

The Proper Calculation of Income from Depletable Natural Resources

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Recognition is growing that income is not being accurately calculated for economies based on natural resources. Some would even say that, for these economies, national accounting methods produce misleading calculations. They lead to measurements that neither faithfully describe economic performance *ex post*, nor can they be used as a basis for useful policy proposals. For such economies, current accounting practices exaggerate income, encourage unsustainable levels of consumption, and obscure the necessity to implement greatly needed policy adjustment. The problem is relevant to practically all countries where nonrenewable resources are being exploited and where renewable resources are being run down without being restored. But it is most acute where such resources are being exploited in the *public* sector, either directly or through foreign interests.

In the more industrialized countries, where exploitation typically occurs in the private sector, tax allowances for depletion tend to correct the calculation of the "value added" believed to be generated by such activities. Such correction of course is effected as depreciation, reducing the gross product by an element to cover depletion. The correction is frequently not exact, but it is a step in the right direction. This process is being helped by the fact that when properties containing marketable natural resources, such as subsoil deposits, exchange hands, their market value tends to reflect their natural-resource content. By contrast, no such correction is made in most of the developing countries, whose economies depend in varying degrees on the exploitation of their natural resources, such as mineral extraction or the commercial logging of forests to make timber and paper. This problem, therefore, is one of paramount importance for the developing world.

The practice in these countries follows the United Nations System of National Accounts (SNA), which treats

revenue derived from the sale of natural resources as current income, or rent, that is available for consumption. If the revenue accrues to the public sector, it can be used just like revenue from any other source, such as the proceeds from income taxes. Given their short perspective, the politicians in charge of such economies often do not want to be reminded that the revenue derived from liquidating their country's natural assets is neither recurrent nor sustainable. And many a developing country rejoices in having its leadership praised for illusory rapid economic growth, apparently high rates of saving and investment, and deceptively stable or near-stable price levels brought about by import surpluses.

Such apparent prosperity is bought at the cost of asset erosion—a sure recipe for future economic decline. Thus natural resources are exported and used up to prop up a truly unbalanced, but seemingly comfortable, external balance. An overvalued exchange rate inevitably develops, and relative prices are upset as a "Dutch Disease" syndrome sets in, whereby the prices of nontradable goods and services rise in relation to those of tradables.¹ Consequently, the economy's capacity is reduced to produce and export the products of nonnatural-resource-based activities that could provide badly needed employment and (sustainable) future income. Any comparative advantage the country may have gets sacrificed during a period of ephemeral prosperity and illusory growth. This is particularly true where the exhaustion of the resource is imminent. Needless to say, the citizens of these countries find it only too easy to adjust to a higher level of consumption.

When the bonanza ends and the natural resource is almost exhausted, standards of living have to fall, and intolerable pressures develop on the external balance. Quite often the country finds itself saddled with a high external debt, which it contracted in the prosperous years when it had overestimated its capacity to borrow and its

creditors had mistakenly assumed that the prosperity would continue. The government then finds itself in an impossible situation in which there are no margins left to provide a cushion for urgently needed policy adjustment that should have been initiated years before. The halcyon period of plenty will have come to an end, and all the putative economizing that had been done during those years is seen in retrospect to have been false and futile. Defective accounting had led economic behavior and policy analysis astray.

The fundamental principle that is flouted by applying conventional national income accounting to depletable resources is the separation that must be maintained between income and capital. This principle tells us that if you liquidate your assets and use the proceeds for consumption, you are living beyond your means, and in doing so you are undermining your ability to create future income. The accounting profession was born, in the late Middle Ages in the city states of the Mediterranean basin, largely to separate from the proceeds accruing to merchants that part which they could use to finance their families' current needs. Those merchants had to guard against consuming their capital, which was the source of their continued well-being. From its infancy the accounting profession specifically has addressed this task. In present-day language the accountants were asked to define sustainable levels of *consumption*, and they could do so only by attempting to *keep capital intact*.

The same principle was taken up by Adam Smith, who saw capital as a means "to increase the productive powers of labor" and as an asset whose maintenance was imperative, since it "is always repaid with great profit, and increases the annual produce by a much greater value than that of the support which such improvements require." *The Wealth of Nations* (Smith 1776) states that:

The gross revenue of all the inhabitants of a great country, comprehends the whole annual produce of their land and labor; the neat revenue, what remains free to them after deducting the expense of maintaining; first, their fixed; and, second, their circulating capital; or what, without encroaching upon their capital, they can place in their stock reserved for immediate consumption, or spend upon their subsistence, conveniences, and amusements. Their real wealth too is in proportion, not to their gross, but to their neat revenue.

The SNA, in failing to distinguish between *unsustainable* receipts, derived from the sale of natural assets, and *sustainable* income, produced by the factors of production, disregards the fundamental Smithian concept of "neat revenue," which should guide the consumption and assessment of the wealth of the revenue recipient.

The distinction between capital and income has remained crucial throughout the development of economics. In the present day, Hicks paraphrased this principle

into a definition of income as that amount which a person can consume during a given period and still be as well off at the end of the period as at the beginning.² More specifically, we are told in no uncertain terms that:

... if a person's receipts are derived from the exploitation of a wasting asset, liable to give out at a future date, we shall say that his receipts are in excess of his income" (Hicks 1946, p. 187).

Natural resources are certainly "wasting assets" if they are nonrenewable (for example, minerals), or, if they are renewable (for example, forests exploited for timber, fisheries, or agricultural soil), are not *actually* renewed through careful maintenance, thus causing the receipts from their exploitation to give out in the future. Ignoring this elementary fact makes a mockery of what has been passing as economic analysis and policy prescription for economies based on natural resources (and in particular, those based on minerals), in which no effort has been made to compensate for draining the national wealth by depleting these resources. Maintaining capital intact is not a marginal issue. It is central to all economic behavior and analysis, and it is a poor economist indeed who is unable to tell capital from income.

Conceptual Background

The confusion of capital and income, which has been the standard approach to income calculation in this area and which derives support from the SNA, is becoming increasingly untenable. This chapter offers a way to estimate the true income content of the proceeds from mineral sales. The treatment of income from renewable resources such as forests, which have to be maintained through replanting, or fisheries, which have to be restocked, is more straightforward. Where such replanting or restocking is effected at technologically acceptable rates that would keep capital intact, these activities could be charged against the gross returns from the natural resource to obtain the net value added generated; this is similar to the way capital consumption is treated in national accounts. Soil erosion also belongs to the same category of a natural resource whose depletion can be offset by restoration, and the cost of restoration should be charged against the gross product of the soil to obtain a true estimate of the net product.

But quite often, particularly in poorer countries, the resource is not restored to the same level of activity. As a result the value added that appears to be generated contains capital elements that should be removed. In this case those who estimate national income should impute a capital consumption charge based on technically acceptable criteria against current receipts to obtain the true income from these activities. For soil erosion, some estimate may be necessary of the declining power of the soil

to produce, and this can be based, for example, on declining land yields over time. This chapter, however, addresses only the problem of estimating income generated from depletable, nonrenewable resources.

My thinking on this topic began to be shaped by a sense of discomfort over what I thought to be an inappropriate use of economic concepts when the pricing of petroleum began to attract the attention of economists in the early 1970s. To my mind the oil market had long been an oligopsonistic market, dominated by powerful multinational conglomerates. Economic analysis had contributed little to understanding how prices were determined in that sort of market, beyond the traditional models of oligopoly theory, which concentrated on how equilibrium was reached rather than on the level of prices produced by it. Later, when oligopsony in the petroleum market gave way to an apparent monopoly allegedly instituted by the Organization of Petroleum Exporting Countries (OPEC), the price increases were too facily attributed to the powers of the exporters' cartel.

It was curious that many analysts overestimated the competition prevailing in that market before 1973 and underestimated it afterward, emphasizing OPEC's monopoly power. It was even more curious that many analysts in the 1970s appeared to think that if free competition were to prevail, competitive equilibrium would indicate a price equal to the marginal cost of *extraction*, which was—and still often is—referred to as *production*, and that it was only because of the alleged cartelization of supply that the price was able to rise above that cost.³

This construction was later challenged by those who were aware that the price of an irreplaceable natural resource, such as petroleum, should perhaps contain a user cost or capital element, representing the erosion of the resource. Even under free competition, the marginal cost of extraction could not possibly indicate an equilibrium price level, since the cost of extraction is tantamount to the cost of asset liquidation and cannot determine the value of the very asset being sold. Hotelling had to be resurrected and used with great dexterity by an important economist like Solow for a more convincing explanation of petroleum price increases before the economic profession could be persuaded.⁴ But it has not been completely persuaded, and doubters still abound.

Parallel to the microeconomic confusion about the pricing of natural resources, other inaccuracies have also been perpetrated and have distorted thinking about macroeconomics in countries where the exploitation of depletable natural resources is significant. If the marginal cost of extraction was the only cost, then any surplus accruing to the sellers was pure rent and represented value added to be included in the gross domestic product (GDP). This certainly is implied by the accounting practices currently being used under the SNA. Based on these practices, the expansion of economic activity as a conse-

quence of accelerating the liquidation of subsoil assets is applauded as good economic performance and is confused with the growth that comes from labor, capital formation, technological progress, and efficient organization. The revenue accruing to countries that deplete their natural resources in this way is reflected in increased saving rates and investment coefficients and in improved parameters, such as incremental capital-output ratios (ICORS), which shed deceptively favorable light on the economic performance of such economies. Policy advice based on these calculations becomes dulled at best—and downright wrong at worst.

The concept of rent in this situation is profoundly misused and totally misapplied. In the perception of the classical economists the rent that qualified as value added derived from the indestructible powers of nature.⁵ Such revenue is clearly sustainable where the powers of nature to reproduce it are not impaired, and it can therefore legitimately be counted as income. The surplus, net of extraction costs, emanating from liquidating natural resources, however, has little kinship with either rent or quasi-rent as defined by Marshall (1920).

There seems to be no alternative to bringing the capital nature of such exploitation into the open and integrating this in all economic thinking and measurements, not just to gauge welfare adequately, but to save the discipline of economics from disrepute. Even noneconomists have on occasion rightly perceived that mineral extraction revenues are not wholly current income. A small and underdeveloped country such as Libya could thus legislate as early as 1963 (when it first began to extract petroleum in commercial quantities) that at least 70 percent of petroleum proceeds had to be allocated to development. The perception was strong in that very poor country that this unique wealth truly belonged to future generations and should not be squandered on consumption, as would be implied by treating its sales as current income. To recall Hicks's standard definition, current income is that part of receipts which, if devoted to consumption, would leave the earner no worse off at the end of the accounting period than at its beginning.

Weakness of the Depreciation Approach

Like other economists of the same bent, I thought first of using the "capital consumption" or "depreciation" approach to treat income from depletable mineral resources. As the resource is depleted by the quantity of extraction during the year, the amount of depletion, valued at current prices, can be deducted from the gross proceeds, just as, for example, the depreciation of capital equipment used for manufacturing is subtracted from the gross value added by manufacturing activities. The mineral extraction earnings can still be reckoned in GDP, provided that the value of the depletion is deducted from

it for calculating *net* income. The problem of the exact valuation of capital consumption in this case appears to be of secondary importance. Much more important is to try to make *some* adjustment. Various methods are already used to treat inventories and other capital assets used up in the process of production. Shortcuts, approximations, and arbitrary estimations are used throughout national income calculations, and no special harm can come from adding the depreciation of natural resources to the list.

On reflection, however, I moved away from this approach, both for practical as well as conceptual considerations. First the conceptual. It is wrong to describe as current production that which is not current production. GDP is an important measurement and is much more in use than NDP (net domestic product). Even if NDP and its national parallel NNP are correctly measured, the whole apparatus of GDP with its structure, input-output relations, and changes over time would remain incorrectly calculated if revenues from depletable resources are counted as value added in GDP.

It is not by chance that the gross product, rather than the net product, is the preferred quantity for macroeconomic analysis. It is often used as a denominator for crucial macroeconomic ratios, with the nominator being money supply, exports, imports, external debt, debt service, savings, capital formation, and so forth. As Hicks has suggested, the concept of net income is usually eschewed because it is always arbitrary. It relies on estimates of depreciation and inventory use that are a mixed bag of historical costs and estimation based on accounting conventions, tax laws and allowances, and insurance company practices, as well as subjective valuation by economic agents who do the reckoning and who have a variety of expectations about the future (Hicks 1981, chap. 9). If an income correction is to be made, it should apply therefore to the gross product itself, and it is not enough to effect the adjustment at the net product level.

Another reason why I discarded the depreciation approach to rectifying income accounting for depletable resource activities is the fact that countries with marketable natural resources are evidently better off than those without such resources, and they can enjoy a higher and sustainable standard of living than the latter by virtue of their resource endowment. Such an advantage should be reflected in calculating the income of both groups. If we deduct from the gross receipts from mineral sales in any one year an amount equal to the depletion along the lines described above, the value of *net income* from this activity becomes zero. Where a country derives 100 percent of its receipts from, say, petroleum extraction—an extreme case of a Saudi Arabia—the depreciation approach (ignoring the multiplier effect of ancillary activities related to extraction as well as the contribution of other sectors to value added) would give us a GDP of 100 and a NDP of

zero—a measurement that is not particularly edifying. For the gross product this approach would not make any adjustment and would simply eliminate the net product altogether. Such a measurement of net income would belie the observable fact that having subsoil mineral deposits to exploit gives their possessors an *income* edge over those who do not have that advantage.

Conversion to a Permanent Income Stream

Mineral deposits and other comparable marketable natural resources are assets. Sales of assets do not generate value added and should not be included in GDP. They do generate liquid funds, however, which can be put to alternative uses. A country may choose to spend the proceeds (net of extraction costs) on consumption or investment or any combination of the two. But this is neither here nor there. From an accounting point of view, however, an income content of the net receipts can be estimated. This income content should be part of GDP since it represents value added. The argument for this proceeds as follows.⁶

If an owner of a wasting asset is to consume no more than his income, he must relend some part of his receipts so that the interest on it will make up for the eventual failure of receipts from the wasting asset in the future. This proposition, which can be found in Hicks (1946, chapter 14), suggested the need to convert the mineral asset concerned into a perpetual income stream. The finite series of earnings from the sale of the resource, say a ten-year series of annual extractions leading to the extinction of the resource, has to be converted to an infinite series of *true* income, such that the capitalized values of the two series are equal. From the annual earnings from sales, an income portion that can be spent on consumption should be identified; the remainder, a capital element, should be set aside year after year and invested to create a perpetual stream of income that would provide the same level of true income, both during the life of the resource as well as after the resource has been exhausted. The two constituent portions of current receipts need to be defined: the income portion and the capital portion. Under certain assumptions, which are neither too restricting nor too unrealistic, the ratio of true income to total receipts is:

$$X/R = 1 - \frac{1}{(1+r)^{n+1}}$$

where X is true income, R the total receipts (net of extraction cost), r the rate of discount, and n the number of periods during which the resource is to be liquidated. $R-X$ would be the user cost or depletion factor that should be set aside as a capital investment and totally excluded from GDP. On the expenditure side, this depletion factor would represent a disinvestment that should

be set against capital formation in new assets, so that total expenditure would still be equal to the true income. If all of the receipts were devoted to consumption and if new capital formation fell short of the depletion factor, the accounts should show a negative value for capital formation, thus reflecting the disinvestment that had occurred in the accounting period.

The ratio X/R depends only on two values: the reserves-to-extraction ratio, that is, the life expectancy of the resource measured in years, and the discount rate. A country that liquidates its mineral reserves over fifty years needs to set aside for reinvestment a smaller portion of its receipts than another that liquidates its reserves over twenty years, and thus it can count a larger portion of its receipts as income. Similarly, if the receipts set aside can be invested at a higher interest rate, say 10 percent, a higher portion would be reckoned to income than if the interest was 5 percent. According to this formula, with a discount rate of 5 percent, a country that liquidates its natural resource over ten years can consider as income only 42 percent of its annual receipts, while another with a fifty-year horizon can reckon as much as 92 percent of its annual receipts to current income. At a 10 percent discount rate the former's current income would be 65 percent of the receipts and the latter's 99 percent, which would require almost no correction to GDP estimates as currently made.

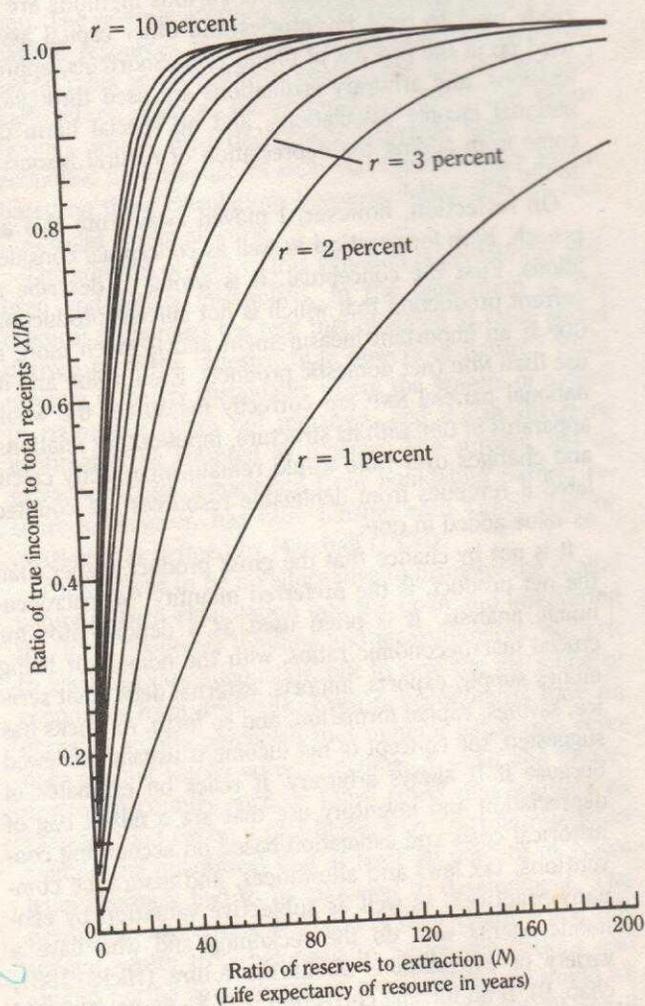
Figure 3-1 shows the ratio X/R (the portion of total receipts that is true income) as a function of the life expectancy of the resource, N , measured in years, at ten alternative discount rates, decreasing from 10 to 1 percent. The same relation is given in Tables 3-1 and 3-2. Table 3-1 shows the income content of mineral sales at eleven alternative discount rates from 0 to 10, for resource life expectancies of 1 to 100 years. This is shown as percentage shares of the receipts that are currently being treated under the SNA as if they were wholly income. Table 3-2 is the complement of Table 3-1 and presents the user cost content of the annual sales, expressed also as a percentage of total receipts, for the same discount rates and life expectancies. This percentage represents the capital element that, I believe, should be excluded from GDP as a depletion factor.

The calculations show that the present practice of counting mineral sales proceeds as current income implies that the fraction

$$\frac{1}{(1+r)^{n+1}}$$

equals zero in the previous formula. For only then would $X/R = 1$. This would be obtained, irrespective of the discount rate, by having $n = \infty$; or alternatively, where n is finite, by having a very high value of the discount rate so that r tends to infinity. Such a high rate of discount implies a very strong time preference of the resource owners and is tantamount to setting a very low value on

Figure 3-1. Income Content of Mineral Sales at Various Life Expectancies and Discount Rates



Note: r = alternative discount rates.

the utility of the resource to future generations. Current practices for calculating GDP according to the injunctions of the SNA are thus seen to be built on one of two untenable premises or a combination of both: that the natural resource being liquidated would last forever and that the welfare of future generations does not matter.

Clarification of the User Cost Approach

In defense of this approach, the following points should be clarified and emphasized.

- A discount rate must be chosen. This decision has to be arbitrary, but the arbitrariness of the discount rate is not in principle any different from the arbitrary estimation methods used extensively under the SNA. A rate

Table 3-1. *Income Content of Mineral Sales (X/R)*
(percent)

Life expectancy of the resource (N) (years)	Discount rate (r)										
	0	1	2	3	4	5	6	7	8	9	10
1	0	2	4	6	8	9	11	13	14	16	17
2	0	3	6	8	11	14	16	18	21	23	25
3	0	4	8	11	15	18	21	24	27	29	32
4	0	5	9	14	18	22	25	29	32	35	38
5	0	6	11	16	21	25	30	33	37	40	44
6	0	7	13	19	24	27	33	38	42	45	49
7	0	8	15	21	27	32	37	42	46	50	53
8	0	9	16	23	30	36	41	46	50	54	58
9	0	10	18	26	32	39	44	49	54	58	61
10	0	10	20	28	35	42	47	52	57	61	65
15	0	15	27	38	47	54	58	66	71	75	78
20	0	19	34	46	56	64	71	76	80	84	86
25	0	22	40	54	64	72	78	83	86	89	92
30	0	27	46	60	70	78	84	88	91	93	95
35	0	30	51	66	75	83	88	91	94	96	97
40	0	34	56	70	80	86	91	94	96	97	98
50	0	40	64	78	86	92	95	97	98	99	99
60	0	46	70	84	91	95	97	99	99	99	100
80	0	55	80	91	96	98	99	100	100	100	100
100	0	63	86	95	98	99	100	100	100	100	100

Note: Figures are rounded to the nearest digit.

Table 3-2. *Capital Content (or "User Cost") of Mineral Sales (1 - X/R)*
(percent)

Life expectancy of the resource (N) (years)	Discount rate (r)										
	0	1	2	3	4	5	6	7	8	9	10
1	100	98	96	94	92	91	89	87	86	84	83
2	100	97	94	92	89	86	84	82	79	77	75
3	100	96	92	89	85	82	79	76	73	71	68
4	100	95	91	86	82	78	75	71	68	65	62
5	100	94	89	84	79	75	70	67	63	60	56
6	100	93	87	81	76	71	67	62	58	55	51
7	100	92	85	79	73	68	63	58	54	50	47
8	100	91	84	77	70	64	59	54	50	46	42
9	100	90	82	74	68	61	56	51	46	42	39
10	100	90	80	72	65	58	53	48	43	39	35
15	100	85	73	62	53	46	42	34	29	25	22
20	100	81	66	54	44	36	29	24	20	16	14
25	100	78	60	46	36	28	22	17	14	11	8
30	100	73	54	40	30	22	16	12	9	7	5
35	100	70	49	34	25	17	12	9	6	4	3
40	100	66	43	30	20	14	9	6	4	3	2
50	100	60	36	28	14	8	5	3	2	1	1
60	100	54	30	16	9	5	3	2	1	1	0
80	100	45	20	9	4	2	1	0	0	0	0
100	100	37	14	5	2	1	0	0	0	0	0

Note: Figures are rounded to the nearest digit.

of 5 percent or thereabouts can be chosen as approximating what the classical economists used to call a natural rate of time preference. This could be changed periodically, say every five years, guided by changes in the long-term market rates.

- Under the proposed formula, the setting aside of part of the proceeds for reinvestment is only a metaphor. The owner may dispose of his receipts any way he chooses. But he should be made aware of the fact that his true income is only a fraction of his total receipts. Proper accounting should convey this fundamental message.

- Equally metaphorical is the process of calculating the yields from investing the set-aside part of the proceeds at the chosen interest rate. As stated previously, the rate should approximate an available market parameter that would indicate prudent behavior for the asset liquidator and would guide his decisions about extraction. Thus he may decide to delay extraction if the market interest rate, available for financial investment, appears lower than the rate at which his resource would appreciate if left in the ground. But he need not in practice sink his funds in physical or financial assets at that interest rate. However, he would be wise to seek such a rate as a minimum yield on his new investments. The so-called Hotelling Rule states that if he left his natural resource alone, it would appreciate at the market discount rate because of its growing scarcity.

- Likewise, the extraction schedule, assumed to be at a constant rate over some time horizon, is also a paradigm and is used only for making the calculations. The owner has a given resource. He may extract it for two years or twenty. Every period he may decide to alter his plans, depending on current prices and the expectations thereof, by increasing or decreasing the annual extraction rate. He is at liberty to do so. All the formula needs is the ratio between the total reserves and the amount extracted in the current period. Suppose an owner, who had been planning to liquidate his reserves over a ten-year period, decides to accelerate extraction because of an expected decline in future prices (reckoning that, since his market share is small, he can do this with impunity, that is, without depressing prices) and now decides on a five-year horizon. All that is necessary is to use the new ratio of reserves to extraction, and this can be decided period by period and changed every year if need be.

- The same applies to the discovery of new deposits—or a downward adjustment in reserves—usually a tough nut to crack. The new discovery does not have to be counted as income, as some have suggested. All that is necessary, if this approach is followed, is to alter the reserves-to-extraction ratio (N) in the calculations, that is, if it is decided to keep the extraction schedule as before. In this case, the discovery will reflect itself in higher income than before, as shown by moving from left to right on the x -axis in Figure 3-1. However, the owner may

very well keep the reserves-to-extraction ratio unchanged by raising his annual extraction when he realizes that the reserves are larger than he had thought. This will also translate into higher income.

- It is not necessary to estimate the absolute value of the total mineral reserves or to resort to what is known as "wealth accounting." Neither is it necessary to predict future prices. The owner of the resource does all the predictions necessary, and these are reflected in his annual extraction, which the accountant has to relate to the size of the total reserves in order to estimate income. By implication, it is assumed that the unit value of the total resource is the same as the current price. Such valuation, appearing in both the numerator and denominator of the formula given earlier, cancels out, and what remains is the ratio between two physical quantities: the size of the reserves and the annual extraction, that is, the number of years remaining before the resource is exhausted. Speculation about the future course of prices, however, does occur, and this, as mentioned above, affects the rate at which the resource is liquidated, but this is not the accountant's problem.

- The problems of the terms of trade or of changed technology that might lead to drastic changes in the valuation of the resource are not addressed here. Such changes have to be acknowledged by the income accountants when they occur. The focus of this approach is on the *volume* of extraction in the accounting period as it relates to the total *volume* of the reserves. In the manner of national accounting, the market valuation of the product is taken as given and is used merely to weight the volume in order to assess the activity's contribution to GDP.

- The proposed method could be applied immediately to mineral deposits that are more or less ascertainable, such as petroleum, for which the industry estimates proven reserves and publishes these estimates regularly.⁷ But even for petroleum, and certainly for metals, owners tend to mine richer and more accessible deposits first, which means that later extractions involve progressively higher extraction costs. Rising extraction costs can undermine the sustainability of the activity as much as the physical exhaustion of the resource. When market prices fall below extraction costs, many previous sellers, still sitting on large deposits, find profitable operation impossible. Estimation of the volume of reserves therefore should be adjusted *downward* by a factor that would reflect the rising future cost of extraction. Shortcuts for such adjustment need to be devised case by case.

- It is important to remember that the issue here is *national* income accounting. Even if the identified global reserves of a mineral get adjusted upward, the fact remains that the reserves of individual countries inevitably are depleted as they are exploited. National income accounting should reflect this individual national aspect of the activity.

Conclusion

Although the user cost approach appears radical in that it seeks to alter the calculation of GDP under the SNA for certain activities, it is economical and practicable. It is an effective way of impressing on developing countries that depend on the exploitation of subsoil deposits that natural resources are being exhausted as they are exploited. The method proposed is in harmony with standard economic concepts. The national income accounting practices set out under the SNA distort these concepts when applied to depletable resources. They falsely call rent that which is not rent, and include in value added that which is not value added. A second-best alternative would be to use the depreciation approach, deducting a depletion factor from an inflated GDP to reach a corrected NDP. The user cost proposed in this chapter would be the correct measurement of this depletion factor, not the "full-value" depreciation, which, as argued above, would wipe out all the activity from the net product.

The correction ought to be made in the *flow* accounts of the SNA at the GDP level. It is not enough to record depletion in balance sheets, reconciliation, or satellite accounts. This approach would make it unnecessary to attempt to show in such accounts absolute values of total reserves and their annual changes—values that would be as arbitrary as they would be unedifying. Its adoption would lead to the proper understanding and measurement of the special economic activity of depletable natural resource exploitation, and consequently to better policy analysis.

Appendix. Splitting Receipts into Income and Capital

In this chapter, receipts from the sales of a depletable natural resource are *net* of extraction cost. The extraction cost contains elements that do not directly generate value added, such as materials used up in the process of extraction, but would normally also contain payments to factors of production, which should be included in GDP in the usual way.

A time series of expected net receipts R from the sale of a resource that, as a result of exploitation, will come to an end in a future year n contains a true income element X , where $X < R$, such that if $R - X$ (the capital content) is invested year after year at interest rate r , the accumulated investment would continue to yield the same level of income X .

It is necessary to identify X/R , that is, the proportion of net receipts that can truly be called income, and its complement $1 - X/R$, the capital element, also as a proportion of net receipts. The capitalized value at interest rate r of the finite series of receipts R should equal the capitalized value at the same interest rate of the

infinite series X . The capitalized value of the finite series R , accruing in equal amounts over a period of n years, would add up to:

$$\sum_0^n R^* = R \frac{\left[1 - \frac{1}{(1+r)^{n+1}}\right]}{1 - \frac{1}{1+r}}$$

The infinite series X would add up to:

$$\sum_0^\infty X^* = \frac{X}{1 - \frac{1}{1+r}}$$

Setting $\sum_0^n R^* = \sum_0^\infty X^*$ and multiplying by the denominator in both quantities,

$$X = R \left[1 - \frac{1}{(1+r)^{n+1}}\right]$$

$$X/R = 1 - \frac{1}{(1+r)^{n+1}}$$

$$1 - X/R = \frac{1}{(1+r)^{n+1}}$$

In this formulation it is assumed that the receipts R accrue at the beginning of each accounting period. If, alternatively, they accrue at the end, the fraction X/R would be $1 - \frac{1}{(1+r)^n}$. It is also assumed that the relative prices of the resource and the goods and services on which the stream of income will be spent do not change.

If there is reason to believe, for instance, that such goods and services will appreciate over time relative to the resource, the capital element to be set aside has to be larger (and the income content smaller) to make it possible to maintain a constant income stream in real terms. The converse is true if there is reason to believe that the resource would appreciate relative to the goods and services that would make up future income. But these are refinements that could be incorporated in the method suggested and would not affect much the results obtained. The method proposed, with the implicit assumption of constant relative prices, seems adequate if the direction in which relative prices will change is uncertain.

Notes

1. The term "Dutch Disease" originated in the 1960s to refer to the adverse effects on Dutch manufacturing of natural gas discoveries. Generally speaking, increased revenues from a natural resource encourages spending on nontraded goods and draws resources out of the traded, nonnatural resource sector, thus stifling diversification and retarding development of non-natural resource exports. See, for example, Corden (1984).

2. See Hicks (1946), p. 172. See also Keynes (1936), chapter

6, on "The Definition of Income, Saving and Investment," and that chapter's "Appendix on User Cost."

3. OPEC admittedly met regularly to agree on the prices at which its members would sell oil. But such prices cleared the market without any quotas imposed to regulate supply. Not until 1982, however, did OPEC behave like a cartel, with individual quotas indicated for its members, but like all cartels this attempt to maintain prices in a declining market palpably failed.

4. See Solow (1974), in which he recalled Hotelling's path-breaking article, "The Economics of Exhaustible Resources," *Journal of Political Economy* 39 (April 1931):137-75.

5. "[T]he original and indestructible powers of the soil" as formulated by Ricardo (1821).

6. I had been thinking along these lines for some time and first expressed my views on this topic in a paper delivered in March 1979 to the staff of the OAPEC in Kuwait (El Serafy 1979). I elaborated these views and proposed a method for estimating income from depletable natural resources in a later paper on absorptive capacity, presented in 1980 to an energy conference organized by the University of Colorado. The concern at the time was that the so-called "capital surplus" economies, which exported petroleum, had too low an absorptive capacity. It was felt that if that could be increased, it would, through increased imports, restore equilibrium to the petroleum buyers' balances of payments. I attacked this approach because it reflected the short-term interests of petroleum consumers and not that of the owners of this scarce resource and of humanity at large. See El Serafy (1981). An appendix to that paper entitled, "How Much of Petroleum Receipts Can Be Reckoned to Income?" proposed the formula shown in the appendix to this chapter.

7. Occasionally estimating reserves would raise controversy,

but this should not inhibit approximations that can be later revised. In the words of the late Sir Dennis Robertson, "it is better to be approximately right than precisely wrong!"

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