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Does the "Resource Curse" hold for Growth in Genuine Income as Well?

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Summary. — Existing studies analyzing the so-called resource curse hypothesis regress growth in gross domestic product (GDP) on some measure of resource intensity. This is problematic as GDP counts natural and other capital depreciation as income. Deducting depreciation from GDP to arrive at genuine income, we test whether the "curse" still holds true. We find supporting evidence, but the growth disadvantage of resource-intensive economies is slightly weaker in terms of genuine income than GDP. We suggest that this provides additional, but somewhat weak and limited, evidence in support of those who argue that the "curse" is partly due to unsustainable over-consumption.

Key words — global, resource curse hypothesis, natural capital, depreciation, genuine income, genuine savings

1. INTRODUCTION

Being richly endowed with natural resources can threaten a country's long-term prosperity as natural resource-intensive economies grow slower over time than economies that are less natural resource-intensive. Sachs and Warner (1995a) were not the first to note this paradoxical result, [1] but their paper spurred an extensive and still growing literature aimed at explaining what drives this result (e.g., Auty, 2001; Auty & Mikesell, 1998; Isham, Woolcock, Pritchett, & Busby, 2003; Manzano & Rigobon, 2001; Mikesell, 1997; Ross, 1999; Sala-i-Martin & Subramanian, 2003). [2] These studies offer a diverse set of explanations covering, among others, terms-of-trade effect, Dutch Disease, debt overhang, institutional quality and other political economy arguments. Others questioned the robustness of the result with respect to changes in the definition of natural resource-intensity (e.g., Stijns, 2001a) and the econometric estimator used (e.g., Manzano & Rigobon, 2001) or observed that in terms of income levels (rather than growth) natural resource-intensive economies on average fare better rather than worse (e.g., Davis, 1995; Gallup, Sachs, & Mellinger, 1999; Mikesell, 1997).

In this article, we do not seek to explain the so-called resource curse directly. Neither do we seek to test whether the "curse" still holds for competing definitions of resource-intensity or alternative estimation techniques. Instead, this paper's original contribution is in examining whether the "curse," as postulated by Sachs and Warner (1995a/1997), holds true for measures of genuine or true income as well. This is important because GDP is a particularly erroneous measure of income for resource-intensive economies.

Existing studies look at growth in real gross domestic product (GDP). Of course, it is well known that GDP contains an element of depreciation of produced capital that should not be counted as income. It would therefore be more correct to analyze growth in real net domestic product (NDP) where depreciation of produced capital has been subtracted from GDP. This is typically not done for two reasons. First, the depreciation term is estimated based on simplifying (and contestable) assumptions and, more

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importantly, for most countries it makes very little difference whether one looks at GDP or NDP. This holds true whether or not economies are intensive in natural resources.

Things are different, however, when one also starts taking into account depreciation of natural capital. Not only can depreciation terms be of significant size, but depreciation also tends to be higher for economies that are intensive in natural resources than for others that are not. With the accounting method for natural capital depreciation described below the correction to GDP can be as high as 30%. There can therefore be a substantial gap between gross income and what might be called genuine income, that is, GDP minus the depreciation of produced *and* natural capital, and the size of the gap is partly determined by the resource-intensity of economies. There is therefore a problem with the existing studies examining the "resource curse" as they analyze growth in GDP instead of growth in true or genuine income.

This article tests whether the "resource curse" holds true for growth in genuine income as well and, if so, whether the negative effect of natural resource-intensity on growth is overestimated or underestimated by erroneously examining growth in GDP. To our knowledge, no other study has ever done this. Winter-Nelson (1995) computes what he calls environmentally adjusted income for 18 African resource exporters, but he merely demonstrates that a strategy of export expansion has led to growth in GDP, but not growth in environmentally adjusted income. He therefore does not test for the "resource curse" itself. In addition, his sample size is very small. Mikesell (1997, p. 195) suggests that if GDP was adjusted for natural capital depreciation, then the "resource curse" would be even stronger during 1980–93. He does not, however, validate his suggestion with any general empirical test, instead referring to Repetto, Magrath, Wells, Beer, and Rossini's (1989) single country study of Indonesia, in which adjusted income grew slower over 1971–84 than GDP. Indeed, we will show that the exact opposite to Mikesell's suggestion is actually the case as the "resource curse" is slightly weaker in terms of growth of genuine income than growth of GDP. [3] Atkinson and Hamilton (2003) examine whether negative genuine savings rates (gross investment minus depreciation of produced and natural capital divided by GDP) can explain the "resource curse," but they do not examine whether the "curse" holds for growth in genuine income.

2. EXPLAINING THE "RESOURCE CURSE"

How can the blessing of an extra endowment of natural resources turn into a curse? *A priori* this represents a puzzle, even a paradox. Following Auty (2001) one can distinguish "exogenous" from "internal" explanations for the poor growth performance of natural resource-intensive economies. Revenue volatility and a long-term declining trend in the terms of trade of resource exporters represent explanation attempts that can be derived from structuralist economic theory *à la* Prebisch (1950). The Dutch Disease phenomenon is another and one of the most frequently cited exogenous explanations. It refers to the decline in the productivity and competitiveness of the manufacturing and other tradeables sector following the real exchange rate appreciation in the wake of a resource boom. This represents a problem if the manufacturing and other tradeables sector is characterized by economies of scale (Gelb & Associates, 1988; Sachs & Warner, 2001). The exogenous explanations leave little space for policy makers to avoid the problem. In comparison, the internal explanations of the "resource curse" all lay the blame squarely at bad policies. A link between the two is given by the fact that the manufacturing and other tradeables sector becomes damaged not only by Dutch Disease, but also by misguided industrial policies in the form of protectionist barriers for import-substitution, which has been typical for many natural resource-intensive economies. Indeed, some studies show that the main problem of resource booms was to allow resource-intensive economies to sustain economically harmful policies longer than less resource-intensive economies that started out with similarly unproductive policies (e.g., Auty, 1993, 1994). More important, resource abundance might lead to a rentier economy with a predatory state: corruption, political conflict and inequalities are rampant, economic institutions are poorly developed, human capital accumulation, entrepeneurship and innovative activity are crowded out and policy makers are more interested in resource transfers than developing and modernizing the country's economy (Auty, 2001; Gylfason, 2001; Isham *et al.*, 2003; Lal & Myint, 1996). [4]

Two studies have emphasized the problem that natural resource abundance allows countries to engage in excessive consumption that is not sustainable into the future. We will concentrate on these two studies as our empirical analysis provides some, but limited, evidence in their favor. Rodríguez and Sachs (1999) employ a Ramsey growth model and a calibrated dynamic general equilibrium model of the Venezuelan economy to argue that economies rich in natural resources are likely to live beyond their means. Indicative of this is that resource-intensive economies, whilst growing slower than less resource-intensive ones, also tend to have higher absolute income levels—a point demonstrated by Rodríguez and Sachs (1999), but already pointed out by others (e.g., Davis, 1995; Mikesell, 1997). In the transition to the steady state, the resource endowment allows the country to afford extraordinary consumption possibilities derived from unsustainably high income levels. In other words, "a resource rich economy will adjust to its steady state from above, not from below" (Rodríguez & Sachs, 1999, p. 4). During the transition it might display negative growth rates in GDP on average. With exogenous productivity growth it might escape negative growth rates, but in any case growth rates will be lower than if the country did not live on unsustainable income levels beyond its means. Theoretically, the problem could be circumvented if the resource-intensive economy invests its resource rents in international assets paying permanent annuities. But, if there are restrictions on investment abroad or a preference for investing domestically, then these economies will experience consumption booms that are unsustainable in the long run. Of course, on a very fundamental level it is not clear that such consumption booms are completely irrational and undesirable. Even a rational inter-temporal social welfare maximizer might want to use some of the windfall gains from resource booms to raise initial consumption levels. This is because the marginal utility of consumption in these economies is likely to be very high and if exogenous productivity growth can be expected then the windfalls can also be used to smooth the inter-temporal consumption path.

Atkinson and Hamilton (2003) provide an argument similar to Rodríguez and Sachs (1999) together with corroborating evidence from cross-sectional growth in GDP regressions. They argue that resource-intensive countries, defined as countries with a high share of natural capital depreciation relative to GDP, are likely to have excessive consumption fuelled by the windfalls of natural resource extraction. Their regressions show that the interaction of large resource rents with government consumption is associated with lower growth. Atkinson and Hamilton (2003) also find that natural resource-intensity in economies with negative genuine savings rates is associated with a growth rate that is statistically significantly below zero. Natural resource-intensity in economies with a positive genuine savings rate is also estimated to have a negative coefficient, but it is not statistically significant. [5] Furthermore, while Sachs and Warner (1995a/1997) did not find evidence that resource-intensity is associated with lower gross savings and investment rates, Atkinson and Hamilton (2003) on the whole find a negative correlation between natural resource-intensity and genuine savings rates. Gylfason and Zoega (2002) find a similar link between investment and savings rates on one hand and resource abundance on the other hand, where resource abundance is defined as the share of natural capital in total national wealth.

Let us turn to a discussion on how one should account for natural capital depreciation and the implications of such accounting for the "resource curse."

3. ACCOUNTING FOR NATURAL CAPITAL DEPRECIATION

Resource economists have studied the importance of as well as methods for accounting for natural capital depreciation at least since Hartwick's (1977) influential paper. There he showed that under certain circumstances economies, which extract a nonrenewable resource, can only maintain their consumption levels over time if they invest the full resource rents into produced capital. Throughout the 1980s and the 1990s accounting for natural capital depreciation has figured prominently in natural resource economics as part of the sustainable development research agenda (El Serafy, 1981, 1989; Repetto *et al.*, 1989; Serôa da Motta & Young, 1995).

That the GDP of natural resource-intensive economies does not reflect their genuine income levels has not escaped the early attention of affected countries either. For example, Shihata (1982, p. 202), then Director-General of the Organisation of Petroleum Exporting

Countries (OPEC) Development Fund, notes that the income of the Arab oil-exporting economies "is in reality a cash exchange for a depletable natural resource." OPEC itself commissioned a study in 1984, which opens with a sentence of admirable clarity: "The GDP of oil-exporting states is exaggerated because some of their 'income' is due to the consumption of depletable oil resources and hence is liquidation of capital, not income" (Stauffer & Lennox, 1984, p. 6).

Unfortunately, how best to account for natural capital depreciation is heavily debated and no consensus has emerged in the relevant literature (El Serafy, 1981, 1989; Hartwick & Hageman, 1993; Santopietro, 1998; Vincent, 1997). It does have a very simple answer, however, as long as one assumes that economies are competitive and intertemporally efficient (Hamilton, 1996; Hartwick & Hageman, 1993; Neumayer, 2003). In this framework natural capital depreciation is equal to total Hotelling (1931) rent:

$$(P - \text{MC}) \cdot R, \tag{1}$$

where P is the resource price, MC is marginal cost and R is resource extraction. In the case of a renewable resource, R would be resource harvesting beyond natural regeneration. One of the major difficulties of applying this theoretically correct method in reality is that data on marginal cost are frequently unavailable. Average cost data are more available. Most studies applying this method have therefore replaced marginal cost with the more readily available average costs and calculated depreciation according to the following formula

$$(P - \text{AC}) \cdot R. \tag{2}$$

A popular alternative has been what is known as the El Serafy (1981, 1989) method:

$$(P - \text{AC}) \cdot R \cdot \left[\frac{1}{(1+r)^{n+1}}\right], \tag{3}$$

where r is the discount rate and n is the number of remaining years of the resource stock. For simplicity, n is often set equal to the static reserves to production ratio, which is the number of years the reserve stock would last if production was the same in the future as in the base year. If $r > 0$ and $n > 0$, then Eqn. (3) will produce a smaller depreciation term for resource extraction than Eqn. (2).

Eqn. (3) is also called the "user cost" of resource extraction since it indicates the share of resource receipts that should be considered as capital depreciation. The formula for the El Serafy method is derived from the following reasoning: receipts from nonrenewable resource extraction should not fully count as what El Serafy calls "sustainable income" because resource extraction leads to a lowering of the resource stock and thus brings with it an element of depreciation of the resource capital stock. [6] While the receipts from the resource stock will end at some finite time, "sustainable income" by definition must last forever. Hence, "sustainable income" is defined as that part of resource receipts which if received infinitely would have a present value just equal to the present value of the finite stream of resource receipts over the life-time of the resource. Natural capital depreciation is then the difference between resource rents and "sustainable income." Appendix A shows why this reasoning leads to Eqn. (3).

Hartwick and Hageman (1993) show that the El Serafy method can be understood as an approximation to Eqn. (1), which to repeat represents the theoretically correct depreciation in a framework of a competitive intertemporally efficient economy. Its main advantage over the World Bank method in Eqn. (2) is that the El Serafy method can use average cost without apology as it does not depend on marginal cost. The World Bank method, on the other hand, needs to replace marginal cost with average cost as marginal cost is not readily available. Due to the replacement of marginal with average cost it can also merely represent an approximation to the theoretically correct method. Which of the two methods creates the greater bias is therefore not clear in general. Under certain assumptions about the resource extraction cost function, the two methods can be shown to be two polar cases of the true depreciation value and the bias depends on the elasticity of the marginal cost curve with respect to the quantity extracted (Serôa da Motta & Ferraz do Amaral, 2000; Vincent, 1997).

In this study, we will use the method given by Eqn. (2). The main reason is that reliable reserve data of natural resources are difficult to obtain. [7] In addition, as long as known reserves last for less than or little more than 20 years or so, which typically holds true for many resource-intensive economies, and the discount rate is significantly below 5%, then the differ-

Table 1. *The difference between net price method and El Serafy method*

n/r	1%	2%	3%	4%	5%	10%
5	5.80	11.20	16.25	20.97	25.38	43.55
10	10.37	19.57	27.76	35.04	41.53	64.95
15	14.72	27.16	37.68	46.61	54.19	78.24
20	18.86	34.02	46.25	56.12	64.11	86.49
30	26.54	45.88	60.00	70.35	77.96	94.79
50	39.80	63.58	77.85	86.47	91.69	99.23
100	63.39	86.47	94.95	98.10	99.28	99.99

Note: Table shows difference between net price method (Eqn. (2)) and El Serafy method (Eqn. (3)) for a value of $100 according to Eqn. (2). n is the number of remaining years of the resource stock and r is the discount rate.

ence between Eqn. (2) and Eqn. (3) is not that large (Atkinson & Hamilton, 2003). To show this, Table 1 plots for various values of n and r the difference between Eqn. (2) and Eqn. (3) for a natural capital depreciation value of $100 according to Eqn. (2). A low discount rate can be justified on the grounds that it is highly uncertain whether the alternative investments that are supposed to provide an infinite stream of income can be expected to generate a high rate of return. An additional justification for using Eqn. (2) is that unexpected developments such as breakthroughs in the price of substitute backstop technologies can hugely decrease the value of large reserve stocks and the longer the stock lasts in the future the more uncertainty there is.

4. ACCOUNTING FOR NATURAL CAPITAL DEPRECIATION AND THE "RESOURCE CURSE"

With Eqn. (2) as the formula for computing natural capital depreciation, how is the growth performance in genuine income levels likely to differ from the growth performance in GDP? *Ceteris paribus*, the "resource curse" is stronger (weaker) in terms of growth of genuine income than growth in GDP if the start period depreciation term relative to GDP is smaller (bigger) than the end period depreciation term relative to GDP. This, of course, depends on the depreciation term in the start period compared to the end period of analysis, but it also depends on their sizes relative to the respective GDP levels from the two periods. Recall that the depreciation term is $(P - \mathrm{AC}) \cdot R$. Average extraction levels tend to have risen during 1970–98. For extraction costs, the trend is very much re-

Table 2. *Change in average resource prices over the period 1970–98 (Index 1970 = 100)*

	1970	1980	1990	1998
Bauxite	100	134.55	95.40	55.86
Copper	100	82.79	66.22	34.77
Gold	100	859.97	355.09	228.61
Hard coal	100	222.59	147.10	104.59
Iron ore	100	104.86	76.86	62.82
Lead	100	136.58	95.60	80.41
Lignite	100	222.72	147.18	104.13
Natural gas	100	211.08	120.04	76.65
Nickel	100	118.27	104.60	46.06
Oil	100	885.74	367.19	173.84
Phosphate rock	100	197.24	122.53	106.64
Silver	100	586.43	90.61	87.27
Tin	100	231.16	56.60	42.07
Zinc	100	123.34	162.27	92.55

Source: World Bank (2003), converted into 1985 prices with the help of the US GDP deflator, taken from World Bank (2001).

source- and country-specific. Prices of resources have also not trended uniformly over this period as Table 2 shows. [8]

Some prices like that of oil, the most important component of natural capital depreciation in value terms, and gold have gone up, whereas the price of many others have fallen. This already implies that *a priori* it is not clear whether accounting for natural capital depreciation weakens or strengthens the "resource curse." But, because what matters is the size of $(P - \text{AC}) \cdot R$ relative to GDP levels, the impact of accounting for natural capital depreciation on the "resource curse" gets even more complex. One therefore needs to employ theory to arrive at a more informed prior expectation about the strength of the "resource curse" in terms of growth of genuine income compared to GDP growth. It is here that Rodríguez and Sachs's (1999) and Atkinson and Hamilton's (2003) arguments are informative. If it is true that resource-intensive economies have excessive consumption spurred by unsustainably high GDP levels, then the growth performance in genuine income levels should be better than the growth performance in GDP, which is boosted by unsustainable resource extraction. This is because genuine income levels are corrected for depreciation of natural capital. They take out the unsustainable parts of GDP. It follows that one can expect the "resource curse," if it exists at all, to be weaker in terms of growth of genuine income than growth of GDP. It is this hypothesis we are going to test now.

5. RESEARCH DESIGN

To demonstrate clearly the effect of natural resource-intensity on growth in genuine income rather than growth in GDP we use Sachs and Warner (1995a/1997) original data set with amendments. We briefly describe the variables used here, but Appendix B also provides detailed and more precise variable definitions and states the sources of data. Maloney (2001, p. 1) criticizes Sachs and Warner (1995a/1997) results on the ground that "growth processes take place across the very long run and probably cannot be convincingly summarized by cross-section regressions of one highly turbulent 20 year period at the end of the 20th century." Unfortunately, no data on natural capital depreciation exist before 1970 so that we cannot extend the period of analysis backwards. But, since we have now access to more updated data, we no longer restrict the analysis to 1970–90, but extend it to 1998 making use of the latest update of the Penn World Tables (Heston, Summers, & Aten, 2002).

Like Sachs & Warner (1995a/1997) we start with regressing the average annual growth rate in GDP over 1970–98 (*GROWTH7098*) on the log of initial GDP per capita (*LGDP70*) and the variable of natural resource intensity. For our measure of natural resource-intensity we follow Sachs and Warner and use their measure of the share of exports of primary products in GNP in 1970 (*RESOURCE70*). [9] Primary products consist of agricultural products, minerals and energy resources. Following the structure of Sachs and Warner (1995a/1997) basic regressions, we then add their measure of trade openness (*OPEN7090*). Unfortunately, this variable could not be updated to 1998. In consequent regressions follow the log of the average gross investment to GDP ratio (*LINV7098*), a measure capturing the average extent of the rule of law (*RULELAW8295*) and the average annual growth in the log of the external terms of trade during 1970–98 (*TTGROWTH7098*). The rule of law variable is not publicly available, but has been provided for the better part of the period of this study free of charge courtesy of Political Risk Services. Note that this variable does not exist before 1982 so that the extent of the rule of law is averaged over 1982–95. We then repeat the set of regressions with growth in genuine income as the dependent variable (*GENGROWTH7098*) and replace *LGDP70* with the log of the initial genuine income level (*LGENINC70*). [10]

Like Sachs and Warner (1995a/1997) we exclude outliers from the sample applying Belsley, Kuh, and Welsch's (1980) criterion. An outlier is an observation with a DFITS that is greater in absolute terms than twice the square root of (k/n), where k is the number of independent variables and n the number of observations, and where DFITS is defined as the square root of $(h_i/(1 - h_i))$, where h_i is an observation's leverage, multiplied by its studentized residual. Applying this criterion excludes Botswana, Gabon, Malaysia, Rwanda and Zambia from the sample. But, as in Sachs and Warner (1995a/1997) the main results uphold if these countries are not excluded.

We take the values of produced and natural capital depreciation from the World Bank's data set on genuine savings, also called adjusted

Table 3. *Estimation results (absolute t-values in parentheses)*

	(1a)	(2a)	(3a)	(4a)	(5a)	(1b)	(2b)	(3b)	(4b)	(5b)
Dependent variable	*GROWTH-7098*	*GROWTH-7098*	*GROWTH-7098*	*GROWTH-7098*	*GROWTH-7098*	*GEN-GROWTH-7098*	*GEN-GROWTH-7098*	*GEN-GROWTH-7098*	*GEN-GROWTH-7098*	*GEN-GROWTH-7098*
LGDP70	0.078	−0.542	−0.813	−0.855	−0.843					
	(0.46)	(2.94)**	(3.92)**	(3.75)**	(3.66)**					
LGENINC70						−0.001	−0.614	−0.879	−0.912	−0.896
						(0.01)	(3.26)**	(4.14)**	(3.92)**	(3.83)**
RESOURCE70	−5.576	−4.107	−3.502	−5.262	−5.383	−5.048	−3.630	−3.061	−5.060	−5.206
	(3.15)**	(2.67)**	(2.33)*	(3.10)**	(3.14)**	(2.84)**	(2.34)*	(2.01)*	(2.96)**	(3.02)**
OPEN7090		2.206	1.979	1.596	1.594		2.159	1.931	1.551	1.549
		(5.62)**	(5.07)**	(3.28)**	(3.27)**		(5.49)**	(4.91)**	(3.17)**	(3.16)**
LINV7098			0.773	0.726	0.755			0.750	0.706	0.741
			(2.55)*	(2.31)*	(2.37)*			(2.46)*	(2.24)*	(2.31)*
RULE8295				0.063	0.051				0.052	0.037
				(0.46)	(0.37)				(0.38)	(0.27)
TTGROWTH7098					−0.051					−0.061
					(0.62)					(0.74)
Constant	1.457	5.624	5.904	6.511	6.371	2.022	6.115	6.394	6.972	6.801
	(0.97)	(3.78)**	(4.09)**	(4.18)**	(4.03)**	(1.32)	(4.04)**	(4.34)**	(4.40)**	(4.23)**
Observations	86	86	86	79	79	86	86	86	79	79
R^2	0.12	0.37	0.41	0.42	0.43	0.09	0.34	0.38	0.40	0.41

* Significant at 0.05 level.
** Significant at 0.01 level.

net savings, published on the Bank's website and available as part of the annual World Development Indicators on CD-Rom.[11] Clearly, depreciation of both produced and natural capital should be taken into account, but nonreported sensitivity analysis showed that natural capital depreciation is the main driver of the results reported below.

The World Bank takes data on the depreciation of produced capital from estimates undertaken by the United Nations Statistics Division. With respect to natural capital depreciation, the World Bank data set includes three categories of natural resources, namely energy, minerals and forestry. Energy consists of oil, gas and coal, whereas minerals encompass bauxite, copper, iron ore, lead, nickel, phosphate rock, tin, zinc, gold and silver. Forestry refers to the production of fuelwood, coniferous softwood, nonconiferous softwood and tropical hardwood.[12] For minerals, (P – AC), or unit rent, is computed as the world price of the resource minus mining, milling, benefication, smelting and transportation to port costs minus a "normal" return to capital. For oil, gas and coal, unit rent is the world price minus lifting costs. For some resources, such as natural gas, where, strictly speaking, there is no single world price, a shadow world price is computed as the average free-on-board price from several points of export. For forestry, unit rent is calculated as the world price for each category of wood minus average unit production costs. This is multiplied by the amount of wood production exceeding the natural increment.

Inevitably, there are some problems with the data. For example, the use of uniform world prices overstates somewhat natural capital depreciation for countries with lower-grade resource deposits. The use of average rather than marginal costs also tends to overestimate depreciation. Both prices and extraction costs often need to be estimated. Extraction costs are sometimes only available for a region rather than countries and only for a number of years, which means that missing values need to be interpolated. Furthermore, for lack of data the World Bank's computations of natural capital depreciation do not cover such items as depletion of fish stocks and water resources and the erosion of topsoil. This together with natural capital depletion being computed by the net price instead of the user cost method (see section 3 above) implies that the natural capital depreciation of mineral and fossil fuel extracting economies is somewhat biased upward relative to that of other economies.[13] These caveats notwithstanding, the data set represents the most ambitious and comprehensive attempt yet at estimating the value of natural capital depreciation.

6. RESULTS

Columns 1a–5a of Table 3 repeat the basic crosscountry growth regressions of columns 1–5 of Table 1 in Sachs and Warner (1995a/1997), the only difference being that we examine growth over 1970–98 rather than 1990. Column 1 includes only the log of initial GDP and the primary exports variable. In the consequent four columns, Sachs and Warner's measure of trade openness, the logged investment rate, the index of the extent of the rule of law and the average annual growth in the log of the external terms of trade are added. Extending the period to 1998 does not change the fundamental result of Sachs and Warner's (1995a/1997) analysis for 1970–90 only: natural resource-intensive economies grow slower. The estimated coefficients for the variable of natural resource-intensity are somewhat smaller, ranging between 3.50 and 5.57 rather than 6.96 and 10.57. This suggests that natural resource economies did relatively better in the 1990s compared to the two decades before. The "resource curse," however, still holds true and the estimated coefficients are still of substantial size as we will see below. A 10-percentage points increase in *RESOURCE70* lowers the growth rate of GDP by about .35% to .56% points. Similar to Sachs and Warner (1995a/1997) there is a positive link between growth on the one hand and trade openness and the investment share on the other hand. The terms-of-trade variable is insignificant. Contrary to Sachs and Warner (1995a/1997) I do not find the rule of law variable to be significant in columns (4a) and (5a). But, I use period-averaged data whereas Sachs and Warner use the 1982 value only, which is not representative over a period of almost 30 years. Columns 1b–5b repeat the analysis for the growth performance in genuine income levels. Results are generally rather similar. In particular, the "resource curse" clearly exists in terms of growth of genuine income as well.

What is discernible from the results reported in Table 3 is that the coefficients of *RESOURCE70* are always smaller in the regressions with *GENGROWTH7098* than with

Table 4. *Tests of equality for coefficients of the natural resource-intensity variable*

	Regression				
	(1)	(2)	(3)	(4)	(5)
Nonstandardized coefficients					
Dependent variable: *GROWTH7098*	−5.576	−4.107	−3.502	−5.262	−5.383
Dependent variable: *GENGROWTH7098*	−5.048	−3.630	−3.061	−5.060	−5.206
χ^2 test equality of coefficients	3.62	3.18	3.15	2.58	2.01
(*p*-value)	(.0571)	(.0743)	(.0758)	(.1085)	(.1562)
Standardized beta coefficients					
Dependent variable: *GROWTH7098*	−.335	−.247	−.210	−.299	−.306
Dependent variable: *GENGROWTH7098*	−.307	−.221	−.186	−.291	−.299
χ^2 test equality of coefficients	2.59	3.41	3.81	1.68	1.18
(*p*-value)	(.1078)	(.0650)	(.0509)	(.1947)	(.2766)

GROWTH7098 as the dependent variable. In other words, the "resource curse" is not as strong in genuine income as in GDP. The difference in the estimated coefficients is, however, rather small. Table 4 reports results testing whether the differences in the coefficients are statistically significant. For the first three regressions we can reject the hypothesis of equality of coefficients at the 10% significance level (but not at the 5% level). In regression 4 we marginally fail to reject and in regression 5 we fail to reject more clearly the hypothesis at the 10% level. Furthermore, one might want to take into account that the distributions of the two dependent variables are not the same. Table 4 therefore also reports beta coefficients, which show by how many standard deviations the dependent variable changes for a one standard deviation increase in the explanatory variable. A one standard deviation increase in *RESOURCE70* is equivalent to an increase in the share of exports of primary products

Table 5. *GDP versus genuine income growth performance of top and bottom 10 resource-intensive countries*

Country	(1) *RESOURCE70*	(2) *GENGROWTH7098*	(3) *GROWTH7098*	Difference (2) − (3)
Guyana	0.51	0.183	0.185	−0.001
Mauritania	0.41	1.228	0.449	0.779
Gambia	0.36	0.370	0.387	−0.017
Mauritius	0.29	4.042	4.024	0.018
Côte d Ivoire	0.29	−0.376	−0.290	−0.087
Uganda	0.27	0.284	0.275	0.009
Venezuela	0.24	−2.185	−2.057	−0.128
Honduras	0.23	0.768	0.746	0.022
Malawi	0.21	0.974	0.978	−0.004
Ghana	0.21	−0.564	−0.566	0.002
Average		0.472	0.413	0.059
Korea (Rep.)	0.02	5.332	5.410	−0.079
China	0.02	3.845	3.792	0.053
India	0.02	2.448	2.410	0.038
Italy	0.02	2.215	2.393	−0.178
Mexico	0.02	0.495	0.599	−0.104
Germany	0.02	1.640	1.650	−0.009
Switzerland	0.02	0.753	1.213	−0.461
Japan	0.01	2.707	3.172	−0.464
United States	0.01	1.895	1.910	−0.015
Bangladesh	0.01	−0.641	−0.650	0.008
Average		2.069	2.190	−0.121

in GNP in 1970 of about 9 percentage points. This increase lowers the growth rate of GDP by between .21 and .34 standard deviations, whereas it lowers the growth rate of genuine income by between .19 and .31 standard deviations. This means that even in terms of genuine income growth the "resource curse" still pertains and remains substantively important. When we test whether the differences in standardized beta coefficients are statistically significant, we find similar results to the tests for the nonstandardized coefficients. In addition, we marginally fail to reject the hypothesis of equality of coefficients at the 10% level also in regression 1 now.

Let us illustrate the result that the "resource curse" is not quite as strong in genuine income as in GDP by showing the growth performance in GDP versus growth in genuine income for the top and bottom 10 resource-intensive countries in our sample as measured by *RESOURCE70* (Table 5). The very resource-intensive countries on average have much lower GDP growth over 1970–98 than the low resource-intensive countries. On average, however, their growth in genuine income is .06 percentage points higher than their GDP growth, whereas the growth in genuine income of the 10 countries with the lowest resource-intensity is .12 percentage points lower than their GDP growth. [14] This illustrates nicely that the "resource curse" is weaker in genuine income, but a substantial gap in growth performance between the two groups of countries pertains in genuine income as well.

7. CONCLUSION

Our results can be summarized in two main propositions. First, natural resource-intensive countries really do suffer from a "resource curse." Existing studies have failed to take into account natural capital depreciation and have analyzed growth of the wrong term, namely GDP, instead of genuine income. In fact, looking at genuine income instead reinforces the robustness of the evidence in favor of the "resource curse." Resource-intensive economies grow slower than their less resource-intensive peers in terms of genuine income as well. Second, however, contrary to Mikesell's (1997) suggestion, the "resource curse" is weaker in terms of growth of genuine income than growth of GDP. Yet, the difference is small and in some estimations we cannot be sure that it is statistically significantly different from zero. This therefore provides additional, but somewhat weak and limited, evidence in support of those like Rodríguez and Sachs (1999) and Atkinson and Hamilton (2003) who try to explain the poor performance of natural resource-intensive economies with reference to unsustainable overconsumption. For natural resource-intensive economies, GDP levels erroneously signal a level of income that is beyond the sustainable level. It induces policy makers to engage in excessive consumption and the country as a whole to living beyond its means. Genuine income corrects GDP for what is truly capital depreciation rather than income. Once this correction is done, we find that the "resource curse" still holds, but it is weaker—as it should be if unsustainable overconsumption is part of the explanation of the "curse."

From the fact that the "resource curse" still upholds if the growth performance is measured in terms of genuine income levels and that the difference in estimated coefficients is small and sometimes not statistically significantly different from zero follows that explanations other than unsustainable overconsumption are required to account for the bulk of the poor growth performance of natural resource-intensive economies. Explaining the "resource curse" therefore remains an important task for future research by natural resource and development scholars.

What are the policy implications of our findings? Surely, leaving resources in the ground is no solution. Rather, the challenge is to ensure that the revenues from natural resource extraction are put to more productive use and the genuine savings rate is raised. But how to achieve this? Discussing these issues thoroughly is beyond the scope of the present article, so we will merely sketch some possibilities here without discussing their merits and feasibility in any detail. Prudent fiscal policy, perhaps coupled with a natural resource fund, can help to stabilize and sterilize some of the revenues. Multilateral donors such as the World Bank can require lenders to use some of the revenues for public sector investment in health and education for the people rather than military and other wasteful expenditures. This has been one of the major conclusions of the Bank's Extractive Industries Review (EIR), which was prompted by criticism from civil society of the Bank's role in financing natural resource projects (http://www.eireview.org). [15] Some of the government-owned funds could

be redistributed to citizens if governments cannot be trusted to use the funds wisely. Careful exchange rate management can mitigate the negative effects of resource booms on other sectors. Together these measures could help stimulating investment in and diversification of the private sector. These measures are, of course, difficult to achieve in countries plagued by poor governance and bad institutional quality, which is typically the case in countries affected by the "resource curse." It is for this reason that in my view the political economy approach that attempts to explain the poor growth performance with the negative impact of natural resource wealth on the state of governance and institutional quality represents the most promising path. On this aspect, Dietz, Neumayer, and De Soysa (2004) show that improving the quality of governance, particularly with respect to corruption, reduces the negative impact of natural resource abundance on genuine savings. While not directly addressing the resource curse, these findings point toward the importance of interaction effects between resource abundance and measures of institutional quality.

In terms of future research, it would be worth while exploring using other model specifications with growth in genuine income as the dependent variable. For example, Stijns (2001a) and others have criticized Sachs & Warner's (1995a/1997) measure of natural resource-intensity. Indeed, in using this measure there is a certain circularity in argument since countries which successfully grow will reach a higher level of income and therefore have a smaller natural-resource exports to income ratio. Another problem is that, depending on the country, the share of agriculture relative to minerals and fossil fuels can be high in Sachs and Warner's (1995a/1997) measure, whereas the "resource curse" refers almost exclusively to mineral and fossil fuel extraction. It would be worthwhile exploring alternative indicators of resource-intensity, for example, a mineral and fossil fuel rent indicator derived from the World Bank (2003) source used here to compute genuine income. It would also be worth while checking if the "resource curse" in genuine income holds for alternative estimation techniques. Tackling these issues is beyond the present paper's scope, however.

NOTES

1. See, for example, Gelb and Associates (1988) and Auty (1993).

2. See Stevens (2003) for a survey.

3. Also note that Roemer (1994) and others argue that Indonesia actually managed its oil boom quite well via competent exchange rate management and a shift from inward-looking to outward-looking policies.

4. Note, however, that Stijns (2001b) shows that if resource abundance is measured as natural resource rents per capita, then economies with resource abundance do not have lower education expenditures per capita.

5. Unfortunately, they do not report whether the negative growth effect of a low genuine savings rate is stronger or weaker in resource intensive relative to resource poor countries.

6. The same reasoning applies to renewable resources if harvesting exceeds natural regeneration.

7. Neumayer (2000) is one of the very few studies applying the El Serafy method for a range of countries.

8. Cuddington (1992) similarly finds nonuniformity in trends of 26 primary commodity prices over the much longer period 1900–83.

9. A reviewer wondered whether this variable and the *LINV7098* variable described further below should be altered in the estimations with growth in genuine income as the dependent variable such that in their denominator GNP or GDP is replaced with genuine income. This is not, however, done here since the numerator of these variables is not adjusted either. For example, the value of primary commodity exports is not adjusted for natural capital depreciation and no sufficient data exist that would allow such adjustment.

10. Such regressions are based on a neoclassical growth model. A reviewer raised the question whether such regressions apply to genuine income at all, given that the neoclassical growth model based on Solow (1956) assumes that a fixed share of national income, not of genuine income, is saved and invested. To start with, there is nothing in the Solow model that prevents it from being broadened to other forms of capital than produced capital. Pender (1998), for example, includes natural

capital in such a model. Furthermore, the steady-state level in the Solow growth model is at the intersection of investment and depreciation. Taking natural capital depreciation into account could therefore be understood as raising depreciation, which would lower the steady-state level of capital.

11. The data can be downloaded from World Bank (2003).

12. For details, see Bolt, Matete, and Clemens (2002).

13. It is not clear whether this bias considerably affects our estimations and if so how. It would represent much greater concern if we were to analyze differences in genuine income *levels* rather than differences in genuine income *growth*. In any case, given the lack of data on other items of natural capital, there is nothing that could be done about it at this stage.

14. Note that this difference is not simply due to most countries in the upper panel being developing countries and most countries in the lower panel being developed ones. Australia and Canada, two classic examples of developed countries with a substantial primary commodity sector (*RESOURCE70* is .1 for both countries), also have slightly higher genuine income than GDP growth (Australia: 1.69 versus 1.66; Canada: 1.92 versus 1.79).

15. World Bank lending to Chad for the development of an oil pipeline is an example where the Bank has at least tried to pressure the lending government into using parts of the funds in a noncorrupt, transparent way that is beneficial to health care and rural development.

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APPENDIX A. DERIVATION OF USER COSTS ACCORDING TO THE EL SERAFY METHOD

The formula for computing user costs according to the El Serafy method can be derived as follows: let P be the resource price, AC average extraction cost, R the amount of resource extracted, r the discount rate and n the number of remaining years of the resource stock if extraction was the same in the future as in the base year, i.e., n is the static reserves to extraction ratio. Then the present value of total resource rents $\mathrm{RR} \equiv (P - \mathrm{AC}) \cdot R$ is equal to:

$$\sum_{i=0}^{n} \frac{\mathrm{RR}}{(1+r)^{i}} = \frac{\mathrm{RR}\left[1 - \frac{1}{(1+r)^{n+1}}\right]}{1 - \frac{1}{1+r}}. \qquad \text{(A.1)}$$

The present value of an infinite stream of "sustainable income" SI is

$$\sum_{i=0}^{\infty} \frac{\text{SI}}{(1+r)^i} = \frac{\text{SI}(1+r)}{r} = \frac{\text{SI}}{1 - \frac{1}{1+r}}. \qquad \text{(A.2)}$$

Setting (A.1) and (A.2) equal and rearranging expresses SI as a fraction of RR:

$$\text{SI} = \text{RR}\left[1 - \frac{1}{(1+r)^{n+1}}\right].$$

The user costs, representing the depreciation of the resource stock, would thus be

$$(\text{RR} - \text{SI}) = \text{RR}\left[\frac{1}{(1+r)^{n+1}}\right]$$

$$= (P - \text{AC}) \cdot R\left[\frac{1}{(1+r)^{n+1}}\right].$$

APPENDIX B. VARIABLE DEFINITION AND SOURCES OF DATA

—*LGDP70*: Natural log of real purchasing power parity adjusted GDP in 1970 divided by the economically-active population in 1970. Economically-active population is defined as population aged 15–64. GDP is converted into 1985 prices with the help of the US GDP deflator (Sachs & Warner's, 1995a/1997, original analysis is in 1985 prices). Source: Heston *et al.* (2002) for GDP (*rgdpch* series), World Bank (2001) for population data and the US GDP deflator.

—*LGENINC70*: Natural log of real purchasing power parity adjusted genuine income in 1970 divided by the economically-active population in 1970. Economically-active population is defined as population aged 15–64. Genuine income is defined as GDP minus depreciation of produced and natural capital stocks. Data for depreciation of produced capital are originally derived from United Nations Statistics Division. Depreciation of natural capital covers oil, gas, coal, bauxite, copper, iron ore, lead, nickel, phosphate rock, tin, zinc, gold and silver and is computed according to net price method (see text for details). Both GDP and depreciation data converted into 1985 prices with the help of the US GDP deflator. Source: Heston *et al.* (2002) for GDP (*rgdpch* series), World Bank (2001) for population data and the US GDP deflator and World Bank (2003) for depreciation data.

—*GROWTH7098*: Real per capita GDP growth rate per annum computed as 100 ∗ (1/28) ∗ (*LGDP98*–*LGDP70*), where *LGDP98* is defined as *LGDP70*, but for 1998. Source: Heston *et al.* (2002).

—*GENGROWTH7098*: Real per capita genuine income growth rate per annum computed as 100 ∗ (1/28) ∗ (*LGENINC98*–*LGENINC70*), where *LGENINC98* is defined as *LGENINC70*, but for 1998. Source: Heston *et al.* (2002) and World Bank (2003).

—*RESOURCE70*: Share of exports of primary products in GNP in 1970. Primary products cover agricultural, mineral and fuel products. Source: Sachs and Warner (1995a/1997) who derive their data from World Bank: World Data 1995 CD-Rom. Sachs and Warner make a number of amendments to this variable, see Sachs and Warner (1995a/1997, p. 29) for details.

—*OPEN7090*: Fraction of years a country is rated as an open economy during 1970–90. Source: Sachs and Warner (1995b).