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In Search of the Missing Resource Curse

Like Dracula, the notion of a natural resource curse reemerges periodically, haunting the development debate, striking fear into the hearts of Latin American policymakers, and causing quantities of ink to be spilled on the various ways in which being blessed with mineral, agricultural, or other natural wealth will lead to anemic growth performance. Adam Smith was perhaps the first to articulate a concern that mining was a bad use of labor and capital and should be discouraged.[1] The idea reappeared in the mid-1950s in Latin America when Raúl Prebisch, on observing slowing regional growth, argued that natural resource industries had fewer possibilities for technological progress and were condemned to decreasing relative prices on their exports.[2] These stylized facts helped justify the import substitution experiment to modify national productive structures. Subsequently, disenchantment with the inefficiencies of protectionism and the consequences of populist macroeconomic policies led to more open trade regimes and less intrusive microeconomic policies, partly with the example of East Asia's rapid export-led growth in mind.

Over the interim, however, two stylized facts have emerged to convert a new generation of analysts to believers in the curse. First, the liberalizing economies, with some notable exceptions, did not become either manufacturing dynamos or major participants in what is loosely called the new knowledge economy. Growth results were not impressive, and in the case of Africa,

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This paper was partly financed by the World Bank's Regional Studies Program of the Latin American and Caribbean Region. We would like to thank Joana Naritomi for inspired research assistance. Cameron Shelton, Thad Dunning, and Francisco Rodríguez provided invaluable feedback and criticisms.

1. "Projects of mining, instead of replacing capital employed in them, together with ordinary profits of stock, commonly absorb both capital and stock. They are the projects, therefore, to which of all others a prudent law-giver, who desired to increase the capital of his nation, would least choose to give any extraordinary encouragement" (Smith 1776, p. 562).

2. Prebisch (1962).

dramatic falls in commodity prices contributed to negative growth rates. With the increased popularity of cross-country growth regressions in the 1990s, numerous authors offered proof that, in fact, natural resources appeared to curse countries with slower growth.[3] Sachs and Warner are arguably the most influential of this group, with several authors drawing on their data and approach.[4] They contend that the resource-rich developing countries across the world have grown more slowly than other developing countries since the 1960s. In 2007, Macartan Humphreys, Jeffrey Sachs, and Joseph Stiglitz published *Escaping the Resource Curse,* which has recently added further credence to the myth.[5] Consequently, the conventional wisdom once again postulates that natural resources are a drag on development, which contradicts the commonsense view that natural riches are riches nonetheless.

Yet there has always been a countervailing current that suggests that common sense was not, in this case, misleading. Most recently, evidence supportive of a more positive view was brought together by Lederman and Maloney in *Natural Resources, Neither Curse nor Destiny,* but the debate goes back substantially farther.[6] Notable observers such as Douglass North and Jacob Viner dissented on the inherent inferiority of, for instance, agriculture relative to manufacturing colonies.[7] Even as Adam Smith was writing *The Wealth of Nations,* the American colonies were declaring their independence on their way to being one of the richest nations in history, based largely on natural resources through much of that process.[8] Other success stories, including Australia, Canada, Finland, and Sweden, remain, to date, net exporters of natural resources.[9] The disappointing experiences of Latin Amer-

3. Auty (1993); Davis (1995); Gylfason, Herbertsson, and Zoega (1999); Neumayer (2004); Mehlum, Moene, and Torvik (2006).

4. Sachs and Warner (1995a, 1995b, 2001).

5. Humphreys, Sachs, and Stiglitz (2007).

6. Lederman and Maloney (2007a).

7. North argued that "the contention that regions must industrialize in order to continue to grow . . . [is] based on some fundamental misconceptions" (1955, p. 252). Viner, the pioneer trade economist, held that "there are no inherent advantages of manufacturing over agriculture" (1952, p. 72).

8. See, for example, Findlay and Lundahl (1994).

9. The literature is clear that these development successes based their growth on natural resources, and several still do (see figure 1). See Irwin (2000) for the United States; Innis (1933) and Watkins (1963) for Canada; Wright (2001) and Czelusta (2001) for Australia; Blomström and Kokko (2006) and Blomström and Meller (1991) for Scandinavia. Latin America also offers its success stories: Monterrey in Mexico, Medellín in Colombia, and São Paulo in Brazil all grew to become dynamic industrial centers based on mining and, in the latter two cases, coffee. Copper-rich Chile has been the region's model economy since the late 1980s.

ica and Africa clearly offer a counterbalance to these success stories, but they do not negate them.

The acknowledgment of the important heterogeneity of experiences has led tentatively to a greater circumspection about the impact of resources, although not necessarily less enchantment with the term *curse*. Humphreys, Sachs, and Stiglitz begin their book by noting that resource-rich countries *often* perform worse than their resource-poor comparators, while Dunning talks of a conditional resource curse—that is, there is a negative growth impact under certain conditions.[10] This is undoubtedly a more careful way to frame the issue, one that moves explaining the heterogeneity to center stage. Nevertheless, the notion of a resource curse suggests more than the existence of a negative tail in the distribution of impact. Dracula's sinister reputation arises not from the occasional involuntary transfusion, but rather from the bloody parasitism that is the central tendency of his character (disclaimer: we have not carefully reviewed any of the relevant empirical literature on this topic).[11]

This article builds on our earlier work to argue that such a negative central tendency does not characterize natural resource abundance, and we would do well to exorcise the curse from the economic discourse. The next section reviews the various channels through which the curse is thought to operate, and we argue that, in many cases, the channel either is not convincingly present or applies to many other factors of production. We then review some of the existing literature, arguing that the existing stylized fact of a curse is tentative at best and certainly not robust enough to impugn an entire category of production. We then examine more carefully the appropriate proxy for measuring resource curse effects and, in the process, suggest what may be driving some findings of a negative impact. Finally, using our preferred proxy, we deploy various estimations methods in search of the missing curse, including an aspect of the resource curse we left relatively unexplored in *Neither Curse nor Destiny,* namely, the voracious political economy channel. Though our results in this dimension are, to some degree, rudimentary, they suggest that this element of the curse, too, merits closer scrutiny and might be a figment of our statistical imagination.

10. Humphreys, Sachs, and Stiglitz (2007); Dunning (2008b).

11. No one, for example, talks about a venture capital curse when nineteen out of twenty venture-capital-financed firms go bankrupt. If the central tendency is for natural resources to have a positive effect, then they remain a blessing, albeit conditional, and we need to understand the complementary factors necessary to maximize it. This is not different from understanding why Taiwan did better with its electronics industry than Mexico or why Italy did better with its fashion industry than Korea did with Project Milan.

The Mechanics of the Curse

The literature offers numerous channels through which the curse might operate. Here we discuss only a few. First, Prebisch popularized the idea that natural resource exporters would experience a secular decline in their terms of trade over time relative to manufacturing exporters.[12] However, Cudington, Ludema, and Jayasuriya find that they cannot reject the hypothesis that relative commodity prices follow a random walk across the twentieth century, with a single break in 1929.[13] That is, there is no intrinsic force driving the observed decline, and prices could as easily rise tomorrow as fall further. While important mean-reverting components are evident commodity by commodity and are, in fact, necessary for stabilization funds to be viable, the notion that long-run prices have a strong unpredictable and permanent component appears more relevant today than at any time in the last half century. Krugman takes exactly the opposite position from Prebisch, arguing that continued growth by China and India, combined with simply "running out of planet," will lead to continued strong excess demand, such that "rich countries will face steady pressure on their economies from rising resource prices, making it harder to raise their standard of living."[14]

Second, beginning with Smith, observers have argued that natural resources are associated with lower human and physical capital accumulation, productivity growth, and spillovers. This case is far from proven, however. Consistent with Viner's early assertion, Martin and Mitra find total factor productivity growth to be higher in agriculture than in manufactures in a large sample of advanced and developing countries.[15] Wright and Czelusta, as well as Irwin, argue that, contrary to Smith's prejudice, mining is a dynamic and knowledge-intensive industry in many countries and was critical to U.S. development.[16] Blomström and Kokko argue the same for forestry in Scandinavia.[17]

Several authors stress the complementarity of essential factors, particularly human capital.[18] Maloney argues that Latin America missed opportunities for rapid resource-based growth as a result of deficient technological

12. Prebisch (1962).
13. Cuddington, Ludema, and Jayasuriya (2007).
14. Paul Krugman, "Running out of Planet to Exploit," *New York Times,* 21 March 2008.
15. Viner (1952); Martin and Mitra (2001).
16. Wright and Czelusta (2007); Irwin (2000).
17. Blomström and Kokko (2006).
18. See Gylfason (2001); Bravo-Ortega and De Gregorio (2007).

adoption, which was driven by two factors: first, deficient national learning or innovative capacity, arising from low investment in human capital and scientific infrastructure, led to weak capacity to innovate or even to take advantage of technological advances abroad; second, the period of inward-looking industrialization discouraged innovation and created a sector whose growth depended on artificial monopoly rents rather than the quasi-rents from technological adoption, while at the same time undermining natural-resource-intensive sectors that had the potential for dynamic growth.[19] Larsen argues that Norway's surge from Scandinavian laggard in the 1960s to regional leader in per capita income was based largely on the opposite strategy; he concludes that "Norwegian oil is a high technology sector which we may assume has much the same positive spillover effects as manufacturing is supposed to have."[20]

These arguments are central to the discussion surrounding the Dutch disease aspect of the curse, according to which resource booms depress manufacturing activity, perhaps through an appreciated exchange rate or through classic Rybczynski effects.[21] If the natural resource sector is not inferior in terms of its growth potential, then this sectoral shift would be of similar import to the canonical displacement of agriculture by manufacturing or the finance-driven exchange rate effects on manufacturing in the United Kingdom.

Third, either for reasons of history or as a result of Dutch disease, natural resource abundance may result in high levels of export concentration, which may increase export price volatility and hence macroeconomic volatility.[22] This is a more general concern, however. Dependence on any one export, be it copper in Chile or microchips in Costa Rica, can leave a country vulnerable to sharp and sudden declines in the terms of trade, with attendant channels of influence through volatility.

Fourth, another important branch of the literature suggests that natural riches produce institutional weaknesses.[23] Tornell and Lane use the term *voracity effect* to describe the phenomenon in which various social groups attempt to capture the economic rents derived from the exploitation of natural resources.[24] Subsequent refinements have focused on how "point source"

19. Maloney (2007).
20. Larsen (2004, p. 17).
21. Gylfason, Herbertsson, and Zoega (1999); Sachs and Warner (2001).
22. Sachs and Warner (1995b) argue that Dutch disease leads to concentration in resource exports, which they assume to have fewer possibilities for productivity growth.
23. See Auty (2001a, 2001b, 2006); Ross (1999); Gelb (1988); Easterly and Levine (2002).
24. Tornell and Lane (1999).

natural resources—those extracted from a narrow geographic or economic base, such as oil or minerals—and plantation crops have more detrimental effects than those that are diffuse, such as livestock or agricultural produce from small family farms.[25] Here again, this concern is not specific to natural resources, but applies to any source of rents. Auty, for instance, points to a similar impact of foreign aid.[26] Natural monopolies, such as the telecommunications sector, have given rise to precisely the same effects in Mexico, and the rent-seeking literature generated by Krueger often focuses on the adverse political economy effects arising from trade restrictions.[27] Rajan and Zingales examine rentier attitudes among the corporate elite, including the manufacturing and financial elites, and the need for financial markets to ensure the pressure of new entry.[28]

That said, there is clearly an important agenda to understand the interaction between political institutions and the emergence of resource sectors. Mehlum, Moene, and Torvik argue the importance of strong institutions to minimize rent-seeking activity.[29] Rodríguez and Gomolin stress that the preexisting centralized state and professionalized military was essential to Venezuela's stellar growth performance in 1920–70, after oil exploitation began in 1920.[30] Dunning offers a model of how differences in the world structure of resources, the degree of societal opposition to elites, and the prior development of the nonresource private sector help predict the incentives for diversification and political stability.[31]

The Elusive Curse

Without question, many of the channels discussed above may have important implications for growth. However, the question is whether, taking all these impacts together, resource abundance has curse-like qualities as a central tendency. The literature uses a variety of proxies for resource abundance, but it has not been able to demonstrate this.

25. Murshed (2004); Isham and others (2005).
26. Auty (2001a, 2001b, 2006).
27. Krueger (1974).
28. Rajan and Zingales (2003).
29. Mehlum, Moene, and Torvik (2006).
30. Rodríguez and Gomolin (forthcoming).
31. Dunning (2008b).

By far, the best known empirical tests for the resource curse are found in the work of Sachs and Warner, who employ natural resource exports as a share of gross domestic product (GDP) as their proxy.[32] Using cross sectional data from the period 1970 to 1990, they persistently find a negative correlation with growth, much to the alarm of many resource-abundant developing countries.[33] Yet, this proxy leads to some counterintuitive results as a measure of resource abundance. Singapore, for example, conducts substantial re-exports of raw materials, which makes it appear to be very resource abundant under Sachs and Warner's measure and, when combined with the country's high growth rates, points to a positive relationship between resource abundance and growth. Because this gross measure is clearly not capturing the country's true factor endowments, Sachs and Warner replace the values of Singapore (as well as Trinidad and Tobago) with net resource exports as a share of GDP.[34] It is not clear why net values should only be used for these two cases. Export processing zones have a strong presence in numerous countries in Asia and Latin America, causing the gross measure to overstate the true level of manufacturing-related factors in these economies.[35] The issue turns out to be central to the finding of a curse. When we replicate the Sachs-Warner results using either a net measure of resource exports or the gross export measure without the adjustments for the two countries, the negative impact of natural-resource abundance on growth disappears.[36]

The interpretation of the Sachs-Warner results is not clear even using their modified data. Sala-i-Martin, Doppelhofer, and Miller, who search for robust regressors across millions of growth regressions, find a persistent negative sign when the proxy enters, but it is not robust enough to be considered a core explanatory variable for growth since other variables appear to absorb its influence.[37] In a similar vein, we show that the negative impact of resources

32. Sachs and Warner (1995a, 1997a, 1997b, 1999, 2001).

33. Their main findings are presented in Sachs and Warner (1997b). The other papers (Sachs and Warner 1995b, 1997a, 1999, 2001) contain the same basic results, at times using a slightly longer time span (1965–90 instead of 1970–89) and often including additional time-invariant explanatory variables such as dummies identifying tropical and landlocked countries, as well as some additional social variables. They use the same data as Barro (1991); Mankiw, Romer, and Weil (1992); and de Long and Summers (1992).

34. See the data appendix in Sachs and Warner (1997b).

35. The variable also shows substantial volatility over time, reflecting terms-of-trade movements; hence the average for the period is probably a better measure than the initial period value that was used by Sachs and Warner in several of their papers.

36. Lederman and Maloney (2007b).

37. Sala-i-Martin, Doppelhofer, and Miller (2004).

also goes away when we control for fixed effects in a panel context. This suggests that it is not Sachs and Warner's particular proxy, but its correlation with unobserved country characteristics that is driving the result.[38] Manzano and Rigobon concur: they argue that the cross-sectional result arises from the accumulation of foreign debt during periods when commodity prices were high, especially in the 1970s, which produced a stifling debt overhang when prices fell.[39] These results, and the analogy to other bubbles, not only further dispel the alleged curse of natural resources, but also imply that the right levers for addressing the lackluster performance of resource-rich developing countries in recent decades lie in the realm of macroeconomic policy rather than trade or industrial policies.

Bravo-Ortega and De Gregorio use the same proxy (as well as natural resource exports over total merchandise exports), and they also find a negative cross-sectional impact but trace its origin to a Dutch disease effect working through human capital.[40] Adding an interactive human capital term suggests that as the stock of human capital rises, the marginal effect of the stock of natural resources on income growth rises and becomes positive. This is broadly consistent with Gylfason, Herbertsson, and Zoega's argument that a national effort in education is especially necessary in resource-rich countries, although without their hypothesis that resource-rich sectors intrinsically require, and thus induce, less education.[41] However, Bravo-Ortega and De Gregorio find that the point at which resources begin to contribute positively to growth occurs at around three years of education, a level achieved by all but the poorest countries.

Sachs and Vial as well as Sachs and Warner confirm a negative and robust relationship using a second, related proxy—namely, the share of natural resources exports in total exports—and this proved somewhat more robust.[42] It does not, however, make Sala-i-Martin, Doppelhofer, and Miller's core of robust regressors.[43] Furthermore, the resource curse disappears when we include a generic measure of concentration (namely, the Herfindahl index) and use export data disaggregated at the four-digit level of the Standard International Trade Classification (SITC).[44] The curse is one of concentration, not

38. Lederman and Maloney (2007b).
39. Manzano and Rigobon (2007).
40. Bravo-Ortega and De Gregorio (2007).
41. Gylfason, Herbertsson, and Zoega (1999).
42. Sachs and Vial (2002); Sachs and Warner (1995a, 1995b).
43. Sala-i-Martin, Doppelhofer, and Miller (2004).
44. Lederman and Maloney (2007b).

resources. This finding is consistent with Auty's concern about a resource drag on growth arising from the limited possibilities of diversification within commodities, although Lederman and Xu argue that diversification into non-resource sectors from a strong resource base is feasible.[45]

Leamer argues that standard Heckscher-Ohlin (H-O) trade theory dictates that the appropriate measure is net exports of resources per worker.[46] This measure has been the basis for extensive research on the determinants of trade patterns.[47] It is our preferred measure in earlier work because it obviates the Singapore issue by netting out resource exports from the beginning.[48] Both cross-section and panel estimations across the Sachs-Warner period yield either insignificant or positive results. Using Maddison's growth data from 1820–1989, Maloney finds suggestive evidence of a positive growth impact of resources from 1820 to 1950, but a negative impact thereafter, driven by Latin America's underperformance.[49]

Finally, a set of papers explores more direct measures of mining production or reserves. Stijns finds no correlation between fuel and mineral reserves and growth in 1970–89.[50] This confirms earlier work by Davis, who documents that mineral-dependent economies, defined by a high share of minerals in exports and GDP, did well relative to other countries in the 1970s and 1980s.[51] Across their several million regressions, Sala-i-Martin, Doppelhofer, and Miller find the mining share in GDP to be consistently positive and to hold a position in the core of explanatory variables.[52] Nunn (2008) reports a positive partial correlation between per capita production of gold, oil, and diamonds

45. Auty (2000); Lederman and Xu (2007).

46. Leamer (1984).

47. For example, Trefler (1995); Antweiler and Trefler (2002); Estevadeordal and Taylor (2002). Assuming identical preferences, a country will show positive net exports of resource-intensive goods if its share of productivity-adjusted world endowments exceeds its share of world consumption. Usually, the net exports are then measured with respect to the quantity of other factors of production, such as the labor force.

48. Lederman and Maloney (2007b). It is worth mentioning that the cited references show that the H-O model of factor endowments performs relatively well for natural resources net exports, but it performs less well for manufactures. The current debate in the trade literature revolves around the question of how the H-O model might be amended (by considering, for example, technological differences across countries, or economies of scale) to help predict better the observed patterns of net exports across countries. But there is not debate about the use of net exports as a proxy for revealed comparative advantage in this literature.

49. Maddison (1994); Maloney (2007).

50. Stijns (2005).

51. Davis (1995).

52. Sala-i-Martin, Doppelhofer, and Miller (2004).

and GDP per capita, in an analysis of long-term fundamental determinants of development, with a special focus on the role of the slave trade and its concomitant economic consequences for African economies.[53] Most recently, Brunnschweiler (2008) finds that per capita mineral and fuel production in 1970 have direct positive effects on economic growth during 1970–2000.[54]

The resource curse thus remains elusive. The cross-country econometric evidence remains weak, with results changing depending on the empirical proxies used to represent relative endowments. Moreover, surprisingly few efforts have been made to understand the theoretical content of trade-data proxies. The following section puts the literature in theoretical context, which in turn helps motivate our empirical strategy.

Clarifying the Curse

Some simple algebra helps clarify some dimensions of the curse and possible approaches and pitfalls to measuring it. Start with a two-factor, two-good economy, where labor is initially immobile across sectors and where endowments of natural resources can only be used to produce natural-resource-intensive commodities. We denote the natural-resource sector by subscript nr and the rest of the economy by subscript 1. Domestic equilibrium in the labor market pertains when all labor, L, is fully employed:

$$L = L_1 + L_{nr}. \tag{1}$$

National income is simply the sum of the income produced by each sector:

$$Y = Y_1 + Y_{nr}. \tag{2}$$

Let K denote the endowment (stock) of natural resources, which are used only in the production of related commodities.[55] Each sector has a production function determined by sector-specific technologies with constant returns to scale:

$$Y_1 = a_{1L} L_1, \tag{3}$$

and

53. Nunn (2008).
54. Brunnschweiler (2008).
55. The modeling approach with a stock of productive resources is standard in the growth literature, and it also appears in recent studies of natural resource production functions (Peretto 2008).

(4) $$Y_{nr} = a_{nr} K^b L_{nr}^{1-b}.$$

National income is therefore

(5) $$Y = a_{1L}\left(L - L_{nr}\right) + a_{nr} K^b L_{nr}^{1-b}.$$

The *a* variables are technologically determined productivity parameters. In the case of sector 1, $a_1 L$ is output per worker, which is always positive. In the case of the natural resource sector, a_{nr} is the output per complementary units of *K* and *L*. Parameter *b* is the natural-resource share in output of that sector, and it is bounded by zero and one.

Fully differentiating equation 5 illustrates that the marginal effect of natural resource endowments on national income has three components, under the assumptions that the marginal effect on the total labor force is zero (that is, $\partial L/\partial K = 0$) and the marginal effect on *K*'s share in natural resource output is also unaffected:

(6) $$\frac{\partial Y}{\partial K} = \left(\frac{\partial a_{1L}}{\partial K}\right)\left(L - L_{nr}\right) + \left(\frac{\partial a_{nr}}{\partial K}\right) K^b L_{nr}^{1-b} + \left(\frac{\partial L_{nr}}{\partial K}\right)\left[\left(1-b\right)a_{nr} - a_{1L}\right]\left(\frac{K}{L_{nr}}\right)^{b} + b a_{nr}\left(\frac{K}{L_{nr}}\right)^{b-1}.$$

The first two elements in equation 6 are the effects of marginal changes or differences in *K* on factor productivities. The literature on the voracity effect, for example, can be interpreted as negative first derivatives of productivity with respect to *K*. As Rodríguez points out, the empirical endogenous growth literature revolves around the issue of the multiplicity of variables that could affect an economy's efficiency of factor use, and institutions are part of that debate.[56] The third element is the marginal effect of *K* on *Y* through the reallocation of labor, that is, the Dutch disease effect. If labor in the natural resource sector increases, then income from the rest of the economy falls as it loses labor, but output rises in the natural resource sector. The net effect of the reallocation effect will depend on the difference in the effective labor productivities across the two sectors. This issue is usually framed in one of two ways: either the alternative sector, perhaps manufactures, exhibits some externality, or the private optimization that led to the reallocation of labor

56. Rodríguez (2007).

somehow implies a social loss. The fourth term is the marginal effect on the output of the natural resource sector, which is equal to the marginal productivity of K's share in the natural resource output.

In a nutshell, various strands of the curse literature argue that, with greater or lesser weight put on particular arguments,

$$\left(\frac{\partial a_{1L}}{\partial K}\right) < 0, \left(\frac{\partial a_{nr}}{\partial K}\right) < 0 \text{ and/or} \quad (7)$$

$$\left(\frac{\partial L_{nr}}{\partial K}\right)\left[\left(1-b\right)a_{nr} - a_{1L}\right]\left(\frac{K}{L_{nr}}\right)^{b} < 0,$$

such that

$$\left(\frac{\partial a_{1L}}{\partial K}\right)\left(L - L_{nr}\right) + \left(\frac{\partial a_{nr}}{\partial K}\right)K^{b}L_{nr}^{1-b} \quad (8)$$

$$+\left(\frac{\partial L_{nr}}{\partial K}\right)\left[\left(1-b\right)a_{nr} - a_{1L}\right]\left(\frac{K}{L_{nr}}\right)^{b} < -ba_{nr}\left(\frac{K}{L_{nr}}\right)^{b-1}$$

in the long run.

Unfortunately for empirical work, K is unobserved. Even data on known mining reserves are inadequate, since endogenous investments in exploration lead to new discoveries. As discussed, some studies use output of oil or mining as a share of GDP, which appear to be positively correlated with GDP per capita or subsequent economic growth.[57] Other studies use gross export receipts as a share of total merchandise exports or as a share of GDP.[58] These proxies of natural resource dependence are found to be positively correlated with GDP per capita, but they are often found to be negatively correlated with subsequent growth.[59]

57. For example, Nunn (2008); Sala-i-Martin, Doppelhofer, and Miller (2004).

58. For example, Sachs and Warner (1997a, 1997b, 2001); Bravo-Ortega and De Gregorio (2007); Gylfason (2001).

59. Bravo-Ortega and De Gregorio (2007) find a positive correlation with per capita GDP. Isham and others (2005) use dummy variables to identify countries according to export structures by looking only at the top two merchandise exports (according to the three-digit SITC), which further confounds the notion of natural resource dependence. Moreover, as mentioned earlier, papers that rely on the Sachs and Warner data are actually using observations based on the gross exports of natural resources as a share of merchandise exports, while a couple of observations (Singapore and Trinidad and Tobago) are actually net exports of natural resources.

Empirical Strategy

The above discussion suggests that the resource curse, like Dracula, is hard to nail down empirically. Getting the right proxy for resource abundance, and understanding its properties, is critical to establishing the credibility of any empirical finding. The mining reserve measures are closest to measuring true abundance, but they capture only a narrow range of products and hence do not obviate the need for a trade-based proxy.

In taking up the search for the curse again, we follow the vast literature on growth empirics but include a couple of innovations that help us identify a floor for the effect of natural resource endowments. A key innovation is the inclusion of the trade-data indicator of relative endowments, which has the desirable property of having an expected positive correlation with natural resource endowments per worker, which is not the case for the preferred proxies used by believers in the resource curse. We also choose an institutional variable that is commonplace in the institutions and growth literature concerning the powers of the executive branch of government, which has been absent in the empirical literature on voracity effects.

Empirical Strategy: Static and Dynamic Growth Models

If relative endowments were observed, an empirical income function consistent with the economic growth literature could be written as

$$y_i = a + h\left[\ln\left(\frac{K}{L}\right)_i\right] + f'\mathbf{X}_i + e_i, \tag{9}$$

where the subscripts represent countries, a is the intercept, y is the natural logarithm of GDP per capita adjusted for purchasing power parity, $\mathbf{X}$ is a matrix of other determinants of cross-country income differences, and e is assumed to be white noise error. We call this the static growth model.[60]

The general form of the dynamic empirical growth model found in the literature since Barro is as follows:[61]

$$y_{it} - y_{it-1} = a + g\left(y_{it-1}\right) + h\left[\ln\left(\frac{K}{L}\right)_{it}\right] + f'\mathbf{X}_{it} + e_{it}. \tag{10}$$

60. The corresponding literature includes Frankel and Romer (1999); Acemoglu, Johnson, and Robinson (2001); Glaeser and others (2004); Acemoglu and Robinson (2005); and Nunn (2008).

61. See Barro (1991).

The obvious difference between equations 9 and 10 is the inclusion of the lagged dependent variable as a regressor. Parameter g is the so-called convergence coefficient, which is interpreted as the conditional rate of convergence between poor and rich countries when $g < 0$. This model is the dynamic version of equation 9, and $g - 1$ is equal to the autoregressive coefficient of y, because the lagged value of y also appears with a negative sign on the left-hand side. We present estimates of the static and dynamic growth models, but with K/L replaced with a proxy discussed below.

A Proxy of Relative Endowments with Desirable Properties: Net Exports per Worker

A good proxy has to be positively correlated with the relevant endowments, so that we can interpret a growth regression coefficient as truly capturing the effect of these endowments. Our preferred indicator is net exports per worker. Net exports are simply the difference between what is produced and what is consumed in the domestic market:

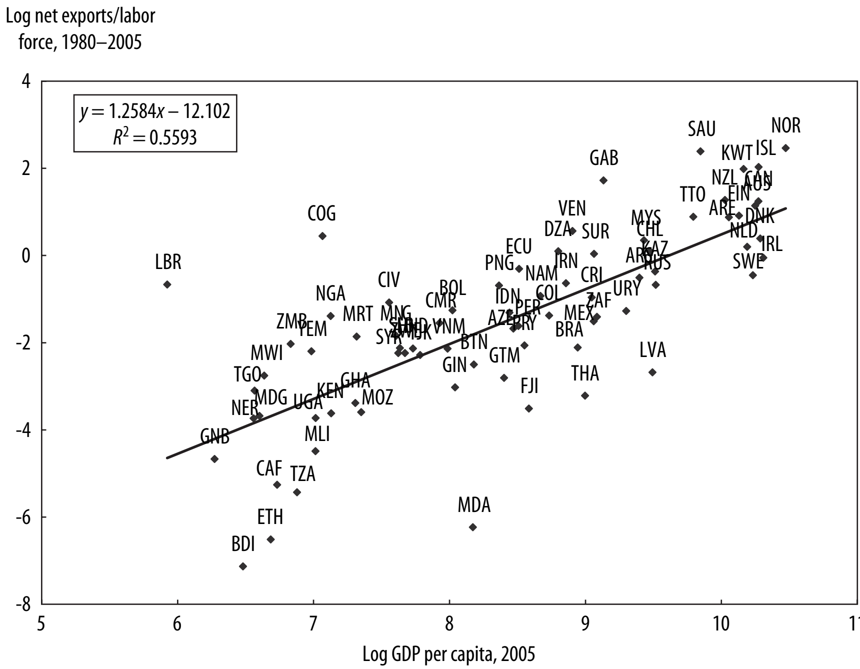
$$\text{(11)} \qquad \frac{NX}{L} = \frac{\left(Y_{nr} - C_{nr}\right)}{L} = \left(1 - c_{nr}\right) a_{nr} \left(\frac{K}{L_{nr}}\right)^{b} - c_{nr} a_{1L} \left(1 - l_{nr}\right),$$

where $0 \leq l_{nr} = (L_{nr}/L) \leq 1$ and $0 \leq c_{nr} \leq 1$. The selling point of this indicator is that it strictly rises with K/L, because the consumption of natural resources is a fraction of total income, $0 < c_{nr} < 1$, and, in a standard Rybczynski effect, labor is attracted to the resource sector as the endowments expand:

$$\text{(12)} \qquad \frac{\partial\left(NX/L\right)}{\partial\left(K/L\right)} = b\left(1 - c_{nr}\right) a_{nr} \left(L_{nr}\right)^{-b} K^{b-1} L \frac{\partial l_{nr}}{\partial\left(K/L\right)} + c_{nr} a_{1L} \frac{\partial l_{nr}}{\partial\left(K/L\right)} \geq 0.$$

The indicator is not without flaws, however. When used as a proxy for K/L in the estimation of income or growth models, it results in two distinct problems, which are both related to the consumption of natural resources. First, the fact that income growth increases natural resource consumption introduces a biased estimate of the partial correlation between NX/L and y. This issue strikes us as nontrivial. Figures 1 and 2 show the relationship between the log of the absolute value of average net exports per worker in 1980–2005 and the log of GDP per capita for exporters and importers of natural

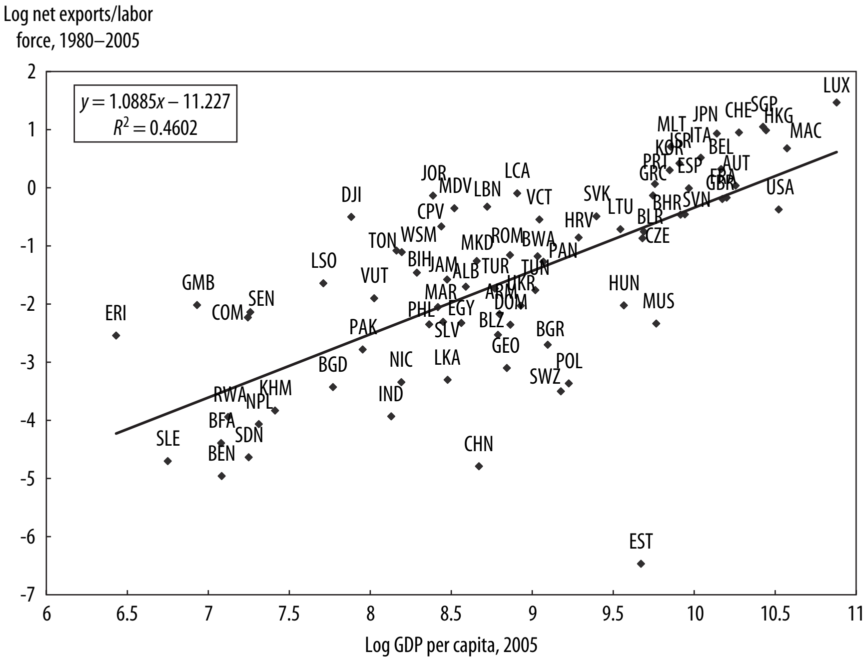
FIGURE 1. Net Exporters of Natural Resources in 1980–2005 and Real GDP per Capita in 2005



resources, respectively. There is a strong positive correlation for both subsamples, and the bivariate elasticity is close to one in both cases. While the positive correlation of exports and income among the net exporters suggests that there is no resource curse in levels, the strong negative correlation among net importers of natural resources strikes us as most plausibly evidence of increased consumption of natural resources with development, with potentially symmetrical effects on imports and exports. This issue is even more extreme when a rise in income from non-resource-related sectors leads to an increase in consumption of resources, giving rise to a negative correlation of growth and *NX/L.* If this is the case, and the analysis in appendix A suggests it is algebraically likely, then the negative bias of the coefficient of net exports is substantial.

The second problem created by the use of our preferred proxy, which is related to a consumption effect of increases in *K/L,* affects the inferences that can be drawn even from unbiased estimates of the (causal) partial correlation

FIGURE 2. Net Importers of Natural Resources in 1980–2005 and Real GDP per Capita in 2005



between Y and NX/L. It is clear from equation 12 that a rise in endowments also gives rise to increased imports and, symmetrically, decreased exports of natural resources that mutes the degree to which movements in NX/L reflect movements in K/L.

To moderate the bias in the estimate of the coefficient of NX/L in income and growth functions, we include imports of natural resources per worker as an additional regressor in the empirical models. Under the assumption that there is also a symmetrical effect on exports, then the sum of the coefficients on NX/L and M/L is a good approximation of the effect of NX/L on y. After this adjustment, we still need to be careful about drawing inferences about the effect of K/L on y based on this unbiased estimate, because it is still potentially a magnified effect of K/L on y—see appendix A.

Still, we think this proxy is preferable to other popular indicators of natural resource dependence used in the curse literature simply because these are not strictly positively correlated with K/L. In addition to the entrepôt problem discussed earlier (Singapore), the ratio of gross natural resource exports over

GDP could potentially be negatively correlated with *K*, since a rise in *K* leads to a rise in exports, which may be less than any induced rise in *Y*.[62] Gross exports of natural resources (which are an unknown fraction of national production) as a share of total merchandise exports can be negatively correlated with *K*/*L* when the share of natural resource consumption resources in national income, such as agricultural products and food, is larger than the consumption share of other goods. Though it may be interesting as a measure of natural resource exports per se, and perhaps more generally as the concentration of exports, it is not an especially good measure if the goal is to show that resource endowments themselves are pernicious.

Executive Constraints as a Key Institutional Variable and Other Controls

As Levine and Renelt first pointed out in the growth context, cross-country growth regressions are sensitive to the control variables included in the specification.[63] A substantial portion of the empirical growth literature focuses on the neoclassical growth model, in which the basic conditioning variables are related to capital accumulation and growth of the labor force per unit of capital. In this regard, we follow the classic paper by Mankiw, Romer, and Weil in our most fully specified models.[64]

With regard to institutions, the recent literature on the resource curse emphasizes the role of so-called point-source resources. Isham and others define point-source natural resources as "those extracted from a narrow geographic or economic base, such as oil, minerals (such as copper and diamonds), and plantation crops (such as sugar and bananas)."[65] They argue that "where extractive institutions were initially laid down, they soon consolidated themselves in ways that reduced the likelihood that over time they would have an interest in generating—or in being subjected to countervailing pressures to generate—either more diverse revenue (export) streams or more open political structures."[66] These statements imply that natural resources should be positively correlated with political characteristics that entail weak checks and balances, which would otherwise limit the capacity of the rentier elites to control these resources, and public policies that might hamper

62. It is straightforward calculus to derive these conditions. They are available on request.
63. Levine and Renelt (1992).
64. Mankiw, Romer, and Weil (1992).
65. Isham and others (2005, p. 143).
66. Isham and others (2005, pp. 145–46).

economic diversification. The literature suggests that such institutional characteristics are negatively correlated with long-term GDP per capita.

It is possible, however, that the resource curse might come alive under certain institutional arrangements. That is, natural resources might not produce poor institutions as suggested by Isham and others, but they might hamper development when they interact with certain types of political institutions. For example, since the voracity effect is a problem of governing the commons, political institutions that yield multiple, fragmented coalitions might be associated with a natural resource curse. This is the argument by Sala-i-Martin and Subramanian.[67] This is a different argument about the heterogeneity of the effects of natural resources, similar to the concerns raised by Dunning.[68] It is entirely consistent with the idea that natural resources might not necessarily produce institutional outcomes that, in turn, interact with natural resources to produce a curse. Our empirical exercises focus on testing this latter hypothesis, and we leave it for future research to test for interactions between institutions and natural resources as the source of the curse.

In light of the above discussion, we include four interactive terms in the estimation of equation 9. Dummy variables for net exporters and net importers are multiplied by the natural logarithm of the absolute value of net exports of natural resources per worker. In addition, the log of natural resource imports per worker is also interacted with the relevant dummies.

As mentioned, coefficient heterogeneity is a concern in growth regressions. To assess the possibility that resources have heterogeneous effects because of interactions with other unobservables, such as institutional quality, we estimate quantile regressions of our basic model with only two conditioning variables (namely, the Sachs-Warner reform index and the growth of terms of trade), followed by a more fully specified model that includes macroeconomic volatility as well as Mankiw, Romer, and Weil's neoclassical growth variables.[69] The recent literature includes other approaches to dealing with heterogeneity in growth regressions.[70] Quantile regressions, however, provide estimates of the coefficients across the conditional distribution of the sample, for example, by allowing the bottom 25 percent of observations to be below the predicted values, while at the same time estimating the coefficients conditional on having 50 percent of the sample above and below the predictions, as

67. Sala-i-Martin and Subramanian (2003).
68. Dunning (2008b).
69. Mankiw, Romer, and Weil (1992).
70. See Durlauf, Kourtellos, and Minkin (2001).

well as the top 75 percent of the sample. If the coefficients are sufficiently different, then we can conclude that resources have distinct effects in different country contexts. The regression errors from each quantile are allowed to be correlated, and they are bootstrapped (with a hundred interactions of random subsamples) because they are unknown a priori.

The discussion of the quantile regressions is followed by the presentation of three-stage least squares (3SLS) estimations of the basic and the fuller specifications of equation 9, but adding Acemoglu, Johnson, and Robinson's institutional variable.[71] We explore the role of institutions (namely, constraints on the executive branch), which could be affected by the relative abundance of natural resources according to the resource curse hypothesis. We follow the relevant literature on institutions and growth by complementing the static GDP per capita function with the population densities of countries circa 1500 as the identifying instrumental variable of the 3SLS estimator, which is the approach of Acemoglu and Robinson and of Glaeser and others.[72] The 3SLS procedure allows for the simultaneous estimation of the growth and institutional equation, with different explanatory variables in each structural equation. For example, imports of natural resources per worker appear in the growth equation, but not as a determinant of executive constraints.

Data and Bivariate Correlations

Standard publicly available sources offer all the necessary data to implement our empirical strategy. The relevant variables are averaged over 1980–2005. The next subsection briefly describes the variable definitions and data sources;

71. Acemoglu, Johnson and Robinson (2002); Acemoglu and Robinson (2005).

72. Acemoglu and Robinson (2005); Glaeser and others (2004). The estimation of per capita GDP in levels using 2SLS entails numerous pitfalls, even when we can conclude that the instrumental variable is correlated with the endogenous explanatory variable but not with the dependent variable. One is that the chosen instrument could be weak in the sense of explaining a very low share of the variance of the endogenous variable (executive constraints in this application); see Dollar and Kraay (2003) for a similar application. Another related pitfall is that the variance of the endogenous variable that explains the variance of the dependent variable should be related to the variance of the instrumental variable; see Dunning (2008b). As discussed in the results section, these issues became unimportant since we do not find much evidence that executive constraint affects the underlying relationship between our proxy for relative natural resource endowments and development.

see table B-1 in appendix B for the full list. We then present the descriptive statistics for net exports of natural resources and performance.

Variable Definitions and Data Sources

The dependent variables are real GDP per capita, its average annual growth rate between 1980 and 2005, and the average annual growth rate in each five-year period. The data come from the latest version of the Penn World Tables, which has data until 2004. We derive data for 2005 by applying the real growth rate of GDP per capita in local currency and constant domestic prices between 2004 and 2005.

The main explanatory variable of interest is the natural logarithm of the absolute value of net exports of natural resources per worker. The trade data come from the United Nations Commodity Trade Statistics Database (UN COMTRADE), as downloaded from the World Bank's data server. The commodity groups of products classified as being intensive in the use of natural resources are Leamer's nonmanufacturing commodities.[73]

With regard to the conditioning variables, we examine how changes in the model specification affect the coefficient on the natural resource variables.[74] The initial multivariate regression model specification includes two variables in addition to the natural resource proxies: (a) the share of years during 1980–1999 when the dummy variable for policy reform was observed, as per the data in Wacziarg and Welch and in Sachs and Warner; and (b) the average annual growth of the terms of trade during 1980–2005, based on data from the World Bank's *World Development Indicators.*[75]

The augmented model includes the executive constraints variable, which is the institutional variable used in Acemoglu and Robinson and in Glaeser and others.[76] The data come from the Polity IV database and have a value that ranges between 1 and 7, with higher values representing less discretion for the executive branch. The econometric models include the natural logarithm of this variable, which makes it easier to interpret coefficient estimates as

73. Leamer (1984, 1995).

74. The strategy is outlined in Lederman and Maloney (2007b).

75. Wacziarg and Welch (2002); Sachs and Warner (1995a, 1995b); World Bank (http://publications.worldbank.org/ecommerce/catalog/product?item_id=631625 [November 2007]). The policy reform index equals 1 if import tariffs are below 40 percent, if there are no significant nontariff barriers, if governments have privatized a significant share of public enterprises, and if the foreign exchange black market premium is below a certain threshold (see appendix B for details).

76. Acemoglu and Robinson (2005); Glaeser and others (2004).

elasticities. The literature argues that constraints on the executive branch should be partially negatively correlated with historical population density, in the first stage of 2SLS estimations.[77] Given the limited coverage of the historical population density variable, we present two sets of 3SLS estimations of the static and dynamic models; one with the limited sample and another with a sample that incorporates observations with imputed values for population density circa 1500. This allows for a discussion about how the limited sample affects the estimated coefficients.[78]

Macroeconomic volatility can also affect economic performance, especially private investment. To the extent that natural resources have higher price volatilities than other goods, this might be a channel through which they affect growth performance. Our measure of macroeconomic uncertainty is the standard deviation of the monthly variation of the log of the real effective exchange rate from *International Financial Statistics,* published by the International Monetary Fund (IMF).[79]

Mankiw, Romer, and Weil's empirical neoclassical growth model includes, in addition to the level of education of the population and the investment rate, the growth of effective units of labor, which is the observed growth of labor for each country minus a global capital depreciation rate plus an estimate of

77. High population densities circa 1500 are presumably associated with the localization of extractive activities and slave trade rather than with permanent settlement. Acemoglu and Robinson (2005, p. 960) state, "The second determinant of European colonization strategy was initial indigenous population density. Where this was high, Europeans were more likely to 'capture' the local population and put it to work in some form of forced labor system. Where initial population density was low, Europeans were more likely to settle themselves and less likely to develop extractive institutions even when they did not settle." Acemoglu, Johnson, and Robinson (2002) provide evidence that for countries colonized by European powers there is a strong negative relationship between population density in 1500 and income per capita today. This relationship is driven by the fact that former colonies with greater population density in 1500 had, and still have, worse property rights institutions. The density of indigenous population per square kilometer in 1500 is therefore an appealing alternative instrument. Because settler mortality and population density in 1500 correspond to different sources of variation in practice (the correlation between the two measures is 0.4), but should have similar effects on property rights, using these two instruments separately is a good check on our results." If the curse-via-politics hypothesis is correct, then we also expect a negative partial correlation in the first-stage equation between our proxy for relative natural resource abundance and the executive constraints index. Finally, Glaeser and others (2004) argue that education trumps institutions. This issue will be important in the interpretation of our results, since we also control for capital accumulation and human capital.

78. The imputed values are estimated using all the other explanatory variables in the equation of the determinants of executive constraints, namely, the log of the absolute value of net exports of natural resources, growth of the terms of trade, and regional dummies.

79. This follows Servén (2003).

the global rate of technological progress.[80] Mankiw, Romer, and Weil assume that the rate of technological progress minus the rate of capital depreciation is equal to 0.05 per year. If the neoclassical growth model is correct, the expected coefficient on the log of the growth of the effective labor force should be around –0.5. Mankiw, Romer, and Weil find this to be within the confidence intervals of the relevant coefficient only for growth regressions with a sample of high-income OECD countries, but not for samples with developing countries. For the sake of consistency, we include the Mankiw-Romer-Weil variable in both the levels and the growth regressions.

Lastly, in light of evidence from the quantile regressions suggesting that there is substantial heterogeneity in the intercepts (see below), we also include regional dummy variables in the 3SLS cross-sectional estimations of the static and dynamic models. The regions are classified into seven groups according to the World Bank's regional groups, as described in table B-1 in appendix B.

Descriptive Statistics of Net Exports of Natural Resources and Performance

Table 1 shows the average annual variation in the terms of trade, the average annual growth of GDP per capita, the average value of the executive constraints index, and the average growth of exports and imports of natural resources in current U.S. dollars. The data show the average of each indicator for countries that were net exporters in all five-year periods during 1980–2005, countries that were net importers in all periods, and two groups of switchers. The lower panel of the table contains the corresponding information for the sample of Latin American and Caribbean economies with available data. The vast majority of countries in the data were either net exporters or net importers, and the number of switchers is small. In the case of Latin America and the Caribbean, the switchers were four small economies, including El Salvador (which became a net exporter, on average, only during 1985–89), Guatemala, Nicaragua, and Paraguay (which was a net importer only in 1995–99).

The net exporters of natural resources experienced terms-of-trade deteriorations, on average, while net importers experienced slight improvements. In the sample period, the Prebisch-Singer hypothesis on the deterioration of the terms of trade could be present, but variations in these relative prices would need to affect either the level of GDP per capita or economic growth in the

80. Mankiw, Romer, and Weil (1992).

TABLE 1. Net Exporters, Net Importers, and Switchers: Selected Indicators[a]
Percent

Sample and country group	*Terms-of-trade growth*	*GDP per capita growth*	*Executive constraint*	*Natural resource imports growth*	*Natural resource exports growth*
All countries, observations with data					
Net natural resource exporters in all periods	−0.41	0.61	3.97	2.22	1.41
	(53)	(59)	(58)	(54)	(54)
Net natural resource importers in all periods	0.11	2.18	4.88	3.31	3.55
	(63)	(72)	(57)	(69)	(69)
Net exporters that became net importers in any period after 1985	0.83	−0.33	3.60	−2.47	−0.64
	(7)	(11)	(10)	(10)	(10)
Net importers that became net exporters in any period after 1985	0.21	1.29	4.05	3.35	7.40
	(12)	(14)	(14)	(13)	(13)
Latin America and the Caribbean					
Net natural resource exporters in all periods	−0.42	0.34	5.48	2.56	2.64
	(15)	(14)	(13)	(15)	(15)
Net natural resource importers in all periods	0.01	1.56	4.99	−0.68	−2.07
	(6)	(9)	(4)	(8)	(9)
Net exporters that became net importers in any period after 1985	0.42	−0.63	4.34	3.94	4.53
	(3)	(3)	(3)	(3)	(3)
Net importers that became net exporters in any period after 1985	−0.49	0.88	5.00	6.00	2.66
	(1)	(1)	(1)	(1)	(1)

a. The table covers the period 1980–2005. The numbers in parentheses indicate the number of countries in each group.

long run for the curse to operate through this channel. Relevant econometric evidence is discussed in the next section.

With respect to executive constraints, table 1 shows that for the global sample, net exporters of natural resources do tend to have lower scores than net importers. This is not true for the sample of Latin American and Caribbean economies, where net exporters actually have higher constraints on the executive branch. In fact, both net exporters and net importers of natural resources in Latin America and the Caribbean had higher average scores than the rest of the global averages during this period.

The growth performance of the net importers was superior to the average of the net exporters. Surprisingly, however, the net importers of natural resources experienced significantly higher growth rates of the value of natural resource exports than the net exporters, in the global sample. Hence, even in this cursory look at the data, it is not clear that growth of natural resource exports per se is in any systematic way related to low growth.

Results

Our results are reported in tables 2 through 5. Table 2 shows the results from the quantile regressions applied to the static model with both sets of control variables (but without regional dummies). Table 3 reports the corresponding estimations of the dynamic model. Tables 4 and 5 contain the 3SLS estimations of both models, including the results with the larger samples that use the imputed values of historical population densities. All tables report the probability values of the null hypothesis that the sum of the coefficients on net exports and imports per worker is zero.[81] For ease of exposition, the coefficients on most of the other explanatory variables and the tests for equivalence of coefficients across quantiles are not reported in the tables, but they are briefly discussed in the text below.

Quantile Regressions

In table 2, the basic model is reported under column 1. Although only the coefficients on imports per worker are statistically significant across all quantiles, the *F* tests suggest that the effect of *NX*/*L* on GDP per capita is statistically significant for all quantiles. The implied elasticities are about 0.75 for the first quantile, 0.66 for net exporters and 0.46 for net importers in the second quantile, and 0.58 and 0.51, respectively, in the third quantile. This evidence implies that natural resources are a blessing for growth, but there is notable heterogeneity across quantiles in this basic specification of the static model. Even if the average share of natural resource consumption in national income was 50 percent, the effect of *K*/*L* on GDP per capita would be quite large, ranging between 0.23 and 0.38. Interestingly, the significantly highest elasticities are those of the lowest quantile, which also have the lowest intercepts and are thus the low-income countries.

The fully specified static model reported under column 2 provides more mixed evidence of a blessing effect. First, the implied effect is significant only among net exporters in the three quantiles (see the *F* tests reported at the bottom of the table). These blessing effects have implied elasticities in the range of 0.30–0.36, and there is no evidence of cross-quantile heterogeneity. Contrary to the curse hypothesis, it seems that the heterogeneous blessing effect is associated with macroeconomic volatility or Mankiw-Romer-Weil

81. For the subsamples of net importers, the sum is the negative of the coefficient on the log of the absolute value of net exports per worker plus the corresponding coefficient on imports per workers.

TABLE 2. Quantile Regression Results of the Basic Model without Regional Dummies: Static Model[a]

Explanatory variable	*(1)*	*(2)*
Quantile 25		
Positive ln (*NX/L*)	0.205	0.120
	(1.93)	(1.17)
Negative ln abs(*NX/L*)	−0.015	0.028
	(0.20)	(0.25)
Positive ln (*M/L*)	0.541	0.184
	(4.56)**	(1.61)
Negative ln (*M/L*)	0.730	0.304
	(5.69)**	(0.92)
Quantile 50		
Positive ln (*NX/L*)	0.087	0.098
	(1.21)	(1.96)
Negative ln abs(*NX/L*)	0.068	0.084
	(1.28)	(0.98)
Positive ln (*M/L*)	0.569	0.261
	(6.60)**	(2.08)*
Negative ln (*M/L*)	0.528	0.164
	(8.07)**	(1.73)
Quantile 75		
Positive ln (*NX/L*)	0.122	0.088
	(2.57)*	(1.32)
Negative ln abs(*NX/L*)	0.026	0.086
	(0.52)	(0.82)
Positive ln (*M/L*)	0.460	0.240
	(6.83)**	(1.31)
Negative ln (*M/L*)	0.533	0.311
	(9.20)**	(1.84)
Constants		
Constant quantile 25	9.088	5.215
	(40.37)**	(3.94)**
Constant quantile 50	9.486	6.294
	(52.07)**	(3.54)**
Constant quantile 75	9.537	6.732
	(65.12)**	(2.74)**
Sum of coefficients		
q25: Positive ln(*NX/L*) + positive ln(*M/L*) = 0		
F test	0.746	0.304
P value	0.00	0.00
q25: Negative ln abs (*NX/L*) + negative ln(*M/L*) = 0		
F test	0.745	0.276
P value	0.00	0.32
q50: Positive ln(*NX/L*) + positive ln(*M/L*) = 0		
F test	0.656	0.359
P value	0.00	0.00

(*continued*)

TABLE 2. Quantile Regression Results of the Basic Model without Regional Dummies: Static Model[a] (*Continued*)

Explanatory variable	*(1)*	*(2)*
q50: Negative ln abs (*NX/L*) + negative ln(*M/L*) = 0		
F test	0.460	0.080
P value	0.00	0.44
q75: Positive ln(*NX/L*) + positive ln(*M/L*) = 0		
F test	0.582	0.328
P value	0.00	0.04
q75: Negative ln abs (*NX/L*) + negative ln(*M/L*) = 0		
F test	0.507	0.225
P value	0.00	0.47
No. observations	103	74

*Statistically significant at the 5 percent level; **statistically significant at the 1 percent level.

a. The dependent variable is the log of GDP per capita in 2005 (PPP dollars). Model 1 includes the Sachs-Warner reform index (average in 1980–2005) and average annual terms-of-trade growth. Model 2 includes the variables in model 1 plus real exchange rate volatility, the log of the average investment rate, the log of the average years of education, and the Mankiw-Romer-Weil variable. Other control variables are included but not reported (see text). Absolute values of *t* statistics are in parentheses.

factor accumulation (or both). Among the other explanatory variables, only educational attainment is significant in the second specification. The range of its coefficient is 0.75 in the lowest quantile to 0.49 in the highest quantile. But they are statistically different across quantiles.

The results in table 3 correspond to the dynamic growth model. The sums of the relevant coefficients in the basic model are statistically significant at the 5 percent level only for net importers in the second quantile and for net exporters and importers in the third quantile. Although all point estimates are positive, those for the highest quantile are the largest in magnitude, implying that a 1 percent increase in NX/L is associated with a rise of 1.1–1.9 percentage points in the average annual growth rate of GDP per capita during 1980–2005. The interquantile heterogeneity in growth rates thus appears to be different from the heterogeneity observed in the static model results reported in table 2. As in the static model, however, the results under column 2 of table 3 suggest that these blessing effects disappear when we control for macroeconomic volatility and factor accumulation.

With regard to other control variables in the dynamic growth models, we found significant cross-quantile heterogeneity in the convergence rate and in the coefficient of *M/L* in both specifications. Convergence is stronger in the second and third quantiles than in the first. Although not statistically different across quantiles, the Sachs-Warner reform index is positive and significant in the first two quantiles. Furthermore, the investment rate is positive and significant in the upper two quantiles.

TABLE 3. Quantile Regression Results of the Basic Model without Regional Dummies: Dynamic Model[a]

Explanatory variable	*(1)*	*(2)*
Quantile 25		
Positive ln (*NX/L*)	0.000	0.001
	(0.18)	(0.07)
Negative ln abs(*NX/L*)	−0.002	−0.003
	(0.81)	(0.33)
Positive ln (*M/L*)	0.004	0.000
	(1.21)	(1.03)
Negative ln (*M/L*)	0.003	0.000
	(0.74)	(1.52)
Quantile 50		
Positive ln (*NX/L*)	0.002	0.000
	(0.85)	(0.33)
Negative ln abs(*NX/L*)	−0.002	−0.007
	(0.68)	(1.53)
Positive ln (*M/L*)	0.004	−0.001
	(1.01)	(0.16)
Negative ln (*M/L*)	0.008	0.009
	(1.80)	(0.01)
Quantile 75		
Positive ln (*NX/L*)	0.003	0.000
	(1.25)	(0.17)
Negative ln abs(*NX/L*)	−0.004	−0.001
	(1.05)	(0.77)
Positive ln (*M/L*)	0.008	0.004
	(2.11)*	(0.11)
Negative ln (*M/L*)	0.015	0.000
	(2.24)*	(0.05)
Constants		
Constant quantile 25	0.003	−0.037
	(0.05)	(0.89)
Constant quantile 50	0.078	0.148
	(1.61)	(0.55)
Constant quantile 75	0.19	0.057
	(3.61)**	(2.46)*
Sum of coefficients		
q25: Positive ln(*NX/L*) + positive ln(*M/L*) = 0		
F test	0.004	0.001
P value	0.30	0.91
q25: Negative ln abs (*NX/L*) + negative ln(*M/L*) = 0		
F test	0.005	0.003
P value	0.14	0.96
q50: Positive ln(*NX/L*) + positive ln(*M/L*) = 0		
F test	0.006	−0.001
P value	0.06	0.75

(*continued*)

TABLE 3. Quantile Regression Results of the Basic Model without Regional Dummies: Dynamic Model[a] (*Continued*)

Explanatory variable	*(1)*	*(2)*
q50: Negative ln abs (*NX*/*L*) + negative ln(*M*/*L*) = 0		
F test	0.010	0.016
P value	0.16	0.61
q75: Positive ln(*NX*/*L*) + positive ln(*M*/*L*) = 0		
F test	0.011	0.004
P value	0.00	0.28
q75: Negative ln abs (*NX*/*L*) + negative ln(*M*/*L*) = 0		
F test	0.019	0.001
P value	0.02	0.12
No. observations	84	74

*Statistically significant at the 5 percent level; **statistically significant at the 1 percent level.

a. The dependent variable is average annual GDP per capita growth, 1980–2005. Model 1 includes the log of GDP per capita in 1980 (PPP dollars), the Sachs-Warner reform index (average in 1980–2005), and the average annual growth of terms of trade. Model 2 includes the variables in model 1 plus real exchange rate volatility, the log of the average investment rate, the log of the average years of education, and the Mankiw-Romer-Weil variable. Other control variables are included but not reported (see text). Absolute values of *t* statistics are in parentheses.

Overall the evidence from the quantile regressions suggests that it is important to control for heterogeneity in intercepts regardless of the model or sample. Also, there is significant heterogeneity in the effect of natural resources, although it appears strongly only in the static model and it is not particularly strong when compared with the intercept heterogeneity. The existing studies that argue that there might be heterogeneity in the effects of proxies of natural resource abundance might be confounding heterogeneity in other potential determinants of growth with heterogeneity of the effects of natural resources.[82] We leave this issue for future research. More importantly, any estimation of these models without some heterogeneity of intercepts is likely to confound the effects of the explanatory variables with differences in the intercepts of the levels and growth rates of GDP per capita. We therefore include regional dummies in the 3SLS estimations of the static and dynamic models discussed below. Future research, however, could use panel-data estimators to assess the effect of natural resources on growth while also controlling for heterogeneity.

Three-Stage Least Squares Estimates of the Static and Dynamic Models

Tables 4 and 5 contain the relevant results for our 3SLS estimates of the static and dynamic models with endogenous institutions. The first two columns

82. For example, Bravo-Ortega and De Gregorio (2007).

in both tables present the results of the basic model, columns 3 and 4 report on the fully specified model, and columns 5 through 8 contain the corresponding results with the augmented samples using the imputed values of historical population densities.

The blessing effects appear strong in table 4, although they are admittedly magnified, as discussed earlier. Indeed, the elasticity of 1 for the subsample of net importers is impossibly large. Moreover, there is no evidence that there is an indirect curse effect via institutional constraints on the executive branch of government, after controlling for regional dummies. Historical population density remains a good instrument, although it is only significant at the 10 percent level in the basic model under column 1.

In the fully specified static model presented in columns 3 and 4, the blessing effect remains significant only for the sample of net exporters of natural resources. This elasticity is close to 0.25. The elasticity for the subsample of net importers declined from a bit over 1 in the basic specification to about 0.19, and it is not statistically significant. Again, there is no evidence of a statistically significant average effect of *NX*/*L* on executive constraints. Furthermore, among the control variables, only the Sachs-Warner reform index is statistically significant and positive, and the Mankiw-Romer-Weil variable capturing the accumulation of effective labor units is negative and significant with a coefficient estimate of approximately −1.3.

The comparable results with the expanded samples are strikingly similar. In the basic model, there are significant blessing effects among net exporters and importers, with the respective elasticities of 0.49 and 0.38. Indeed, the latter estimate for net importers is much more reasonable than the estimate of close to 1 that appeared in the restricted sample. In the fully specified model under columns 7 and 8, the blessing effect remains significant, but only at the 10 percent level. Interestingly, there might be a blessing effect via institutions, because net exports per worker appear with a positive and significant coefficient in column 8. The point estimates are not significantly different from those reported in columns 1–4, however, suggesting that the results might not be driven by the small sample.

Table 5 also suggests that natural resources could be a blessing, even for growth in 1980–2005. This blessing effect is significant only among net importers in the restricted samples and the basic specification. In the fully specified model, but with the smaller corresponding sample, the blessing effect is significant only among net exporters. In both specifications, there is no evidence of an indirect curse effect via institutions.

TABLE 4. 3SLS Estimates of Models with Endogenous Institutions: Static Model[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Positive ln (*NX/L*)	0.156	–0.020	0.015	0.045	0.140	–0.013	0.055	0.059
	(2.29)*	(0.65)	(0.20)	(1.28)	(1.96)	(0.54)	(0.95)	(2.09)*
Negative ln abs (*NX/L*)	–0.105	–0.027	0.149	–0.061	0.069	–0.046	0.045	–0.031
	(0.91)	(0.69)	(1.24)	(1.51)	(1.03)	(1.64)	(0.72)	(0.95)
Positive ln (*M/L*)	0.351		0.233		0.350		0.131	
	(3.47)**		(2.16)*		(2.77)**		(1.38)	
Negative ln (*M/L*)	0.932		0.334		0.448		0.178	
	(4.50)**		(1.65)		(5.01)**		(1.57)	
Log executive constraints	1.416		1.427		1.972		1.148	
	(2.72)**		(2.28)*		(1.60)		(1.85)	
Log population density 1500		–0.079		–0.105				
		(1.96)		(3.12)**				
Imputed log population density 1500						–0.084		–0.102
						(2.14)*		(3.09)**
Sum of coefficients								
Positive ln(NX/L) + positive ln(M/L) = 0								
F test	0.507	. . .	0.248	. . .	0.490	. . .	0.190	. . .
P value	0.00	. . .	0.04	. . .	0.00	. . .	0.09	. . .
Negative ln abs(NX/L) + negative ln(M/L) = 0								
F test	1.040	. . .	0.019	. . .	0.380	. . .	0.130	. . .
P value	0.01	. . .	0.55	. . .	0.00	. . .	0.39	. . .
No. observations	51	51	43	43	98	98	71	71
R squared	0.77	0.63	0.89	0.73	0.65	0.62	0.92	0.75

*Statistically significant at the 5 percent level; **statistically significant at the 1 percent level.

. . . Not applicable.

a. In regressions 1, 3, 5, and 7, the dependent variable is the log of GDP per capita in 2005 (PPP dollars); in regressions 2, 4, 6, and 8, it is the log of executive constraints. Models 1 and 5 include the log of GDP per capita in 1980 (PPP dollars), the Sachs-Warner reform index (average in 1980–2005), the average annual terms-of-trade growth, and regional dummies. Models 2, 4, 6, and 8 include the average annual terms-of-trade growth (1980–2005) and regional dummies. Models 3 and 7 include the variables in model 1 plus real exchange rate volatility, the log of the average investment rate, the log of the average years of education, and the Mankiw-Romer-Weil variable. Other control variables are included but not reported (see text). Absolute values of *t* statistics are in parentheses.

TABLE 5. 3SLS Estimates of Models with Endogenous Institutions: Dynamic Model[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
Positive ln (*NX/L*)	–0.0021	–0.0205	–0.0012	0.0450	–0.0003	0.0001	–0.0007	0.0590
	(1.18)	(0.65)	(0.76)	(1.28)	(0.17)	(0.00)	(0.37)	(2.09)*
Negative ln abs (*NX/L*)	–0.0028	–0.0270	0.0007	–0.0610	–0.0047	–0.0181	–0.0029	–0.0310
	(1.10)	(0.69)	(0.26)	(1.51)	(2.32)*	(0.56)	(1.17)	(0.95)
Positive ln (*M/L*)	0.0060		0.0026		0.0056		0.0030	
	(2.18)*		(1.12)		(2.15)*		(1.01)	
Negative ln (*M/L*)	0.0126		0.0062		0.0104		0.0044	
	(2.40)*		(1.37)		(2.64)**		(1.21)	
Log executive constraints	0.0212		0.0020		0.2732		0.0211	
	(1.99)		(1.58)		(1.29)		(0.86)	
Log population density 1500		–0.0790		–0.1050				
		(1.96)		(3.12)**				
Imputed log population density 1500						–0.1022		–0.1020
						(3.09)**		(3.09)**
Sum of coefficients								
Positive ln(NX/L) + positive ln(M/L) = 0								
F test	0.004	. . .	0.001	. . .	0.005	. . .	0.002	. . .
P value	0.14	. . .	0.04	. . .	0.05	. . .	0.47	. . .
Negative ln abs(NX/L) + negative ln(M/L) = 0								
F test	0.020	. . .	0.010	. . .	0.020	. . .	0.010	. . .
P value	0.04	. . .	0.55	. . .	0.01	. . .	0.17	. . .
No. observations	51	51	43	43	79	79	71	71
R squared	0.77	0.63	0.82	0.73	0.51	0.68	0.92	0.75

*Statistically significant at the 5 percent level; **statistically significant at the 1 percent level.

. . . Not applicable.

a. In regressions 1, 3, 5, and 7, the dependent variable is the log of GDP per capita in 2005 (PPP dollars); in regressions 2, 4, 6, and 8, it is the log of executive constraints. Models 1 and 5 include the log of GDP per capita in 1980 (PPP dollars), the Sachs-Warner reform index (average in 1980–2005), the average annual terms-of-trade growth, and regional dummies. Models 2, 4, 6, and 8 include the average annual terms-of-trade growth (1980–2005) and regional dummies. Models 3 and 7 include the variables in model 1 plus real exchange rate volatility, the log of the average investment rate, the log of the average years of education, and the Mankiw-Romer-Weil variable. Other control variables are included but not reported (see text). Absolute values of *t* statistics are in parentheses.

With the expanded samples, the blessing effect appears significant for both net exporters and net importers in the basic specification. Neither is significant in the full specification, which again suggests that if there is a blessing, it might operate through factor accumulation or macroeconomic volatility (or both). Perhaps more importantly, the changes in the point estimates and their levels of significance stemming from the change of samples also suggest that there is probably significant heterogeneity of effects across subsamples of countries.

Among the control variables, the Sachs-Warner reform index appears positive and significant in the estimation of models 1 and 3, but not in 5 or 7. The Mankiw-Romer-Weil variable of the growth of effective units of labor is significant at approximately –0.04 in both the restricted and expanded samples in models 3 and 7. This is about one-tenth of the magnitude predicted by neoclassical growth theory without controlling for the effects of the other determinants of growth included in our specifications.

Summary and Conclusions

Our review of the literature on the resource curse indicated that the evidence in support of the curse is weak at best. The measurement of relative endowments and the potential heterogeneity in the effects of such endowments on development and growth are important issues. Moreover, some of the international econometric evidence that appears to support the curse hypothesis is based on the use of weak proxies and even on nonstandard manipulations of influential data points.

This mixed evidence in favor of a resource curse also needs to be reconciled with some obvious historical facts, ranging from the successful development of now rich countries to the success of numerous developing economies, from Rwanda to Chile. The idea that natural resources inevitably worsen political or other institutions that might be important for development also seems to have ignored historical facts related to the evolution of such institutions. Examples abound of countries in which "good" institutional characteristics emerged prior to the discovery of natural resources. This is the case of Venezuela, which may explain the strong economic growth of this economy for almost fifty years.

In the process of reviewing the existing literature and linking it to current data, we have highlighted an important weakness in the empirical literature that uses trade-based proxies for relative endowments. That is, the variables of choice of the propagators of the curse are weak proxies for relative endowments. Our own previous work ignores the analytical contents of these empirical proxies, which might explain why we have been able to so easily drive a stake of doubt into the heart of the resource demons. Our preferred proxy, net exports per worker, while flawed, can help push the literature forward, because in certain circumstances, the simultaneous estimation of coefficients for the samples of net exporters and net importers can provide a magnified effect of natural resources on development.

With new data, new econometric analyses provided definitive evidence that there is no curse, not even indirectly through the political institutions that would most likely be affected by the curse-via-politics effects, which has been central in the literature on the point-source nature of natural resources. In fact, the direct positive effect of natural resources can be substantial, although we cannot be sure about its exact magnitude given the imperfect correlation between relative endowments and our trade-data proxy variable. Furthermore, we found heterogeneity in the potential blessing effects of natural resource endowments. In the static model, the poorest countries benefit the most, whereas in the dynamic model, the richest seem to have benefitted the most. In both cases, these blessing effects tend to disappear when we control for macroeconomic volatility and factor accumulation.

Our exploration of this material has convinced us that we know less than what we thought we knew, especially after reading the existing literature. It remains a topic for future research to study potential interactions between natural resources and human capital or innovation. We do know, however, that there might be substantial international heterogeneity in the effects of other determinants of growth, and there is certainly a cross-country heterogeneity intercept. Any cross-sectional estimation with cross-country data thus needs to control for mean shifters, such as regional dummies. Preferably, panel-data estimators should be applied, because they allow the analyst to control for fixed effects.

Much remains to be learned from historical case studies and perhaps from cross-country statistical analysis of the interaction between natural resources and institutions, despite the unreliable existing evidence concerning the curse-through-politics hypothesis. From a policy viewpoint, institutional arrangements to smooth out the economic consequences of natural resource windfalls make as much sense as more general discussions about countercyclical fiscal policies. Although the resource curse is elusive, we do not argue against commonsense policies that in some countries might be inextricable from natural riches.

Appendix A: Sources of Bias in *NX/L*

In the context of our two-sector growth model, we generate an exogenous labor productivity shock associated with sector 1 and, for simplicity, assume that the shock does not affect the allocation of labor (that is, $\partial L_{nr}/\partial a_{1L} = 0$) or the stock of K and L or the consumption shares. The marginal change in net exports per worker associated with a marginal change in productivity is then

$$\frac{\partial(NX/L)}{\partial a_{1L}} = -c_{nr}\left(1 - l_{nr}\right). \tag{13}$$

This consumption effect of a productivity improvement is strictly negative.[1] Hence, the reverse effect of productivity growth on observed net exports of natural resources would be reflected in a decline in net exports of natural resources per worker, and any estimation of an income or growth model with NX/L as an explanatory variable will yield downward-biased estimates of the effect of NX/L on Y. Allowing for a reallocation of labor into sector 1 as a consequence of the improvement in productivity in that sector would further reduce net exports of natural resources per worker, thus further biasing estimates of the effect of NX/L on Y.

A productivity change in the natural resource sector would affect NX/L as follows:

$$\frac{\partial(NX/L)}{\partial a_{nr}} = \left(1 - c_{nr}\right)\left(\frac{K}{L}\right)^{b}. \tag{14}$$

If there is a curse, $\partial a_{nr} < 0$, then NX/L would decline as export earnings fall more than imports because $c_{nr} > 0$. The fall in gross imports of natural resources would be proportional to the share of income spent on the consumption of natural resources:

$$\partial a_{nr} c_{nr}\left(\frac{K}{L}\right)^{b} < 0, \tag{15}$$

when $\partial a_{nr} < 0$. Under a curse, the negative effect of NX/L would be attenuated by the fall in imports. If natural resources are a blessing in terms of

1. A productivity shock affecting the natural resource sector would correspond to a positive shock on output (that is, a blessing). The earlier version of this paper had erroneously confounded this positive effect with an endogenous decline in *NX/L* resulting from a positive productivity shock in sector 1.

improvements in labor productivity in either sector, then imports would rise with income (which is the reason the coefficient on *NX/L* is biased downward in income functions). Hence, reverse causality under a blessing effect would bias the estimated coefficient of *NX/L* downward due to the rise of imports of natural resources. However tempting it is to estimate equations 9 and 10 with *NX/L* as a proxy for unobserved *K/L,* the consumption effect will contaminate estimates of the effect of *NX/L* on *Y,* thereby producing biases.

To address the endogeneity biases, we estimate augmented versions of the static and dynamic models, which include the natural logarithm of imports of natural resources per worker (*M/L*) as an additional regressor. If there is a resource curse, then the coefficients on *NX/L* and *M/L* would be negative (see the discussion on equation 12 in the main text). If natural resources are a blessing, then the coefficients on *NX/L* and *M/L* should be positive. The attenuation effect of the reverse causality effect would be captured by the coefficient on imports.

More formally, the estimated model can be rewritten to account explicitly for the reverse causality effect:

$$y_i = a + \left(\overleftarrow{d} - \vec{d}_X - \vec{d}_M\right)\left[\ln\left(\frac{NX}{L}\right)_i\right] + f'\mathbf{X}_i + e_i, \tag{16}$$

where coefficient *b* in equation 8 equals $\overleftarrow{d} - \vec{d}_X - \vec{d}_M$, which is the sum of the direct effect minus the reverse causality effect. In the context of our two-sector growth model and assuming that the relevant effects operate only through changes in productivities in either sector, the direct effect can be derived from equation 8:

$$\overleftarrow{d}\left\{\left[\frac{\partial a_{1L}}{\partial\left(NX/L\right)}\right]\left(L - L_{nr}\right) + \left[\frac{\partial a_{nr}}{\partial\left(NX/L\right)}\right]K^b L^{1-b}\right\}\frac{\left(NX/L\right)}{y}. \tag{17}$$

The reverse causality effect can be derived from equations 13 and 14:

$$\vec{d}_x + \vec{d}_M = \left[\partial a_{1L} c_{nr}\left(1 - l_{nr}\right) + \partial a_{nr} c_{nr}\left(\frac{K}{L}\right)^b\right]\frac{\left(NX/L\right)}{y}, \tag{18}$$

which is a composite consumption effect coming from increases in factor productivity in each sector and will equal the effect of *y* on gross imports (exports) of natural resources per worker. By including *M/L* in the estimation equation, we can get an estimate of $\vec{d}_M$.[2] The empirical income function thus becomes

$$y_i = a + \left(\overleftarrow{d} - \vec{d}_x\right)\left[\ln\left(\frac{NX}{L}\right)_i\right] + \vec{d}_m\left[\ln\left(\frac{M}{L}\right)_i\right] + c'\mathbf{X}_i + e_i. \tag{19}$$

We assume that the consumption effect on exports is equal to the consumption effect on imports. Thus the sum of $\overleftarrow{d} - \vec{d}_x$ plus $\vec{d}_M$ approximates an unbiased estimate of the elasticity of y with respect to NX/L.

A remaining weakness of equation 18 is that we are interested in estimates of

$$\frac{\partial y}{\partial\left(K/L\right)}\frac{\left(K/L\right)}{y}, \tag{20}$$

whereas

$$\overleftarrow{d} = \frac{\partial y}{\partial\left(\frac{NX}{L}\right)}\frac{\left(NX/L\right)}{y}. \tag{21}$$

The function linking K/L with NX/L was presented as equation 12, which is

$$\frac{\partial\left(NX/L\right)}{\partial\left(K/L\right)} = b\left(1 - c_{nr}\right)a_{nr}\left(L_{nr}\right)^{-b} K^{b-1}L\frac{\partial l_{nr}}{\partial\left(K/L\right)} + c_{nr}a_{1L}\frac{\partial l_{nr}}{\partial\left(K/L\right)} \geq 0. \tag{22}$$

The supply and consumption components in our proxy are separable. Assume that the Rybczynski effect (the second element in equation 22) is close to zero and let

$$z = \frac{\partial\left(NX/L\right)}{\partial\left(K/L\right)}\frac{\left(K\right)}{\left(NX\right)} = z_S - z_C, \tag{23}$$

2. Alternatively, we could include X/L, but the resulting estimate could be contaminated by a supply-side effect on exports.

where $z_s = ba_{nr}(K/L)^b/NX$ is the unattenuated supply-driven elasticity and $z_c = c_{nr}\,ba_{nr}(K/L_{nr})^b/NX$ is the consumption-driven attenuation of the corresponding elasticity.

The marginal effect of K/L on y is the product of the marginal of effect of NX/L on y times the marginal effect of K/L on NX/L. After stripping out $\vec{d}$ with the inclusion of M/L as a regressor in equation 18, the estimate of the effect of K/L on y, based on our proxy, is still biased:

$$\text{(24)} \qquad \frac{\partial y}{\partial\left(K/L\right)}\frac{\left(K/L\right)}{y} = \left(\overleftarrow{d} - \vec{d}_X + \vec{d}_M\right)\left(z_S - z_C\right) = \left(1 - c_{nr}\right)\left(\overleftarrow{d} - \vec{d}_X + \vec{d}_M\right).$$

That is, the downward bias in z produces a multiplicatively positive bias for the inference about the effect of K/L on y based on estimates of the effect of NX/L on y. Any blessing or curse effect apparent in the approximated elasticity of y with respect to NX/L will be an exaggerated measure of the underlying effect of K/L on y, because the supply elasticity of NX/L with respect to K/L is underestimated due to the consumption effect. Multiplying $(\overleftarrow{d} - \vec{d}_X + \vec{d}_M)$ by one minus the share of income spent in the consumption of natural resources would yield an estimate closer to an unbiased estimate of the elasticity of y with respect to K/L. Of course, if the Rybczynski effect is significant in (21), then our estimates could even be a negatively biased estimate of the effect of K/L on y.

Appendix B: Data and Summary Statistics

TABLE B-1. Data, Variable Definitions, and Sources

Variable	*Definition*	*Source*
Natural resources / labor force	Net exports of natural resources divided by the labor force. Net exports of natural resources are defined as exports minus imports of natural-resource-related goods, based on Leamer's commodity clusters.[a] Labor force is the population between 15–64 years of age.	WDI and UN COMTRADE
Growth of GDP per capita, 1980–2005	Average yearly growth of real GDP per capita (constant prices: chain series) in 1980–2005.	Authors' construction, using Penn World Table (Summers, Heston, and Aten 2002)
Log GDP per capita	Real GDP per capita (constant prices: chain series), defined as the ratio of total GDP to total population in 2005.	Penn World Table (Summers, Heston, and Aten, 2002)

(*continued*)

TABLE B-1. Data, Variable Definitions, and Sources (*Continued*)

Variable	*Definition*	*Source*
Openness	Percentage of years with an open economic regime. A country has a closed trade policy if it has at least one of the following characteristics: (1) nontariff barriers (NTBs) covering 40 percent or more of trade; (2) average tariff rates of 40 percent or more; (3) a black market exchange rate that is depreciated by 20 percent or more relative to the official exchange rate, on average, in the 1970s or 1980s; (4) a socialist economic system; or (5) a state monopoly on major exports.	Sachs and Warner (1995a), updated by Wacziarg and Welch (2003)
Terms-of-trade growth	Growth of the external terms of trade, defined as the ratio of an export price index to an import price index of goods and services.	WDI
Std. dev. real effective exchange rate	Standard deviation of monthly interannual changes in real effective exchange rates.	Authors' construction, using IMF data
Executive constraints	Institutionalized constraints on the decisionmaking powers of chief executives, whether individuals or collectivities. It is a 1–7 category scale, in which a higher score means more constraint on the executive. Equals one if the country is not independent.	Marshall and Jaggers (2002)
Log investment	Natural log of the share of investment over GDP.	Penn World Table (Summers, Heston, and Aten 2002)
Log school attainment	Natural log of years of schooling of the adult population.	Barro and Lee (2000)
MRW	Based on Mankiw, Romer, and Weil (1992), the variable is the natural log of the average growth of the labor force plus 0.05. The constant 0.05 is assumed to be the sum of depreciation rate and technological growth.	WDI
Population density in 1500	Total population divided by total arable land in 1500 A.D.	McEvedy and Jones (1978) as cited in Acemoglu, Johnson, and Robinson (2002)
Regional dummies	Eight dummies for world regions as defined by the World Bank: East Asia and the Pacific; Europe and Central Asia, high income; high-income OECD member countries; high-income: non-OECD countries; Latin America and the Caribbean; the Middle East and North Africa; South Asia; sub-Saharan Africa.	World Bank

a. SITC sections 0–9, 11, 12, 21–29, 32–35, 41–43, 63, 64, 68, and 94 (Leamer 1995).

TABLE B-2. Summary Statistics[a]

Variable	*No. observations*	*Mean*	*Std. deviation*
Growth of GDP per capita 1980–2005	138	0.01359	0.02048
Log GDP per capita in 1980	152	8.30638	1.10774
Executive constraints	155	1.23111	0.61816
Natural resources/labor force > 0	133	0.67116	2.48421
Natural resources/labor force < 0	133	0.15405	0.57328
Openness	141	0.55319	0.41906
Std. dev. real effective exchange rate	175	0.06932	0.07930
Log investment	184	2.47441	0.57929
Log school attainment	97	1.58728	0.62581
MRW	185	−2.66020	0.20589
Terms-of-trade growth	145	0.00302	0.04458
Log population density in 1500	97	0.48645	1.52470

a. Cross-section data. All variables are measured in 2005.