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ON THE INTERPRETATION AND APPLICABILITY OF A "GREEN NATIONAL PRODUCT"

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Several economists have recently suggested that the national product should be adjusted for the value of environmental damages. In this paper we look at some of the difficulties one encounters when the correcting formulae derived from simple theoretical models are transferred to applied national accounting. In particular, the paper is concerned with the question of whether a corrected national income measure will actually provide relevant information for policy-makers.

It is shown that a "green national product" will be very difficult to interpret. In general, it may not give any indications of the necessity of imposing stronger environmental policy actions. Nor does it indicate the hypothetical state of the economy after a change in environmental efforts.

1. INTRODUCTION

Quite a few economists have suggested that net national product should be adjusted for the value of environmental damages (see, for instance, Mäler, 1991; Hartwick, 1990; Harrison, 1989). The Statistical Division of the United Nations has also for some time pursued this line of thought. In UN (1993) they outline a satellite account to the SNA (System of National Accounts) for environmental goods and natural resources. This framework, called the SEEA (System for Integrated Environmental and Economic Accounting), is based upon resource accounts measured in physical units, but monetary valuation of the depletion and degradation of natural resources and environmental goods is also proposed. One important goal for this valuation is to establish an environmentally corrected NDP, "Eco Domestic Product" (EDP). In fact, three different versions of EDP, resulting from the use of three different valuation methods, are proposed. Some countries, e.g. Sweden and Mexico, have decided to develop tentative accounts, either along the lines of the UN proposals or with similar methods.

The purpose of this paper is to illuminate some of the difficulties one encounters when the correcting formulae derived from simple theoretical models are transferred to applied national accounting. In particular, we are concerned with the question of whether an environmentally adjusted NDP will actually be suitable as a device for integrated economic and environmental policy formation.

2. THE AIM OF A CORRECTED NATIONAL PRODUCT

In spite of the extensive discussion on whether or not to adjust NDP, the purpose of actually doing so does not, to us, seem entirely clear. We want to

focus on this; the case of the statistician who collects vast amounts of data, which nobody ultimately uses, is already far too common. Moreover, if an environmentally corrected national product is actually used, there seems to be a considerable risk that it will be misinterpreted.

The Hicksian concept of income (Hicks, 1947) frequently serves as background for adjusting the national accounts measures (see e.g., Ahmad *et al.*, 1989). Accordingly, NDP should measure the maximum amount the inhabitants of a country could consume during the accounting period without being worse off in the end of the period than in its beginning[1]. A corrected NDP could then be regarded as a measure of a sustainable development, as Hueting, Bosch and de Boer (1992) do. In addition, however, several other aims of correcting NDP can be noted. One is that of creating a measure which corresponds better to our perception of welfare (Mäler, 1991), while another is to achieve a proper measure of value-added in the economy such as in Peskin, Floor and Barnes (1992). The need for an indicator of the overall severity of environmental damages that occurred during the accounting period seems to be still another aim of establishing a "green national product." It is not evident that all these issues should be treated by the same method.

The interim Handbook of the SEEA (UN, 1993) proposes three different EDP measures. They differ from each other with respect to the valuation method used in calculating the deterioration of natural capital; applying market valuation, maintenance costs, and a combination of market valuation and willingness to pay, respectively. All three versions seem to be motivated by the analogy between deterioration of man-made and natural capital. We therefore interpret the aim of the corrections as that of providing a better measure of value-added, rather than welfare measurement. Bartelmus and van Tongeren (1994, p. 21) suggest an additional aim for the proposed corrections: "Replacing conventional growth indicators, notably GDP or NDP, by EDP and expanding the scope of key variables such as capital and capital formation to include natural capital (use) in dynamic growth models could thus provide early warning-signals about the trends and limits of sustainable economic growth."

We think much of the demand for a "green GDP" is caused by the fear that authorities will take no notice of environmental degradation as long as GDP increases, and that a common feature of the proposals of "greening" the national product is that they are meant to provide a better informational background for evaluating and eventually changing policy. Hence, our scope will be to look at whether or not an environmentally adjusted national product actually provides a better tool for this purpose.

[1]Since Hicks' definition of income, as stated on p. 173 of his "Value and Capital", is the starting point of the debate, we would like to draw attention to the following pages in the very same book. On those pages, Hicks emphasizes that in a dynamic framework, the concept of income is very difficult to specify in an unequivocal manner, without making the concept so vague that it becomes useless for dynamic analysis. On page 177, he concludes: "By eschewing *utility* we were able to sharpen the edge of our conclusions in economic statics; for the same reason, we shall be well advised to eschew *income* and *saving* in economic dynamics. They are bad tools, which break in our hands."

3. The Theoretical Justification for a "Green GNP" as a Welfare Measure

The seminal article by Weitzman (1976) is often referred to as the theoretical background for "greening" the net national product. Weitzman demonstrates that in a competitive, closed economy with perfect foresight (i.e. conditions of intertemporal efficiency are fulfilled), NDP can be interpreted as a measure of welfare. Weitzman defines welfare as the discounted value of future consumption. He shows that the maximum welfare attainable along a competitive trajectory is exactly the same as what would be obtained from a hypothetical *constant* consumption level equal to NDP[2]. Weitzman emphasizes that all sources of economic growth must be included in the notion of "capital." Thus, natural and environmental resources and human capital should ideally be included in the capital stock.

Hartwick (1990) and Mäler (1991) extend Weitzman's model to explicitly include natural resources and the environment, and propose corrections of NDP to account for the degradation of the wealth of natural resources and the value of the environment. However, Weitzman's point of departure seems to be quite different from that of the other two. Weitzman demonstrates under which assumptions NDP can be interpreted as a welfare measure, and comes up with a rather strict answer[3]. Mäler and Hartwick, on the other hand, though relying on approximately the same limiting theoretical assumptions as Weitzman, interpret the results from their models as prescriptions for applied national accounting. Such an interpretation alters the requirements to the realism of the model significantly. Brekke (1994) and Asheim (1986, 1994) point out that several of the assumptions cannot be altered without altering the results significantly.

There is a general problem in using a theoretical optimization model as a background for practical policy decisions. The model shows that if the described economy sticks to an optimal growth path, NDP minus the deterioration of natural resources and the environment is a measure of welfare in the Weitzman sense. But this result says nothing about the interpretation of NDP outside optimum. It would be self-contradictory to first use the model as a rationale for changing the national accounts, and then to use the accounts to show the need for changing the policy. Assuming that the economy is on an optimal path corresponds rather badly to the starting point of the whole debate on "green national product"; namely that a lot of people are concerned about the environment because they believe it is over-exploited. That is, one does not consider the resource allocation in this field to be optimal at all. If the correction of NDP is aimed at showing how far the economy has strayed from some optimal path, one should certainly not start with an assumption of optimality.

[2]Note that Weitzman emphasizes that NDP does not measure the maximum constant sustainable consumption level which is currently attainable [it is easy to interpret Mäler's statements on pp. 11 and 13 in Mäler (1991) in this direction]. Any deviation from the *optimal* consumption path, for instance by generally keeping to a path of constant consumption, would break down the justification of using NDP as a welfare measure. A non-optimal consumption path would cause changes in the scarcity prices, and thus disqualify the use of linear scarcity prices in the accounting equation.

[3]Weitzman emphasizes the theoretical nature of the exercise by starting with the statement, "We abstract heroically in more ways than one."

The theoretical approach also avoids an important part of the problem of valuing the environment. A shadow price measures the net impact on social welfare of a unit increase in the supply of that good (Drèze and Stern, 1987). Hence, shadow prices cannot be determined without defining social welfare. In Hartwick's and Mäler's models, the optimality criterion is clearly defined, and the shadow prices can be read out of the Hamiltonian. However, such values will be sensitive to any change in model formulation, including the definition of social welfare. Decision-makers do generally not have the same opinions of what is good and bad for society. In the case of such disagreements, only those policy-makers who accept the normative implications of the chosen welfare function will be able to use the EDP derived from the analysis as a welfare measure.[4]

4. Environmental Goods: Values and Their Interpretation

4.1. *Diverging Marginal Values*

A fairly common approach to the valuation of non-traded goods seems to be that it is a technical problem, which can be solved by introducing advanced measurement techniques, or by agreeing that all one needs is a crude approximation. Basicly, however, it is a question of defining properly what it is one wants to know.

Since markets for most environmental goods do not exist, we do not have any direct information of the marginal money value of those goods (as related to other goods). This difficulty cannot be solved simply by trying to estimate the value: The problem is not only that the market does not reveal any information, but that it simply *does not work*. No mechanism is present which can be expected to move the resource allocation in a direction of efficiency. Hence, there is no concensus between suppliers and consumers, nor among the different suppliers or different users, on what the marginal value of the good is. In such a situation, the estimated value of the environment will have a different interpretation depending on the measurement technique used, since different methods simply measure different values. A seemingly technical discussion of measurement methods to calculate EDP may thus be rooted in disagreement about the desired interpretation of EDP. Few of those who have proposed to correct GDP or NDP have provided precise interpretation of the proposed EDP measures.

4.2. *An Example: The Case of the Unsuccessful Environmental Policy*

The following example may illustrate that different valuation techniques give the answer to different questions. Imagine an industrial plant which emits a hazardous chemical into a river. Assume further that the country in question has a very inefficient environmental policy. Therefore, the owners of the plant do not bother to clean the emissions before they reach the river, although we will assume that the costs of doing so, in this case, would have been minimal. Once emitted into the river, the waste kills all organisms living there, and makes the water useless to the people who live downstream.

[4]See Brekke *et al.* (1994).

What is the value of this environmental deterioration? According to the maintenance cost approach, the value is in this case equal to the hypothetical costs of *avoiding* the emissions, which were, in our example, low.[5] If, on the other hand, we choose the hypothetical costs of *restoring* the actual damage as an estimate, the environmental correction would become large or even infinite, since it is very improbable that humans would be capable of restoring all damages.

Still another possibility is to estimate the value of the damage to the people living by the river. Even this approach would be ambiguous, however. For example, if those people are very poor, they might well state that they are not *willing to pay* much to get back to the previous conditions (because they do not have much to pay), whereas the amount of money they would need to be *as well off as before* might be substantial.[6] As we see, the environmental correction can take on almost any value we like, if we just define "the environmental value" in the right manner.

In our example, the resulting corrected NDP might vary from close to current NDP to minus infinity. This was not due to inaccurate measurement, but to the fact that we were measuring different things. In general, avoidance costs, repair costs, willingness to pay and willingness to accept will not be equal.

4.3. *Another Example: The Disappearing Sectors*

The second version of EDP in UN (1993) is defined as net domestic product minus hypothetical costs to keep environmental standards intact within the accounting period. Let us take a look at the interpretation of this measure. Suppose that the economy can be divided into two sectors, namely A and B. Hence, EDP is defined as $EDP = E_A + E_B - N_A - N_B$, there E_i is the net product of sector i, and N_i is the least cost (hypothetical) of avoiding or restoring environmental degradation caused by sector i.

Let us now assume that both sectors emit hazardous substances which accumulate in nature. This means that a constant level of emissions is not sufficient to maintain the previous environmental standard; the emissions must stop. Both sectors are capable of reducing the emissions at a certain cost, but only sector A is capable of eliminating the emissions entirely. For sector B, least cost of maintaining the environmental standard will then be equal to its net product. Hence, $EDP = E_A + E_B - N_A - E_B = E_A - N_A$.

Sector B has been netted out, and consequently no contribution from this sector will be contained in EDP. Thus, if emissions from sector B of other hazardous components increased or decreased, or if actual economic activity in this sector changed, this would not have any impact on the level of EDP.

If neither sector A nor B were able to stop their emissions of accumulating substances (for instance CO_2 emissions), EDP would be equal to zero, regardless of all other aspects of environmental standards and the level of economic activity.

[5]Maintenance cost is defined as the least (hypothetical) cost of keeping the environmental standard unchanged during the accounting period. This is the valuation principle which is used for calculating the second version of EDP in UN (1993).

[6]See Hanemann (1991). Hanemann demonstrates that if few substitutes are available for the public good in question, the disparity between willingness to pay and willingness to accept may be large or even infinite.

This result was obtained because the hazardous substances were accumulated in nature, so that constant levels of emissions were not sufficient to maintain current standards. Regarding substances which do not accumulate, a similar problem arises when it comes to *changes* in EDP during the year. If a firm increased its production during the accounting period, and this could not have been possible without environmental degradation, the environmental correction must be set equal to the increase in net product of that firm.

A lot of firms would not exist if they were not allowed to damage their surroundings to some extent. This does not mean that it is not of interest to monitor their environmental and economic performance. The exclusion of such firms in the EDP measure is, however, the consequence of defining the value of the environmental changes as the costs of keeping environmental standards unchanged.

Why do we get this seemingly absurd result? It is, actually, a logical consequence of the question we have posed. By choosing the maintenance cost approach, we got an EDP designed to measure *the part of current economic activity which could have taken place without degrading the environment.* If no economic activity is possible without hazardous emissions, then the correct answer to this question is, in fact, zero. If one, on the other hand, for example expects EDP to measure welfare, the exercise above undoubtedly must appear rather odd.

By extending the above example slightly, we come up with a variety of possibilities in which EDP will give quite confusing signals. Innovations in environmental technologies will, for instance, lead to less costly abatement. This will lead to a reduced monetary valuation of a given environmental degradation, so that the difference between NDP and EDP shrinks even if the environment is just as bad as before.

Similarly, EDP at maintenance costs can hardly be regarded as an early warning-signal concerning the sustainability of economic growth. The reason is that this valuation method is not based on measuring *the effects on the environment* of the economic activity which took place during the accounting period, but rather on the costs of something that *should* have been done but was not. For example, if environmental damages measured in physical units is a positive function of NDP, and the unit cost of abatement activities is kept constant, EDP can only decline over time if NDP declines too. The reason is that the possibility of closing down economic activities provides an upper bound on the environmental correction.[7] Consequently, defining sustainable economic growth as a positive trend in EDP will in many cases unfortunately not be very different from using the traditional indicators of GDP or NDP.[8]

[7]If emitted substances do not accumulate in nature, then the environmental standard of last year can be kept simply by keeping economic activity constant, so the environmental correction cannot exceed the increase in NDP in this case. If substances accumulate, a constant environmental standard may require that economic activity is reduced, and the correction item may exceed the increase in NDP. But then this was reflected in last year's EDP as well, and the change in EDP will not exceed the change in NDP.

[8]Bartelmus and van Tongeren (1994) propose a definition of sustainable economic growth as a positive trend in (real) EDP. They do not specify which of the versions of EDP in UN (1993) they are considering. However, since EDP at maintenance cost is the EDP version on which they seem to put most emphasis, it seems natural to interpret their proposal this way.

5. Traded Natural Resources

In the case of traded natural resources, such as soil, fish and timber, market values do exist, and the valuation problem, although still present in some cases, becomes less urgent. Ideally, the national accounts should separate income or remuneration on the stock of resources from changes in these stocks, similarly to the separation between depreciation and remuneration on man-made capital. Thus, the net national product becomes exaggerated as a measure of value-added if a large part of current income is based on extraction of natural resources. In addition, national account figures in such economies are biased in the sense that degradation of the value of some categories of wealth, man-made capital, is accounted for, while for others, like natural resources, it is not (Ahmad *et al.*, 1989).

In the revised system of national accounts (SNA) (UN, 1992), an expansion of the balance sheets is proposed, including balance sheets for natural resources. In the SEEA (UN, 1993), the market value of depletion of natural resources is included in the production account as well, yielding the first of the three versions of EDP.

El Serafy and Lutz (1989) refer to two different approaches of measuring degradation of natural resources, the depreciation approach and the user cost approach. The depreciation approach, proposed by Harrison (1989) among others, implies deductions in NDP for the change in the stock of natural resources, and is motivated by the analogy to depreciation of man-made capital. The simplest suggestion would be to subtract for the value of extraction.[9] However, this value includes both income and depreciation of the resource. To make the proposal consistent with the concept of capital in the national accounts, the wealth of the stock has to be estimated, and the depreciation of the stock is measured as a change in wealth.

The user cost approach (El Serafy, 1989) provides a method to sort out the "true income" of revenues without making estimates of wealth. If part of the revenues were invested, then future returns on that capital would allow for a higher sustainable consumption than if the country did not possess the natural resource in the first place. El Serafy argues that one should calculate the "true income" part of the revenues, and that the residual part of the revenues (net of extraction costs) should be deducted from GDP.[10]

There may be a good case for adjusting the income measures in the national accounts for changes in the wealth of those natural resources which have market values. This may help to illustrate the important fact that income generated by sales of natural resources has its counterpart in reductions of wealth. It is important, however, to emphasize the limits of such an adjusted national product. Otherwise, complex management decisions are easily turned into a subject of

[9]The value of extraction from a natural resource might be estimated as the product of natural resources in excess of a normal remuneration on labour and capital [see e.g. Aaheim (1986)].

[10]Some of his assumptions actually seem to be incompatible. The derivation of the formula relies on constant prices and extraction levels, but at some points he also seems to assume producer behaviour according to the Hotelling rule. If prices were expected to be constant and the interest rates were positive, the optimal producer behaviour would be to extract all of the resource at once.

simple technical procedures, and mismanagement of the resources may be the result.

5.1. *The Norwegian Petroleum Wealth: The Importance of Uncertainty*

EDP, whether measured according to the depreciation or user cost approach, takes no uncertainty into account. Economies which are largely based on the extraction of natural resources are very sensitive to changes in world market prices of these resources. In addition, there is usually considerable uncertainty regarding the reserve estimates and other assumptions. Thus, one must consider if the uncertainty regarding the wealth of some natural resources is so significant that indicators disregarding this uncertainty will be misleading.

An economic policy based on the idea that a consumption level equal to EDP can be sustained may prove to be fairly disastrous. The recent history of Norwegian petroleum wealth illustrates this. In Norway, the wealth of petroleum has been calculated as expected net present value of the rent from oil and gas (Aslaksen *et al.*, 1990). The estimates are based on expectations of prices and future production profiles, prevailing in the year for which the estimate is made. The expectations, shown in Figure 1, are taken from different official documents. The rule of thumb for the predictions is evident: The price of crude oil starts at the current level and follow some sort of "Hotelling rule" in the future.

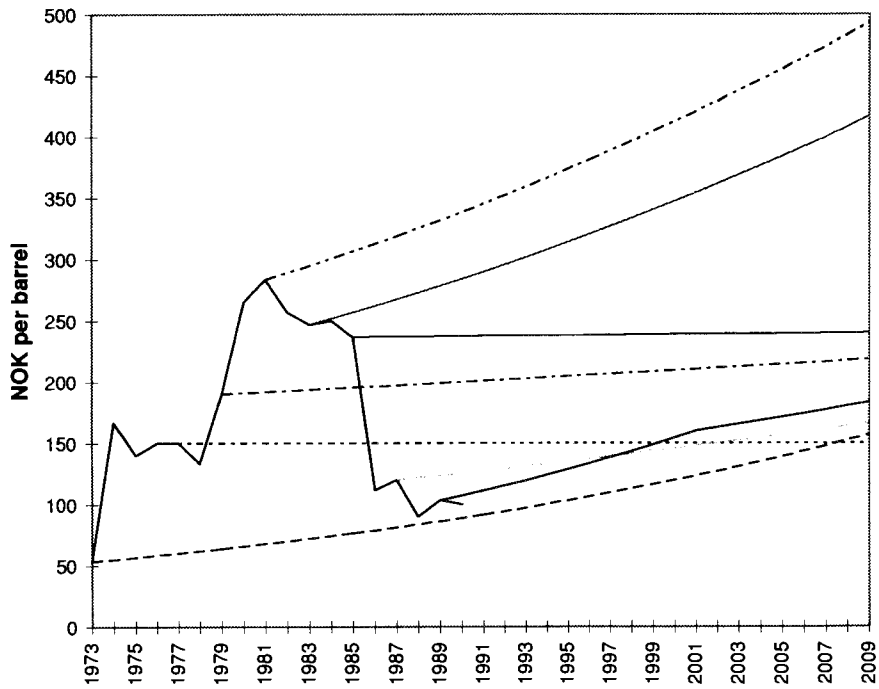

Figure 1. Actual and Expected Oil Price, Deflated by the GDP Index of Norway, 1986 = 100. Predictions of the Price of Crude Oil. US $ per Barrel.
Source: Governmental White Papers (national budgets, long-term programmes and others).

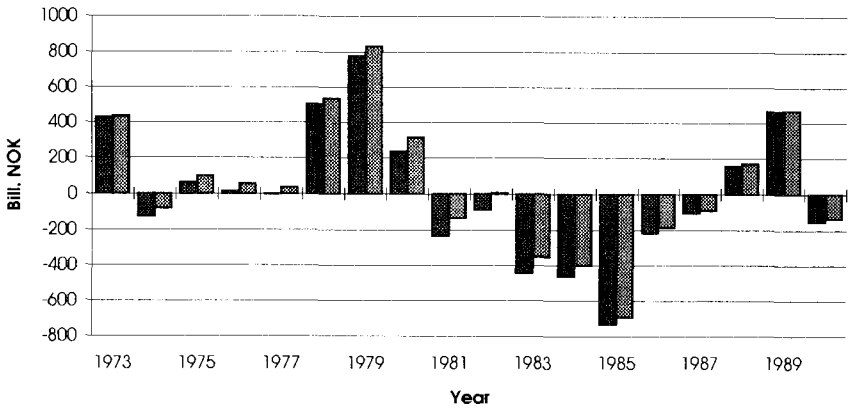

Figure 2. Changes in the Wealth of Petroleum. 1973 1990. Bill. NOK.
Source: Aslaksen *et al.* (1990).

Figure 2 shows the changes in the wealth of petroleum from 1973 to 1990. The first bar in each year shows the total change in the wealth from the preceding year. The second bar shows the pure effect of changes in the expectations of the future price of oil.

For some years the change in wealth exceeds GDP for Norway, and the main reason for the fluctuations in the wealth is changes in the expectation of the price of oil. The effect of changing expectations in prices actually predominates the change in total wealth for some years. This is due to the fact that the expected return from the wealth exceeds the rent. Thus, the deterministic factors that contribute to changes in the wealth of petroleum (the value of extraction and expected return) are "negligible" compared to the effect of the uncertain factors (such as prices and resource estimates). If the Norwegian authorities had tried to encourage a consumption level equal to the estimated permanent income in the early 1980s, with no regards of uncertainty, this would certainly have caused grave problems for the Norwegian economy in the years to follow.

In the "user cost method" of El Serafy only *current* prices, extraction and interest rate enter the formula. However, if the approach is meant to provide estimates of sustainable income, the implicit assumption is that future prices and extraction levels can reasonably be treated *as if* they were known with certainty to be constant over time. Even if the national accountant does not have to relate to uncertainty when estimated EDP according to the user cost approach, uncertainty remains essential for an understanding of the concept of sustainable income. In order to make the uncertainty transparent, it might be better to provide separate information about the development of the wealth of resources than to "hide" it in an adjusted NDP.

6. An Alternative: The Modelling Approach

Is national accounting a suitable tool for answering those questions the corrections aim at? We believe that if the purpose is to analyze a *hypothetical* or a *normative* question, i.e. what *could* or *should* have happened, this is questionable.

The second version of EDP in UN (1993) can be interpreted as an attempt to answer the following question: What would the level of economic activity be if no degradation of the environment were allowed? We will take a look at this question, comparing the results of an accounting procedure and a macroeconomic model.

If the economy was really changed to such a state of sustainability, a vast reallocation of resources would probably have to take place. Polluting activities would cease to be profitable, and labour and capital would move to new expanding sectors, such as production of cleaning equipment. This would have consequences for all real variables in the economy. A subtraction of hypothetical cleaning activities from SNA figures would say nothing about these changes. If the changes were small, this would not matter much, but unfortunately, most nations are currently in a situation which is very different from the one described here.

Assume that the economy can be described by two sectors. A "multiple" good, which may either be consumed or invested, is produced in sector 1. This good is termed x_1. Sector 2 produces what we may call abatement activities. An example of such an activity is medical care for people suffering from respiratory diseases caused by air pollution. To increase environmental quality or to decrease the damage from a bad environment, production in sector 2 will have to be increased.

The production level in sector 2, x_2, is assumed to be exogenously determined. The model allocates available resources in the economy, here described as given amounts of labour and capital, to sector 1 and sector 2, given that both sectors minimize costs.

NDP is calculated as the value of x_1 measured at market prices, plus the value of x_2. For x_2 we define the value-added as the sum of labour and capital costs.[11] The first two rows in Table 1 displays our "base case" in this economy, yielding a NDP on 2 121. (The exogenous numbers are arbitrarily chosen.)

TABLE 1.

CORRECTION *v.* MACROECONOMIC FIGURES AT EQUAL INCREASE IN ENVIRONMENTAL EFFORTS

	Correction of NDP		Model Approach		
				Values	
	Volume Index	Value	Volume Index	Nominal Prices	Constant Prices
Production of x_1	1,555	1,944	1,494	1,927	1,868
Private consumption	1,307	1,634	1,267	1,634	1,584
Investments	248	310	227	293	284
Production of x_2	150	177	200	236	236
Gross domestic product		2,121		2,163	2,104
Corrections for sustainability		79			
Eco-domestic product (EDP)		2,042			

[11]Depreciation of man-made capital is neglected, thus NDP equals GDP.

Assume that some environmental damages occur in the base case. In order to keep environmental quality unchanged, assume that an increase in x_2 from 150 to 200 in volume terms would have been required. The environmental adjustment of NDP, according to the maintenance cost approach, would then be 50 times the unit cost of x_2. In our example, this leads to a correction item amounting to 3.7 percent of NDP.

But what about the macroeconomic effects of actually increasing production in sector 2? The resources needed to increase production of x_2 have to be taken from somewhere, notably from sector 1. This could not happen without changing relative prices. In the correction procedure, the problem is treated like the increased abatement activity does not affect the rest of the economy. The correction therefore remains a nominal one. All volumes, like investment, consumption and employment remain unchanged. The economy produces the same amount as before, and *in additon* it abates more.

We will now use the simple model described above, and increase x_2 exogenously from 150 to 200. In the third through fifth column of Table 1 the macroeconomic effects of this is shown. The reallocation of labour and capital implies *a change in all prices* as well as lower production of the multiple good x_1. This implies that the volume index of both consumption and investments are reduced, presumably leading to a loss of welfare. Measured in nominal prices, however, NDP is increased. This is mainly explained by the increase in the price of x_1, compared with the base case, caused by a higher shortage of investment and consumption goods.

In constant prices NDP is reduced, but less than shown by the correction procedure, since the model reallocates resources instead of withdrawing them. The reduction amounts to 0.8 percent of the base case NDP, as compared to the environmental correction of 3.7 percent in the accounting procedure. Moreover, the model provides estimates of changes in consumption and investment levels, as well as other real variables, resulting from the change in policy. No such information is obtained from the correction procedure.

7. Some Comments on the SEEA

The System for Integrated Environmental and Economic Accounting (SEEA) (UN, 1993) is based on a framework for environmental and natural resource accounting in physical units. This framework may prove to be very valuable for environmental and resource economists in the future, providing a common international framework, compatible with the SNA, for compilations of environmentally-related data. We believe, however, that the part of SEEA which is concerned with monetary valuation is too weakly founded. This section provides some comments on the interpretation and applicability of the EDP measures proposed in the SEEA, without aiming at a full review of the Handbook.

7.1. *EDP*1

EDP1 (which is termed EDP version IV.1 in UN, 1993) differs from NDP in that market values of extracted natural resources are defined as depreciation

of natural capital and deducted, similarly to depreciation of man-made capital. The Handbook describes various approaches to the valuation issue, but does not recommend the use of any specific method. The precise interpretation of EDP1 is therefore somewhat unclear to us. In particular, it remains somewhat unclear whether the intention is that returns on the natural resource wealth should be included in EDP1 or not.

EDP1, depending, of course, on its accurate interpretation, may provide useful information for some purposes. Its main problem is, as was discussed in section 5, that it focuses on the deterministic factors of intertemporal resource management, thus possibly drawing attention away from the considerable uncertainty which any responsible policy maker ought to consider.

EDP1 only takes into account those changes in the natural resource wealth which are caused by extraction. Changes in estimated reserves are treated as "other volume changes," which remain in the asset accounts. Further, changed prices or price expectations are accounted for as nominal revaluations, which are not deducted. Consequently, the problem with EDP1 is not only that it does not take uncertainty into account, but also that it cannot not warn policy-makers about those price changes which *have already occurred* during the accounting period.

This implies that EDP1 may be considerably flawed as a measure of expected sustainable income. For example, an EDP1 for Norway in the mid-eighties would not have indicated any need of a changed economic policy, although the dramatic fall in oil prices led to an approximately 50 percent reduction in petroleum wealth estimates from 1985 to 1986.

7.2. *EDP2*

EDP2 defines the depreciation of natural capital as the hypothetical costs of avoiding the environmental deterioration (maintenance costs). This seems to be that version of EDP measure on which the authors of the Handbook put most emphasis. One might regard EDP2 as an attempt to indicate what the economic activity could have been if the environmental standard were kept unchanged. In section 6 we demonstrated that EDP2 can only give a reliable answer to this question if the required economic change is small. Further, as explained in section 4, EDP2 can neither indicate the effects on human welfare of a deteriorating environment, nor can we expect it to give any early warning-signals about the state of the environment. If damages accumulate, and the price of abatement technology is decreasing, EDP2 can actually *increase* over time even if NDP is constant and the physical environment is getting worse.

7.3. *EDP3*

EDP3 is meant to be calculated by a demand-side approach, using a combination of market valuation and willingness to pay estimates. The authors of the Handbook apparently put little emphasis on this version and do not envisage that EDP3 should be calculated on a routine basis (Bartelmus and van Tongeren, 1994).

The SEEA seems to treat EDP3 as one possible way to measure value-added, rather than as a welfare measure. The demand for a welfare measure seems to be

prominent in the ongoing debate, however. It should therefore be emphasized that interpreting EDP3 as a welfare measure requires several ethical assumptions which are clearly controversial. Further, the economic interpretation of willingness to pay-statements is not obvious. One problem is discussed by Kahnemann and Knetsch (1992) who show that willingness to pay is little sensitive to variations in the magnitude of the environmental problem under consideration. They suspect this is because statements of willingness to pay includes a substantial part which is due to a more general engagement in environmental problems ("the warm glow of giving"). If this is true, the development in EDP3 over time may reflect variations in people's willingness to give to good causes, rather than the development in environmental quality. For a more general discussion, see for instance, Diamond and Hausman, 1994.

To summarize, the proposed EDP measures are very easily misinterpreted. If the numbers are to be useful for policy-makers, their meaning must be clear. We would therefore urge the authors of the Handbook to provide precise interpretations of the proposed EDP measures, as well as explanations of what use they are intended for.

Our intuition is, however, that whichever version we are talking about, EDP is a measure which is so aggregated that too much information is lost on the way. We would recommend that the UN puts more emphasis on other parts of the SEEA than the monetary valuation. For example, a set of environmental indicators in physical units, calculated on the basis of the natural resource accounts, could be very informative both to policy-makers and the general public (see Alfsen and Sæbø, 1993).

8. Conclusions

Intuitively, the idea of an environmentally adjusted national product is appealing. However, the interpretation of such a measure is crucially dependent of the method of measurement. In this paper, we have argued that

- —the information provided by corrected NDP figures are very easily misinterpreted,
- —the figures will not in general give early warnings of the need of imposing stronger environmental policy actions,
- —as a method of estimating the consequences of imposing a policy of stronger environmental efforts, correction of NDP is a very crude (and inconsistent) technique, which does not capture main aspects of such changes.

In the ongoing debate on this issue, little weight has so far been put on defining *which question a corrected national product is really meant to answer.* It is therefore not surprising that the various discussants seem to disagree strongly with each other regarding which method of measurement is the correct one. The correct measurement method will of course vary with the question asked. The first step to reach a generally accepted method of integrating environmental and economic analysis, should therefore be to clarify what it really is one wants to know. When this is clear, we can proceed to discuss what is the best tool for analyzing that topic.

We have argued that when it comes to estimating the effects of *hypothetical* changes, macroeconomic models are better suited than the national accounts. We are aware that macroeconomic models have quite a few drawbacks as well. Building such a model requires both a great amount of data and a great amount of work. Numerous assumptions have to be made on which the results will rely heavily. These objections are nevertheless also true if the national accounts are to be used for such purposes. Moreover, a model can be run several times with varying assumptions to analyze different questions. Accounting procedures are not flexible in this manner.

When it comes to measuring *observed* environmental changes, this is clearly an accounting task. Valuing such changes in *monetary terms* on a macro level might, however, be more confusing than illuminating.

We actually do not think that the link between economic and environmental analysis and policy requires such valuation. In Norway, environmental variables measured in physical units have been included in macroeconomic models which are used by the Ministry of Finance. This has facilitated several analyses of the impacts on emissions to air of changes in economic and/or environmental policy (see, for instance, Brendemoen and Vennemo, 1994). Environment-related input–output analyses, which is mentioned in UN (1993) as a possible application of the SEEA, have also been carried out (Halvorsen *et al*, 1991) using emission data in physical units.

We would like to emphasize that we find the task of integrating environmental and economic policy and analysis a very important one. Focusing on an environmentally adjusted national product might be a two-edged sword, however. Because of its difficult interpretation, EDP might easily give policy-makers the impression that environmental problems are *less* urgent than they actually are.

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