WELFARE ECONOMICS AND THE MEASUREMENT OF NNP*

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Some relationships between NNP and economic welfare are explored in the confines of a simple, static welfare maximization model. Various assumptions concerning both the measurement of NNP and the economic system underlying this model are dropped *seriatem* and the implications for the correspondence between NNP and economic welfare are examined.

The following conclusions emerge. There are several classes of resource reorganization in which NNP and welfare move in the same direction, so that NNP can serve as an ordinal proxy for welfare. These include changes in taxes or competitive imperfections which result in product substitution and movements along the transformation function.

With a general qualification, NNP-welfare correspondence is preserved for allocative changes which affect the real costs and prices of goods included in NNP or of non-included goods in inelastic demand; changes in involuntary unemployment; and changes in technological externalities affecting producers. There are other cases where changes in NNP and welfare are not positively correlated. Included here are changes in real costs of non-included goods for which demand is elastic and changes in technological externalities imposed on consumers.

Welfare economists have expended considerable effort, stretching over several decades, outlining the relationship between social or economic welfare and some hypothetical, perfectly measured national product or income. Over the same period national income accountants have developed ever improving procedures for defining, measuring, and extending the national income accounts. Little cross-fertilization has taken place. The purpose of this paper is to link economic welfare and national income in the confines of a simple, static welfare maximization model so as to derive inferences for the interpretation and measurement of national product and income.

The hypothesis that national income is an ordinal proxy of economic welfare is a welfare proposition not testable with the pragmatic tools of positive economics. Such a hypothesis can be tested only through an examination of the assumptions which underly it (Graaff, 1957, p. 3). The welfare economist has been content to restrict his concern to the assumptions necessary to make a perfectly measured national income a correct proxy for welfare, focusing on the index number problem (Hicks, 1940; Samuelson, 1950; Malinvaud, 1972). Questions as to what variables are included in a perfect measure and what the national income, as presently calculated, actually measures have been largely ignored. The national income accountant tends toward the view that national income was not intended to be and is not a measure of welfare, and he who interprets it as one is in

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error. This position also leaves some questions unanswered. If there really is no implied relationship between NNP and welfare, why do we bother to measure NNP? Why is the basic NNP definition qualified by imputations and why are these imputations made and not others? A basic question of this paper is not confronted at all: What, if any, is the relationship between whatever NNP measures and welfare? In the middle there are those who interpret NNP as a loose measure of "economic capacity" or "production potential" and view an increase in NNP as representing at least a potential increase in economic welfare. Presumably, the wide variety of reasons which make a change in NNP neither necessary nor sufficient for a change in welfare are regarded as unimportant and/or irreconcilable.

These various interpretations of NNP notwithstanding, it is still the most commonly employed objective function for macroeconomic analysis and policy. Even in microeconomic public policy—the evaluation of individual projects—the most commonly used criterion is the benefit–cost ratio or net benefits; yet benefit–cost analysis can be viewed in social income accounting terms as a partial government value added statement; wherein for at least one activity, the product or benefit side of the account is estimated.

A few welfare implications of a national product or income objective function are spelled out in this paper. First, a simple welfare maximization model is set forth which illustrates the relationship between a "correctly measured" NNP and economic welfare for a closed, static economy at optimum optimorum. Next, the assumptions of perfect measurement, statics and the conditions necessary to achieve the optimum optimorum will be temporarily dropped, one by one. In each case, some implications for the positive correspondence between NNP and welfare will be examined, always assuming that *all* the other conditions underlying the model are met.

The NNP-Welfare Maximization Model

The model is developed for a two person, two good world. There are two individuals, A and B, who receive utilities U_A and U_B from consuming two consumer goods C^1 and C^2. Factor inputs are assumed (for the moment) fixed. The model is:

$$\text{Max } W = W(U_A, U_B)$$

where W is the economic welfare function and $U_A = U_A(C_A^1, C_A^2)$, $U_B = U_B(C_B^1, C_B^2)$. The individual utility functions, U_A and U_B, are defined in terms of ordinal preferences.

The transformation function is:

$$G(C_A^1 + C_B^1, C_A^2 + C_B^2) = 0.$$

Maximization under the transformation constraint yields the familiar first order marginal rate of substitution conditions for a Pareto optimum: $\text{MRS}_A^{12} = \text{MRS}_B^{12} = \text{MRT}^{12}$. Both A's and B's marginal rate of substitution of C^1 for C^2 are equal to each other and to the marginal rate of transformation in production.

The definition of NNP is:[1]

$$\text{NNP} = P^1(C_A^1 + C_B^1) + P^2(C_A^2 + C_B^2)$$

where P^1 and P^2 are efficiency prices such that:

$$\frac{P^1}{P^2} = \text{MRS}_A^{12} = \text{MRS}_B^{12} = \text{MRT}^{12}$$

The model is diagrammed in Figure I. TT is the transformation curve. $\bar{I}$ is one of a set of Bergson–Samuelson social indifference curves which are assumed to exist and to be convex and nonintersecting (Bergson, 1938; Samuelson, 1956). These two curves define the optimum optimorum at R and NNP is represented by the dashed line. The slopes of the NNP line, the transformation curve and the social indifference curve are all equal at welfare maximizing output R.

Welfare is maximized for any given level of NNP so that an increase in NNP is both a necessary and sufficient condition to increase welfare. Underlying this

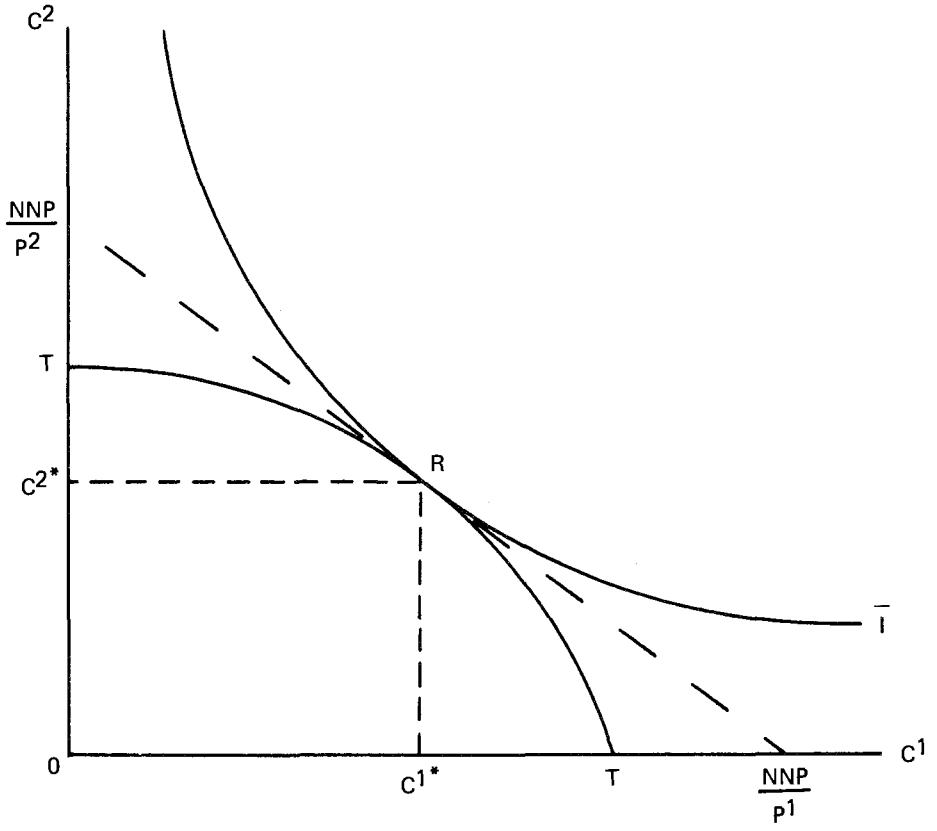

Figure I

[1]An assumption here is that there is available a price index which allows a single measure of *real* NNP (rather than one in terms of C^1 and another in terms of C^2), as well as a measure of *nominal* NNP in terms of the base period prices of the index.

conclusion are assumptions that the economic welfare function is fixed (implicit here also is the assumption that population is fixed) and that the transformation and economic welfare functions have the indicated convex shapes. These assumptions will be maintained throughout this paper. However, there are four other conditions necessary for the existence of this unambiguous static relationship between NNP and welfare, which will not be maintained. These are:

(1) NNP is "correctly" measured.
(2) The transformation function is fixed.
(3) The economy is in long-run static equilibrium; perfect competition exists in all markets; there are zero technological externalities; and full employment exists so that the economy is at a Pareto optimal point on its transformation curve.
(4) The distribution of income is the ethically correct one indicated by the economic welfare function so that from all Pareto optimal points on the transformation curve, the optimum optimorum R is selected.

Condition (1) is a definition and measurement phenomenon. Conditions (2) and (3) include the reasons a market economy can diverge from the optimum optimorum at R and, in terms of comparative statics, why NNP and welfare can change. Condition (4) is necessary for accurate specification of the economic welfare function. Each of these conditions will be discussed in turn, always assuming that all the conditions except the one under discussion are met.

The Measurement of NNP

The above model does not tell us how to "correctly" measure NNP. It does indicate that all goods included in individual utility functions must be included in the transformation function and that "correct" measurement of NNP dictates that they be included there also. Answers to questions concerning what goods should be included in NNP lie in the murky depths of the specification of the welfare function.[2] Even if agreement existed on this determination, the ancillary practical issue of measurability arises.

These points aside, something can still be said about what happens to the welfare-NNP correspondence in the general case if a good appearing in the welfare function is left out of NNP. If any good which enters utility functions is excluded from the budget constraint, i.e., NNP, the ordinal association between NNP and W *may* be broken. Consider the two consumer good model above, factors fixed. Let C^1 be a good which for some reason is *not* included in NNP, e.g., advertising financed radio and television broadcasting or home production. This situation is illustrated in Figure II. The initial equilibrium level is at R and $\text{NNP} = P^2C^{2*}$, since C^1 is not counted. Let the price or real cost of producing C^1 fall by h with no change in P^2, creating a new equilibrium at Q. Whatever prices

[2]No distinction is made in this paper between social welfare, economic welfare and welfare. It might be that an appropriate distinction between social and economic welfare is to define social welfare as inclusive of variables which have zero marginal rate of transformation with respect to all other variables in the transformation function and to define economic welfare as being exclusive of such zero opportunity cost goods.

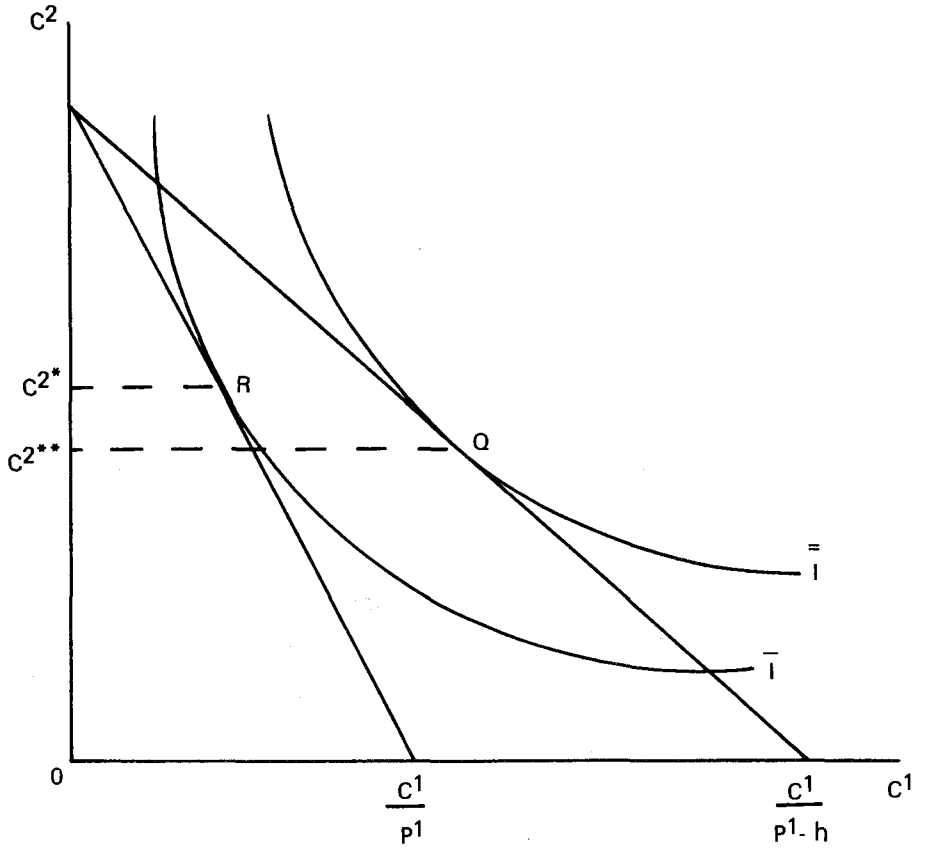

Figure II

are used, NNP has fallen by $C^{2*} - C^{2**}$ in real terms, whereas W has risen from $\bar{I}$ to $\bar{\bar{I}}$. This is the case of a non-included good for which the demand is elastic. For non-included goods for which demand is inelastic, NNP and W will still move in the same direction if the price of the non-included good changes.

The exclusion of leisure is a special case of this phenomenon. It is complicated since the price of leisure, or the wage rate, is a major determinant of income. But the ordinal relationship between NNP excluding a leisure imputation and welfare is preserved as long as the substitution effect of a wage change dominates the income effect, i.e., the supply curve of labor is not backward bending.

The incorporation of variable inputs can be made with one change in the above model. Redefine C_1 as F, where F is an input which at the margin yields disutility. It might be labor hours or loss of clean air. Now the model is: Max $W = W(U_A, U_B)$; where $U_A = U_A(C_A, F_A)$, $U_B = U_B(C_B, F_B)$; and the production constraint is $J[(C_A + C_B), (F_A + F_B)] = 0$. The first order marginal rate of substitution conditions are the same (except for sign), but the connection between NNP and W which existed in the fixed factor model above has now been broken.

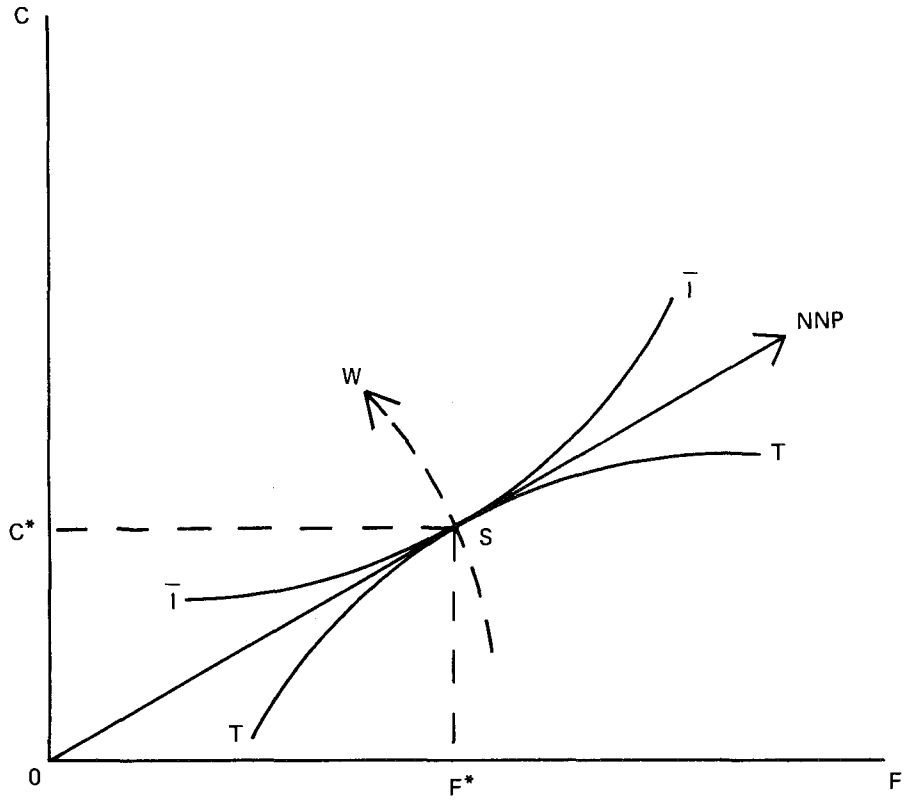

Figure III

This is illustrated diagrammatically in Figure III. Perfectly measured, welfare maximizing Net National Product and Income are now: $NNP = P^cC_A + P^cC_B = P^cC$; $NNY = P^fF_A + P^fF_B = P^fF$; and $NNP = NNY$.

Given P^f and P^c, NNP can be measured on either the F or C axis along the NNP line. The slope of this line is $C/F = P^f/P^c$. Maximum welfare is at S and $NNP = P^fF^* = P^cC^*$. NNP in constant prices changes as one moves along a line with the slope P^f/P^c, but the W expansion path, initially at least, is perpendicular to this line. Starting from any point on or inside the transformation function TT, an increase in welfare requires an increase in P^f/P^c, i.e., an increase in the ratio of factor price to consumer good price.

The Transformation Curve Condition

The transformation curve can shift outward in response to increasing factor supplies or technological change. If it shifts so that some portion of the new transformation curve is northeast of the optimum R, it must be *possible* to consume more of all goods, and NNP and welfare move in the same direction. But the transformation curve might shift in a very nonneutral way, out along some portions, and in along other portions. R would become an unachievable point if

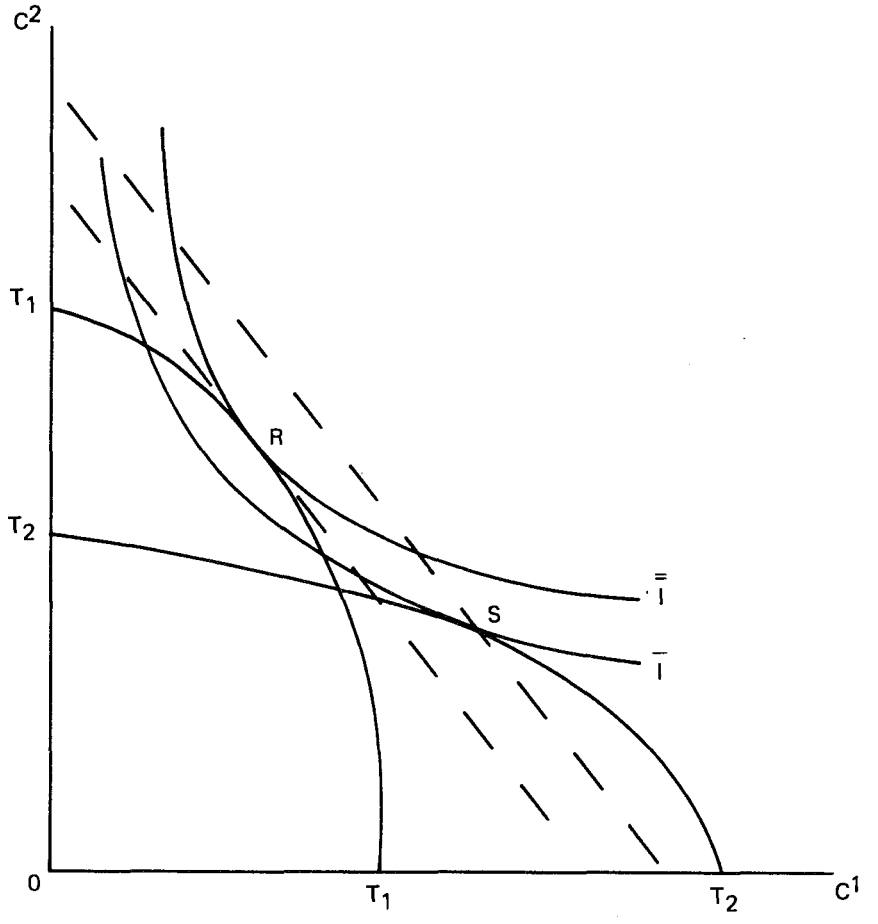

Figure IV

the new transformation curve ran southwest of it. Figure IV illustrates a case in which the transformation function shifts from T_1T_1 to T_2T_2. The optimum shifts from R to S. Although S is on a lower indifference curve than R, NNP rises in terms of the old prices. For consistency between NNP and welfare, NNP must be measured in terms of the new prices, i.e., in terms of the price ratio prevailing at S rather than R. Such a change in the transformation curve might be caused by technological change, favoring the production of C^1, accompanied by increasing opportunity costs of extracting increasingly depleted natural resource inputs required for the production of C^2.

Competition, Externalities and Unemployment

If the economy were on the transformation curve but not at the optimum R (a situation which might be caused by lack of perfect competition among sellers in product markets, tax distortions or anything else which causes a divergence of prices from marginal costs), for any movement toward or away from R, NNP and

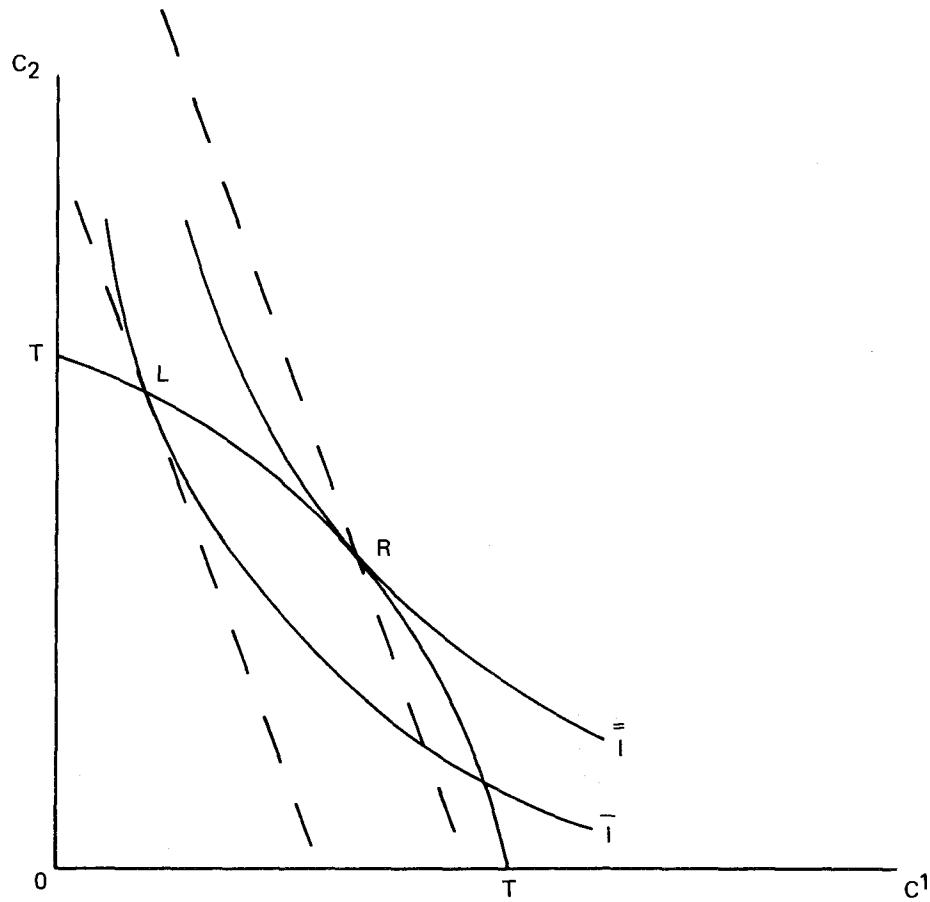

Figure V

welfare move in the same direction. This is the case whether NNP is measured in terms of the old prices or the new prices. In terms of Figure V, if the economy is somewhere on the transformation curve other than R, say at L, a movement to R will raise welfare from $\bar{I}$ to $\bar{\bar{I}}$, and NNP, represented by the dashed line, will shift outward in terms of the old prices (indicated by the slope of $\bar{I}$ at L) or the new prices (not shown but indicated by the slope of $\bar{\bar{I}}$ at R). An assumption here is that individuals are utility maximizing with respect to NNP prices, i.e., the common marginal rate of substitution is equal to the ratio of the prices which consumers pay and with which NNP is measured. In other words, the NNP line is tangent to a social indifference curve, not the transformation curve.

This correspondence between product and welfare does not hold if product is measured in terms of national income at factor cost. National income at factor cost prices would come closer (under perfect competition they would be equal) to the price ratio represented by the marginal rate of transformation. These prices differ from NNP prices by the wedge of indirect business taxes and transfer payments. Some lack of correspondence between national income at factor cost and welfare

can be seen by imagining a national income at factor cost line (not shown) tangent to the transformation curve at L, shifting from L to R. Welfare rises, but national income at factor cost, measured in the old prices, falls. It rises only if measured in the new prices.

An economy may be inside its transformation curve because of unemployment or because of an inefficient employment of factors. With respect to the correspondence between NNP and welfare only rather weak statements can be made for this all too important case. The reason is the index number problem accompanied by a lack of information concerning the reasons an economy is constrained to an inefficient point and why NNP changes from this point. The only shifts inside the transformation curve for which NNP (defined in both old and new prices) and welfare are unambiguously related are those which take place in a northeasterly or southwesterly direction. That is, an increase in NNP (in the old or new prices) is a sufficient condition for an increase in welfare only if the production of no good *decreases*.

The existence of technological externalities affects the NNP/welfare relation in two ways. First, their existence may prevent the market from reaching an optimum at R. Prevailing price ratios will be equal to private, not social, marginal rates of substitution and transformation. Second, they may or may not be included in the NNP measure. The latter issue is of primary interest.

Scitovsky has classified technological externalities or spillovers into effects of four types: producer–producer, producer–consumer, consumer–producer, and consumer–consumer [1954]. In turn, each effect constitutes either a "benefit" or a "cost." With respect to the accounting of such effects, all effects on producers, whether they be of the producer–producer or consumer–producer types, will be reflected in NNP; positively in the case of external benefits, negatively in the case of external costs. They will be so reflected in NNP because by affecting producer production functions, they also affect real output. This is not the case, however, with respect to externalities imposed on consumers. Because they do not directly affect the production sector, they are not reflected in aggregate production. Thus, there is an accounting inconsistency in the treatment of technological externalities.

Were it decided to make social income accounting methodology inclusive of externalities on consumers, there are various procedures which would be consistent with the above model and prevailing national income methodology. One procedure would be to impute external consumer benefits as a credit in the production account and a debit in the household account. External consumer costs would be a debit in the production account and a credit in the household account. Such a procedure requires a balancing entry which could be the deduction of net external costs over benefits on both the debit side of the production account and credit side of the household account. Let B = external consumer benefits and C = external consumer costs, the accounting construct would appear as follows:

Production Sector		*Household Sector*	
C	B	B	C
$-(C-B)$			$-(C-B)$

Were this done, whenever externalities on consumers were internalized and monetized, NNP would not change.

A significantly important case of external effects on consumers is that of "instrumental" or "defensive" expenditures, expenditures necessary for the maintenance of the system which do not (necessarily) represent an increase in welfare in the sense of increasing the range of choices open to consumers. Such expenditures might arise in the private sector, e.g., increasing expenditures because of congestion for the same quantity/quality of transport, or in the public sector where the popular example is national defense.

Externalities may be involved in the consumption of national defense insofar as nations with higher NNP devote a larger portion of their NNP to national defense. This phenomenon may not be due to externalities but to the fact that national defense is an income superior good (and that high NNP is correlated with high NNP *per capita*), or in part it may be because large NNP countries *require* more national defense, a diseconomy of scale. But there is a clear international externality involved also. The quality of national security—or equivalently, the cost of national insecurity—for any given national defense expenditure in an inverse function of other countries' national defense expenditures.[3]

Following the logic of the international externality, if all other countries undertook no national defense expenditure, no one country would either, assuming the country were not militarily imperialistic. Viewed in this way, the accounting treatment of defense expenditures would be the same as the accounting for external costs on consumers. In terms of the producing sector, the cost of national insecurity (a function of other countries' military expenditures) would appear as a debit. Insofar as these external costs were monetized (and thus, internalized) through home defense expenditures, external costs would be reduced by the same amount. No entry of any kind would appear on the credit side of the production account.[4] Such treatment is analogous to private firms undertaking pollution abatement expenditures, thus internalizing and monetizing the external pollution costs. There would be no effect on NNP or welfare only if the external costs were already imputed.

Income Distribution

The distributional implications of an aggregate income objective function are most often ignored or otherwise circumvented through assuming (1) that the

[3]An analogous international externality is international pollution.

[4]The problem of empirically estimating the value of national security or insecurity is the same and intractable. In the construction of a welfare index, the appropriate (second best) procedure may be to net defense expenditures from NNP. This is what Nordhaus and Tobin did in their *Measure of Economic Welfare* (1972).

[5]There is also the welfare argument that insofar as the distributional impacts of different policies are more or less randomly distributed, the continual application over time of one of the hypothetical compensation criteria of Kaldor, Hicks or Scitovsky may lead to Pareto optimality in the long run (Hotelling, 1938; Hicks, 1941). From the point of view of the *desirability* of using a hypothetical compensation principle for policy making, there are the following points made by Head: Large individual losses can still occur; individual attitudes toward distributional uncertainty may preclude the acceptance of any hypothetical compensation criterion; gross maldistributions can be preserved and perpetuated; and that "the distributional ethics of a well-ordered lottery are anyway not widely accepted in modern civilized communities" (1965, pp. 388, 389).

distribution is always optimal; or (2) that any unwanted distributional effects can be corrected through a progressive tax system, i.e., Musgrave's "manager of the distribution branch" is always doing his/her job; or (3) that increases in aggregate income represent *potential* Pareto optimal improvements rather than real ones.[5] To substantiate any of these assertions requires (1) knowledge of the economic welfare function, and (2) a solution to the problem of selecting a price index to measure changes in nominal and real income, particularly when relative prices change.

A perfectly competitive economy without externalities can reach a Pareto optimal point on the transformation curve; and given initial resource endowments a distribution of income is determined. Any change in this distribution forces a movement along the transformation curve. Unless one has knowledge of the economic welfare function—or at least in which direction along the transformation function the optimum optimorum lies—there is no way of telling whether welfare increases or decreases. In addition, given concavity of the transformation function, for any movement along the transformation curve, national product measured in terms of the old prices (which are equal to the marginal rate of transformation, given perfect competition and no tax distortions) always falls; and national product measured in terms of the new prices always rises. Thus, redistributions cause movements along the transformation function; welfare rises or falls; NNP in terms of the old prices falls; in terms of the new prices it rises. In addition, if these redistributions take place through any mechanism other than neutral lump sum transfers, the transformation curve itself may shift.

Summary and Conclusions

The objective has been to delineate and untangle in simple fashion some linkages between national product and welfare. In the confines of a "rockbottom" welfare maximization model, the following conclusions emerge. The choice of variables to include in NNP derive from the economic welfare function. This value judgement is ameliorated by considerations of measurability and, in general, those variables most easily measured are those contained in accounting records of producing units. Also, there are several classes of resource reorganization in which NNP and welfare move in the same direction, so that NNP can serve as an ordinal proxy for welfare. These include changes in taxes or competitive imperfections which result in product substitution and movements along the transformation curve. Also, increases in NNP arising from technological changes, causing an outward shift of the transformation curve, reflect increases in welfare, provided that NNP is measured in terms of the new prices; or if measured in terms of the old prices, that the conservationists' concern is met for it still to be *possible* to produce the old quantities of goods.

With a general qualification, the NNP-welfare correspondence is preserved for allocative improvements in efficiency which lower the real costs and prices of goods included in NNP or of non-included goods in inelastic demand; changes in involuntary unemployment; and changes in technological externalities affecting producers. The general qualification is that the change in NNP is such that the production of all goods increases or decreases, so as to avoid the index number

problem. There are other cases where changes in NNP and welfare are not positively correlated. Included here are changes in real costs of non-included goods for which demand is elastic and changes in technological externalities imposed on consumers.

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