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Green Accounting, Institutional Quality and Investment Decisions: Macroeconomic Implications from an Analysis of the Oil and Mining Sector

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Abstract

This paper investigates the effect of institutional quality on sustainable development. Institutional quality is assumed to determine the (perceived) risk in the face of which oil and mining firms determine their level of investment in physical and natural capital. Since these two types of capital are used jointly in the industry's production process, the firms face a dual investment decision, whereby they have to decide on the investment into both types of capital simultaneously. It is shown that this production structure implies that better institutional quality can increase as well as decrease the speed of resource extraction. However, due to the structure of national accounting data, this fact has so far not been adequately accounted for in preceding studies. By integrating the dual investment model into the green accounting approach it is then shown that the form of capital aggregation in national accounting can lead to an underestimation of the effect of institutional quality on sustainable development and potentially on economic growth. The results imply that it could be useful to investigate the macroeconomic effects of institutional quality on the oil and mining sector separately from those on the rest of the economy.

Keywords: exhaustible resource extraction, institutions, ownership risk, resource curse, adjusted net saving /genuine saving, green accounting, sustainable development

JEL: Q32, Q56, Q01

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1 Introduction

The existing literature argues that institutional quality has a positive effect on sustainable development. Contrary to this, I show that the effect can also be negative. More specifically, integrating a dual investment model into the green accounting framework that measures (weak) sustainable development leads to a predicted effect whose direction is unclear. I start from the basic premise that, all other things being equal, better institutions lead to higher rates of saving and investment through their effect on the level of uncertainty and risk. The reasoning behind this is that strong institutions encourage households and firms to invest by ensuring that rules do not change arbitrarily, which allows long-term planning.

Institutions are understood as "the humanly devised constraints that structure political, economic and social interaction.[...][They] have been devised by human beings to create order and reduce uncertainty in exchange." (North, 1991, p.97).[1] In short, they are the written and unwritten rules and norms that organize the life of individuals (Glaeser, Lopez-de Silanes, La Porta & Shleifer, 2004) and as such provide the framework in which interactions in an economy take place (The World Bank, 2002). In this sense, institutions provide the environment in which economic actors take decisions and they thus influence the structure and effects of economic incentives in society.

However, at the heart of this influence on the macroeconomic environment are microeconomic decisions. The approaches towards institutions and growth share the assumption that property rights and political stability, among others, are deemed important to foster investments in capital. Institutional quality can then be thought of as a background risk as described in Elbers, Gunning & Kinsey (2007), where the insecurity that arises from the (perceived) likelihood of a shock occurring in the future (e.g. a war breaking out or the threat of expropriation) has a powerful effect on firms' and households' investment decisions, although the event may never actually occur. [2]

[1]For an overview of the concept of institutions, see e.g. Juetting, 2003.

One of the channels that has received much attention is the relationship between institutions and growth (for an overview see e.g. Acemoglu, 2009; Aghion & Howitt, 2009). In this context, institutions provide the environment in which firms and individuals decide on their economic activity, such as investments and the level of production. Weak institutions can lead to a poor enforcement of property rights, a higher threat of expropriation, nationalization or generally higher ownership risk. In that way, institutions have a major impact on the macroeconomic environment.

This line of reasoning is also valid when the concept of capital is extended to include natural and intangible capital in addition to physical capital. When overall capital is the sum of these three forms of capital, change in overall capital from one period to the next is the sum of the changes of its parts (The World Bank, 2006):

$$\Delta K = \Delta K^P + \Delta K^N + \Delta K^H \tag{1}$$

where K = overall capital, K^P=produced capital, K^N=natural capital, K^H=human capital and Δ stands for the change from one period to the next.

The effect of institutional quality on the change in natural capital (ΔK^N) is widely expected to be positive, implying that better institutions lead to less disinvestment (lower extraction rates) in natural capital. This goes back to Hotelling (1931) who shows that an "increase in the discount rate leads to a faster depletion of exhaustible resources" (quoted from Farzin, 1984, p.841) and to van Long (1975) who shows how the exploitation of exhaustible resources changes under the threat of nationalization. A recent application on how countries with incomplete property rights are likely to overuse their natural capital is given by van der Ploeg (2010) who shows that countries with different groups with imperfectly defined property rights on natural resources can suffer from to overexploitation.

[2] Background risk is understood as exogenous risks that are not under the control of the agent, and that are independent of endogenous risks, see Eeckhoudt, Gollier & Schlesinger (1996).

Among the most frequent theoretical and empirical explanations for the so-called 'resource curse', that is the fact that countries with a high share of natural resources tend to suffer from low rates of economic growth despite their good resource endowment, is the impact of institutional quality (van der Ploeg, 2011; Deacon, 2011). This view can be summarized in the hypothesis that "the resource curse can be turned into a blessing for countries with good institutions" (van der Ploeg, 2011, pp. 373-374). More specifically, there is also evidence that resource-abundant countries have greater rates of investment and saving if they have good institutions (Atkinson & Hamilton, 2003) and that institutional quality plays a particularly important role for development in countries with large resource endowments (International Monetary Fund, 2012).

Most of the reasoning in this literature is based on what Laurent-Lucchetti & Santugini (2012) call a "conventional wisdom of resource economics" and which is in fact one of the central propositions in the economics of exhaustible resources: A higher risk of expropriation decreases the expected marginal rate of return of exploiting the natural resource stock in the future, which increases extraction today. This implies that increasing the risk of expropriation leads to a higher discount rate and hence larger disinvestment in the natural capital stock. This decreases the potential future returns compared to the case of later extraction, leading to an overuse of the resource stock by the firm and thus to higher extraction in the presence of a weak institutional environment.

The effect of institutional quality on the change in overall capital (ΔK in equation 1) is expected to be positive as a result of the expected positive effects on its parts. This has been discussed and shown empirically by Dietz, Neumayer & Soysa (2007) and Stoever (2012). However, the two papers also find that the effect of institutional quality on the change in physical capital (ΔK^P, using gross or net national saving rates) is not statistically significant. The present paper aims to investigate the reason(s) for this surprising result. To this end, I integrate a dual investment model into the green national accounting framework that measures (weak) sustainable development (ΔK) and investigate the effect of this integration on the expected impact of institutional quality on the change in overall capital. The contribution of this article is therefore firstly to explain the empirical results found in Stoever (2012) from a theoretical perspective. Secondly, I aim to shed light on the debate about institutions and sustainable development. Thirdly, I wish to contribute to the discussion on institutions and economic development.

The results show that the theoretical model can explain the 'missing' effect on the change in physical capital with the capital aggregation in green national accounting. This implies that if capital was aggregated in line with the dual investment model, it would potentially be possible to better analyze how institutional quality works on the macroeconomic level. The results are therefore highly relevant for empirical attempts to investigate the effects of institutional quality on sustainable development, saving and growth, especially those approaches that target resource-dependent economies with large oil and mining industries.

The article proceeds with an overview of the relevant literature in section 2, before the impact of institutions (modeled by ownership risk) is investigated from a theoretical perspective in section 3. The subsequent section 4 presents the results and is followed by a discussion of the implications and potential empirical approaches to validate the model in section 5. Section 6 concludes.

2 Background

2.1 Three forms of capital in practice: Adjusted Net Saving

The empirical counterpart or equivalent of equation 1 is the indicator Adjusted Net Saving (ANS):[3,4]

$$ANS = \underbrace{GSR + CFC}_{\Delta K^P} + \underbrace{EDE}_{\Delta K^H} + \underbrace{NFD + END + MID + CO2 + PM10}_{\Delta K^N} \tag{2}$$

[3]The indicator is also known as *Genuine Saving* .

[4]Note that the indicator does not account for population growth or technological progress.

Where

ANS = Adjusted Net Saving, GSR = Gross savings rate, CFC = Consumption of fixed capital, EDE = Education expenditure, NFD = Net Forest depletion, END = Energy depletion, MID = Mineral depletion, CO2 = Damage from CO2 and PM10 = Damage from PM10

Large parts of the variation in ANS stem from ΔK^P (GNS and CFC) and from energy and mining depletion (END and MID), which forms a part of ΔK^N.[5] I therefore investigate the effect of institutional quality on the change in physical capital and natural capital, with a focus on the investment decisions of firms in the oil and mining sector.

2.2 Investment in natural capital as a dual investment decision

The general Hotelling result has been complemented by a more detailed analysis of the decisions underlying resource extraction by including physical capital in the investment decision. The investment or harvesting decision now involves two forms of capital, namely natural and physical capital. The firm has to decide jointly in their investment as they are both involved in the same exploitation process. For natural capital, the firm has to decide on the rate of resource extraction, while for physical capital it has to determine the level of investment. The decision is hence modeled as a dual investment problem (for an overview, see Charles, 2005).

In this approach, natural resources are treated as capital stocks, just as in the sustainable development framework - with extraction being interpreted as dis-investment and conservation and sustainable use [for renewable resources] seen as "investment in the resource" or in natural capital, a concept that goes back, among others, to Clark & Munro (1975).

Physical capital, the second component in the dual decision, typically exhibits strong irreversibility in its investments, i.e. very limited or no other uses for the investments outside the resource industry. This type of investment is common in resource industries, which rely heavily on spe-

[5]This can be shown by comparing the coefficients of a multinomial OLS regression of ANS on its components.

cialized machinery such as oil rigs or mine shafts. Including this type of investment in the model goes back to Arrow (1968) (cited in Charles, 2005).

2.3 Dual investment and institutional quality

A number of papers that model dual investment decision in natural resource industries find that a change in institutional quality (modeled e.g. by the discount rate or ownership risk) may have positive as well as negative effects on the speed of extraction of an exhaustible resource.

Farzin (1984) shows that "the basic proposition that a reduction in the discount rate leads to greater conservation of an exhaustible resource is not generally valid" (p. 841). He models two sectors, one including the resource itself and the other one producing a substitute. He then proceeds to show that the effect of a change in the discount rate depends on the capital required in the substitute and the resource sector and on the size and value of the resource stock. The main result for the purpose of my paper is that a change in institutional quality (in this case the discount rate) can impact the speed of extraction in qualitatively different ways, depending on the physical capital intensity that is needed to extract the resource.

In a closely related approach Lasserre (1982) models an extractive firm and also introduces produced capital to the extraction process to analyze the effect of a rise in the discount rate on the speed of extraction of exhaustible resources. He finds that the effect may be negative, depending on capital intensity; more specifically, the effect is negative if physical capital is relatively scarcer than the natural resource.

In a more recent paper Laurent-Lucchetti & Santugini (2012) start from the mixed empirical evidence of the effect of ownership risk on the speed of resource extraction. They develop a theoretical model that is able to support these mixed observations, using a dynamic game, where two firms earn a profit from the exploitation of a common-pool resource and resource exploitation is governed by a contract between a government and the two firms. The authors show that the direction of the effect of risk of expropriation depends on the elasticity of demand. Furthermore, they show that in the presence of ownership risk that includes a risk of expropriation, an increase in the latter may decrease present extraction.

Likewise, Bohn & Deacon (2000) focus on the effect of an exogenously given ownership risk on the behavior of firms. They build their model for exhaustible resources along the lines of Farzin (1984) and Lasserre (1982) (here: single firm, no contract with government) and additionally show the ambiguous effects of property rights on the use of natural resources empirically. They provide evidence that high ownership risk reduces resource extraction in some circumstances, namely for petroleum and mining, both of which require large upfront investments, while increasing it for other resources such as forests.[6]

I use the model presented in Bohn & Deacon (2000) with only some minor changes:I will abstract from decisions on drilling/exploration and additionally, I will focus on the dual investment decision in natural and physical capital, and refer to Bohn & Deacon (2000) for the effect of institutions on investment in other parts of physical and natural capital. While the aim in Bohn & Deacon (2000) is to directly apply the model empirically, I connect it to ANS and the green accounting framework. I thus explicitly develop the effects of institutions on these parts of natural and physical capital, before connecting the model to the measurement of sustainable development in the subsequent section.

3 Model

3.1 From three to five forms of capital

In the ANS framework, changes in the stocks of produced, human and natural capital from one period to the next and their sum (ΔK) are considered. The change in the stock of total capital can be seen as (dis-)investment and analogously, ΔK^i is interpreted as (dis-)investment in a

[6] Additionally, they study the effect of insecure ownership on investment in general physical. This part will not be derived in detail in this article, but I will refer to their results in the following section.

particular form of capital K^i. To integrate the dual investment model into the ANS equation (1), overall physical capital (K^P) is divided into the part that is involved in the exploitation of oil and mining resources (K_S^P) and all other forms of produced capital (K_G^P). For natural capital, I distinguish between natural capital for whose exploitation special equipment is needed, such as e.g. oil or mineral reserves (K_S^N) and general natural capital that is drawn down using ordinary labor (K_G^N).

Equation 1 can then be rewritten as

$$ANS = \Delta K_G^P + \Delta K_G^N + \Delta K_S^P + \Delta K_S^N + \Delta K^H \quad (3)$$

Where

K = Overall capital

K_G^N = Natural capital which is drawn down using ordinary labor

K_S^N = Natural capital for whose exploitation special equipment is needed, such as e.g. oil or mineral reserves

K_S^P = Produced capital that is used for exploiting these forms of natural capital

K_G^P = All other forms of produced capital

K^H = Human capital and

Δ stands for the change from one period to the next.

3.2 Ownership risk and investment in general capital

The impact of institutions expressed as ownership risk on investment in all forms of capital discussed here can be presented in the general form shown in Bohn & Deacon (2000): Ownership risk now includes any event that keeps the investor from claiming the earnings of his investment. It is an all-or-nothing event: With the probability π_t, the investor loses all claims to his investment at the start of $t+1$. With the probability $1-\pi_t$ no expropriation will occur in $t+1$. The part of institutions that matters for investment decisions is hence restricted to this type of risk in the current approach.

The expropriation event can be described by the 0-1 variable ξ_t which indicates whether period-t profits are expropriated or not. Furthermore, the evolution of (π, ξ) follows a bivariate Markov process with the transition function $G(\pi_{t+1}, \xi_{t+1}|\pi_t, \xi_t)$. Persistence is ensured as for $\xi_{t+1} = 0$, π_{t+1} is a function of π_t. For $\xi_{t+1} = 1$, $\pi_{t+1} = 1$, so that for all future periods $\xi_{t+s} = 1$, for $s > 0$, i.e. all future profits are zero after an expropriation in period t.

The investor then maximizes his current profits (PR_t) plus the discounted value of the project's future payoff:

$$V_t(\pi_t, \xi_t, \ldots) = max\left\{PR_t + \frac{1}{1+r} \cdot V_{t+1}(\pi_{t+1}, \xi_{t+1}, \ldots)dG(\pi_{t+1}, \xi_{t+1}|\pi_t, \xi_t)\right\} \tag{4}$$

for $\xi_t = 0$ and $V_t(\pi_t, \xi_t, \ldots) = 0$ for $\xi_t = 1$ (expropriation in period t), where V_t is the value function and ... stands for potential additional state variables. A small open economy is assumed, so that the world interest rate r is exogenously given and assumed to be positive.

For general produced capital (K_G^P) Bohn & Deacon (2000) show that investment is decreasing in π, i.e. insecure ownership causes agents not to invest or to invest less in produced capital.[7] This follows the logic of the literature presented in the introduction for K^P. For general natural capital (K_G^N) the authors show that when property rights are insecure and the risk of losing one's resources is high, future returns are discounted more heavily, which leads to disinvestment in the stock of K_G^N. This is in line with the "conventional wisdom" of resource economics presented in the introduction for K^N.

3.3 Ownership risk and investment in special capital

In the case of mining and oil extraction, production involves special-purpose produced capital (K_S^P) and natural capital (K_S^N). The effect of ownership risk on (dis-)investment decisions for these two forms of capital is not as straightforward as in the two cases above and will therefore

[7]A similar exercise should be conducted for human capital (K^H), but this is not considered here.

be investigated in detail in the following section. Again, Bohn & Deacon (2000) provide the framework for the analysis.

To determine the relationship between ownership risk (π) and investment in the two forms of capital involved in oil/mining production (K_S^P and K_S^N), I proceed in three steps: First, the optimization problem of the firm is formulated and the firm's optimal production-to-reserves ratio, which depends on π, is derived. Based on this, I then show how π influences K_S^P and K_S^N.

As in the general framework, the firm maximizes its current profits (PR_t) plus the discounted value of future payoffs. The firm has (fixed) initial reserves (R_0) and an initial produced capital equipment (K_0^S, short notation for $K_{S,0}^P$). The production in period t is denoted Z_t and the production equipment in period t as K_t^S (short notation for $K_{S,t}^P$). Hence, the remaining reserves of the firm in period $t+1$ are $R_{t+1} = R_t - Z_t$.

For production, a Cobb-Douglas function is assumed, which implies constant returns, using specialized capital (K_t), labor (N_t), produced materials (goods) (Y_t) and (known) reserves (R_t):

$$Z_t = K_t^{\gamma} \cdot N_t^{\eta} \cdot Y_t^{\mu} \cdot R_t^{1-\eta-\gamma-\mu} \tag{5}$$

with $\gamma > 0$, $\eta > 0$, $\mu > 0$, $1 - \gamma - \eta - \mu > 0$

While materials and labor are variable within the period, capital and reserves are already determined at the beginning of the period. Assuming a fixed wage rate w implies that oil production labor is assumed to be specialized and internationally mobile. Unit costs for materials, total variable costs are then the sum of labor and material costs: $wN_t^S + Y_t^S$.

Variable costs per unit of production for producing at given K_t^S and R_t can then be expressed in terms of the production-to-reserves ratio (Z_t/R_t) and the capital-to-reserves ratio (K_t^S/R_t) as[8]

$$\chi(Z_t/R_t)^{\beta}(K_t^S/R_t)^{-\nu} \tag{6}$$

with $\beta > 0$, $\nu > 0$ and $\beta - \nu > 0$ and $\chi = w^{\frac{\eta}{\eta+\mu}} \cdot [(\frac{\mu}{\eta})^{-\frac{\mu}{\eta+\mu}} + (\frac{\mu}{\eta})^{\frac{\eta}{\eta+\mu}}]$.

Given that the firm is not expropriated (i.e. $\xi = 0$), its profit function can be written as

$$PR_t = (p_t - \chi z_t^{\beta} k_t^{-\nu}) z_t R_t + (1-\delta)K_t^S - K_{t+1}^S \tag{7}$$

where p_t is the oil price in period t and δ is the depreciation rate, i.e. the profit in period t equals the production revenues minus the production and equipment costs and where $z_t = Z_t/R_t$ is the production-to-reserves ratio and $k_t = K_t^S/R_t$ is the capital-to-reserves ratio. The optimization problem of the firm given initial capital and reserves can then be formulated accordingly.[9]

To arrive at the relationship between ownership risk (π) and the production-to-reserves ratio (z_t), I solve for the optimal production-to-reserves ratio and the optimal capital-to-reserves ratio using the first order conditions. Using the fact that PR_t is linearly homogeneous in $(R_t, R_{t+1}, K_t^O, K_{t+1}^O)$, it is possible to derive the value per unit of reserves (v^O). This makes it possible to express z_t and k_{t+1} as functions of k_t, p_t and π_t:[10]

$$dz_t = \frac{1}{\chi_z} \cdot [(1-\Omega_p) \cdot dp_t + (\Omega_{\pi 0} - \Omega_{\pi}) \cdot d\pi_t + \chi_k dk_t] \tag{8}$$

where $\chi_k = \nu \cdot \chi \cdot (1+\beta) \cdot k_t^{\nu-1} \cdot z_t^{\beta} > 0$, $\chi_z = \nu \cdot \chi \cdot (1+\beta) \cdot k_t^{\nu-1} > 0$, $\Omega_{\pi 0} = \frac{1}{1+r} \cdot \int v^0 dG^{\epsilon}$, $\Omega_{\pi} = \frac{1-\pi_t}{1+r} \cdot \int v_{\pi}^0 f_{\pi}^{\pi} dG^{\epsilon}$, $\Omega_p = \frac{1-\pi_t}{1+r} \cdot \int v_p^0 f_p^p dG^{\epsilon}$,

[8] The derivation of the unit cost function can be found in appendix A.1.
[9] The derivation as well as details on the notation of the optimization problem can be found in appendix A.2.
[10] A detailed derivation of equations 8 and 9 can be found in appendix A.3.

That is, $z_t = z(p_t, \pi_t, k_t)$, i.e. z_t can be expressed as a function of the oil price, ownership risk and the capital-to-reserves ratio.

Secondly,

$$dk_{t+1} = \frac{1}{\kappa} \cdot [\Omega_p \cdot dp_t - (\chi_\pi + \Omega_{\pi 0} - \Omega_\pi) \cdot d\pi_t] \tag{9}$$

where $\kappa = \frac{\beta-\nu}{\nu} \cdot [1 - \frac{1-\delta}{1+r} \cdot (1-\pi_t)] > 0$ and $\chi_\pi = \frac{\beta-\nu}{\nu} \cdot \frac{1-\delta}{1+r} \cdot k_{t+1} > 0$.

That is, $k_{t+1} = k(p_t, \pi_t)$, that is the capital-to-reserves ratio can be expressed as a function of the oil price and ownership risk.

4 Results

4.1 Ownership risk and five forms of capital

Under reasonable assumptions on $\Omega_{\pi 0}$, Ω_π and Ω_p[11] in equations 8 and 9, z_t is an increasing function of p_t, k_t, and π_t, that is the production-to-reserves ratio in period t (and hence the production) increases ceteris paribus with higher ownership risk in period t and also with a higher capital-to-reserves ratio. The positive effect of ownership risk (π) on the optimal current production rate can be explained by the fact that a higher ownership risk reduces the value of leaving reserves in the ground for future production and therefore leads to faster exploitation, that is it increases z_t.

The capital-to-reserves ratio in $t+1$ (k_{t+1}) is increasing in p_t and decreasing in π_t. The reasoning behind the first relationship is that higher future oil prices (p_t) provide an incentive to increase the optimal capital-to-reserves ratio to be able to exploit known resources faster. The latter effect is caused by the circumstance that higher ownership risk leads to a reduction of the expected payoff from oil/mining capital (K_S^P) and therefore to a lower capital-to-reserves ratio (k_t).

[11] A detailed derivation of the conditions on Ω_p, Ω_π, $\Omega_{\pi 0}$ can be found in appendix A.4.

Combining equations 8 and 9, the optimal extraction rate can be expressed as

$$z_{t+1} = z(\underbrace{p_{t+1}}_{+}, \underbrace{\pi_{t+1}}_{+}, k_{t+1}(\underbrace{p_t}_{+}, \underbrace{\pi_t}_{-}) \tag{10}$$

Where

z_t = production-to-reserves ratio

p_t = oil price

π_t = ownership risk

k_t = capital-to-reserves ratio

That is, z_{t+1} is increasing in p_{t+1}, π_{t+1} and p_t and decreasing in π_t. The essential result for the purpose of this paper is that π_t and π_{t+1} in this expression have opposing effects on z_{t+1}. While higher π_{t+1} increases the production before expropriation takes place, increasing π_t reduces the investment in oil capital, thereby raising extraction costs and slowing extraction (volume) in the future.

Due to the joint production of K_S^P and K_S^N, investment in K_S^P and hence increasing production Z_t implies a reduction in the stock of the resource, i.e. it decreases ΔK_S^N. Therefore, the effects of π on K_S^N are assumed to be opposite to those shown for K_S^P. These insights will be put into the context of sustainable development in the next section.

4.2 Back from five to three forms of capital

Summarizing the results from the previous paragraph, firstly, K_G^P decreases in π_t, that is higher ownership risk reduces investment in K_G^P. Secondly, for K_G^N, higher ownership risk leads to heavier discounting and therefore faster exploitation of K_G^N. And thirdly, the aggregated effect of π_t and π_{t+1} on z_{t+1} and hence on K_S^P and K_S^N is ambiguous.

I can now use equation 3 to investigate the effect of ownership risk on produced and natural capital for sustainable development. This yields the following results in the context of the effect of better institutions or lower ownership risk on ANS:

$$ANS = \underbrace{\Delta K_G^P}_{+} + \underbrace{\Delta K_S^P}_{+/-} + \underbrace{\Delta K_G^N}_{+} + \underbrace{\Delta K_S^N}_{+/-} + \Delta K_H \tag{11}$$

For the original ANS equation (1), this implies

$$ANS = \underbrace{\Delta K^P}_{+/-} + \underbrace{\Delta K^N}_{+/-} + \Delta K^H \tag{12}$$

The aggregate effect of ownership risk on ΔK^P and ΔK^N is ambiguous. Therefore, when applied to the national accounting framework, it is possible that lower ownership risk leads to a positive overall effect on the change in K^N and to an effect that is not measurable on overall K^P.

5 Implications and Discussion of an Empirical Validation

The impacts of institutional quality on saving of different forms of capital are thus able to yield the effects that seemed at first surprising in the empirical results e.g. by Stoever (2012). This is caused by the different impacts of ownership risk on different parts of K^P, which are able to cancel each other out in the (aggregated) empirical outcome. It is thus possible that positive and negative effects of institutions are covered by the aggregation into K^P in green national accounting. In order to better assess the effect(s) of institutional quality on produced capital, e.g. for analyzing policies which aim at improving institutional quality, it may be useful to investigate the effects on K_G^P and K_S^P separately.

For an empirical validation of the model, a straightforward approach would be to proceed in three steps: Firstly, to (re-)estimate the impact of institutional quality on ΔK^P following the approaches used in Dietz et al. (2007) and Stoever (2012). Secondly, to estimate the impact of institutional quality on ΔK^P_G. Thirdly, the two effects should be compared. From the model, we expect a positive effect on ΔK^P_G.[12] For this validation strategy to work, it is crucial to construct ΔK^P_G. This can be done by subtracting the investment in physical capital in the oil and mining sector (ΔK^P_S) from the change in overall capital (ΔK^P). [13]

However, there are several severe challenges that hinder the implementation from producing convincing results: In addition to methodological challenges (e.g. Deacon (2011); Albouy (2012)), the restrictions to the data available suggest that alternative strategies to empirically test the predictions from the model might be more promising. This is left for future research. For further investigations of the effects of institutions on the macroeconomic level, this paper nevertheless shows that it is crucial to carefully consider the oil and mining sector and be aware of the special setup of the sector in terms of different types of capital.

6 Conclusions

This paper adds to the literature on the influence of institutional quality on sustainable development by examining the effects of institutions on saving of different forms of capital and integrating the results into a green national accounting framework.

It was shown that the differing effects of institutions on different forms of capital that were found in the empirical analysis can be explained from a theoretical perspective. That the green national accounting framework divides forms of capital such that the parts of capital that are joint in production are contained in different aggregates, makes it possible for positive and negative effects of institutions on saving to cancel each other out in the ANS equation.

[12] This exercise has been conducted by the author. Some of the results can be found in appendix B or obtained from the author upon request.

[13] Unfortunately, national data on the investment in physical capital in the oil and mining sector is scarce and either only valid for a subset of countries or include very little variation over (except for common interpolated trends).

The counteracting effects of institutional quality on different parts within natural and physical capital respectively have implications for policy recommendations, as improving institutional quality may in fact lead to faster resource exploitation (depending on the resource). This complicates policy recommendations from an environmental perspective, since better institutional quality may not only lead to desired outcomes such as higher saving and investment in K_G^P, but also to higher disinvestment into K_S^N, which is likely to be accompanied by higher CO_2 emissions and less sustainable development.

Additionally, the results can potentially add to the discussion on two closely related issues, namely the discussion on institutions and growth and the resource curse debate. The dependent variable considered in both approaches is economic growth and usually measured by GDP or a closely-related indicator. In the framework of this paper, this translates into K^P. As shown in the previous section, the positive effect of π on ΔK_G^P can be counteracted by the ambiguous effect on K_S^P, so that the overall effect on K^P does not need to be positive. This may be especially relevant for countries with a high share of those natural resources whose exploitation is intensive in physical capital. These are typically precisely those countries and resources on which the resource curse literature focuses.

While my results and their interpretation are very much in line with the theoretical parts of both strands of literature, they may add another angle to the interpretation of the empirical results and support the impact of institutions on growth, i.e. when only the overall effect of π on ΔK^P is considered, the 'true' effect of π on K^P may be underestimated due to the counteracting effect on K_S^P. As a consequence, one must presume that the real effect of institutions on growth may be underestimated in the empirical literature due to the different impacts of institutions on the two parts of produced capital, which are typically subsumed into one aggregate in the empirical applications.

Summing up, the theoretical model can explain the 'missing' effect on physical capital with the capital aggregation in national accounting. If capital was aggregated in line with the dual investment model, it would then potentially be possible to better analyze the impact of institutional quality on the macro level. The results also imply that it might be useful to investigate the macroeconomic effects of institutional quality on the oil and mining sector separately from those on the rest of the economy.

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A. Theoretical Appendix

The derivations in the appendix follow the ones in Bohn & Deacon (2000) with only minor changes and some additional explanations.

A.1 Derivation of the cost function

For production, a Cobb-Douglas function is assumed, with constant returns, using specialized capital (K_t), labor (N_t), produced materials (goods) (Y_t) and (known) reserves (R_t).

$$Z_t = K_t^{\gamma} \cdot N_t^{\eta} \cdot Y_t^{\mu} \cdot R_t^{1-\eta-\gamma-\mu}$$

with $\gamma > 0$, $\eta > 0$, $\mu > 0$, $1 - \gamma - \eta - \mu > 0$

While materials and labor are variable within the period, capital and reserves are already determined at the beginning of the period. Assuming a fixed wage rate w (oil production labor is assumed to be internationally mobile) and unit costs for materials, total variable costs are $wN_t^O + Y_t^O$.

Cost minimization implies $\frac{Y_t^0}{N_t^0} = \frac{\mu w}{\eta}$, which yields the following input requirements for producing Z_t at given K_t and R_t:

$$N_t^0 = Z_t^{\frac{1}{\eta+\mu}} \cdot (K_t^0)^{\frac{-\gamma}{\eta+\mu}} \cdot R_t^{\frac{-(1-\eta-\gamma-\mu)}{\eta+\mu}} \cdot (\frac{\mu w}{\eta})^{\frac{-\mu}{\eta+\mu}}$$

$$Y_t^0 = Z_t^{\frac{1}{\eta+\mu}} \cdot (K_t^0)^{\frac{-\gamma}{\eta+\mu}} \cdot R_t^{\frac{-(1-\eta-\gamma-\mu)}{\eta+\mu}} \cdot (\frac{\mu w}{\eta})^{\frac{-\eta}{\eta+\mu}}$$

Variable cost per unit of production are then

$$\begin{aligned}\frac{w \cdot N_t^0 + Y_t^0}{Z_t} &= \chi \cdot Z_t^{\frac{1}{\eta+\mu}} \cdot (K_t^0)^{\frac{-\gamma}{\eta+\mu}} \cdot \frac{R_t^{\frac{-(1-\eta-\gamma-\mu)}{\eta+\mu}}}{Z_t} \\ &= \chi \cdot z_t^{\frac{1}{\eta+\mu}-1} \cdot k_t^{\frac{-\gamma}{\eta+\mu}}\end{aligned}$$

with $\chi = w^{\frac{\eta}{\eta+\mu}} \cdot [(\frac{\mu}{\eta})^{-\frac{\mu}{\eta+\mu}} + (\frac{\mu}{\eta})^{\frac{\eta}{\eta+\mu}}]$, $z_t = \frac{Z_t}{R_t}$ and $k_t = \frac{K_t^0}{R_t}$.

$\beta = \frac{1}{\eta+\mu} - 1$ and $\nu = \frac{\gamma}{\eta+\mu}$ yields the cost function used in the main text (with $K_t^0 = K_t^S$:

$$\chi(Z_t/R_t)^{\beta}(K_t^O/R_t)^{-\nu}$$

with $\beta > 0$, $\nu > 0$ and $\beta - \nu > 0$.

A.2 Derivation of optimization problem

Using the cost function derived above and given that the firm is not expropriated (i.e. $\xi = 0$), its profit function then is

$$PR_t = p_t Z_t - \chi Z_t^{\beta+1}(K_t^O)^{-\nu} + (1-\delta)K_t^O - K_{t+1}^O \tag{13}$$

where p_t: oil price in period t, δ: depreciation rate

which can be written as

$$PR_t = (p_t - \chi z_t^{\beta} k_t^{-\nu}) z_t R_t + (1-\delta)K_t^O - K_{t+1}^O \tag{14}$$

where $z_t = Z_t/R_t$: production-to-reserves ratio, $k_t = K_t^O/R_t$: capital-to-reserves ratio.

The optimization problem of the firm, given initial capital and reserves, can be written as

$$V^O(R_t, K_t^O, p_t, \pi_t, \xi_t) = maxPR_t(R_t, R_{t+1}, K_t, K_{t+1})$$
$$+ \frac{1-\pi_t}{1+r} \cdot \int V^O(R_{t+1}, K_{t+1}^O f^p(p_t^f, \epsilon_{t+1}^p), f^\pi(\pi_t, \epsilon_{t+1}^\pi), 0) \cdot dG^\epsilon(\epsilon_{t+1}^p, \epsilon_{t+1}^\pi) \tag{15}$$

The notation follows Bohn & Deacon (2000) in that "[t]he assumption that x_t and π_t are Markov processes can be formalized by writing $x_{t+1} = f^x(x_t, \epsilon_{t+1}^x$ and $\pi_{t+1} = f^\pi(\pi_t, \epsilon_{t+1}^\pi)$, where ϵ_{t+1}^x and ϵ_{t+1}^π are white noise processes. The integral $\int v_K d$ in [the first order conditions] can then be written as

$$\int V_K dG = (1-\pi_t) \cdot \int v_K(k_{t+1}, H_{t+1}, f^x(x_t, \epsilon_{t+1}^x), f^\pi(\pi_t, \epsilon_{t+1}^\pi, 0) \cdot dG^\epsilon(\epsilon_{t+1}^x, \epsilon_{t+1}^\pi)$$

where the right hand side integral is over the marginal distributions of the innovations to x and π. We have used the fact that $V = 0$ if $\xi_{t+1} = 1$, which occurs with probability π." (Bohn & Deacon, 2000, p. A-1)

A.3 Derivation of optimal ratios

To arrive at the relationship between π and the production-to-reserves ratio (z_t), I need to solve for the optimal production-to-reserves ratio and the optimal capital-to-reserves ratio using the first order conditions:

FOC1:

$$p_t - \chi(1+\beta)K_t^{-\nu} z_t^\beta = \frac{1-\pi_t}{1+r} \cdot \int V_R^O dG^\epsilon \tag{16}$$

FOC2:

$$1 = \frac{1-\pi_t}{1+r} \cdot \int V_K^O dG^\epsilon \tag{17}$$

The envelope theorem yields

$$V_R^O = \frac{\delta PR_t}{\delta R_t} = (\beta - \nu) \cdot \xi z_{t+1}^{\beta+1} k_{t+1}^{-\nu} \tag{18}$$

and

$$\begin{aligned} V_K^O = \frac{\delta PR_t}{\delta K_t} &= \nu \xi z_{t+1}^{\beta+1} k_{t+1}^{-\nu-1} + 1 - \delta \\ &= \frac{\nu}{\beta - \nu} k_{t+1}^{-1} V_R^O + 1 - \delta \end{aligned} \tag{19}$$

Since PR_t is linearly homogeneous in $(R_t, R_{t+1}, K_t^O, K_{t+1}^O)$, the FOCs are homogeneous of degree zero in these variables. The value function is therefore homogeneous in $(R_t,\ K_t^0)$.

It is possible to derive the value per unit of reserves (v^O):

$$V^0(R_t, K_t^0, p_t, \pi_t, 1) = R_t \cdot V^0(1, \frac{K_t^0}{R_t}, p_t, \pi_t, 1) \equiv R_t \cdot v^0(k_t, p_t, \pi_t)$$

Then substitute $V_R^0 = v^0(\cdot) - k_t \cdot v_k^0(\cdot)$ and $v_k^0 = v_k^0(\cdot)$ into equations 16, 17, 18 and 19, so that z_t and k_{t+1} can be expressed as functions of k_t, p_t and π_t.

When using equation 19, equation 17 can be rewritten as

$$\frac{\beta - \nu}{\nu} \cdot [1 - \frac{1-\delta}{1+r} \cdot (1 - \pi_t)] \cdot k_{t+1} = \frac{1 - \pi_t}{1 + r} \cdot \int v^0 dG^\epsilon - k_{t+1} \tag{20}$$

$$= p_t - \chi \cdot (1 + \beta) \cdot k_t^{-\nu} \cdot z_t^\beta \tag{21}$$

Taking the total differential of equation 16 (where the right hand side is equal to $\frac{1-\pi_t}{1+r} \cdot \int v^0(\cdot) - k_t \cdot v_K^0(\cdot) dG^\epsilon$) yields

$$
\begin{aligned}
& dp_t - (-\nu) \cdot \chi \cdot (1+\beta) \cdot k_t^{\nu-1} \cdot z_t^{\beta} dk_t - \beta \cdot \chi \cdot (1+\beta) k_t^{\nu} dz_t \\
& = -[\frac{1}{1+r} \cdot \int v^0 dG^{\epsilon}] d\pi_t + [\frac{1-\pi_t}{1+r} \cdot \int v_{\pi}^0 f_{\pi}^{\pi} dG^{\epsilon}] \cdot d\pi_t \\
& + [\frac{1-\pi_z}{1+r} \int v_k^0 dG^{\epsilon} - 1] \cdot dk_{t+1} + [\frac{1-\pi_t}{1+r} \cdot \int v_p^0 f_p^p dG^{\epsilon}] \cdot dp_t \\
& = -(\Omega_{\pi 0} - \Omega_{\pi}) \cdot d\pi_t + \Omega_p \cdot dp_t
\end{aligned}
$$

where $\Omega_{\pi 0} = \frac{1}{1+r} \cdot \int v^0 dG^{\epsilon}$, $\Omega_{\pi} = \frac{1-\pi_t}{1+r} \cdot \int v_{\pi}^0 f_{\pi}^{\pi} dG^{\epsilon}$, $\Omega_p = \frac{1-\pi_t}{1+r} \cdot \int v_p^0 f_p^p dG^{\epsilon}$, and $[\frac{1-\pi_z}{1+r} \int v_k^0 dG^{\epsilon} - 1] \cdot dk_{t+1} = 0$ due to equation 17.

In short,

$$
dp_t + \nu \cdot \chi \cdot (1+\beta) \cdot k_t^{\nu-1} \cdot z_t^{\beta} dk_t - \beta \cdot \chi \cdot (1+\beta) k_t^{\nu} dz_t = -(\Omega_{\pi 0} - \Omega_{\pi}) \cdot d\pi_t + \Omega_p \cdot dp_t \tag{22}
$$

which can be rearranged into the expression from the main text:

$$
dz_t = \frac{1}{\chi_z} \cdot [(1 - \Omega_p) \cdot dp_t + (\Omega_{\pi 0} - \Omega_{\pi}) \cdot d\pi_t + \chi_k dk_t]
$$

where $\chi_k = \nu \cdot \chi \cdot (1+\beta) \cdot k_t^{\nu-1} \cdot z_t^{\beta} > 0$, and $\chi_z = \nu \cdot \chi \cdot (1+\beta) \cdot k_t^{\nu-1} > 0$.

Along the same lines, the total differential of equation 20 is

$$
dp_t - (-\nu) \cdot \chi \cdot (1+\beta) \cdot k_t^{\nu-1} \cdot z_t^{\beta} dk_t - \beta \cdot \chi \cdot (1+\beta) k_t^{\nu} dz_t \tag{23}
$$

$$
= \frac{\beta - \nu}{\nu} \cdot \frac{1-\delta}{1+r} \cdot k_{t+1} \cdot d\pi_t + \frac{\beta - \nu}{\nu} \cdot [1 - \frac{1-\delta}{1+r} \cdot (1 - \pi_t)] \cdot dk_{t+1} \tag{24}
$$

which can be rearranged into the second expression from the main text:

$$dk_{t+1} = \frac{1}{\kappa} \cdot [\Omega_p \cdot dp_t - (\chi_\pi + \Omega_{\pi 0} - \Omega_\pi) \cdot d\pi_t]$$

where $\kappa = \frac{\beta-\nu}{\nu} \cdot [1 - \frac{1-\delta}{1+r} \cdot (1-\pi_t)] > 0$ and $\chi_\pi = \frac{\beta-\nu}{\nu} \cdot \frac{1-\delta}{1+r} \cdot k_{t+1} > 0$.

A.4 Conditions on $\Omega_{\pi 0}, \Omega_\pi$ and Ω_p

In the main text I claim that "under reasonable assumptions on $\Omega_{\pi 0}, \Omega_\pi$ and Ω_p, z_t is an increasing function of p_t, k_t, and π_t". The aim here is therefore to determine sign of $\frac{\partial z^*}{\partial p_t}$ and $\frac{\partial z^*}{\partial \pi_t}$.

From equation 19 it follows that

$$v^0 = V_R^0 + k_{t+1} \cdot V_K^0 = \frac{\beta}{\beta - \nu} \cdot V_R^0 + (1-\delta) \cdot k_{t+1} \tag{25}$$

Then

$$\begin{aligned} v_p^0 &= \frac{dv^0}{dp_{t+1}} \\ &= \frac{\beta}{\beta-\nu} \cdot \frac{dV_R^0}{dp_{t+1}} \\ &= \beta \cdot (\beta+1) \cdot \chi \cdot z_{t+1}^{\beta} \cdot k_{t+1}^{-\nu} \cdot \frac{\partial z_{t+1}^*}{\partial p_{t+1}} \\ &= z_{t+1} \cdot (1 - \Omega_p) \end{aligned} \tag{26}$$

and

$$
\begin{aligned}
v_\pi^0 &= \frac{dv^0}{d\pi_{t+1}} \\
&= \frac{\beta}{\beta-\nu} \cdot \frac{dV_R^0}{dp_{t+1}} \\
&= \beta \cdot (\beta+1) \cdot \chi \cdot z_{t+1}^{\beta} \cdot k_{t+1}^{-\nu} \cdot \frac{\partial z_{t+1}^*}{\partial \pi_{t+1}} \\
&= z_{t+1} \cdot (\Omega_{\pi 0} - \Omega_\pi)
\end{aligned} \tag{27}
$$

Using equations 26 and 27, a limit and induction argument can be used in order to show determine first the sign of $\frac{\partial z_t^*}{\partial p_t}$ and then the sign of $\frac{\partial z_t^*}{\partial \pi_t}$.

"In the final period of a finite horizon problem ($t = T$, $n = 1$ periods from the end) $v_p^0 = 0$. $\rightarrow \Omega_p^1 = 0 \rightarrow \partial \frac{z_t^*}{\partial p_t} = \frac{1}{\chi_z} > 0$. In period $t = T - 1$ ($n = 2$), $\Omega_p^1 = 0$ implies $v_p^0 = z_{t+1} \leq 1 \rightarrow \Omega_p^2 \leq \frac{1-\pi_t}{1+r} \cdot \int f_p^p dG^\epsilon < \frac{1}{1+r}$, provided $0 \leq f_p^p \leq 1$.
For the induction, assume that $0 \leq \Omega_p^n < \frac{1}{1+r}$ in some period $t + 1 = T - n$.
Then

$$
\Omega_p^{n+1} = \frac{1-\pi_t}{1+r} \cdot \int (1 - \Omega_p^n) \cdot z_{t+1} \cdot f_p^p dG^\epsilon \tag{28}
$$

also satisfies $0 \leq \Omega_p^t \leq \frac{1}{1+r}$, provided that $0 \leq f_p^p \leq 1$. Thus, $0 \leq \frac{r}{1+r}/\chi_z \leq (1 - \Omega_p)/\chi_z = \frac{\partial z_t^*}{\partial p_t} < \frac{1}{\chi_z}$ applies for all t in a finite horizon problem, which implies $0 < \frac{\partial z_t^*}{\partial p_t} < \frac{1}{\chi_z}$ for the infinite horizon problem." (Bohn & Deacon, 2000, p. A-11)

A similar argument can be made for $\frac{\partial z_t^*}{\partial \pi_t}$, although "the general conditions for $\frac{\partial z_t^*}{\partial \pi_z} > 0$ are more complicated, because $\Omega_{\pi 0}$ may vary over time. But if f_π^π is sufficiently small or r and π_t sufficiently large, we have $0 \leq \Omega_\pi < \Omega_{\pi 0}$, which implies $\frac{z_t^*}{\partial \pi_t} < 0$; this is assumed throughout the paper." (Bohn & Deacon, 2000, p. A-12)

These are the "reasonable assumptions on $\Omega_{\pi 0}, \Omega_\pi$ and Ω_p", which I refer to in the main text.

B. Empirical Appendix

Estimation strategy

For an empirical validation of the model, a straightforward approach would be to proceed in three steps: Firstly, to (re-)estimate the impact of institutional quality on ΔK^P following the approaches used in Dietz et al. (2007) and Stoever (2012). Secondly, to estimate the impact of institutional quality on ΔK^P_G. Thirdly, the two effects should be compared. From the model, we expect a positive effect on ΔK^P_G.

Firstly, I estimate the impact of institutional quality in overall produced capital (K^P). To do so, I use two different approaches, which are used in the literature, and neither of which is strictly preferable to the other. Approach A is to instrument the potentially endogenous institutional quality with settler mortality and conduct a two-stage-least-square estimation. This approach is in line with the estimations conducted in Acemoglu, Johnson & Robinson (2001) or Stoever (2012), but comes at the cost of reducing sample size (as settler mortality is only available for countries that were colonized by European countries at some point) and losing the time dimension, due to the time-less nature of the instrument. I hence conduct a two stage least square estimation, instrumenting institutional quality by settler mortality in the first stage[14] and regressing net national saving (NNS or ΔK^P) on institutional quality in the second stage.

Approach B follows Dietz et al. (2007) in estimating the effects while keeping the data's panel structure and estimating country fixed effects.[15] Although this makes use of the time dimension and keeps coverage of countries intact, it cannot rule out endogeneity.
As one can only either account for endogeneity (approach A) or include country fixed effects (approach B), I report the results from both approaches.

I then proceed by estimating the impact of institutional quality on general produced capital (K^P_G).

[14] For a discussion of the setup, see Stoever (2012), for a discussion of the instrument see e.g. Acemoglu, Johnson & Robinson (2012) and Albouy (2012).
[15] Atkinson & Hamilton (2003) use a similar approach, but with cross-country data.

Construction of general produced capital

As K_G^P is not directly observable in the data, I construct it from available data on K^P and K_S^P in the following way: I use the extraction costs in the oil and mining sector as a proxy for the investment into this part of physical capital (ΔK_S^P). I hence assume that the extraction costs are highly correlated with the physical investment in both industries, albeit not necessarily at the same level:[16]

$$\Delta K_S^P = a \cdot c_i^{EM} \tag{29}$$

where c_i^{EM} stands for the extraction costs for energy and mineral depletion in country i and a represents a factor that is multiplied with the extraction costs to reach the level of investment in K_S^P.

As $NNS_i = \Delta K_G^P + \Delta K_S^P$, this implies that

$$\Delta K_G^P = NNS_i - a \cdot c_i^{EM} \tag{30}$$

With these assumptions, it is possible to divide K^P into its sub-parts using national green accounting data.

Data

In the third step, I compare these two effects to see if it changes in line with the theoretical model, i.e. if the second effect is bigger than the first one.

[16]Note that there is no time dimension in the IV estimation due to the choice of the instrument.

Variable	Source
Net National Saving	Worldbank, WDI (2013)
Institutional quality	Kaufmann & Kray (2013)
Settler mortality	Acemoglu et al. (2001)
Adjusted Net Saving	Worldbank, WDI (2013)/ANS database
Gross Saving Rate	Worldbank, WDI (2013)
Gross national income per capita	Worldbank, WDI (2013)
GDP growth	Worldbank, WDI (2013)
Age dependency	Worldbank, WDI (2013)
Urbanization	Worldbank, WDI (2013)
Institutional quality	International Country Risk Guide (ICRG)
Costs of resource extraction	Worldbank /ANS database

Variables and data sources

IV Approach

Estimated Equations

First stage:

$$R_i = \zeta + \beta log M_i + [X_i' \delta] + \nu_i \tag{31}$$

Where

R_i = quality of institutions in country i, M_i = instrument for institutional quality in country i, X_i = vector of covariates that affect all variables (none in basic specification) and ν_i is an error term.

Second stage:

$$NNS_{v,i} = \mu + \alpha \hat{R}_i + [X_i' \gamma] + \epsilon_i, \tag{32}$$

Where

$NNS_{v,i}$: ΔK^P (for $v = 0$), ΔK_G^P (for $v = 1$) in country i, $\hat{R}_i$ = fitted values from first stage estimation for country i and ϵ_i is an error term.

Results

dependent variable	theoretical counterpart	coefficient	std error	p-value
NNS	ΔK^P	0.055*	(0.027)	0.051
NNS - c^{EM}	ΔK_G^P	0.060**	(0.027)	0.032

N=61

2SLS estimation at $a = 1$

Estimated equation, first stage: $R_i = \zeta + \beta log M_i + \nu_i$

Estimated equation, second stage: $NNS_{v,i} = \mu + \alpha \hat{R}_i + \epsilon_i$

Significance levels : $*$: 10% $**$: 5% $***$: 1%

Approach using panel data

Estimated Equations

$$GrossSR_{i,t} = \alpha + \beta_1 lnY_{i,t} + \beta_2 Growth_{i,t-1} + \beta_3 Age_{i,t} + \beta_4 Urban_{i,t} + \beta_5 Inst_{i,t} + \beta_6 Rs_{i,t} + \beta_7 Inst_{i,t} * Rs_{i,t} + T_t + \epsilon_{i,t} \quad (33)$$

Where

$GrossSR_{i,t}$ = gross savings rate in country i in period t,

$lnY_{i,t}$ = GNI per capita (ln),

$Growth_{i,t-1}$ = GDP growth_{t-1},

$Age_{i,t}$ = age dependency,

$Urban_{i,t}$ = urbanization,

$Inst_{i,t}$ = institutional quality,

$Rs_{i,t}$ = resource exports,

$Inst_{i,t} * Rs_{i,t}$ = resource exports*institutional quality

T_t = year dummies,

ϵ_i is an error term.

Example: Results for bureaucratic quality, Arellano-Bond estimation

	one-step		two-step	
	ΔK^P	ΔK^P_G	ΔK^P	ΔK^P_G
$(\text{GS/GNI})_{t-1}$	0.398***	0.367***	0.398***	0.408***
	(0.077)	(0.068)	(0.018)	(0.021)
GNI per capita (ln)	0.032	0.728	-0.334	-0.657
	(1.240)	(1.273)	(0.856)	(0.740)
GDP growth_{t-1}	0.120***	0.150***	0.120***	0.153***
	(0.045)	(0.046)	(0.015)	(0.011)
Age dependency	-23.229**	-27.197***	-22.130***	-30.713***
	(9.624)	(9.951)	(6.707)	(7.474)
Urbanization	-0.158	-0.169	-0.119	-0.142
	(0.179)	(0.172)	(0.137)	(0.157)
Resource exports	0.068	0.055	0.061**	0.098***
	(0.053)	(0.053)	(0.028)	(0.025)
Institutional quality	0.097	0.052	0.025	0.697*
	(0.475)	(0.454)	(0.329)	(0.395)
Resource exports*	-0.011	-0.009	-0.011	-0.019***
Institutional quality	(0.017)	(0.016)	(0.007)	(0.007)
cons	34.876**	32.692	35.041***	41.057***
	(16.037)	(15.286)	(13.569)	(14.329)
Number of observations: 1165				
Number of countries: 107				

Table 1: Gross savings rate, Arellano-Bond est. (robust se), bureaucratic quality, 1984-2001

Brief Overview and Discussion of Results

Some of the results can be drawn from the analysis: Using fixed effects or Arellano-Bond estimations produces results that are highly dependent on estimation procedure, period considered and the specific institutional quality measure used. In comparison, the IV approach produces more robust results which are in line with the expectations from the model (possibly due to construction of ΔK^P_G and the lack of a time dimension in the estimation). Taken at face value, the IV results indicate that the mechanism considered might be driving the results (and are also robust to inclusion of different periods); although the size of the effect turns out to be relatively small.

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