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Are Oil Producers Rich?
Geoffrey Heal

Resource Curse

Chapter 6: Are Oil-Producers Rich?

Geoffrey Heal*

Abstract

What can national income accounting tell us about whether resource-depleting nations are rich or poor? I argue that most conventional statements of national income overestimate the incomes of such countries by failing to account for resource depletion. Perhaps more importantly, they typically overestimate investment. I derive here a correct measure of trends in sustainable welfare which takes account of the changes in all capital stocks, including stocks of natural capital. This chapter also demonstrates how this measure can be calculated for individual countries and used to ascertain whether oil-exporting countries are consuming too much too quickly.

Introduction

There is a popular image of an oil producing country, a real stereotype: It is of a very rich land where no-one needs to work and everything is provided by the state. True, some other aspects of the image are typically less attractive, but the essential popular image relates to extreme abundance. Yet, in sharp contrast to this we find a vast and growing literature on the "resource curse" that documents how and why an abundance of natural resources, in fact, leads to social and economic problems. How can we reconcile these conflicting images? How can we reconcile the seemingly obvious fact that oil makes a country rich with the equally undeniable fact that few countries heavily dependent on the production of oil are as rich, in terms of per capita income, as many developed countries (Norway is an obvious exception), and, moreover, rarely even appear to be moving towards that goal?

This chapter focuses on features of this paradox that can be illuminated by thinking clearly about the basic ideas of income and wealth, and about how these ideas relate to accounts of national income and national wealth; that is, to national income statements and national balance sheets. The role of capital markets proves to be central to the apparent paradox of poor resource-exporting countries. I shall argue that the exhaustibility of oil makes income generated from oil quite different from income generated by other sources in terms of its implications for the country's underlying wealth, and that a failure to see this explains much of the apparent paradox.

Before developing these arguments in detail, some facts may shed light on the problem. Take Saudi Arabia, an extreme case and for some a poster child for the oil producer as economic utopia: Its proven reserves of oil are 262.7 billion barrels, and its population is 25 million.[1] So, at $30 per barrel -- a typical oil price for 2003 and 2004 -- its oil wealth per capita is $315,240. Does this make Saudi Arabia rich? Imagine that Saudi Arabia truly were a country where oil wealth meant that no one needed to work. If the wealth were to be invested at a 4% real return, this would provide a typical family of four with about $50,000 per year (that is, assuming an equal division of the wealth or income; we know however that for reasons discussed in this book, oil wealth is usually spread very unequally). This would be a very comfortable income indeed, but would not qualify as rich by Western standards. Doing the same calculation for all oil-producing countries in the Middle East, the number for a family of four is closer to $8,000. If we move the oil price up to its present level in 2006, say $60, then we double these numbers, implying that an average Saudi family -- if it could invest its share of the country's oil wealth -- could earn $100,000 per year; an average family in a typical Middle Eastern oil producer would make about $16,000 per year. So, even at current elevated oil prices, while oil wealth could dramatically increase the quality of living for a family of four, these numbers are not necessarily consistent with the images of 'extreme' abundance.

But there is a second way of looking at the data that makes oil wealth seem even less abundant. Saudi Arabia produces about 8 million barrels of oil daily for an annual oil revenue of $175 billion. Expressed per family of four, this is $28,000 per year -- barely above the U.S. poverty line, even at $60 per barrel. At the average oil price for the last decade, the figure is well below the U.S. poverty level -- even for Saudi Arabia, one of the richest oil-producing countries in the world! Furthermore, and most importantly, this income, if used for consumption, is *not sustainable* since it depends on the depletion of a finite stock. As discussed below, the real income, taking into account the depletion of stocks, is considerably lower still and may be near zero. This second way of calculating oil revenues is in fact the more realistic of the two approaches since Saudi Arabia is not in a position to invest its oil wealth: Most of this wealth lies in the ground earning no income.

The contrast between these two calculations foreshadows a point I shall be emphasizing in the sections that follow. To summarize briefly, if Saudi Arabia could sell all its oil now and invest the proceeds at 4% then a typical family could earn about $100,000 per year. (Selling all that oil, however, would surely force the price down dramatically given the inelasticity of demand.) But, if Saudi Arabia just extracts as much oil as it can -- about 8 million barrels daily -- then the per family income is just over a quarter of this, at $28,000. Why the difference? The important point to learn from this is that capital markets matter to oil producing countries. Their access to these markets, and how well they use them, is a major factor in determining their living standards. In fact, they depend on capital markets as much as they depend on their natural resources. Oil in the ground earns no income and contributes nothing to welfare, however envious the rest of the world may be of this asset. Envy, however, does not pay interest, whereas money in an investment fund does, so it clearly pays (from a financial point of view) to turn oil in the ground into money in a bank account. But this involves huge transactions and assumptions about future oil prices (for more political economy arguments on why keeping wealth in the ground may be safer, see Chapter 2). In other words, it involves access to a comprehensive set of capital markets.

One message of this chapter is that if we think clearly about what we mean by income and wealth, then a resource-rich country such as Saudi Arabia is not necessarily "rich" in the conventional sense (Also see Chapter 7). Its income as properly measured may be near zero, and whether it owns wealth and can convert some of this into income depends entirely on its access to capital markets. Thus, the central role of capital markets in the welfare of resource-rich countries, which has perhaps not been adequately highlighted elsewhere, is another message of this chapter.

A third point that I emphasize is that *any measure of income or of wealth change must allow for the depletion of the natural resource stock*. Conventional measures of national income like Gross National Income (GNI) and Gross Domestic Product (GDP) do not do this account and therefore overstate, probably quite significantly, the real income of these countries. From the perspective of understanding the evolution of long-run welfare -- the "sustainability" perspective -- the important measure is what Heal and Kriström (2005) call national wealth, the change in which can be captured by the World Bank's (1997) "genuine savings" measure. This is the value *at shadow prices* of the changes in all capital stocks, including changes in natural resource stocks. The shadow price of a good is the social value of an extra increment of the good: If there is a market price it equals the market price corrected for external costs or benefits associated with the use of the good. Depletion of natural resources has, of course, to be included in calculating the value of the change in capital stocks. In the last section of the paper I review some recent calculations (from Arrow et al. 2004) of trends in total capital stock per capita for a range of countries, including some oil producers. Incorporating the changes in natural capital stocks makes a big difference to our perception of a country's sustainability if it is a resource exporter. All resource exporters appear to be depleting natural capital faster than they are building up other forms of capital, and so are becoming poorer, whatever their income levels.

The next section of the chapter sets out a rather general model and uses it to draw some broad conclusions about welfare. It also provides a framework for a series of applications to more specific models that capture key aspects of resource-rich but otherwise underdeveloped countries. A final section summarizes the arguments and suggests some policy implications. Central to these sections is to understand that savings and investment as reported by conventional national income accounts are grossly overstated: Real investment is less than measured investment by the amount of resource depletion. Hence, very high rates of savings and investment as conventionally measured are needed if there is to be real accumulation of capital to sustain future welfare.

General Welfare Results and Applications

We begin with a general mathematical proposition and a result on welfare in dynamic economic models. We define a *state valuation function*, $V(S)$ that tells us the present value of the benefits that can be obtained from a current level of capital stock (the "state"), S. It is a measure of the maximum amount of welfare that an economy can produce now and in the future. This is found by using a welfare function $u(C_t)$ that records welfare from consuming C_t at each instant t, and then summing (integrating) this value from time t=0 up to t=∞, placing lower weights on more distant periods. Using the framework and notation in Heal and Kriström (2005), the intertemporal optimization problem of maximizing the present value of welfare given some initial state S_0 is given by:

$$V(S_0) = Max\int_0^{\infty} u(C_t)e^{-\delta t}dt$$

subject to a set of constraints imposed by technology, institutions and resource availability.

This is the classical optimal growth problem of which special cases are well-known.[2] From an analysis of the solutions to such problems one can prove that:

- The rate of change of the state valuation function, *V*, equals the value of investment at shadow prices.
- Both of these are equal to the rate of change of national income, where national income is defined as the present value of consumption at supporting prices.

These features are summarized in the following proposition (note that in this example national income refers to the present discounted value of consumption at all dates, calculated at shadow prices):

Proposition 1 (Heal and Kriström 2005): The change in welfare over time is exactly equal to "genuine savings" which is itself exactly equal to the change in national income over time. Formally we have:

$$\frac{dV}{dt} = \sum_i \lambda_i \frac{dS_i}{dt} = \frac{d}{dt}(\text{National Income}) = \frac{d}{dt}\left(\int_0 \sum \lambda_i c_i e^{-\delta t} dt\right)$$

Here λ_i is the shadow price of capital good *i*, the stock of which is S_i. The term $\sum_i \lambda_i \frac{dS_i}{dt}$ represents "genuine savings" and records the total value of investment (including resource depletion). This quantity has recently been the subject of extensive study by the World Bank (2005). Proposition 1 is critical in what follows: It tells us that both the value of investment and the change in the value of national income are good measures of future welfare changes. The more invested today, the higher future welfare. It is important to emphasize that welfare changes are given by the value of investment *at shadow prices*, $\sum_i \lambda_i \frac{dS_i}{dt}$, and not by the total change in wealth, $\frac{d}{dt}(\sum_i \lambda_i S_i)$ which would, in addition, contain a term in capital gains.[3] It is important to note that capital gains have no role to play in accounting for natural resources.

The next issue is to investigate these measures in particular contexts that relate directly to the resource curse.

Models of Resource Depletion

The Hotelling case

Hotelling's model (1931) provides a simple and well-understood framework for beginning this process. There is an initial stock S_0 of an exhaustible resource (such as oil), consumption of which at time t is C_t, and the rate of depletion of the resource stock is given simply by the rate at which it is consumed or $\frac{dS}{dt} = -C$, conditional on $S_t \geq 0$.

The usual way to measure Net National Product (NNP) is consumption plus investment. But in this framework, since consumption equals the rate of depletion, net income (consumption plus investment) is always zero by definition. Formally:

$$NNP = \frac{dS}{dt} + C = 0$$

In an economy that lives purely by resource depletion, income in the sense of net national product is always zero, even though wealth is positive. In other words there is no *sustainable* positive level of spending in this framework. This makes intuitive sense: The economy has a fixed resource base that can only change in one way, downwards. So, potential welfare must drop as the resource is consumed.

Access to capital markets makes a big difference to this conclusion, and, in fact, overturns it: With access to capital markets it is possible to get a sustainable spending level and a non-zero income. Imagine that, instead of producing the resource gradually over time, the country sells the *entire* stock of the resource S_0 at one go and invests the proceeds: Now the interest on this investment gives a sustainable consumption level. Indeed it is precisely what Hicks (1939) called *income*: That is, income is the return on capital. Formally, if r is the interest rate and Y_0 is income, we have:

$$Y_0 = rS_0$$

In this modified framework with overseas investment, the depletion of the capital stock is now $\frac{dS}{dt} = rS - C$, where the first term is income and the second is expenditure, and so NNP, which is investment plus consumption, is now given by:

$$NNP = \frac{dS}{dt} + C = rS \neq 0$$

So access to capital markets transforms NNP from zero to a positive number: It allows the transformation of non-earning assets into earning assets, making a fundamental difference to income. This is the point that is reflected in the numerical example pertaining to Saudi Arabia in the introduction. Providing access to capital markets is like giving the economy a superior technology, a greater intertemporally feasible set: Even though the physical resource base is unchanged, its welfare potential is improved.

An Open Economy

The next move is to develop this insight about capital markets further. I no longer assume that the entire stock of the resource is sold up front. I shall assume that a flow of the resource can be extracted and then either consumed at home or sold abroad and the revenues from this invested overseas. So, at each date, the output of the resource is either consumed C or invested abroad I_f, and the economy's basic accounting identity is that the sum of consumption and overseas investment must equal the depletion of the resource plus any income earned on existing overseas investments:

$$C + I_f = -\frac{dS}{dt} + rK_f \quad (2)$$

Where K_f is overseas capital and r is the interest rate on this, and I_f is overseas investment so that $I_f = \frac{dK_f}{dt}$. Consider a path that solves the maximization problem $Max\int_0^\infty u(C)e^{-\delta t}dt$ subject to (2).

The two conditions that need to be satisfied at the solution are:

(i) That, on the margin, investing overseas and consuming must be equally valuable ($u' = \lambda_s = \lambda_i = \lambda$); and

(ii) That the percentage change in the (shadow) price of the resource over time is equal to the difference between the discount rate and the return on overseas investment ($\frac{d\lambda}{dt}\frac{1}{\lambda} = \delta - r$). If the latter exceeds the former then the price of the resource will fall over time because the return to investment is so large that the resource is in effect becoming more abundant.

Net national product is now $C + I_f + \frac{dS}{dt} = rK_f$ so it is equivalent to the interest on overseas investments, just as in the previous section. The change in the state valuation function, V, is $\lambda\left(I_f + \frac{dS}{dt}\right)$, the value of investment including capital investment and stock depletion. This represents the change in the present value of welfare as a result of investment and depletion: Welfare is increasing if the value of investment exceeds that of stock depletion.

A natural next step in extending the model is to let r be a function of overseas investment, K_f, reflecting diminishing returns to investment in overseas opportunities. Given the scale on which oil countries must invest, the possibility that they will move the market against them is real. In this case, the second condition above has to change to include a term reflecting the impact of investment on the return to capital: $\frac{d\lambda}{dt}\frac{1}{\lambda} = \delta - r - \frac{dr}{dK_f}K_f$.

A stationary solution (in which $\frac{d\lambda}{dt} = 0$) would then require: $\delta = r + \frac{dr}{dK_f}K_f$. With $\frac{d\lambda}{dt} = 0$, consumption is also constant. Over time, the resource stock S falls to zero and the overseas capital stock K rises to some constant value. In this case NNP is $r(K_f)K_f$ and the change in welfare as a result of investment and depletion is again $\lambda\left(I_f + \frac{dS_t}{dt}\right)$.

The bottom line here is that, as the introduction to this chapter suggested, access to capital markets makes a huge difference to the economic constraints on a resource-rich country. Its income -- even accounting for depreciation -- goes from zero to a positive number, equal to interest on overseas investments; there is a positive consumption level that can now be sustained indefinitely.

An Open Economy with Extraction Capital

So far we have assumed that the economy can extract any amount of the resource without incurring any costs. This is, however, somewhat unrealistic. Suppose instead that you have to invest in order to extract the resource, and that, as above, you can invest the proceeds from sale in overseas assets. Let I_d denote domestic investment in extraction capital K_d, and I_f denote investment in overseas interest-bearing assets K_f with interest rate r. The rate at which the resource can be extracted is bounded by the amount of investment in extraction capital, so that if R is the extraction rate then $R \leq \alpha K_d$. As before, we maximize the welfare from all future consumption where consumption is given by the output of the resource, minus investments in domestic and overseas capital, plus interest on existing overseas investments. Assuming that the output of the resource is proportional to the capital available for resource extraction (that is, $\frac{dS}{dt} = \alpha K_d$) we have:

$$C = \alpha Kd - I_f - I_d + rK_f$$

At any solution to this problem the values of both types of capital must be equal if there is investment in both (that is, $u' = \lambda_f = \lambda_d$ if both I_f and I_d are positive). At the optimum, however, λ_f and λ_d should change at different rates, since the change in λ_f should reflect the difference between the discount rate and the interest rate on foreign assets, while the change in λ_d should reflect the difference between the discount rate and the efficiency of the extraction technology (α). Hence, because they change at different rates but must be equal if both I_f and I_d are positive, it cannot be that the country invests both in foreign assets and in extraction for any length of time. Presumably countries start off by investing in positive capital extraction and later -- once the stock of extraction capital is built up to an appropriate level -- shift investment to foreign investment, leaving extraction capital constant.

In this model as in the earlier ones, all investment levels will feature in NNP:

$$NNP = C + r_f K_f + I_f + I_d - \alpha K_d$$

and the change in the state valuation function is $\lambda_f I_f + \lambda_d I_d - \lambda_s \alpha K_d$. Hence, again, the depletion of the resource needs to be taken into account in the measurement of welfare.

Extraction Capital and Use in Production

As the final variant of the basic Hotelling model of resource depletion, I consider the case of a closed economy that extracts a resource and then uses it in domestic production. Extraction of the resource leads to domestic output, which can be invested. So the resource can, as in the previous sections, be transformed into a capital stock, this time through the domestic production process. Extraction of the resource is costly: To be precise, $X(R)$ is the cost of extracting at rate R. We assume that X is increasing in R. Domestic production depends on inputs of capital and the resource and is given by $Y=f(K,R)$, where the capital stock, K, depends on investment I. This time we aim to maximize the integral of the welfare from consumption conditional on the constraints that $\frac{dS}{dt} = R$ and the accounting identity: $Y = C + I + X$, or equivalently: $I = f(K,R) - C - X(R)$.

A solution to this problem requires that that the shadow price of the resource equals its marginal productivity in the domestic economy ($\partial F/\partial R$); that consumption and investment are valued equally on the margin; that the resource price follows Hotelling's Rule (the percentage change in the price of the good is exactly equal to the discount rate) and remains constant in present value terms; and, finally, that the accumulation of capital follows the well-known Keynes-Ramsey rule. This rule -- which states that the percentage change in the shadow price of the capital good must be equal to the difference between the discount rate and the marginal return to capital in the economy (see e.g. Heal 1973) -- simply specifies that the country's capital assets be efficiently used, and that the breakdown of income between consumption and investment is such that the returns to each are equal on the margin.

Net National Product in this case should be:

$$NNP = C + I - R$$

and the change in welfare is $I - R$. Once again, the possibility of transforming the resource into a capital stock means that, in spite of its exhaustibility, the economy can attain a positive income level. Indeed, a positive level may even be sustainable, depending on whether the resource is "essential" or not, as shown in Dasgupta and Heal (1979).

Theoretical Summary

The theoretical models developed so far, which certainly capture what is unique about resource-based economies, imply very clearly that accounting for the changes in capital stocks is a prerequisite for understanding the evolution of welfare in an economy. As the natural resource stock is an important capital stock -- often the most important (see World Bank 2005) -- this means that depletion of this stock *must be measured and recorded in national income accounts if these are to have any predictive value for welfare*. In plain English, resource depletion must be deducted from national income. This is not conventionally done and, as a result, national income figures are too high and the growth of national income is overstated. But national income in the conventional sense is not the best measure if we are interested in the long-run welfare potential of the economy. The right measure instead is $\sum_i \lambda_i \frac{dS_i}{dt}$, the value of investment at current shadow prices. Again, stock depletion will feature in this.

This is not the only point to emerge from this discussion: Another related point is that a resource-rich country's relationship with capital markets is important in determining its living standards. Oil in the ground brings in no income and is inherently depletable. Through trade and capital markets, however, or through use as an input into domestic production, it can be converted to a stock of wealth of another sort, which generates income and can in principle be preserved indefinitely.

In the next section we show the practical applicability of this framework, summarizing recent work by Arrow et al. (2004). This work attempts to compute the value of investment at current shadow prices $\sum_i \lambda_i \frac{dS_i}{dt}$ for a wide range of countries, from rich industrialized to poor developing and oil-producing. The calculation of trends in genuine wealth per capita, allowing for technical change, allows us to rank countries by their long-run welfare trends. A striking conclusion is that *most oil-exporting countries have a negative trend in long-run welfare*. The conclusions of Arrow et al. are supported by a recent study just released by the World Bank (2005), which presents more recent results for a wide range of countries and also shows that resource-rich countries are depleting their overall capital stocks and facing declining welfare levels, and will continue to do so unless they substantially change their policies (the World Bank study does not allow for technical progress).

Applications

The first table shows the results that Arrow et al. (2004) find when we compute the value of investment at current shadow prices $\sum_i \lambda_i \frac{dS_i}{dt}$ for a wide range of countries, including two rich industrial countries, the United States and the United Kingdom.; two rapidly growing developing countries, India and China; two very poor developing countries/regions, Bangladesh and Sub-Saharan Africa; and one oil-exporting region, the Middle East and North Africa. The data cover the period 1970 to 2001and are taken from the World Bank (1997).[4] The first numerical column shows domestic net investment, the starting point of the calculations and an estimate of investment in physical capital. To this is added expenditure on education as an indicator of investment in human capital. We then add investment (usually disinvestment) in various types of environmental capital. The third numerical column shows an estimate of the social cost of CO2 emissions; the fourth column the depletion of energy resources (particularly large for the Middle East and North Africa). The next column represents forest depletion, large for Nepal and zero for the U.S. where there has actually been re-growth of forests over the period of interest. The final column gives the sum, an estimate of genuine investment as a percent of national income. This is an estimate of the value of investment at current shadow prices $\sum_i \lambda_i \frac{dS_i}{dt}$. Full details of the data and the calculations are in Arrow et al. (2004).

Table 6.1

Estimates of Genuine Investment as % of GDP for a sample of countries

	Domestic Net I	Education	CO2	Energy	Mineral	Forest	GI
Bangladesh	7.89	1.53	−0.25	−0.61	0.00	−1.41	7.14
India	11.74	3.29	−1.17	−2.89	−0.46	−1.05	9.47
Nepal	14.82	2.65	−0.20	−0.00	−0.30	−3.67	13.31
Pakistan	10.92	2.02	−0.75	−2.60	−0.00	−0.84	8.75
China	30.06	1.96	−2.48	−6.11	−0.50	−0.22	22.72
Sub-Saharan Africa	3.49	4.78	−0.81	−7.31	−1.71	−0.52	−2.09
M East N Africa	14.72	4.70	−0.80	−25.54	−0.12	−0.06	−7.09
United Kingdom	3.70	5.21	−0.32	−1.20	0.00	0.00	7.38
United States	5.73	5.62	−0.42	−1.95	−0.05	0.00	8.94

Clearly there are many shortcomings here, and I shall talk about correcting some of them shortly. Amongst the shortcomings that we do not correct are the inadequacy of educational expenditure as a measure of investment in human capital, and the incompleteness of the list of categories of environmental capital for whose depletion we allow. Both could be serious sources of error, but it has so far not been possible to obtain data to take this process further. Nonetheless the numbers that emerge make some intuitive sense. For example, for the Middle East and North Africa, a domestic net investment of +14.72% turns into a genuine savings of -7.09% after allowing for the depletion of energy resources, drawing attention to the fact that this part of the world lives unsustainably by depleting an exhaustible resource, as in the Hotelling models reviewed earlier. Sub-Saharan Africa is also shown to be living unsustainably, a tragic and not surprising result. Allowance for the impact of HIV/AIDS on human capital would probably make their genuine investment number even worse. The remaining countries all appear from these numbers to have positive genuine investment and thus meet one of the criteria for sustainability, namely that the present value of future welfare obtainable from capital stocks be non-decreasing.

All of these numbers omit two factors that could be important, however: One is population change, omitted from the earlier discussion but a real issue in several countries; and the other is technical change. A higher rate of population growth will presumably increase the level of investment required to maintain living standards constant so that the numbers in Table 6.1 will overstate the extent of sustainability with a growing population and vice versa. Technological progress will act in the opposite direction, allowing humans to extract more welfare from a given set of resources. So, we make two more modifications to the data in Table 6.1, adjusting for population growth and for technological progress. Neither factor was part of the theory developed earlier in this chapter and, to my knowledge, there is little to no discussion of either of these issues in the literature on sustainability or on optimal growth with environmental resources. Yet, intuition suggests that they are important, and the numbers in Arrow et al confirm this, indicating a lacuna in the theory developed so far.

Table 6.2

Genuine Investment as % of GDP Adjusted for Population and Technical Change

	GI	Growth of Genuine Weath	Population Growth	Growth of Genuine Weath p.c.	Growth of Total Factor Productivity	Growth of p.c. genuine wealth (adjusted for total factor productivity growth)	Standard GDP p.c. growth rate
Bangladesh	7.14	1.07	2.16	-1.09	0.81	0.30	1.88
India	9.47	1.42	1.99	-0.57	0.64	0.54	2.96
Nepal	13.31	2.00	2.24	-0.24	0.51	0.63	1.86
Pakistan	8.75	1.31	2.66	2.06	1.13	0.59	2.21
China	22.72	3.41	1.35	-3.05	3.64	8.33	7.77
Sub-Saharan Africa	-2.09	-0.31	2.74	-3.05	0.28	-2.58	-0.01
M East N Africa	-7.09	-1.06	2.37	-3.43	-0.23	-3.82	0.74
UK	7.38	1.48	0.18	1.30	0.58	2.29	2.19
US	8.94	1.79	1.07	0.72	0.02	0.75	1.99

Table 6.2 shows the results of these modifications. The first column is the last column from Table 6.1, our preliminary estimates of genuine savings. The second column gives an estimate of the growth rate of genuine wealth derived from the previous column using an assumed GDP/wealth ratio (see Arrow et al. 2004 for details). The fourth gives the growth rate of genuine wealth per capita, using the population growth rate given in the third numerical column. This is followed by an estimate of the growth rate of total factor productivity and then the growth rate of per capital genuine wealth adjusted for total factor productivity growth. For comparison purposes, the last column gives the conventional figure for growth of GDP per capita.

Only two estimates of the growth of genuine wealth per capita are negative, the same two as before, but many others are probably not significantly positive. The high population growth rates of Bangladesh, Nepal and Sub-Saharan Africa all act to reduce their countries' rates of genuine savings.

Although the methodology differs in some technical details, and does not allow for technical progress, our results are very consistent with those of the World Bank (2005), which cover a much greater range of countries. The World Bank concludes that most resource-dependent countries are not replacing the capital that they deplete in extracting their resources and are therefore reducing their long-run welfare potential.

A clear implication of this work is that we are measuring the income of oil-producers wrongly. We know how to measure it better: The issue is now to ensure that the data needed for this is collected and incorporated into the accounts. For oil producers, the most important data is the depletion of oil and gas reserves. In addition, we need data on the changes in other forms of capital stocks -- other natural resources (such as water and soil), environmental impacts (such as pollution and CO2 emission), and on the accumulation or decumulation of overseas assets. As some overseas assets are privately held, measuring these might not always be straightforward.

Conclusions

I began this chapter by referring to the paradox of resource-rich countries -- if they are resource rich they should be rich financially too, but it seems that they rarely are. Some of the paradox can be resolved just by looking at the numbers, as I did in the introduction. This shows that even the richest of oil-rich countries are not that rich. Even Saudi Arabia with oil at $60 per barrel could barely lift its population above the U.S. poverty level if it were to spread its oil earnings equally. The numbers in the introduction also suggested something else that the more formal analysis corroborated: Access to capital markets matters and is a part of the resolution of the paradox. A country with modest oil reserves and no access to capital markets is not rich in any real sense.

The analytical models established two further points. One is that national income is measured wrongly in resource-rich countries, as they do not subtract depreciation of their asset base from their income figures. In failing to do so, they omit from their calculations the fact that their income from resource use is generated by the depletion of a non-augmentable asset. It is like augmenting the family income by selling the family silver: It cannot last and is really a form of asset disposal -- not a source of income. Indeed, in U.S. corporate accounting conventions, the sale of oil or gas is recognized as asset disposal. A proper measure of income allows for resource depletion. Conventional measures of investment will greatly overstate the real investment rate in resource-based economies. And a measure of the sustainability of welfare is based on the value of the changes in all forms of capital, natural and other. This fact emphasizes the importance to resource-rich countries of a conscious policy of investing some of the income from resource sales, as noted also by the World Bank 2005. A commonly-suggested rule of thumb is to invest the revenues from resource production net of production costs, a rule known as Hartwick's Rule (1977).[5] While this rule may not be optimal under all circumstances, the fact that conventional measures overstate investment does suggest the need for very high apparent investment rates to provide a firm basis for future welfare. The figures suggest that no resource-rich countries are attaining appropriate investment levels: All are depleting their natural capital and not replacing it with any other form of capital, a sure road to poverty in the long run (Also see Chapters 2 and 7).

The second key lesson is that the value of resources depends on access to capital markets so that income from sales can be invested. Indeed, in an ideal world, resource-rich countries would be able to borrow responsibly on the security of their resources and invest the proceeds, although the pitfalls of irresponsible borrowing are large and discussed in Chapters 1, 2, and 11. Or, they would be able to sell their oil forward (although again, as discussed in Chapter 8, there are political challenges that accompany this solution). In either case, if used wisely, capital markets can transform the possibilities open to a resource-based economy and governments need to act on this basis.

There is still work to be done in this area. Foremost is the need for better data on capital accumulation or decumulation (for all forms of capital) for resource-rich countries. Then we need to understand better the obstacles to better access to capital markets on the part of oil-producing countries, particularly those that are underdeveloped. They would benefit from being able to sell their resources forward to a much greater degree than is now possible. It may be that this is impossible because countries cannot always be legally bound to uphold their agreements in these types of arrangements, so that counterparties have no redress in the event of default. But there may be remedies for this, through clever institutional arrangements that exploit cooperative strategies from repeated games. And an obvious fact in most poor, oil-rich countries is that the income from oil wealth is usually spread very unevenly through the country. Thus, while we need a greater appreciation for those factors that can increase income in oil-rich countries, such as making use of capital markets, further investigation needs to proceed in tandem with efforts to understand better how to prevent the emergence of the usual syndrome linking oil, corruption and inequality.

[*] Paul Garret Professor of Public Policy and Corporate Responsibility, Columbia Business School and School of International Affairs (gmh1@columbia.edu). I am grateful to Macartan Humphreys for valuable comments on an earlier draft.

[1]Figures come from the BP Statistical Review of World Energy (available at www.bp.com), and from the CIA Factbook.

[2] Special cases include the Hotelling model (1931); the Solow model (1956); and the Dasgupta-Heal-Solow model (see Dasgupta and Heal 1974; Solow 1974).

[3] Since $\frac{d}{dt}(\sum_i \lambda_i S_i) = \sum_i \lambda_i \frac{dS_i}{dt} + \sum_i \frac{d\lambda_i}{dt} S_i$

[4] To be precise, the coverage is as follows: Bangladesh 1973-2001; India 1970-2001; Nepal 19702001; China 1982-2001 (without 1994); Sub-Saharan Africa 1974-82 and 1986-2001; Middle East and North Africa 1976-89 and 1991-2001; U.K. 1971-2001; and U.S. 1970-2001.

[5] For a critique of this rule, see Asheim et al. (2002).

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