NATURAL RESOURCE ABUNDANCE AND ECONOMIC GROWTH

Jeffrey D. Sachs and Andrew M. Warner

Center for International Development and
Harvard Institute for International Development

Harvard University
Cambridge MA

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ABSTRACT

One of the surprising features of modern economic growth is that economies abundant in natural resources have tended to grow slower than economies without substantial natural resources. In this paper we show that economies with a high ratio of natural resource exports to GDP in 1970 (the base year) tended to grow slowly during the subsequent 20-year period 1970-1990. This negative relationship holds true even after controlling for many variables found to be important for economic growth by previous authors. We discuss several theories and present additional evidence to understand the source of this negative association.

I. INTRODUCTION

One of the surprising features of economic life is that resource-poor economies often vastly outperform resource-rich economies in economic growth. The basic pattern is evident in a sample of 95 developing countries in Figure 1, where we graph each country's annual growth rate between 1970-90 in relation to the country's natural resource-based exports in 1970, measured as a percent of GDP. Resource-based exports are defined as agriculture, minerals, and fuels. On average, countries which started the period with a high value of resource-based exports to GDP tended to experience slower growth during the following twenty years. Later in the paper we will show that this basic negative relationship is present after controlling for a number of other variables introduced in previous growth studies. It is also present even though, for lack of complete data, we have excluded eight slow-growing oil-exporting economies: Bahrain, Iraq, Libya, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates.

The oddity of resource-poor economies outperforming resource-rich economies has been a recurring motif of economic history. In the seventeenth century, resource-poor Netherlands eclipsed Spain, despite the overflow of gold and silver from the Spanish colonies in the New World. In the nineteenth and twentieth centuries, resource-poor countries such as Switzerland and Japan surged ahead of resource-abundant economies such as Russia. In the past thirty years, the world’s star performers have been the resource-poor Newly Industrializing Economies of East Asia -- Korea, Taiwan, Hong Kong,

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Singapore -- while many resource-rich economies such as the oil-rich countries of Mexico, Nigeria, and Venezuela, have gone bankrupt.

The negative association between resource abundance and growth in recent decades certainly poses a conceptual puzzle. After all, natural resources increase wealth and purchasing power over imports, so that resource abundance might be expected to raise an economy's investment and growth rates as well. Many oil-rich countries have aimed to use their vast oil revenues to finance diversified investments and a “big push” in industrial development. Venezuelans called this “sowing the seeds of oil revenues.” Moreover, when a natural resource has high transport costs, then its physical availability within the economy may be essential for the introduction of a new industry or a new technology[1]. As a key historical example, coal and iron ore deposits were the **sine qua non** for the development of an indigenous steel industry in the late nineteenth century. In that case, resource-rich economies such as Britain, Germany, and the U.S., experienced particularly rapid industrial development at the end of the last century. With falling transport costs, however, the physical availability of resources within the national economy is rarely as decisive today as it was a century ago. Thus, Japan and Korea have succeeded in become world-class steel producers despite their virtual complete dependence on imports of iron ore. Nevertheless, even if natural resources are no longer a decisive advantage to economic growth, it is surely surprising that they might pose an actual disadvantage. Is there a curse to easy riches?

Many previous researchers have noted the problems with resource-intensive economies in the 1970s and 1980s, though to the best of our knowledge, none has confirmed the adverse effects of resource abundance on growth on the basis of a worldwide, comparative study of growth, as we do in this paper. Important earlier findings of the failures of resource-led development include several outstanding works, such as the volume of papers edited by Neary and Van Wijnbergen [1986], a series of studies by Alan Gelb, culminating in Gelb [1988], and several key studies by Auty, most comprehensively in Auty [1990]. These studies suggest many of the economic and political factors that may have played a role in the disappointing

[1] We are grateful to Jeffrey Williamson for helpful discussions on this point.

performance of resource-abundant economies, and so provide a basis for some of the hypotheses tested later in the paper on the cross-country data. A recent and fascinating paper by Berge *et. al.* [1994] is similar in motivation and spirit to this paper, and also points to the adverse role of natural resource endowments (measured mainly by land and population density) on growth and manufacturing exports.

The rest of the paper is organized as follows. In section II we summarize a number of theoretical arguments to explain the negative association between resource intensity and growth. In section III we show our evidence from the 1970-1989 period. In section IV we look at additional cross-country evidence to try to better understand the sources of the inverse association between resource abundance and growth. In section V we present a summary and some thoughts about future research in this area.

II. A Summary of The Theory

There are indeed a large number of hypotheses that can be raised to account for the negative relationship presented in figure 1 (in addition to the hypothesis, later discarded, that the negative relationship is purely spurious). One early explanation of the phenomenon is social: that easy riches lead to sloth. The sixteenth century French political philosopher Jean Bodin [1576, reprinted 1962] asserted as much when he claimed that:

> men of a fat and fertile soil, are most commonly effeminate and cowards; whereas contrariwise a barren country make men temperate by necessity, and by consequence careful, vigilant, and industrious. [V, I, 565][2]

More recent thinking in development economics stresses the lack of positive externalities coming from natural resource sectors, in contrast to manufacturing. There are shades of this theme in both the development literature in the 1950's and 1960's, and the Dutch Disease models of the 1970s and 1980s.

[2] Cited in Holmes [1995, p. 109] from Bodin, [transl. Knolles, ed. McRae [1962]].

For example, Hirschman [1958], Seers [1964], and Baldwin [1966] promoted the view that beneficial "forward and backward linkages" from primary exports to the rest of the economy would be small. The basic idea was that manufacturing, as opposed to natural-resource production, leads to a more complex division of labor and hence to a higher standard of living. This negative assessment of resource-based development in due course led to a revisionist literature describing successful cases of staples-led growth. See for example Roemer [1970] on Peru, and further cases reviewed in Lewis [1989].

The global commodity price booms of the 1970's promoted additional research about the economics of natural resource booms. An excellent summary of this literature can be found in the volume edited by Neary and Van Wijnbergen [1986]. One of the main subjects in this literature was how macroeconomic policy responded to commodity price booms. The question about the long-term growth effects of natural resource production and/or natural resource booms was studied implicitly through the issue of whether natural resource production promoted de-industrialization (the Dutch disease). The further link between de-industrialization and slow growth was probably presumed to exist in many cases but was not the subject of extensive analysis. Overall, this literature did not yield a cross country study examining the relationship between natural resource abundance and growth, although many of the issues we discuss here were certainly known to the authors of these earlier studies.

Dutch disease models demonstrate that the existence of large natural resource sectors, or booms in these natural resource sectors, will affect the distribution of employment throughout the economy, as wealth effects pull resources in and out of non-traded sectors. These sectoral shifts can affect long term growth, as shown in another context for example in Matsuyama [1992]. In Matsuyama's model there are two sectors, agriculture and manufacturing. Manufacturing is characterized by learning-by-doing that is external to individual firms, that is, the rate of human capital accumulation in the economy is proportional to total sectoral production, not to the production of an individual firm. Hence the social return to manufacturing employment exceeds the private return. Any force which pushes the economy away from manufacturing and towards agriculture will lower the growth rate by reducing the learning-induced growth of manufacturing. Matsuyama shows that trade liberalization in a land-intensive economy could actually slow economic growth by inducing the economy to shift resources away from manufacturing and towards agriculture.

In Matsuyama's model, the adverse effects of agricultural production arise because the agricultural sector directly employs the factors of production that otherwise would be in manufacturing. Such a framework may be useful for studying labor-intensive production of natural resources, such as in agriculture, but is less relevant for a natural resource sector like oil production, which use very little labor, and therefore does not directly draw employment from manufacturing. However, it is not difficult to extend Matsuyama's same point in a setting that is more appropriate for natural resource intensive economies, using the framework of the Dutch disease models.

We present such a model in the working paper version of this paper[3], and here limit ourselves to a summary of the main points. In our version of the Dutch disease model, the economy has three sectors: a tradeable natural resource sector, a tradeable (non-resource) manufacturing sector, and a non-traded sector. Capital and labor are used in the manufacturing and non-traded sectors, but not in the natural resource sector. The greater the natural resource endowment, the higher is the demand for non-tradeable goods, and consequently, the smaller is the allocation of labor and capital to the manufacturing sector. Therefore, when natural resources are abundant, tradeables production is concentrated in natural resources rather than manufacturing, and capital and labor that otherwise might be employed in manufacturing are pulled into the non-traded goods sector. As a corollary, when an economy experiences a resource boom (either a terms-of-trade improvement, or a resource discovery), the manufacturing sector tends to shrink and the non-traded goods sector tends to expand.

The shrinkage of the manufacturing sector is dubbed the “disease,” though there is nothing *harmful* about the decline in manufacturing if neoclassical, competitive conditions prevail in the economy. The Dutch Disease can be a real disease, however -- and a source of chronic slow growth -- if there is something special about the sources of growth in manufacturing, such as the "backward and forward linkages" stressed by Hirschman and others, if such linkages constitute production externalities, or the learning-by-doing stressed by Matsuyama. If manufacturing is characterized by externalities in production,

[3] See NBER working paper No. 5398, or HIID discussion paper No. 517a.

then the shrinkage of the manufacturing sector caused by resource abundance can lead to a socially inefficient decline in growth[4]. The economy loses the benefits of the external economies or increasing returns to scale in manufacturing.

We highlight two points that come out of such a model. First, quite simply, economies with larger resource sectors will grow slower, holding constant resource booms. Second, a *temporary* resource boom can lead to a particular path of GDP, as we illustrate in figure 2. Suppose there are two identical economies, both initially growing at the same rate, so that the log of GNP proceeds along the straight line between point O and point A. Now suppose that one economy has a resource boom at time T_0 so that GNP immediately rises to point B. In the short run this economy will have a higher GNP. If the resource boom causes a decline in growth, however, GNP in the booming economy can eventually fall below the other economy. Even if the booming economy eventually reverts to its pre-boom growth rate, it may still have a permanently-lower level of GNP than the other economy. Measured growth will also probably be lower, although one can see from the figure that the time interval over which growth is measured matters for this conclusion, and there is an issue about the appropriate way to control for natural resource booms.[5]

It is important to stress, however, that the negative effect of large resource endowments on growth need not depend on the presence of production externalities in manufacturing, but instead could result from increasing returns to scale in education or job training. Consider the following simple example. Suppose that an increase in workers' education raises the productivity of labor in manufactures, but not in the non-tradeable sector. Thus, a young person incurs the costs of education only if he or she expects to be employed in the manufacturing sector. Suppose further that the education production function is such that

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[4] Various authors have subscribed to the maintained assumption that manufacturing has larger positive externalities than other forms of economic activity. The empirical support for this is based on the observations that countries with more diversified exports seem to do better, and that growth tends to be positively correlated with growth in manufacturing production and manufacturing exports, rather on micro-level evidence. Therefore it remains somewhat speculative.

[5] In the empirical section, we measure growth between 1970 and 1989, so typically the resource booms took place in the first half of this time period. We do three things in an attempt to hold constant the effect of the resource booms: we control for the change in the terms of trade and the variance in the terms of trade between 1970 and 1989, and we split the sample into the 1970s and 1980s and run separate regressions for each decade.

the skill level of a school graduate is a multiple, greater than one, of the skill level of the teacher (herein lies the increasing returns). In an overlapping generations model, a resource-rich economy can arrive at a stationary state in which each generation chooses to forgo education, and to work directly in the non-tradeable sector, since the price and hence market wage in that sector is above the marginal value product of labor in manufacturing. In a resource-poor economy, by contrast, workers will move into manufactures, and will have the incentive to invest in education, since higher-skilled manufacturing workers earn a premium over uneducated workers. The education process will produce not only skilled workers, but also more skilled teachers in the next generation. This in turn will lead to yet greater skills in the school graduates of the following generation. It is easy to see that a virtuous circle of endogenous growth can result, in which each generation chooses to become educated, and each thereby reaches a higher level of skills than the preceding generation.

Another line of argument focuses on the global conditions of the natural resource industry. For one reason or another, the general theme has been that natural resources were likely to be a declining industry at the world level. The famous hypothesis of Raul Prebisch [1950] and Hans Singer [1950] of a secular decline in the terms-of-trade of primary commodities vis-a-vis manufactures can be put into this category.[6] They argued that resource-based growth would be frustrated by secular decline in world prices of natural resources. Closely related views forecasted that world demand for primary products would grow slower that demand for manufacturers or that productivity growth would be faster in manufacturing than in natural resource production.

The "Prebisch hypothesis" of declining relative prices of raw materials was widely taken to mean that developing countries should shun their dependency on natural resource exports by promoting industrialization. The great historical mistake of this thinking, promoted for example by the United Nations Commission for Latin America, was to recommend industrialization through prolonged import-substitution behind tariff and quota barriers, rather than through export promotion. Inward-looking state-led

[6] United Nations (Raul Prebisch), *The Economic Development of Latin America and its Principal Problems* (Lake Success, N.Y.), and Hans W. Singer, “The Distribution of Trade between Investing and Borrowing Countries,” *American Economic Review*, 40 [May 1950], 473-85.

industrialization foundered almost everywhere that it was attempted [see Sachs and Warner 1995 for a recent cross-country analysis of the adverse effects of this long-term growth strategy].

An alternative approach lies in the area of political economy. Natural resource production typically generates high economic rents. Gelb [1988], in particular, stresses that governments typically earned most of the rents from natural resource exploitation. Mancur Olsen for example would argue that societies are subject to impediments to innovation from special-interest groups, and that these groups are especially powerful when they can obtain government revenues from easily-taxed natural resources. Therefore innovation tends to be impeded in natural resource-abundant societies[7]. Others argue that natural resource abundance inevitably leads to greater corruption and inefficient bureaucracies; or that high rents distract governments from investing in the ability to produce growth supporting public goods, such as infrastructure or legal codes[8]. A related view is that resource abundant economies that can live off resource exports are more likely to follow some form of state-led development policies, including import protection[9]. Lane and Tornell [1995] argue that a windfall coming from a terms-of-trade improvement or a discovery of natural resource deposits can lead to a "feeding frenzy" in which competing factions fight for the natural resource rents, and end up inefficiently exhausting the public good. In general, as long as rent seeking is a dead weight loss, anything that encourages rent seeking will lower steady state income and therefore growth along the path to the steady state. The case studies in Gelb [1988] and Auty [1990] lend support to these political channels of influence.

A further line of argument is that resources *per se* are not a problem, its just that they tend to have more volatile world prices, and volatility is the problem. The fact that natural resource prices are more volatile than other prices is well established. This probably translates into greater ex-ante uncertainty for primary commodity producers, and also extends through to other sectors in resource-abundant economies. It is also well known that greater uncertainty can reduce factor accumulation through greater risk or

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[7] Private correspondence with Mancur Olsen (1994).

[8] This is a common view among representatives from mining companies for example.

[9] Using the data in Sachs and Warner [1995] we find that resource-intensive economies liberalized later than resource-poor economies.

because it raises the option value of waiting, although the magnitude of these volatility effects not known very precisely.

A final argument is that governments that controlled natural resource rents tended to waste the rents through profligate or inappropriate consumption. Supporting this, there is the related idea that commodity price forecasts in the 1970's and 1980's turned out to be systematically biased, specifically too optimistic, and this served to encourage large public investments in projects that were hugely inefficient when the price forecasts turned out to be incorrect. As a result, the argument goes, the natural-resource-intensive economies ended up with more inappropriate capital on their hands than other economies. However, if all that was happening was that the resource rents were consumed rather than invested, or that the investment that was done yielded low returns, then the path of GDP in natural resource abundant economies would be lower than it would have been in the *same* economies with optimal policies. But such economies would not necessarily grow *slower* than other resource-poor economies. In other words, to explain the *negative* association we find below, there must be something else going on beyond wasteful policies.

This completes our summary of the arguments about the links between natural resource abundance and growth. In the next section we present the basic evidence for the period 1970-1989. In the following section we examine additional evidence on a number of the theoretical points discussed in this section.

III. Evidence on Natural Resource Abundance and Growth 1970-1989.

In this section we show the evidence of an inverse association between natural resource abundance and growth during the period 1970-1990. We present the findings in the context of empirical cross-country growth equations described in Barro [1991] and used subsequently by may other authors. In this framework, the growth equations have the following general form:

$$\ln(y(T)/y(0))/T = \alpha_0 + \alpha_1 \ln(y(0)) + \alpha_2 Z + \epsilon \qquad \textbf{(1)}$$

The general form of equation (1) has been derived by several authors. While the derivations differ across studies, the core hypothesis is that cross-sectional growth rates can be explained by transitional dynamics, and that countries adjust to their steady state income with a speed that is less than infinite. The sign of α_1 provides a crucial test of this hypothesis. If α_1 is negative, the adjustment path to the steady state is concave, with the speed of transition faster at the beginning, when the country is furthest from its steady state income level. Z is a vector of economic characteristics that determine a country's steady state income level, and thus its growth rate.

Our goal is to test whether measures of natural resource intensity are among the Z's. Our preferred measure of resource dependence is the ratio of primary-product exports to GDP in 1970, which we denote SXP. We have also tested other possible measures of resource dependence, as we shall mention.

We start in table I with a series of regressions that are designed mainly to demonstrate that the inverse association obtains after controlling for a number of other regressors. In the first regression, we regress growth in GDP (divided by the economically active population between 1970 and 1990, denoted GEA7090) on the log of initial GDP (per economically active population, denoted LGDPEA70) and the share of primary exports in GDP in 1970 (SXP). A higher share of primary exports in 1970 is associated with lower growth in the next two decades, with an estimated coefficient of -9.43 and a t-statistic of -4.75. To gauge the size of this coefficient, note that SXP is measured as a share of GDP, with a cross-country mean in 1970 of 0.16 and a standard deviation of 0.16. Regression 1 implies that a unit standard deviation increase in the share of primary exports in 1970 would be associated with a reduction in annual growth of 1.51 percentage points (-1.51=-9.43*0.16). Other regressions later in the paper imply a lower impact, with the lowest being -3.89 (table IX) which translates into a reduction in annual growth of 0.62 percentage points. Later in the paper we will try to say more about both direct and indirect effects of resource intensity on growth, but for now these calculations provide a rough idea of the estimated magnitudes.

It is possible that this negative association between natural resource intensity and growth is spurious, reflecting an association between resource wealth and something else that affects growth. Some common arguments are that resource-rich countries are more likely to adopt import- substituting, state-led development strategies, are less likely to accumulate capital at home because they can live off natural resource rents, are more prone to rent-seeking and to develop large inefficient bureaucracies, or are less likely to develop market supporting legal institutions. In addition, a long-standing view in the development literature is that countries that specialize in natural resource exports are more likely to suffer from unpredictable and disruptive shocks in global commodity prices.

Therefore, the remaining regressions in table I are designed to show that the resource intensity variable remains significant after controlling for variables that measure a number of these ideas. In regression 1.2 we add a variable for outward orientation, SOPEN, that measures the fraction of years between 1965 and 1989 that the country was integrated with the global economy. A country is said to be integrated if it maintained reasonably low tariffs and quotas, and did not have an excessively high black market exchange rate premium, was not socialist, and avoided extreme state-control of its export sector [see Sachs and Warner, 1995 for more details on the formal criteria]. A country that was open every year between 1965 and 1989 received a value SOPEN = 1. A country that was always closed during these years received a value SOPEN = 0.

We have also tried other policy-related variables in these regressions such as the fiscal deficit or the average inflation rate. We found that these variables were not significant when SOPEN was in the regression, so we have dropped them in favor of SOPEN. However, we cannot exclude the possibility that there are other unobserved or mis-measured policy variables that are correlated with SOPEN. The SOPEN variable may therefore be picking up some of the effects of these variables in addition to openness.

Nevertheless, although the data do not allow us to distinguish sharply between openness and other correlated policies, the regression results do show that the package of policies captured by SOPEN were strongly and positively associated with growth during the 1970-1989 period[10]. In addition, the natural resource variable remains significant after controlling for this variable.

The other variables considered in table I are designed to control for capital accumulation, institutional quality, and global commodity price shocks. The variables considered are: INV7089, the investment to GDP ratio averaged over the period 1970-1989; RL, the rule of law variable used in Keefer and Knack [1995] and Barro [1996]; and DTT7090, average annual growth of the ratio of export to import prices between 1971 and 1990.

The regressions in table I show that the share of primary exports in GDP remains significant after controlling for these variables. Although the regressions in Table I are exploratory, and thus we are somewhat hesitant to stress a structural interpretation, we do think the results are informative about the following general points. First, whatever the exact nature of the adverse effect of natural resource abundance on economic growth, the evidence suggests that it is not simply a proxy for institutional quality or import-substituting industrialization policy, to the extent that these are measured by RL and SOPEN. It also seems that the adverse effect is not operating mainly by lowering investment rates, since the negative correlation is maintained even after controlling for investment rates[11]. Further, since SXP remains significant after controlling for long-run changes in the external terms-of-trade, resource intensity is not

[10] For the vast majority of the developing world, the basic policy choice whether to follow an inward-looking or outward-looking development strategy was decided before 1970 and was maintained until the late 1980's. So we see little evidence that reverse causality from growth to the SOPEN variable is an important econometric issue with these regressions. We present our argument in further detail in Sachs and Warner [1995].

[11] We are sympathetic to the criticism that investment may be endogenous and thus either should not be included in this specification, or should be estimated with instrumental variables. However, we include it nevertheless to make the point that the SXP effect is significant even after controlling for investment. Our conclusions about SXP and SOPEN would obtain if we dropped investment from the regressions.

simply a proxy for adverse trends in global export prices of resource intensive economies.[12] The effect also remains significant after we control for regional dummy variables. Finally, it is interesting to note that even within the small set of fast growing Asian tigers there is an adverse effect of natural resource abundance, since resource-poor Singapore, Hong Kong, and Korea have grown faster than resource-rich Malaysia and Thailand.

We consider two further checks for robustness: looking for extreme observations and trying alternative measures of primary resource intensity. To check for outliers, we follow the criterion suggested by Belsley, Kuh and Welsch [1980, p. 28]. The basic idea is to exclude observations that have both extremely high residuals and high leverage on the regression results.[13] Applying their criteria, we exclude Chad, Gabon, Guyana, and Malaysia from the regressions in table 1.

We also considered separately the oil economies, since they are an important sub-group within the set of resource intensive economies. Previous growth studies have either eliminated these countries from the sample [for example, Mankiw, Romer, and Weil, 1992] or controlled for them with dummy variables [Barro, 1995]. Of the 71 countries in the sample for regression 1.5 in table I, 11 exported a significant amount of crude oil or crude oil products. If these countries are excluded, and regression 1.5 is instead estimated with only 60 countries, the estimated coefficient on SXP is -9.59 (t-ratio=-6.36). This is only slightly different from the results reported in table 1. In this sense, the oil economies in our sample are not driving the basic result.

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[12] We have also controlled for additional variables that are not reported in table I. First, other measures of the quality of government institutions, such as the bureaucratic quality indicator from Political Risk Services, tend to be collinear with the rule of law variable. So the regression evidence does allow us to distinguish between various measures of institutional quality. Second, we have tried a variable which measures the standard deviation of the terms of trade rather than just the change, but it was not significant. Third, we tried an income inequality measure in an earlier draft of this paper, but it was not significant, and tended to severely reduce the sample. Fourth, an oil economy dummy was not significant.

[13]The leverage of an observation is a multivariate measure of the distance of it's X values from the means in the sample. Belsley, Kuh and Welsch [1980] recommend using the DFITS statistic, due to Welsch and Kuh [1977], which combines these two according to the formula DFITS=r/((h/(1-h))^(½), and further suggest excluding an observation if DFITS exceeds 2(k/n)^(½). In the formulas above, r is the residual, h is the leverage, k is the number of regressors and n is the sample size. We applied this selection criterion using the residuals from regression 1.2 in table I, and excluded Chad, Gabon, Guyana, and Malaysia from regression 1.2 and the other regressions in table 1.

Nevertheless, if we look at growth for seven additional oil economies excluded from our sample, we would probably find an even stronger negative association between growth and natural resource abundance, because the excluded countries tend to have especially slow growth. In table II, we show growth rates for these seven countries. These countries are not included in the regression sample because they lack data on GDP for either 1970 or 1990 or both, but all would have a high share of natural resource exports in GDP. The table shows that the fastest growing country in this group, Oman, grew only at 0.69 percent per year.

We also checked robustness by trying alternative measures of natural resource abundance. In Table III we report the estimated natural resource coefficients from four regressions, each of which varies only the measure of natural resource intensity. Regression 3.1 is a version of regression 1.5, using other full-sample instead of excluding the outliers. Regression 3.2 replaces SXP with SNR, which measures the share of mineral production in GDP in 1971. This is constructed using country-specific production data from the U.S. Bureau of Mines for the top twenty-three minerals in 1971. These production figures were then valued at U.S. import prices and divided by the U.S. dollar value of GDP to obtain SNR. Regression 3.2 shows that mineral production in 1971 is also negatively associated with subsequent growth. Our third measure of resource intensity is PXI70, the share of primary exports in total exports in 1970 (rather than the share of primary exports in GDP, which is SXP). Our fourth measure is the log of land area per person in 1971. Regressions 3.3 and 3.4 show that both are also negatively associated with subsequent growth.[14]

The reason we prefer the SXP variable to these alternatives involves both theory and measurement issues. In the Dutch disease model we present in the working paper version of this paper, what matters is the share of the economies labor force employed in non-tradeables production rather than tradeable manufactures. This share depends on the level of demand for non-tradeables which, in turn, depends on the wealth effect from natural resources. The size of this wealth effect is better captured by the share of resource exports in total GDP rather than just exports (hence the preference for SXP over PXI70).

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[14] We also experimented with preliminary data developed at the World Bank, that attempts to measure the productive wealth of the world's economies, and to allocate that wealth among human capital, physical capital, and natural resources. We used the proportion of natural resource wealth in total productive wealth as a measure of resource abundance. As with the other measures, a high proportion of resource wealth is associated with slower economic growth, holding constant other relevant variables.

Political economy arguments call for measurement of the actual or potential economic rents associated with natural resources. It appears impossible to base this on cross-country data on proven reserves of minerals. Reserve data exists for major natural resources such as crude oil and natural gas, but not for the others, and this is important if one wants to include developing countries in the sample. In our view, SXP has better coverage of primary production than SNR, which measures only minerals and fuel production. In addition, from looking at the Bureau of Mine's data for 1971, on which SNR is based, it is clear that mineral production for some of the poorer countries was simply not recorded, or contains obvious guesses. Therefore we think that SXP simply has fewer gross measurement errors than SNR and prefer it largely on that basis.[15] Finally, we prefer SXP to land area per person because land is not a very precise measure of primary production, though land abundance does tend to be correlated with our measures of natural resource abundance.

A further way to check robustness is to see if SXP remains significant in regression specifications of other studies. To look at this, we added our variables to regressions from four previous studies: Barro [1991], De Long and Summers [1991], King and Levine [1993], and Mankiw, Romer and Weil [1992]. In tables IV through VII we present the results. Each table contains an attempted replication of the original regression in the first column and regressions with three new variables in the second column. There are three important points to bear in mind regarding the replications. The first is that we generally change the sample period to 1970-1990; the second is that we measure growth as growth per economically active population rather than growth per person (economically active is defined as within the ages 15 through 64), and the third is that we use real GDP data from version 5.6 of the Summers and Heston data, and some of the earlier studies, of necessity, used earlier versions of this data or used World Bank data. These three points together mean that we do not match the original specifications exactly. The new variables we introduce are the SXP variable from this paper, the SOPEN variable from Sachs and Warner [1995], and growth in the external terms of trade (DTT7090). We retain the change in terms of trade in the regressions

[15] We note that estimates of mineral reserves only seem to be available for oil and gas and a few major minerals. We did not find reserve data with sufficient resource and country coverage to be useful for this paper. Moreover, experts at the U.S. Bureau of Mines report that reserve estimates for many countries and minerals are simply a fixed multiple of production anyway, so that they may not have much more information than the production figures.

even when it is insignificant, so that the SXP coefficient may be interpreted as an effect that controls for long-term changes in global commodity prices.

In table IV, regression 4.2, we show that SXP and SOPEN remain significant when included in a modified Barro [1991] specification. The estimated coefficient on SXP is -9.17 (t-ratio= -6.26) and on SOPEN is 1.96 (t-ratio=4.57). With the exception of initial income and the average investment ratio, a number of the variables in the original specification no longer appear significant, although the signs in the original study are preserved. We have not investigated the reasons for the differing results in detail, but three possible explanations are updated and revised data, a different time period, and the fact that we are examining growth divided by the economically active population rather than dividing by population.

In table V we report a similar replication exercise with the financial variables of King and Levine [1993]. The original study considered four different measures of financial deepening; and we have estimated regressions with all four. In table V we illustrate a typical result with the LLY70 variable, which measures the ratio of total banking system liabilities plus currency to GDP in 1970. The regressions tend to prefer the SXP and SOPEN variables to the financial deepening variables. For example, in regression (5.2) the estimated coefficient on LLY70 is 1.44 (t-ratio=1.38), down from 4.74 (3.80), and the estimated coefficient on SXP is -6.63 (-4.33) and on SOPEN is 2.41 (5.13).

In table VI we return to estimation of the Solow model, as in Mankiw, Romer, and Weil [1992]. In these regressions we continue to find that SXP and SOPEN are significant. The main change from the original specification is that population growth is no longer significant.

In table VII we re-examine the hypothesis in De Long and Summers [1991] that growth is related to the share of investment expenditures on machinery and equipment, rather than structures. We replicate their basic result in the first column: a significant coefficient on EQUIP and an insignificant coefficient on NES (investment spending on everything else). In the second regression, we find that the equipment variable is no longer significant in the presence of SXP and SOPEN, which in turn are significant. It is worth mentioning that the equipment investment variable is only available for 62 countries, so that the sample behind the regressions in table VII is much smaller than in the other regressions.

From this brief review of other studies, our general conclusion is that natural resource intensity and openness represent additional explanations for cross country growth that have not been considered by other studies. These two variables are significant when added to regression specifications of other studies; they substantially raise the adjusted R^2's; and they sometimes make the previous variables statistically insignificant.

Our results so far have been about growth of the entire economy, rather than growth in the part of the economy that excludes the natural resource sector. There are two main reasons for this. The first reason is that growth of the entire economy is the main object of interest of the previous growth literature, and we want to preserve comparability with previous results. The second reason is that data on GDP in the non-natural resource sector of the economy are difficult to obtain, especially with sufficient time and cross-country coverage for our purposes. Nevertheless, several models, including the Dutch disease model in our working paper, predict results for growth in the non-resource sector specifically, so it is worth considering the available data, however imperfect.

We do so in the second regression in table VIII. Our measure of growth in the non-resource sector is based on real value added data in manufacturing and services from World Bank sources[16], (we call growth in this aggregate GNR7089). This covers most of the non-resource economy, but excludes construction, electricity, gas and water (which are not reported separately in the World Bank data). Although measurement error is a potential issue for GNR7089, we use it exclusively as a dependent variable.

A regression of growth of non-resource GDP on natural resource intensity and a number of other variables is presented in regression 8.2 of table VIII. The specification is similar to regression 1.4 in table I. The results indicate that growth in real value added in manufacturing and services was indeed slower in natural-resource-intensive economies. When the full set of regressions in table 1 is re-run with GNR7089 instead of GEA7090, the signs and statistical significance of the estimated coefficients are similar to those in table 1, with the single exception of the rule of law variable, which is sometimes insignificant.

We also check two other implications of the dynamic Dutch disease story in table VIII. In the first

[16] The data are from the *World Data 1995* CD-Rom.

regression we show evidence that resource intensive economies did indeed have slower growth in manufacturing exports, after holding constant the initial share of manufacturing exports in total exports (SMX70). In the third regression, we show evidence that resource-intensive economies had a higher ratio of output of services to output of manufactures. This is consistent with the prediction of the Dutch disease models that the ratio of non-traded to (non-resource) traded output will be higher in resource intensive economies, to the extent that services proxy the non-traded sector and manufactures proxy the non-resource traded sector.

Another potential issue is whether we are loosing important information by averaging over two decades (the 70's and the 80's) which were quite different for primary exporters. World prices for primary commodities rose sharply in the 1970s and then fell nearly as sharply in the 1980s. Is our result attributable to the fact that we happen to be looking at a period which saw large swings in primary commodity prices? To examine this we present growth regressions in table IX estimated separately for the decade of the 1970 and the 1980s. Note that in this table SOPEN is now average years open for the 1970s or 1980s, depending on the regression, DTT refers to the change in the terms of trade between 1970 and 1980, for the first regression, and 1980 and 1989 for the second, and INV is average investment for either the 1970s or 1980s. Since the rule of law variable is measured only as of 1982, we use it only in the 1980's regression; otherwise, the specification is similar to that of table I.

The main conclusion from the first regression is that we find a negative natural resource intensity effect even in the booming 1970s, when global conditions were so auspicious for primary producers. Even after we control for the effects of terms of trade increases via the DTT variable, which has a positive and significant effect on growth, we find that primary resource intensive countries grew slower than other countries in the 1970s. The estimated SXP coefficient is significant in the two sub-periods and in fact is not statistically different in the 1970s and the 1980s. We also find that open countries grew faster than closed economies in both sub-periods, with a slightly more positive effect in the 1980s. In addition, these effects obtain even after holding constant the average rate of investment.[17]

[17] A possible further criticism of our result can be seen by considering the following example. Suppose two economies start with the same natural resource endowment, but that only the first one follows pro-growth policies. If we measure SXP after some time has elapsed, and the policies continue, then we

Another way to approach the evidence is to try to identify cases of high-growth, resource-abundant economies, which would be counter-examples to our general proposition. Are there developing economies that are in the top quartile of resource abundance (measured by SXP, for example) and that have sustained high levels of growth? We find only two cases of developing countries (defined as 1971 income < $5,000 per capita on a PPP basis) that were in the top quartile on SXP, and had sustained per capita growth of greater than or equal to 2.0 percent per annum for the period 1970-89. These countries are Malaysia and Mauritius. The fact that there are only two such cases is, of course, striking, since the top quartile of SXP includes 23 developing countries. Both Malaysia and Mauritius were quite open to trade, at least in the sense of having zero-tariff Export Processing Zones to stimulate labor-intensive manufacturing exports. Both have had their growth sustained by the very rapid development of such exports. Thus, even in these cases, it is manufacturing exports rather than resource-led growth that accounts for the sustained high levels of economic growth.[18]

will observe that the second economy has higher SXP and slower growth than the first, but the reason is entirely due to the policies rather than anything about resource intensity. One way to check this is to control for *previous* growth in the regressions. We find that growth in the 1960's does not enter the regression significantly, and does not alter the significance of the SXP coefficient.

[18] Botswana is sometimes also included as an example of a natural resource abundant economy that grew rapidly. Data from the Ministry of Finance in Botswana (reported in Modise Modise [1996]) indicate that in 1970, when we measure SXP, diamond exports were only about 5 percent of GDP. What happened was that several diamond mines began producing in the next 15 years. One possible interpretation of Botswana's growth is that they have had a 20-year natural resource boom, driven not by a rise in world diamond prices, but rather by diamond discoveries and consequent production increases.

IV. PATHWAYS CONNECTING RESOURCE-INTENSITY AND GROWTH

In this section we present some preliminary evidence to better understand what lies behind the negative relation between natural resource intensity and growth. We start by listing a number of possible channels. One hypothesis is that high natural resource abundance leads to increased rent-seeking, corruption, and poorer overall government efficiency. In this connection, we note that Political Risk Services, the company that produces the rule of law index also produces an index for bureaucratic quality. The simple correlation between this variable and the rule of law variable is 0.98, so the variables are nearly identical from a statistical point of view even though they are given different labels. Hence, the data do not permit sharp distinctions between rule of law and bureaucratic quality; it is best to regard the rule of law variable as a general index for the efficiency of legal and government institutions. In any case, we will see if there is any evidence that resource intensity works through this variable in affecting growth. We allow for the fact poor government institutions may depress growth directly or indirectly by depressing investment demand.

A second hypothesis is that high resource wealth has encouraged developing countries to pursue protectionist, state-led development strategies, as they try to combat the Dutch Disease effects of the resource abundance. This inward-looking development may result in lower investment rates and/or low growth rates directly, even controlling for investment rates. A third hypothesis is that countries with higher natural resource abundance would have higher overall demand and higher relative prices of non-traded goods. This might affect the relative prices of investment goods (which have a large traded component), with effects on investment rates and growth. A final hypothesis is that high resource abundance leads to increased aggregate demand that shifts labor away from high learning-by-doing sectors and thus depresses growth in labor productivity, as in the Dutch Disease cum learning model in the working paper version of this paper[19]. This effect, as well as further unspecified effects, may be captured by the SXP variable that enters directly in the growth equation, after controlling for trade policy and the quality of

[19] "Natural Resource Abundance and Economic Growth", NBER working paper No. 5398, December 1995.

government institutions.

We summarize this discussion of the direct and indirectly effects of resource intensity on growth with the following set of equations. We view this model as a starting point for exploration, rather than as a definitive structural model of the pathways from resource abundance to growth.

$$GEA7089 = \alpha_0 + \alpha_1 * SXP + \alpha_2 * SOPEN + \alpha_3 * INV7089 + \alpha_4 * RL + \alpha_5 * LGDP70 + \varepsilon_1 \quad (1.5)$$

$$INV7089 = \beta_0 + \beta_1 * LPIP70 + \beta_2 * RL + \beta_3 * SOPEN + \beta_4 * SXP + \varepsilon_2 \quad (10.2)$$

$$SOPEN = \theta_0 + \theta_1 * SXP + \theta_2 * SXP^2 + \theta_3 * LAND + \varepsilon_3 \quad (10.4)$$

$$RL = \eta_0 + \eta_1 * SXP + \eta_2 * LGDP70 + \varepsilon_4 \quad (11.4)$$

$$LPIP70 = \gamma_0 + \gamma_1 * SXP + \gamma_2 * LGDPEA70 + \gamma_3 * SOPEN + \varepsilon_5 \quad (10.5)$$

The numbers of these equations correspond to regressions in three tables. For example, the first equation above is given the number 1.5 because our preferred estimates are reported in Table I, regression 5. As shown, estimates of the other equations are in tables X and XI. There is one variable that has not been introduced, LPIP70, which is the log of the ratio of the investment deflator to the overall GDP deflator in 1970. This variable measures the price of investment goods, relative to overall prices. Several recent studies, for example, Warner [1994], and Taylor [1994], have found this or similar variables to be significant determinants of investment rates, with a higher price of investment goods associated with a lower rate of investment relative to GDP. Both price indexes, for investment goods and for the GDP deflator, are taken from version 5.6 of the Summers and Heston data.

Clearly this is an oversimplified model, with particularly inadequate explanations for RL and SOPEN. We present the results merely as an initial foray into a more structural assessment of the pathways from SXP to growth. We have also tried to estimate this as a system with instrumental variables, but it turns out that the instruments suggested by the model above do not have sufficient sample variation to obtain meaningful estimates. Estimation as a system without instrumental variables, yields estimates which are close to the single-equation least squares estimates. For simplicity, we present least squares estimates, viewing them as imperfect but still informative estimates of the pathways from natural resource abundance to growth.

Estimates of these equations, and related results, are in tables X and XI. We have already seen some empirical support for the idea that the quality of legal and government institutions is positively associated with growth (regression 1.5 in table I), although occasionally the estimated effect is only marginally significant (regression 8.2 for example). In table XI we present additional evidence that resource abundant countries have poorer scores on a variety of measures of institutional quality. (As discussed above the five regressions in table 11 do not represent independent information, because the dependent variables are highly correlated with each other.)

We also find evidence that natural resource abundance may affect growth indirectly through the extent of trade openness. First, we postulate, and find supporting evidence, for a U-shaped relation between openness (measured as SOPEN, on the y-axis) and resource intensity (measured as SXP, on the x-axis). Our reasoning is as follows. Resource abundance squeezes the manufacturing sector, as in the Dutch Disease. In almost all countries, the squeeze of manufactures provokes some protectionist response that aims to promote industrialization **despite** the Dutch Disease effects. For the most highly resource-endowed economies, however, such as the oil-rich states of the Middle East, the natural resource base is so vast that there is no strong pressure to develop an extensive industrial sector (other than in oil-based sectors such as petrochemicals and refining). Thus, for the most extreme resource-based cases, openness to trade (SOPEN) would tend to be high. The overall effect would therefore be a U-shaped relationship between SXP and SOPEN.

There is statistical support for this idea in regression 10.4, where we find a negative estimated coefficient on the level of SXP and a positive coefficient on SXP^2. The dependent variable SOPEN, is a fraction that ranges between 1 (if a country was open for the whole period 1965-1989) and 0 (if a country was never open). The estimated trough of the “U” is when the share of primary exports in GDP equals

0.29. For countries below that value -- which is almost all countries in the sample -- higher primary exports tend to promote economic closure (that is, a low value of SOPEN). Above that threshold, higher SXP tends to promote openness. Two interesting examples on the positive part of the “U” are Malaysia and Saudi Arabia. These countries are extremely resource rich, and have also had a long tradition of open trade.

Since the vast majority of our countries have SXP values on the negatively sloped part of the “U” relation, we evaluate the effect of SXP growth via SOPEN at the mean of SXP (0.16), along the negatively sloped part of the U-shaped relation. Starting from the mean of SXP, our estimates imply that a unit-standard deviation increase in SXP from its mean (that is, from 0.16 to 0.32) reduces SOPEN by 0.06. Taken at face value, since SOPEN measures the fraction of years between 1965 and 1989 that a country is rated as open, this estimate implies that a country with a value of SXP one standard deviation above the mean would have been open for about 1.4 years less on average than a country with the mean value of SXP.

We also look at the cross country relationship between natural resource abundance and four other variables: savings rates, investment rates, rates of human capital accumulation and the relative price of investment goods. First, regarding savings rates, we do not find strong evidence that resource abundant economies have higher savings rates. Simple bi-variate data plots show that only three resource abundant economies, Gabon, Kuwait, and Saudi Arabia, had unusually high average savings rates (over the period 1970-1989). But if we exclude these three countries there is no clear cross-country relation. Moreover, even with the three high-savings countries included in the sample, a regression of average saving rates on the level of GDP and SXP does not yield a significant coefficient on SXP (see regression 10.1 in table X, which also controls for initial GDP). Therefore, although it is possible that a more elaborate study would change this conclusion, the simple evidence does not support a positive association between resource abundance and average savings.

We reach similar conclusions when we examine the data on investment and human capital association. As we show in regression 10.2 in table X, average investment rates are not significantly associated with natural resource abundance. There is some evidence of a positive relation between investment (this is sensitive to whether investment is entered as a ratio or in logs) and openness and the rule of law variable, and some evidence of a negative relation with the relative price of investment goods, but after controlling for these variables, no significant effect of natural resource intensity. We also find little direct evidence that more resource intensive countries have had significantly lower rates of human capital accumulation, as shown in regression 10.3. We have tried excluding outliers (Bahrain, Korea, and Kuwait) from the human capital regression, and estimating stock-adjustment equations where the change in the human capital stock is regressed on the initial level of human capital, SXP and initial income, but still find no statistical relation between SXP and human capital accumulation.

In summary, we have attempted to find evidence for indirect effects of resource intensity on growth by looking at the cross-country relation between resource intensity and possible explanatory variables in growth regressions. We find evidence that resource intensity has been related to institutional quality (as summarized by the variables in table XI) and broad policy choice (as summarized by the SOPEN variable). But we find little evidence that it is related to human or physical capital accumulation or savings rates. We now turn to some simple calculations in an attempt to quantify both the direct and the indirect impact of resource intensity on growth.

One approach to determining the magnitude of the indirect effects of resource abundance on growth is to examine the size of the estimated SXP coefficient as we successively control for the additional variables. In table 1 the estimated SXP coefficient is -9.43 in the regression 1.1 in which we only control for initial income; and -10.26 in regression 1.5 that controls for an additional 4 variables. This simple evidence suggests that the indirect effects are not large; otherwise the additional controls should drive the estimated coefficient on SXP down as we read from left to right in table 1.

Another approach is to calculate the size of the indirect effects using the estimated coefficients. We first consider the rule of law variable. Suppose we were to increase SXP by a unit standard deviation (0.16). The coefficient estimate in table XI implies that this would be associated with a reduction in the rule of law index of -0.88 (=0.16*-5.47). To calculate the effect on GDP, recall that the dependent variable in the growth regression is 100/20 *(ln(GDP90) - ln(GDP70). If we multiply both sides of the equation through by 20/100, then the estimated coefficient on RL in the growth equation times 20/100 is an estimate of $\partial \ln(GDP89)/\partial RL$, holding constant GDP in 1970 and all the other variables. The 0.40 coefficient in regression 1.5, implies that ∂ln(GDP89)/∂RL=0.08. Therefore, the full effect of a unit standard deviation increase in SXP on LN(GDP89) would be -0.88*0.08=-0.07, equivalent to a reduction of GDP89 of only about 7 percent. So according to this calculation, the indirect effect of resource intensity operating through the quality of legal and government institutions is not large.

We also examine the size of indirect effects operating thorough openness policy, as summarized by our SOPEN variable. If we allow SXP to rise one standard deviation from its mean, the estimates in regression 10.4 imply that ∂LN(GDP89) would be -0.05*1.34*(20/100)=-0.014, equivalent to a reduction of only about 1.4 percent in GDP90. Again, this is not large.

Our main conclusion is that the estimated direct effect of SXP on growth is large in comparison with these estimates of the indirect effects. These results lend tentative support to the view that the dynamic Dutch disease effects we emphasize in the growth model of the working paper version are quantitatively important. However, it may also be the case that the normal downward bias in estimated regression coefficients, due to measurement errors in the independent variables, serve to depress the estimated indirect effects more than the direct effects. Of course, we cannot precisely separate true effects from measurement bias with the data we have at hand.

IV. Summary and Conclusions.

In this paper we have argued that there has been an inverse association between natural resource intensity and growth between 1970 and 1990. The finding appears robust in the sense that it remains significant in cross-country growth regressions after controlling for a large number of additional variables that **other** studies have claimed to be important in explaining cross-country growth. The list of additional variables includes initial GDP, openness policy, investment rates, human capital accumulation rates, changes in the external terms of trade, government expenditure ratios, terms of trade volatility, and the efficiency of government institutions. We find that the effect remains when we introduce alternative measures of natural resource abundance. It remains when we measure growth in the non-natural-resource sector of the economy. It also appears to hold for the decade of the 1970s and the 1980s separately. A striking “non-parametric” support of the findings is the very few cases of resource-abundant developing countries that sustained even 2 percent per annum growth during 1970-90: only Malaysia and Mauritius, out of 18 countries.

These results can be interpreted in the context of three literatures. Many of the ideas in the theoretical literature on endogenous growth are difficult to test; but in the cases where they can be tested, endogenous growth ideas have not found strong support in explaining differences in growth across countries. To the extent that such models contain the general idea that the industrial structure matters to growth, our results are at least mildly supportive. More specifically, our results are consistent with the view that a key division that matters for endogenous growth effects is tradeable manufacturing versus natural resource sectors.

Finally, these results may be placed in the context of the empirical literature on the determinants of cross-country growth rates. We continue to find, as have many other studies, that there is evidence for conditional convergence, as suggested by neoclassical models of economic growth, since the estimated coefficients on initial GDP are typically significantly negative. We also find that policy matters for growth as summarized by our SOPEN variable [and related results in Sachs and Warner [1995]].

Although this paper does find evidence for a negative relation between natural resource intensity and subsequent growth, it would be a mistake to conclude that countries should subsidize or protect non-resource-based as a basic strategy for growth. First, although the results here using highly aggregated data are suggestive, they are far from definitive. Second, as argued in Sachs and Warner [1995], the evidence from the recent past suggests that there are simpler and more basic policies that can be followed to raise national growth rates, especially open trade. Third, the welfare implications of resource abundance can be quite different from the growth implications. Resource abundance may be good for consumption even if not good for growth; policies might be good for GDP growth, while reducing real consumption. Put differently, government policies to promote non-resource industries would entail direct welfare costs of their own, and these could easily be larger than the benefits from shifting out of natural resource industries.[20] Therefore, we regard the issue of appropriate growth-oriented policies for resource-abundant countries to be an open and important topic for further analysis.

[20] Nor should our results be taken to deny that there are benefits from good policies regarding natural resource exploitation. Compare, for example, the experiences of the primary producers in Asia, namely Malaysia, Indonesia and Thailand with those in Africa [see Roemer, 1994].

Variables: descriptions and sources

Note: The sources will at times be abbreviated as follows. **PWT56**: *Penn World Tables, mark 5.6* (See Summers and Heston (1991) for description). **WD95**: *World Data 1995 CD-ROM* disk, distributed by the World Bank. **TSDB**: *Taiwan Statistical Data Book, 1995 or 1996.*

Table I.

LGDPEA70 — Natural log of real GDP divided by the economically-active population in 1970. The Real GDP data correspond to the series *RGDPCH* from the *Penn World Tables, Mark 5.6,* (see Summers and Heston 1981), and are in 1985 International Prices. The economically active population is defined as the number of people between the ages 15-64. The source for the population data is *World Data CD-ROM, 1995, World Bank.* Since the World Bank population data is given as percentage shares of total population, and the real gdp data is given in per-capita terms, the actual calculation is ln(RGDPCH*(100/sea70)), where sea70 is the share of the total population aged 15-64. The Taiwan data are from **TSDB**.

GEA7090 — Average annual growth in real GDP divided by the economically active population between the years 1970 and 1990. Exact calculation is 100*(1/20)*ln(GDPEA90/GDPEA70). The Taiwan data are from **TSDB**.

SXP — Share of exports of primary products in GNP in 1970. Primary products or natural resource exports are exports of “fuels” and “non-fuel primary products” from the *World Data 1995 CD-ROM* disk, produced by the World Bank. Non-fuel primary products correspond to SITC categories 0, 1, 2, 4, and 68. Fuels correspond to SITC category 3. These categories are from revision 1 of the SITC. GNP is taken from the same source. Both numerator and denominator are measured in nominal dollars. The *World Data* uses a smoothed exchange rate to convert local currency GNP to dollars. This describes the basic data. In addition, we made the following modifications. Bangladesh: 1975 data. Bahrain: 1980 data. Botswana: Exports of Diamonds in 1970 taken from Modise (1996). Cape Verde: export data for 1972 taken from World Tables 1994, World Bank; GNP data taken from the *World Data 1995 CD-ROM* disk. China: 1980 data. Cyprus: 1975 data. Jordan 1985 data. Iran: GNP in 1970 calculated with data in the *Penn World Tables, mark 5.6* together with price and exchange rate data in the *World Data 1995 CD-ROM* disk. Myanmar: 1970 GNP converted to dollars by the authors using the 1970 nominal exchange rate. Taiwan: Exports taken from *Taiwan Statistical Data Book 1995*, page 194 and GNP taken from 1996 volume, page 1. Uganda: 1980 data. South Africa: the published trade statistics do not include raw diamonds and gold, so these were added by the authors using data in *Bulletin of Statistics,* The Republic of South Africa, Pretoria, December 1972 and June 1992. Singapore: used *net* exports of natural resources because Singapore simply re-exports a lot of natural resources which originate elsewhere. Trinidad: used net exports for the same reason as Singapore. United Arab Emirates: 1973 data. Zimbabwe: 1980 data.

SOPEN — The fraction of years during the period 1970-1990 in which the country is rated as an open economy according to the criteria in Sachs and Warner [1995].

LINV7089 — Natural log of the ratio of real gross domestic investment (public plus private) to real GDP, averaged over the period 1970-1989. Source: **PWT56**.

RL Rule of Law index. This is an index constructed by the Center for Institutional Reform and the Informal Sector (IRIS) from data printed in the International Country Risk Guide, published by Political Risk Services. This variable "reflects the degree to which the citizens of a country are willing to accept the established institutions to make and implement laws and adjudicate disputes" Scored 0 (low) -6 (high). Measured as of 1982. See Keefer and Knack [1995] for further details.

DTT7090 Average annual growth in the log of the external terms of trade between 1970 and 1990. The external terms of trade is the ratio of an export price index to an import price index. The exact calculation is 100*(1/20)*(LN(TT1990) - LN(TT1970)). Source: WD95. For Singapore, we used the growth rate of the terms of trade from World Tables, 1994, to calculate TT1970. For Taiwan, the source is TSDB (1970 data was not available, so 1973 data was used instead).

Table III.

PXI70 Primary export intensity in 1970. Ratio of primary exports to total merchandise exports in 1970. See SXP for the definition of primary exports. Source: *World Data 1995 CD-ROM* disk. Additional modifications are as follows. In 10 countries the published data implied a share slightly in execss of 1.0, so these countries were given a share of 1.0 (Cape Verde, Gambia, Bahrain, Iran, Kuwait, Oman, Philippines, Vanuatu, Libya, and Kiribati). Taiwan: Data taken from *Taiwan Statistical Data Book 1995*, page 194. South Africa: the published trade statistics do not include raw diamonds and gold, so these were added by the authors using data in *Bulletin of Statistics,* The Republic of South Africa, Pretoria, December 1972 and June 1992. Singapore: given a value of 0.01 to deal with the re-exporting issue (based on GDP and labor force data).

SNR The share of mineral production in GNP in 1971.
SNR= (M71*1,000/(GNPD71*POP70))

M71 The value of mineral production in 1971. This is calculated by the authors from price and quantity data:

$$M71_j = \sum_{i=1}^{23} p_i * mq_{i,j} \qquad \textbf{(29)}$$

The sum is over 23 minerals (I index). Minerals were selected for this list if they were ranked in the top 23 in terms of value of production in 1973. In 1973, the value of total world production of these 23 minerals was $156,276 million dollars. The value of world production of all minerals was $159,201 million dollars. So these 23 minerals cover 98 percent of world production in 1973. [Source: 1974 Minerals Yearbook, table 5, p. 31.]

The price data are implicit U.S. import prices of each mineral, calculated by taking the ratio of real and nominal imports into the U.S. in 1971. These data are taken from the 1971 Minerals Yearbook.

The quantities are from real production data, by country and by minerals for the year 1971. This is taken from the 1973 minerals yearbook because it contains the last revisions for 1971 data. For each of the 23 minerals, the country-coverage is complete.

POP70 Population in 1970 (thousands). Taken from Summers and Heston, version 5.6.

GNPD71	GNP in dollars in 1971. For most countries, the data are taken from the World Tables data diskette, World Bank, 1994.
LAND	The log of the ratio of total land area to population in 1971. The land data are from table 1 of the FAO's 1971 Production Yearbook. For a few countries with incomplete data in the 1971 Yearbook, we use the data in the 1993 Production Yearbook. Land area rarely changes dramatically over time.

Table IV.

SEC70	Secondary school enrollment rate. Source: Barro and Lee, 1994.
PRI70	Primary school enrollment rate. Source: Barro and Lee, 1994.
GVXDXE	Ratio of real government 'consumption' spending net of spending on the military and education to real GDP. Source: Barro and Lee, 1994, who in turn used the PWT version 5.5.
REVCOUP	Number of revolutions and coups per year, averaged over the period 1970-1985. Source Barro and Lee, 1994.
ASSASSP	Number of assassinations per million population per year, 1970-1985. Source: Barro and Lee, 1994.
PPI70DEV	The deviation of the log of the price level of investment (PPP I / Xrate relative to the U.S.) from the cross country sample mean in 1970. Source: Authors calculation based on the PISH5 price data in Barro and Lee, 1994.

Table V.

KLLLY70	The ratio of the liabilities of financial intermediaries plus currency in circulation to GDP in 1970. Source: King and Levine [1993].
KLLSEC	Log of years of secondary education in the population 1970 1989. Source: King and Levine [1993].

Table VI.

GP7090	Population growth per-annum 1970-1990. Source: **PWT56**.

Table VII.

LFG	Growth in the labor force. Source: De Long and Summers [1991], data appendix.
EQUIP	Investment spending on equipment as a fraction of GDP, average between 1970-85. Source: De Long and Summers [1991], Appendix IV: Data Table XVI, page 495.
NES	Investment spending on structures and goods other that equipment, average between 1970-1985. Source: De Long and Summers [1991], data appendix.

Table VIII.

SMX70 Share of manufacturing exports in total exports, 1970. Source: World Bank, *World Data, 1995* CD-ROM, and Taiwan Statistical Data Book 1995.

DMX7090 Change in the share of manufacturing exports in total exports (SMX90-SMX70). Source: World Bank, *World Data, 1995* CD-ROM, and Taiwan Statistical Data Book 1995.

GNR7090 Real growth per-capita in the non-natural resource sector of the economy. Calculated as growth in the sum of real value added in manufactures and service sectors. Data refer to 1970-1990 where possible, but for the following countries it is instead average growth over the folowing sub-periods: Belgium 75-90; France 77-90; Australia 74-90; New Zealand 77-90; Costa Rica 71-90; Guatemala 70-87; Source: World Bank, *World Data, 1995* CD-ROM, and Taiwan Statistical Data Book 1995.

LGDPNR70 Natural log of GNP produced in sectors other than the natural resource sector. Calculated as ln(exp(LGDPEA70)*SNR1970/100), where SNR1970 is the ratio of the sum of manufacturing value added and services value added to GDP. Sources: **WD95** for the shares of GNP in manufacturing and services, and **TSDB** for Taiwan.

SERVS70 Ratio of value added in services to value added in manufacturing. Source: **WD95** and **TSDB.**

Table IX.

GEA7080 1970-1980 version of GEA7090.

GEA8090 1980-1990 version of GEA7090.

SOPEN7 Version of SOPEN for the decade of the 1970s only.

SOPEN8 Version of SOPEN for the decade of the 1980s only.

SXP80 SXP calculated for 1980 rather than 1970.

DTT7080 Version of DTT7090 for 1970-1980.

DTT8090 Version of DTT7090 for 1970-1980.

LINV7079 Version of LINV7090 for 1970-1980.

LINV8089 Version of LINV7090 for 1970-1980.

LGDPEA80 Version of LGDPEA70 for 1980.

Table X.

NS7089 National saving as a percent of GDP. Source: World Bank, *World Data 1995*, CD-ROM.

LPIP70 The log of the ratio of the investment deflator to the GDP deflator in 1970. The deflators are the PPP deflators reported in version 5.6 of the Penn World Tables [see Summers and Heston [1991] for a description of an earlier version of this data). In the Summers and

Heston notation, LPIP70 = ln(PI/P), using 1970 data.

DTYR7090 Change in the total years of education in the population aver age 15 from 1970-1990. Source: “International Data on Education”, Robert Barro and Jong-Wha Lee, January 1996.

Table XI.

BQ Bureaucratic quality index. See the sources for RL. A high score means “autonomy from political pressure”, and “strength and expertise to govern without drastic changes in policy or interruptions in government services.” Scored 0-6.

CORR Corruption in government index. See the sources for RL. A low score means “illegal payments are generally expected throughout .. government”, in the form of “bribes connected with import and export licenses, exchange controls, tax assessments, police protection, or loans.” Scored 0-6.

RE Risk of expropriation index. See the sources for RL. Scored 0-10, with lower scores for high risk of “outright confiscation” or “forced nationalization.”

GRC Government repudiation of contracts index. See the sources for RL. Scored 0-10, with a low score indicating high “risk of a modification in a contract taking the form of a repudiation, postponement or scaling down.”

Miscellaneous

GR6070 Average annual real growth per-capita between 1960 and 1970: GR6070 = (100/10)* ln(gdpr70 /gdpr60), where gdpr60 and gdpr70 are the RGDPCH data taken from **PWT56**.

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TABLE I. PARTIAL ASSOCIATIONS BETWEEN GROWTH (1970-90) AND NATURAL RESOURCE INTENSITY (1971)

Dependent Variable: GEA7090

	(1.1)	(1.2)	(1.3)	(1.4)	(1.5)
LGDPEA70	-0.11 (0.55)	-0.96 (-5.16)	-1.34 (-7.77)	-1.76 (-8.56)	-1.79 (-8.82)
SXP	-9.43 (-4.75)	-6.96 (-4.55)	-7.29 (-5.57)	-10.57 (-7.01)	-10.26 (-6.89)
SOPEN		3.06 (8.05)	2.42 (7.06)	1.33 (3.35)	1.34 (3.44)
INV7089			1.25 (5.63)	1.02 (3.45)	0.81 (2.63)
RL				0.36 (3.54)	0.40 (3.94)
DTT7090					0.09 (1.85)
Adjusted R^2	0.20	0.55	0.67	0.72	0.73
Sample size	87	87	87	71	71
Standard error	1.62	1.22	1.04	0.93	0.92

The numbers in parentheses are t-statistics. The variable SXP is the measure of primary resource intensity. These regressions are designed to show that the inverse association between growth and natural resource intensity is robust to the inclusion of a number of other variables and to the exclusion of outlying observations. The regressions exclude four countries (Chad, Gabon, Guyana, and Malaysia) that were deemed to be outliers according to a procedure suggested by Belsley, Kuh and Welsch [1980], which considers both the leverage and the residuals in deciding whether an observation is an outlier. If these four countries were not excluded, the estimated coefficients on SXP would range from -6.0 to -8.5, with t-ratios always exceeding 4 in absolute value.

TABLE II. GROWTH RATES OF SEVEN OIL-ECONOMIES NOT IN THE REGRESSION SAMPLE

	Entire Economy (years)[1]
Bahrain	-0.75 (75-88)
Iraq	-1.88 (70-87)
Kuwait	-5.39 (70-89)
Oman	0.69 (70-89)
Qatar	-7.70 (80-90)
Saudi Arabia	-0.76 (70-89)
United Arab Emirates	-4.60 (73-89)

[1] Source: Penn World Tables, version 5.6 and World Bank, *World Data 1995*.

TABLE III. ASSOCIATIONS BETWEEN GROWTH AND RESOURCE INTENSITY USING ALTERNATIVE MEASURES OF RESOURCE INTENSITY

Dependent Variable: GEA7089

	(3.1)	(3.2)	(3.3)	(3.4)
SXP	-8.28 (-6.67)	-	-	-
SNR	-	-6.45 (-3.95)	-	-
PXI70	-	-	-2.50 (-3.89)	-
LAND	-	-	-	-0.39 (-3.78)
Adjusted R^2	0.73	0.63	0.63	0.64
Sample size	74	74	73	74
Standard error	0.97	1.12	1.14	1.12

The numbers in parentheses are t-statistics. The natural resource intensity variables are first, the SXP variable used in table 1, which measures natural resource exports divided by GDP in 1970; second, SNR (mineral production divided by GNP in 1970); third, PXI70 (natural resource exports divided by total exports in 1970), and LAND (the log of arable land area divided by population). The other explanatory variables in the regressions are LGDPEA70, SOPEN, RL, DTT7090 and LINV7089.

TABLE IV. ESTIMATION OF BARRO [1991] WITH VARIABLES FROM THIS PAPER

Dependent Variable: GEA7089

	(4.1)	(4.2)
SXP	-	-9.17
		(-6.26)
SOPEN	-	1.96
		(4.57)
DTT7090	-	0.10
		(1.54)
LGDPEA70	-1.31	-1.92
	(-3.12)	(-6.21)
SEC70	3.51	2.89
	(1.69)	(1.83)
PRI70	-0.38	0.20
	(-0.34)	(0.24)
GVXDXE	-4.67	-4.24
	(-1.11)	(-1.47)
REVCOUP	-0.04	-1.04
	(-0.04)	(-1.71)
ASSASSP	-1.62	0.89
	(-1.05)	(0.81)
PPI70DEV	-0.41	0.03
	(-0.86)	(0.08)
INV7089	0.17	0.09
	(4.14)	(2.67)
Adjusted R^2	0.34	0.71
Sample size	70	69
Standard error	1.57	1.04

The numbers in parentheses are t-statistics. The first regression reports our replication of regression 24 in Barro [1991]. The replication is close but not exact, due to a different sample (1970-89 rather than 1960-1989) and revisions in the GDP data from Summers and Heston data (we use version 5.6 and we measure growth per economically active population rather than growth per-capita). The other variables are as follows. SEC70 is the secondary school enrollment rate. PRI70 is the primary school enrollment rate. GVXDXE is the ratio of real government consumption spending (excluding spending on the military and education) to real GDP. REVCOUP is the average number of revolutions and coups over the period 1970-1985. ASSASSP is the average number of assassinations per million persons over the period 1970-1985. PPI70DEV measures the deviation of the (log) price level of investment goods from the cross country mean in 1970. INV7090 is the mean ratio of real gross domestic investment (public plus private) to real GDP over the period 1970-1990.

TABLE V. ESTIMATION OF KING AND LEVINE [1993], WITH VARIABLES FROM THIS PAPER

Dependent Variable: GEA7090

	(5.1)	(5.2)
SXP	-	-6.63
		(-4.33)
SOPEN	-	2.41
		(5.13)
DTT7090	-	0.15
		(2.51)
LGDPEA70	-0.78	-1.17
	(-2.09)	(-4.14)
LSEC	0.44	0.19
	(1.18)	(0.66)
LLY70	4.74	1.44
	(3.80)	(1.38)
Adjusted R^2	0.19	0.56
Sample size	74	71
Standard error	1.59	1.18

The numbers in parentheses are t-statistics. The regression in column (1) is our replication of the regression in appendix table VII of King and Levine [1993]. We update their growth and initial GDP variable with GEA7090 and LGDPEA70 respectively, so the replication is not exactly the same. The main difference is that initial GDP and LSEC are not significant in regression 5.1 with the updated growth data, but they were in the original study. LSEC is the log of the secondary school enrollment rate in 1970. LLY70 is the 1970 value of liabilities of the banking system plus currency divided by GDP.

TABLE VI. ESTIMATION OF MANKIW, ROMER AND WEIL [1992], WITH VARIABLES FROM THIS PAPER

Dependent Variable: GEA7089

	(6.1)	(6.2)
SXP	-	-6.65
		(-5.22)
SOPEN	-	2.40
		(5.50)
DTT7189	-	0.04
		(0.81)
LGDPEA70	-1.00	-1.28
	(-4.07)	(-6.02)
GP7090	-0.56	0.14
	(-2.85)	(0.76)
INV7089	0.14	0.11
	(5.67)	(4.71)
Adjusted R^2	0.32	0.62
Sample size	103	89
Standard error	1.55	1.15

The numbers in parentheses are t-statistics. The regression in column (1) matches the specification in table IV, page 426, of Mankiw, Romer, and Weil [1992]. The results are close to the original, although with a different time period (1970-90, rather than 1960-85), a larger sample, (110 rather than 98) and updated data, they are not identical. GEA7090 is average annual real growth per economically active person in 1970 (the economically active population is defined as the population between the ages of 15 and 65); LGDPEA is the log of real GDP per economically active person in 1970; GP7090 is population growth; INV7090 is the ratio of investment to GDP, averaged over the period 1970-1990.

TABLE VII. ESTIMATION OF DELONG AND SUMMERS [1991], WITH VARIABLES FROM THIS PAPER

Dependent Variable: GEA7089

	(7.1)	(7.2)
SXP	-	-7.73
		(-4.89)
SOPEN	-	2.70
		(5.57)
DTT7189	-	-0.01
		(-0.18)
LGDPEA70	-0.66	-1.29
	(-2.21)	(-5.98)
LFG	-12.25	38.79
	(-0.56)	(2.39)
EQUIP	26.07	15.81
	(2.89)	(2.49)
NES	10.26	6.71
	(2.50)	(2.26)
Adjusted R^2	0.23	0.66
Sample size	57	55
Standard error	1.46	0.98

The numbers in parentheses are t-statistics. Regression 7.1 is an attempted replication of De Long and Summers [1992], see for example regression 4, table 1, page 162. But the samples are quite different due to the exclusion of many natural resource abundant countries from their sample as well as Hong Kong and Singapore, and this turns out to make a difference in the results. The other explanatory variables are taken from De Long and Summers without revision. They are LFG, labor force growth; EQUIP, the fraction of investment expenditures on producer's durable equipment; and NES, the fraction of investment expenditures on everything else, primarily structures.

TABLE VIII. ASSOCIATIONS BETWEEN NATURAL RESOURCE ABUNDANCE AND SECTORAL DATA

Dependent Variables:

	Increase in Export share of Manufactures 1970-1989	Growth of Services and Manufactures Output 1970-1990	Ratio of Services to Manufactures Output 1970
	(8.1)	(8.2)	(8.3)
SXP	-0.46	-5.92	6.54
	(-2.42)	(3.45)	(3.91)
SOPEN	0.18	3.14	-
	(3.48)	(4.80)	
SMX70	-0.45	-	-
	(-4.75)		
LGDPEA70		-1.27	-
		(-4.84)	
LINV7089		1.50	-
		(2.78)	
RL		-0.06	-
		(-0.34)	
Adjusted R^2	0.19	0.57	0.16
Sample size	89	52	74
Standard error	0.18	1.41	1.99

The numbers in parentheses are t-statistics. Regression (8.1) shows that natural resource abundant countries had slower growth in their share of manufacturing exports, holding constant the initial share. Regression (8.2) shows the growth equation estimated with a proxy for growth in non-resource economy as the dependent variable (rather than growth in total gdp). The proxy for the non-resource sector includes output of transport, storage and communications, wholesale and retail trade, banking, insurance, real estate, services, public administration and defense, and manufacturing. The two missing sectors are: construction, and electricity, gas and water. The final regresion shows the positive association between resource abundance and output of the service sector relative to manufacturing (in the initial year, 1970). To the extent that the service sector proxies the non-traded sector and manufactures the non-resource traded sector, this provides some corroboration of the predictions of the dutch disease and non-traded models. Data are described in the appendix.

TABLE IX. ESTIMATED GROWTH REGRESSIONS FOR THE DECADES OF THE 1970S AND 1980S SEPARATELY.

	Growth 1970-1979 (GEA7080)	Growth 1980-1989 (GEA8090)
Log GDP in initial year	-1.25	-1.88
	(-4.07)	(-5.00)
SXP	-3.89	-6.15
	(-2.43)	(-3.42)
SOPEN[1]	1.82	2.51
	(3.10)	(4.14)
DTT[1]	0.11	0.02
	(3.23)	(0.17)
LINV[1]	1.51	0.63
	(4.15)	(1.25)
RL	-	0.55
		(3.34)
Adjusted R^2	0.31	0.60
Sample size	101	73
Standard error	2.04	1.52

[*] SOPEN, DTT and LINV are synchronized with the dependent variable, so they are for the 1970s in the first regression and the 1980s in the second regression. RL is measured circa 1980, so it is not included in the regression for the 1970's. SXP is the 1970 value in both regressions. The numbers in parentheses are t-statistics.

TABLE X. ASSOCIATIONS BETWEEN NATURAL RESOURCE ABUNDANCE AND OTHER EXPLANATORY VARIABLES

Dependent Variables:

	National Saving % GDP,70-89 (NS7089) (10.1)	Investment Ratio % GDP, 70-89 (LINV7089) (10.2)	Human Capital Accumulation Change, 70-90 (DTYR7090) (10.3)	Share of Years Open 65-89 (SOPEN) (10.4)	Relative Price of Investment Goods 70-89 (LPIP70) (10.5)
LGDPEA70	6.38 (7.69)	-	0.05 (0.45)	-	-0.16 (-2.71)
SXP	0.19 (0.03)	0.40 (1.19)	-0.95 (-1.05)	-1.89 (-2.51)	0.08 (0.26)
SXP^2	-	-	-	3.24 (3.20)	-
SOPEN	-	0.14 (1.19)	-	-	-0.40 (-3.24)
RL	-	0.06 (2.22)	-	-	-
LPIP70	-	-0.82 (-7.53)	-	-	-
LAND	-	-	-	-0.09 (-3.64)	-
Adjusted R^2	0.36	0.67	-0.01	0.21	0.31
Sample size	104	80	90	104	102
Standard error	7.64	0.31	0.89	0.40	0.43

The numbers in parentheses are t-statistics.

TABLE XI. ASSOCIATIONS BETWEEN QUALITY OF INSTITUTIONS AND NATURAL RESOURCE INTENSITY

Dependent variables:

	Government Repudiation of Contracts (GRC)	Risk of Expropriation (RE)	Corruption (CORR)	Rule of Law (RL)	Bureaucratic Quality (BQ)
	(11.1)	(11.2)	(11.3)	(11.4)	(11.5)
Log Real GDP 1980	0.49	0.44	1.35	1.31	1.35
	(2.35)	(1.66)	(8.49)	(7.80)	(8.58)
SXP	-3.90	-4.60	-3.29	-5.47	-5.86
	(-3.41)	(-3.17)	(-3.17)	(-5.00)	(-5.70)
Adjusted R^2	0.16	0.12	0.48	0.49	0.55
Sample size	65	65	85	85	85
Standard error	1.40	1.78	1.40	1.47	1.38

The numbers in parentheses are t-statistics. These five measures of institutional quality were constructed from Political Risk Services survey data by the Center for Institutional Reform and the Informal Sector. They are measured on the following scale, from low to high: Government Repudiation of Contracts (0-10); Risk of Expropriation (0-10); Corruption (0-6); Rule of Law (0-6); Bureaucratic Quality (0-6). These series are highly correlated across countries.

Figure 1. Growth and Natural Resource Intensity

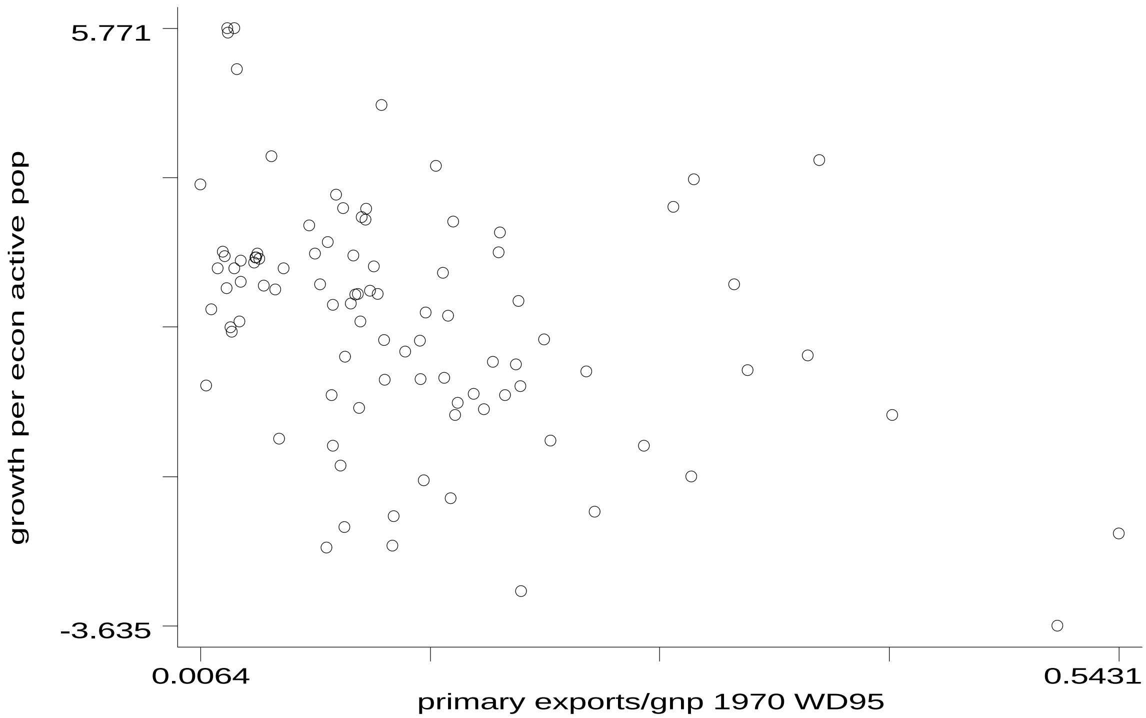
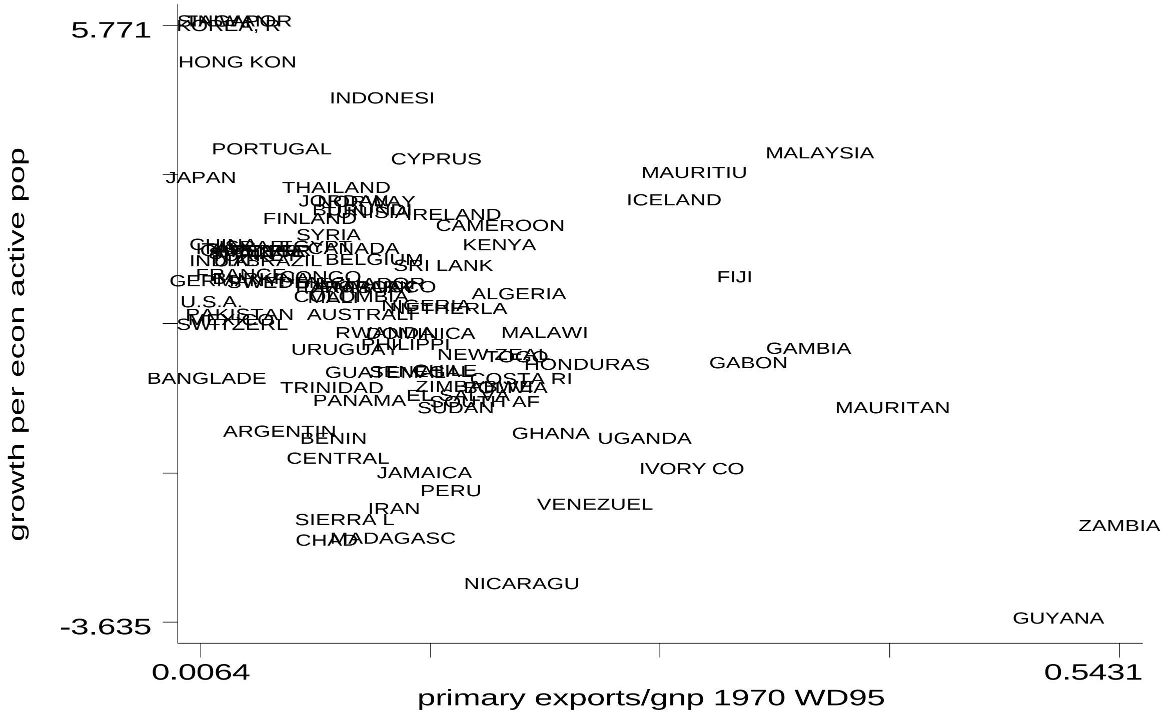


Figure 1. Growth and Natural Resource Intensity



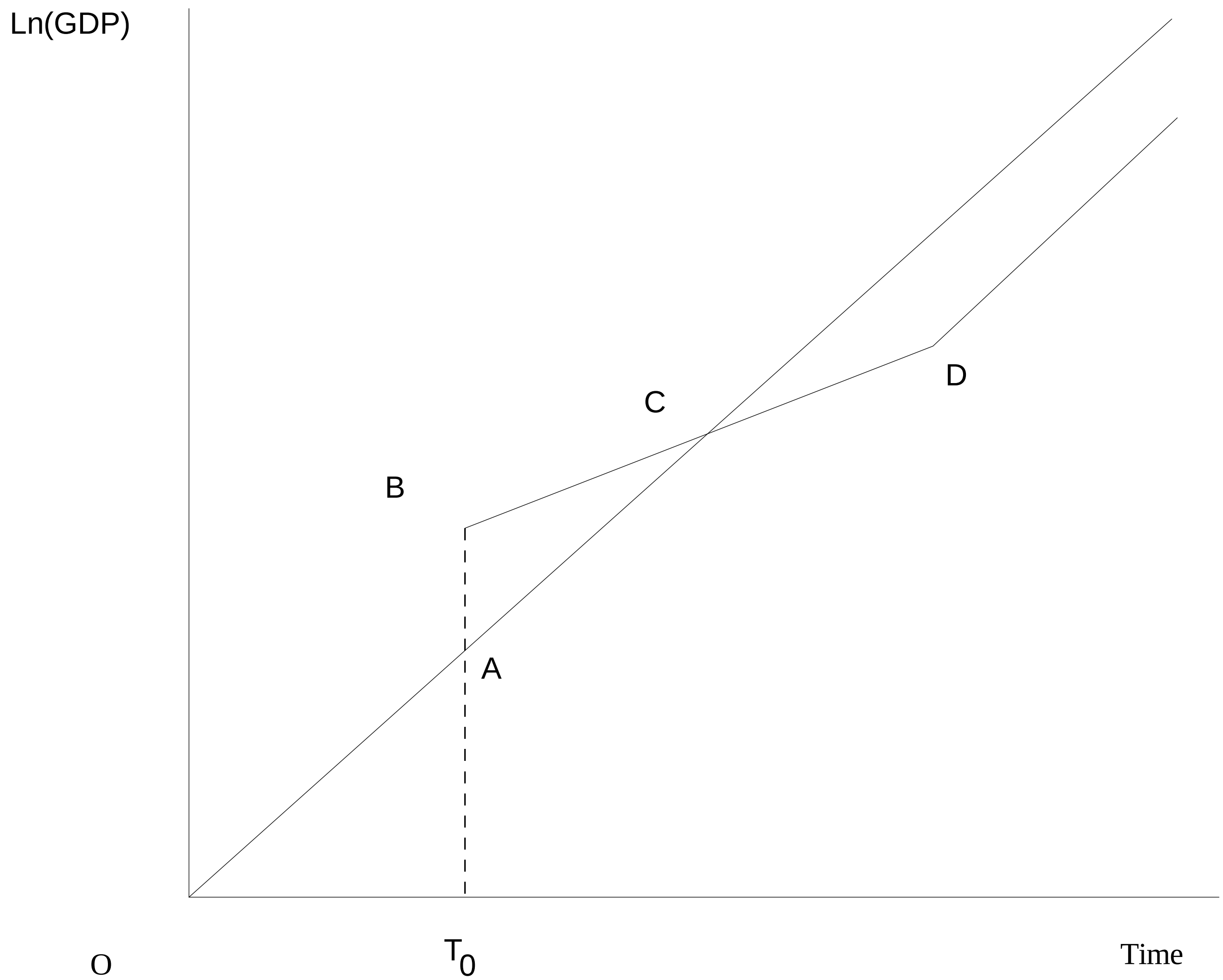


Figure 2