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58

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A new approach to the natural resource curse. growth or income effects?

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Abstract:

This paper suggests there is little evidence for what have been called the "Natural Resource Curse". In fact, the empirical result linking natural resource abundance and poor economic performance is reflecting the effect of negative shocks on commodity markets (both, in terms of prices and of total demand), that during the estimation period, affected many natural resource rich economies´ income levels, as a consequence of these economies greater exposure to shocks. This paper shows that the empirical link between natural resource richness and economic growth disappears once controlled for shock incidence. Therefore, the empirical result know as "Natural Resource Curse" cannot be interpreted as a growth handicap of natural resource rich economies but as a reflection of their greater vulnerability to shocks.

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Resumen:

En este papel de trabajo se sostiene que el resultado empírico que relaciona la presencia de abundantes recursos naturales con bajas tasas de crecimiento refleja el efecto que sobre los niveles de actividad económica causa una mayor exposición a choques externos y la prevalencia de choques negativos durante el periodo de estimación. Los resultados sugieren que no existe evidencia contundente, a favor de la hipótesis de la "maldición de los recursos naturales". Por el contrario, se sugiere que la asociación negativa encontrada entre la variable de riqueza en recursos naturales y el crecimiento económico en las décadas de los setenta y ochenta recoge la incidencia de choques negativos en los mercados de productos primarios (precios y cantidades demandadas) y por lo tanto es el reflejo de la vulnerabilidad externa de las economías ricas en recursos naturales mas que una pretendida deficiencia en su dinamismo económico.

1. Introduction

Academic and policy circles alike have given, at one point or another, strong support to the idea that being natural resource "rich" is some sort of curse many developing countries have to live with. Even though it is fair to say that there has been dissent from this "absolute truth", the argumentation in favor of the existence of such curse has been so loud that in many cases its validity is taken for granted. A few quotations should help to make this point clear.

From the policy circles standpoint, the resource curse is a tempting expedient to refer to when performance is less than desirable:

> "Oil is the devil excrement. We -Venezuelans- are drowning in the devil's excrement" (Perez Alfonzo, OPEC founder)
>
> "We are in part to blame, but this is the curse of being born with a cooper spoon in our mouths" (Kaunda, President of Zambia)
>
> "All in all, I wish we had discovered water" (Yamani, Oil Minister of Saudi Arabia)[1]

However, it has been the support given in academic circles what has made the "Natural Resource Curse" (NRC) a widely accepted concept. The following are precise examples of the strength with which the idea has been proposed in academic circles:

> "Resource based industrialization contribution's to economic growth has been at best minor and at worst negative" (Auty, 1990)
>
> "One of the surprising features of economic life is that resource-poor economies often vastly outperform resource-rich economies in economic growth" (Sachs and Warner, 1997).
>
> "Resource abundance is an important determinant of economic failure" (Rodriguez and Sachs, 1999)
>
> "There is now strong evidence that states with abundant resource wealth perform less well than their resource-poor counterparts" (Ross, 1999)

[1] These three quotations have been taken from Michael Ross, 1999.

To establish the validity of the NRC claim is not trivial. Three quarters of Sub Saharan African countries and more than a half of the countries in Latin America, The Caribbean, North Africa and the Middle East rely on primary commodities to generate at least half of their export income[2].

The idea of a NR curse can be derived from casual observation. If countries are divided in terms of natural resource richness (using the most widely used measure, namely primary exports as a percentage of GDP) it can be observed that the top quartile (natural resource rich economies) grew at an annual rate of 0.6% while the bottom quartile grew at a rate of 2.2% during the last quarter of the twentieth century.

Not only natural resource richness seems to be associated with slower growth at the aggregate level, but also most of the biggest "growth collapses" observed during the last quarter of the twentieth century took place in countries that would be classified as NR rich. The top ten list of growth collapses during the mentioned period includes four oil rich economies (U.A.E., Saudi Arabia, Venezuela and Brunei), two top exporter of zinc (Zambia and Congo, RD) a major cocoa exporter (Cote d' Ivore) and three civil war torn countries (Niger, Nicaragua and Sierra Leone). All but three of them (the civil war torn countries) belong to the top quartile of NR rich economies according to Sachs and Warner's measure.

Already by 1980, Nankani had shown that leading hard-rock minerals and oil exporters experienced lower growth than a control group of non-mineral exporters (1.9% vs. 3.8% per annum). Another study (Wheeler, 1984) suggested a negative correlation between the share of hard-rock mineral in total exports and growth.

Sachs and Warner's study (1995, 1997) has become by far the most influential paper on this literature. Compared to the previous literature on the subject this study widened the geographical scope of the research, widened the definition of NR richness and most important, controlled for characteristics that could be correlated to NR richness and that have a direct impact on growth to avoid biases in the estimates of the NRC.

Sachs and Warner (1997) estimated that a one-standard positive deviation in their preferred measure of NR richness in 1970 (Primary exports as a % of GDP) was associated with a reduction in 1.5 percent points in growth rates over the next two decades. Further refinements have led them (Sachs and Warner, 1999) to believe

[2] *Ibid.*

that the magnitude of the effect is somewhat smaller (about 0.4 percent points less for each additional positive one-standard deviation).

However, even the more conservative estimate is of considerable significance. For example, a typical Sub-Sahara African country would be about one and a half standard deviations above the high income countries' average in terms of primary exports as a percentage of GDP, the most conservative Sachs and Warner's results would suggest that they should have grown 0.6 percent points more per year during the period 1970-1989 had they not been NR richer than high income countries. That means that their GDP per capita in 1989 would have been almost 13% higher were they not so NR rich. Extrapolating these results, the typical Sub-Saharan country will fall behind a further 25% in the next fifty years just as a consequence of its excess NR richness.

After Sachs and Warner (1995, 1997), there has been a growing literature that has made efforts to quantify the magnitude of the curse. This literature builds upon the previous attempts by using alternative measures of NR richness, different estimation techniques and introducing new control variables. The results are not conclusive, but the feeling that NR's are a harmful entity has remained.

1.1 Explaining the natural resource curse. competing hypothesis

There is much more controversy about the mechanisms linking NR richness and economic performance than about the nature of the NR richness effect on economic growth (the existence of the curse itself). Even among the defendants of the NRC there is no agreement on how it operates.

Even before the issue of the NRC became a subject of empirical estimation there were hypotheses linking natural resource richness and poor economic performance. Already in the early fifties, stucturalist economists (Prebish, 1950) suggested that commodity exporters would suffer from a steady deterioration in terms of trade that would negatively affect their economic performance. At around the same time another group of economists argued that natural resources generated few "backward" and "forward" links with the rest of the economy, and that this kind of "enclave" sector at best would not be able to serve as a catalyst of economic performance in developing economies.

Those arguments however faded with time. The first one because there was no compelling evidence about a secular trend in terms of trade at the aggregate, cross-country level and definitely not at the country case level. Also because even if true the argument does not support any policy intervention. The lack of "backward-forward" links argument also faded because between its proposal time and 1976 most of the commodity producer sectors in developing countries were nationalized, presumably increasing the links with the rest of the economy even if at least only through a higher level of domestic spending.

However, the empirical regularity was strong enough to attract new attention to the development of new hypotheses that could explain the curse. In consequence, in recent years a new group of competing hypotheses has been developed in an attempt to account for the empirical regularity known as NRC. Here I present a summary containing what have become the most popular theoretical approaches among the supporters of the NRC idea.

1.1.1 The lack of dynamic properties of natural resource intensive activities.

Matsuyama (1992) presents an explanation of the curse based on the existence of positive externalities on non-resource intensive activities. Those non-resource intensive activities become inefficiently underdeveloped because of the negative impact of relative prices as consequence of the income generated by the resource intensive sector, the "Dutch Disease" logic developed in Corden (1982) and Corden and Neary (1984).

In Matsuyama's paper a natural resource boom affects the relative size of sectors within the economy, the boom will increase demand for non-tradable goods reducing the availability of factor of production (labor) in the non-resource, tradable sector. This result can have dynamic implications (affect growth performance) if the non-resource, tradable sector is subject to externalities (learning-by-doing external to the relevant operational level) in production that promote economic growth, not common in the other sectors of the economy. This is the mechanism known as "Dynamic Dutch Disease".

An unexplored channel that could be related to the "lack of dynamism" idea is the potential effect of natural resource richness on the "self-discovery" process. Hausmann and Rodrik (2002) propose that economic development through adoption takes place as a self-discovery process. Countries need to invest to discover the true costs of production in new activities. The presence of economic rents derived from the natural resource could increase the cost of discovery for a

given discovery technology (by increasing the wage level of the domestic economy, considering that the discovery process uses labor as a factor of production). If the discovery process exhibits learning by doing properties then a high initial cost of discovering could trap a natural resource rich economy in an equilibrium where innovation rates (and therefore, growth rates) are low.

1.1.2 The political economy impact of natural resource rents.

This line of argumentation is by far the one that has received more attention and has produced more alternative explanations reflected in an extensive literature. Generalizing, this line can be divided in three distinct broad arguments.

One possible argument is the one proposed by Lane and Tornell (1998) and called the "Voracity Effect". This argument proposes that countries with weak institutions and power fragmentation tend to overspend when faced with a windfall. Natural resource rich countries are more prone to windfalls; therefore they are more likely to engage in overspending. In fact the development of a natural resource rich sector could be analyzed as a "windfall" itself. The logic is as follows: a windfall increases the productivity of the formal sector of the economy enhancing the taxation capacity of the fiscal authorities. This enhanced fiscal capacity generates a more than proportional increase in transfers since each power group tries to maximize its share on the transfers. The more than proportional increase in transfers, forces an endogenous increase in distortionary taxes harming economic growth.

An alternative explanation, Rodrik (1998), links poor economic performance and natural resource richness through the effect of negative external shocks (instead of through positive shocks as in Lane and Tornell, 1998). This explanation interacts external shocks with latent conflict and weak institutions to explain the "implausibly" large effect of negative shocks on economic growth reported by Easterly et al (1993). According to Rodrik (1998) high degrees of social conflict combined with weak institutions of conflict management magnify the economic costs of exogenous growth by the effect of the distributional conflicts that are triggered. Such conflicts affect the overall efficiency of the economy and potential growth by delaying needed adjustments[3] (fiscal policy, real exchange rate, real wages) and by diverting activities from the productive spheres into rent seeking.

[3] See [1] Alesina, A. and A. Drazen (1991): "Why are stabilizations delayed?"

Natural resource rich countries would be more prone to this kind of phenomenon because of their greater exposure to significant external shocks (terms of trade).

Another line of argumentation proposes that institutional outcomes are in fact endogenous to the natural resource richness of a country. Broadly speaking Engerman and Sokoloff (1997, 2002) argue that paths of institutional development and therefore economic performance are linked to factor endowments. More closely related to the NRC literature, Karl (1997) studies five oil rich economies and develops a theory of "rentier states". This hypothesis proposed that in countries with large natural resource endowments, large rents, subject to distribution are present fostering the development of "rentier states" that encompass a unique institutional setting tailored to the political distribution of rents that tend to weaken formal institutions and authority. Through that channel natural resource richness negatively affect the prospects for economic growth.

Providing some empirical evidence to that kind of hypothesis, Isham et al (2003) argue that not only natural resource dependant economies are more vulnerable to external shocks, but also the institutional capability to respond to those shocks is endogenously determined by the export composition. They argue and provide evidence supporting that the concentration of natural resource richness in commodities that are extracted from a narrow geographic or economic base ("point-source" natural resources) are strongly associated with weak public institutions which are, in turn, associated to slower growth.

1.1.3 Convergence from above.

Rodriguez and Sachs' (1999) argue that resource rich countries tend to converge to their steady state level of income from above once the exhaustible natural resource faces depletion. This convergence "from above" is the result of political/social constraints on investment that force the investment of the natural resource rent to take place domestically. This distortion makes the capital stock to overshoot its steady state; both, allowing extraordinary levels of consumption in the transition path and forcing the economy to converge to the steady state from above when per worker rents are not enough to maintain such high capital stock. According to this view, the empirical regularity linking natural resource richness to slower growth is the consequence of the convergence to their steady stats from above.

1.1.4 Volatility-induced Dutch Disease (inefficient specialization).

Hausmann and Rigobon (2002) interact the "dutch disease" logic with the volatility that characterizes natural resource abundant economies and with financial frictions to generate a dynamic resource curse. They argue that in countries where the natural resource sector is big enough the volatility in relative prices can generate incentives against the rest of the tradable sector. That would be the case if there were imperfections in the financial system that does not allow them to insure away from the volatility created by unstable relative prices. This volatility in the non-resource intensive sector leads to specialization in the natural resource sector. This specialization fosters volatility even more (by making the economy more dependant on the volatile source of international income), making capital accumulation more expensive in the tradable sector and reducing the growth capacity of the whole economy. Supporting the volatility hypothesis, Lederman and Maloney (2003) argue that it is export concentration (a proxy of exposure to volatility) and not natural resource richness what drives Sachs and Warner's (1995) result. According to their results once controlling for export concentration, natural resource richness is at best insignificant.

1.1.5 Debt overhang.

Manzano and Rigobon (2001) argue against defining the regularity found by Sachs and Warner (1995) as a "Natural Resource Curse". They propose that in a world where credit constraints are important, export income serves as international collateral, in consequence the optimal borrowing policy for natural resource rich economies tend to be procyclical, creating a boom-bust cycle. According to the authors, natural resource rich countries over borrowed in the seventies taking advantage of high price of commodities and suffered the consequences of the debt overhang during the eighties and nineties once the positive shock to commodity prices was reversed. This explanation proposes that it is a financial imperfection rather than a resource curse what lies behind poor performance of natural resource rich countries in the last quarter of century.

As can be seen there are a few hypothesis that compete or complement each other in the process of explaining the NRC phenomenon. This explanations rely on different causation channels all of them plausible from a theoretical point of view. In consequence the NRC issue remains an open empirical question.

Furthermore, recent research has pointed out the need to also explore channels through which NR richness could have a positive impact on economic growth. Even if the net aggregate effect were to be negative it is important to know which channels work in each direction to understand the situation on a case-by-case

basis. Some research has pointed out to the potential positive effects of NR richness on technological progress when they are combined with high "learning capacity" (Maloney, 2002 and Lederman and Maloney, 2003). Another argument in favor of a positive effect of NR richness on economic growth is the "big push" argument presented by Sachs and Warner (1999). The logic is that if low-income traps are a relevant concept (critical market size to make profitable to incur in the fixed costs of industrialization), in consequence, the impulse resulting from a natural resource boon could conduce to overcome the trap. A comprehensive study that is able to decompose the impact of NR richness according to the different channels of causation remains to be done. Until then is difficult to extrapolate from aggregate result to specific cases and reach policy conclusions.

2. Facts and puzzles in the cross-country growth literature. What can we learn?

As a consequence of the increase on the availability of standardized cross-country data set, notably the Penn World Tables data set (Summer and Heston, 1991) there has been an almost explosive increase in the empirical growth literature making intensive use of cross-country regression tools, following the work of Barro (1991). The conclusions of this vast literature remain a source of conflict yet to be sorted out. However, the work done has allowed to clarify some facts about growth dynamics and to highlight some mayor puzzles. The NRC literature is one of those areas where some progress has been made but where some issues remain unsolved. Both, looking at the NRC and broader cross-country growth regression literatures can help to identify leads that can help to understand the nature of the relationship between NRR and economic growth.

2.1. The high volatility/low persistence of growth rates puzzle

One of the most interesting findings of the literature is that growth has shown remarkably little persistence across decades while country characteristics (determinants of long term growth in endogenous growth models or growth out of steady state in neoclassical models) show a much higher degree of persistence. (Easterly, et al 1993). In fact, trade; fiscal and industrial policies as well as the

institutional setting tend to observe small changes overtime for a given country when compared with the changes observed in growth rates.

The evidence on low economic growth persistence across time combined with high persistence in growth determinants (policies and country characteristics that have been found related to growth in previous work) has led Easterly et. al. (1993) to attempt explaining low economic growth persistence as the consequence of temporary external shocks that are arguably independent of "relevant" country characteristics and by definition, of low persistence.

In fact, Easterly et al (1993) findings suggest that external shocks in general, and terms of trade shocks in particular, have a significant explanatory power over growth rates differentials across countries and across time. However, they also recognize that their estimation of the terms of trade shocks' effect on economic growth is implausibly large considering the implications of the neoclassical framework.

This is particularly interesting since exposure to external shock is not independent from country characteristics. Developing countries tend to observe a less diversified package of exports, making them more vulnerable to world market fluctuations. That might be part of the reason why growth tends to be more volatile among Non-OECD countries (Easterly, Islam and Stiglitz, 2000)

The finding that the low persistence of growth rates is associated with external shocks episodes and that exposure to external shocks might be associated with some "fundamental" characteristics of an economy (NR dependence) can shed some light on the NRC literature.

In most of the literature the concept of NRR is understood as an economic fundamental with high persistence, after all NRR measures tend to be much less volatile than economic growth. Since high persistence fundamentals do a poor job explaining growth dynamics, the bulk of the NRC literature is in trouble. It is very difficult to explain the high variance observed in the dependent variable with the little variance observed in the candidate explanatory variable. In this context NRR would be in the same boat with all the other fundamentals that do a poor job explaining growth.

How do we reconcile this with the fact that a NRC result tends to arise in the cross-country estimation? To start with, Easterly et al (1993) give a first clue. The high volatility of growth rates seems to be associated with external shock episodes. Easterly, Islam and Stiglitz (2000) suggest that external shocks episodes

are associates with less diversified package of exports. Finally, Lederman and Maloney (2003) find that NRR could be proxying for export concentration. In consequence, the negative association observed in the date between NRR and economic growth for the 1970-1989 period might just be capturing the effect of negative external shocks on growth which is consistent with the variable's low persistence.

2.2. The growth collapses puzzle

A fifth of the countries for which there is readily data available (Penn Tables) have experienced growth collapses[4] (an average negative rate of growth of GDP per capita) during the last quarter of the twentieth century. This came as a surprise precisely after a period of rapid growth in almost all regions of the world and considering the independence processes in vast regions of the developing world that were believed to be a promise for economic growth and development. It also came as a surprise, considering what at the moment was understood as a great improvement of the understanding of the growth process during the fifties and sixties. What happened? Why did so many countries collapse in their effort to sustain economic growth?

Interestingly, most growth collapse stories have taken place in countries that already at the start of the growth collapse episode were among the poorest of the world. This issue is behind the lack of convergence observed in the income date during the same period and makes the phenomenon more of a puzzle.

As previously noticed, those growth collapses have taken place among countries that are regarded as NRR. In fact, the notoriety of them has been an incentive to the development of the NRC literature. That is why the growth collapse puzzle is relevant in understanding the association between NRR and economic growth.

A first question that needs to be answered in order to understand the nature of growth collapse episodes, and its association with the NRR of a country, is whether the phenomenon should be regarded as static or as a dynamic one. In other words, it is important to assess whether the "growth collapses" are in fact

[4] The group is integrated by: Angola, Burundi, Central African Republic, Comoros, Cote d'Ivoire, Gambia, Guinea Bissau, Jamaica, Madagascar, Mozambique, Namibia, Niger, Nigeria, Peru, Sierra Leone, South Africa, Togo, Venezuela, Zambia and Zimbabwe.

growth collapses (a permanent reduction in the ability to growth –dynamic phenomenon-) or if on the contrary they are the observed transition dynamics generated by an output collapse (a reduction in the level of activity given the available technology –static phenomenon-).

Once posed the question about the nature of the collapse (growth vs. income) it is interesting to think about how much responsibility those collapse episodes have in driving the findings associated with the NRC. If those findings are mostly driven by the collapse episodes and those episodes are "income" rather than "growth" collapses then, the validity of the conclusions drown from the NRC literature should be questioned.

3. Facts and puzzles in the Natural Resource Curse literature. What can we learn?

The last decade has seen a copious amount of work done to refine and interpret the empirical result know as the NRC. Being this empirical regularity of such relevance for developing economies there has been a lot of effort put into better understanding what the result means. In that context, Sachs and Warner's result has been subject to considerable robustness testing sometimes favoring their findings and many times qualifying the conditions under which the regularity holds. Reviewing the list of robustness test is a useful exercise to better understand the true nature of the result. Here are succinctly presented the most relevant robustness test performed as well as their implications to the interpretation of the NRC.

3.1. Sensitivity to definition of Natural Resource Richness

Sachs and Warner's results correspond to the use of the share of primary exports on GDP as a proxy for natural resource richness (NRR). As Lederman and Maloney (2003) suggest, this variable is of intrinsic interest but is hardly the most appropriate proxy for NRR. According to Leamer (1984) the standard Hecksher-Ohlin trade theory dictates that the appropriate measure of NRR would be net export of natural resources per worker.

It is important to notice that the choice of the proxy for NRR is a key issue both because the proxy might be capturing different dimensions of the issue and because the country ranking in terms of NR richness greatly changes with changes in the proxy used.

As an example it is interesting to notice that using Sachs and Warner's measure of NR richness, the share of primary exports on GDP, the five top countries in the sample at the beginning of the period in analysis (1971) were Bahrain, Somalia, Saudi Arabia, Kuwait and Oman. Excluding oil producers the top five NR rich countries were Somalia, Guyana, Liberia, Mauritania and Zambia.

On the other hand, using Leamer's measure, net export of primary resources per worker the top NR richest countries happen to be Norway, New Zealand, Trinidad and Tobago, Canada, Finland and Australia (Lederman and Maloney, 2003).

The difference not only appears at the top end of the distribution. As a complementary example it is useful to observe that Sachs and Warner's measure ranks countries such as Brazil and USA as NR poor countries (bottom quartile of the distribution)

The contrast in the country ranking is so stark that it raises suspicion about the interpretation of Sachs and Warner's results.

As expected from the differences in rankings, the use of Leamer's measure leads to considerably different conclusions about the link between NRR and economic growth. In fact, the top quartile of NRR economies according to Leamer's measure, grew on average at 1.1% a year while the bottom quartile grew only 0.7% a year on average during the last quarter of the twentieth century.

Furthermore, confirming the preliminary evidence suggested by the division of the sample in quartiles, Lederman and Maloney (2003) find that Leamer's measure of NRR has no statistically significant relationship with growth and if any the relationship is positive.

Stijns (2001) approach the NRC estimation issue by directly testing the impact of natural resource reserves (oil, gas, coal, minerals and land) on economic growth. In the same line as Lederman and Maloney (2003), with the exception of land, he does not find a statistically significant relationship between reserve measures (NRR proxy) and economic growth.

What can be learnt from these findings? The lack of robustness of the NRC results to the choice of NRR proxy suggest that it might not be NR richness itself but dependency on primary exports what is associated with slower growth rates. This does not reduce the relevance of Sachs and Warner's results, but at the least it is a warning about the way people read them. If anything, their results suggest that high natural resource dependence is associated with slower growth. Natural resource richness and natural resource dependence are different concepts and the policy implications of having each of those two related to economic growth might well be there different.

3.2. Sensitivity to the time frame of estimation

Natural resource richness has not always been associated with poor economic performance. On the contrary, older literature is prolific in identifying the positive effects of natural resource richness on economic growth. In fact, the "big push" literature suggests that natural resource richness can help countries to escape from poverty traps (Sachs and Warner, 1999). These "older" ideas about the association between natural resource richness and economic growth seem to have been affected by the empirical evidence available at the time.

As far as I have been able to identify, all the rigorous empirical work to estimate the effect of NRR on economic growth has been done using post 1970 data (post 1960 in a few cases). The reason behind this "time frame bias" is precisely the availability of reliable data for a wide set of countries in terms of both, the dependent variable (economic growth) and the set of explanatory variables (including the proxy for NRR). However, it cannot be assured that in effect the choice of the time frame is not biasing the result. A more ad hoc approach to the available evidence is helpful to identify whether there is room to think Sachs and Warner's results are valid outside its own estimation time frame (1970-1989).

Even for data closest to the base time frame estimation, the negative association between NRR and economic growth tend to disappear. According to Auty (1993), oil exporters and hard-mineral exporters grew more or the same during the 1960-1971 period (respectively a per capita annual average of 2.9% and 2.5%) than other middle and low-income countries.

Looking at pre-1960 growth rates it can be seen that in general, countries and regions regarded as NRR had experienced growth rates in excess of the world average.

Maddison (1991, 1995) suggests that the NR advantage of the "Western Offshoots" (United States, Canada, Australia and New Zealand) played an important role in fostering economic growth directly and indirectly through the attraction of labor and human capital (migration).

Both, the "Western Offshoots" and Latin American countries (commonly regarded as NRR during the nineteenth and twentieth centuries) grew more than the world average between 1870 and 1913 and again between 1913 and 1950. Even during the 1950-1973 period, oil-rich Middle East grew at rates well above the world average (a per capita annual average of 4.4% versus 2.9%). In the 1913-1950 and 1950-1973 the best performer countries of Maddison's seven-country sample for Latin American in terms of average per capita growth were Venezuela (5.3%) and Brazil (3.7%), both countries regarded as NRR. Pre-independence data for Africa would not be so useful for the comparison because of the effect of colonialism on domestic economic growth. However, in Maddison's sample during the 1950-1973 period, Botswana (5.2%) and Gabon (3.8%), two NRR counties, show up as the fastest growers of the continent (Maddison, 1995).

Even if this partial evidence is by no means enough to assume a positive association between NRR and economic growth it is enough to raise serious doubts about the validity of the NRC hypothesis outside the base time frame estimation (1970-1989).

What can we learn from this finding? The suggested lack of robustness of the NRC results to the choice of the time frame of estimation seems to indicate that there might be something especial about the specific period of estimation (1970-1989) that could be driving the results. Again, this does not reduce the relevance of Sachs and Warner's results but constitutes another warning about the way they should be read. If anything they suggest that natural resource dependence was associated with slower growth during the period of reference. If there is something specific about this period driving the results, the policy implications could change dramatically.

3.3. Sensitivity to the choice of estimation technique

Most of the results that suggest the existence of a NRC, including Sachs and Warner (1995, 1997), rely on cross-section regressions to estimate the impact of NRR on economic growth. Presumably, the reason for this choice is the perception that most of the variance in terms of the independent variable (natural resource richness) is in fact found cross section and not in the time dimension. According to that view natural resource richness is a fundamental characteristic of the economy that tends to change little overtime.

However, new sources of natural resources are discovered periodically. In fact it has been argued that natural resource reserves are endogenous to the state of technology (Stijns, 2001). Same as with new discoveries, natural resource richness face depletion at different rates in different countries. Additionally, growth rates tend to observe low persistence over time (Easterly et al, 1993). These dynamic properties of both the dependent and the explanatory variable have led some authors to consider estimation techniques where the time dimension plays a role. Following this approach Manzano and Rigobon (2001) use pooled and fixed effect panel data regressions to re-estimate the effects of NRR on economic growth.

What is interesting is that the negative association between NRR and economic growth observed in cross-sectional data does not seem to be present in the panel data. In other words, the NRC findings are not particularly robust to the choice of estimation technique.

Manzano and Rigobon (2001) notice that in fact the NRC result remains present in the cross-section approach even when they refine the measure of economic growth to account only for the effect of NRR on the economic growth of the non-resource sector. However, they find that the effect goes down both in economic and statistic significance when a pool panel data approach is used and completely disappears when panel fix effects are used as the estimation technique.

What can we learn from this finding? What seems to be behind the lack of robustness is the greater time variance observed in growth rates than in the NRR proxy. Manzano and Rigobon (2001) suggest that the reason behind this lack of robustness is a potential correlation of the NRR variable with an unobserved country characteristic. Even though they do not mention it, this unobservable characteristic associated with NRR could be related to the exposure to external shocks during the estimation period. In any case this is yet an additional warning

about the usual reading of the NRC findings. If anything, those findings only suggest that cross-country variance in the measure of natural resource dependence was associated (higher NR dependence/lower growth) with cross-country growth variance during the period of reference.

3.4. Sensitivity to the inclusion of some control variables

Even though the NRC result seems to be robust to the inclusion of the traditional set of conditioning variables in the growth literature more recent studies have demonstrated that the result tends to disappear with the inclusion of trade composition or foreign debt related variables.

Sachs and Warner (1997) claim that they document a statistically significant, inverse and robust association between NRR and economic growth. Their robustness claim comes from testing the stability of the results to the inclusion of variables that are conventionally included in the set of regressors of cross-country growth regressions. Those control variables include initial level of income (convergence hypothesis), investment rates, human capital accumulation rates, changes in terms of trade, government expenditure ratios, terms of trade volatility and the efficiency of government institutions.

More recently Manzano and Rigobon (2001) have shown that the NRC results are not robust to the inclusion of a variable reflecting the indebtedness of developing economies. They argue that the lack of robustness to this inclusion is the consequence of credit markets imperfections. According to them if countries use their natural resources as an implicit collateral, NRR countries would have been able to contract more debt during the boom of the seventies and therefore more exposed to a "debt overhang" in the post 1980 period.

In favor of the NRC argument it could be argued that in a world where NRR is an implicit collateral, the amount of contracted debt is a measure of the market valuation of the future stream of natural resource related income. Therefore, the indebtedness of a developing economy would be precisely a more refined measure of NRR.

It could also be the case that high indebtedness in 1981 is in turn a proxy for a negative external shock in the late seventies. This would be the case not only if

countries borrowed as a response to a shock perceived to be temporary but also if the adjustment to the shock involved a GDP contraction and/or a real exchange rate depreciation. If this is the case this variable would be capturing the fact that NRR countries were more likely to suffer GDP loses as a consequence of negative external shocks during the period of reference.

Lederman and Maloney (2003) have shown the NRC results' lack of robustness to the inclusion of export concentration measures. When they control, in the growth specification, for a Herfindahl's export concentration index they find that NRR (either measured as net exports per capita or share of primary exports on GDP) is positively associated with economic growth, being the association statistically significant.

What can we learn from these findings? The lack of robustness in this dimension suggest that the NRC findings are driven mostly by the risk involved in having a narrow export base rather than a pure negative effect of NRR on growth. This could be the case if NRR countries that tend to export a few commodities were affected by a negative terms of trade shock during the reference period. It also could be the reflection of a more general negative effect of volatility on economic growth (Hausmann, 2002). It could also be that rent seeking is more likely to happen when sources of rent are readily identifiable.

As in the previous cases of lack of robustness, this result does not eliminate the relevance of Sachs and Warner's findings however they further qualify them. A more careful reading of the NRC findings would be that cross-country variance in the measure of natural resource dependence was associated (higher NR dependence/lower growth) with cross-country growth variance during the period of reference and this association is likely to reflect the fact that NRR serves as a proxy for export concentration and high indebtedness which in turn might just reflect exposure to a particularly bad external shock episode.

3.5. Sensitivity to the income/growth specification choice

It makes sense to believe that if NRR has a negative effect on economic growth, in the long run NRR countries should have lower income levels than their counterparts NR poor countries. This result would be even stronger if we believe NRR have a negative effect on non-resource economic growth and we compare non-resource income levels.

If growth rates exhibit low persistence and we believe the effect of NRR on growth is a fundamental phenomenon that affects long-term growth rates then it would make more sense to test the NRC hypothesis using high persistence income level than using low persistence growth rates.

However, studies that do both exercises to check the NRC hypothesis are bound to find striking results. While they might find a negative association between NRR and growth rates (with all the qualifications previously established) they are also likely to find a positive association between NRR and income levels (Rodriguez and Sachs, 1999)

These results have been generally overlooked and pose a challenge to the proponents of "all-times" NRC. If we assume that all economies have a genesis, those results show that NRR have had a positive impact on growth during some time periods and therefore the NRC is not an "all-times" valid hypothesis. These results can be reconciled in the best of cases (for NRC proponents) if the negative association between NRR and economic growth is confined to limited time spans.

This dichotomy between growth and income effects seems to suggest that the NRC results are specific of the 1970-1989 period and are associated with particular events that took place at the time. In particular, this evidence is consistent with the idea that this negative association results could be driven by the fact that a significant group of NRR countries suffered a negative external shock during the period and not by any consistent effect of NRR on long term economic growth.

To summarize, the results that support the NRC hypothesis have to be taken carefully because they are sensitive to the definition of NRR, to the time span of reference, to the choice of estimation technique, to the inclusion of key control variables and to the specification choice of the dependent variable (growth vs. income levels). All those shortcomings are consistent with the hypothesis that those results (negative association of NRR and economic growth) are the consequence of a negative external shock shared by many NR dependent countries during the period under analysis. If this is the case, the NRC results would be looking more at a one-time income level effect than a permanent effect on growth rates.

4. Growth effects vs. Income effects. Are we misreading the NRC results in cross-country growth regressions?

How do we read the NRC results from cross-country regressions? Let's take Sachs and Warner's 1997 results. The dependent variable is average GDP growth during the 1970-1989 period; the relevant explanatory variable is share of primary exports on GDP (NRR proxy). After controlling for initial income, openness, investment rates, rule of law, change in terms of trade and regional dummies, they get a coefficient (average annual GDP growth on NRR) of –5.54, significant at the 99% level. The standard deviation of the NRR proxy variable is 0.12

Therefore, the results can be read in the following way: being one standard deviation NR richer than an otherwise identical country (in the dimensions controlled for) in 1970 is associated with a 0.7 percentage point lower average rate of growth during the 1970-1989 period. This result is usually extrapolated to attribute to it a more general meaning: "resource abundance is an important determinant of economic failure" (Rodriguez and Sachs, 1999), "countries with a high value of resource-based exports to GDP tend to have a lower growth rate" (Sachs and Warner, 1997). Is this the correct way to read those results? What is wrong with this reading?

First of all, this reading assumes that GDP growth is a stable, high persistence variable that can, in consequence, be aggregated in a twenty-year span without losing valuable information and also can be "explained" by another stable, high persistence variable as NRR. The findings of Easterly et al (1993) are against this presumption.

It also assumes that the effect of NRR on growth is homogeneous enough that referring to the effect in the "average" country is meaningful. The stark difference of experiences between countries like Botswana, Mauritius and even Norway in one hand and Saudi Arabia, Nigeria and Venezuela in the other should be enough to be careful with this assumption.

The usual reading of the evidence neglects the fact that observed growth rates during any time span might be the result of a transition dynamic from one balanced growth path to another and not a long term phenomenon. In any case, it fails to differentiate between the two possibilities.

Figure 1. Growth paths and the NRC literature

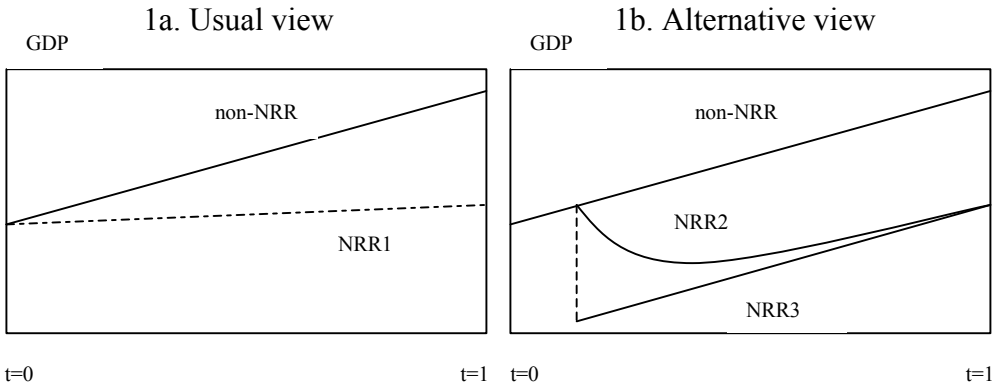

Figure 1 makes the point. The aggregation of growth rates is equivalent to the drawing of a straight line connecting the initial and final point and assumes that that slope of the line contains all relevant information. Figure 1a portrays the usual reading of the evidence; NRR countries grow less than their non-NRR counterparts. Figure 1b presents two alternatives that could be missed because of aggregation.

Notice that even though NRR2 and NRR3 have the same average GDP growth rate as NRR1 between t=0 and t=1 (all of them lower than the average growth of non-NRR) NRR2 have, and NRR3 converges to, the same "long term" growth rate as non-NRR, which is higher than the "long term" growth rate of NRR1. We certainly would not like to mistake NRR2 or NRR3 for NRR1 because they represent different dynamics that coincide only because of the exercise's capricious time aggregation.

To the previously exposed we would have to add that the explanatory variable proxy choice might not be the best because it could be capturing something that is not what it intended (export concentration, high indebtedness).

If we want to look carefully at the effects of NRR on long-term growth (the relationship the literature is ultimately interested on) then the usual choice of both the dependent (average growth rate) and explanatory variable (share of primary exports on GDP) might not be the most appropriate. More recent efforts have looked over the choice issue in terms of the explanatory variable but have not considered alternative proxies for the dependent variable (long term growth). In

that regard, future efforts will have to address the issue of looking for alternatives that allow to properly identifying the long-term growth before attempting to test the NRC hypothesis.

The following section presents a basic model that allows understanding why NRR countries could observe growth paths as the ones described in Figure 1 as NRR2 and NRR3. It is important to emphasize the fact that the model presents a framework in which NRR countries could face an "income collapse", similar to what is observed on NRR2 and NRR3 trajectories, but not necessarily have to. This would be consistent with the evidence of NRR countries that have observed outstanding economic performance in recent years (Botswana, Mauritius, Norway).

4.1 Anatomy of a Natural Resource Related Income Collapse.

Is the observed regularity linking natural resource richness and lower economic growth during the last quarter of the twentieth century an effect on long-term growth rates or an income adjustment?

This section presents a simple production model that allows describing the anatomy of an income adjustment in response to a negative external shock and sheds some light on how the adjustment could be mistakenly taken as a slow down in growth rates when looked from a cross-country growth regression perspective.

The model introduces the idea of an independent external constraint on production without having to abandon the neoclassical framework where decisions are assumed to be made rationally and economic agents respond to incentives. One simple way to incorporate the idea of an independent external constraint on production is to assume that one factor of production (in this case capital) is only produced abroad. This is a simplifying assumption and a more realistic model could include two kinds of capital goods (domestic and foreign), but it would not significantly change the basic results.

In this simple model it is assumed there are two goods: domestically produced goods (d) and internationally produced goods (i). The domestic goods are sold at

Pd and international goods are sold at Pi. E is defined as the relative price Pd/Pi (latin style). Pd is normalized to one (used as a numeraire)

There are two types of economic agents. The first type are the workers, who provide labor and own natural resources and therefore capture both, returns to labor (wage bill) and natural resource transfers from abroad (notice that any other transfer from abroad –aid, remittances, etc- would play the same role in the model). The second type are the capitalists, who provide capital and in consequence receive capital returns as income.

Workers are domestic agents and only consume domestic goods. Capitalists are international and consume foreign goods. This simplifying assumption is not far removed from reality if we consider that most countries final goods imports are a relatively small proportion of consumption. On the other hand, if capital is internationally provided it makes sense to assume that the owners will consume mostly abroad.

In the model, the production of international goods is taken as exogenously given. The production of domestic goods results from the combination of two factors of production: labor and capital. All labor is provided domestically. Labor is not mobile and its domestic supply is fix, therefore the domestic labor market has to clear and wage is domestically determined. Capital is entirely composed of international produced goods, is provided internationally and fully depreciates after one period. This assumption could be better understood if the period length is set to be equal to the time required for full depreciation . The production process of domestic goods can be represented by a standard constant-returns-to-scale Cobb-Douglas production function:

$$(1) Y = AK^{a} L^{1-a}$$

Capitalists organize production and combine capital and labor to maximize profits. Both factors of production are paid according to the marginal returns. Capitalists also decide between investing domestically and investing abroad and they exploit any arbitrage opportunity such that in equilibrium returns from investing abroad equal returns from investing domestically. The model omits deliberately risk issues and optimal portfolio considerations for simplicity reasons.

$$(2) MPL = w = (1-a)\frac{Y}{L}$$

$$(3) MPK = (1+r)E = a\,\frac{Y}{K}$$

Since workers use all their income to consume and they only consume domestic goods, the domestic market equilibrium is given by:

$$(4) Y = wL + ER$$

The domestic market equilibrium condition determines the equilibrium relative price. This is the case because in equilibrium workers exchange their natural resource income for capitalists' share on domestic production.

$$(5) E^{*} = a\,\frac{Y}{R}$$

As can be read from the equation, the bigger the resource income the higher the relative price of domestic goods to foreign goods (the more appreciated the real exchange rate). It is also interesting to notice that the elasticity of the real exchange rate to changes in resource income is a positive function of a . The higher the technical coefficient of imported capital in the production function the bigger the exchange rate reaction to resource income changes.

The foreign exchange market equilibrium condition determines the amount of capital that capitalists are willing to invest, since the foreign exchange restriction will affect how much of their domestic production share can be exchange for foreign liquidity. The supply of foreign exchange is given by the resource income (R) while the demand is given by the share of domestic income in hands of capitalists, which want to access foreign exchange to buy new capital and consume foreign goods.

$$(6) R = (1+r)K$$

In consequence the optimal level of capital would be such that capital returns can be fully converted into foreign currency at an exchange rate that guarantees that domestic returns are equal to international returns.

$$(7) K^{*} = \frac{R}{(1+r)}$$

This link between resource income and capital accumulation is precisely what makes domestic output dependant on foreign income. In fact, domestic output per worker (y) is a function of resource income per worker.

$$(8) y = A\left[\frac{R}{L} * \frac{1}{(1+r)}\right]^{a}$$

It can be seen from the above expression that a reduction in resource income per worker would negatively affect domestic output per worker by reducing capital accumulation. The elasticity would be equivalent to the share of foreign capital on domestic production.

If a country faces an external shock (resource income per worker has gone down) during a given period it will show off as a reduction in output per worker when comparing the end with the beginning of the period. This result would be read as a reduction of average growth rates during the period

As can be seen, a one-time shock on R would affect the equilibrium level of domestic production. However, the long term growth dynamics are completely independent of the phenomenon here described.

The balance growth path "level" of the economy will be given by R/L and r, while the steady state growth rate will be given by the rate of technological progress. It can be seen that a fall in R/L will not affect long term growth, understood as the underlying rate of technological change, but will show up as a slow down on average growth while the shock takes place[5].

It is also interesting to see that an eventual slow down on average growth is the consequence of a reduction on resource income and not something intrinsically related with being NRR. In other words, NRR countries that do not face an external shock would not observe a reduction on average growth rates, while non-NRR countries that face some kind of external shock (reduction in aid, fall in remittances, etc) would in fact see a reduction on average growth rates. However, if during a particular period there is a high correlation between the incidence of negative external shocks and being NRR the later could be taken by mistake as the responsible for slower growth rates.

[5] See figures 1a and 1b.

5. Empirical estimation. Identifying income effects with a cross-country approach.

In order to test the natural resource curse (NRC) hypothesis against the alternative hypothesis here presented, this paper makes use of Sachs and Warner's (1997) database[6] and methodology.

Even though the shortcomings of Sachs and Warner's methodology are well known and have been discuss in extent by the more recent literature, this paper makes use of it to strengthen the point that is not a methodological but a conceptual mistake what lies behind Sachs and Warner's results.

The empirical strategy goes as follows. First, the relationship between natural resource richness (NRR) and economic growth (change in output per worker) is evaluated using alternative measures for NRR, all of them derived from Sachs and Warner's measure, primary exports as a share of GDP (this is to make the point that measurement issues are not the main source of discrepancies with Sachs and Warner's results).

Second, an empirical link between the prevalence of external shocks (defined as changes in primary exports per worker) and growth is investigated. Alternative definitions of the external shocks variable are evaluated.

The link between the two key independent variables, NRR and shock prevalence is also investigated in order to test the idea that the former might be substituting by the latter, generating an omitted variable bias.

Sachs and Warner's results are reproduced for comparison purposes and their basic equation is then re-estimated using the already discussed alternative NRR measures. Using Sachs and Warner's control variables both hypotheses (NRC vs. Income effects) are tested against each other. Finally the preferred specification is subject to additional control variables proposed by Sachs and Warner.

[6] For a full description of the date refer to Sachs and Warner (1997).

In order to test the NRC hypothesis several NRR measures are examined. All of them use Sachs and Warner's preferred measure, primary exports as a share of GDP (sxp), as input. The first NRR variable used is "sxpn", which corresponds to a normalization of the original sxp variable (mean=0, standard deviation=1). This transformation is used to facilitate the interpretation of the NRR coefficient. All other alternative measures are binary, built using Sachs and Warner's continuous variable (sxp). The use of a binary measure is particularly helpful to analyze differential effects of external shocks according to the NRR characteristics of a given economy.

The first definition of natural resource richness (NRR1) uses sxp's world average as the critical point to divide the sample between NRR (NRR1=1) and non-NRR countries (NRR1=0). The second NRR definition takes sxp's average plus one standard deviation as the threshold. Finally, NRR3 uses world median as the division point.

To implement the second step of the empirical strategy, which consist on establishing a link between measured growth rates and external shocks, is necessary to choose an appropriate measure of what is referred here as external shocks. In that regard three alternatives are considered as a measure of external shocks, all based on changes in natural resource exports per worker in the considered period. "Shock1" is a binary variable that equals one whenever average growth of natural-resource exports per worker (NRXpc) is negative (a negative shock) and zero otherwise. "Shock2" is also a binary variable; however the threshold level is the world average for the original variable (NRXpc). Finally, "Shock3" is the normalized version (mean=0, standard deviation=1) of NRXpc.

Following the reproduction of Sachs and Warner's results, for comparison purposes, both hypotheses, natural resource curse versus prevalence of external shocks, are tested. In order to proceed is necessary to separate the effects of NRR from the shocks effects, therefore it is crucial to identify possible differential effects of NRR on measured growth for two kinds of groups: countries that suffered external shocks versus countries that did not. To do so, NRR variables are interacted with shock variables. Two of such interaction variables are considered. "int2" corresponds to the multiplication of sxpn and shock2, since shock2 is a binary variable it allows to identify different effects of sxpn (NRR variable) on measured growth. "int23" is similar but uses a binary version of sxpn (NRR3).

Finally, the preferred specification is subject to additional control tests to assess the robustness of the results.

Establishing a link between measured growth rates and natural resource richness

As has been mentioned before, previous research[7] has emphasized the negative link between natural resource richness and economic growth; those results are broadly known as the "natural resource curse". For clarity purpose it is useful to review what the data says about this link. A simple regression of growth rates on natural resource richness measures makes the point.

Table 1.
NRR and growth –preliminary results using different NRR measures-

Dependent Variable: GDP growth 1970-1990 (gea7090)					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Nrr1	-1.2303** (0.4211)				
Nrr2		-1.5360* (0.7805)			
Nrr3			-1.3606** (0.3615)		
Sxp				-7.2222** (1.6810)	
Sxpn					-1.1694** (0.2722)
Constant	1.5215** (0.2160)	1.2948** (0.1961)	1.8422** (0.2488)	2.1297** (0.2800)	0.9846** (0.1840)
Observations	95	95	95	95	95

[7] Auty (1990); Sachs and Warner (1997); Rodriguez and Sachs (1999); Ross (1999); Isham et. al. (2003) among others.

Adjusted R-squared	0.0742	0.0297	0.1228	0.1566	0.1566
** significant at the 99% level, * significant at the 95% level					

The first three columns in table 1 correspond to binary measures of natural resource richness. Those results allow to distinguish average growth rates for two sets of countries (NRR versus non-NRR) slightly changing the group definition in every case. The results point out that NRR-countries grew between 1.2% and 1.5% less that their counterparts during the considered period (1970-1990). While non-NRR countries grew at an average per worker rate of between 1.3% and 1.8%, NRR grew at rates between -0.3% and 0.5%. Also important, this binary distinction between NRR and non-NRR economies account for up to 12% of the variation in growth rates across countries during the period. Attending to the explanatory power and precision of estimation of each of the alternative binary measures, NRR3 appears to do a better job separating both groups.

When a continuous version of NRR is included (sxpn) the explanatory power of that single variable increase to account for close to 16% of the variance in growth performance across countries. It is worth noting that the coefficient linking one standard deviation in NRR in this context is very close to Sachs and Warner's findings once controlling for other relevant variables (-1.1694 versus -1.1443)

Establishing a link between measured growth rates and prevalence of external shocks (level effect)

As the model previously presented states, an alternative explanation for the apparently solid link between NRR and measured growth would be the higher prevalence of negative external shocks among NRR countries during the period under analysis. In order to start testing that hypothesis it is important to establish the link between prevalence of external shocks and measured growth (as well as testing the link between shock prevalence and NRR).

The first two columns in table 1 correspond to binary measures of shock prevalence. Those results allow to distinguish average growth rates for two sets of countries (shock-affected versus non-shock-affected countries) slightly changing the group definition in every case. The results point out that shock-affected-

countries grew between 1.3% and 1.4% less that their counterparts during the considered period (1970-1990). While countries that were not affected by shocks (as defined here) grew at an average per worker rate of between 1.6% and 2.0%, shock-affected countries grew at rates between 0.2% and 0.6%. Also important, this binary distinction between shock affected economies and their counterparts account for up to 14% of the variation in growth rates across countries during the period.

Attending to the explanatory power and precision of estimation of each of the alternative binary measures, shock2 appears to do a better job separating both groups.

Table 2.
External shocks and growth –preliminary results using different shock measures-

Dependent Variable: GDP growth 1970-1990 (gea7090)			
Variables	**(1)**	**(2)**	**(3)**
shock1	-1.3858** (0.4022)		
shock2		-1.3654** (0.3643)	
shock3			-0.9135** (0.1554)
Constant	1.5947** (0.2149)	1.9952** (0.2782)	1.1832** (0.1631)
Observations	84	84	84
Adjusted R-squared	0.1158	0.1358	0.2879
** significant at the 99% level, * significant at the 95% level			

When a continuous version of "shock prevalence" is included (shock3), the explanatory power of that single variable increases to account for close to 29% of the variance in growth performance across countries. It looks, therefore as a very important part of the story behind growth performance between 1970 and 1990, even more important (according to this very crude measure) than NRR itself.

It is very telling the striking similarity observed in these results compared to the results observed previously when the data was divided according to NRR criteria. This similarity, if nothing else, points in the direction of a potential important correlation between the two variables.

Establishing a link between natural resource richness and the prevalence of external shocks

One potential explanation of why measures of NRR fare so well explaining measured growth variance across countries could be that it is capturing some other feature that is relevant for growth (or whatever is being measured as growth).

It was pointed out before that there is a similarity of the results when the sample is divided according to NRR compared to the results obtained when the sample is divided according to shock prevalence. This suggests that a correlation between those two variables might exist and therefore NRR coefficients could be upward bias, accounting for the effect associated with the prevalence of negative shocks.

Table 3.
Alternative explanations. NRR vs. Shocks

Dependent Variable: GDP growth 1970-1990 (gea7090)		
Variables	**(1)**	**(2)**
sxpn	-1.1694** (0.2722)	-0.6774* (0.2760)
shock3		-0.7771** (0.1596)
Constant	0.9816** (0.1840)	1.9952** (1.0564)

Observations	95	79
Adjusted R-squared	0.1566	0.3345
** significant at the 99% level, * significant at the 95% level		

According to the data, the preferred binary variable for NRR (NRR3) exhibits a correlation of 0.396 and 0.352 with the binary variables for shock prevalence (shock1 and shock2). It also exhibits a correlation of 0.396 with the continuous version of the variable (shock3). When the two continuous variables are compared (sxpn and shock3) the show a correlation of 0.304

Being the case that both variables are positively correlated and that each of the variables is negatively correlated with measured growth it is to expect that in a regression where only one of the two is included as a explanatory variable the resultant coefficient would be upward biased.

As can be seen from Table 3, controlling for shock prevalence considerably reduces the magnitude and the statistical significance of Sachs and Warner's NRR variable (sxpn). However, even after controlling for the prevalence of shocks, the measure of NRR remains significant. Therefore the simple correlation between those two variables is not enough to explain what is behind the NRC result. A more complex interaction is needed to support the idea that the NRC result is capturing something related to shock prevalence.

Establishing differential effects of NRR on measured growth according to prevalence of shocks (testing for interactive effects)

In order to test the hypothesis that the NRC result is capturing an interaction between natural resource richness and the higher prevalence of bad shocks in this group of countries during the 1970-1990 period, the differential effects of NRR on measured growth according to shock prevalence are compared.

The sample of countries is divided in four groups according to NRR and shock prevalence (NRR countries affected by a shock[8], NRR countries not affected by a shock[9], non-NRR affected by a shock[10] and non-NRR not affected by a shock[11]) using the preferred binary measures. The average growth rate is reported for each group in the following table:

Table 4.
Growth rates according to NRR and prevalence of negative shocks.

Yearly average (1970-1990)				
	Shock	**No-Shock**	**Average**	**Difference**
NRR	0.038%	1.996%	0.450%	-1.958%
Non-NRR	1.673%	2.016%	1.850%	-0.343%
Average	0.638%	2.010%	1.177%	-1.372%
Difference	-1.635%	-0.020%	-1.400%	-1.615%[12]

As can be seen from Table 4, NRR countries only performed worse than non-NRR countries when facing a shock. Among non-NRR countries, those who suffered a shock performed slightly worse on average, the difference however is significantly smaller than within NRR countries. This is the case because the

[8] The countries identified as NRR that were affected by a shock during the 1970-1990 period are: Algeria, Gabon, Gambia, Ghana, Ivory Coast, Kenya, Madagascar, Malawi, Mauritania, Morocco, Nigeria, Senegal, South Africa, Togo, Zaire, Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Jamaica, Nicaragua, Bolivia, Guyana, Peru, Venezuela, Indonesia, Iran, Philippines, Sri Lanka, and Fiji (31 countries) .

[9] The countries identified as NRR that were not affected by a shock during the 1970-1990 period are: Cameroon, Chile, Malaysia, Belgium, Iceland, Ireland, Netherlands, New Zealand (8 countries).

[10] The countries identified as non-NRR that were affected by a shock during the 1970-1990 period are: Benin, Burkina Faso, Burundi, Chad, Tunisia, Canada, Haiti, Trinidad and Tobago, Bangladesh, India, Israel, Japan, Jordan, Pakistan, Syria, Finland, Portugal, Sweden and Switzerland (19 countries).

[11] The countries identified as non-NRR that were not affected by a shock during the 1970-1990 period are: Congo, Egypt, Mali, Mexico, USA, Argentina, Brazil, Colombia, Paraguay, Uruguay, Hong Kong, Korea, Thailand, Austria, Denmark, France, Germany, Greece, Italy, Norway, Spain, United Kingdom, Australia (23 countries).

[12] Differences in differences.

shock is defined as a contraction in primary exports per worker and therefore countries with a bigger share of economic activity concentrated in the primary sector will be more affected when facing a shock of the same magnitude compared to the size of the primary sector. It is to notice that the NRC result virtually disappears among countries that did not face negative shocks. This result tend to confirm the hypothesis that measured growth differences are associated to shock prevalence (and therefore are level effects) rather than to NRR.

Estimating interaction effects between NRR and prevalence of shocks on a cross-country growth equation

According to the previous data analysis NRR and shock prevalence interact to affect measured growth.

In fact that is consistent with the idea that external shocks (defined by negative changes in primary exports per worker compared to a given benchmark) are an important source of "slowdown" and the strength of this effect depends on how "exposed" to those shocks countries are. This exposure depends on the relative size of the primary sector, or in this paper's words, how "NRR" they are.

Table 5.
Alternative explanations. NRR vs. Shocks. Including interactions

Dependent Variable: GDP growth 1970-1990 (gea7090)					
Variables	**(1)**	**(2)**	**(3)**	**(7)**	**(8)**
lgdpea70	-1.3671** (0.1798)	-1.0689** (0.1967)	-1.3308** (0.1750)	-1.3636** (0.1918)	-1.4170** (0.1812)
sopen	2.4750** (0.3476)	2.1587** (0.3927)	2.7075** (0.3547)	1.8047** (0.3946)	1.7212** (0.3673)
livin7089	1.3807** (0.2217)	0.9409** (0.2816)	1.3882** (0.2548)	1.4046** (0.2742)	1.5408** (0.2598)
sxpn	-1.1443** (0.1898)		-1.0700** (0.2128)		-0.3403 (0.4221)
nrr3				-0.3238 (0.4656)	
shock2				-0.1716 (0.3495)	-1.0726** (0.3226)

shock3		-0.6144** (0.1311)	-0.4605** (0.1181)		
int2					-1.1227* (0.4801)
int23				-1.2796* (0.5781)	
Constant	7.6989** (1.2867)	6.7131** (1.4103)	7.6721** (1.2239)	8.8367** (1.4245)	8.7328** (1.3257)
Observ.	91	81	77	77	77
Adjusted R-squared	0.6687	0.5689	0.6916	0.6254	0.6736
** significant at the 99% level, * significant at the 95% level					

Table 5 shows the results of various regressions including interaction terms. The first regression replicates Sachs and Warner's (1997) main equation. Since the data base, the estimation technique and the time span are the same it is not surprising that the results confirm Sachs and Warner's. The only difference is that the NRR variable has been normalized and therefore expressed in standard deviation units. The NRC reading of the results is that one standard deviation NRR above world average is associated with a 1.14% less annual growth (at least in the 1970-1990 period).

To place this result in a context lets take two countries. Venezuela is 1.38 standard deviations "richer" than the US in terms of natural resources. According to S&W estimates, Venezuela should have grown 1.57% a year less than the US. In fact, Venezuela grew 3.19% a year less than the US between 1970 and 1990. Therefore, according to S&W about half the difference in growth performance comes from the fact that Venezuela is a "richer" country in terms of natural resources. This is an example of how crucial is NRR if Sachs and Warner's results were to be believed.

Regression 2 estimates the "shock" effects using S&W control variables but excluding the NRR measure. It can be seen that a negative shock on primary exports per worker during the period is associated with lower growth rates (-0.6% a year), all control variables remain statistically significant and with the expected sign.

Regression 3 includes both the NRR variable and the shock variable. It can be seen that compared to regressions 1 and 2 the coefficients associated to both variables loose some statistical significance and magnitude. This is the result of the positive correlation between the two. However, they both remain statistically significant and important from an economic point of view. The inclusion of the shock variable as a control per se does not significantly change the results that favor the NRC hypothesis.

Regression 4 introduces a binary interaction term (NRR, Shocks). Both original variables NRR3 and Shock3 are binary, this allows to separate four groups in the same fashion as in table 4 but controlling for other relevant variables. Group 4 (non-NRR, no-Shock) is consider the baseline against which all others are compared. The results are displayed on Table 6.

Table 6.
Estimated effects on growth rates. Interaction terms included

Measured growth rates (1970-1990)			
	Shock	**No-Shock**	**Difference**
NRR	-1.6034%	-0.3238%*	-1.2796%
Non-NRR	-0.1716%*	0	-0.1716%*
Difference	-1.4318%	-0.3238%*	-1.1080%

* Not statistically significant at any conventional confidence level

From regression 4 it can be observed that the inclusion of the interaction term makes the coefficients of both variables (NRR and Shock2) much smaller and statistically not significant. The interaction term is significant and negative as expected; the coefficient's magnitude is considerable.

These results suggest that NRR is not per se negatively associated with growth rates. Only when NRR is combined with shock prevalence the NRC result reappears. This finding tends to confirm what was already suggested by the simple dissagregation of the data in four groups according to NRR and shock

prevalence status. The effect of being NRR on growth, in the absence of a negative external shock, is statistically not significantly different from zero.

It is also true that the estimated effect of shock prevalence on growth by itself (effect on non-NRR countries) is not significantly different from zero. However, this is hardly a surprise. The effect of a shock is given by the interaction between strength of the shock and the exposure to the shock. Being the shock defined as a negative change in primary exports, the effect of a shock of a given magnitude will depend on the expose to such shock .In this case the exposure for non-NRR countries is minimal, since exposure is given by the relative size of primary exports compared to the overall size of the economy. These results strongly support the idea that measured growth can be affected by a shock (level effects) while it casts important doubts on the validity of the NRC hypothesis.

Regression 5 is similar to the previous one, being the only difference that NRR is captured by the continuous version of the variable (sxpn). As a result, the interaction variable is not binary. The results are quite similar to the ones previously discussed. The coefficient associated with the NRR variable is small (compared to S&W benchmark) and statistically not significant. The interaction term is negative (as expected) and statistically significant. In this case the interaction coefficient constitutes the differential effect of a shock on growth between countries separated by one standard deviation in terms of NRR.

It is worth noting that the coefficient associated to the shock variable is now statistically significant and of considerable bigger magnitude than before. There is no surprise or inconsistency on that result. The equivalent coefficient in the previous variable represented the effect of a shock on a typical non-NRR country, while the coefficient in this regression estimates the effect of a shock in a typical country taking the entire sample. A typical non-NRR country is 0.62 standard deviations below the world average level of NR richness. For this particular group (here defined as non-NRR using NRR2 as the definition) the average ratio of primary export to GDP is 5.8%, while for the world as a whole the figure is 15.6% (or almost triple).

The coefficient associated with shocks on regression 5 suggest that on an average country (where sxp=0.156) being subject to a shock (as defined here) is associated with a lower annual growth rate of 1.07%. This result is shown to emphasize that for a typical country a negative shock on primary exports per worker is associated with significantly slower growth (over a twenty year period it composes to a income level 23% lower than otherwise). This findings support the idea of some

kind of income level effect is being reflected in growth measures, if we assume shocks affect income levels rather than the growth process itself.

Controlling for additional variables.

Table 7 includes some additional control variables suggested by Sachs and Warner (1997). The chosen variables are the four most commonly used control variables by S&W aside from the ones included in the core estimation.

Those four variables are: rule of law (rl), average terms of trade growth rate (dtt7090), government consumption as a proportion of GDP (gvxdxe) and average years of secondary education of the population, expressed in logarithms (kllsec).

Looking at the coefficients associated with the additional control variables, the results are somewhat similar to what is reported by Sachs and Warner. Rule of law seems to be positively associated with measured growth, and the coefficient is statistically significant. Government consumption is negatively associated with growth, but the estimate is not significant. Secondary education is positively associated with growth but is not significant either.

Table 7.
NRR, Shocks and growth. Including additional control variables.

Dependent Variable: GDP growth 1970-1990 (gea7090)					
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**
Lgdpea70	-1.4170**	-1.6545**	-1.7317**	-1.7866**	-1.6767**
	(0.1812)	(0.2282)	(0.2106)	(0.2288)	(0.3149)
Sopen	1.7212**	1.3973**	1.5272**	1.5433**	1.4136**
	(0.3674)	(0.4114)	(0.3792)	(0.3863)	(0.4449)
linv7089	1.5408**	1.2123**	0.7475*	0.6155	0.5949
	(0.2598)	(0.3609)	(0.3574)	(0.4231)	(0.4605)
Sxpn	-0.3403	-0.4055	-0.4247	-0.4020	-0.4008
	(0.4222)	(0.4071)	(0.3735)	(0.3800)	(0.3868)
Shock2	-1.0726**	-0.9604**	-1.1537**	-1.1023**	-1.1832**
	(0.3226)	(0.3462)	(0.3224)	(0.3354)	(0.3584)
int2	-1.1227*	-1.2745**	-1.2170**	-1.1452*	-1.4092**
	(0.4801)	(0.5009)	(0.4598)	(0.4778)	(0.5467)

Rl		0.2197* (0.1155)	0.2848** (0.1076)	0.3077** (0.1142)	0.2446+ (0.1299)
dtt7090			0.1636** (0.0473)	0.1602** (0.0492)	0.1856** (0.0602)
Gvxdxe				-2.0831 (3.0972)	-1.2546 (4.2330)
Kllsec					0.1438 (0.3265)
Constant	8.7328** (1.3257)	11.0562** (1.7228)	12.9061** (1.6686)	13.8142** (2.1515)	13.3465** (3.0330)
Observations	77	66	66	66	57
Adjusted R-squared	0.6736	0.6849	0.7349	0.7301	0.7352
** significant at the 99% level, * significant at the 95% level, + significant at the 90% level					

Terms of trade average growth rate deserves an especial comment.

This variable is somewhat related to the shock variable here used, nonetheless it is just partially related. Changes in primary exports per worker can be certainly caused by changes in export prices; however changes in volume of exports are not reflected by terms of trade changes even though the underlying economic cause might be the same (changes in world demand or supply). In a few cases this variable (terms of trade) have been used as a proxy for something that could be interpreted as what is referred here as "income effect"[13]. The fact that the variable used here to pick up the "income effect" is robust to the inclusion of this alternative shows that terms of trade changes do not capture the same as what has been defined here as external shocks.

However, as can be seen from Table 7, the most important observation is that none of the control variables affect significantly the coefficients associated with NRR, shocks or the interaction terms. Their statistical significance and magnitude remain similar; the results are robust to the inclusion of these relevant controls. Therefore none of the previous conclusions are in any way affected by the inclusion of these additional controls.

[13] Easterly et al. (1993)

7. Final remarks

The empirical result that has been identified with the name of "Natural Resource Curse" is a very important one for the developing world, this is the case because many developing countries have an economic structure very dependent on natural resource based activities.

Is it certainly the case that, according to the classification here used, natural resource rich countries have experienced a less favorable growth performance compared to their counterparts during the period between 1970 and 1990 (or the last third of the twentieth century loosely speaking). However, we should not jump so quickly to what looks like the evident conclusion. This empirical regularity does not necessarily mean that natural resource richness is bad for growth.

The results presented in the previous section suggest that the apparently negative effect of NR richness on growth is driven by the interaction between NR richness and the prevalence of shocks during the period under analysis, combined with the negative effect of adverse shocks on measured growth.

In other words, it is the fact that thirty one out of thirty nine NRR countries (according to the proposed classification) faced an external shock (as here defined) what drives Sachs and Warner's results. It is not that NR richness is bad for growth, just that NRR countries happened to be more shock prone during the revised period. In fact the coefficient estimated for the growth effects of an adverse shock on NRR countries is very similar to Sachs and Warner's estimate for the growth effect of NRR itself.

Again, if we believe shocks affect the income level of an economy rather than its growth rate potential then we would be talking of the results as an "income effect" rather than as a "growth effect", and the responsible for this "effect" would be exposure to shocks and not NR richness.

GDP per worker's average growth rates (measured growth) synthesizes a mix of long term growth, short term deviations from potential (not so relevant other than in the short term) and more important to our point, adjustments to changes in equilibrium income levels at a given time as a result of shocks. Analyzing the observed variable (measured GDP growth) to make inference about an unobserved but more relevant variable (growth potential or long term growth)

could lead to the wrong conclusions. Having in mind the difference between the observed and the ideal variable could help avoid mistakes, and choosing an observed variable as close as possible to the ideal should be part of the research effort to guarantee good results.

In the same way in which a lot of effort has gone towards finding the proper proxies for the relevant independent variables (NR richness in this case), new research in the area will need to think of alternative ways to capture underlying long term growth in an effort to obtain more precise estimates. This is one of the research lines that seem promising to me, not only in the quest for further clarifying the effect of NR richness on growth but for empirical work on economic growth in general.

This paper is not making the point that NR richness has zero effect on growth. The lack of statistically significance of the coefficient associated with the NRR variable, once controlling for shock effects and the interactive term, probably reflects that NR richness can potentially affect growth experiences in both directions, depending on the transmission channels. Therefore, the result is likely to be case specific depending on how strong each transmission channel is for each particular experience.

A work of contrasting the relative strength of alternative transmission channels through which NR richness affect growth remain to be done, both from a cross country and a case study perspective.

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