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Natural Resource Abundance and Economic Growth

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This paper explores whether natural resource abundance leads, other things equal, to slower growth rates. We distinguish between natural resource dependence (RD) and the natural resource endowment (RE). We estimate three models, using World Bank data on national capital stocks. In a one-equation model we show that RD has a negative effect on growth rates, apparently confirming the main results of the resource "curse" literature. RE, however, has a positive impact on growth. We then estimate a two-equation model, in which the impacts of RE are much weaker. Finally, we estimate a three-equation model, in which the impacts of natural resources on growth disappears.

Keywords: resource abundance, growth, resource curse

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The observation that countries with abundant natural resources seem to grow more slowly than those with scarce resources has been put forward by a number of researchers, including Gelb (1988), Auty (2001), Ranis (1991), and Lal and Myint (1996). Recently the relationship was apparently given a clear econometric expression in the work of Sachs and Warner (1995, 1997). Continued work has focused on trying to explain why this apparently negative relationship between growth and natural resource endowment should exist.[1]

In this paper we use capital stock data from a World Bank data set to examine this relationship. We show that the negative impact of natural resources on growth, while apparently present in a simple econometric model, disappears when a more complete model is used.

Natural Resources and Growth

There have been many detailed studies of individual countries to explore the contribution of natural resources to economic growth. The question is whether there is a general probabilistic relationship that will show up in an econometric approach, in particular country cross-section data. In this case, as in any other, specification is everything, and needs to have a clearly articulated economic basis.

Our analysis proceeds on the assumption that there is such a thing as natural resource endowment, distinct from the structure of an economy that establishes itself in any particular state of that endowment. Said another way, we view the structure of the economy, not as an

[1] For a succinct review of the literature see Sarrat and Jiwanji (2001).

independent factor, but something that develops in part, in response to fundamental conditions in a country. The idea that natural resource endowment can be taken as an objective precondition has been contested, on the grounds that this endowment is not "fixed by nature," but in fact endogenously determined by a country's technological capacities. This idea goes back a long way, for example to the monumental work of Erich Zimmerman: "Resources are highly dynamic concepts; they are not, they become, they evolve out of the triune interaction of nature, man, and culture. . . .:[2] But this is a long-run phenomenon. It does not negate the interest in looking at the impact, in the short run, of resource endowments as defined by current technology. Why have countries which would appear to have reasonably abundant natural resource stocks, under current technologies, not been able to turn these stocks into economic growth?[3]

Why these thoughts are important is that in their well-known paper Sachs and Warner (2001) use, as a measure of natural resource scarcity, primary exports as a proportion of GDP. Using a cross-section analysis of 87 countries, and in a variety of specifications, they show that this variable is consistently, negatively, associated with growth in per capita incomes. Their multivariate models include both contemporaneous economic type variables (initial GDP, commodity price trends, investment) and contextual, or institutional type variables (the degree of openness of the economy, the presence of the "rule of law"). The negative sign in the resource abundance variable is regarded as conclusive evidence of the "resource curse": abundant natural resources leading, on average, to slower growth.

As a measure of resource abundance, primary exports as a proportion of GDP is a

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[2]Zimmerman, 1933, p. 4.

[3]In fact the notion of endowments probably makes in a longer run setting as well, though in this case it would have to be defined with reference to country specific resource discovery and development functions, in particular in terms of the extent to which any particular country such a function would have to shift to create competitive resource stocks in that country.

misleading index.[4] It registers primarily the sectoral importance of primary industries, in the economy and in terms of exports. A country heavily dependent on primary industries would be regarded as a resource-rich country by this variable. But the resource dependence of the economy and resource endowment are different things.[5] It is possible for a resource abundant country to have a small primary sector (the U.S. is a leading example), and on the other hand for a resource poor country nevertheless to have an economy that is heavily dependent on primary sectors (several good examples are in Tanzania and Burundi).

In the following sections we present three econometric models designed to investigate the role of natural resources in economic growth. We start with a simple equation model, because this has been the main approach used by others. We then go to a two-equation model, in which we explain both growth and the sectoral dependence on primary industries. Finally we move to a three-equation model, which recognizes that many of the other variables in use are also endogenous. The reason for presenting three progressively more complicated models, rather than simply to specify the one thought to be the most appropriate, is to look at the impact of model specification on the conclusions one draws about the role of natural resources. We will see that as the models become more complete, the apparent negative influence of natural resources gets smaller and ultimately vanishes.

Data

Our strategy is to use the Sachs and Warner country data on all other variables, but

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[4]Sachs and Warner check their results using alternative indices, but they are subject to the same reservations.

[5]This has not escaped the attention of others. In particular Jean-Phillip Stijns (2001b) points out that resource dependence and resource abundance are different things. He then reruns the SW model, but replacing their measure of resource dependence with data on estimated natural resource reserves, as constructed by him from a number of sources. His results show no significant impact of a country's natural resource stocks on growth rates.

introduce capital stock data from a recent World Bank effort to estimate natural, human, and produced capital figures for countries of the world. Natural resource assets in the World Bank data set are built up from estimates of agricultural land, pasture land, forests, protected areas, metals and materials, and coal, oil and natural gas. Very briefly,[6] agricultural cropland is valued as a stream of land rents in an infinite time horizon. Individual rental rates for rice, wheat and maize, varying from 30 to 50 percent of gross value of production, are used for valuation of cereal lands. Other lands are then valued at 80 percent of this rate to allow for the fact that other crops are likely to yield lower returns. Pasture land is valued in a way similar to that for crop-land but in this case, it is valued at 45 percent of gross value of its output of meat, wool and milk. As for the valuation of timber, there are two cases. In cases where exploitation is sustainable, i.e., the harvest rate is lower than the annual growth rate, it is valued as the present value of a constant resource rent with an infinite horizon. Otherwise, it is valued as the present value of a constant resource rent over its life span. Non-timber benefits are valued by assuming that 10 percent of the forest area is used for non-timber production. Protected areas are valued with an opportunity cost approach, where the value assigned for pasture land is used as a proxy for a minimal value of protected area. The assumption is being made, in other words, that protected areas could otherwise have been used for pasture, agriculture or forestry. Minerals and metals are valued as the present value of a constant stream of resource rent for the life of proved reserves. Eight metals and minerals, bauxite, copper, iron ore, lead, nickel, phosphate rock, tin and zinc, are included. Fossil fuels, including oil, coal and gas, are valued similarly. In cases where there are no data on reserves, a time to exhaustion of 20 years is assumed. Fisheries have not been included into the estimation due to both data availability and the fact that fishery rents

[6]See the World Bank report for greater detail.

are often zero as a result of poor management.

Natural resource stocks are estimated by capitalizing (at 4 percent) these estimated rents. Produced assets are valued using a perpetual inventory model based on data for investment and life tables for assets. Human capital is measured as a residual.

Models and Results

Model I

This is a single equation model of the following form:

$$\Delta GDP = f\left(GDP_0, IR, OP, RL, TT, RE, RD\right)$$

where:

ΔGDP is average annual growth in per capita GDP from 1970 to 1990,[7]

GDP_0 is initial GDP,

IR is investment rate,

OP is the degree to which the economy is open to world markets,

RL is the presence of the "rule of law" in the country,

TT is changes in terms of trade,

RD is resource dependence, and

RE is resource endowment.

The first six of these are taken from the database used by Sachs and Warner. Resource dependence is defined as the proportion of total capital that is accounted for by natural resource capital.

[7] ΔGDP, the dependent variable, is the change in per capita GDP from 1970 to 1990; TT is the average annual growth in the export to import price ratio from 1970 to 1990; IR is the log of investment to GDP ratio averaged over 1970 to 1989. "Openness," OP, is the fraction of years between 1965 and 1989 in which the country was integrated with the global economy, which means maintaining relatively low tariffs and having a relatively modest black market exchange rate premium; rule of law, RL, is an index indicating the degree to which citizens are willing to accept established institutions. See Sachs and Warner for more details.

It is a variable analogous to the resource dependence variable used by SW, as it reflects the extent to which an economy is dependent on natural resources (primary industries). RE is natural resource capital per capita for the year of the World Bank data, 1994.

Results from Model I are shown in Table 1. These are largely consistent with SW. In particular, the negative coefficient on RD apparently shows the strongly negative impact on growth of having a resource-dependent economy. Resource dependence is measured somewhat differently from SW, but the results are the same. A more interesting result is the coefficient on resource endowment. This is positive and significant. This simple model appears to corroborate Sachs and Warner, but adds a wrinkle: natural resource endowment appears to have a positive impact on growth, apart from the negative effect of the resource-dependence variable. Note also that in this model the only variable that is not statistically significant is investment itself.

Model II

Model II is a two-equation model. Its underlying premise is that resource dependence and resource endowment are not equivalent factors in an economic sense. Resource endowment is a fundamental factor describing an original state, while dependence is endogenous, and indexes how the economy has developed as a result of its endowment, and of other factors. The model is:

$$\Delta GDP = f\left(GDP_0, IR, TT, RD, RE\right)$$

$$RD = q\left(OP, RL, RE\right)$$

The first of these is the growth equation, in which growth is related to several contemporaneous economic variables, natural resource endowment (RE), and the dependence of the economy on natural resource sectors (RD). The second equation examines why countries develop resource dependent economies; it specifies resource dependence, defined as natural capital share of total capital, as a function of several contextual factors (the openness of the economy and the rule of law) and natural resource abundance.

This model has a straightforward recursive structure and was estimated as such. Resource dependence is determined by several underlying factors, among which is natural resource endowment. Resource dependence then helps to determine, as in the Sachs and Warner case, growth rates. But resource endowment may also have a direct impact on growth, for example by providing rents for investment in non-resource capital.

The results from Model II are shown in Table 2. All of the variables in the growth equation are significant at least at the 5 percent level; in fact, all but two meet a 1 percent criterion. Initial GDP has a negative relationship to growth (conditional convergence), while capital accumulation and price shocks have positive coefficients. These are consistent with the results of Sachs and Warner.

The variable that expresses resource dependence of the economy (natural resource capital as a percent of total capital) is again negative, mirroring the basic result of Sachs and Warner. Note that this effect is now much weaker than in the single-equation model.

Again, however, resource dependency and resource abundance are not the same thing, and the coefficient on resource abundance (natural capital per capita) is, in fact, positive. Looking at the dependency equation we see that the resource abundance is positive and significant. This shows the negative side of natural resources: countries with relatively abundant resources are prone, again probabilistically, to develop resource dependent economies, which appear to grow slower. Note in particular, however, that in this model the impact of resource dependence is much smaller than in Model I (-.29 compared to –15.56). We note that the openness of an economy works against having a resource dependent economy, while "rule of law" is negative but not significant.

Model III

We now move to a three-equation model. One can argue that Models I and II are incompletely specified because they do not explicitly account for human capital. Human capital as a factor in economic growth has been explored by many researchers (Barro, 2001; Easterly, 2001; Blankenau and Simpson, 2004; Birdsall et al., 2001; Self and Grabowski, 2004), thus we include it in the growth equation. But human capital can be thought of as endogenous also; thus we include a separate equation for this. This also allows us to examine the impacts of natural resource endowments. Several authors (Gylfason, 2001; Stijns, 2001a) have stressed the importance of potential interactions between natural resource capital and human capital, though they hypothesize different impacts. We therefore posit a model in which human capital is added to the two equations of Model II, with a third equation for explaining the growth in the stock of human capital. The model is:

$$\Delta \text{GDP} = f\left(\text{GDP}_0, \text{IR}, \text{TT}, \text{RD}, \text{RE}, \text{HC}\right)$$

$$\text{RD} = q\left(\text{OP}, \text{RL}, \text{RE}, \text{HC}\right)$$

$$\text{HC} = h\left(\text{HI}, \text{OP}, \text{RL}, \text{RE}\right)$$

where the new variables are:

HC: human capital, defined as the dollar value of per capita human resources in 1994,

HI: investment in human capital, defined as educational expenditures as a percent of GDP, average for the period 1970 to 1990.

This model is also recursive. Human capital is determined by the third equation. It then appears in the second equation to help determine resource dependence. Resource dependence is then used in the first equation to help determine growth rates. Both resource endowment and human capital also appear in the growth equation to assess the possible direct effects of these variables.

Results of Model III are shown in Table 3. The most interesting result is that in the growth equation the impacts of natural resources have dropped out, at least in the sense of statistical significance. Neither resource endowment nor resource dependence have a significant impact on growth. All the other variables in the growth equation are significant; in particular, human capital, which has a positive impact. In addition, investment in produced capital, IR, is now positive and significant. From the other equations we find that resource endowment has a significant positive effect on resource dependence, but no effect on the human capital variable. The only anomalous result in this model is the sign on rule of law in the second equation; it is positive and significant, indicating that greater rule of law has the effect of increasing resource dependence among these countries.

SUMMARY

Economic growth is a complicated process, and the role of natural resources in growth can also be expected to be complicated. The well-known results of Sachs and Warner (2001) about the negative impact of natural resources were derived with a variable that actually measures the natural resource dependence of an economy, not its natural resource endowment. When we use a single-equation model to explain growth, we find the negative impact of resource endowment but a significant positive effect of natural resource endowment. We explored two more complete models to sort out these effects. A two-equation model in which resource dependence is first determined by resource endowment and other factors, then applied recursively in a growth equation. The impact of natural resource endowments and resource dependence are still significant in the growth equation, but their impact is substantially smaller than in the single-equation model. We then used a three-equation model, in which human capital is linked recursively through its impacts on resource dependence. In this model we find that the impacts of natural resources on growth have disappeared.

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Table 1. Results from the One-Equation Model[1]

Intercept	18.41	RL: Rule of law	.54
	1.97		.11
	<.0001***		<.0001***
GDP_0: Initial GDP	-2.31	TT: Prices	.18
	.24		.05
	<.0001***		.0019***
IR: Investment	.45	RE: Endowment	.06
	.28		.02
	.1193		.0007***
OP: Open	1.07	RD: Natural capital share	-15.56
	.37	of total capital	2.30
	.0059***		<.0001***

[1]The first number is the coefficient, the second is the standard error and the third is p value. *, ** and *** indicate significant at 10%, 5% and 1% levels, respectively.

Table 2. Results of Model II

Growth Equation		Resource Dependence Equation	
Intercept	16.60 5.21 .002***	Intercept	10.73 1.29 <.0001***
GDP: Initial GDP	-2.05 .56 .0005***	OP: Openness	-6.47 2.11 .0033***
IR: Investment	1.32 .40 .0019***	RL: Rule of law	-.52 .54 (.3379)
TT: Terms of trade	.18 .08 .0411**	RE: Resource endowment	.30 .08 .0007***
RD: Resource dependence	-.29 .10 .0043***		
RE: Resource endowment	.12 .05 .0147**		

Table 3. Results of Estimating Model III

Growth Equation		Resource Dependence Equation		Human Capital Equation	
Intercept	21.88 3.86 <.0001***	Intercept	8.72 1.22 <.0001***	Intercept	-19.60 12.63 .127
GDP_0: Initial GDP	-2.90 .44 <.0001***	OP: Openness	-.26 2.41 .91	HI: Investment in human capital	1.46 3.50 .678
IR: Investment	.64 .32 .048**	RL: Rule of law	2.62 .86 .0035***	RE: Resource endowment	.19 .56 .739
TT: Terms of trade	.27 .06 .0001***	RE: Resource endowment	.32 .07 <.0001***	RL: Rule of law	24.86 3.84 <.0001***
RE: Resource endowment	.03 .03 .416	HC: Human capital	-.12 .03 <.0001***	OP: Openness	52.96 14.31 .0005***
RD: Resource dependence	-.06 .07 .413				
HC: Human capital	.03 .005 <.0001***				