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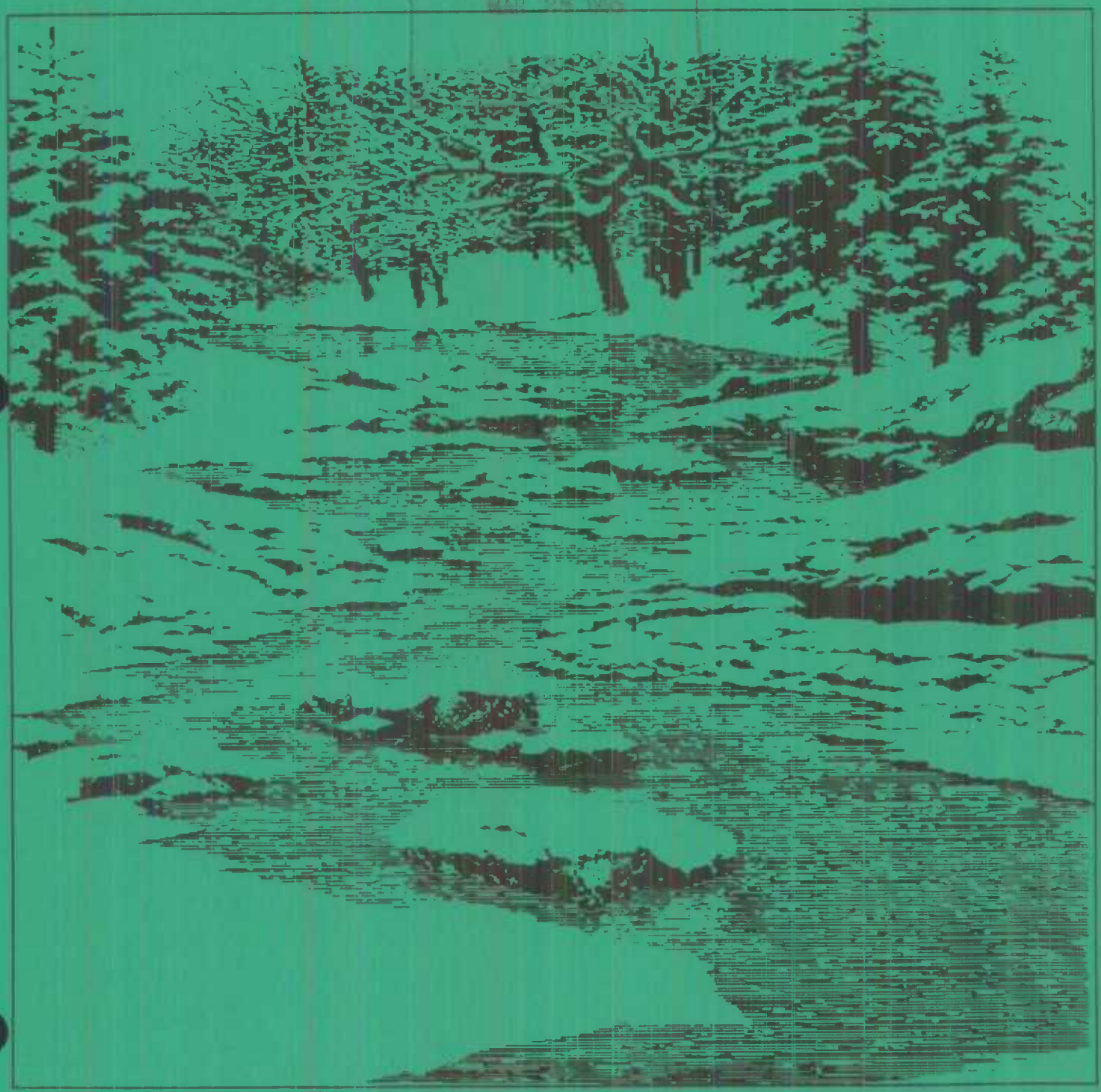

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Proposed Treatments of the Environment and Natural Resources in the National Accounts: A Critical Assessment

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This paper is one in a series of internal discussion papers produced in Statistics Canada's National Accounts and Environment Division. These papers address topics related to environmental statistics and the National Accounts components which are currently under development.

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Proposed Treatments of the Environment and Natural Resources in the National Accounts: A Critical Assessment

Kirk Hamilton[1]
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The motivations for proposing new treatments of environment and natural resources within the National Accounts are varied:

- the accounts measure the products of economic activity but not the by-products (e.g. pollutants);
- some environmental protection expenditures are measured as final output (the *defensive expenditures* question);
- depreciation of environmental assets and natural resources is not measured;
- environmental assets and natural resources are not valued in national wealth;
- environmental liabilities (e.g. chemical dumps or nuclear wastes without permanent storage) are not measured.

A prominent concern is that the national accounts cannot measure the *sustainability* of economic activity in the face of environmental degradation and resource depletion. This concern was recently articulated by the World Commission on Environment and Development (1987).

Critics of the treatment of the environment in the national accounts have generally taken one of three approaches: (i) that product is incorrectly measured, and therefore Gross Domestic Product[2] should be adjusted; (ii) that depreciation is incorrectly or incompletely measured, and therefore Net Domestic Product should be adjusted; and (iii) that wealth is incompletely measured, so that the measure of National Wealth should be expanded.

This article assesses these approaches in turn, comments on common issues in the valuation of environmental deterioration and resource depletion, and offers some thoughts on the measurement of economic sustainability.

Adjusting GDP

Defensive Expenditures. An area of considerable confusion and controversy is the treatment of expenditures on environmental protection and enhancement within the accounts. While intermediate expenditures on pollution abatement, for instance, by private businesses are clearly not part of domestic product, there are a variety of expenditures by households and governments on environmental protection that currently are measured as part of domestic product. The issues with respect to the latter expenditures fall into two classes: measurement of welfare and definition of final and intermediate output.

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1. Stewart Wells, Peter Victor, Rob Smith, John Hartwick and John Livernois provided useful inputs to this paper.

2. The literature variously discusses domestic and national product. Since this distinction is not key to the arguments that follow, both concepts of product will be used, according to the context.

Juster (1973) was among the first to question whether final expenditures by households and governments to protect the environment should be measured in GNP. His argument concerns welfare: that final expenditures on environmental protection generally do not improve the state of the environment but merely prevent further deterioration. In this instance welfare does not increase and Juster argues that such final expenditures should therefore not be measured in GNP.

There are two responses to this argument. The first is rather narrow: GNP (and GDP) measure only activity, not welfare, and therefore making welfare adjustments to GNP runs counter to the intent in measuring GNP.

The second response is broader: if the goal is a measure of welfare, deducting final expenditures on environmental protection may still not make sense. Consider two cases: (i) households choose to spend some of their income on environmental protection, e.g. an anti-pollution device for their car, and therefore consume less of other goods and services; and (ii) households choose to consume more goods and services rather than the anti-pollution device. In case (i) the households enjoy lower benefits from consumption of goods and services but greater environmental quality compared with case (ii). Whether measured welfare would be higher in case (i) or (ii) is not immediately obvious, since it involves the utility that may be derived from X dollars worth of goods and services compared with the utility derived from the marginally cleaner environment that spending the same X dollars on the anti-pollution device would give. In the absence of regulations or coercion the accounts would measure a *revealed* preference: if households are spending on environmental protection it is because their welfare will be increased by so doing.

The distinction between final and intermediate expenditure for certain classes of environmental expenditure was questioned by Herfindahl and Kneese (1973). To give a variation on their example, suppose that certain environmental expenditures, e.g. on waste management, are made by government but that the services resulting are consumed by the business sector. If these services were viewed as intrinsically intermediate in character, should measured GNP not therefore be smaller? What this question ignores is that if the services *were* intermediate inputs to business, then costs and output prices would be higher, leading to a higher nominal GNP. Comparing two equilibrium states, whether waste management services are public or private should not affect measured GNP.

User Cost in Resource Extraction. A question often closely linked to environmental degradation is resource depletion. The lack of any treatment of resource depletion in national accounting was the motivation for work by Ward (1982) and El Serafy (1989). The problem they pose is this: for many countries natural resource extraction and harvest is a large proportion of GDP, but this represents a drawing down of natural assets not measured in the national accounts - should GDP be adjusted to represent this user cost?

El Serafy gives the most detailed answer to this question: true income from resource extraction equals the perpetual income attainable from investing a portion of the net returns from this extraction. He derives the following formula for true income X, given a resource yielding net returns R for $n+1$ years and interest rate r by equating two asset values:

$$\sum_{j=0}^{n} \frac{R}{(1+r)^j} = \sum_{j=0}^{\infty} \frac{X}{(1+r)^j} . \qquad (1)$$

Therefore,

$$X = R(1 - \frac{1}{(1+r)^{n+1}}) . \qquad (2)$$

Investing $R-X$ each year for n+1 years will yield a fund whose interest payments (at rate r) equal X.

El Serafy goes on to conclude that GDP should include only X as net income from resource extraction, rather than R. This has the obvious problem that the national accounting identity would no longer hold, but a compensating adjustment to final demand[3] equal to $R-X$ would re-establish the balance.

What El Serafy terms the "user cost" is measured as $R-X$. Re-arranging terms we can derive:

$$R-X = \frac{R}{(1+r)^{n+1}} . \tag{3}$$

This implies that the user cost in consuming resources is the present value of the last unit of the resource produced. In El Serafy's formulation this user cost is constant over time.

Keynes (1936) defined user cost as the decline in value of an asset through its use over some accounting period. If we value an exhaustible resource using present values then, under the assumptions employed by El Serafy, the value at time t of a resource of total life $n+1$ (i.e. for $0 \le t \le n$) is given by:

$$V_t = \sum_{j=0}^{n-t} \frac{R}{(1+r)^j} . \tag{4}$$

The decline in value from year t to year $t+1$ is easily shown to be:

$$V_t - V_{t+1} = \frac{R}{(1+r)^{n-t}} . \tag{5}$$

This bears only an apparent similarity to expression (3). The Keynesian concept yields an increasing user cost as the resource is exhausted, as opposed to the fixed "user cost" of El Serafy.[4]

There remains the question of whether user cost should be included in GDP. El Serafy is unconvincing in arguing that because NDP is poorly measured (owing to the difficulties in measuring depreciation) that user cost should therefore be deducted from GDP. To the extent that El Serafy is arguing that the total value added of the exhaustible resource sectors should not be included in gross product because it is not sustainable, this is an argument against measuring gross product in general - by this logic we should only calculate NDP as a measure of domestic product. As Anne Harrison points out (1989, p. 22) the whole point about GDP as a *gross* measure is that it includes consumption of assets.

It does seem a burden on the national accounts to measure a portion of value added in the resource sectors as the perpetual income obtainable by investing some portion of surplus - many would argue that there are enough imputations and heroic assumptions in the construction of the accounts as they stand. If the question is whether an economy is developing sustainably, a more direct measure, as argued below, is whether total wealth including natural resources is increasing or decreasing.

Environmental Services and Damage. Peskin (1989) has been a long-standing proponent of expanding the production boundary in national accounting in order to include the services provided by the environment. His method requires the measurement of two basic values:

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3. such as a non-competitive import from nature, as suggested by Butterfield (1990)

4. If El Serafy proposed decreasing n each year in his formulation, i.e. to recalculate "user cost" as the resource is exhausted, this would be equivalent to investing $V_t - V_{t+1}$ each year, which would yield a fund of value $\frac{(n+1)R}{(1+r)}$ when the resource is exhausted.

- Environmental Services (ES). The value of services provided by the environment to the economy - Peskin conceives of these as being principally waste disposal services, which may be valued at what it would cost the producer to dispose of waste by means other than emitting directly to the environment.

- Environmental Damages (ED). The value of damages caused by deterioration in environmental quality. Peskin defines two types of damages: direct, for example ill health caused by air pollution; and indirect, for example the loss of the use of an asset such as a lake when it becomes polluted.

This leads to two alternative definitions of an adjusted GNP:

$$GNP_1 = GNP - ED \tag{6}$$

$$GNP_2 = GNP + ES. \tag{7}$$

GNP_2, as Peskin notes, is problematic because the value of free (from the producer's viewpoint) waste disposal services is already included in the surplus of the production sectors.

GNP_1 is a welfare-adjusted GNP measure, in the sense that the stream of benefits that we take from the environment is reduced when an environmental asset such as a lake is polluted, or, more directly, when health is affected adversely by environmental deterioration. Peskin gives no guidance on how GNP_1 is to be measured - to cite just two measurement difficulties: how much loss of health is environment related and how is this to be valued? and how should one value the collective loss of use of a lake when it becomes polluted?

Peskin's insights are useful: the environment provides waste disposal services outside the market, but the use of these services by producers may incur damages to other parties.

Including Environmental Deterioration in Gross Product. Anne Harrison (1989) makes an interesting observation when she notes that *gross* product is termed gross in conventional GDP because it includes the deterioration of reproducible capital. She concludes that if natural assets are to be measured as part of a country's asset base, along with reproducible capital, then GDP should really be increased to include the deterioration of these assets through exploitation and pollution.

A consequence of this approach would be that NDP would decrease (with respect to its conventional measure) for countries that are not spending enough on environmental protection to maintain current environmental quality, while it would remain the same for countries that are spending just enough to prevent or repair the environmental deterioration.

Again the question of how to value environmental deterioration is left as an exercise for the reader. One point is clear: we cannot assume that the value of environmental deterioration is just equal to the value of current environmental protection expenditures. It may be true for reproducible assets such as roads or dams (the examples given by Harrison) that repair and maintenance expenditures just offset depreciation, but there is no reason for this to be true in general for environmental expenditures.

To measure Harrison's expanded GDP, values would have to be placed on both the actual environmental deterioration and that which would have occurred if current protection expenditures were not made. To be consistent with traditional measures of gross product, the value of environmental deterioration should equal the change in the value of the environment as an asset - a non-trivial measurement problem.

Adjustments to Net Domestic Product

Natural Resource Depletion. Persuasive arguments for treating natural resource depletion as equivalent to depreciation of reproducible capital are found in *Wasting Assets: Natural Resources in the National*

Accounts, the report by the World Resources Institute (Repetto et al. 1989). Appealing to Hicksian notions of income, that you should only count as income that which exceeds your asset consumption, Repetto argues for the deduction of natural resource depletion from conventional NNP to arrive at a redefined NNP.

This approach is based on two assumptions: (i) that natural resource stocks should be viewed as national assets in the same manner as reproducible assets; and (ii) that the basis of valuation for the natural assets should be the "net price method", wherein the net price is the market price of the resource less the average unit costs of production (including depreciation of reproducible capital). For exhaustible resources such as oil, Repetto et al. measure depletion as the net price times the quantity extracted in the accounting period. They go on to argue that NNP should be reduced by this amount.

The methodology employed in *Wasting Assets* treats discoveries of resources as negative depletion, so that NNP can exceed GNP. As argued below, it would be more accurate to view discoveries as akin to revaluations or capital gains. When the Indonesian data in *Wasting Assets* are corrected to eliminate this anomalous treatment of discoveries, the calculated NNP growth rate is 5.8%, compared to the 4.0% shown in the study (and compared with the 7.1% growth rate for Indonesian GNP).

Hartwick (1990) provides a more formal derivation of corrections to NNP to allow for resource depletion. He shows that NNP may be represented as the suitably normalized Hamiltonian of the set of equations describing a model of a dynamic competitive economy with an endogenous optimal savings rate, in which resource extraction and discovery are explicitly included. The result is the following formula for NNP:

$$NNP = C + \dot{K} - [F_R - f_R][R - D] \,. \tag{8}$$

Here C is consumption, $\dot{K}$ is the change in the reproducible capital stock, F_R is the market price of resources, f_R the marginal cost of resource extraction, R the quantity of resource extracted and D the quantity of resource discovered.

This result shares with Repetto et al. the property that discoveries are treated as negative depletion, or (eliminating the double negative) as additions to net product. John Livernois has pointed out that if exploration costs are a function of the amount discovered and cumulative discoveries (to represent the increasing difficulty of finding new resources), rather than the size of the stock of resources as in Hartwick's derivation, then for g_D being the marginal cost of finding resources the expression for NNP becomes:

$$NNP = C + \dot{K} - [F_R - f_R]R + g_D D. \tag{9}$$

Here discoveries are measured in NNP as $g_D D$, which may be thought of as an investment - in fact, for an exploration cost function which is linear in amount discovered, this term is just equal to the total cost of discovering reserves D.

Another characteristic of the formalism adopted by Hartwick is that resources are treated as one homogeneous pool with a rising marginal cost of extraction. For this model it is indeed true that the difference between marginal cost and market price is the correct basis of valuation of depletion. However in an earlier paper (Hartwick and Lindsay, 1989) it is argued that marginal costs should be used to value depletion of US oil stocks, where marginal costs are considered to be the costs of frontier oil. This ignores the fact that oil in the US is a heterogeneous resource, with costs of extraction varying with geological characteristics, and so does not fit this model.

The question of the treatment of resource discoveries in the national accounts is an interesting one. The United Nations (1977) recommends accounting for resource discoveries in the national balance sheets as a

reconciliation item, linking the value of stocks between accounting periods. In this scheme discoveries therefore show up neither as current income nor product. Conceptually, discoveries represent a change in information about the state of nature - they could therefore be viewed as being akin to capital gains, where asset prices serve as carriers of information about scarcity.

Environmental Degradation. Deducting a value of environmental degradation from GNP to give a new measure of net product is one suggestion in the United Nations draft guidelines for a Satellite System of Integrated Environment and Economy Accounts (United Nations 1990). These guidelines build on a paper by Bartelmus, Stahmer and van Tongeren (1989). The basic logic is that environmental deterioration is conceptually equivalent to depreciation of reproducible assets.

The guidelines suggest valuing environmental degradation as the cost of returning the environment to its original state at the beginning of the accounting period, i.e. the cost of potential abatement or restoration to achieve constant environmental quality.

This is on the surface a practical method of valuation. It is not necessarily simple, since there are diminishing returns (in terms of abatement achieved) per unit of investment in pollution control that may be difficult to measure. There is also the question of process change. For cost reasons it will increasingly be more efficient to alter production processes than to add "end of pipe" pollution control equipment. Where the cost of widgets produced with low-pollution processes is higher than widgets produced with traditional processes there is a basis for measuring the costs of pollution control. What is likely, however, is that the thrust of technological change will be to produce lower cost widgets with lower pollution emissions, in which case there is no measurable cost of pollution control.

This treatment of the valuation of environmental degradation is cost based and thus does not value the change in services provided by the environment as it degrades. It therefore strays rather far from either welfare measurement or analogies with the depreciation of reproducible assets.

This approach bears some resemblance to the ideas of Hueting and Bosch (1990). Their suggestion is to value environmental degradation as the difference between currently measured GDP and the GDP consistent with sustainable use of the environment. They itemize the process of measuring this "sustainable GDP", involving mainly the measurement of sustainable rates of use of the environment (buffering and absorptive capacities, rates of cycling and growth), costs of reducing environmental emissions to sustainable levels, and reduction of levels of certain economic activities to sustainable levels (e.g. reduction in use of private automobiles to meet CO_2 emission targets).

Hueting and Bosch correctly point out the difficulties in valuing the demand for environmental services that make welfare measures intractable. However, they are sanguine in their assumption that sustainable use of the environment can be unambiguously measured, and the preceding criticisms of cost-based approaches, and the challenges that process changes present to these approaches, are relevant. Rather than measuring a sustainable GDP, it would be more accurate to describe their work as a thorough attempt to measure the cost of achieving sustainable use of the environment.

Expanding Measures of National Wealth

Surprisingly little has been written about extending wealth measures as a means of bringing resources and the environment into the national accounts. Scott (1956) argued for doing this for two reasons: (i) capital per worker or per unit of output is not an unequivocal measure of wealth, especially for nations rich in natural resources; and (ii) for nations with declining natural resources, additional capital will be required to maintain wealth. What Scott had in mind, and what will be discussed below, are commercial resources where market prices exist. A preliminary discussion of this material appears in Hamilton (1989).

In addition to the problem of valuing depreciation of natural resources inherent in approaches such as

Repetto el al., wealth accounting must deal with two other issues: measures of resource extent and valuing stocks of natural resources.

For sub-soil resources the distinction is usually made between *total resources*, which are a probabilistic measure of total resource extent, and *reserves* which represent the amount of resource that is known, with a high degree of probability, to exist and to be producible profitably at current prices and costs. For national accounting purposes the reserve is obviously the correct measure of extent, but it complicates matters that resource extent, as well as value, is a function of prices and costs. Moreover, while resource lands containing a known quantity of $50 petroleum would not currently be a reserve (with oil prices hovering at $20 per barrel), such lands might have a value to an entrepreneur if there were an expectation of rising oil prices.

This latter point is at the heart of the question of valuing natural resource stocks. In most countries resources are on public lands and there is no market in resource tracts (although there may be bids for production leases). The value of resource tracts must therefore be derived. On the usual assumption that the price of an asset should equal the discounted stream of benefits derived from its ownership, the present value of rents from a resource tract would appear to be a good valuation of the wealth that the tract represents. However, this requires assumptions about discount rates, production profiles and resource rents extending into the future.

The choice of discount rate is obviously important. Since resources are often on public lands this would argue for using a social rate of discount. Some environmentalists would argue that to account for the welfare of future generations the rate of discount should be zero. As Landefeld and Hines (1985) point out, if the rate of increase of unit rents equals the discount rate, this is equivalent to a zero discount rate in the present value calculation - this is of course the Hotelling optimality condition and the basis of the net price method employed by Repetto et al. Unfortunately the assumptions required for the Hotelling theory, constant extraction costs for a homogeneous resource of known extent, do not apply in the real world - even moderately more realistic assumptions as employed by Levhari and Liviatan (1977) lead to optimal extraction programmes in which rents must increase at some rate less than the discount rate.

An interesting alternative to present value calculations is to value current reserves at the cost of finding new reserves through exploration; this is described in Gervais (1990). A difficulty with the exploration cost approach is that it strays from the usual assumption of market valuation employed in the wealth accounts. Resource deposits featuring higher unit rents should have a higher value in a properly functioning market than those with lower unit rents (after controlling for deposit size); the exploration cost approach would employ a fixed unit value, the unit cost of finding new reserves. Moreover, the private firm exploring for resources will spend on exploration up to the point where the marginal dollar spent equals the present value of net returns on the marginal resource found, but these are private net returns and not a measure of resource rent - they do not therefore represent the returns to the owner of the resource which must be the basis of establishing wealth values.

Living resources represent a possible anomaly in wealth accounting. To take the example of forestry, any present value calculation of the worth of forest resources will necessarily give the highest weight to currently standing commercial timber. Yet for countries with large tracts of mature forest the goal of forest development is to achieve optimal rotations of trees, in effect creating slow-growing crops, which necessitates harvesting the mature forests first. It is possible, therefore, that proper forest management will lead to a lower standing volume but a yield that is economically optimal and *sustainable*. Because trees can take 60 years to reach commercial size in temperate regions of the world, there will be an apparent decline in wealth inherent in the transition from harvest of mature virgin timber to managed forestry. This is a subject requiring further research.

The inclusion of living resources in wealth accounts offers an indirect means of measuring the effects of environmental deterioration. If the statistical system is sufficiently sensitive, the effects of acid rain, for

instance, should appear as damage to the stock of living resources and would lead to a decline in wealth.

One criticism that is often made of valuing resources and their depletion in the wealth accounts is that, as resources become increasingly scarce, their prices increase and therefore wealth may not decline as quantities of remaining resources decline. This is incorrect: if the wealth value of a resource is based on rents, as argued earlier, increasing resource prices will generally be accompanied by increasing extraction costs as more marginal resources are exploited, so that unit rents may not in fact increase when resource prices do. What is true is that resource price fluctuations from year to year will produce volatility in the wealth measures.

Some Issues

A striking aspect of the various proposals for altering the national accounts with respect to environment and resource issues is the extent to which they are concerned with measuring the altered flows of benefits from the environment as it changes (Harrison is the exception to this). Because these are not market transactions, they are arguably outside the scope of the national accounts and are more properly viewed as attempts to derive new welfare measures. Researchers who are concerned with welfare measurement quickly conclude, however, that the issues are broader than resources and the environment. The result is wide-ranging measures of welfare as described by Nordhaus and Tobin (1972), Juster (1973), Eisner (1989), and Daly and Cobb (1990).

Another striking feature of many of the proposals is the use of costs of abatement as the measure of environmental depletion. Aside from the problems of measurement alluded to earlier, there is a clear divergence between these approaches and any attempt to measure either environmental asset values or the flow of benefits from the environment. To expand on the latter point, only for an efficient environmental policy would it be true that marginal costs of abatement equal marginal benefits to society.

The literature contains remarkably little discussion of the measurement of resource rents. It is useful to conceive of rent literally as the maximum payment that the owner of a resource could charge a prospective producer of the resource, such that the producer will choose to produce, i.e. such that net profits after rental payments give an adequate return on capital invested. In the absence of free markets in resource deposits, since governments are generally the owners, much of the problem in imputing a value to natural resource stocks and depletion reduces to imputing unit rents. The problem with this definition of rent for the national accountant and statistician is that rents are not observed (although a well-conceived system of royalties should capture the available rents).

The measurement of depletion of exhaustible resources is necessarily closely linked to this operational definition of rent. Because resource deposits of different grades (and therefore costs of production) are typically exploited in the same accounting period, the measure of total resource rents will include both Hotelling rents (on the marginal deposit) and Ricardian rents (on the infra-marginal deposits). This non-homogeneity of resource deposits implies that the Hartwick model does not apply, and therefore that depletion may not be measured simply by multiplying price minus marginal unit cost times the quantity of resource produced. Repetto argues for estimating depletion as the total rents taken in the accounting period. El Serafy is ultimately not measuring depletion with his formulation, but rather a hypothetical constant stream of income from resources.

If resource stocks are valued using present values then, under the assumptions of constant rents extending over the lifetime of the resource and fixed interest rates, depletion is given by expression (5). This has several consequences: (i) if the interest rate is 0, this reduces to the Repetto valuation of depletion; (ii) for resources of fixed extent, depletion increases year by year as the remaining resource stock shrinks; and (iii) if new resources are discovered, the value of depletion declines.

Valuing environmental assets outside the market system is, if anything, hampered by too many

alternatives. The range of imputations, including damage cost assessments, benefits measurement, travel costs, hedonic pricing and contingent valuation is admirably described and criticized in Pearce, Markandya and Barbier (1989). The most direct of these methods is contingent valuation, but the work by Knetsch (1990) raises considerable questions about this approach. Calling on a substantial body of experimental evidence, Knetsch claims that willingness to accept compensation may be a factor of 2 to 10 times higher than willingness to pay, owing to an "endowment effect". Since contingent valuation attempts to measure willingness to pay for environmental amenities, Knetsch's critique may be a serious blow.

There is a general attempt in the construction of the national accounts to keep imputations to a minimum and observable transactions to a maximum. Any attempt to value environmental assets directly in the accounts would run counter to this. If such imputations were presented in a satellite account there would still be a need to show the confidence bounds for the measures.

It is by no means accepted by all national accountants that depletion of natural resources should enter the measurement of Net Domestic Product. Depreciation of fixed assets in the accounts represents what enterprises choose to claim for tax purposes as the decline in value of the capital stock - it is not the user cost of capital because it is influenced by the tax system. Therefore if one desired measures of net income and product that reflect user costs for reproducible capital and natural resources, estimates of *both* user costs would be required and the result would be conceptually different from NDP as currently measured in the accounts. The latter statement should not be construed as saying it would not be worthwhile to derive new measures of net income and product - quite the opposite, since this would more accurately measure Hicksian notions of income.

Measures of Sustainability

Given the current prominence of concerns over the sustainability of economic development, it is worth considering what indicators of sustainability would derive from altered national accounting aggregates. A limited and purely economic definition of sustainability could be as follows: an economy is developing sustainably if current activities are not damaging the potential for income in the future.

A net domestic product adjusted to reflect depletion of natural resources is of course only a measure of potentially sustainable product. A better measure of whether an economy is actually developing sustainably would therefore be an adjusted net investment which deducts the user costs for capital and resources - if this is negative then sustainability may indeed be threatened.

Should the gap in growth rates between GDP and adjusted net product be an indicator of sustainability? This is implicitly favoured in the work of Repetto et al. If resource rents were the only deduction made to arrive at net product and if resource rents were constant from year to year, then the growth rates of GDP and net product would be the same; if resource rents were a constant proportion of GDP, then the net product growth rate would necessarily be less than that of GDP. Differences in growth rates can therefore give no clear signal of sustainability.

Expanded wealth accounting offers an alternative to these approaches. It provides a significant indicator of sustainability: the trend in *total* wealth (natural and reproducible) per capita. This has the advantage over an adjusted net investment indicator that it includes resource discoveries.

However, all of these potential indicators of sustainability share a major limitation: *global* environmental effects are not easily captured in *national* accounts.

Concluding Comments

The literature suggests a certain fixation with getting one number right, whether that number is GDP or NDP or national wealth, whereas the environment and natural resources are clearly complex and multi-dimensional. In economic policy-making there is little suggestion that GDP or its growth rate is the only indicator needed to guide policy. A broader perspective would suggest that it is important not to over-burden GDP as an indicator for policy-making that includes environmental considerations. That being said, better measures of income and wealth are still desirable and worth research effort.

With sustainability becoming a policy goal, it is essential that our indicators tell us where we're going rather than where we've been. *Forward-looking* indicators such as expanded measures of net investment or national wealth therefore deserve our attention.

Wealth accounting appears to be a neglected avenue in dealing with resource and environment issues. Expanded wealth accounts would yield useful information on the relative importance of reproducible wealth and natural wealth for a country, and provide an important enhancement of the balance sheet accounts for the resource sectors. Wealth accounts for commercial resources give an indirect measure, via living resources, of the value of environmental deterioration. And total wealth per capita is a superior indicator of sustainability.

Will measures such as net product or total wealth be used in policy-making? Gross product is currently the dominant indicator. It is arguable that when unemployment and inflation are the primary economic problems to be solved then gross product is the correct indicator, because it correlates well with measures of these problems. It is equally arguable that when the deterioration of the environment becomes a major socio-economic problem then measures of net product and total wealth will find their place.

References

Ahmad, Y.J., El Serafy, S., and Lutz, E., (eds), 1989, "Environmental Accounting for Sustainable Development", Washington: World Bank.

Bartelmus, P., Stahmer, C., and van Tongeren, J., 1989, "Integrated Environmental and Economic Accounting", International Association for Research on Income and Wealth, 21st General Conference, Lahnstein, West Germany, August 1989.

Butterfield, D.W., 1990, "Natural Resources in National Accounting: A Suggested Treatment", Dept. of Economics, McMaster University, August 1990.

Daly, H.E., and Cobb, J.B. Jr., 1990, "The Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future", Boston: Beacon Press.

Eisner, R., 1989, "The Total Incomes System of Accounts", Chicago: University of Chicago Press.

El Serafy, S., 1989, "The Proper Calculation of Income from Depletable Natural Resources", in Ahmad op. cit.

Gervais, Y., 1990, "Some Issues in the Development of Natural Resources Satellite Accounts: Valuation of Non-Renewable Resources", National Accounts and Environment Division, Discussion paper no. 4, Ottawa: Statistics Canada.

Hamilton, K.E., 1989, "Natural Resources and National Wealth", National Accounts and Environment Division, Discussion paper no. 1, Ottawa: Statistics Canada.

Harrison, A., 1989, "Introducing Natural Capital into the SNA", in Ahmad op. cit.

Hartwick, J.M., 1990, "Natural Resources, National Accounting and Economic Depreciation", Journal of Public Economics 43 (1990) 291-304.

Hartwick, J.M., and Lindsay, R., 1989, "NNP and Economic Depreciation of Exhaustible Resource Stocks", Kingston: Queens University Department of Economics Discussion Paper no. 741.

Herfindahl, O.C., and Kneese, A.V., 1973, "Measuring Social and Economic Change: Benefits and Costs of Environmental Pollution", in Moss op. cit.

Hueting, R., and Bosch, P., 1990, "On the Correction of National Income for Environmental Losses", Statistical Journal of the United Nations ECE 7 (1990) 75-83.

Juster, F.T., 1973, "A Framework for the Measurement of Economic and Social Performance", in Moss op. cit.

Keynes, J.M., 1936, "The General Theory of Employment, Interest and Money", London: Macmillan.

Knetsch, J.L., 1990, "Environmental Policy Implications of Disparities Between Willingness to Pay and Compensation Demanded Measures of Values", J. Environmental Economics and Management 18, 227-237 (1990).

Landefeld, J.S., and Hines, J.R., 1985, "National Accounting for Non-Renewable Resources in the Mining Industries", Review of Income and Wealth 31, 1 (March): 1-20.

Levhari, D. and Liviatan, N., 1977, "Notes on Hotelling's Economics of Exhaustible Resources", Canadian Journal of Economics 10, 2 (May): 177-192.

Moss, M. (ed), 1973, Studies in Income and Wealth, Vol. 38: The Measurement of Economic Performance, New York: Columbia University Press.

Nordhaus, W.D., and Tobin, J., 1972, "Is Growth Obsolete?", in Economic Growth, General Series 96, New York: National Bureau of Economic Research.

Pearce, D.W., Markandya, A., and Barbier, E., 1989, "Blueprint for a Green Economy", London: Earthscan Publications.

Peskin, H., 1989, "A Proposed Environmental Accounts Framework" in Ahmad op. cit.

Repetto, R., Magrath, W., Wells, M., Beer, C., and Rossini, F. 1989, "Wasting Assets: Natural Resources in the National Accounts", Washington: World Resources Institute.

Scott, A., 1956, "National Wealth and Natural Wealth", Canadian Journal of Economics and Political Science 22, 3 (August): 373-378.

United Nations, 1977, "Provisional International Guidelines on the National and Sectoral Balance Sheet and Reconciliation Accounts of the System of National Accounts", Series M, No. 60, United Nations Statistical Office, New York.

United Nations, 1990, "SNA Handbook on Integrated Environmental and Economic Accounting. Preliminary draft of part 1: General Concepts", United Nations Statistical Office, New York.

Ward, M., 1982, "Accounting for the Depletion of Natural Resources in the National Accounts of Developing Economies", Paris: OECD Development Centre, Publication no. CD/R(82)3010.

World Commission on Environment and Development, 1987, "Our Common Future", Oxford: Oxford University Press.

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1. Hamilton, Kirk (July 1989): ***Natural Resources and National Wealth***.

2. Hamilton, Kirk and Douglas Trant (December 1989): ***Statistical Aspects of the Application of Geographic Information Systems in Canadian Environment Statistics***; Journal of Official Statistics 1989, vol. 5, no. 4, pp. 337-348.

3. Smith, Robert (September 1990): ***An Annotated Bibliography of the Resource and Environmental Accounting and Valuation Literature***.

4. Gervais, Yvan (October 1990): ***Some Issues in the Development of Natural Resources Satellite Accounts: Valuation of Non-renewable Resources.***

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