Replicating Sachs and Warner: The 1997 Working Paper

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Abstract

This paper is the first of a series reporting on my attempt to replicate the seven Sachs and Warner resource curse papers. Here I report on their 1997 working paper, the first for which there is a publicly available data set. Exact pure replication is achieved, save for three inconsequential errors in reported t-statistics. Statistical replication shows that some of the Sachs and Warner results attempting to determine the cause of the resource curse are not robust to the country sample. Scientific replication shows that findings of the resource curse are not sensitive to different models of resource intensiveness, though they are subject to omitted variable bias. The difficulties experienced in the replication attempt due to reporting errors in the published paper show the value of making both data *and* code publicly available.

Keywords: replication, Sachs and Warner, resource curse.

JEL Codes: O13, Q32, Q33, B40, C80

*I would like to thank Bruce McCullough for the encouragement to write up my efforts on this replication, which I completed in 2004, and for his comments on an earlier draft of the paper.

Replicating Sachs and Warner: The 1997 Working Paper

Introduction

This paper is the first of a series of reports on my attempt to replicate seven empirical papers published by Jeffrey Sachs and Andrew Warner finding that there is a "resource curse" (Sachs and Warner 1995, 1997a, 1997b, 1997c, 1999a, 1999b, 2001).[1] The resource curse suggests that economies with a high proportion of primary production activity in 1970 suffered from slower than expected economic growth between 1970 and 1990. The resource exporting economies are mainly developing economies, and so the result has critical importance for development theory. Sachs and Warner (SW hereafter) argue that this slower growth is due to lost external economies of scale in manufacturing as that sector shrinks, a negative version of the Dutch disease. Even though the presence of a resource curse has been disputed (e.g., Alexeev and Conrad 2009, Lederman and Maloney 2007a), worries about the curse invoke policy incentives that dissuade the production of primary products in favour of manufacturing.

Five of SW's seven resource curse papers are amongst the highest cited papers in resource and development economics. Table 1 lists the number of citations and annual citation rate for each paper. Auffhammer (2009) proposes that their 2001 *European Economic Review* paper is the most cited environmental and resource economics paper of the last decade. According to Harzing's Publish or Perish software, the paper in the *Journal of African Economies* is the most cited paper ever to be published in that journal.

[1] An earlier version of the 1995 NBER paper was published as HIID Development Discussion Paper No. 517a, October 1995. There are other works in which one or both of the authors address economic growth, but I have deemed them to be too far astray from the original resource curse work to be included in this list.

Table 1: Citations and Citation Rate for the Seven Sachs and Warner Resource Curse Papers

Paper	Place of Publication	Citations to date	Average annual citation rate
Sachs and Warner 1995, 1997a	NBER, HIID*	1,959	115
Sachs and Warner 1997b	*AER*	535	36
Sachs and Warner 1997c	*JAE*	776	52
Sachs and Warner 1999a	*JDE*	671	52
Sachs and Warner 1999b	*EE Book Chapter*	88	7
Sachs and Warner 2001	*EER*	1,074	98

Based on Harzig's Publish or Perish software, v 3.2.4150, search conducted on 6/24/2011.
*Google Scholar combines cites for the 1995 paper with the 1997a paper, and lists these as the 1995 paper.

In the physical sciences, such path-breaking and cited work would have been replicated dozens of times by now. In the social sciences, and in economics in particular, replication of results is rare; there is a lack of demand for replication in economics, such that undertakings on the supply side carry risks that are not compensated with the reward of publication (Hammermesh 2007; McCullough, McGreary, and Harrison 2008). As McCullough, McGreary, and Harrison (2006, 1093) muse, "If Pons and Fleischman had published their cold fusion results in an economics journal, the world would still be awaiting lower utility bills." Of course, we now know that replication attempts revealed claims of cold fusion to be false.

Given the practical limitations to replicating all published work, one strategy is to select those works that have had greatest influence on the field and on public policy. The SW portfolio on the resource curse fits that criterion. To my knowledge the portfolio has not been tested for reproducibility of results. In fact, Stijns (2005) notes his *inability* to replicate regressions 1.3, 1.4, and 1.5 in SW's 1997a paper, even though he replicates regressions 1.1 and 1.2. Mehlum et al. (2006) do, on the other hand, manage to replicate regression 1.4, but do not comment on the reproducibility of other results. Schonger

(2002) replicates the coefficient estimates in SW regressions 1.1 through 1.5, though he reports SW's t-statistics, which I will show to be erroneous.

In this paper I report on my attempt to purely replicate each of the 32 least-squares regressions in the SW 1997a paper.[2] The 1997a paper is the same as the pioneering 1995 NBER working paper, only with the growth period extended from 1970-1989 to 1970-1990. Data for the 1995 working paper has not been publicly provided and that paper is therefore not replicable. I also note that the 1995 working paper has never been published, while portions of the 1997a paper have been published in Meier and Rauch (2000, 161-167).

Hammermesh (2007) defines three types of replication: pure replication, "to make or do something again in exactly the same way;" statistical replication, "different sample, but the identical model and underlying population;" and scientific replication, "different sample, different population, and perhaps similar but not identical model." I primarily conduct pure and statistical replication in this paper, though I make brief mention of scientific replication in the final section of the paper. The paper is probably best read with a copy of Sachs and Warner (1997a) at hand. That paper is easily located on Google.

The Nature of the Sachs and Warner Resource Curse Studies

In 1995, SW produced a paper examining primary resources' role in economic growth. Their purpose was to investigate what they variously call "a conceptual puzzle," "a surprising feature of economic life," and an "oddity:" namely, the negative association

[2]My students and I have attempted to replicate each of the four SW journal articles, and I can report that exact replication was rare and that some of Sachs and Warner's findings in those articles are in dispute. The *Journal of Development Economics* and *Journal of African Economies* papers are the most problematic. I have yet to attempt to replicate the book chapter.

identified by previous researchers between the intensity of a country's natural resource (agriculture, mining, and fuels) production and subsequent economic growth. In the 1995 paper SW examine the impact of resource intensity in 1970 against productivity growth from 1970 to 1989. A second paper, written in 1997 (Sachs and Warner 1997a), updates the growth period to 1990 with little impact on the results. Both find empirical support for a resource curse.

In the 1997 paper SW calculate for a population of 211 developed and developing countries the intensity of natural resource production in 1970. Resource intensiveness is initially measured as the 1970 share of agricultural, mining, and fuel exports in GNP (variable SXP). They measure economic growth as the average annual change in real GDP per economically active population from 1970 to 1990 (variable GEA7090), which is growth in labor productivity. They regress growth on 1970 primary resource share using ordinary least squares linear regressions, controlling for the log of the 1970 real GDP per economically active population (variable LGDPEA70). The regression results show that conditional on initial income levels, those economies with higher levels of resource exports grew more slowly from 1970 to 1990. This "resource curse" is maintained as additional conditioning variables are added in a series of 8 regressions in Tables I, III, IV, V, VI, and VII. SW produce three additional tables of regressions (Tables VIII, X, and XI) exploring indirect routes through which primary exports may be causing the slower growth. Their results of these regressions support their hypotheses, presented in detail in the 1995 paper, that a shrinking manufacturing sector is to blame, a negative form of Dutch disease a la Matsuyama (1992).

The Pure Replication Attempt

SW provide a readme file describing four data files: a STATA (version 5) do file that they apparently use to do the econometric analysis; a STATA data set; and Excel and HTML files with the data. The five files are currently available at http://www.cid.harvard.edu/ciddata/ciddata.html. There is no description of the codes used for the variables in the data file, though many of these can be found in the 1997a paper. I used EViews 5.1 with an Intel Pentium M 1.86 GHz processor to conduct the replication given the data presented in the downloadable Excel file.

As they note in footnote 13 of their paper, SW first check their sample for outliers. They regress GEA7090 on LGDPEA70, SXP, and SOPEN (a measure of trade openness), which is regression 1.2 in their paper, and determine outliers based on the DFITS statistic computed in STATA. The DFITS results are included as a column in the data files. While the paper states that an observation is excluded if DFITS > $2\sqrt{k/n}$ where k is the number of regressors (inclusive of the constant) and n is the sample size, the STATA code actually tests for $|\text{DFITS}| > 2\sqrt{k/n}$ since DFITS can be negative. There is complete data for GEA7090, LGDPEA70, SXP, and SOPEN for 91 of the 211 countries, and so $k = 4$ and $n = 91$. On the basis of this test they exclude Chad, Gabon, Guyana, and Malaysia as outliers from regression 1.2 and the other four regressions in Table I (see Table 2 below), which is the table at the centre of their tests for a resource curse. This produces a sample size of 87. I am able to replicate their list of outliers by computing the DFITS statistic using STATA version 11.2.[3]

[3] I thank Arturo Vazquez Cordano and Michael Heeley for assisting me with this portion of the replication attempt.

Table 2: Regressions in Table I of Sachs and Warner (1997a) Testing for the Resource Curse

Regression	Specification
Regression 1.1	$GEA7090 = \alpha_0 + \alpha_1 LGDPEA70 + \alpha_2 SXP + \varepsilon$
Regression 1.2	$GEA7090 = \alpha_0 + \alpha_1 LGDPEA70 + \alpha_2 SXP + \alpha_3 SOPEN + \varepsilon$
Regression 1.3	$GEA7090 = \alpha_0 + \alpha_1 LGDPEA70 + \alpha_2 SXP + \alpha_3 SOPEN + \alpha_4 INV7089 + \varepsilon$
Regression 1.4	$GEA7090 = \alpha_0 + \alpha_1 LGDPEA70 + \alpha_2 SXP + \alpha_3 SOPEN + \alpha_4 INV7089 + \alpha_5 RL + \varepsilon$
Regression 1.5	$GEA7090 = \alpha_0 + \alpha_1 LGDPEA70 + \alpha_2 SXP + \alpha_3 SOPEN + \alpha_4 INV7089 + \alpha_5 RL + \alpha_6 DTT7090 + \varepsilon$

SW identify the 87 countries they use in the Table 1 regressions by the code excl1 = 0.00 in their HTML and Excel data files, while the excluded countries are coded excl1 = 1.00. SW do not include in their paper a list of countries for which they have complete data, and never refer to variable excl1 as the code for whether a country was included in the Table I regressions or not. I list the 87 countries in Appendix 1. One would not be able to come up with the correct country sample for regression 1.1, for which there is complete data for 91 countries excluding the four outliers, if one did not read the STATA file to know which four countries to exclude.[4]

Given the 87 countries in the sample, I replicated regression 1.1 successfully save for two differences in the reported t-statistic values in regression 1.1. Table 3 below reports the results including the regression constant, which is not reported by SW. Regression 1.2 was also successfully replicated.

[4] Cape Verdi Islands, Iceland, Fiji, and Panama are excluded from Regression 1.1 so as to make a consistent sample across the first three regressions.

Table 3: Sachs and Warner Regression 1.1 with Corrections in Bold. Dependent variable: Average annual growth in real GDP per economically active population, 1970 – 1990 (GEA7090)

	(SW 1.1)	(GD 1.1)
Constant		3.29 (1.84)
Initial productivity (LGDPEA70)	-0.11 (0.55)	-0.11 **(-0.54)**
Primary exports in GNP in 1970 (SXP)	-9.43 (-4.75)	-9.43 **(-4.74)**
Openness (SOPEN)		
Ln of Investment Ratio (LINV7089)		
Rule of Law Index (RL)		
Growth in Terms of Trade (DTT7090)		
Adjusted R^2	0.20	0.20
Sample Size	87	87
Standard error	1.62	1.62

An initial problem with replicating regressions 1.3 through 1.5 had to do with the reported regressor INV7089 (the investment to GDP ratio averaged over the period 1970-1989). The raw data file contained both INV7089 and LINV7089, the latter being the natural log of the former. The regression table in the paper reports that INV7089 was used in regressions 1.3 through 1.5. This is what tripped up Stijns in his replication attempt – he

used INV7089.[5] The SW STATA do file shows that the correct regressor is LINV7089.[6] With this adjustment, regressions 1.3 through 1.5 are also exactly replicated. The country size drops to 71 regressions 1.4 and 1.5 because there are 16 countries for which no rule of law (RL) data is available (see Appendix 1). There is an error in the Title of Table I in SW: it should be "Partial Associations Between Growth (1970-90) and Natural Resource Intensity (1970)," not "Partial Associations Between Growth (1970-90) and Natural Resource Intensity (1971)."[7]

SW then go on to note in a footnote to their Table I that if the four outliers are not excluded the estimated coefficients on SXP "range from -6.0 to -8.5, with t-ratios always exceeding 4 in absolute value." I have verified that this is the case, though since Chad does not have rule of law (RL) data it is technically not added back to regressions 1.4 and 1.5 in this exercise.

The remaining 27 regressions in the paper revert to the full sample size of 211 countries, including the outliers. This is not made clear in the paper, but is clear in the STATA file. The sample size for each regression is now simply the number of countries for which the data for the set of regressors was complete.

The next table of regression results is Table III, which tests whether the resource curse finding in Table I is dependent on the measure of resource intensity by introducing three

[5] I can replicate regressions SW3 through SW5 in Stijns (2005, p. 117) by using INV7089 in SW regressions 1.3 through 1.5.
[6] Mehlum et al. (2006) correctly note that the regressor is log investment, which is why their replication was successful.
[7] The notes to the data state that SXP is for 1970, taken from a 1995 World Bank data diskette. I have verified that the diskette only contains 1970 data for fuel and non-fuel exports. It does not contain 1971 data.

additional intensity measures, including a resource endowment measure, LAND, and using those in regression 1.5. From the STATA file the dependent variable in these regressions is actually GEA7090, not GEA7089 as reported by SW in the table. Since the outliers were only removed from the Table I regressions, regression 3.1 is regression 1.5 with Gabon, Guyana, and Malaysia added to the sample (again, there is no rule of law value for Chad). This is why the sample size rises by three. I was able to replicate the regressions in Table III exactly save for the t-statistic on LAND in regression 3.4. It should be -4.08, not -3.78. The SNR variable is reported in the table notes as being mineral production divided by GNP in 1970. The paper's text and variable descriptions state that the data is from 1971. I am unable to replicate their SNR values using 1971 data, though many values are close.

Given that Table III finds that the measure of resource intensiveness is immaterial, SW stay with their preferred measure, SXP, in the remaining regressions. Table IV adds more conditioning variables to the regression. In Table IV the dependent variable is actually GEA7090, not GEA7089 as reported by SW in the table. The table notes refer to variable INV7090, and yet the regressor is reported as INV7089 in both the table and the STATA file. The data files only contain data for INV7089, and so this is the correct regressor. Note that the investment variable is not logged in this table.

Tables V, VI, and VII add still different control variables to check for the robustness of the resource curse. I managed to exactly replicate Tables V, VI, and VII. In Table V the independent variables are actually KLLSEC and KLLLY70, not LSEC and LLY70 as listed by SW in the table. In Tables VI and VII the dependent variable is actually GEA7090, not GEA7089 as reported by SW in the table.

Table VIII regresses sectoral data against variable SXP and additional conditioning variables looking for a causal mechanism for the resource curse. I had some trouble replicating regression 8.2 in Table VIII until I realized that the independent variable is LGDPNR70 (natural log of GNP produced in sectors other than the natural resource sector) per the table notes on p. 32 and the STATA file, not LGDPEA70 as reported by SW in Table VIII.

Table IX tests to see whether the resource curse differed between the 1970s and 1980s. In regression 9.2 variable SXP80 is used in the regression, not SXP as reported by SW in the regression and in the table note. With this change I replicated regressions 9.1 and 9.2. Note that the column headings should be Growth 1970 – 1980 and Growth 1980 – 1990, not Growth 1970 – 1979 and Growth 1980 – 1989 as reported by SW in the table.

In footnote 17 SW mention that policy in earlier periods may be driving the resource curse results seen in the 1970s and 1980s. The state that they test for this by controlling for growth in the 1960s, but that "growth in the 1960's does not enter the regression significantly, and does not alter the significance of the SXP coefficient" (p. 20). It is not clear from the footnote text which regression they test this way. The note comes in the same paragraph as discussions of regressions 9.1 and 9.2, which test for a changing resource curse effect between the 1970s and the 1980s. The STATA file makes it clear that they test regression 1.5 with the outliers removed, controlling for GR6070 (average annual real growth per capita from 1960 to 1970).[8] I confirm that that GR6070 is

[8] The STATA file incorrectly refers to footnote 18 instead of footnote 17. Footnote 18 is a discussion about Botswana.

Table 4: Sachs and Warner Regressions 9.1 and 9.2. Dependent variable: Average annual growth in real GDP per economically active population, 1970 – 1980 (GEA7080) in 9.1 and 1980 – 1990 (GEA8090) in 9.2.

	(9.1)	(9.1a)	(9.2)	(9.2a)
Constant	8.21 (3.65)	7.91 (3.34)	13.05 (4.70)	14.05 (5.16)
Initial productivity (LGDPEA70)	-1.25 (-4.07)	-1.23 (-3.81)	-1.88 (-5.00)	-1.99 (-5.47)
Primary exports in GNP (SXP, SXP80)*	-3.89 (-2.43)	-2.64 (-1.36)	-6.15 (-3.42)	-5.59 (-3.21)
Openness (SOPEN7, SOPEN8)*	1.82 (3.10)	1.89 (3.05)	2.51 (4.14)	2.11 (3.50)
Growth in Terms of Trade (DTT7080, DTT8090)*	0.11 (3.23)	0.11 (3.20)	0.02 (0.17)	0.04 (0.43)
Ln of Investment Ratio (LINV7079, LINV8089)*	1.51 (4.15)	1.52 (3.60)	0.63 (1.25)	0.39 (0.78)
Rule of Law Index (RL)			0.55 (3.34)	0.58 (3.60)
Growth in 1960s (GR6070)		-0.02 (-0.18)		0.23 (2.02)
Adjusted R^2	0.31	0.28	0.60	0.61
Sample Size	101	96	73	71
Standard error	2.04	2.08	1.52	1.46

*SXP, SOPEN, DTT, and LINV are all synchronized with the dependent variable, and so regression 9.1 uses the data for the 1970's and regression 9.2 uses the data for the 1980's. RL is for the 1980's, and so is not used in the 1970's regression.

statistically insignificant in that regression and that the significance of the SXP coefficient only goes down from -6.89 to -6.51 when GR6070 is included as an independent variable. However, if I add GR6070 to regression 9.1, which tests for the resource curse in only the 1970s, SXP becomes statistically insignificant, suggesting that there may be something to their theory, at least for the resource curse of the 1970s (Adding GD6070 to regression 9.2, which tests for the resource curse in the 1980s, does not cause SXP80 to become statistically insignificant. GR6070 is, however, statistically significant in that case). Table

4 above provides the comparison of the two regressions with and without GR6070 as a conditioning variable.

Table X investigates the relationship between natural resource intensity and other economic variables. Table XI investigates the relationship between natural resource intensity and the quality of institutions. All of the regressions in these tables were replicated.

The conclusion of this section is that SW's results can be exactly purely replicated once the countries included in the regressions are determined and the errors in the paper's reported regressors are corrected. Both adjustments required information from the STATA file. The replication revealed three inconsequential differences in the reported t-statistics (two in regression 1.1 and one in regression 3.4). I have reported the correct values. There is no doubt that the SW data allows them to measure a resource curse in the 1970s and 1980s that is robust to various sets of conditioning variables. The only question mark given their econometric method is the robustness of the resource curse in the 1970s, since conditioning on growth in the previous decade (a proxy for policy in the previous decade) causes the coefficient on SXP to become insignificant. As I will show in the next section, in addition their regressions in Tables VII, X, and XI seeking to explain the mechanisms through which the resource curse operates are not always robust to the country sample.

The replication attempt took longer than it should have because of the many inconsistencies between the reported regressors in the paper and the actual regressors in the STATA file. Without the STATA file the replication may have been impossible. Even

with the STATA file, eleven years ago I along with then graduate students Jean-Philippe Stijns at Berkeley and Martin Schonger at Bonn shared our frustrations for quite some time at not being able to replicate the results of Table I. It was Martin who eventually realized, in 2001, that the independent variable in Table I should be LINV7089, not INV7089. His replication of SW Table I is included in his thesis (Schonger 2002).

Statistical Replication

As I noted above, SW do not maintain a consistent country sample across the various regressions. For example, SW regressions 3.1 through 3.4 are just regression 1.5 with three reported outliers (Gabon, Guyana, and Malaysia) omitted from the sample in regression 1.5 added back. The inconsistency of country selection across regressions is a troubling aspect of SW's empirical work. For the record, regressions 1.1 through 1.5 and 3.1 through 3.4 sample from the set of 87 and 91 countries listed in Appendix 1, respectively, while the regressions in Table 4 onwards sample from an expanded set of the full 211 countries in the data base and use the set of countries for which complete data for that regression is available.

In an examination of sample effects, I can confirm that the resource curse associated with the alternative indicators of resource intensiveness listed in Table III is not changed by excluding the three outliers. I can also confirm that it is not Singapore and Trinidad & Tobago that are driving the resource curse result, as suggested by Lederman and Maloney (2007b); the results in Tables I and III are robust to the removal of those two countries.

The 91-country sample used in the resource curse tests in Tables I and III only includes 3 of the top 10 resource-intensive economies (as measured by SXP) in the data set.

Resource intensive countries such as Iraq, Oman, Saudi Arabia, Botswana, Niger, and Zaire have no growth data and so are not included. These countries' omission is not inconsequential. SW suggest that Botswana is an example of a natural resource-abundant economy that grew rapidly, and that its exclusion may be biasing the results towards a resource curse. Indeed, when Sala-i-martin et al. (2004) find that the fraction of mining (and oil and gas) in GDP in 1988 has a *positive* effect on overall economic growth from 1960-1996, contrary to the received wisdom of the resource curse, they posit that this may be because of the inclusion of the "outlier" Botswana. But Botswana is, rather, an example of a non-resource abundant economy (SXP = 0.05 in 1970) that grew rapidly in the 1970s and 1980s, supporting the resource curse. It is more like Hong Kong (SXP = 0.03) and Singapore (SXP = 0.03) than a resource-abundant economy. Adding Botswana to the country sample should not overturn the resource curse results, but strengthen them. Somalia, Tanzania, Barbados, Haiti, and Myanmar, some of the poorer performing developing economies in the non-resource intensive category, also lack growth data, and so are excluded. Adding these countries to the sample may weaken the resource curse.

To see whether the findings of a resource curse in Table 1 are dependent on country sample, I expanded the data sample for Table I's regressions 1.2 and 1.3 to 101 countries by filling in the missing growth data for Oman, Saudi Arabia, Botswana, Niger, Zaire, Somalia, Tanzania, Barbados, Haiti, and Myanmar using GEA7089 data rather than GEA7090 data, taken from the same data source as GEA7090. These countries had complete data in each of the other regressors. The two regressions still show a statistically significant resource curse, supporting Davis's (2011) proposition that Sala-i-martin et al. (2004) find a resource blessing not because of the inclusion of Botswana in their sample,

but because they measure resource intensity near the end of the growth period and are picking up reversion in production levels.

I also use the SW 91 country set listed in Appendix 1 to test all of the regressions in Tables VIII, X, and XI, which explore indirect routes through which primary exports may be causing the slower growth. This seems more appropriate than the approach SW take, which includes any country with complete data in the sample, since one is interested in the indirect routes operating in the country set in which the resource curse has been identified. It turns out that delimiting the investigation to the 91-country set matters in seven of the regressions. First, the SXP coefficient in regression 8.1 turns from statistically significant to statistically insignificant due to the removal of 9 countries from the sample, weakening SW's conjectures about the resource curse observed in Table I operating through a decline in manufacturing and lost external economics of scale. Second, the SXP^2 coefficient in regression 10.4 turns from statistically significant to statistically insignificant due to the removal of 13 countries from the sample, a lack of support for SW's claim that there is a U-shaped relationship between resource intensity and trade openness and that the heavily resource intensive economies are less protectionist than other resource intensive economies. Finally, the SXP coefficient turns from significant to insignificant in each of regressions 11.1 through 11.5 due to the elimination of 10 or more countries from the sample, depending on the regression. The latter results weaken SW's proposition that higher resource intensity is related to poorer institutional quality, and that this is part of the reason for slower growth.

The results of this section indicate that SW's finding of the resource curse is robust to different country samples. Their evidence that the resource curse is a result of resource

production's impact on institutional quality and manufacturing output is not robust to country sample.

Scientific Replication

One of the debates in the resource curse literature is whether or not empirical findings of a resource curse are robust to the way that primary production intensity is modeled (Davis 2011). Since variable SXP has been suggested to pick up trade patterns not necessarily related to endowments (Lederman and Maloney 2007b), and since minerals and energy have been particularly targeted amongst primary production activities as being responsible for the resource curse (Butkiewicz and Yanikkaya 2010), I replaced SXP with SNR in each of the 9 SW resource curse regressions that contained GEA7090 as the dependent variable and SXP as an independent variable. The difference between the statistical significance of the two variables in each regression is minimal under both the original sample of 91 countries and also under the full country sample with growth data for 10 countries added. This is also the case when the resource intensity variables LAND (land area per capita in 1971) and PXI70 (ratio of primary exports to total exports in 1970) replace SXP, with the exception that PXI70 is statistically insignificant in regression 5.2 given the 91 country sample. This lends support to Davis's (2011) suggestion that those who find no resource curse when using different measures of resource intensity are finding differences due to when a country's resource intensity is measured—near the beginning or near the end of the growth period—rather than due to how it is modeled.

In a test for missing regressors Davis (2011) finds that change in resource production over the growth period is statistically significant in SW's Table I regressions, and that once

this is modeled the size of the resource curse effect drops or even goes to zero. This is a case where scientific replication fails.

Conclusions

Given the low-replicability equilibrium of economics research (Anderson et al. 2008), there was little likelihood that this pure replication would be a success. The success of the replication would have been impossible had SW not included an appropriately commented STATA file with their data. This reinforces the calls in the replication literature for authors to make available their data *and* code.

Overall, my pure replication effort confirms SW's conclusion that countries with intensive primary resource production as of 1970 grew more slowly from 1970 to 1990 than otherwise equivalent economies that did not have large primary resource sectors as of 1970. This should be of some comfort to the thousands who have cited SW's results in support of a resource curse and to the many more who have been influenced by them in terms of development policy. Under statistical replication there is a lack of robustness of certain of their regressions investigating mechanisms by which the resource curse operates. This causes me to suspect that the paper's attempt to explain the resource curse via an endogenous growth effect involving shrinking manufactures or poor institutions is more tentative than even SW suggest.

Pure and statistical replication does not test the validity of the econometric specification that SW use, only that their reported results are consistent with the data that they provide. For example, their regressions may have endogeneity problems (Alexeev and Conrad

2009), or bias as a result of dropping countries for which there are missing values.[9] Scientific replication indeed shows that there is an omitted variable in the model. Once change in primary resource production is included as an independent variable the resource curse weakens and in some specifications disappears (Davis 2011). That finding was only possible as an extension of this replication effort. Now that their results have been purely replicated, additional and long overdue formal investigations as to appropriate econometric specification can commence.

[9] Listwise deletion will yield biased coefficient estimates when the missingness of data is correlated with the level of the dependent variable, in this case real per capita economic growth.

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Appendix 1: Country list and data, Table I, Sachs and Warner (1997a), including outliers.*

	Country	DTT7090	GEA7090	LGDPEA70	LINV7089	RL	SOPEN	SXP
1	ALGERIA	6.09	1.48	8.25	3.30	2.00	0.00	0.19
2	BENIN	-3.11	-0.80	7.68	1.49	.	0.04	0.08
3	BURKINA FASO	-0.61	1.72	6.54	2.25	.	0.00	0.04
4	BURUNDI	-6.46	2.80	6.43	1.82	.	0.00	0.10
5	CAMEROON	-2.54	2.56	7.29	2.36	3.00	0.00	0.18
6	CENTRAL AFR.R.	0.09	-1.11	7.20	1.67	.	0.00	0.09
7	CONGO	7.44	1.74	8.03	2.22	.	0.00	0.08
8	EGYPT	-0.52	2.23	7.67	1.64	1.00	0.00	0.07
9	GAMBIA	-2.04	0.61	7.17	1.80	.	0.19	0.36
10	GHANA	-3.26	-0.73	7.62	1.62	1.00	0.19	0.21
11	IVORY COAST	-1.20	-1.29	8.07	2.31	.	0.00	0.29
12	KENYA	-0.80	2.24	7.11	2.68	2.00	0.12	0.18
13	MADAGASCAR	-2.15	-2.37	7.67	0.33	.	0.00	0.12
14	MALAWI	-1.05	0.87	6.76	2.42	1.00	0.00	0.21
15	MALI	0.25	1.42	6.68	1.77	.	0.08	0.08
16	MAURITANIA	-2.50	-0.32	7.38	2.84	.	0.00	0.41
17	MAURITIUS	1.39	3.39	8.41	2.34	.	1.00	0.29
18	MOROCCO	1.71	1.59	7.93	2.42	1.00	0.23	0.11
19	NIGERIA	5.95	1.30	7.32	2.71	1.00	0.15	0.14
20	RWANDA	-2.86	0.86	7.16	1.55	.	0.00	0.11
21	SENEGAL	0.77	0.25	7.67	1.63	1.00	0.00	0.14
22	SIERRA LEONE	-2.52	-2.09	7.87	0.31	.	0.00	0.09
23	SOUTH AFRICA	-2.20	-0.23	8.68	2.92	.	0.00	0.17
24	SUDAN	-0.13	-0.32	7.34	1.88	1.00	0.00	0.16
25	TOGO	-0.26	0.47	7.06	2.91	2.00	0.00	0.19
26	TUNISIA	4.04	2.76	7.97	2.68	3.00	0.04	0.10
27	UGANDA	-3.82	-0.80	7.16	0.92	1.00	0.08	0.27
28	ZAMBIA	-4.40	-2.18	7.68	2.77	3.00	0.00	0.54
29	ZIMBABWE	-3.47	0.02	7.72	2.70	1.00	0.00	0.17
30	CANADA	-0.68	2.19	9.70	3.19	6.00	1.00	0.10
31	COSTA RICA	-2.45	0.13	8.65	2.85	4.00	0.15	0.19
32	DOMINICAN REP.	-1.31	0.85	8.04	2.88	3.00	0.00	0.13
33	EL SALVADOR	-2.51	-0.12	8.18	2.10	1.00	0.04	0.16
34	GUATEMALA	-2.40	0.23	8.28	2.22	1.00	0.08	0.11
35	HONDURAS	-1.63	0.36	7.81	2.60	1.00	0.00	0.23
36	JAMAICA	-0.45	-1.35	8.63	2.94	1.00	0.38	0.14
37	MEXICO	1.78	1.06	8.99	2.84	4.00	0.15	0.02
38	NICARAGUA	-3.61	-3.09	8.47	2.50	1.00	0.00	0.19
39	TRINIDAD&TOBAGO	1.42	-0.01	9.45	2.57	4.00	0.00	0.08
40	U.S.A.	-1.41	1.34	9.95	3.13	6.00	1.00	0.01
41	ARGENTINA	-2.74	-0.69	9.09	2.83	2.00	0.00	0.05
42	BOLIVIA	1.17	-0.01	8.04	2.73	1.00	0.73	0.18
43	BRAZIL	-2.45	1.99	8.41	2.98	4.00	0.00	0.05
44	CHILE	-4.56	0.26	8.77	2.90	5.00	0.58	0.15
45	COLOMBIA	-1.81	1.43	8.33	2.75	2.00	0.19	0.09
46	ECUADOR	5.37	1.64	8.16	3.13	4.00	0.73	0.11
47	PARAGUAY	-1.12	1.58	7.93	2.74	1.00	0.04	0.10
48	PERU	-2.59	-1.63	8.56	2.86	2.00	0.12	0.15
49	URUGUAY	-0.95	0.59	8.78	2.66	3.00	0.00	0.09
50	VENEZUELA	4.80	-1.85	9.62	3.10	3.00	0.04	0.24
51	BANGLADESH	-2.75	0.14	7.83	1.14	1.00	0.00	0.01

	Country	DTT7090	GEA7090	LGDPEA70	LINV7089	RL	SOPEN	SXP
52	CHINA	-0.34	2.25	7.13	3.02	.	0.00	0.02
53	HONG KONG	-2.00	5.12	8.94	3.03	6.00	1.00	0.03
54	INDIA	-2.02	1.99	7.27	2.65	3.00	0.00	0.02
55	INDONESIA	4.62	4.56	7.18	3.07	1.00	0.77	0.11
56	IRAN	7.68	-1.91	9.16	3.02	1.00	0.00	0.12
57	ISRAEL	-0.05	2.22	9.21	3.20	1.00	0.19	0.04
58	JAPAN	-0.96	3.31	9.27	3.54	6.00	1.00	0.01
59	JORDAN	-0.21	2.93	7.93	2.82	1.00	1.00	0.09
60	KOREA, REP.	-0.83	5.71	8.03	3.29	3.00	0.85	0.02
61	PAKISTAN	-2.63	1.15	7.62	2.26	1.00	0.00	0.03
62	PHILIPPINES	-2.35	0.68	7.90	2.80	1.00	0.08	0.13
63	SINGAPORE	1.14	5.77	8.56	3.58	6.00	1.00	0.03
64	SRI LANKA	-1.18	1.92	7.73	2.39	2.00	0.23	0.15
65	SYRIA	6.64	2.40	8.50	2.73	1.00	0.04	0.08
66	TAIWAN	-0.20	5.77	8.25	3.20	6.00	1.00	0.02
67	THAILAND	-1.00	3.15	8.01	2.87	3.00	1.00	0.09
68	AUSTRIA	-0.25	2.16	9.41	3.25	6.00	1.00	0.04
69	BELGIUM	-0.26	2.02	9.49	3.10	6.00	1.00	0.11
70	CYPRUS	-3.18	3.60	8.76	3.28	.	1.00	0.14
71	DENMARK	-0.40	1.59	9.62	3.20	6.00	1.00	0.10
72	FINLAND	0.46	2.66	9.41	3.52	6.00	1.00	0.07
73	FRANCE	0.07	1.77	9.60	3.29	6.00	1.00	0.03
74	GERMANY, WEST	-0.09	1.68	9.60	3.25	6.00	1.00	0.02
75	GREECE	-1.07	2.14	8.80	3.20	3.00	1.00	0.04
76	IRELAND	-0.27	2.73	9.07	3.26	5.00	0.96	0.15
77	ITALY	-0.55	2.19	9.37	3.25	5.00	1.00	0.02
78	NETHERLANDS	-0.29	1.25	9.60	3.15	6.00	1.00	0.15
79	NORWAY	0.40	2.92	9.46	3.48	6.00	1.00	0.10
80	PORTUGAL	1.73	3.75	8.58	3.14	6.00	1.00	0.05
81	SPAIN	-0.64	2.12	9.15	3.22	5.00	1.00	0.03
82	SWEDEN	0.14	1.66	9.71	3.11	6.00	1.00	0.05
83	SWITZERLAND	-0.18	0.99	9.89	3.36	6.00	1.00	0.02
84	TURKEY	-1.14	2.09	8.30	3.11	3.00	0.04	0.04
85	U.K.	-0.14	1.99	9.52	2.90	6.00	1.00	0.03
86	AUSTRALIA	-1.51	1.15	9.75	3.31	6.00	1.00	0.10
87	NEW ZEALAND	0.27	0.51	9.66	3.17	6.00	0.15	0.18
	Outliers							
88	CHAD	2.26	-2.40	7.09	0.79		0.00	0.08
89	GABON	7.97	0.39	8.70	3.34	2.00	0.00	0.33
90	GUYANA	-1.51	-3.64	8.22	3.01	0.00	0.08	0.51
91	MALAYSIA	0.52	3.69	8.33	3.26	4.00	1.00	0.37

*The original data is reported up to 16 decimal places.

Appendix 2: Alphabetic list of Sachs and Warner regression variables mentioned in this paper

DTT7080 Average annual growth of the natural logarithm of the external terms of trade between 1970 and 1980.

DTT8090 Average annual growth of the natural logarithm of the external terms of trade between 1980 and 1990.

DTT7090 Average annual growth of the natural logarithm of the external terms of trade between 1970 and 1990.

GEA7080 Average annual growth of purchasing power adjusted GDP per person aged 15-64 (economically active population) between the years 1970 and 1980.

GEA8090 Average annual growth of purchasing power adjusted GDP per person aged 15-64 (economically active population) between the years 1970 and 1980.

GEA7089 Average annual growth of purchasing power adjusted GDP per person aged 15-64 (economically active population) between the years 1970 and 1989.

GEA7090 Average annual growth of purchasing power adjusted GDP per person aged 15-64 (economically active population) between the years 1970 and 1990.

GR6070 Average annual real per-capita growth between 1960 and 1970.

LAND Natural logarithm of the ratio of total land area to population in 1971.

LGDPEA70 Natural logarithm of real GDP per person aged 15-64 in 1970.

LGDPEA80 Natural logarithm of real GDP per person aged 15-64 in 1980.

LGDPNR70 Natural logarithm of GNP produced in sectors other than the natural resource sector in 1970.

LINV7079 Natural logarithm of the ratio of real gross domestic investment (public plus private) to real GDP, averaged over the period 1970-1979.

LINV8089 Natural logarithm of the ratio of real gross domestic investment (public plus private) to real GDP, averaged over the period 1980-1989.

LINV7089 Natural logarithm of the ratio of real gross domestic investment (public plus private) to real GDP, averaged over the period 1970-1989.

PXI70 Ratio of primary exports to total merchandise exports in 1970.

RL Index for rule of law ranging from 0 (low) to 6 (high) measured as of 1982.

SOPEN The fraction of years during 1970-1990 in which Sachs and Warner rate an economy as open.

SOPEN7 The fraction of years during 1970-1980 in which Sachs and Warner rate an economy as open.

SOPEN8 The fraction of years during 1980-1990 in which Sachs and Warner rate an economy as open.

SNR Share of mineral production in GNP in 1971.

SXP Share of primary products exports in GNP in 1970.

SXP80 Share of primary products exports in GNP in 1980.