The reason is that the amount of private good to which you need to renounce for each additional unit of the public good increases with λ. It also implies that the private-to-public good ratio decreases with the weight of the public good in the utility function.

Substituting conditions (6) and (7) into (8), we can write the optimal capital tax

rate as

$$\begin{aligned} \tau_i &= 0 \quad \text{if } Z_i \geqslant \frac{rK_i}{\alpha(1-\beta)\phi} \\ \tau_i &= \frac{r-\alpha(1-\beta)\phi\frac{Z_i}{K_i}}{\alpha(1-\beta)(1+\phi)-1} \quad \text{otherwise,} \end{aligned} \tag{9}$$

with

$$\phi = \frac{1}{\gamma}\left[1+\frac{\lambda}{1-\alpha\lambda(1-\beta)}\right]. \tag{10}$$

Expression (9) defines τ_i as an implicit solution because K_i is actually a function of τ_i. In order to know how the tax rate reacts to changes in exogenous variables and parameters, we can use expressions (3), (4) and (9) which imply that

$$\frac{(r+\tau_i)^{\alpha\lambda(1-\beta)}}{\left[1-\frac{\alpha(1-\beta)(1+\phi)}{1+r/\tau_i}\right]^{1-\alpha\lambda(1-\beta)}} = \frac{\alpha(1-\beta)^{\alpha\lambda(1-\beta)}A^{\lambda}\left(\frac{L_i}{a_i}\right)^{\alpha\lambda\beta}}{(\phi Z_i)^{1-\alpha\lambda(1-\beta)}}. \tag{11}$$

This equality solves implicitly τ_i as a function of r and region-specific characteristics.

The LHS of expression (11) equals $r^{\alpha\lambda(1-\beta)}$ when τ_i equals *zero*, and rises with τ_i if $\alpha\lambda(1-\beta) < 1$ which is the case suggested by the calibration below. Hence, when the last inequality holds, the optimal value of τ_i is unique and decreases with the endowment Z_i. 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 zero. In particular, expression (11) says that

$$Z_i \geq \left[\frac{\alpha(1-\beta)^{\alpha\lambda(1-\beta)}A^{\lambda}\left(\frac{L_i}{a_i}\right)^{\alpha\lambda\beta}}{r^{\alpha\lambda(1-\beta)}\phi^{1-\alpha\lambda(1-\beta)}}\right]^{\frac{1}{1-\alpha\lambda(1-\beta)}} \quad \Longrightarrow \quad \tau_i = 0. \tag{12}$$

If, on the other hand, Z_i is *zero* then the tax rate reaches its highest value ($\tau_i^{\max}$). When there is no natural endowment, the LHS in equality (11) needs to go to infinity; that is, $1 + r/\tau_i = \alpha(1-\beta)(1+\phi)$, meaning that

$$Z_i = 0 \quad \Longrightarrow \quad \tau_i = \tau_i^{\max} = \frac{r}{\alpha(1-\beta)(1+\phi)-1}. \tag{13}$$

In the absence of natural endowment, the optimal tax depends exclusively on the interest rate.

In expression (11), the effects of the agglomeration externality parameter λ and the interest rate are ambiguous. From equality (9), we deduce that their direct impact on

τ_i is clear: in (9), the tax rate decreases with the agglomeration externality and rises with the interest rate. However, their general equilibrium effects that work through the physical capital stock K_i affect τ_i in the opposite direction. For the parameter values calibrated below, the direct effects dominate.

2.4 Equilibrium

Governments choose taxes according to (9). The interest rate r then moves until the capital market clears, that is, until

$$K_i + K_j = K; \tag{14}$$

where K is the nation's capital stock, which is taken as given. At that point, the whole economy is in equilibrium.

The stocks K_i and K_j need to be such that the returns to capital are equalized across economies. This non-arbitrage condition is the following:

$$r = \alpha(1-\beta)\frac{Y_i}{K_i} - \tau_i = \alpha(1-\beta)\frac{Y_j}{K_j} - \tau_j. \tag{15}$$

Employing production function (2) and clearing condition (14), expression (15) can be rewritten as

$$\left(\frac{L_j}{a_j}\right)^{\beta\alpha\lambda}\left(\frac{K-K_i}{a_j}\right)^{(1-\beta)\alpha\lambda-1} - \left(\frac{L_i}{a_i}\right)^{\beta\alpha\lambda}\left(\frac{K_i}{a_i}\right)^{(1-\beta)\alpha\lambda-1} = \frac{\tau_j - \tau_i}{\alpha(1-\beta)A^{\lambda}}. \tag{16}$$

Expressions (15) and (16) allow obtaining K_i as a function of the interest rate, the country's aggregate capital stock and regions' characteristics. We can easily deduce that, as the tax gap increases, there is a reallocation of capital from the economy that imposes higher taxes to the one with a lower tax rate.

An interesting case is the non-natural-endowment one. If $Z_i = Z_j = 0$, tax rates are equalized across regions, and then the optimal capital stock is given by the following closed-form solution obtained using expression (16):

$$K_i = \frac{K}{1 + \left[\left(\frac{L_j}{L_i}\right)^{\beta\alpha\lambda}\left(\frac{a_i}{a_j}\right)^{\alpha\lambda-1}\right]^{\frac{1}{1-(1-\beta)\alpha\lambda}}}. \tag{17}$$

Economy's i capital stock depends on is relative labor allocation and relative land surface. Because labor and capital are complementary in production, a relatively larger

labor endowment increases the capital stock. The effect of the relative land area, on the other hand, depends on whether the agglomeration externality effect dominates congestion. If it does ($\alpha\lambda > 1$), more land reduces the optimal capital stock because, *ceteris paribus*, there is less population density. The opposite is true if congestion dominates ($\alpha\lambda < 1$).

In absence of natural riches, it is also possible to derived a closed-form expression for the equilibrium interest rate. The production function (1), the expression for the interest rate in (15), and the solutions for the optimal tax rate (13), and the capital stock (17), deliver

$$r = \left[\alpha(1-\beta) - \frac{1}{1+\phi}\right] A^{\lambda} \left[\frac{\left(\frac{L_i^{\beta\alpha\lambda}}{a_i^{\alpha\lambda-1}}\right)^{\frac{1}{1-(1-\beta)\alpha\lambda}} + \left(\frac{L_j^{\beta\alpha\lambda}}{a_j^{\alpha\lambda-1}}\right)^{\frac{1}{1-(1-\beta)\alpha\lambda}}}{K}\right]^{1-(1-\beta)\alpha\lambda}.$$

Density increases the equilibrium interest rate when the agglomeration effect dominates, because it causes a positive total factor productivity effect in the economy.

It is not possible to find out analytically the exact impact of changes in the natural endowment on the country's income level. Regions that enjoy a natural-resource discovery will reduce taxes, and attract capital; but whether this brings a gain or a loss for the nation is unclear. As a consequence, we carry out a quantitative exercise to dig deeper on this issue. We calibrate first the parameters, and then present the model predictions.

2.5 Calibration

We calibrate the model to the U.S. economy. Given that the share of natural-resource rents in U.S. GDP is only of about 0.86 percent – this was the value for 2009 according to World Bank (2011a) – we use the equilibrium in the non-natural-endowment case to perform this task; this considerably simplifies matters.

Parente and Prescott (2000) report that a share of capital of 0.25, a land share of 0.05, and a labor share of 0.70 are consistent with the U.S. growth experience. We then assign values of 0.95 and 0.73 to α and β, respectively. To pick a number for the agglomeration externality, we recall results in Ciccone and Hall (1996). These authors estimate that $\alpha\lambda = 1.04$; that is, doubling employment density in a county results in a 4 percent increase in total factor productivity. This gives a value of 1.1 to λ.

The productivity parameter A in the production function is normalized to 1. Densities in the resource-abundant and resource-scarce regions are proxied using Ciccone and Hall's (1996) agglomeration index. Their measure of density is simply the intensity of labor, human, and physical capital relative to physical space. Density is high when there is a large amount of labor and capital per square foot. Their estimated range for the 50 contiguous U.S. states goes from the 1.1 of Montana, a resource-rich state, to the 1.67 estimated in the District of Columbia, a natural-resource poor area. Alaska, the less agglomerated and one of most natural resource rich states, is then not included in their analysis. Nevertheless, we choose $L_i/a_i = 1.1$ and $L_j/a_j = 1.67$.

The value of the aggregate capital stock K is, in turn, picked so that the capital-output ratio at steady state for the whole economy equals 3. Finally, the parameter γ, that is, the weight of public goods in the utility function is calibrated to reproduce the share of the U.S. government in GDP, used as a proxy for the ratio $G/(C+G)$ in the model. In the last 30 years, U.S. government spending as a fraction of GDP has been between about 20 and 30 percent, depending of how you measure it. We choose an intermediate value of 25 percent; which implies that γ equals 0.84.

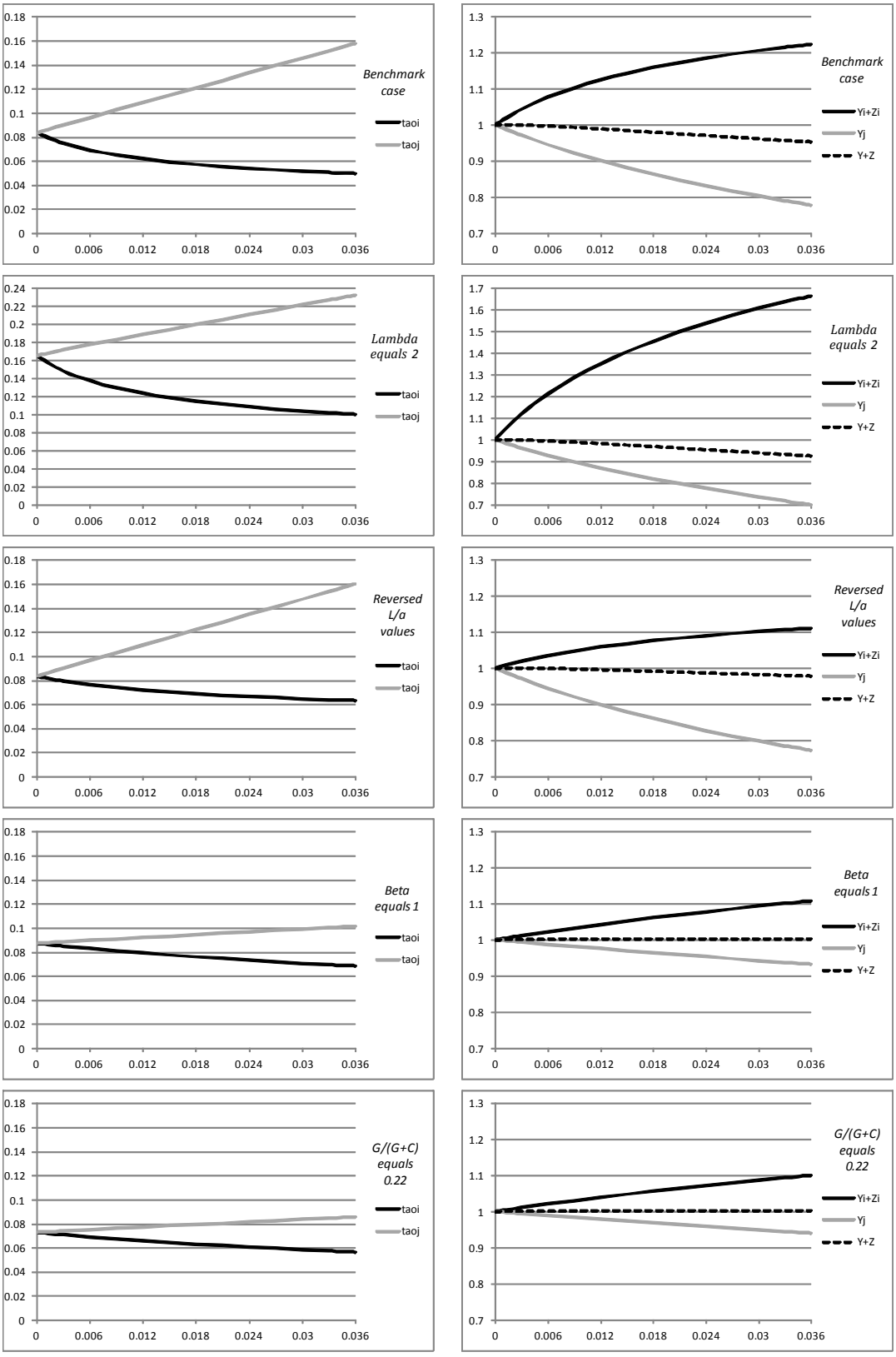
2.6 Results

We now suppose that there is a natural resource windfall in region i, and compute the equilibrium values of some key variables depending on the size of this shock. We consider a maximum value for Z_i of 0.036, which represents a 0.86 percent of the country's GDP in the $Z = 0$ scenario. This maximum is a relatively big perturbation that amounts to the whole contribution in 2009 of natural resources to U.S. GDP.

Figure 3 presents results for five different parameterizations. The first row gives the benchmark case described in the calibration section. The second row is obtained when the agglomeration externality parameter λ rises to 2. In this case, the value of γ is also modified to maintain the share of the public good invariant, and then abstract from demand-side effects. In the third row, the densities of the two regions are interchanged, L_i/a_i equals 1.67 and L_j/a_j equals 1.1. In the fourth row, the labor share β falls to 0.7, and is equivalent to making the lack of labor mobility less important. Finally, row 5 shows results when the share of the public good in total income $G/(C+G)$ becomes 22%, lower than the benchmark.

The two columns in figure 3 provide results for tax rates and income levels (vertical

Figure 3: Tax Rates (left) and Relative Output Levels (Right) Predicted by Model



axes) as a function of the natural endowment variable Z_i (horizontal axis). Recall that, by assumption, region j does not own natural riches ($Z_j = 0$). More specifically, the LHS column gives results for the tax rates τ_i (taoi, black line) and τ_j (taoj, grey line). The RHS column, in turn, shows the predicted values of income in region j (Y_j, solid grey line), and income plus natural resource endowment in region i ($Y_i + Z_i$, black line) and in the whole country ($Y + Z_i = Y_i + Y_j + Z_i$, dashed black line).

The qualitative effects on tax rates and regional income are the same across rows. In particular, when $Z_i = Z_j = 0$, tax rates in both regions coincide. As the natural endowment rises in i, this region reduces pressure on taxpayers, attacking capital. Region j then responds in the opposite direction, rising its capital tax rate to be able to finance public goods, thus amplifying the capital outflow. Income in region j falls due to this, but increases in region i because of both the capital inflow and the natural-resource discovery.

The difference across scenarios is quantitative as well as whether economy-wide income falls or not. Look at the dashed line in the RHS panels. In the benchmark economy (first row), the country's income falls as Z_i increases. The reason is the labor's lack of mobility. This rigidity makes capital more sensitive to shocks. As capital moves away from the resource poor region, the economy gets as well away from the fully-flexible optimal capital-labor ratios – recall that diminishing marginal returns makes optimal to equalize capital-labor ratios across regions. The resource windfall moves the economy further away from that outcome, increasing the degree of inefficiency, and reducing country-wide output.

Agglomeration economies amplify the effect of input reallocations on output production. As a result, a larger agglomeration externality contributes to make the decrease in income larger as Z_i rises (see row two in figure 3). If labor were fully mobile, the agglomeration externality would cause all labor and capital to move to region i as soon as new natural riches are discovered, increasing the nation's welfare level. A similar impact would be obtained if labor had a sufficiently large degree of mobility. However, when labor is sufficiently immobile, and as a consequence, the externality is *de facto* not able to induce increasing returns, only a fraction of capital is reallocated, and then the externality serves to generate a stronger effect on tax rates, and as a consequence, on total income. Mathematically, the effect on the tax rate can be seen in expression (9), the impact of a larger Z_i on τ_i rises with ϕ, and ϕ increases with λ.

Row three presents results if natural-resource rich region are more densely populated that resource-poor areas; the opposite to what we observe in reality. Now, the negative effect on total income is weaker. The reason is again given by expression (9): as K_i rises, an increase in Z_i induces a smaller variation in the tax rate τ_i; as a result, capital flows less and the effects on income become weaker. This is precisely the effect of a higher density in the region that enjoys the increase in Z, because the higher population density increases its initial capital stock.

Rows four and five in figure 3 represent two cases in which income levels in the country do not fall with natural riches. The first one (fourth row) is when the labor share is sufficiently low. This makes labor and, therefore, labor immobility less important. In the case of $\beta = 0.7$, the effect of a change in Z on economy-wide output is negligible. We find the same effect in row five, which gives results when the share of pubic goods in total consumption falls to 22%. In both cases, the ultimate reason for the lack of a negative impact on total income is that taxes and, as a consequence, capital do not react as much in the resource-poor region to changes in Z.

In sum, theory shows that a natural-resource windfall can harm country's GDP due to fiscal decentralization. This is the case if regions fix taxes to try to attack capital, and there is sufficiently low degree of labor mobility. The effect is amplified by agglomeration economies and a larger density in resource-rich areas. A larger share of public-goods consumption in GDP also contributes to strengthen the negative impact.

3 Empirical Evidence

This section provides empirical support for the main hypothesis of the paper; namely, that fiscally decentralized economies are more vulnerable to the growth curse of natural resources. It also tries to test the amplification mechanisms to which theory has pointed out. Given that the fundamental findings on the curse are rooted in the seminal work of Sachs and Warner (1997), subsection 3.1 tests our hypothesis using their database and cross-sectional methodology. Later, subsection 3.2 departs from Sachs and Warner and undertakes panel estimations using an extended sample of countries and years covered. Finally, in subsection 3.3, we undertake various robustness checks.

A detailed description of all variables and their sources are given in appendix 2. Appendix 3 provides the nations included in each of the samples. Appendix 4 presents descriptive statistics for all variables employ in the paper.

3.1 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 52 countries that covers the period of 1970-1990.

We test the following model:

$$\hat{y}_i = \alpha_0 + \alpha_1 X_i + \varepsilon_i; \tag{18}$$

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; and ε_i is the disturbance.

We start using the GDP share of mineral output in 1970 as the resource share proxy. 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*.[10] 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*). This indicator is a number between 0 and 100; the closer it is to 100 the more independent sub-national governments are in terms of relying on their own revenue sources for their expenditures, implying that the country as a whole is more fiscally decentralized.[11]

Results appear in table 1. Regression 1 replicates Sachs and Warner's (1997) analysis with the addition of Mehlum *et al.*'s (2006) interaction term of institutional

[10] 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.

[11] Given that Sachs and Warner's (1997) 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 52 countries.

quality and resources, as well as Hodler's (2004) interaction term of fractionalization and resources. Results on convergence, resource abundance, openness, investment, institutional quality, ethnicity, terms of trade, education, and landlocked economies, replicate those presented in previous studies in terms of signs and occasionally significance; however, previous results on the interaction terms are less robust to our sample.[12]

In regression 2 we add the fiscal decentralization measure; results do not change. In regression 3 we add the interaction term between the resource share proxy and fiscal decentralization; its coefficient is negative and significant which confirms our main hypothesis by showing that the negative growth effect of resources is transmitted through the decentralization channel. In addition, despite being non-significant, the coefficient on the resource share proxy becomes positive. *[Cannot follow the sentence:] Results do not change qualitatively even if each of the variables in regression 3 are added to the regression separately, or in different order so that, for instance, the level of fiscal decentralization and its interaction term with resource share are added first rather than last.* Results do not change either if other resource measures used by Sachs and Warner, like the share of primary exports in total exports or out of total GDP, are adopted.[13]

To further strengthen our claim, let us now try to test the main mechanisms that drive the result that fiscally decentralized nations do not benefit from resource windfalls: the lack of labor mobility, and agglomeration differences across regions. For this, we construct a measure that encompasses both of them. In particular, we divide each country's total non-agglomerated area by its total area (both in square kilometers).[14] Because lack of labor mobility should imply a lower degree of agglomeration in the nation, the constructed index is affected by labor mobility and by differences in agglomeration.[15] A higher value is interpreted as an indication of lower labor mobility

[12] Even when they enter the model separately, without including the fiscal decentralization index, Mehlum *et al.*'s (2006) and Hodler's (2004) results do not hold (results available from the authors). The reason can be our limited sample, or the use of an output-based resource measure – as opposed to an export-based one used in their studies.

[13] We present results using the GDP share of mineral output because it provides a larger sample. Nonetheless, we explicitly show with panel data that results hold using an exports-based measure in the following subsection.

[14] The calculation of non-agglomerated areas follows the definition of non-agglomeration as given by the UN (on per-country basis).

[15] Puga (1999), for example, argues that labor mobility and agglomeration levels are positively correlated.

and agglomeration differences.[16]

The model prediction is that decentralized economies with a higher index are more vulnerable to the growth curse. We multiply the initially used fiscal decentralization measure and the above index, and refer to the updated index as *potential vulnerability*. Results are presented in regression 5, and confirm those presented in regression 3. This provides some validation to the underlying mechanism, implying that resource endowments hurt decentralized economies through the labor mobility and non-agglomeration channels.

One key concern in the resource curse literature is the potential endogeneity of Sachs and Warner's resource abundance measure (Van der Ploeg 2011). To address this issue in the 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 (specifically, the one used in the regressions of table 1), because it captures an economy's amount of proven natural reserves rather than its capacity to produce or export them.

In table 2 we reproduce the regressions presented in table 1, but using the GDP share of natural capital in 2000 as the resource share proxy.[17] As we can see in regression 7, initial results are consistent with Brunnschweiler and Bulte's (2008), Mehlum *et al.*'s (2006) and Holder's (2004), in terms of sign and significance. The addition of fiscal decentralization in regression 8 does not alter the outcome. The key result is presented in regression 9, where the interaction term of fiscal decentralization and resource share is added; we observe that despite using this relatively more exogenous resource share measure, the coefficient on the interaction term remains negative and significant, further confirming the main hypothesis. Results hold as well in regression 12, when we adopt the previously discussed *potential vulnerability* measure.

The model implies that, in addition to agglomeration levels, the size of regional governments play a role as well: larger regional governments can potentially amplify

[16] Importantly, the sample shows a weak relationship between this agglomeration measure and economic growth ($\rho = 0.00$, $p < 0.876$), so that it is not necessarily the case that developed countries present a lower value, which mitigates endogeneity related concerns.

[17] The World Bank also provides this measure for 1994 and 2005. Results do not change qualitatively in case either of them is used. The 2000 one is preferred because it provides the largest sample size of 51 countries.

the negative growth effect of natural resources. We test this prediction, by reproducing regression 12 under a different potential vulnerability measure. Thus, we construct a new variable labeled *modified potential vulnerability*, in which we multiply the level of fiscal decentralization (vertical imbalance) by the GDP share of general government final consumption expenditure in 1972. Here we are assuming that larger shares at the national level imply larger shares at the regional level. Regression 14 presents the results using the new proxy for the interaction variable. The interaction term does not only remain strongly significant, but also increases in magnitude. This strengthens the empirical link to the model, and gives some indication that the size of regional governments may indeed be relevant for our hypothesis.

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.[18] 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. Land area is based on geographic factors, and therefore, should be exogenous to growth.

To implement this we follow Wooldridge's (2002) approach to instrument 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 and use it in the second-stage of TSLS estimation. Results for the mineral-output-based resource share are presented in regressions 4 and 6 of table 1, and those for the natural capital based resource share are presented in regressions 10 and 13 of table 2.

First stage results confirm the validity of the instrument, through the F-statistic. Second stage estimation, in turn, shows that the key result remains: the coefficient on the interaction term of decentralization and resources is negative and significant in all cases.

[18] See Arzaghi and Henderson (2005), Oates (1972), Panizza (1999), and Treisman (2006).

3.2 Panel Data Analyses

The previous cross-sectional analyses, a la Sacks and Wagner, raise several concerns. First, the time period covered is limited (1970-1990). Second, the sample covers merely 52 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 74 countries; the maximum number provided by the World Bank's Fiscal Decentralization Indicators. The use of this panel allows addressing the above concerns.

We estimate the following model:

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

The variables $\hat{y}_{it}$, X_{it} and ε_{it} are the same ones as in regression (18), for country i at date t; the only difference is that we now do not include ethnicity and terms of trade as controls due to lack of data. The dummies φ_i and η_t represent country and time fixed effects that control for omitted variable bias. All variables are measured in the initial year of the corresponding time interval to mitigate endogeneity concerns; and are expressed in deviations from period means so that time effects are cancelled. *[Isn't this inconsistent with the time dummies/fixed effects?]*

Not all the explanatory variables employed in the panel estimation are measured in the same way as in the cross-section analysis, due to data limitations. Nevertheless, all our measures are standard in the economic growth literature (see appendix 2). We can not use the World Bank's natural stock numbers to measure the resource share, due again to data limitations. Instead, we follow Arezki and Van der Ploeg (2011) that assumes that natural capital is equal to the discounted stream of resource rents, and employ the GDP share of *[discounted?]* primary rents.[19]

Results appear in regressions 15 to 17 of table 3. In all them, results on convergence, openness, investment, institutional quality, education, and decentralization are similar in sign, and occasionally in significance to previous findings with cross-section estimation. Regressions 15 and 16 show a non-significant coefficient on resources when fixed effects are included, something already found by Manzano and Rigobon (2001).

[19] Arezki and Van der Ploeg (2011) suppose that demand is isoelastic and marginal extraction costs are zero. The Hotelling rule then implies that resource prices grow at the market interest rate, and natural capital is equal to the discounted stream of resource rents.

The interaction of resources with institutional quality also appears as non-significant. Interestingly, regression 17 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.

To address the concern over the potential endogeneity of the fiscal decentralization measure, we once again employ an IV approach. In the fixed-effects framework, we can no longer adopt a time-fixed instrument as land area; we need to consider a time-varying one. We then consider, as instrument, the average level of democracy in the 10 years preceding the corresponding time interval. On the one hand, the democracy level is considered a key determinant of fiscal decentralization; on the other, the lagged average makes it relatively exogenous to growth in the following period.

The democracy measure is taken from the commonly used Polity IV Project. Estimation of the endogenous interaction term is done using the procedure discussed above. Results appear in regression 18 of table 3. First stage results validate the instrument through the F-statistic. The second stage shows that the main result holds, as the interaction term of interest remains negative and significant.

3.3 Additional Robustness Checks

Regressions 19 to 23 in table 3, and table 4 contain further robustness tests of our main hypothesis. We begin by considering with the panel data an exports-based resource measure widely used in the resource curse literature: Sachs and Warner's GDP share of primary exports. Regressions 19 to 22 reproduce regressions 15 to 18 but employing the exports-based measure. Despite the reduced country coverage (70 compared to the previous 74), results on all variables, including our interaction term, are similar in sign and significance. In addition, the inclusion of the interaction term reduces the effect of resources on growth by an order of magnitude as it did before.

Nonetheless, as we mentioned above, this measure has been criticized for its potential endogeneity to growth. We therefore take next an IV approach and instrument the exports-based proxy with the GDP share of *discounted* mineral rents in $t-1$. We view this measure as a suitable IV, because it is highly correlated with the exports-based proxy ($\rho = 0.74$), and relatively exogenous to growth. Its exogeneity can be justified as follows: first, *discounted* primary rents is a stock that under reasonable assumptions can provide an indication for proven reserves or stocks of natural mineral capital, thus

making it less correlated with 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 terms is carried out using the previously described procedure. Results are reported in regression 23 of table 3. In this regression, both fiscal decentralization and resource share are instrumented. Again, first stage results validate both instruments, and the second stage confirms 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 42 developing and developed countries over the years 1965-2000. The Kearney 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. Regressions 24 through 27 in table 4 replicate regressions 15 to18 using the Kearney measure and a panel that covers the period of 1965-2000 with 5-year intervals. The new regressions show similar results to previous estimations, the only difference is a relatively higher magnitude for the interaction term. Our main result, therefore, seems to be robust to different decentralization measures.

One could argue that democracy is not a strong instrument for fiscal decentralization because is correlated with income. Above, we dealt with this employing lag values of the democracy variable that should suffer less from this criticism. Nevertheless, we now test the cross-sectional version of our panel to be able to employ the logarithm of land area as an instrument for fiscal decentralization, rather than democracy. More specifically, we extend the previously used Sachs and Warner 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 11 gives the outcome of this exercise for the period of 1970-2008. Our main finding is once again confirmed. Although not presented, similar results arise when the time interval that goes from 1990 to 2008 is used instead.

An additional concern might be that we test the hypothesis using Barro-type growth regressions; we could have worked with level regressions instead, in the spirit of Hall and Jones (1999) and Acemoglu *et al.* (2001). However, following the reasoning of Mehlum *et al.* (2006), undertaking level regressions requires using different resource share measures, since our measures are normalized by GDP. Notice that, *ceteris paribus*, countries with high GDP may appear as resource scarce, while countries with low GDP may appear resource abundant. Controlling for initial income corrects for that; yet, doing so while having income at the end of the period as the dependent variable is clearly equivalent to undertaking a growth regression.

4 Conclusion

The question of why resource endowments lead to divergent outcomes continues to attract much interest among economists. This paper has presented a novel answer to that question. The hypothesis is that countries with a high degree of fiscal decentralization are more vulnerable to the natural resource curse.

We have presented a theory that suggests a simple mechanism for the occurrence of a natural resource curse in fiscally decentralized countries. In these economies, natural riches give the region in which they are located an advantage in the inter-regional competition over capital. This means that capital flows from natural-resource-poor areas to regions that experience natural-resource windfalls. We have shown that if labor mobility is constrained, total output in the country can drop as a result of such a movement of capital; put differently, the loss of output in resource-scarce regions outweighs the sum of the increase in output and natural resource rents in resource-abundant areas. We have also found that the negative effect is amplified because natural resources tend to be located in non-agglomerated and sparsely populated areas.

The main hypothesis has been empirically tested and confirmed. First, we have 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.

These insights carry certain policy implications for resource rich economies, especially in terms of emphasizing the importance of labor mobility and proper management

of resources in fiscally decentralized nations. Nonetheless, results may be sensitive to the specific periods and countries investigated. Future research should further test our results, and analyzed in more detailed the mechanisms that drive them.

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TABLE 1. *Cross-country growth regressions, using the GDP share of mineral output* as the resource share proxy [Cross-section, Sachs and Warner (1997) database, period: 1970-1990]

	Initial results	Decentralization measure is *'Vertical Imbalance'*			Decentralization measure is *'Potential Vulnerability'*	
Dependent variable: Average annual growth in real per capita GDP, 1970-1990	(1) (OLS)	(2) (OLS)	(3) (OLS)	(4) (TSLS)	(5) (OLS)	(6) (TSLS)
Resource Share (GDP share of mineral output)	-15.68* (8.86)	-15.88 (9.75)	2.68 (14.47)	17.54 (17.13)	1.87 (14.81)	11.12 (16.47)
Logarithm of Initial Income	-1.63*** (0.38)	-1.63*** (0.39)	-1.72*** (0.38)	-1.69*** (0.35)	-1.69*** (0.38)	-1.71*** (0.36)
Openness	2.2*** (0.46)	2.18*** (0.47)	2.26*** (0.47)	2.28*** (0.47)	2.27*** (0.47)	2.24*** (0.47)
Investment	0.59 (0.37)	0.62 (0.55)	0.84 (0.51)	0.16 (0.41)	0.72 (0.49)	0.24 (0.41)
Institutional quality	0.08 (0.37)	0.08 (0.22)	0.14 (0.23)	0.23 (0.22)	0.15 (0.23)	0.22 (0.22)
Ethnicity	-0.01** (0.006)	-0.01** (0.006)	-0.01* (0.006)	-0.01** (0.006)	-0.01* (0.006)	-0.01** (0.006)
Terms of trade	0.21* (0.11)	0.22* (0.11)	0.15 (0.12)	0.13 (0.12)	0.15 (0.12)	0.14 (0.12)
Education	2.06* (1.2)	2.08* (1.2)	2.27* (1.16)	2.18* (1.14)	2.14* (1.18)	2.17* (1.16)
Landlocked economies	-0.49 (0.44)	-0.5 (0.46)	-0.48 (0.36)	-0.28 (0.36)	-0.43 (0.38)	-0.32 (0.38)
Ethnicity x Resource share	0.02 (0.05)	0.02 (0.05)	0.006 (0.05)	-0.009 (0.04)	0.009 (0.05)	0.006 (0.04)
Institutional quality x Resource share	3.34 (2.43)	3.39 (2.66)	1.49 (2.91)	-0.64 (3.01)	1.33 (2.94)	-0.03 (3.03)
Decentralization		0.0008 (0.01)	0.01 (0.01)	0.01 (0.01)	0.009 (0.01)	0.009 (0.01)
Decentralization x Resource share			**-0.14** (0.06)**	**-0.25*** (0.09)**	**-0.13** (0.06)**	**-0.2** (0.08)**
Adjusted R-squared	0.7155	0.7156	0.739	0.746	0.7366	0.7405
Observations	52	52	52	52	52	52

FIRST STAGE RESULTS

Dependent variable: Decentralization	Regression (4)	Regression (6)
Logarithm of land area	4.52*** (1.31)	5.43*** (1.16)
Adjusted R-squared	0.693	0.7364
Observations	52	52
F-Statistic	12.46	16.73

Standard errors are robust and appear in parentheses for independent variables. Superscripts correspond to a 10, 5 and 1% level of significance. In the first stage results only the coefficient on the relevant instrument (land area) is reported, yet regressions include all variables reported in the second stage results. All regressions include an intercept. For description and source of variables as well as list of economies included in each regression see Appendices 2 and 3. For descriptive statistics see Appendix 4.

TABLE 2. *Cross-country growth regressions, using the GDP share of natural capital* as the resource share proxy [Cross-section, Sachs and Warner (1997) database, period: 1970-1990, unless specified otherwise]

	Initial results	Decentralization measure is *'Vertical Imbalance'*				Decentralization measure is *'Potential Vulnerability'*		Decentralization measure is the *'Modified Potential Vulnerability'*
Dependent variable: Average annual growth in real per capita GDP, 1970-1990	(7) (OLS)	(8) (OLS)	(9) (OLS)	(10) (TSLS)	(11) (TSLS) Period: 1970-2008	(12) (OLS)	(13) (TSLS)	(14)
Resource Share (GDP share of mineral output)	-24.92 (28.58)	-25.8 (28.62)	10.72 (27.01)	17.27 (27.47)	6.23 (54.59)	7 .67 (27.29)	14.34 (27.56)	-7.66 (22.8)
Logarithm of Initial Income	-1.78*** (0.34)	-1.71*** (0.36)	-2.02*** (0.38)	-1.94*** (0.34)	-2.22*** (0.45)	-1.99*** (0.37)	-1.94*** (0.34)	-2.1*** (0.32)
Openness	2.79*** (0.56)	2.79*** (0.55)	2.81*** (0.49)	2.75*** (0.49)	5.09*** (1.45)	2.81*** (0.49)	2.75*** (0.49)	2.65*** (0.48)
Investment	0.19 (0.34)	-0.35 (0.49)	0.07 (0.45)	-0.26 (0.39)	1.16 (0.85)	-0.05 (0.42)	-0.22 (0.39)	0.08 (0.48)
Institutional quality	0.02 (0.2)	0.04 (0.19)	0.04 (0.21)	0.05 (0.19)	-0.43 (0.44)	0.05 (0.2)	0.05 (0.19)	0.05 (0.19)
Ethnicity	-0.01** (0.007)	-0.01* (0.007)	-0.01 (0.007)	-0.01 (0.007)	-0.04 (0.03)	-0.01 (0.007)	-0.01 (0.007)	-0.01* (0.007)
Terms of trade	0.12 (0.08)	0.13 (0.07)	0.16** (0.06)	0.16** (0.07)	0.05 (0.11)	0.16** (0.06)	0.16** (0.07)	0.14** (0.06)
Education	1.96 (1.27)	1.58 (1.27)	2.85** (1.29)	2.68** (1.28)	4.43* (2.49)	2.72** (1.23)	2.69** (1.28)	2.47** (1.19)
Landlocked economies	-0.39 (0.56)	-0.11 (0.53)	0.22 (0.45)	0.41 (0.51)	0.19 (0.91)	0.28 (0.45)	0.39 (0.49)	0.27 (0.45)
Ethnicity x Resource share	-0.12 (0.3)	-0.21 (0.31)	-0.62** (0.27)	-0.71** (0.26)	-1.06 (0.68)	-0.61** (0.27)	-0.66** (0.29)	-0.51** (0.24)
Institutional quality x Resource share	8.3* (4.4)	9.29** (4.37)	7.84** (3.67)	8.14** (3.77)	18.32** (7.2)	7.97** (3.74)	7.89** (3.81)	10.97*** (3.31)
Decentralization		-0.01 (0.01)	0.008 (0.01)	0.002 (0.01)	-0.001 (0.03)	0.004 (0.01)	-0.001 (0.01)	0.0006 (0.0005)
Decentralization x Resource share			**-0.39*** (0.08)**	**-0.46*** (0.1)**	**-0.71** (0.27)**	**-0.37*** (0.09)**	**-0.43*** (0.09)**	**-2.88*** (0.49)**
Adjusted R-squared	0.7091	0.7183	0.7853	0.7733	0.6517	0.7827	0.7695	0.8005
Observations	51	51	51	51	51	51	51	51

FIRST STAGE RESULTS

Dependent variable: Decentralization	Regressions (10) and (11)	Regression (13)
Logarithm of land area	3.59*** (0.99)	4.93*** (0.91)
Adjusted R-squared	0.7823	0.8146
Observations	51	51
F-Statistic	17.2	21.16

Standard errors are robust and appear in parentheses for independent variables. Superscripts correspond to a 10, 5 and 1% level of significance. First stage regressions include all relevant variables. All regressions include an intercept. For description, sources, and descriptive statistics of variables, as well as list of economies included in each regression, see Appendices 2-4.

TABLE 3. *Cross-country growth regressions* [panel with fixed effects, period: 1972-2008, in 9-year intervals]

Dependent variable: Average annual growth in real per capita GDP, 1972-2008 (9-year intervals)	Using GDP share of primary rents as the resource share proxy					Using GDP share of primary exports as the resource share proxy				
	Initial results	Adding decentralization ('Vertical Imbalance')				Initial results	Adding decentralization ('Vertical Imbalance')			
	(15)	(16)	(17)	(18) (TSLS)	(19) (TSLS)	(20)	(21)	(22)	(23) (TSLS)	(24) (TSLS)
Resource share (GDP share of primary rents)	-12.06	-13.91	-3.14	-2.89	-0.1					
	(16.39)	(16.27)	(16.9)	(16.91)	(17.47)					
Resource share (GDP share of primary exports)						-20.22	-20.75	-6.98	-5.84	-10.45
						(13.2)	(13.25)	(12.59)	(12.65)	(9.32)
Logarithm of initial income	-5.08***	-4.72***	-4.13***	-4.02***	-3.99***	-3.98***	-3.82***	-3.57***	-3.35***	-3.42***
	(1.15)	(1.27)	(1.15)	(1.08)	(1.1)	(1.03)	(1.1)	(0.99)	(1.01)	(1.01)
Openness	0.73	0.65	0.69	0.64	0.63	0.51	0.45	0.45	0.3	0.09
	(1.26)	(1.17)	(1.13)	(1.17)	(1.12)	(1.28)	(1.28)	(1.24)	(1.23)	(1.07)
Investment	0.93	0.95	0.86	0.75	0.82	0.67	0.63	0.27	0.26	0.46
	(1.13)	(1.15)	(1.12)	(1.16)	(1.1)	(1.21)	(1.23)	(1.29)	(1.29)	(1.16)
Institutional quality	0.51**	0.49**	0.48***	0.47**	0.43**	0.36	0.34	0.31	0.3	0.34
	(0.19)	(0.2)	(0.18)	(0.19)	(0.19)	(0.21)	(0.22)	(0.21)	(0.21)	(0.23)
Education	0.49*	0.44*	0.36	0.32	0.25	0.32	0.31	0.27	0.24	0.29
	(0.26)	(0.25)	(0.22)	(0.23)	(0.22)	(0.24)	(0.24)	(0.23)	(0.23)	(0.23)
Institutional quality x Resource share	1.03	1.55	3.57	3.99	4.99**	3.27	3.45	4.42*	4.13	6.51**
	(3.42)	(3.37)	(3.02)	(3.15)	(1.92)	(2.89)	(2.9)	(2.61)	(2.69)	(2.7)
Decentralization		-0.02*	-0.0003	-0.01	-0.01		-0.006	0.01	-0.005	0.004
		(0.01)	(0.01)	(0.01)	(0.01)		(0.01)	(0.01)	(0.01)	(0.01)
Decentralization x Resource share			**-0.45****	**-0.51****	**-0.66*****			**-0.42****	**-0.42****	**-0.8****
			(0.17)	**(0.21)**	**(0.22)**			**(0.19)**	**(0.19)**	**(0.34)**
Adjusted R-squared	0.6509	0.6559	0.6788	0.6752	0.6832	0.7106	0.7091	0.7106	0.7232	0.7326
Observations	208	208	208	208	208	184	184	184	184	184
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of economies included	74	74	74	74	74	70	70	70	70	70

FIRST STAGE RESULTS				
Dependent variable: Decentralization	Regression (18)	Regression (19)	Regression (23)	Regression (24)
Level of democracy int-1	5.63*** (0.65)	5.65*** (0.93)	5.49*** (0.67)	5.55*** (0.67)
Adjusted R-squared	0.7962	0.7942	0.7944	0.7934
Observations	208	208	184	184
F-Statistic	10.98	10.86	10.18	10.25
Dependent variable: GDP share of primary rents/exports	Regression (18)	Regression (19)	Regression (23)	Regression (24)
GDP share of mineral rents in t-1		0.32** (0.12)		0.67*** (0.07)
Adjusted R-squared		0.9592		0.9006
Observations		208		184
F-Statistic		61.14		22.81

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. In the first stage results only coefficient on the relevant instruments (level of democracy in t-1, and GDP share of mineral rents in t-1) are reported, yet regressions include all variables reported in the second stage results. Note that in regressions (18) and (23) only decentralization is instrumented (by the level of democracy in t-1), while in regressions (19) and (24) both decentralization and resource share are instrumented (the former by the level of democracy in t-1, and the latter by the GDP share of mineral rents in t-1). 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 source of variables as well as list of economies included in each regression and descriptive statistics see Appendices 2-4.

TABLE 4. *Cross-country growth regressions, using the Revenue Raising Authority component of the 'Kearney Decentralization Index'* as the decentralization index [panel with fixed effects, period: 1965-2000, in 5-year intervals]

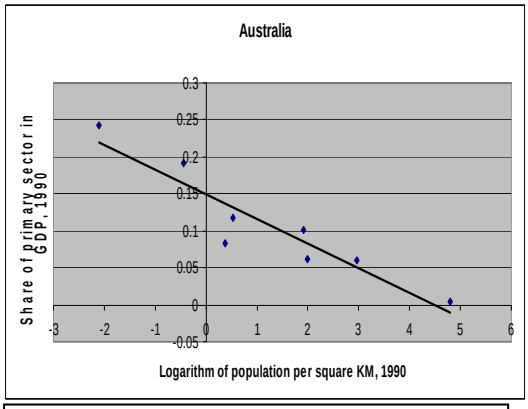
Dependent variable: Average annual growth in real per capita GDP, 1965-2000 (5-year intervals)	Initial results	Adding decentralization (Revenue Raising Authority component of the 'Kearney Decentralization Index')			
	(25)	(26)	(27)	(28) (TSLS)	(29) (TSLS)
Resource share (GDP share of primary rents)	-5.73	-5.65	-4.47	-4.12	0.31
	(4.86)	(4.87)	(4.88)	(5.13)	(5.39)
Logarithm of initial income	-2.35*	-2.35*	-2.34*	-2.34*	-2.34*
	(1.22)	(1.23)	(1.24)	(1.27)	(1.29)
Openness	1.69	1.54	1.45	1.42	1.29
	(1.81)	(1.8)	(1.84)	(1.87)	(1.83)
Investment	2.34***	2.36***	2.31***	2.33***	2.32***
	(0.63)	(0.62)	(0.63)	(0.62)	(0.63)
Institutional quality	0.12	0.12	0.09	0.08	0.12
	(0.21)	(0.21)	(0.21)	(0.21)	(0.2)
Education	0.82***	0.84***	0.85***	0.89***	0.91***
	(0.24)	(0.25)	(0.24)	(0.24)	(0.25)
Institutional quality x Resource share	0.64	0.84***	1.21	1.41	0.85
	(1.18)	(0.25)	(1.17)	(1.07)	(0.98)
Decentralization		-0.13	0.004	-0.07	-0.11
		(0.27)	(0.28)	(0.27)	(0.27)
Decentralization x Resource share			**-2.67****	**-3.6****	**-4.07****
			(1.21)	**(1.73)**	**(1.94)**
Adjusted R-squared	0.5802	0.5788	0.5798	0.58	0.58
Observations	232	232	232	232	232
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Number of economies included	43	43	43	43	43

FIRST STAGE RESULTS		
Dependent variable: Decentralization	Regression (28)	Regression (29)
Level of democracy in t-1	0.06**	0.07**
	(0.03)	(0.03)
Adjusted R-squared	0.7904	0.8368
Observations	232	232
F-Statistic	18.42	18.55
Dependent variable: GDP share of primary rents	Regression (28)	Regression (29)
GDP share of mineral rents in t-1		0.39***
		(0.12)
Adjusted R-squared		0.9145
Observations		232
F-Statistic		38.72

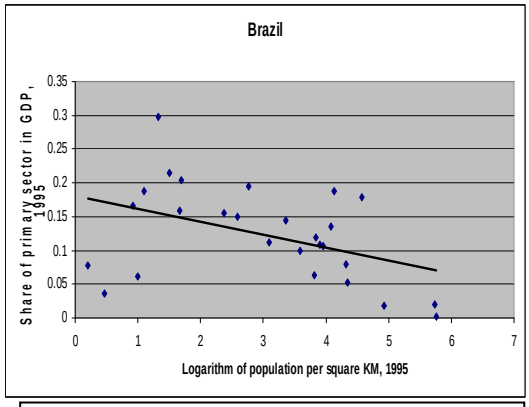
Standard errors are robust, clustered by country, and appear in parentheses for independent variables. Superscripts correspond to a 10, 5 and 1% level of significance. In the first stage results only the coefficient on the relevant instruments (level of democracy in t-1, and GDP share of mineral rents in t-1) is reported, yet the regression includes all variables reported in the second stage results. Note that in regression (28) only decentralization is instrumented (by the level of democracy in t-1), while in regression (29) both decentralization and resource share are instrumented (the former by the level of democracy in t-1, and the latter by the GDP share of mineral rents in t-1).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 source of variables as well as list of economies included in each regression see Appendices 2 and 3. For descriptive statistics see Appendix 4.

Appendix 1: Agglomeration VS. Resources in Various Federations

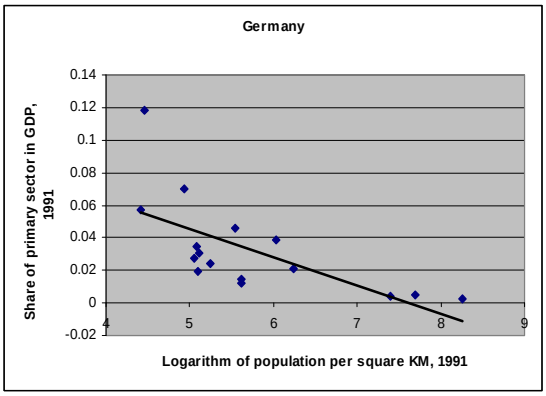
Note that all graphs are at the federal-state level (so that each point represents a federal-state within the respective federation). All data was retrieved from the corresponding statistical bureaus of each federation.



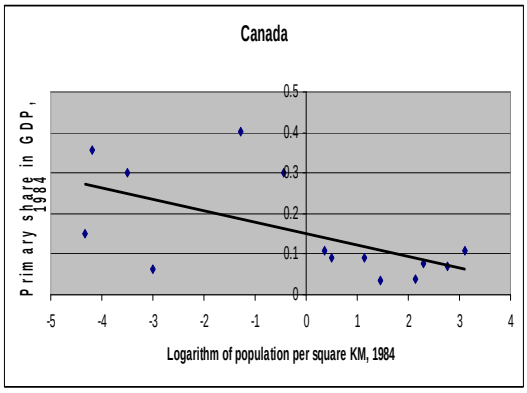
Resources = 0.1497 - 0.0333Agglomeration
R-squared = 0.8688 , p<0.00



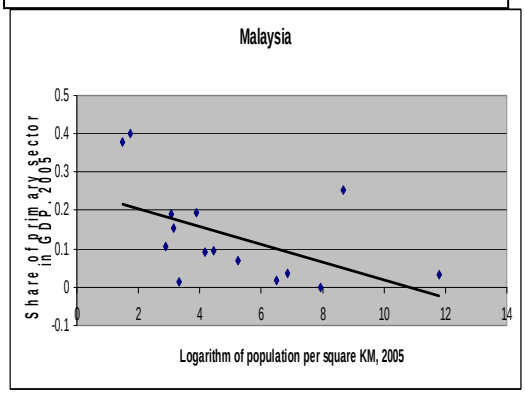
Resources = 0.1802 – 0.0189Agglomeration
R-squared = 0.1844 , p<0.02



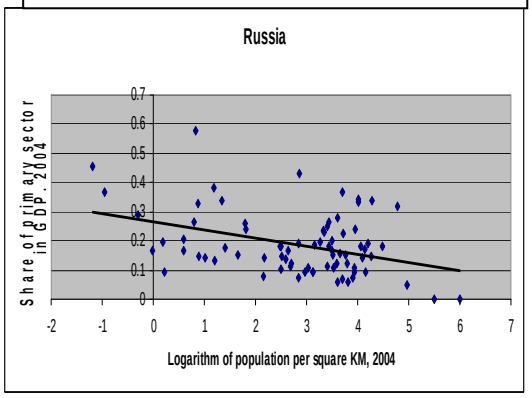
Resources = 0.1322 - 0.0173Agglomeration
R-squared = 0.4366 , p<0.00



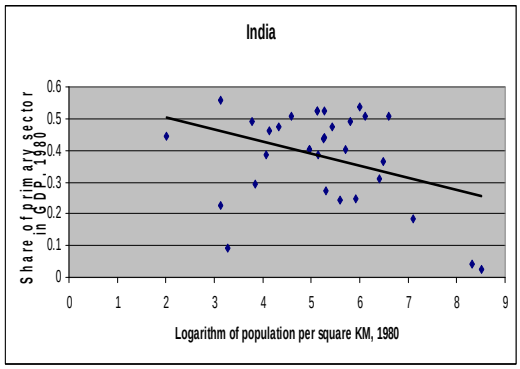
Resources = 0.151 - 0.0282Agglomeration
R-squared = 0.369 , p<0.02



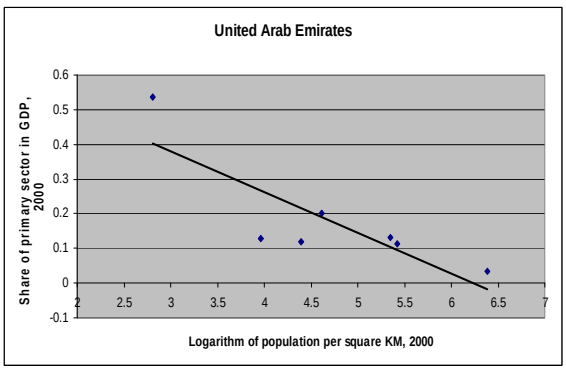
Resources = 0.2531 - 0.0233Agglomeration
R-squared = 0.274 , p<0.04



Resources = 0.2645 - 0.029Agglomeration
R-squared = 0.1468 , p<0.00



Resources = 0.5784 - 0.0378Agglomeration
R-squared = 0.1326 , p<0.04



Resources = 0.7333 - 0.1175Agglomeration
R-squared = 0.6875 , p<0.02

Appendix 2: List of Variables Used in the Regressions

Tables 1 – 2 (Cross-section estimations)

Source of variables in these tables is Sachs and Warner (1997), unless stated otherwise (variable names as in Sachs and Warner (1997), or otherwise their source appear in parentheses).

Growth (dependent variable): Measure 1 (used in all regressions, except (11)): Average annual growth in real per capita GDP in the years 1970-1990 expressed as a number between -4 and 6 (gea7090).

Measure 2 (used in Regression (11)): Average annual growth in real per capita GDP in the years 1970-2008 expressed as a number between -2 and 18 (Source: World Development Indicators).

Logarithm of initial income: The log of real per capita GDP in 1970 (lgdpea70).

Resource share: Measure 1 (used in Table 1): Share of mineral production in total GDP in 1970 expressed as a number between 0 and 1 (snr).

Measure 2 (used in Table 2): Share of natural capital in total GDP in 2000 expressed as a number between 0 and 1 (Source: World Bank 2006).

Openness: The fraction of years over the period 1970-1990 in which the country is rated as economically 'open', according to Sachs and Warner (1997) expressed as a number between 0 and 1 (open6590).

Investment: The log of the ratio of real gross domestic investment to real GDP, averaged over the period 1970-1989 (linv7089).

Institutional quality: The rule of law index from the International Country Risk Guide, in 1982, expressed as a number between one and six, six presenting best institutional quality and one least (rl).

Ethnicity: Measure of ethno-linguistic fractionalization; measures the probability that two randomly-selected people from a country will not belong to the same ethnic or linguistic group, expressed as a number between 0 and 100 (ethling).

Terms of Trade: The average annual growth rate in the log of the external terms of trade between 1970 and 1990 expressed as a number between -10 and 10. External terms of trade are defined as the ratio of an export price index to an import price index (dtt7090).

Education: Secondary school enrollment rate in 1970 expressed as a number between 0 and 1 (sec70).
Landlocked economies: A dummy variable for landlocked economies (access).

Decentralization: *'Vertical Imbalance'*: The extent to which sub-national governments rely on their own revenue sources for their expenditures, measured in initial year (closest to 1970, in case data is available for one of the years in the 1970-1975 period) and expressed as a number between 0 and 100. Source: World Bank Fiscal Decentralization Indicators.

'Potential Vulnerability': The share of non-agglomerated area in total area in 2001 (Source: Center for International Earth Science Information Network at Columbia University) multiplied by the *'Vertical Imbalance'* measure, expressed as a number between 0 and 100.

'Modified Potential Vulnerability': The share of general government final consumption expenditure in total GDP in 1972 (Source: World Development Indicators) multiplied by the *'Vertical Imbalance'* measure, expressed as a number between 0 and 100.

Land area: The logarithm of land area in square kilometers; used as an instrument for decentralization in Tables 1 and 2 (Regressions (4), (6), (10), and (13)). Source: World Bank Development Indicators.

Tables 3 – 4 (Panel estimations)
Note that Table 3 employs a panel that covers the period of 1972-2008 with 9-year intervals, whereas Table 4 employs a panel that covers the period of 1965-2000. Thus, variables correspond to those periods and time intervals in either case. Unless stated otherwise, variables are measured in the initial year of the corresponding time interval.

Growth (dependent variable): Measure 1 (used in Table 3): Average annual growth in real per capita GDP in the years 1972-2008, in 9-year intervals, expressed as a number between -9 and 13. Source: World Bank Development Indicators.
Measure 2 (used in Table 4): Average annual growth in real per capita GDP in the years 1965-2000, in 5-year intervals, expressed as a number between -12 and 22. Source: World Bank Development Indicators.
Logarithm of initial Income: The log of real GDP per capita. Source: World Bank Development Indicators.

Resource share: Measure 1: GDP share of primary rents, expressed as a number between 0 and 1. Source: World Bank Development Indicators.

Measure 2: GDP share of primary exports, expressed as a number between 0 and 1. Source: World Bank Development Indicators.

Measure 3 (used in Table 3 (Regressions (19), (24) and (29)) as an instrument for GDP share of primary rents or exports): GDP share of mineral rents in t-1, expressed as a number between 0 and 1. Source: World Bank Development Indicators.

Openness: Share of total trade (exports and imports) in total GDP, expressed as a number between 0 and 4. Source: Penn World Table 7.0.

Investment: The log of the ratio of real gross domestic investment to real GDP. Source: Penn World Table 7.0.

Institutional quality: Civil Liberties Index, expressed as a number between one and seven, seven presenting best institutional quality and one least. Source: Freedom House.

Education: Average years of total schooling for population aged 15 and over, expressed as a number between 0 and 13. Source: Barro and Lee (2010).

Decentralization: *'Vertical Imbalance'* (used in Table 3): The extent to which sub-national governments rely on their own revenue sources for their expenditures, expressed as a number between 0 and 100. Source: World Bank Fiscal Decentralization Indicators.

'Kearney Decentralization Index' (used in Table 4): The Revenue-Raising component of the 'Kearney Decentralization Index' (available for the years 1965-1995) expressed as a number between zero and four with four having the highest level of revenue-raising autonomy and zero the least. Source: Arzaghi and Henderson (2005).

Democracy: The level of democracy; used as an instrument for decentralization in Tables 3 and 4 (Regressions (18), (19), (23), (24), (28) and (29)). Democracy level is computed as the average level in the 10 years preceding to the initial year in the corresponding time interval, and expressed as a number between 1 and 10 where 10 represents the highest level of democracy, and 1 the lowest. Source: Polity IV Project, Integrated Network for Societal Conflict Research.

Appendix 3: List of Countries Covered in Each Table

Table 1: Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Denmark, Dominican Republic, Ecuador, Finland, France, West Germany, Greece, Guatemala, Honduras, India, Indonesia, Iran, Ireland, Israel, Italy, Kenya, Korea Republic, Malawi, Malaysia, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Paraguay, Peru, Philippines, Portugal, Senegal, Spain, Sri Lanka, Sudan, Sweden, Switzerland, Thailand, Trinidad and Tobago, Tunisia, United Kingdom, United States, Uruguay, Venezuela, Zambia. **Table 2:** Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Costa Rica, Denmark, Dominican Republic, Ecuador, Finland, France, West Germany, Greece, Guatemala, Honduras, India, Indonesia, Iran, Ireland, Israel, Italy, Kenya, Korea Republic, Malawi, Malaysia, Mexico, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Paraguay, Peru, Philippines, Portugal, Senegal, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Trinidad and Tobago, Tunisia, United Kingdom, United States, Uruguay, Venezuela, Zambia. **Table 3 (Regressions (15)-(19)):** Albania, Australia, Austria, Belgium, Bolivia, Botswana, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Dominican Republic, Ecuador, Estonia, Fiji, Finland, France, Gambia, Germany, Greece, Guatemala, Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Kenya, Korea Republic, Latvia, Lithuania, Luxemburg, Malawi, Malaysia, Mauritius, Mexico, Moldova, Mongolia, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Senegal, Slovak Republic, Slovenia, Spain, Sri Lanka, Swaziland, Sweden, Switzerland, Thailand, Tunisia, Uganda, United Kingdom, United States, Zambia, Zimbabwe. **Table 3 (Regression (20)-(24)):** Albania, Australia, Austria, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, China, Colombia, Costa Rica, Croatia, Czech Republic, Denmark, Dominican Republic, Ecuador, Estonia, Fiji, Finland, France, Gambia, Germany, Greece, Guatemala,

Honduras, Hungary, Iceland, India, Indonesia, Iran, Ireland, Israel, Italy, Korea Republic, Latvia, Lithuania, Malawi, Malaysia, Mauritius, Mexico, Moldova, Mongolia, Netherlands, New Zealand, Nicaragua, Norway, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russian Federation, Senegal, Slovak Republic, Slovenia, Spain, Sri Lanka, Sweden, Switzerland, Thailand, Tunisia, United Kingdom, United States, Zambia, Zimbabwe.
Table 4: Algeria, Argentina, Australia, Bangladesh, Brazil, Cameroon, Canada, Chile, China, Colombia, Ecuador, Egypt, France, Germany, Ghana, Great Britain, Greece, Hungary, India, Indonesia, Italy, Japan, Kenya, Korea Republic, Malaysia, Mexico, Mozambique, Nepal, Netherlands, Pakistan, Peru, Philippines, Poland, Romania, Russian Federation, Spain, Sri Lanka, Syria, Thailand, United States, Uganda, Venezuela, Zaire.

Appendix 4: Descriptive Statistics of Variables in Each Table

Tables 1 and 2

Variable	Mean	Standard Deviation	Minimum	Maximum
Growth, 1970-1990 (53)	1.3	1.6	-3.09	5.7
Growth, 1970-2008 (53)	3.4	3.1	-1.2	17.77
GDP share of mineral output (53)	0.04	0.08	0	0.37
GDP share of natural capital (52)	0.02	0.05	0.0001	0.38
Logarithm of initial income (53)	8.65	0.86	6.76	9.95
Openness (53)	0.5	0.45	0	1
Investment (53)	2.86	0.49	1.33	3.61
Institutional quality (53)	3.56	2.005	1	6
Ethnicity (53)	36.89	28.35	0	89
Terms of trade (53)	-0.41	2.32	-4.69	7.38
Education (52)	0.17	0.14	0.005	0.54
Landlocked economies (53)	0.13	0.34	0	1
Vertical Imbalance (53)	67.15	23.94	7.02	99.82
Potential Vulnerability (53)	62.47	24.75	3.96	98.98
Modified Potential Vulnerability (53)	9.63	4.31	0.97	20.55
Logarithm of land area (53)	12.65	1.97	6.54	16.03

Table 3

Variable	Mean	Standard Deviation	Minimum	Maximum
Growth, 1972-2008 (312)	2.13	2.75	-8.06	12.98
GDP share of primary rents (388)	0.05	0.09	0	0.78
GDP share of primary exports (322)	0.06	0.08	0.001	0.64
GDP share of mineral rents (389)	0.03	0.08	0	0.78
Logarithm of initial income (398)	8.75	1.25	4.91	11.4
Openness (462)	0.71	0.42	0.02	3.24
Investment (462)	24.4	9.23	5.17	70.31
Institutional quality (376)	4.86	1.83	1	7
Education (400)	7.17	2.82	0.57	12.7
Vertical Imbalance (250)	45.72	21.25	0.91	97.38
Level of democracy (454)	5.95	3.76	0	10

Table 4

Variable	Mean	Standard Deviation	Minimum	Maximum
Growth, 1965-2000 (333)	2.14	2.98	-11.39	22.38
GDP share of primary rents (313)	0.07	0.1	0	0.93
GDP share of mineral rents (315)	0.05	0.1	0	0.92
Logarithm of initial income (381)	7.49	1.57	4.43	10.51
Openness (382)	0.39	0.24	0.05	1.92
Investment (379)	24.75	8.81	1.34	58.31
Institutional quality (256)	4.31	2.19	1	7
Education (441)	5.45	2.95	0.13	12.71
Kearney Decentralization Index (380)	1.18	1.06	0	3.56
Level of democracy (425)	4.36	3.97	0	10