The Natural Resource Curse, Fiscal Decentralization, and Agglomeration Economies

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Abstract

Natural resource abundance is a blessing for some countries, yet is a curse for others. The degree of fiscal decentralization may account for this divergent outcome. Resources tend to locate in remote, non-agglomerated, and sparsely populated areas; a high degree of fiscal decentralization gives a resource abundant region an advantage in the inter-regional tax competition over capital so that it attracts some capital from agglomerated and densely populated regions. Given a sufficiently high agglomeration level, any such movement of capital would bring a loss of output in the agglomerated region that outweighs the sum of gains from resource income and increased output in the remote region – so that aggregate product in the economy drops. This theory is empirically tested -and confirmed- building on Sachs and Warner's influential works on the resource curse, employing the World Bank's Fiscal Decentralization Indicators, and taking the United States as a case study.

Keywords: Natural Resources, Economic Growth, Resource Curse, Fiscal Decentralization, Agglomeration Economies, Tax Competition

JEL *classification*: C21, O13, O18, O57, Q33

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1. Introduction

Since the influential works of Sachs and Warner (1995, 1997, 1999, 2001) the so-called resource curse, describing an inverse relationship between resource abundance and economic growth,[1] has attracted considerable attention; further studies provided additional empirical evidence of this phenomenon as well as various potential explanations for its occurrence.[2]

Nonetheless, the question of why resource endowments is a blessing for some countries yet is a curse for others, remains a puzzle. Lane and Tornell (1996) suggest that the existence of powerful groups in conjunction with weak institutions provide an explanation, Mehlum et al. (2006) argue it is rather strictly the quality of institutions that matter, Hodler (2004) provides a similar argument for the level of fractionalization, and finally Andersen and Aslaksen (2008) point at constitutional arrangements as a viable determinant. This paper contributes to this strand of the literature, as it presents an additional potential explanation – the level of fiscal decentralization.[3]

As a first step, I follow Mehlum et al. (2006) and plot in Figure 1 the average annual real per capita GDP growth from 1970 to 1990 versus resource abundance.[4] Panel (A) is based on all 48 countries of the data set, and provides a strong indication for an

[1] The meaning of 'resource-abundance' should be properly defined, as it may carry some confusion with it. For an extensive discussion over the precise terminologies of natural resources see Laroui and Van der Zwaan (2002). In this paper the definition used follows that which is usually employed by economists studying the 'Dutch Disease' – 'resource abundance' refers to the amount of already exploited natural resources and reserves proven to be economically exploitable.

[2] For further discussion see Auty 2001, Gylfason 2000, 2001, Gylfason et al. 1999, Lane and Tornell 1996, Leite and Weidmann 1999, Papyrakis and Gerlagh 2004, Rodriquez and Sachs 1999, Sachs and Warner 1997, 1999, 2001.

[3] 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, and 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.

[4] Note that 'G' represents average annual real per capita GDP growth, while 'R' represents resource abundance (measured by primary exports as share of total exports in 1970; an elaborated discussion over the resource measures used appears in the empirical part of the paper).

occurrence of a resource curse. In panels (B) and (C), the sample is split to two equal sub-samples according to the degree of fiscal decentralization (a measure to be discussed in-detail in the empirical part of the paper); results indicate that a resource curse appears in countries with a relatively higher degree of fiscal decentralization (panel (B)), yet it

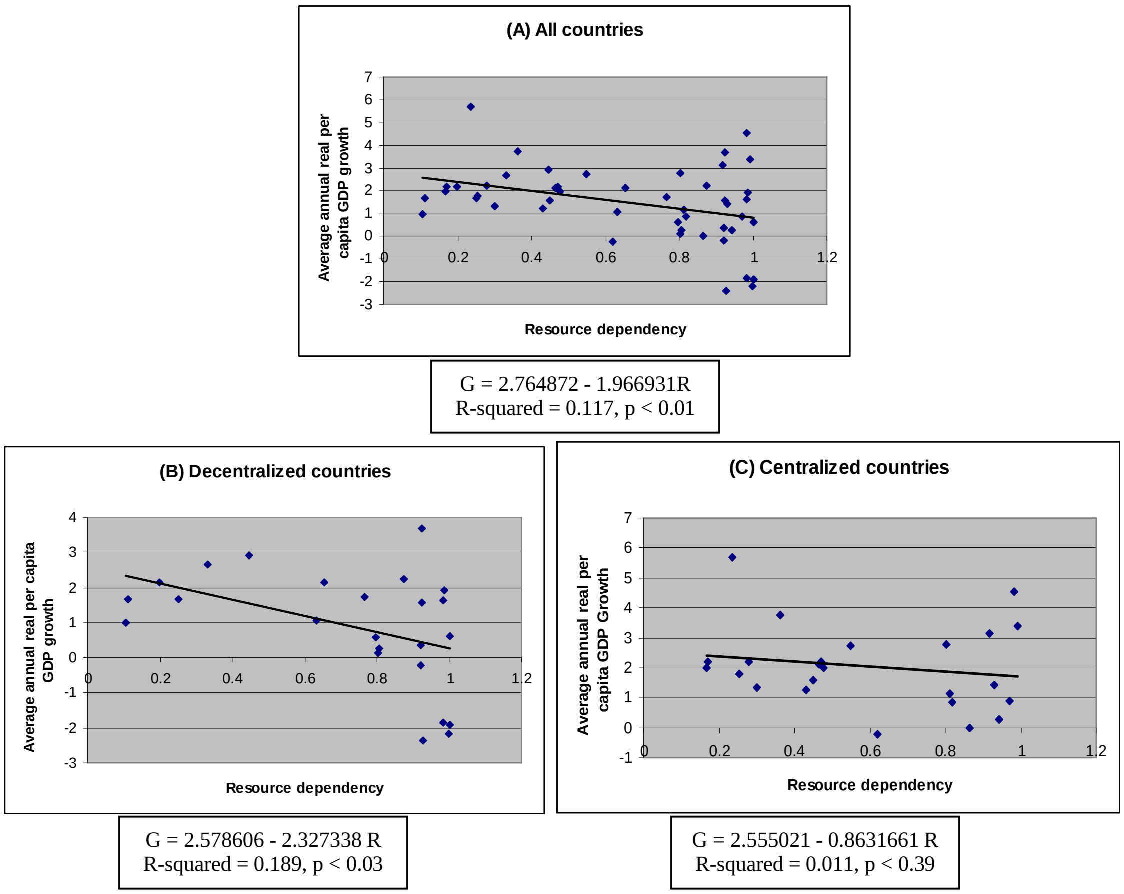

FIGURE 1. *Resource-abundance and economic growth in: (A) all countries (B) decentralized countries (C) centralized countries*

completely disappears in countries with a relatively lower degree of fiscal decentralization (panel (C)).[5] This preliminary result is maintained when I control for

[5] The countries in panel (B) are: Austria, Costa Rica, Ecuador, Fiji, Finland, Gambia, West Germany, Greece, Honduras, Iran, Kenya, Madagascar, Malaysia, Mexico, Norway, Panama, Paraguay, Senegal, Sri Lanka, Sweden, Switzerland, Uruguay, Venezuela, and Zambia. The countries in panel (C) are: Australia, Canada, Chile, Colombia, Denmark, Dominican Republic, France, India, Indonesia, Ireland, Israel, Italy,

various factors, as will be evident in the empirical part of the paper. On this basis, I assert that the degree of fiscal decentralization provides an additional explanation for the divergent effects of resource endowments.

Based on the premise that resources tend to locate in remote, non-agglomerated, and sparsely populated regions, I construct a simple two-region model of capital tax competition (extending Zodrow and Mieszkowski's (1986) basic capital tax competition model), where one of the regions exhibits agglomeration economies.[6] The model shows that once an economy is fiscally decentralized a resource endowment in the remote region gives it an advantage in the inter-regional tax competition over the nation's capital, so that some amount of capital is attracted to it from the agglomerated region; given a sufficiently high agglomeration or population density levels in the resource scarce region, any such capital movement will cause output loss in the resource scarce region in magnitude that outweighs the sum of gains of the resource income and the output increase in the resource rich region, so that aggregate product in the economy drops. In addition, the model shows this mechanism only intensifies as institutional quality weakens (triggered by rent-seeking behavior rather than tax competition, as corruption increases), alleviating concerns of its exclusive applicability to economies with high institutional quality.

To empirically test the main hypothesis, I use the World Bank's Fiscal Decentralization Indicators in conjunction with Sachs and Warner's (1997) data set. Adding the fiscal decentralization measure and an interaction term of it with the resource abundance proxy to the regressions made by Sachs and Warner (1997) provide significant results (in the expected directions) that are robust to using different fiscal decentralization measures as well as different resource share proxies; these results hold when controlling for investment, openness, institutional quality, ethnicity, terms of trade, secondary school enrollment, and (following Hodler's (2004) and Mehlum et al.'s (2006) findings)

Korea Republic, Malawi, Mauritius, Netherlands, Portugal, South Africa, Spain, Thailand, Trinidad and Tobago, Tunisia, United Kingdom, and United States.

[6] 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.

interaction terms of ethnicity and institutional quality with the resource share proxy. In addition, I construct a cross-country agglomeration index and use it to show that decentralized economies with greater shares of non-agglomerated areas are potentially more vulnerable to the resource curse, as the model suggests.

Finally, empirical evidence that support the main predictions of the model is provided, taking the United States as a case study. I find that resource abundance is associated with more competitive tax environments, greater amounts of physical capital per capita, and lower agglomeration levels. Thus, movement of capital from agglomerated to non-agglomerated regions (due to resource abundance and a tax competition that follows) is observed, which confirms the mechanism suggested.

The paper is structured as follows – Section 2 presents the setup of the model, and goes through the theoretical analysis. Section 3 provides empirical evidence for both the main hypothesis as well as for the mechanism of the model, and undertakes robust checks to the empirical findings. Section 4 concludes.

2. THE MODEL

Let us consider the benchmark setting of the model, under the framework of the basic capital tax competition model of Zodrow and Mieszkowski (1986), in its simplest form. There exists an economy with two symmetric regions, each having a manufacturing sector. Production in each region is undertaken by capital (K) and labor (L), employed through a constant returns to scale neoclassical production function that follows the Inada Conditions (F(K,L)); it takes place in the manufacturing sector, to produce a final good (Y) that is either consumed (X) or converted to a pure public good (G). The starting population size of each region is L_i (where $L_1 + L_2 = N$ and $L_i \geq 1$).[7] Labor market is inelastic so that each resident is employed and provides one unit of labor. Thus, we have:

$$Y_i = F(K_i, L_i) = X_i + G_i \tag{1}$$

[7] Note that throughout the paper 'i' represents the region, where $i \in (1,2)$. Also in terms of notation, subscripts represent the region, while superscripts represent the sector; in addition, capital letters represent level variables, while small ones represent per capita terms.

There is a fixed supply of capital in the economy (where $K_1 + K_2 = K^*$), that is equally owned by its residents (so that each owns: $K^* / N = k^*$). To be able to focus on the effects of capital mobility (following the empirical observations) I assume capital is perfectly (and costlessly) mobile, while labor is completely immobile.[8] Since the focus is on decentralized economies, I take the simplifying assumption that regions have complete autonomy on determination of tax rates well as on tax retention and usage; thus, each region has a government that levies a per-unit, source-based, capital tax to finance a pure public good, so that:

$$G_i = T_i K_i \quad (2)$$

The after-tax rate of return on capital is ρ; although determined endogenously (by the free capital mobility condition, which will be presented later), ρ is taken as given by each region. Following that, the pre-tax rate of return on capital would be $\rho + T_i$. There are many firms (each being a price taker) operating in each of the regions, and there is free entry to the market. Capital markets are competitive so that profit maximization by each firm yields:[9]

$$f_{k_i}(k_i) = \rho + T_i \quad (3)$$

Also, the free entry condition yields:[10]

$$w_i = f(k_i) - f_{k_i} k_i \quad (4)$$

Residents of this economy have identical preferences, represented by a strictly quasi-concave utility function, U(X,G), with the following properties:

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[8] In a previous paper I show that on a regional basis capital flows to regions rich in point-source resources, while labor does not flow to regions rich in diffuse-source resources (results available from the author). Therefore, in this paper I focus on capital mobility, leaving labor immobile for simplicity. In addition, note that in the context of this model, capital refers specifically to physical capital, rather than to other types of capital (such as financial capital, or human capital).

[9] Profit of a representative firm in either of the regions is: $\pi_i = L_i(f(k_i) - (\rho + T_i)k_i - w_i)$ Therefore, profit would be maximized at: $d\pi_i / dk_i = 0$

[10] The free entry condition imposes $\pi = 0$, for all firms in the nation.

$U_X, U_G > 0, U_{XX}, U_{GG} < 0, U_{XG} > 0;$[11] in addition, they own equal shares of the firms (in their respective regions). Therefore, given that residents spend all their income on private consumption, a representative resident's budget constraint would be:

$$x_i = f(k_i) - (\rho + T_i)k_i + \rho k^* \tag{5}$$

Each region competes for the economy's capital stock, by means of tax competition (so that a capital tax competition arises, modeled along Cournot-Nash lines). This is a static, one-period model, where the order of events is as follows – each region sets its capital tax level, based on which capital is reallocated across the economy; this, in turn, determines the regional wage and public goods levels (which sets the per-capita utility levels).

That said, by equation (3) each region derives $k_i(T_i)$ so that it can vary k_i by its choice of T_i. Totally differentiating equation (3) with respect to k_i and T_i, we get:

$$\frac{dk_i}{dT_i} = \frac{1}{f_{k_i k_i}} < 0 \tag{6}$$

By equation (2), we get:

$$\frac{dG_i}{dT_i} = L_i k_i + T_i L_i \frac{dk_i}{dT_i} \tag{7}$$

Also, by differentiating equation (5) with respect to T_i and substituting equation (6), we get:

$$\frac{dx_i}{dT_i} = -k_i \tag{8}$$

Each region aims to set the tax level that would maximize the welfare of its residents. Keeping this objective in mind, each region would, thus, maximize the utility of a representative resident, subject to the budget constraints of the region and the resident.

[11] In effect, making X and G normal goods with diminishing returns. In addition, it is assumed that marginal utilities of X and G go to infinity as each approaches zero, or otherwise go to zero as each approaches infinity (similar to the Inada Conditions of the production side).

Therefore, in its simplest form the problem of each of the regions would be expressed as follows:[12]

$$\underset{\{T_i\}}{Max}\, U(x_i, G_i)$$

Let us denote U_{G_i} / U_{X_i} by $m(x_i, G_i)$; thus, we get:[13]

$$\frac{dx_i}{dT_i} + m(x_i, G_i)\frac{dG_i}{dT_i} = 0 \tag{9}$$

Substituting equations (7) and (8) to equation (9) and rearranging, we get:[14]

$$L_i m(x_i, G_i) = \frac{1}{1 + \frac{T_i}{k_i}\frac{dk_i}{dT_i}} > 1 \tag{10}$$

In equilibrium, the following capital mobility condition must hold:[15]

$$f_{k_1} - T_1 = f_{k_2} - T_2 \tag{11}$$

Therefore, in equilibrium equations (10) (for each of the regions) and (11) must hold, which means that capital tax rates will be positive in each of the regions, in equilibrium.

2.1 Agglomeration Economies

Departing from the benchmark setting let us now assume there exists agglomeration economies in Region 1.[16] Following Ciccone and Hall (1996), this agglomeration effect is

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[12] Note that given the assumptions made on the utility function, as well as based on the setting of the problem, there would be an interior solution to the given problem, in each of the regions, such that $T_i, k_i, G_i, x_i > 0$. Therefore, corner solutions are not considered in this case.

[13] This was derived by totally differentiating $U(x_i, G_i)$ with respect to x_i and G_i.

[14] The following result replicates that which was derived by Zodrow and Mieszkowski (1986). It can be given a *Modified Samuelson Condition* (Batina 1990) interpretation, showing how the public good is undersupplied in each of the regions due to the non-cooperative behavior. To emphasize this point further a MCPF (Marginal Cost of Public Funds) interpretation can be adopted here as well (Browning, 1976), showing how in equilibrium each of the regions will face excess costs when raising an additional unit of revenue, caused by the usage of distortionary taxes and the tax competition.

[15] Capital will place where its marginal product is higher, until it is equated across regions.

modeled by adding L^{α} ($\alpha > 0$, and is exogenously determined)[17] to the production undertaken in Region 1 (such that $Y_1 = L_1^{\alpha} F(K_1, L_1)$). In terms of describing agglomeration effects, this addition has three interpretations[18] – firstly it indicates labor is more complementary to capital in the agglomerated region, secondly it implies that the agglomerated region presents higher wage rates, and thirdly it says that production in the agglomerated region exhibits increasing returns to scale in labor and capital (thus, making workers in Region 1 more productive than those of Region 2). In effect, α represents the degree of agglomeration, where a higher α means greater agglomeration effects.[19]

Following the analysis of the benchmark setting, nothing changes in the behavior of Region 2, whereas in Region 1 equations (3) through (6) now become:

$$L_1^{\alpha} f_{k_1}(k_1) = \rho + T_1 \tag{12}$$

$$w_1 = L_1^{\alpha}(f(k_1) - f_{k_1} k_1) \tag{13}$$

$$x_1 = L_1^{\alpha} f(k_1) - (\rho + T_1)k_1 + \rho k^* \tag{14}$$

$$\frac{dk_1}{dT_1} = \frac{1}{L_1^{\alpha} f_{k_1 k_1}} < 0 \tag{15}$$

Thus, going through the maximization problem of Region 1, and plugging equations (12)-(15) as was done previously, we get the following reaction function:

$$L_1 m(x_1, G_1) = \frac{1}{1 + \dfrac{T_1}{L_1^{\alpha} k_1 f_{k_1 k_1}}} > 1 \tag{16}$$

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[16] This extension relates to Bucovetsky's (1991) work; however, while he sourced the asymmetry between the regions in their relative population sizes, in this work no assumption is made over the relative regional population sizes and the asymmetry is mainly sourced in the agglomeration effects.

[17] The assumption that α is exogenously determined captures the idea that once resources are discovered the economy is at a certain agglomeration level that is exogenous to the resource discovery.

[18] Each such interpretation follows the definition of agglomeration as described by Krugman (1991), Ciccone and Hall (1996), and others.

[19] Note that in terms of Ciccone and Hall (1996) α represents both the effects of congestion and agglomeration, because in this model acreage does not vary between regions.

Also, equation (11) now becomes:

$$L_1^{\alpha} f_{k_1} - T_1 = f_{k_2} - T_2 \tag{17}$$

As before, equations (16) (for each of the regions) and (17) must hold in equilibrium, so that regional tax rates would be positive, in equilibrium.

2.2 The Natural Resource Curse in Decentralized Countries

Let us assume Region 2 receives an exogenous and immobile resource endowment (Q), which it taxes on a lump-sum basis (z).[20] Therefore, in this case the regional budget constraint would be:

$$G_2 = T_2 K_2 + z \tag{18}$$

Total output of Region 2 would now be:

$$Y_2 = X_2 + G_2 = F(K_2, L_2) + Q \tag{19}$$

The resource is equally owned by residents of Region 2 (so that: $q^* = Q / L_2$) and it provides an exogenously-determined rate of return of μ. Therefore, the budget constraint of a representative resident in Region 2 would be:

$$x_2 = f(k_2) - f_{k_2} k_2 - z / L_2 + \rho k^* + \mu q^* \tag{20}$$

Once again, the regions engage in a capital tax competition. Note that Region 1 behaves according to the analysis presented previously; therefore, let us see how the situation changes in Region 2, as its problem is analyzed as follows:

$$\underset{\{T_2, z\}}{Max} U(x_2, G_2)$$

Substituting equations (20) and (18) to the given problem, we get the following first order conditions:

$$U_{X_2} = U_{G_2} L_2 \tag{21}$$

$$U_{X_2} \frac{dx_2}{dT_2} + U_{G_2} \frac{dG_2}{dT_2} = 0 \tag{22}$$

[20] Note that results do not change if otherwise a per-unit, source based (and thus distortionary), tax is imposed instead of the lump-sum one. Usage of lump-sum tax simplifies the analysis. This, in fact, follows the reasoning of Zodrow and Mieszkowski (1986) who used a lump sum tax as well (with the introduction of local public services) in their analysis.

Note that $\frac{dx_2}{dT_2}, \frac{dG_2}{dT_2}$ are identical in computation to equations (7) and (8), only with the corresponding notation. Thus, if we substitute these to the first order conditions and solve, we get the following:

$$T_2 = 0 \tag{19}$$

This means that if the lump sum tax on the resource rents is unrestricted or that otherwise the discovered resource is substantial enough (in the sense that sufficient taxes can be levied on the resource rents so that the efficient level of public good is supplied) then Region 2 can, in fact, efficiently lower its capital tax rates to zero, while as was seen in the previous analysis, the tax rate of Region 1 remains positive.[21] This emphasizes the fiscal advantage the resource gives to the region in which it was found.

Therefore, the capital mobility condition now becomes:

$$L_1^{\alpha} f_{k_1} - T_1 = f_{k_2} \tag{20}$$

Comparing equation (20) to (17) we see that once the resource is introduced to Region 2 (so that it can engage in the inter-regional tax competition more aggressively) at least some positive amount of capital will be drawn to it (since $T_1 > T_2 = 0$); let us mark this amount as K^m. In effect, this means that K^m amount of capital moves from the agglomerated region to the non-agglomerated one; therefore, in case the output loss from the misusage of those K^m capital in the agglomerated region outweighs the output gain from both the usage of the K^m capital in the non-agglomerated region as well as the resource revenues themselves, then this explains why resource abundance can be a 'curse' in decentralized countries. Let us show this in terms of the model, and solve for the agglomeration level (in Region 1) above which a resource endowment (in Region 2) would lower the overall output level of the economy.

Let us denote the equilibrium level of capital in each region (under scenario (20)) as $K_i^{\sim}$. This means that once the resource is introduced and result (20) is derived (so that

[21] The cases of a restricted 'z' or a relatively small resource discovery are not analyzed, since they would present identical mechanisms (to the one presented) only in smaller magnitudes, deeming them uninteresting in terms of providing additional theoretical insights.

K^m capital moves from Region 1 to Region 2), then the gain for the economy as a whole would be:[22]

$$Q + \int_{K_2^{\sim}}^{K_2^{\sim}+K^m} F_{K_2}(L_2) K_2 dK_2 + \int_{K_2^{\sim}}^{K_2^{\sim}+K^m} F_{L_2}(K_2) L_2 dK_2 \tag{21}$$

While the loss for the economy as a whole would be:[23]

$$\int_{K_1^{\sim}-K^m}^{K_1^{\sim}} L_1^{\alpha} F_{K_1}(L_1) K_1 dK_1 + \int_{K_1^{\sim}-K^m}^{K_1^{\sim}} \alpha L_1^{\alpha-1} F_{L_1}(K_1) L_1 dK_1 \tag{22}$$

Solving for the level of agglomeration for which (22) equals (21) yields:

$$\alpha^* = \ln\left(\frac{\mathrm{Q} + \int_{K_2^{\sim}}^{K_2^{\sim}+K^m} F_{K_2}(L_2) K_2 dK_2 + \int_{K_2^{\sim}}^{K_2^{\sim}+K^m} F_{L_2}(K_2) L_2 dK_2}{\int_{K_1^{\sim}-K^m}^{K_1^{\sim}} F_{K_1}(L_1) K_1 dK_1 + \frac{\alpha}{L_1} \int_{K_1^{\sim}-K^m}^{K_1^{\sim}} F_{L_1}(K_1) L_1 dK_1} \right) \frac{1}{\ln(L_1)} \tag{23}$$

Proposition 1. *Once the economy is highly decentralized (so that regions have complete autonomy over determination of tax rates as well as over tax retention and usage) in case the agglomerated region bears enough agglomeration, so that $\alpha > \alpha^*$, an economy experiences decreased overall output (in increased increments) once a resource is introduced in its non-agglomerated region.*

Proof. Once $\alpha > \alpha^*$ *then* $(22) > (21)$ *so that output of the economy as a whole drops; since technology follows the Inada Conditions, aggregate output drops in greater increments as the magnitude of capital movement increases.* □

Proposition 2. *The more populated Region 1 is the lower α^* would be; meaning, greater population density lowers the agglomeration level required to derive a natural resource curse.*

Proof. From equation (23) we get: $\frac{d\alpha^*}{dL_1} < 0$ □

Thus, the above results provide an explanation for observing resource curse effects in decentralized countries. Since the expectation is that discovered resources would be

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[22] The gain for the economy is comprised of the resource endowment (Q), and the sum of the marginal products of capital and labor multiplied by the corresponding factor in Region 1 (taken as an integral over the relevant range of capital).

[23] The loss for the economy is comprised of the sum of the marginal products of capital and labor multiplied by the corresponding factor in Region 2 (taken as an integral over the relevant range of capital).

located in remote, non-agglomerated, and sparsely populated regions, the model shows that once an economy is decentralized, so that the region in which the discovered resource is located can tax and benefit from its rents, then given a resource endowment (in the non-agglomerated region) the economy as a whole will have its output decreased rather than the opposite. The following exercise shows that having a more centralized regime may mitigate this.

2.3 Allocation in a Centralized Regime

Let us consider the other extreme case and assume there exists a benevolent social planner who allocates the capital in the economy (so that no authority is given to the regional governments in that regard, and thus the economy is completely centralized) such that residents' welfare is maximized. The problem of the social planner would be:

$$\underset{\{K_1,K_2\}}{Max}(L_1^{\alpha}F(K_1,L_1)+F(K_2,L_2)+Q)$$

$$\text{Subject to: } K_1+K_2=K^*$$

By solving the above problem, we get the following first order condition:

$$L_1^{\alpha}F_{K_1}(L_1)=F_{K_2}(L_2) \qquad (24)$$

Proposition 3. *Greater agglomeration and density levels in Region 1 lead to directing greater amounts of capital to Region 1, in equilibrium (to the extent that if* $L_1 \geq L_2$ *then* $K_1 > K_2$*).*

Proof. The above results are immediately derived from equation (24), without undertaking further mathematical manipulation. □

Therefore, we see how in a centralized regime the social planner takes advantage of the agglomeration and population density by directing resources to the region that presents them in greater amounts, as opposed to the decentralized scenario where resources were drawn from that region, thus causing the curse. Furthermore, unlike the observations made in the decentralized scenario, under the extreme case of complete centralization a resource endowment would not cause for loss of output due to misusage of capital –for any given levels of agglomeration and density– as the social planner would direct the rents more efficiently across the economy, to the locations with the higher returns. This emphasizes why resource curse effects are observed in decentralized economies, as the above mechanics show how a greater degree of centralization mitigates the loss of output due to the capital movement from agglomerated locations to non-agglomerated ones.[24]

2.4 Allocation in a Corrupted (Decentralized) Economy

Let us introduce variability in corruption levels into the model. Following Torvik (2002), I model corruption as redistribution of government tax revenue to residents, which can be regarded as revenues stolen by residents (or otherwise as tax evasion); in effect, residents get a fraction θ of their government's revenue. The more corrupt is the economy, the greater θ would be. Thus, under this formulation each region allocates only a 1-θ fraction of total tax revenue to supplying the public good, and residents are better off by having increased income, yet are also worse off by the decreased public good provision levels. Following the decentralized case where Region 1 exhibits agglomeration economies and Region 2 receives a resource endowment, we get:

$$G_1 = (1-\theta)T_1 K_1 \tag{25}$$

$$G_2 = (1-\theta)(T_2 K_2 + z) \tag{26}$$

$$x_1 = L_1^{\alpha} f(k_1) - (\rho + (1-\theta)T_1)k_1 + \rho k^* \tag{27}$$

$$x_2 = f(k_2) - (\rho + (1-\theta)T_2)k_2 - (1-\theta)z / L_2 + \rho k^* + \mu q^* \tag{28}$$

By undertaking the same analysis presented in the benchmark case, solving the maximization problem of Region 1 yields:

$$L_1 m(x_1, G_1) = \frac{1}{1 + \frac{T_1}{L_1^{\alpha} k_1} \frac{dk_1}{dT_1}} - \frac{\theta}{(1-\theta)(1 + \frac{L_1^{\alpha} f_{k_1 k_1} k_1}{T_1})} \tag{29}$$

Solving the same problem for Region 2 yields an identical expression as (29), only having '1' on the left hand side, so that in equilibrium:

$$T_2 \to 0 \tag{30}$$

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[24] Note that this model ignores the regular 'Dutch Disease' effects and institutional-ills, which can remain relevant under the centralized and decentralized scenarios. This is done so the focus would be on the specific difference between centralized and decentralized economies, showing how the resource curse is more likely to affect a decentralized economy, yet in turn disappear (or be reversed) in a centralized one.

Equations (25)-(28) show that in equilibrium public good provision will decrease by the same fraction in each region, while income of residents will increase by a greater amount in Region 2, due to the resource; in addition, equations (29)-(30) show that in equilibrium tax rates in both regions would have to increase to maintain the efficient level of public good,[25] yet would still be driven to zero in Region 2 provided a sufficiently profitable resource is introduced.[26]

Proposition 4. *The natural resource curse in decentralized countries becomes worse with higher national corruption levels.*

Proof. Since T_1 .increases as θ increases, then by Equation (20) we see that greater corruption levels lead to greater capital flows to Region 2, thus intensifying the curse. □

This result mitigates concerns regarding the applicability of the initially suggested mechanism to economies with weak institutions, as it suggests that the mechanism rather intensifies in such economies. Also, it helps to explain the empirical observation made by Michaels and Caselli (2009), who show that Brazilian municipalities did not decrease tax rates with increases in oil endowments (contrary to the initial prediction of the model).[27]

Note that making labor mobile would only intensify the process further as higher corruption levels would bring greater amounts of labor to Region 2 given the potential to steal greater amounts of revenues (presenting greater overall income levels to residents in that region). Also, this means that as corruption increases greater emphasis would be given to rent-seeking behavior (rather than tax competition mechanisms) as the triggering mechanism for the resource reallocation process. This shows that in economies with particularly weak institutions that do not promote tax competition mechanisms (and perhaps do not use tax revenues towards public good provision) the basic resource

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[25] This is because the addition of θ would increase the LHS of Equation (29), while decrease its RHS, so that tax rates must be increased to balance that back to equilibrium.

[26] Note that it is implicitly assumed that governments would still aim at supplying the efficient level of public goods despite the higher corruption. This acts as a simplifying assumption. A more realistic view on this would make public good provision endogenous to corruption levels so that more corrupted governments would not necessarily aim at providing the efficient level of public goods.

[27] Michaels and Caselli (2009) present a ‘missing money’ mechanism in Brazilian municipalities, thus implying for the relatively weak institutions in Brazil.

reallocation process still occurs, so that the curse of decentralized regimes remains applicable and even potentially intensifies.[28]

3. Empirical Evidence

This section provides empirical support for both the main hypothesis of the paper, as well as for the mechanism suggested (taking the United States as a case study); robust checks are presented as well. In the first sub-section the growth effects of natural resources are estimated; to correlate this to the model (which does not discuss growth per-se), I assume that the one period of the model represents the entire transition period from one steady state to another, having an approximate constant growth rate throughout that timeframe.

3.1 Testing the Main Hypothesis

The main hypothesis of this paper is that resource abundance is harmful to countries with a high degree of fiscal decentralization, yet is beneficial for countries with a low degree of fiscal decentralization. To test this hypothesis against Sachs and Warner's (1997), I use their data and methodology.[29] As for a fiscal decentralization measure, I follow Davoodi and Zou (1998), Oates (1985, 1993), and Zhang and Zou (1998), and use the World Bank's Fiscal Decentralization Indicators.[30] Since the World Bank provides several such measures, I use the one that most closely resembles the model's notion of

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[28] Nonetheless, Russia is consistently ranked amongst the most corrupt economies (by 'Transparency International') yet Treisman and Cai (2005) nevertheless find it exhibits an inter-regional tax competition mechanism, where regional governments compete for production factors through both tax means as well as public good provision. Having this mechanism in Russia implies it is also applicable to highly corrupted economies (so that it does not only involve a rent-seeking mechanism in those levels of corruption).

[29] Please refer to Sachs and Warner (1997) for full description of data and sources. Note that this data can be downloaded from the Centre for International Development at Harvard.

[30] The World Bank Fiscal Decentralization Indicators are based on data from the International Monetary Fund's *Government Finance Statistics*. In terms of coverage, indicators are only provided for countries that reported expenditures at both the national and sub-national levels. Nonetheless, as is 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 on differences in the degree of fiscal decentralization between countries included in the sample and those that are not (as the sample ranges from highly decentralized countries, to highly centralized ones).

fiscal decentralization, which is the degree to which sub-national governments fund their expenditures through their own revenue sources. 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.[31]

Following Sachs and Warner (1997), let us test the following model:[32]

$$G^i = \alpha_0 + \alpha_1 \ln(Y_0{}^i) + \alpha_2 R^i + \alpha_3 Z^i + \varepsilon^i \quad (31)$$

Where 'G' is average annual real per capita GDP growth (1970-1990), $'Y_0'$ is per capita GDP in 1970, 'R' is the resource-share proxy measured in 1970,[33] and 'Z' is a vector of control variables that includes openness, investment, institutional quality, ethnicity, terms of trade, secondary school enrollment, fiscal decentralization measure, and interaction terms of ethnicity, institutional quality, and the fiscal decentralization measure with the resource-share proxy.[34]

Results are presented in Table 1. Regression 1 confirms (and in fact, replicates) Sachs and Warner's (1995, 1997) results on convergence, openness, investment, institutional quality, and resource abundance. In Regression 2 the fiscal decentralization measure is added, having a negative and significant coefficient, as expected. In Regression 3 the interaction term between the fiscal decentralization and resource-share measures is added; not only does its coefficient have a negative and significant coefficient (implying how a higher degree of fiscal decentralization amplifies the growth curse), but it also turns the coefficient of the resource-share proxy to be positive and slightly significant (at the 10% level). This result holds in Regression 4 where additional explanatory variables are added (ethnicity, terms of trade, and secondary school

[31] 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 did not have such a measure available up to 1975 were not included in the sample; this amounts to having 48 countries in the sample.

[32] Where 'i' denotes the country.

[33] Resource-share is measured as the share of mineral output in total GDP. Additional measures will be considered when checking for robustness.

[34] Note that a list of variables (with their description and sources) is provided in Appendix 1.

enrollment) and even strengthens with respect to the coefficient of the resource-share proxy which increases in both magnitude and significance. Following Hodler's (2004) and Mehlum et al.'s (2006) results, interaction terms of ethnicity and institutional quality with the resource-share proxy are added in Regression 5; the coefficient on the interaction term of the fiscal decentralization measure with the resource-share proxy remains negative and significant, whereas the coefficients of the former two interaction terms are insignificant. Although these regression results are not presented, the results do not change qualitatively even if each of the variables in Regressions 4 and 5 are added separately to the regression.

Let us now test the hypothesis that decentralized economies do not benefit from resource endowments due to factor movements to non-agglomerated regions.[35] I construct a measure for an economy's *potential vulnerability* to this, by dividing each country's total non-agglomerated area by its total area (both in square kilometers).[36] Since by definition resources are located in non-agglomerated areas, this estimate gives a measure of an economy's capacity to be damaged by misusage of factors in non-agglomerated areas, triggered by resource endowments. Note that this measure has an insignificant relationship with resource abundance (r^2=0.00, p<0.415); meaning, having larger shares of non-agglomerated areas does not necessarily lead to greater resource dependence. Also, note that the sample shows weak relation between this measure and growth or per capita income, so that it is not necessarily the case that richer countries present a lower measure.[37]

[35] Instead, this can also be viewed as the resource endowment inhibiting further agglomeration in the more densely populated region (thus, also hurting aggregate output).

[36] All data was retrieved from the Center for International Earth Science Information Network at Columbia University; data is relevant for 2001. The calculation of non-agglomerated areas follows the definition of non-agglomeration as given by the UN (on per-country basis).

[37] This, in turn, mitigates endogeneity-related concerns; however, even if this measure was to correlate with an unobserved variable the expectation would be that such correlation would be negative, so that estimations are biased upwards. Since estimators are already negative (as seen in Table 2) this implies that in case an omitted variable bias is indeed potentially applicable, the real estimator would only be more negative (implying that results would not change qualitatively, and would only strengthen quantitatively).

The prediction is that decentralized economies with greater ‘capacity’ (as measured by the above index) are more vulnerable to the growth curse; thus, I multiply the initially used fiscal decentralization measure and the above index (such that higher measures refer to economies with greater decentralization and ‘capacity’ measures), and use this updated index instead of the decentralization measure to follow the same regressions of Table 1. Results are presented in Table 2, and follow those of Table 1 but with greater magnitude and significance. This provides some validation to the underlying mechanism, implying that resource endowments hurt decentralized economies through the non-agglomeration channel. Indeed, this test only looks at the final outcome (effect on growth) and does not confirm the mechanisms of tax competition and capital reallocation to non-agglomerated regions; nonetheless, these mechanisms will be tested and confirmed in the final section, for the case of the United States.

3.2 Robust Checks

Let us test the model presented in equation (31), using a different fiscal decentralization measure. Thus, I use a Fiscal Decentralization Indicator (from the indicators presented by the World Bank) that measures the degree of tax autonomy of sub-national governments. This is measured by the share of local tax revenue out of total sub-national revenues (once again, reported as a number between 0 and 100, so that the closer it is to 100 the greater the degree of fiscal decentralization). All other data remains as before.

Results are presented in Table 3, and are not much different than those presented in Table 1 for the initial fiscal decentralization measure. The coefficient of the interaction term between the fiscal decentralization measure and the resource-share proxy is negative and significant in each of the regressions and remains so even when all the previously-mentioned control variables and interaction terms are added; an exception to this is made when the terms of trade variable is added (which is why it was left for Regression 4) where the significance of the coefficient in-interest drops slightly (to $p<0.09$). Once again, note that even though all the separate regression outcomes are not presented, results do not change qualitatively in case each of the variables (after Regression 1) is added separately to the regression.

Let us now test the model of equation (31) using different resource-share measures. In Sachs and Warner's (1995, 1997) analysis, as well as in those of other resource curse studies, a measure usually used is that of primary exports as share of either total exports or of total GDP. Following that, I test the model using two additional resource-share measures; the first is the share of exports of point-source resources out of total exports, and the second is the same share only out of total GDP. All data was retrieved from the cross-country database of the World Bank; all other variables remain the same (including using the initial measure of fiscal decentralization).

Results for the first resource-share measure are presented in Table 4, while those for the second appear in Table 5. For both measures, the coefficient of the interaction term between the fiscal decentralization measure and the resource-share proxy remains negative and significant in all regressions except in the one where the two other interaction terms are entered together to the regression (making the interaction term of interest insignificant); thus, besides that specific case, the main result is maintained even when different resource-share measures are considered.

3.3 Testing the Suggested Mechanism for the United States

Let us test the suggested mechanism taking the United States as a case study. The United States presents a relevant and valid example because firstly, it is a federation so that it exhibits a relatively high degree of fiscal decentralization by definition,[38] secondly its states are quite heterogeneous in terms of resource abundance, and thirdly it has relatively strong institutions which by Proposition 4 implies that in case the mechanism is validated for it then it is expected to also be validated for many other economies.[39]

To be able to validate the suggested mechanism, I examine the state-level correlation between resource abundance and the tax environment, per capita capital

[38] Nonetheless, according to the World Bank's Fiscal Decentralization Indicators the US is considered to be relatively centralized; however, this is mainly due to its equalization schemes. It nevertheless constitutes a relevant example in that respect, because of the high fiscal autonomy given to its states.

[39] Given that most other economies have institutional quality that is either comparable or inferior to that of the United States.

formation level, and agglomeration level. Note that in all instances I use the share of primary output out of total GDP as the proxy for resource abundance.[40]

3.3.1 Resources and the Tax Environment

Let us test the following model:[41]

$$Tax^i = \alpha_0 + \alpha_1 R^i + \varepsilon^i \tag{32}$$

Where 'R' is the resource-share proxy (measured in 2006), and 'Tax' is the average 'State Business Tax Climate Index' for 2006-2011. This index, published annually (since 2006) by the US Tax Foundation, ranks US states by their 'tax-friendliness' to business. The Index is a number from 1 to 10, where 1 is least friendly, and 10 is friendliest. The general ranking is based on an average of five 'Business Tax Climate Indices' for each of five tax groups; namely – unemployment insurance tax, corporate tax, sales tax, income tax, and property tax. I test equation (32) twice; in the first case the general 'State Business Tax Climate Index' is used, and in the second the corporate-tax 'State Business Tax Climate Index' is employed (due to its relevancy to the model, which discusses capital taxes).

In both cases the result is positive and significant (r^2 = 0.2213, p<0.00 in the former case, and r^2 = 0.1128, p<0.017 in the latter case), implying that resource abundant states tend to present more competitive tax environments.

3.3.2 Resources and Capital

Let us test the following model:

$$Cap^i = \alpha_0 + \alpha_1 R^i + \varepsilon^i \tag{33}$$

Where 'R' is the resource-share proxy (measured in 1997), and 'Cap' is the average per capita physical capital formation level for 1997-2006.[42] The result is positive and significant (r^2 = 0.5532, p<0.00) implying that resource abundant states tend to attract

[40] All state-level data on resource-share was retrieved from the US Bureau of Economic Analysis.

[41] In this test, as well as in the following ones of this section, 'i' denotes a state.

[42] All data on physical capital was retrieved from the US Bureau of Economic Analysis. Note that due to data availability limitations the sample does not include the following states: District of Columbia, Montana, North Dakota, Nevada, South Dakota, and Wyoming.

higher levels of physical capital.[43] This result is also confirmed for Russia (Treisman 2009),[44] as well as for Canada (Raveh 2010).

3.3.3 Resources and Agglomeration

Let us test the following model:

$$Agg^{i} = \alpha_0 + \alpha_1 R^{i} + \varepsilon^{i} \tag{34}$$

Where 'R' is the resource-share proxy (measured in 1977), and 'Agg' is the state-level agglomeration index of Ciccone and Hall (1996). The index, measured in 1988, ranks US states according to their agglomeration level (the higher it is, the higher is the agglomeration level of a state).[45] This index is particularly appealing for this current test for two reasons; firstly, the model follows Ciccone and Hall (1996) in the modeling of agglomeration effects so that their index should correspond well to the model, and secondly, since Ciccone and Hall treat land as equal in their model they specifically exclude any output and employment effects of the primary sector when computing the index, which means that this index provides a measure of agglomeration level that is independent of state-level resource abundance measures (meaning, results are not driven by the richness or scarcity of resources in any given state, thus providing an objective measure of agglomeration for the given test).[46]

The result is negative and significant (r^2 = 0.4255, p<0.00), implying that resources tend to locate in non-agglomerated and sparsely populated regions.

3.3.4 Validating the Mechanism

[43] While capital formation provides good indication for the amount of physical capital that was formatted, or otherwise imported, by a certain region, it does not provide any indication for the source of the capital in case it was indeed imported (so that it could have, essentially, been imported to the region from other intra-federal sources as much as from other countries); therefore, by assuming that the mobility costs of physical capital decrease with distance (implying that physical capital is imported mostly from nearby regions), this imperfect measure of intra-federal physical capital flows still permits tentative conclusions.

[44] Although in his measure of initial endowment Treisman and Cai (2005) includes endowments of human capital and physical infrastructure, in addition to those of natural resources.

[45] Please refer to Ciccone and Hall (1996) for complete details on this index.

[46] As a result they drop Alaska, Louisiana, West Virginia and Wyoming from the index, given their relatively high dependence on the primary sector.

Given the results presented in this section, we see that in the United States resource abundant states tend to present more competitive tax environments, attract greater amounts of physical capital, and present lower levels of agglomeration economies, so that in effect capital flows from agglomerated regions to non-agglomerated ones (thus, validating the suggested mechanism). The output loss from the usage of capital in non-agglomerated regions rather than agglomerated ones is implied through the findings of previous studies; specifically, for the case of the United States Ciccone and Hall (1996) show firstly that more than half of the variance in output per worker is explained by the density of economic activity,[47] and secondly that the (positive) association between agglomeration and productivity is even stronger than that between education and productivity, to the extent that a doubling of employment density increases average labor productivity by approximately 6 percent.[48] Assuming that labor and capital are complementary (as is done in the model) these results imply that in the United States the foregone aggregate output due to the misusage of capital in non-agglomerated regions is potentially substantial.[49] To generalize this further, Brulhart and Sbergami (2008) show that the potential foregone growth is highest rather in the poorest countries; thus, together with Proposition 4 this provides an indication that the main result could potentially generalize beyond the case of the United States or other equally developed countries, and would actually intensify in less developed ones.[50]

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[47] In 1988 the output per worker in the most productive state was two thirds higher than that in the least productive one, implying that this variance in labor productivity was quite substantial.

[48] Similar findings were also derived for other regions (See Brulhart and Mathys 2008, and Ciccone 2002).

[49] To the extent that $\alpha > \alpha^*$ which in terms of the model means that aggregate output in the United States drops in case a resource is found in a remote region. Nonetheless, note that an equalization scheme mitigates that (as it raises a country's degree of centralization, based on the measures used in this paper) which explains why a resource curse is not observed in the United States (as well as in Canada or Australia, which are also expected to have a relatively high degree of decentralization) as well as why the United States (again, in addition to Canada and Australia) is ranked amongst the more centralized countries based on the World Bank Fiscal Decentralization Indicators.

[50] Although the expectation is that in less developed countries agglomeration would be less apparent, the foregone growth could rather be drawn from the population densities (since as the model shows, higher

4. Concluding Remarks

The question of why resource endowments lead to divergent outcomes continues to attract much interest among economists. This paper attempts to present an additional answer to that question; the main hypothesis is that countries with a high degree of fiscal decentralization are more vulnerable to the so-called natural resource curse.

Celebrated counter-examples are Venezuela and Botswana; both are heavily endowed with natural resources, yet the former experienced negative growth rates in the period of 1965-1990, 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.

By extending the work of Zodrow and Mieszkowski (1986), the model suggests a simple mechanism for the occurrence of a natural resource curse in fiscally decentralized countries. In highly decentralized economies a resource endowment gives the region in which it is located an advantage in the inter-regional tax competition over capital so that some amount of capital is drawn to it. Since resources tend to locate in remote, sparsely populated, and non-agglomerated regions, capital flows from agglomerated and highly populated regions to non-agglomerated and sparsely populated ones. Having sufficiently high agglomeration or population density levels would cause aggregate output in the economy to drop with any such movement of capital, as the loss of output in the agglomerated region would outweigh the sum of increased output in the non-agglomerated region and the resource output itself. In addition, the model shows this mechanism would only intensify as corruption-level increases (though the triggering force would be rent-seeking behavior rather than tax competition), mitigating concerns regarding the validity of the suggested mechanism in economies with weak institutions.

This theory is empirically tested, and confirmed, using Sachs and Warner's (1997) data set in conjunction with the World Bank's Fiscal Decentralization Indicators and a cross-country agglomeration index; results are robust to different resource-share

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population densities decrease α^*), or from inhibiting the emergence of agglomeration as is implied by Brulhart and Sbergami (2008).

and fiscal decentralization measures. In addition, empirical evidence is provided for the validation of the mechanism in the United States.

These insights may carry certain policy implications for resource rich economies. Nonetheless, given the limited sample size it should be noted that results may be sensitive to the specific periods and countries investigated. Future research may test the main hypothesis for extended periods and a larger sample size. An additional limitation rests on the assumption over the exogeneity of the degree of fiscal decentralization. In economies where natural resources were discovered at an early stage, the degree of fiscal decentralization may actually be endogenous to the resource discovery, rather than the opposite; thus, this notion of endogenous decentralization merits further research.

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Appendix 1: List of Variables Used in the Regressions

G

Average annual growth in real GDP per person in the years 1970-1990. Source: Sachs and Warner (1997).

LnY_0

The log of real GDP per capita in 1970. Source: Sachs and Warner (1997).

Resource-share

Measure 1 (used in Tables 1, 2, 3): Share of mineral production in total GDP, in 1970. Source: Sachs and Warner (1997).

Measure 2 (used in Table 4): Share of exports of point-source resources out of total exports, in 1970. Source: World Bank.

Measure 3 (used in Table 5): Share of exports of point-source resources out of total GDP, in 1970. Source: World Bank.

Measure 4: (used in Section 3.3): Share of primary production in total GSP (at the state level), in 1977, 1997, and 2006. Source: US Bureau of Economic Analysis.

Openness

The fraction of years over the period 1970-1990 in which the country is rated as economically open. Source: Sachs and Warner (1997).

Investments

The log of the ratio of real gross domestic investment to real GDP, averaged over the period 1970-1989. Source: Sachs and Warner (1997).

Institutional – quality

The rule of law index from the International Country Risk Guide. Source: Sachs and Warner (1997).

Decentralization

Measure 1 (used in Tables 1, 2, 4, 5): The extent to which sub-national governments rely on their own revenue sources for their expenditures. Source: World Bank Fiscal Decentralization Indicators.

Measure 2 (used in Table 3): The fraction of tax-revenue out of total revenue of sub-national governments. Source: World Bank Fiscal Decentralization Indicators.

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. Source: Sachs and Warner (1997).

Terms of Trade

The average annual growth rate in the log of the external terms of trade between 1970 and 1990. External terms of trade are defined as the ratio of an export price index to an import price index. Source: Sachs and Warner (1997).

Secondary

Secondary school enrollment rate. Source: Sachs and Warner (1997)

Tax

Average of the 'State Business Tax Climate' (under the general index, and the corporate-tax index) for 2006-2011. Source: US Tax Foundation.

Cap

Average of state-level physical capital formation for 1997-2006. Source: US Bureau of Economic Analysis.

Agg
State-level density index in 1988. Source: Ciccone and Hall (1996).

Potential-Vulnerability
Total non-agglomerated area divided by total area (both in square-kilometers, in 2001) multiplied by ‘Measure 1’ of decentralization. Source: Center for International Earth Science Information Network at Columbia University.

Tables

TABLE 1. *Cross-country growth regressions, as in equation (31)*

Dependent variable: G	(1)	(2)	(3)	(4)	(5)
LnY_0	-1.03133*** (0.2827251)	-1.03977*** (0.2696865)	-1.12938*** (0.3016955)	-1.53527*** (0.369672)	-1.55668*** (0.3657131)
Resource-share	-4.834356** (1.976576)	-5.20885*** (1.892994)	7.959715* (4.426939)	9.574843** (4.655918)	17.99191 (15.35616)
Openness	2.198221*** (0.6502446)	1.813671*** (0.6446935)	2.051534*** (0.5404735)	2.093378*** (0.6453463)	2.064971*** (0.6408677)
Investments	1.3804753** (0.6316999)	1.5104591** (0.6054368)	1.6051781** (0.6649918)	1.4312241** (0.6400786)	1.4765251** (0.6349475)
Institutional quality	-0.0695953 (0.1598002)	-0.0375524 (0.1531191)	-0.0435244 (0.1663922)	-0.0234722 (0.1815559)	-0.0282861 (0.1972332)
Decentralization		-0.013255** (0.0060682)	-0.0004703 (0.0077054)	0.0021696 (0.0076591)	0.0032077 (0.0077196)
Decentralization x Resource share			**-0.16391*** (0.0497473)**	**-0.16918*** (0.0460583)**	**-0.18728*** (0.0589395)**
Ethnicity				-0.0107618* (0.0061532)	-0.0077233 (0.0064181)
Terms of trade				0.0766425 (0.0881956)	0.0317594 (0.1261204)
Secondary				1.1368061* (1.136806)	2.189066* (1.12204)
Ethnicity x Resource share					-0.0457595 (0.044218)
Institutional-quality x Resource share					-1.506834 (3.172589)
R-squared	0.6504	0.6903	0.7449	0.7888	0.7931
N	44	44	44	43	43

Note: Standard errors are robust, and clustered by federation. Standard deviations for independent variables appear in parentheses. Superscripts correspond to a 10, 5 and 1% level of significance.

TABLE 2. *Cross-country growth regressions, as in equation (31), using the 'potential vulnerability' measure (instead of decentralization)*

Dependent variable: G	(1)	(2)	(3)	(4)
LnY_0	-1.08149*** (0.3086269)	-1.15655 *** (0.2925429)	-1.54456*** (0.3644936)	-1.56279*** (0.3627893)
Resource-share	-5.125767** (2.17043)	7.370448* (4.325586)	8.836363* (4.684169)	7.683663 (7.31059)
Openness	1.731396*** (0.5288838)	2.01806*** (0.473754)	2.0712*** (0.6607158)	2.04277*** (0.6527509)
Investments	1.527727*** (0.3614857)	1.620076** (0.3461282)	1.44453** (0.6513082)	1.477838** (0.6458226)
Institutional quality	-0.0266414 (0.1630934)	-0.0334725 (0.1626523)	-0.0168727 (0.1763552)	0.036383 (0.1922965)
Potential-vulnerability	-0.014714** (0.0068355)	-0.0017803 (0.0077712)	0.0008637 (0.0081325)	0.0019549 (0.0084121)
Potential-vulnerability x Resource share		**-0.16051*** (0.0493931)**	**-0.16451*** (0.0477883)**	**-0.18282*** (0.0627853)**
Ethnicity			-0.0104209* (0.0059888)	-0.007831 (0.0062614)
Terms of trade			0.0729155 (0.0874601)	0.0297318 (0.1265215)
Secondary			2.131713* (1.157875)	2.185249* (1.146248)
Ethnicity x Resource share				-0.0388097 (0.0422918
Institutional-quality x Resource share				1.567744 (3.206667)
R-squared	0.7122	0.7627	0.7918	0.7953
N	45	45	43	43

Note: Standard errors are robust, and clustered by federation. Standard deviations for independent variables appear in parentheses. Superscripts correspond to a 10, 5 and 1% level of significance.

TABLE 3. *Cross-country growth regressions, as in equation (31), using level of tax-autonomy as the fiscal decentralization measure*

Dependent variable: G	(1)	(2)	(3)	(4)
LnY_0	-1.35923*** (0.3260202)	-1.60091*** (0.3035236)	-1.59180*** (0.336566)	-1.89027*** (0.3207262)
Resource-share	1.392931 (4.225283)	1.966771 (4.432649)	1.922866 (8.687374)	-16.73506 (10.12938)
Openness	2.324475*** (0.5099492)	2.060459*** (0.5375463)	2.008024*** (0.6035224)	1.900966*** (0.5461853)
Investments	1.3180861** (0.6360415)	1.5092412** (0 .6731072)	1.4450513** (0.6463283)	1.5678081** (0.5851186)
Institutional quality	0.0414778 (0.1661382)	0.0487909 (0.1580045)	0.0541648 (0.1701824)	0.0205032 (0.1540993)
Decentralization	0.002504 (0.0089186)	0.0027883 (0.0092497)	0.0043237 (0.0097734)	0.006647 (0.0088609)
Decentralization x Resource share	**-0.166574**** **(0.0727885)**	**-0.172132**** **(0.075937)**	**-0.225988**** **(0.0097734)**	**-0.168017*** **(0.0963913)**
Ethnicity		-0.0042048 (0.005947)	-0.0065546 (0.0067236)	-0.0113061 (0.0062865)
Secondary		1.729987 (1.10109)	1.869325 (1.533522)	2.647741 (1.410261)
Institutional-quality x Resource share			-0.2888045 (2.391439)	4.25465 (2.66426)
Ethnicity x Resource share			0.059122 (0.0801282)	0.0947188 (0.073377)
Terms of trade				0.258637*** (0.0888393)
R-squared	0.7153	0.7456	0.7499	0.8023
N	47	45	45	45

Note: Standard errors are robust, and clustered by federation. Standard deviations for independent variables appear in parentheses. Superscripts correspond to a 10, 5 and 1% level of significance.

TABLE 4. *Cross-country growth regressions, as in equation (31), using share of exports of point-source resources out of total exports as the resource-share proxy*

Dependent variable: G	(1)	(2)	(3)	(4)	(5)
LnY_0	-0.880471** (0.3646846)	-1.36258*** (0.3737157)	-1.20851*** (0.3385816)	-1.31404*** (0.3325397)	-1.25093*** (0.375272)
Resource-share	1.252563 (1.422099)	1.931363 (1.758219)	4.613334* (2.607112)	-3.823351 (4.973574)	0.0425797 (9.612731)
Openness	2.313803*** (0.7474287)	2.157653*** (0.6940024)	2.10618*** (0.671295)	2.229959*** (0.6947846)	2.171755*** (0.7420342)
Investments	1.5330261** (0.6840888)	1.28586* (0.6458927)	1.461579** (0.671113)	1.493276** (0.6732404)	1.501498** (0.6909746)
Institutional quality	-0.200767 (0.199687)	-0.123458 (0.179922)	-0.1990295 (0.1630682)	-0.2344341 (0.1869804)	-0.2288407 (0.189325)
Decentralization	-0.0064798 (0.0088393)	-0.0033204 (0.0082008)	-0.0028291 (0.0085378)	-0.0024237 (0.0088681)	-0.0025336 (0.0088709)
Decentralization x Resource share	**-0.041286**** **(0.0204431)**	**-0.05748***** **(0.021168)**	**-0.082347**** **(0.0334965)**	**-0.042828**** **(0.0192557)**	**-0.0624438** **(0.0495474)**
Ethnicity		-0.014717* (0.007453)	-0.0108309 (0.008154)	-0.0135157* (0.0070927)	-0.0119141 (0.0064181)
Terms of trade		0.1780687 (0.1188625)	0.218271 (0.1435323)	0.2153645 (0.144393)	0.2215052 (0.1495588)
Secondary		2.448015* (1.286565)	2.323207* (1.302021)	2.263759* (1.252156)	2.273406* (1.275457)
Ethnicity x Resource share			-0.0541383 (0.0414884)		-0.0293288 (0.0623424)
Institutional-quality x Resource share				1.475113 (1.235898)	0.8565848 (1.806299)
R-squared	0.66	0.7480	0.7592	0.7594	0.7607
N	43	43	43	43	43

Note: Standard errors are robust, and clustered by federation. Standard deviations for independent variables appear in parentheses. Superscripts correspond to a 10, 5 and 1% level of significance.

TABLE 5. *Cross-country growth regressions, as in equation (31), using share of exports of point-source resources out of total GDP as the resource-share proxy*

Dependent variable: G	(1)	(2)	(3)	(4)	(5)
LnY_0	-0.807116** (0.3609121)	-1.23615*** (0.371845)	-1.22079*** (0.3786123)	-1.20463*** (0.36833)	-1.22831*** (0.374715)
Resource-share	2.103215 (1.746934)	2.898086 (1.943486)	3.997349 (3.615031)	-3.599773 (9.306273)	-32.62621 (44.17976)
Openness	2.30194*** (0.7796155)	2.046873*** (0.7073358)	2.053489*** (0.711325)	2.05698*** (0.710069)	2.035946*** (0.7114031)
Investments	1.637681** (0.6727717)	1.454012** (0.632333)	1.469111** (0.6542048)	1.497325** (0.6534535)	1.512545** (0.6526773)
Institutional quality	-0.2553639 (0.1980332)	-0.1721973 (0.1648909)	-0.1805295 (0.1636116)	-0.2001134 (0.1649522)	-0.2210455 (0.17375)
Decentralization	-0.0060043 (0.0081232)	-0.0031605 (0.0077687)	-0.0030428 (0.0080344)	0.0029996 (0.0080764)	-0.003433 (0.0085166)
Decentralization x Resource share	**-0.13156***** **(0.0416332)**	**-0.18734***** **(0.0578351)**	**-0.19311***** **(0.0692713)**	**-0.15886***** **(0.0525913)**	**-0.0241243** **(0.2070135)**
Ethnicity		-0.0122597* (0.0071432)	-0.0117788 (0.0078935)	-0.0115159 (0.0075004)	-0.0130167 (0.0081453)
Terms of trade		0.2247439* (0.1319533)	0.2269212 (0.1375892)	0.2332839 (0.1425155)	0.2426417 (0.1491389)
Secondary		2.322048* (1.258722)	2.298127* (1.281483)	2.2354* (1.258624)	2.154997* (1.236527)
Ethnicity x Resource share			-0.0195766 (0.0534768)		0.1556119 (0.2101512)
Institutional-quality x Resource share				1.555027 (2.228642)	6.410356 (7.850319)
R-squared	0.6751	0.7683	0.7686	0.77	0.7728
N	43	43	43	43	43

Note: Standard errors are robust, and clustered by federation. Standard deviations for independent variables appear in parentheses. Superscripts correspond to a 10, 5 and 1% level of significance.