NATIONAL INCOME, WELFARE, AND THE ENVIRONMENT

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This article explores the assumptions underlying present definitions of national income in its principal uses, and considers the alterations that would be needed to allow for the inclusion of environmental quality. A numerical example illustrates the impact of alternative measures. The discussion concludes that if we want national income to conform more closely to theoretical concepts of welfare indices, then we need to include a proxy for those environmental services that would not be completely free goods if it were possible to overcome their inherent non-marketability. The least unsatisfactory proxy would be the spending on environmental protection.

I

Despite the recent interest in amending National Income Accounts to reflect the impacts of economic activity on the environment in less misleading ways than at present,[1] there has been a tendency in this literature to ignore the justifications for using the Accounts at all in the ways that we do. The aim of this article is to try to review the issues from a more basic perspective, and to use this to discuss the inevitable compromises that will have to be made in choosing whether to continue with current practices or how to change.

II

National Income (NI) Accounts have many uses but there seem to be two categories that are particularly important. One set of uses concerns the control of the economy, with the Accounts used as a tool in analysis and prediction, since they are a convenient summary of the level of economic activity. For example in an "Okun's Law" approach to predicting unemployment, the forecast growth in national product is an essential input. Similarly many macro-economic econometric studies explaining (and forecasting) such variables as wage changes or imports use aggregate output per worker or income as explanatory factors. The other set of uses for the Accounts is to provide an indicator of economic welfare.

For macro-economic control and forecasting, the "correct" way to include environmental spending in the National Accounts is an empirical matter. If this spending alters, but such variables as employment do not, then we should like measured GNP to remain unchanged as well. At present, GNP gives misleading results, e.g. an increase in the proportion of the labour force engaged in pollution control leads to a fall in measured real GNP per worker. A numerical example of this point will be given later on, but the reason for the drop in "real" GNP is straightforward—the increase in resources devoted to environmental protection leads to (i) a fall in the output of measured final production with the same total

[1]E.g. Drechsler [2].

inputs in the economy or (ii) increased use of inputs but no increase in measured output or (iii) some combination of the two. In all three cases there seems to have been a decline in productivity below the level previously predicted, and thus a disturbance in the relationships between inputs and GNP on which forecasts and economic control rely.

The main attacks on current National Accounting, however, have not been because it might lead to incorrect macro-economic evaluations but have concentrated on the over-estimate of the increase in welfare resulting from insufficient attention to environmental quality.[2] Thus there are suggestions that spending on environmental quality should be subtracted from National Accounts (e.g. government financed waste disposal or water treatment), as such spending merely prevents environmental degradation, and does not represent a net increase in living standards.[3]

The implication of many such attacks on current NI Accounts is that the numbers are cardinal measures of aggregate (or *per capita*) utility. Statements of the type that the measured doubling of NI since some date is false, because of the concomitant growth in disamenities, only make sense if cardinal utility is implicit (except for the few who believe that welfare is actually lower than in the past because the disutility of environmental degradation has outweighed the utility from consumption).[4] If NI is cardinal, then one would indeed want it to include the value that is put on a clear blue sky, and to change when this value changes because the sky has been obscured by an increase in smoke.

The "correct" way to alter NI Accounts to allow for environmental quality will depend on the sense in which they serve as a welfare measure, and in particular on the role of the prices used as weights. As is well known, in the theoretical literature the Accounts serve as a welfare indicator from either the production or consumption side,[5] and environmental considerations could be viewed from either of these aspects.

The kind of welfare question which National Product answers is whether the economy could produce more in one year than another; i.e. there is a comparison of production possibility frontiers. The use of prices (net of indirect taxes) as weights is only strictly justified if there is perfect competition, since the correct weights when the production pattern changes are marginal rates of transformation, so that we need prices equal to marginal costs. Even less realistic conditions are needed for National Product to be an exact cardinal measure, i.e. for a doubling of National Product to imply that we could produce twice as much of everything.[6] Thus it would be enough to incorporate environmental factors in a way that gives the right ordering of National Product. The "correct" incorpora-

[2]Among the best known such attacks is that by Mishan [10], p. 46.

[3]See the paper by Juster in M. Moss, ed. [11], and the subsequent discussion.

[4]Similarly statements that a true NI index had a larger or smaller rate of growth than the standard one are only interesting if both indices are cardinal, yet such statements are made, e.g. Meyer's comment in M. Moss [11], p. 550.

[5]The role of investment in a consumption approach will be dealt with later, as will the question of net or gross production. There are major problems in simultaneously considering production and consumption approaches in a *broad* welfare view, i.e. comprising more than the actual points in the two years—see Samuelson [13].

[6]In the absence of a homothetic production possibility map, the index is not even unique; thus cardinality would result from constant returns to scale, constant overall factor proportions, and no technical change (or very special types of change—see Fisher and Shell [3], Essay II).

tion of the environmental services and of spending on the environment can be considered analogous to the inclusion of the services from the stock of capital and of investment. The former should definitely be included and the latter is usually judged to be best included as *net* investment—i.e. investment to merely maintain the existing stock of capital does not shift the production possibility frontier out.

Although the services from the environment should be included, the problem is how to measure them. Since the reason that so many aspects of the quality of life are omitted from NI Accounts is precisely that they are not marketed, any monetary proxies are likely to be extremely arguable.

The same problem applies to the value of the net investment in the environmental capital stock. The obvious analogy is the problem of government provision of goods, services and net public investment where the convention is to value the production by the inputs, although there is remarkably little justification for this procedure in the literature.[7] As in the case of the government sector, net investment in the environmental capital stock could be justifiably measured by the inputs if the following conditions held (ignoring technical change): (i) as before, perfect competition in all product and factor markets, so that price ratios = marginal cost ratios = marginal rates of transformation; (ii) constant returns to scale in all sectors; (iii) no pure profits so that all costs represent opportunity costs (related to the previous two conditions because of the adding-up problem); (iv) similar factor ratios in all sectors including the non-marketed (so that the marginal rates of transformation are constant for non-marginal shifts of factors between sectors). Under these conditions, the non-marketed sectors could legitimately be measured by their inputs, even if the National Product is considered to be a cardinal measure. The fourth condition is necessary because there is no price of the final output, and thus no equivalent to the tangent to a production possibility frontier representing a value when inputs have changed. The same idea can be seen in Figure 1, where N represents the output of the Non-marketed Sector (for the case where physical units of N exist), and Y "other goods". If all inputs were shifted from D into production of Y, only OA could be produced, not OC, unless AB is a straight line. Thus OC does not represent the value of Y that could be produced if we use the price of Y as a *numéraire*.[8] If the fourth condition did not hold, but the others did, valuation of the non-marketed sectors by their inputs might still be legitimate in an ordinal measure. For example if $\sum P_0Q_1 > \sum P_0Q_0$, then Q_1 represents higher productive potential than Q_0 (in Figure 1 E is outside the tangent to AB through D). In other words, under the first three conditions, if the non-marketed goods and services had been marketed, then they would have been sold at a price equal to the average cost of the inputs, while average equals marginal cost.

Although the measurement of the value of output by the cost of inputs might be applicable to net investment in the environment[9] (at least in the ideal world of

[7]Little [8], p. 233–234, has an extremely brief discussion, which cheerfully accepts any difficulties, as he anyway considers that NI indices have no precise meaning. Hicks [5] and Kuznets [7] suggest that government spending should be split between those items which contribute to final welfare and those which are intermediate products. Also see [6], chapter 2.

[8]Weitzman [18], relaxing an assumption of Samuelson [14], mentions a similar point with respect to adding investment to consumption in NI.

[9]Leaving aside the case where the environment is improved by refraining from other production.

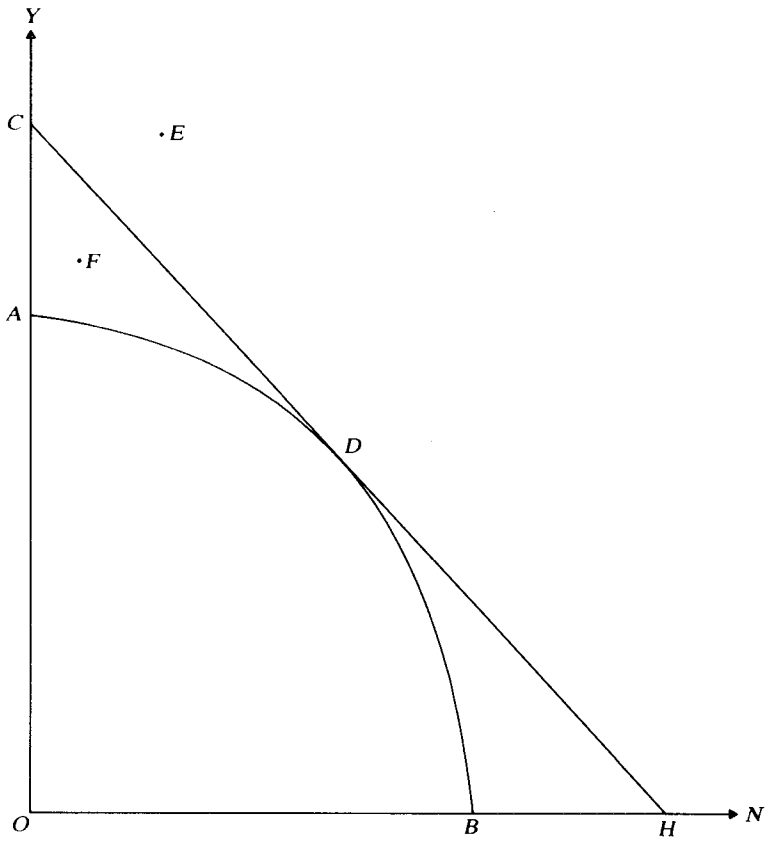

Figure 1.

the above conditions), it cannot generally be applied to proxying the value of all the services of the environment, where these services are final "consumption" goods. To the extent, however, that other, remunerated, inputs are also required for the consumption, the cost of these other inputs could provide a partial measure of environmental services. As stated above, the aim in incorporating the environment into the Accounts is that if the economy could have produced more of *all* scarce goods and services (including those of the environment), in one situation than in another then the index of Net National Product should be higher.[10] Thus the requirement is that the proxy for environmental services should move in the same direction as the services themselves.[11]

[10]The ordering may be partial, rather than complete. In Figure 1, which has been drawn with the normal curvature, if one uses the tangent rather than the production possibility frontier itself (which is generally unknown) point F in Figure 1 cannot be known to represent higher production possibilities. It can also be seen from this diagram that the sentence in the text should strictly be reversed, i.e. the comparison refers to bundles comparable to Q_0, not Q_1, when output increases. See Samuelson [13] for the classic discussion of these issues, with the standard assumptions about convexity. However it has now been realized that polluting activities may well lead to non-convexity of the production possibility set, e.g. Starrett [17], and the same result may occur even with spending to reduce pollution. Thus there are problems with NI giving a partial ordering of production possibilities once we allow for pollution.

[11]We shall ignore the problem of distinguishing environmental improvements which contribute directly to welfare, e.g. cleaner water for swimming in, from those which improve intermediate goods, e.g. cleaner water for use by downstream factories.

The alternative approach to NI as a measure of welfare is to justify it as a measure of the utility given by the consumption of goods and services, where the use of prices as weights requires that all consumers have the same marginal rates of substitution.[12] Since price discrimination is a very special case of imperfect competition, this seems less restrictive than the need for perfect competition in all product and factor markets. However NI would not be a correct cardinal measure of utility, even if utility was itself both cardinal and interpersonally comparable. *A fortiori*, if a utilitarian social welfare function is rejected, NI can only be ordinal.[13]

For the consumption interpretation of NI the ideal way to incorporate environmental services is to estimate their value to consumers. Although such estimation is theoretically possible in many cases, the estimates are likely to be contentious and probably it will never be practicable to re-do them each year. These drawbacks apply both to the benefits from environmental services and to the damages from pollution. Eventually, however, it might be possible to have a large number of studies, especially on the damages from pollution, which would be revised at irregular intervals and could be used in considering long-run changes in welfare. If such studies were incorporated into NI, then, for comparability with the rest of consumption, marginal and not total values should be used. Nevertheless, for the foreseeable future, any systematic undertaking of such estimates would appear to be unlikely.

In the absence of any obvious measures of the value of environmental services to consumers, one might again consider the analogy of the treatment of the government sector in NI. However the correct way to deal with government activity cannot be deduced from a consideration of the consumption approach to NI on its own. The optimal provision of government (and public goods generally) is given by relating sums of marginal rates of substitution to marginal rates of transformation. If the provision is optimal, then one can use the approach discussed above in connection with National Product.[14] Similarly the value of investment in the environment could be measured by the inputs.

The usual approaches to NI in terms of consumer utility or preference concentrate on indifference surfaces, or preferences, with respect to consumer goods. The figures for NI accounts add in *net* investment—the attempt by Nordhaus and Tobin to estimate a wider set of numbers than is normally

[12]If we are prepared (as we should not be) to overlook problems of income distribution—see Sen [16] for how one might incorporate distribution.

[13]This holds even if all indifference maps were homothetic, so that all Engels curves were linear. What homotheticity provides is an unambiguous "cardinal indicator of ordinal utility" (Samuelson and Swamy [15]). For *National* Income, the relevant indifference curves are social indifference curves, which would, in general, be non-homothetic even if individual maps were homothetic. If the welfare judgement is to be phrased in terms of a social welfare function, while the precise function is unknown, then the social indifference curves must be (like individual indifference curves) convex to the origin if $\sum P_1Q_1 > \sum P_1Q_0$ is to imply higher welfare—otherwise even point F could be on a higher social indifference curve than D in Figure 1. See De Graaf [4], p. 162–163. However, as with the production comparison mentioned in footnote 10, pollution may lead to non-convexities in (individual) indifference surfaces.

[14]If (market) production and consumption were perfectly competitive, and provision of public goods optimal, there would be a separating hyperplane (e.g. line CH in Figure 1) to the production possibility and indifference sets. It is this tangent which is then used to provide the partial ordinal ranking of both production and utility. Also see footnote 7 on final versus intermediate public goods. The same references discuss the use of market prices or factor costs when there are indirect taxes.

assembled also stresses that Net, rather than Gross, National Product is relevant.[15] Weitzman has recently shown that, under some assumptions, the addition of net investment to current consumption to give a single number "consumption equivalent" can be justified (despite problems analogous to those discussed above concerning the addition of non-marketed output and private production to obtain a single figure for National Product when the production frontier is non-linear).[16]

The results of the discussion so far are that NI cannot be viewed as a cardinal measure of welfare, and that the most that can reasonably be asked of NI Accounts is a ranking of positions over time, or between countries. For such a ranking the relevant concept is that NI be given by Net National Product. Within this framework, changes in the value of services provided by the environment and (positive or negative) net investment in future environmental levels should ideally be included. In this context one would distinguish between activities which alter the value of environmental services only within the accounting period, e.g. emission of noise, and those which have a longer lasting effect, e.g. open-cast mining in scenic areas or installation of machinery to reduce noise. The concept of net investment only applies to the latter group of activities.

However, as has been stressed, direct evaluation of environmental services (or their present value in the case of investment) is not feasible at present. The best approximation to the ideal treatment would be to value these services by the inputs devoted to them. To avoid the basic problem of a drop in measured NI when more resources are devoted to pollution prevention, it would be simplest to set up a separate category of final expenditure, or at least a "new" consumption good, labelled "Environmental Services" or "Environmental Protection" and valued by its inputs. Where a separate firm sells environmental protection, e.g. waste disposal, the services could be directly valued in the normal way. Such a sector would come closer to the correct welfare ranking from either the consumption or the production approach.

As mentioned above, one might try to split the spending into that which improves the flow of services during the same period and that which improves the flow over several periods. For example, an increase in the resources devoted to smoke prevention each year would proxy for the resulting increase in the value of clean air (or decrease in the cost of dirty air), while an investment in land reclamation would count as an investment in the environment.[17] Without direct valuation of the services of the environment, failure to make this distinction would falsely imply a drop in environmental services, if equivalent investment was not repeated in subsequent years. Alternatively, if the new final expenditure sector were labelled "Environmental Protection" such a split could be omitted. Most importantly, the ranking of *total* NI from year to year would be the same whether current and investment expenditure were split or not.

[15]See Nordhaus and Tobin [12], although their "Measure of Economic Welfare" is not quite the same as NNP. The distinction is not so much a matter of a production *versus* a consumption approach, but of the correct classification of final goods and services. See also Kuznets [6].

[16]See Weitzman [16].

[17]On the reasonable assumption that pollution prevention will never be taken beyond the point where marginal benefit equals marginal cost, and is likely to fall short of this level, the cost of the inputs will never overestimate the value of the environmental improvement and may well underestimate it.

The inclusion of a separate Environmental Sector in the NI Accounts seems to be the opposite approach to that taken by those who would *deduct* such expenditure from NI.[18] This difference partly stems from two related considerations: *First* if NI is viewed as a cardinal measure of welfare, then one tends to want to compare current levels with some Garden of Eden where there is no pollution at all.[19] Under such circumstances devoting any inputs at all to pollution prevention could be taken as evidence that we are worse off than in the ideal state of nature, and hence that the value of marketed goods and services overestimates welfare. However once the ordinal nature of NI is appreciated, the important thing becomes to correctly rank different levels over time. *Second* any increase in spending on pollution control over a period of time could be a result of: (i) legal or other pressures leading to more stringent limits on pollution, etc., and therefore to an improvement in the environment, (ii) a change in the volume and pattern of production, so that without the extra inputs the quality of the environment would have deteriorated, and the extra expenditure is needed to maintain the *status quo*, (iii) some mixture of these two cases. In case (i) adding the inputs to NI would give a better index than the current practice which shows a fall in NI. In cases (ii) and (iii) the earlier stress on net investment suggests that current practice does overestimate the increase in NI from new goods. Thus one would like to include in the new environmental sector only case (i) and that part of the inputs in case (iii) which lead to an improvement in environmental quality.[20] However, again remembering the ordinal nature of NI, if the expenditure cannot be separated, the results should not be too misleading and would be no worse than current practice. The main danger of continuing with our current procedures is that policy makers may be misled into believing that measures to improve the environment reduce NI, and hence welfare—the inclusion of an Environmental Sector would help to avoid this problem.[21]

The way that an Environmental Sector could be incorporated in NI Accounts can be illustrated by a numerical example, and this is the purpose of the next section. This example will also be useful in showing some of the problems that would have to be faced in setting up an Environmental Sector, and possible answers to them.

[18]See footnote 3 and Nordhaus and Tobin [12], p. 28.

[19]Juster [11], p. 67, uses an example where long-term trends in output are being measured against the benchmark of a "simpler agrarian society". He also takes it for granted "that the environment is clearly worse today than it was in the mid-1950s" [11], p. 66.

[20]Some of the proponents of deducting pollution prevention, reclamation, etc., from NI seem to be worried about case (ii), when the anti-pollution activity is undertaken by the government or some other agency, e.g. Nordhaus and Tobin [12], p. 28.

[21]The divergence between the approach taken here and the views of those who would like to deduct environmental expenditure can be ascribed mainly to different assumptions about the relative importance of cases (i) and (ii) over time and to different concerns about the consequences of the wrong choice: e.g. Juster [11] is concerned with evaluating the historical record of long-run growth and not with implications for future policy on pollution. Provided that the basic data are collected, individuals empirically studying past economic growth can make any adjustment they like. Misapprehensions of the meaning of NI as a single number are both more likely, and will have more serious effects, among those using them as a quick reference point for current and future policies.

III

In this numerical example of how an environmental sector could be incorporated into NI Accounts, we assume a two-sector economy producing intermediate products (M) and consumer goods (C). Mainly for simplicity, but partly to fit the conditions under which NI is a strictly valid indicator of welfare,[22] we also assume:

(i) closed economy;
(ii) government sector can be ignored (no taxes or government expenditure);
(iii) production is by labour only (machines are non-existent or have an infinite life);
(iv) no profits;
(v) constant returns in both sectors;
(vi) fix a wage rate of £1 per worker, and initially a price of £1 per unit output in each sector;
(vii) the pollution to be dealt with occurs only in the production of consumer goods;
(viii) pollution control uses men and intermediate materials in the same proportions as production of C.

The initial situation is that production of the intermediate good employs 100 workers to produce 100 units of M, which are bought by the consumption goods industry. The latter employs 200 workers and produces 300 units of C, selling at £1 per unit. Table 1 shows the National Income in both the final expenditure and National Product (value added) measures. If the control of waste emission is tightened up so that 5% of the resources used in the production of C (10 workers and 5 units of M) are required to prevent pollution of the environment, the production of C will fall to 285 units.[23] To cover the costs of production (which continue to be £300 if we assume a "polluter pays" approach), the price per unit of C will have to rise to £1.053 (=300/285)—since this model has only one consumer good and no assets, there is no need for a demand function.

In seeing what would happen to NI under current practice certain problems become apparent. One problem is whether the firms treat their own emissions, or hire a waste disposal firm to clear up their pollution. Current cost expenditure is unaltered as shown in line 3 of Table 1; however, the split of National Product will vary, as shown in lines 4 (own treatment) and 5. In the latter, the C sector pays £15 to the waste disposal firm, which buys 5 units of M and employs 10 men, while buying 95 units of M and employing 190 workers itself. When we look at what happens to constant price NI under present practice there are various possibilities.

[22]In addition to the discussion in the previous section, and footnote 6, Mirlees [9], p. 5, points out that "so long as there is only one nonproduced input (labour), constant returns to scale everywhere, and no capital, prices can, in general, be determined uniquely", and that in such a case these are the "suitable prices for evaluating National Income".

[23]Equivalently the new controls could be said to mean that to deal with the waste emitted by producing 57 units of C requires 2 workers and 1 unit of M.

TABLE 1
NI WITHOUT ENVIRONMENTAL SPENDING DISTINGUISHED

	M	*C*	*W*	NI
Initial Position				
1. Expenditure		300		300
2. National Product (Value added)	100	200		300
After Pollution Control				
3. Current price expenditure		300		300
4. Current cost NP (Value added) Own waste treatment	100	200		300
5. Current cost NP (Value added) Waste treatment firm hired	100	190[a]	10	300
6. Constant Price expenditure		285		285
7. Constant cost NP (Value added) Double deflation Own waste treatment	100	185[b]		285
8. Constant cost NP (Value added) Double deflation Waste treatment firm hired	100	175[c]	10	285
9. Constant cost NP (Value added) No double deflation Own waste treatment	100	190[d]		290
10. Constant cost NP (Value added) No double deflation Waste treatment firm hired	100	190[d]	10	300

[a] $190 = 300 - 95 - 15$.
[b] $185 = (0.95 \times 300) - 100$.
[c] $175 = (0.95 \times 300) - 95 - 15$.
[d] $190 = 0.95 \times 200$.

One choice is between base and current price weights.[24] At this point I shall only show the base weighted NI as this is the more common for National Product Accounts (see Table 3, line 4 for the Paasche quantity index). Another issue is how the Product Accounts are deflated. The correct method is "double deflation", i.e. inputs and outputs are separately deflated by the appropriate price indices, and constant price value added is the difference between the deflated inputs and the deflated output. In practice (at least in the U.K.) base price value added is simply multiplied by some proxy—for 80% of GNP gross output change is used as the proxy.[25] When the relationship between inputs and outputs alters (as in this example), the alternatives to double deflation lead to differences between

[24]The partial orderings referred to in footnotes 10 and 13 imply that only certain comparisons are meaningful. Whether it is current or base price weights which are relevant will depend on whether one is looking for a utility or a production indicator and on whether the index has increased or decreased. Fisher and Shell [3] suggest that, contrary to usual practice, production comparisons of NI should use current price weights (to reflect the current tastes for goods). In this example, where the change in NI is due to "tastes" changing, the current price NI index might seem more suitable—however, paradoxically, the price of the good whose relative demand has fallen (ordinary consumption goods relative to environmental services) has become more expensive, since pollution arises during the production of this good.

[25]See C.S.O. [1], pp. 2–3.

constant price expenditure and "constant price" output. Line 6 in Table 1 shows constant price expenditure. Lines 7 and 8 show the constant price measures of output where the firm treats its own waste and uses a waste disposal firm (W), respectively, with double deflation; and lines 9 and 10 the same situations without double deflation.

From Table 1, lines 6–10, we can confirm that constant price National Income seems to fall when resources are switched to protecting the environment. In addition, if double deflation is not used then discrepancies occur between the estimates of National Income and National Product, and also National Product itself differs according to whether the anti-pollution activities are undertaken within the firms producing it or by specialised firms.[26]

The results of allowing for an environmental sector as a separate category of final output are shown in Table 2, where lines 3^1–10^1 give the numbers corresponding to lines 3–10 in Table 1, and where E is the spending on environmental protection. To simplify the table the production sector W is lumped together with the expenditure sector E, just as C is used to denote both consumption expenditure and the production of consumption goods. The main

TABLE 2

NI WITH ENVIRONMENTAL SPENDING FACTOR

	M	C	E	NI
Initial Position				
1. Expenditure		300		300
2. NP (Value added)	100	200		300
After Pollution Control				
3^1. Current price expenditure		300	15	315
4^1. Current cost NP (Value added) Own waste treatment	100	205[a]	10	315
5^1. Current cost NP (Value added) Waste treatment firm hired	100	205[a]	10	315
6^1. Constant price expenditure		285	15	300
7^1. Constant cost NP (Value added) Double deflation Own waste treatment	100	190[b]	10	300
8^1. Constant cost NP (Value added) Double deflation Waste treatment firm hired	100	190[b]	10	300
9^1. Constant cost NP (Value added) No double deflation Own waste treatment	100	190[c]	10	300
10^1. Constant cost NP (Value added) No double deflation Waste treatment firm hired	100	190[c]	10	300

[a] $205 = 300 - 95$ (since 95 is value of M used in producing C).
[b] $190 = (0.95 \times 300) - 95$.
[c] $190 = 0.95 \times 200$.

[26] By chance, in line 10, NI is unchanged when the incorrect method is used. If the other incorrect proxy, which multiplies base price value added by an input change index (used for 17% of UK GNP) were applied here, line 9 would be 300, but line 10 would be 310.

question that arises is how to incorporate the costs for the firms that cause pollution. The output of the environmental sector can be measured by its inputs (under the assumptions listed earlier, when there is a waste disposal firm, its output also equals its inputs), but the firms in C pay for these inputs. If we compare this case with other cases where a firm pays for the output of a final expenditure sector, e.g. government or investment, then the firm's value added in the production of good C should include the amounts spent on environmental protection. In the case of direct taxation, or purchase of new machinery, the expenditure is viewed as coming out of the firm's surplus, not as part of its costs—i.e. profits are not the same as cash flow. The expenditure on pollution treatment, even when undertaken by the polluter, is like taxation: it is imposed on the polluter rather than voluntarily undertaken as part of the production process to make profits. If this approach is taken, then an adjustment would have to be made in going from the Inland Revenue profit figures to those used in the NI Accounts.

An alternative approach might seem to be to treat company expenditure on environmental protection in the way that indirect taxation is treated in NI Accounts—i.e. in order to reconcile GNP at factor cost with total expenditure, indirect taxes are deducted from the latter. In this case in lines 3^1–5^1, NI would be 300. However when considering constant price expenditure, NI would be misleading unless no deduction were made. Even in the case when Government expenditure changes, indirect taxation gives rise to problems. From the consumption point of view, it is NI as expenditure, or NP at market prices which is relevant and gives a correct indicator. In terms of the earlier discussion, indirect taxation drives a wedge between the consumption and production interpretations of NI. From the production viewpoint, when government activity increases and is financed by indirect taxation, *constant price* estimates of NP at factor cost (if derived as constant price expenditure minus tax) imply a fall in productive capacity, which has not occurred. This can be seen by considering what would happen in our $C = £300$ example if government expenditure is now introduced at a level of £15, financed by indirect taxes on C of £15. Constant price consumption expenditure is now $0.95 \times £300 = £285$, government expenditure £15. Therefore since NI at factor prices = total expenditure minus indirect taxes, we have that $NI = £(285 + 15 - 15) = £285$. The estimate of real National Product at factor prices would only be correct if no deflation were undertaken when prices change because of indirect tax changes.[27]

Comparing Tables 1 and 2, the most important result is that the 5% drop in constant price NI is avoided when there is an environmental sector. In addition, but of much less importance, in this example we avoid the discrepancy between constant price National Income and National Product when double deflation is not used, but value added is proxied by real gross output instead.

The constant value of fixed price output shown in Table 2 will remain constant whatever quantities of resources are devoted to environmental services.

[27] A somewhat similar point is made by Colm in [6], pp. 119–121. From the published sources that I have seen, it is not clear how the constant price GNP at factor cost measured from output is reconciled with GNP at factor cost measured as total expenditure minus indirect taxes.

The sole qualification needed is that this is strictly true only if the prices used as weights are those of a base period when no resources were devoted to the environmental sector. If, however, the weights are those taken from a situation when there is already some environmental expenditure, then an increase in such expenditure will lead to a slight fall in measured NI, though far less than the drop when no environmental sector is recognized. This can be seen in our example if the anti-pollution laws are toughened further, now requiring that 20 men and 10 units of M are used for waste prevention,[28] so that 270 units of C are produced and they are sold at £1.11 per unit. If we denote the situation with no pollution prevention by **0**, that with 10 men and $5M$ used in pollution prevention by **1**, and that with 20 men and $10M$ used in pollution prevention by **2**, the values of NI will be as summarized in Table 3. In this table, except at P_0 prices, NI falls slightly as environmental quality is improved. With the assumptions used for this example, if Y_0 is the value of P_0Q_0 (i.e. current value national income with no waste treatment), then considering two situations where proportions **m** and **n** of both inputs into the consumption goods sector go on environmental protection, $P_nQ_m = mY_0 + [(1-m)/(1-n)]\ Y_0$ for $1 > n \geq 0$, $1 > m \geq 0$. If no environmental sector is recognized, this reduces to $P_nQ_m = [(1-m)/(1-n)]Y_0$. From these formulae it follows that $P_nQ_m > P_nQ_k$ for $k > m \geq 0$, $1 > n > 0$. It also follows that the drop in measured real GNP as waste disposal increases is less when an environmental sector is recognized.

Although the above examples deal with cases where the waste disposal occurs in the consumption goods sector, similar results occur when waste treatment is needed in the intermediate goods sector. With assumptions (i)–(v) above, the formulae for national income also hold when **n**, **m**, **k** refer simply to the proportions of the *total* labour force involved in environmental protection,

TABLE 3

SUMMARY OF NATIONAL INCOME EXAMPLES

		Environmental Sector	No Environmental Sector	
	Price, Quantity	NI and NP[a]	NI and NP (Double Deflation)	NP (No Double Deflation, Own Waste Treatment)[b]
1.	P_0Q_0	300	300	300
2.	P_0Q_1	300	285	290
3.	P_0Q_2	300	270	280
4.	P_1Q_0	315.79	315.79	310.53
5.	P_1Q_1	315	300	300
6.	P_1Q_2	314.21	284.21	289.47
7.	P_2Q_0	333.33	333.33	322.22
8.	P_2Q_1	331.67	316.67	311.11
9.	P_2Q_2	330	300	300

[a]Where there is an environmental sector, the results are the same even if double deflation is not used.

[b]When double deflation is not used, and a separate waste disposal firm is hired, NP estimated from (incorrect) constant price value added is equal to 300 in all cases.

[28]In terms of footnote 23, producing 27 units of C now requires 2 workers and 1 unit of M to be used in pollution control.

whichever sector the waste arises in—where these proportions include those indirectly involved by producing intermediate goods which are used in waste treatment. Of course, the value added attribution of National Income will differ according to where the pollution arises.

The reason why measured real NI declines when using price weights other than those arising when there is no expenditure on preventing pollution is that the current price of a unit of output of consumption goods includes the necessary cost of any concomitant waste disposal. The environmental sector, however, is valued at a "price" measuring only the direct use of inputs. This point can be seen in terms of the formulae above. If the proportion of inputs used in waste disposal increases from **m** to **k**, the change in real national income valued at constant prices taken from the time when that proportion was **n** is $P_nQ_k - P_nQ_m = (k-m)Y_0 + [(m-k)/(1-n)]Y_0$, where the first term is the increase in expenditure on the environment and the second (negative) term the value of the reduced real expenditure on consumer goods. For $n > 0$, the second term outweighs the first. The same problem of a drop in measured real NI would occur if an increase in the size of the government sector was financed by a rise in corporation tax—*and* the tax increase was passed on in increased prices.

IV

The discussion has concentrated on environmental protection costs arising in the production sectors, not in the consumption of goods. In the absence of hedonic price indices, a completely satisfactory approach to the household sector seems unlikely. Unless one treats cars with modified exhaust systems, for example, as new or better goods, they will show up in the National Income Accounts as a reduction in real output. This is related to the general issue of quality changes. If such "quality" changes are not allowed for, it might seem sensible to treat the extra production costs as environmental expenditure by the car industry. However, unless extreme care is taken, double counting could easily result. For example, if sulphur limits are placed on fuels, the extra refining costs should not be attributed to environmental expenditure by the oil industry, but the extra cost of burning low-sulphur oil should be included by the industries using it—otherwise an industry switching to gas, where gas is more expensive than untreated oil, would be counted as having no extra costs from the anti-sulphur dioxide regulations. *Ad hoc* decisions might be made, e.g. because most high-sulphur oil is used by industry, oil companies should not count desulphurization as an environmental cost, but they should count the extra cost of low-lead petrol. However, unless an item is known to be used only by households and not by other firms, such *ad hoc* decisions would complicate data collection. A compromise might be to attribute the environmental expenditure to those producing the goods only where the legal requirement was framed in terms of selling the good rather than buying it. The car example used above would thus put the expenditure by the makers into the environment sector, whereas low-sulphur fuel costs would be counted in the burners' sectors. Even here ambiguities might result, as the law sometimes forbids both use and sale, e.g. coal in smoke-free areas of the U.K. The simplicity of consistently collecting anti-pollution cost data from those who would otherwise

have polluted will probably make it worthwhile to ignore the problems of household consumption goods.

The final conclusion of the discussion would seem to be that if we want NI to correspond more closely to theoretical concepts of welfare indices, then we need to include a proxy for those environmental services that would not be completely free goods if it were possible to overcome their inherent non-marketability (i.e. where there would not be excess supply at a zero price). The least unsatisfactory proxy would be the spending on environmental protection. The lengthy numerical example showed some of the problems that might arise and discussed ways by which they might be surmounted.

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