# Natural Resources and Economic Growth: The Role of Investment

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Is it possible that relying too heavily on natural resources affects saving and investment in a way that hampers economic growth? – and thus, in the long run, the level of output per capita. This paper reviews the literature, explores the data and compares and contrasts the explanatory power and interplay of natural resources and civil liberties, our proxy for institutional variables currently under scrutiny in the literature. We propose that natural resources may be viewed as an exogenous factor that hampers economic development and investment as well as institutions.

Natural resources are an important source of national wealth around the world. Yet, experience shows that natural riches are neither necessary nor sufficient for economic prosperity and progress. Among the world's richest countries are Hong Kong, Japan, Luxembourg, Singapore and Switzerland, and they clearly do not owe their national wealth to nature. In this paper we maintain that relying too heavily on natural resources may reduce saving, investment and growth, as well as lowering the level of output per capita in the long run.

Among developing countries, natural resources are in many cases prevalent. This may to some extent reflect their underdevelopment: the modest size of the modern sector of the economy makes agriculture and other natural-resource-based economic activity relatively important. But there are also examples of countries that are genuinely rich in terms of natural resources but still have not been able to sustain economic growth while other countries, similarly endowed, have succeeded. Take Botswana and Sierra Leone, both of which produce diamonds for export. By and

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JEL: O11.
Keywords: Economic growth, natural resources, investment.

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large, Botswana has managed the revenue and rent stream from its main natural resource in ways that have contributed to impressive economic growth since independence in 1966 – in fact, the world's highest recorded rate of growth of gross national product (GNP) per capita from 1965 to 1998, even if it slowed down after 1990. Meanwhile, Sierra Leone has remained mired in poverty, ravaged by crippling internal warfare as local warlords have continued to fight for control over the diamond trade. Sierra Leone was the world's poorest country in 1998 according to the World Bank (2000).

In our thesis, natural resources are an essentially exogenous factor that can hamper economic growth through macroeconomic channels as well as through institutions. This hypothesis differs from that of, among others, Acemoglu, Johnson and Robinson (2001) who proposed that living conditions in colonial times dictated whether Europeans decided to settle down in the colonies and bring in European institutions. According to this alternative hypothesis, economic performance depends on current institutions, which depend on past institutions, which in turn depend on living conditions – e.g., settler mortality – in colonial times. Acemoglu, Johnson and Robinson (2001) claim that once institutions are accounted for there is no room left for other explanations of economic growth having to do with economic policy or geography (Sachs, 2003). In contrast, we argue that dependence on natural resources today affects current institutions as well as macroeconomic outcomes.

## 1. Preview

Table 1 is representative of the empirical findings on natural resources and growth that have emerged from some recent studies, beginning with Sachs and Warner (1995). The table covers 85 countries, and shows economic growth per capita from 1965 to 1998 and natural resource dependence as measured by the share of natural capital in national wealth in 1994 – i.e., the share of natural capital in total capital, which comprises physical, human and natural capital (but not social capital; see World Bank, 1997).[1] The growth rate has been adjusted for initial income.[2] The table

[1] The natural capital variable used here is close to the source: it is intended to come closer to a direct measurement of the intensity of natural resources across countries than the various proxies that have been used in earlier studies, mainly the share of primary (i.e., nonmanufacturing) exports in total exports or in gross domestic product (GDP) and the share of the primary sector in employment or the labour force. Alas, 1994 is the only year for which the World Bank has as yet produced data on natural capital, for 92 countries. In most cases, however, the share of natural capital in national wealth in 1994

indicates that good growth performance appears incompatible with a share of natural resources in excess of 15 percent of national wealth.[3] More generally, the countries in our sample appear to be concentrated on the diagonal linking the southwest and northeast corners of the table. There are also quite a few countries above the diagonal, with slow economic growth and a small endowment of natural resources, including several countries in Central and South America and the Caribbean. Perhaps more interestingly, we detect two distinct groups of countries. The first group consists of eight African countries (Central African Republic, Chad, Guinea-Bissau, Madagascar, Mali, Niger, Sierra Leone and Zambia), all of which depend on natural resources, with natural capital constituting more than a quarter of their national wealth, and have experienced negative per capita growth since 1965. The other group also has eight countries that are relatively independent of their natural resources by our measure, but whose economies have grown rapidly since 1965 (Botswana[4], China, Indonesia, Japan, Korea, Malaysia, Mauritius and Thailand). The remaining 69 countries in our sample fall between the two extremes.

A question now arises: What makes the eight high-performance economies in the second group different from the eight African laggards in the first? As an empirical matter, a key factor that distinguishes the two groups is saving and investment. Specifically, the group of natural-resource-dependent, slow-growth countries shown in the southwest corner of Table 1 has an average gross saving rate of only 5 percent, ranging from -2 percent in Guinea-Bissau to 19 percent in Zambia, whereas the natural-resource-free, high-growth group shown in the northeast corner has an average gross saving rate of 32 percent, with individual observations clustered in the

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is probably a pretty good proxy for natural resource dependence in the period under review, 1965-1998. There are exceptions, true, such as Malaysia, Mauritius and Mexico, where the share of primary exports in merchandise exports decreased dramatically from 1965 to 1998 as a result of economic diversification away from primary production. Even so, all the empirical results reported in this paper can be reproduced without significant deviations by using the average primary export share during 1965-1998 rather than the natural capital share in 1994 as a proxy for natural resource dependence, and also by measuring growth in terms of GNP per worker rather than GNP per capita.

[2] By growth adjusted for initial income is meant that part of economic growth that is not explained by the country's initial stage of development, obtained from a regression of growth during 1965-1998 on initial GNP per capita (i.e., in 1965) as well as natural capital.

3 The reason why there are 85 countries in the sample and not 92 is that (a) for six countries for which estimates of natural capital exist, there are missing data on either economic growth since 1965 (Bolivia, Germany, Tanzania, Uganda and Vietnam) or civil liberties (Namibia) and (b) Saudi-Arabia is omitted because of extreme fluctuations in its recorded average rate of economic growth over the period under review. With the exception of Saudi-Arabia, no outliers are excluded from the analysis, so that the sample size remains the same, 85, throughout the paper.

[4] Botswana's natural capital share is small as shown in Table 1 because the World Bank does not provide an estimate of the country's diamond rent.

range between 28 and 35 percent. A similar pattern emerges when we replace gross domestic saving with gross domestic investment. In this case, the group of natural-resource-dependent, slow-growth countries has an average gross investment rate of 14 percent, ranging from 7 percent in Chad to 29 percent in Guinea-Bissau, whereas the natural-resource-free, high-growth group has an average gross investment rate of 28 percent, with individual observations clustered in the range between 26 and 31 percent. Hence our focus is on saving and investment in this paper.

**Table 1. Natural resource dependence and economic growth**

| | **Growth of GNP per capita per year 1965-1998, adjusted for initial income (%)** | | | | | | |
|---|---|---|---|---|---|---|---|
| Share of natural capital in national wealth (%) | ≤ -3% | -3%< ≤-2% | -2%< ≤ -1% | -1%< ≤ 0% | 0%< ≤ 1% | 1%< ≤ 2% | 3%< |
| ≤ 5% | Jordan | El Salvador<br>South Africa | Guatemala<br>Morocco | Lesotho<br>Netherlands<br>Switzerland<br>Turkey<br>U.K.<br>U.S. | Austria<br>Belgium<br>Denmark<br>Egypt<br>France<br>Greece<br>Italy<br>Portugal<br>Spain | Japan<br>Mauritius | Korea |
| 5% < ≤10% | Benin<br>Ghana<br>Haiti | Honduras<br>Jamaica<br>Kenya<br>Peru<br>Zimbabwe | Argentina<br>Costa Rica<br>Panama<br>Philippines | Brazil<br>Chile<br>Colombia<br>Dominican Rep.<br>Mexico<br>Pakistan<br>Sri Lanka<br>Sweden<br>Trinidad, Tobago<br>Tunisia | Finland<br>Ireland<br>Norway | Malaysia<br>Thailand | Botswana<br>China |
| 10% < ≤ 15% | Nicaragua<br>Malawi<br>Mozambique | Congo<br>The Gambia | Bangladesh<br>Uruguay | Australia<br>Paraguay | Canada | Indonesia | |
| 15% < ≤ 20% | Côte d'Ivoire<br>Senegal<br>Togo<br>Venezuela | Burkina Faso<br>Burundi<br>Nepal<br>Papua New Guinea | Ecuador<br>New Zealand | India | | | |
| 20%< ≤ 25% | Mauritania<br>Rwanda | Cameroon | | | | | |
| 25%< ≤ 30% | Sierra Leone | | | | | | |
| 30%< | Central African Rep.<br>Chad<br>Guinea Bissau<br>Madagascar<br>Mali<br>Niger<br>Zambia | | | | | | |

## 2. Literature

Natural resources are a fixed factor of production and hence, almost by definition, impose a restriction on economic growth potential. This restriction may – depending on the nature of the production technology – cause a growing labour force and a growing stock of capital to run into diminishing returns. This is the first reason for an adverse effect of natural resources on growth found in the literature. Nordhaus (1992) has shown that the steady-state rate of growth of output per capita in an economy with natural resources is proportional to the rate of technological progress adjusted for a "population growth drag" due to diminishing returns as well as a "natural resource depletion drag" due to declining levels of exhaustible natural resources.

Second, huge natural resource rents may create opportunities for rent-seeking behaviour on a large scale on the part of producers, thus diverting resources away from more socially fruitful economic activity (Auty, 2001; Gelb, 1988). For example, Tornell and Lane (1998) show that terms-of-trade windfalls and natural resource booms may trigger political interaction, or games, among powerful interest groups – games that result in current account deficits, disproportionate fiscal redistribution and reduced growth. In extreme cases, civil wars break out – such as Africa's diamond wars – which not only divert factors of production from socially productive uses but also destroy societal institutions and the rule of law. Collier and Hoeffler (1998) show empirically how natural resources increase the probability of civil war. Another extreme case involves foreign governments invading with destructive consequences and the accompanying defence expenditures. Military expenditures tend to inhibit growth through their adverse effects on capital formation and resource allocation (Knight, Loayza and Villaneuva, 1996).

Third, natural resource abundance can lead to the Dutch disease, which can appear in several guises. A natural resource boom and the associated surge in raw-material exports can drive up the real exchange rate of the currency, thus possibly reducing manufacturing and services exports (Corden, 1984). Recurrent booms and busts tend to increase real exchange rate volatility (Gylfason, Herbertsson and Zoega, 1999), thus reducing investment in the tradable sector as well as exports and imports of goods and services. The Dutch disease can also strike in countries that do not have their own currency (e.g., Greenland, which uses the Danish krone; see Paldam, 1997). A boom in the primary sector then increases wages in that sector, thereby attracting

labour from other industries or imposing higher wage costs on them, especially in countries with centralized wage bargaining. Through some or all of these channels the Dutch disease can reduce total exports relative to GNP (Gylfason, 1999) or at least skew the composition of exports away from manufacturing and services exports that may contribute more to economic growth.

This idea accords with the view that technological discoveries and innovation take place in manufacturing rather than agriculture (Kaldor, 1966). To the extent that the great productivity improvements that have taken place in agriculture in recent decades reflect technological spillovers from other sectors, the Dutch disease may slow down economic growth by impeding manufacturing and services exports, which are probably good for growth (Frankel and Romer, 1999)[5] – not only their quantity but their kind and quality as well.[6]

Fourth, natural resource abundance may reduce private and public incentives to accumulate human capital due to a high level of non-wage income – e.g., dividends, social spending and low taxes. Empirical evidence shows that, across countries, school enrolment at all levels is inversely related to natural resource dependence, as measured by the share of the labour force engaged in primary production (Gylfason, Herbertsson and Zoega, 1999). There is also evidence that, across countries, public expenditures on education relative to national income, expected years of schooling and secondary-school enrolment rates are all inversely related to the share of natural capital in national wealth (Gylfason, 2001). This matters because more and better education may be good for growth. For example, Temple (1999) shows that economic growth varies directly with educational attainment across countries once a few outliers have been removed from the sample of Benhabib and Spiegel (1994), who had found limited support in their data for the hypothesis that education is good for growth.

Finally, and this point is closely related to the preceding one, abundant natural resources may imbue people with a false sense of security and lead governments to lose sight of the need for good and growth-friendly economic management, including free trade, bureaucratic efficiency, institutional quality and sustainable development

[5] A dissenting view is expressed in Rodriguez and Rodrik (2000).

[6] In our sample of 85 countries, there is a significant negative correlation between the ratio of exports to GDP, adjusted for country size based on population, and the share of natural capital in national wealth (not shown). There is also a significant positive correlation between the export ratio adjusted for country size and per capita growth adjusted for initial income (not shown).

(Sachs and Warner, 1999; Rodriguez and Sachs, 1999). Put differently, abundant natural capital may crowd out social capital in a similar manner as human capital (Woolcock, 1998; Paldam and Svendsen, 2000). Unconditional foreign aid may be a case in point (Burnside and Dollar, 2000).

## 3. Resource dependence or path dependence?

Above we made the empirical observation that differences in saving and investment distinguish the resource-rich, slow-growth countries in our sample from the resource-poor, rapid-growth countries. We focus on two possible explanations for this pattern.

First, the mechanisms surveyed in Section 2 above – population growth and resource depletion drag, rent seeking, Dutch disease, neglect of education – can all be expected to reduce saving and investment. When resources are devoted to rent seeking and internal strife and corruption, productive investment is likely to suffer. Similarly, when investment in human and social capital is adversely affected by natural resources, investment in physical capital may also suffer. And the Dutch disease – through wages or the real exchange rate – will shrink the manufacturing and other export sectors and hamper investment.

Another view is that poor institutions are mainly to blame for low growth. The problem of endogeneity can be resolved either by arguing that natural resources may affect the institutional environment or that the current poor state of affairs is a result of institutional heritage: adverse living conditions in colonial times reduced the inflow of Europeans to the colonies and prevented Western institutions from taking hold. Following this thesis, the former colonies still suffer poor institutions that deter saving, investment and growth. In this case the problem is not excessive reliance on natural resources at present but institutional path dependence. Our empirical strategy in Section 4 is intended to enable us to distinguish between those two hypotheses.

In Gylfason, Herbertsson and Zoega (1999) we derive the effect of the Dutch disease on economic growth in a two-sector model with tradable and non-tradable goods. An appreciation of the domestic currency in real terms lowers the price of tradable output and reduces investment, learning and growth. Increased volatility of the real exchange rate has the same effect. In a recent paper (Gylfason and Zoega, 2003) we develop a model of rent-seeking behaviour that also produces an adverse effect of natural resources on growth. We assume that learning mainly occurs in

manufacturing and not in the primary sector. It follows that if the riches of nature tempt workers away from manufacturing and into the primary sector, there will be fewer hands left to work in manufacturing, hence less learning and lower rates of growth. The growth of output per capita will then be an increasing function of the scale and scope of the manufacturing sector and a decreasing function of the natural resource rent.

We will now continue to explore the effect of natural resources on growth through investment. Following Nordhaus (1992) we assume that output is produced by labour $L$, natural resources $N$ and capital $K$ and the production function to be of the Cobb-Douglas variety with constant returns to scale:

$$Y = AL^{a}N^{b}K^{1-a-b} \tag{1}$$

where $A$ represents overall efficiency, including technology and quality. This gives a production function that generates smooth and differentiable isoquants in L-N-K space. We can rewrite equation (1) in per capita terms: $y = An^{b}k^{1-a-b}$ where $y = Y/L$, $n = N/L$ and $k = K/L$. Equation (1) encapsulates a technology where natural resources can be bundled together with either labour or capital in the production process (Bruno, 1984).[7]

We distinguish between the intensity and abundance of natural resources. By intensity, or dependence, we mean the importance of natural resources to the national economy while abundance refers to the supply (per capita) of the natural resources. Within the Cobb-Douglas framework, the exponents in the aggregate production function (1) denote factor shares while the factor inputs are absolute quantities. An increase in the parameter $b$ thus means that the economy now relies more heavily on natural resources in producing output – independently of its supply – while an increase in $N$ implies that the supply has increased. The distinction between dependence and abundance allows us to distinguish between the effect of a change in the factor share $b$ on growth, on the one hand, and a change in the abundance of the natural resource $N$, on the other.

A class of capitalists owns the stock of capital and individuals also own the natural

[7] Like Nordhaus (1992) we can justify the constant returns to scale assumption by appealing to the standard replication argument: An economy that has twice as many workers, twice as extensive natural resources and twice as much capital is also going to produce twice as much output. We will test this assumption empirically below.

resources. The total stock of natural resources is given and hence also the supply of their services. We take these services to be fixed and exogenous so that no opportunities for intertemporal allocation of these resources arise. We assume a perfectly competitive market for the services of natural resources. In equilibrium, supply of and demand for natural resources are equalized and the marginal product is equal to their real price. Similarly, there is perfect competition in the market for labour and the marginal product of labour is equal to the real wage. Finally, we have a market for capital where the owners of capital sell its services to firms.

Assuming a constant capital/output ratio $K/Y$ – a reasonable assumption in steady state – we can rewrite equation (1) in terms of logarithms and then derive the following expression for the rate of growth of output per capita g:

$$g = \left(\frac{1}{a+b}\right) g_A - \left(\frac{b}{a+b}\right)(g_L - g_N) \tag{2}$$

where $g_A$, $g_L$ and $g_N$ are the rates of growth of technology, the labour force and the natural resource. If the resource is renewable and constant, $g_N$ disappears from the equation. If the resource is non-renewable and a fraction $u$ of the remaining stock of the resource is used up every year, then the term $g_L - g_N$ can be replaced by $g_L$ + u in equation (2).[8] This sum represents the two drags discussed by Nordhaus (1992).

Notice the conflict between the advance of technology that increases output per capita over time and the diminishing returns due to the fixed or declining supply of the natural resource. The drag on growth is greater, the higher is the value of $b$ – that is, the greater is the dependence on natural resources – and the higher are the rates of population growth $g_L$ and resource depletion $u$. This effect is uncontroversial: The inability to augment one factor of production is bound to introduce diminishing returns to the remaining factors. Clearly if production is heavily dependent on the natural resource – that is, if the value of the parameter $b$ is high – the drag becomes more severe.

We will now show that the effect of natural resources on growth is not confined to the steady-state growth drag described above. The level of saving and investment may also be affected. This affects the level of steady-state income per capita as well as its rate of growth in the transition to a steady state.

[8] If the resource is managed such that it grows at the same rate as output, equation (2) simplifies to the neoclassical steady-state solution: $g = g_A$.

Consumption per worker, $c = C/L$, is proportional to output per worker:

$$c = (1 - s)y \tag{3}$$

where $s = S/Y$ is the saving rate. In the transition towards a Solovian steady state the capital/labour ratio evolves according to

$$g_k = g_K - g_L = \frac{sY - \delta K}{K} - g_L = s\frac{y}{k} - \delta - g_L \tag{4}$$

where $g_k$ is the growth of the capital/labour ratio and $\delta$ is the depreciation rate. We now assume away technical progress. In the steady state where $g_k = 0$, the capital/output ratio is an increasing function of the saving rate and a decreasing function of the depreciation rate and the rate of population growth:

$$\frac{k}{y} = \frac{s}{g_L + \delta} \tag{5}$$

Solving the normalized version of equation (1) and equation (5) together for $y$ and substituting the result into the consumption function (3) gives

$$c = (1 - s)A^{\frac{1}{a+b}} n^{\frac{b}{a+b}} \left( \frac{s}{g_L + \delta} \right)^{\frac{1-a-b}{a+b}} \tag{6}$$

Maximizing consumption per capita in equation (6) with respect to $s$ gives the following simple solution for the optimal saving rate:[9]

$$s = 1 - a - b \tag{7}$$

Hence, the greater the role of natural resources in the generation of national output – i.e., the greater $b$ in equation (1) – the smaller is the optimal saving rate. Put differently, the presence of natural resources – that is, a positive share of natural resources in national income – reduces the marginal productivity of capital and thereby also the propensity to save. This way, natural capital crowds out physical capital. In an economy without natural resources ($b = 0$), the optimal saving rate in equation (6) obviously becomes $1 - a$, the traditional form of the golden-rule formula.

[9] This derivation does not constitute microeconomic optimization from first principles, as we assume the saving rate to be fixed. However, it is possible to bypass this assumption and derive the optimal saving rate in the Ramsey model instead; this yields $s = (1 - a - b)[(\delta + g_L)/(\delta + \rho)]$ where $\rho$ is the pure rate of time preference. This result simplifies to $s = 1 - a - b$ as in the Solow model if $g_L = \rho$. In either case, the optimal rate of saving varies inversely with the share of natural resources in national income.

The differential equation (4) has the Bernoulli form and can be solved so as to describe the evolution of capital over time:

$$k_t^{a+b} = \left[ k_0^{a+b} - \frac{sAn^b}{g_L + \delta} \right] e^{-(a+b)(g_L+\delta)t} + \frac{sAn^b}{g_L + \delta} \tag{8}$$

where the subscript $t$ denotes time and $k_0$ denotes the initial stock of capital per worker. Equation (8) implies that the speed of adjustment towards steady state $(a+b)(g_L+\delta)$ is increasing in the dependence on natural resources $b$. The economy will converge to the last term in the equation:

$$\lim_{t\to\infty} k_t = \left( \frac{sAn^b}{g_L + \delta} \right)^{\frac{1}{a+b}} \tag{9}$$

The corresponding steady-state solution for output per capita is found by substituting equation (9) into the normalized version of equation (1) or, equivalently, by combining equations (3) and (6):

$$y = A^{\frac{1}{a+b}} n^{\frac{b}{a+b}} \left( \frac{s}{g_L + \delta} \right)^{\frac{1-a-b}{a+b}} \tag{10}$$

Increased dependence on natural resources reduces the saving rate by equation (7) and thereby also the steady-state levels of capital and output per worker by equations (9) and (10). Given the current stock of capital, however, the rate of economic growth is reduced during the transition to the steady state. We acknowledge but do not pursue here the possibility, stressed in Section 2, that natural resource dependence may also adversely affect the efficiency parameter $A$, which reflects education and the quality of institutions among other things and exerts a strong influence on steady-state output per capita and transitional growth.

## 4. Natural resources and institutions

The hypotheses outlined above can be tested by estimating the following equations:

$$g = f_1(y_0, h, i, b, n, c, p) \tag{11}$$

$$h = f_2(y_0, b, n, c) \tag{12}$$

$$i = f_3(y_0, b, n, c) \tag{13}$$

(14) $c = f_4(y_0, b, n)$

The rate of per capita economic growth is a decreasing function of initial output per capita $y_0$ as well as of the dependence on natural resources $b$ and population growth $p$, and an increasing function of education $h$, the investment rate $i$, the abundance of natural resources $n$ and the set of relevant institutions $c$, which we proxy by an index of civil liberties. Further, we postulate that both education and investment vary inversely with natural resource dependence and directly with natural resource abundance and the extent of civil liberties. We also allow education and investment to depend on initial income. At last, we view civil liberties as a function of the three exogenous variables in the model, i.e., initial income and the two natural resource variables.

Before embarking on the regression analysis below, let us inspect the data. Figure 1 shows a scatterplot of economic growth per capita from 1965 to 1998 and natural resource dependence measured as before.[10] The group of eight low-growth, natural-resource-dependent African countries identified in Table 1 is visible in the southeast corner of Figure 1. The high-growth, natural-resource-free countries are also easy to spot in the northwest corner of the figure. In Figure 2 we plot the investment ratio against natural resource dependence over the same period, 1965-1998. Apart from the two clusters in the corners, the relationship between the two variables is not very clear to the naked eye, even if it remains statistically significant when the two clusters are removed.

We want to assess the effects of natural resource dependence as measured by the share of natural resources in national wealth and of natural resource abundance as measured by natural capital per person on investment and growth. Moreover, we want to test whether the inclusion of civil liberties, our proxy for institutions, in our model renders the natural resource variables or other determinants of growth insignificant. The first four rows in Table 2 report seemingly unrelated regression (SUR) estimates of a system of four equations for the 85 countries in our sample where

(a) economic growth per capita depends on the share of gross domestic investment in GDP 1965-1998, the gross secondary-school enrolment rate, the

[10] When we purge the natural capital share of that part which is explained by the country's initial income per head, we get very similar results as in Figure 1.

natural capital share, natural capital per person, civil liberties,[11] population growth, and the logarithm of initial per capita income (i.e., in 1965), defined as purchasing-power-parity adjusted GNP per capita in 1998 divided by an appropriate growth factor;

(b) the enrolment rate in turn depends on the natural capital share, natural capital per person, civil liberties and initial income;

(c) investment also depends on the natural capital share, natural capital per person, civil liberties and initial income, and

(d) civil liberties depend on the natural capital share, natural capital per person and initial income.

The recursive nature of the system shown in Table 2 and the conceivable correlation of the error terms in the three equations make SUR an appropriate estimation procedure (Lahiri and Schmidt, 1978). In particular, this method produces unbiased, efficient and consistent parameter estimates without any need to correct for simultaneity bias, provided that equations (11)-(14) are correctly specified.[12]

All the parameter estimates in Table 2 are economically and statistically significant, with one exception (the effect of civil liberties on investment). The coefficient on initial income in the growth equation indicates a convergence speed of almost 2 percent per year, which is close to the 2-3 percent range typically reported in statistical growth research. These results are consistent with earlier work that assumes constant returns to scale and ascribes roughly three-fourths of output to capital in a broad sense (Mankiw, Romer and Weil, 1992). Nordhaus (1992) ascribes one-fifth of output to natural resources (energy and land) and the rest to capital and labour, arguing that the historical growth record is consistent with constant returns to scale.

There is both a direct effect of the natural capital share on growth in Table 2 as well as an indirect effect through education and the additional indirect effect through investment. As far as we know, this linkage – from heavy dependence on natural resources to slow growth via investment – has not been documented in econometric work before. Moreover, the table shows that an increase in civil liberties stimulates growth directly as well as indirectly by encouraging education and perhaps also

[11] The civil liberties index is an average for the years 1972-1990 and is taken from Przeworski et al. (2000). The index ranges from 1 (full civil liberties) to 7 (negligible civil liberties). All other data are taken from the World Bank (2000, 1997).

[12] However, the fact that ordinary least squares (OLS) estimates of the system (not shown) are almost the same as the SUR estimates shown in Table 2 indicates that the correlation of error terms across

investment as well, even if the latter effect is statistically insignificant. These effects appear to be fairly strong. For example, an increase in civil liberties from the level of Turkey or Uruguay in the middle of the range to that of, say, Switzerland and the U.K. at the top goes along with an increase in per capita growth by one percentage point.

**Table 2. Regression results: Growth and gross investment**

| Dependent variable | Natural capital share | Natural capital per person | Initial income | Population growth | Civil liberties index | Enrolment rate | Gross investment | $R^2$ |
|---|---|---|---|---|---|---|---|---|
| Economic growth | -0.08<br>(5.8) | 0.05<br>(2.7) | -1.89<br>(9.2) | -0.56<br>(3.0) | -0.27<br>(2.5) | 0.02<br>(2.5) | 0.08<br>(3.7) | 0.75 |
| Enrolment rate | -0.77<br>(4.1) | 0.54<br>(2.2) | 13.00<br>(5.2) | | -3.82<br>(2.5) | | | 0.77 |
| Gross investment | -0.26<br>(4.0) | 0.16<br>(1.8) | -1.92<br>(2.2) | | -0.73<br>(1.4) | | | 0.24 |
| Civil liberties | 0.04<br>(3.1) | -0.05<br>(2.9) | -0.95<br>(6.5) | | | | | 0.65 |
| Economic growth | -0.13<br>(8.8) | 0.09<br>(4.5) | -1.57<br>(8.1) | -1.01<br>(5.5) | | | | 0.62 |

Note: 85 observations. t-statistics are shown within parentheses. Constant terms are not shown. An increase in civil liberties makes the civil liberties index go down.

Notice, furthermore, that an increase in natural capital per person has a positive effect on growth, education and investment. Because natural capital per person equals, by definition, the multiple of the share of natural capital in national wealth and wealth per person, we can infer from Table 2 that the total effect of an increase in the natural capital share on economic growth is -0.13 [= -0.08 + (-0.77 × 0.04) + (-0.26 × 0.07)] plus 0.073 [= 0.04 + (0.54 × 0.04) + (0.16 × 0.07)] times wealth per person (in hundreds of thousands of US dollars). Therefore, the total effect of an increase in the natural capital share on growth declines with wealth per person but remains negative as long as national wealth per capita is below USD 180,000 (= $0.13/0.073 \times 10^5$), which is roughly the cut-off point between the 20 industrial countries and 65 developing countries in the sample.[13] The bottom line in the table shows the reduced-

equations is of minor consequence.

[13] To be on guard against the possibility that the natural capital share may in fact be a proxy for the level of development, we added to our system an auxiliary regression of the natural capital share against a constant as well as the logarithm of initial income and natural capital per person. The effect of initial income on the natural capital share is significantly negative, with a coefficient of -6.33 (with t = 6.1), and the effect of natural capital per person on the natural capital share is significantly positive, with a coefficient of 0.52 (with t = 4.0), but in other respects the estimation results are virtually identical to the ones shown in Table 2. Hence, when we take the statistical relationship between natural

form regression of growth on the three exogenous variables in our model.

## 5. Conclusion

In this paper, we have proposed a linkage between natural resources and economic growth, through saving and investment. The results of our regression analysis can be summarized as follows:

- Accumulation of physical capital through investment, human capital through secondary education and social capital through civil liberties is inversely related to the share of natural capital in national wealth.
- Economic growth is inversely related to natural resource dependence as well as to initial income and directly related to the level of education, investment and civil liberties.
- Even if the dependence on natural resources adversely influences investment, education, civil liberties and growth, the abundance of natural resources measured by resources per head of population varies directly with investment, education, civil liberties and growth.
- The influence of natural resources on investment, education and growth documented in earlier research survives the introduction of a variable measuring civil liberties. Natural resources appear to have an additional indirect effect on investment, education and growth through the nature and quality of social institutions.

Hence, we have seen that the natural resource variable survived the introduction of the institutional variables. Likewise, the institutional variables survived the introduction of the natural resource variable. It thus appears that, on its own, neither story can explain growth retardation in full. This does not surprise us: economic growth is a complicated process that is driven forward by several different, interrelated factors. However, the onus rests with the natural resource story because international differences in the dependence on natural resources can also explain the diversity of institutions across countries. It thus seems that natural resources may affect growth both directly through macroeconomic variables, as well as indirectly through institutions.

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capital and initial income into account, the evidence for absolute convergence weakens a bit.

## References


Acemoglu, Daron, Simon Johnson and James A. Robinson (2001), "The Colonial Origins of Comparative Development: An Empirical Investigation," *American Economic Review* 91, December, 1369-1401.

Auty, Richard M. (2001), "The Political Economy of Resource-Driven Growth," *European Economic Review* 45, May, 839-846.

Benhabib, Jess, and Mark M. Spiegel (1994), "The Role of Human Capital in Economic Development: Evidence from Aggregate Cross-Country Data," *Journal of Monetary Economics* 34, 143-174.

Bruno, Michael (1984), "Raw Materials, Profits, and the Productivity Slowdown," *Quarterly Journal of Economics* 99, February, 1-28.

Burnside, Craig, and David Dollar (2000), "Aid, Policies, and Growth," *American Economic Review* 90, September, 847-868.

Collier, Paul, and Anke E. Hoeffler (1998), "On the Economic Causes of Civil War," *Oxford Economic Papers* 50, 563-73.

Corden, W. Max (1984), "Booming Sector and Dutch Disease Economics: Survey and Consolidation," *Oxford Economic Papers* 36, 359-380.

Frankel, Jeffrey A., and David Romer (1999), "Does Trade Cause Growth?," *American Economic Review* 89, June, 379-399.

Gelb, A. (1988), *Windfall Gains: Blessing or Curse?*, Oxford University Press, Oxford and New York.

Gylfason, Thorvaldur (1999), "Exports, Inflation, and Growth," *World Development* 27, June, 1031-1057.

Gylfason, Thorvaldur (2001), "Natural Resources, Education, and Economic Development," *European Economic Review* 45, May, 847-859.

Gylfason, Thorvaldur, Tryggvi Thor Herbertsson and Gylfi Zoega (1999), "A Mixed Blessing: Natural Resources and Economic Growth," *Macroeconomic Dynamics* 3, June, 204-225.

Gylfason, Thorvaldur, and Gylfi Zoega (2003), "Inequality and Economic Growth: Do Natural Resources Matter?", Ch. 9 in Theo Eicher and Stephen Turnovsky (eds.), *Inequality and Growth: Theory and Policy Implications*, MIT Press.

Kaldor, Nicolas (1966), *Causes of the Slow Rate of Growth in the United Kingdom*, Cambridge University Press, Cambridge, England.

Knight, Malcolm, Norman Loayza and Delano Villaneuva (1996), "The Peace Dividend: Military Spending and Economic Growth," *IMF Staff Papers* 43, March, 1-37.

Lahiri, Kajal, and Peter Schmidt (1978), "On the Estimation of Triangular Structural Systems," *Econometrica* 46, 1217-1221.

Mankiw, N. Gregory, David Romer, and David N. Weil (1992), "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics* 107, May, 407-437.

Nordhaus, William D. (1992), "Lethal Model 2: The Limits to Growth Revisited," *Brookings Papers on Economic Activity* 2, 1-43.

Paldam, Martin (1997), "Dutch Disease and Rent Seeking: The Greenland Model," *European Journal of Political Economy* 13, August, 591-614.

Paldam, Martin, and Gert Tinggaard Svendsen (2000), "An Essay on Social Capital: Looking at the Fire behind the Smoke," *European Journal of Political Economy* 16, June, 339-366.

Przeworski, Adam, Michael E. Alvarez, José Antonio Cheibub and Fernando Limongi (2000), *Democracy and Development: Political Institutions and Well-Being in the World, 1950-1990*, Cambridge University Press, Cambridge.

Rodriguez, Francisco, and Jeffrey D. Sachs (1999), "Why Do Resource-Abundant Economies Grow More Slowly? A New Explanation and an Application to Venezuela," *Journal of Economic Growth* 4, September, 277-303.

Rodriguez, Francisco, and Dani Rodrik (2000), "Trade Policy and Economic Growth: A Skeptic's Guide to the Cross-National Evidence," *NBER Macroeconomics Manual.*

Sachs, Jeffrey D. (2003), "Institutions Don´t Rule: Direct Effects of Geography on Per Capita Income," NBER Working Paper No. 9490, February.

Sachs, Jeffrey D., and Andrew M. Warner (1995, revised 1997, 1999), "Natural Resource Abundance and Economic Growth," NBER Working Paper 5398, Cambridge, Massachusetts.

Sachs, Jeffrey D., and Andrew M. Warner (1999), "Natural Resource Intensity and Economic Growth," Ch. 2 in Jörg Mayer, Brian Chambers and Ayisha Farooq (eds.), *Development Policies in Natural Resource Economies*, Edward Elgar, Cheltenham, UK, and Northampton, Massachusetts.

Temple, Jonathan (1999), "A Positive Effect of Human Capital on Growth,"

*Economics Letters* 65, October, 131-134.

Tornell, Aaron, and Philip R. Lane (1998), "Are Windfalls a Curse? A Non-representative Agent Model of the Current Account," *Journal of International Economics* 44, 83-112.

Woolcock, Michael (1998), "Social Capital and Economic Development: Toward a Theoretical Synthesis and Policy Framework," *Theory and Society* 27, April, 151-208.

World Bank (1997), "Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development," *Environmentally Sustainable Development Studies and Monographs Series* No. 17, World Bank, Washington, D.C.

World Bank (2000), *World Development Indicators 2000*, World Bank, Washington, D.C.

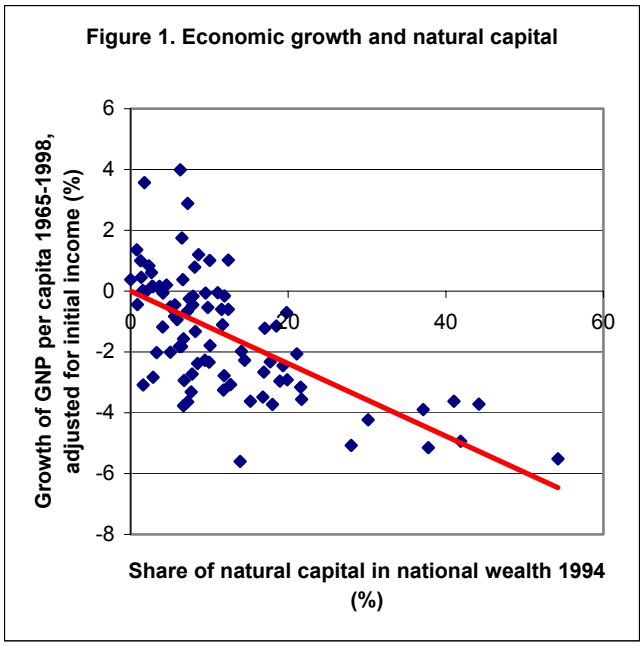
Figure 1. Economic growth and natural capital
Growth of GNP per capita 1965-1998, adjusted for initial income (%)
6
4
2
0
-2
-4
-6
-8
0
20
40
60
Share of natural capital in national wealth 1994 (%)

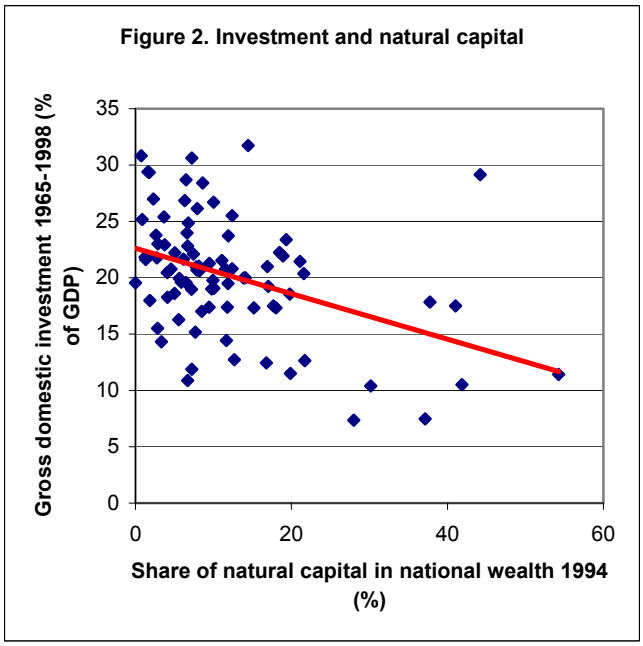
Figure 2. Investment and natural capital
Gross domestic investment 1965-1998 (% of GDP)
35
30
25
20
15
10
5
0
0
20
40
60
Share of natural capital in national wealth 1994 (%)