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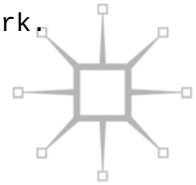
Green National Accounting

Abstract
Extending conventional national product measures, green national accounting provides better indicators of economic welfare and of the sustainability of welfare levels. The main theoretical result shows that in an undistorted economy net national product is proportional to welfare, provided some rather stringent conditions are met. With appropriately used shadow prices, the welfare effects of externalities and world market changes can be accounted for and sustainable income – the hypothetical level of consumption that can be sustained into the future – can be calculated. Practical approaches have been proposed to adjust conventional national income figures roughly in the spirit of the theoretical results.

Green National Accounting[1] extends conventional national product measures, to provide better indicators of economic welfare, as well as indicators of the degree to which welfare levels can be sustained.

Conventional national accounts measure the size of the market or commercial activities, but do not necessarily measure very well (i) how these activities translate into welfare and (ii) how non-marketed activities goods contribute to the welfare of citizens. A big part[2] of the greening of national accounts concerns issues related to the environment. For example, production of certain goods that generate market value contributes to national income, but if the production generates undesirable pollution as a by-product, the contribution to welfare might be actually negative. Conventional national accounts ignore the reduction in air quality since air quality is not traded on markets and is left out from conventional national accounts. As another example, consider the depletion of oil reserves. Oil companies' profits contribute to conventional national income, but the fact that

[1] A clearer but less commonly used term is *comprehensive* national income accounting (cf. Weitzman 2002). Being comprehensive is older idea. Cf. Nordhaus/Tobin (1972) and Daly/Cobb (1989).
[2] Green accounting it should be seen as the general principle to extend the national accounts and therefore also includes non-environmental extensions, for examples: leisure, commuting costs, housekeeping work. (Cf Nordhaus and Tobin, 1972, who did not use the heading of GREEN national accounting).



less reserves will be available in future is left unaccounted, even though this may affect welfare of future generations.

The aim of measuring economic welfare by a simple number is without doubt challenging, since it is inevitably related to the formal economic concept of individual utility and the theoretical problems of aggregating utility and interpersonal utility comparisons. The theoretical approaches to green accounting circumvent these problems by assuming a social welfare function and representative agents in highly stylized models. Because of lack of data and various other constraints, the more applied approaches to green accounting are only loosely rooted in formal theory and sometimes include issues of (intergenerational) income distribution on an ad-hoc basis.
The focus of green accounting is much more on dynamic and intergenerational aspects than on intragenerational issues. It typically tries to measure to what degree the life-time utility of the representative agent in a country increases over time, and to what degree it is higher than in other countries. It sometimes also tries to measure to what degree intratemporal levels of utility of the representative agent in a country can be maintained over time, whether the economy is investing enough to maintain non-decreasing utility levels, and how much a country can consume more than another country when both of them would ensure utility levels of their inhabitants are not declining over time. The latter type of questions is often associated with “sustainability accounting” as a particular branch of green accounting.

Green accounting starts from a broad concept of economic welfare, which goes beyond welfare depending on just marketed produced goods. Thus, welfare is allowed to depend on health, environmental amenities, pollution levels, or availability of natural resources. Even altruistic preferences are allowed: utility levels of future generations may matter for the welfare objective of current generations. Society might care in particular for the utility levels of those generations that are worse off in future. The extreme case of this implies *maximin preferences*: only the generation with lowest utility levels gets a positive weight in the social welfare function and reductions in other generations welfare do not count. This contrasts to *utilitarian preferences*, in which every generation gets a weight, and utility levels of generations further in future often get a lower weight because of a positive utility discount rate.

Welfare in an undistorted economy

A fundamental theoretical result concerns the measurement in undistorted competitive (and hence by construction welfare-maximizing) economies (Weitzman, 1976 and 2003), which we

will refer to as the *Weitzman principle*.[3] Consider a society that manages to maximize its own social welfare function, either because there are no externalities, or because all existing externalities are internalized by appropriate policy. In such an economy, green net national product (NNP) can be calculated and this measure is proportional to total welfare.[4] Moreover, green net investment can be calculated and a positive (negative) value of this measure always implies an increase (decrease) in instantaneous welfare.

To start with, we consider the simplest model economy (as in Weitzman, 1976), in which a single consumption good is produced from a single capital good, representative agents maximize utility discounted at a constant rate, and the social welfare function is the sum of individual utilities. Then the sum of the value of consumption and net investment, valued against market prices, is proportional to welfare. Note that this sum is equal to the conventional NNP number for this economy.[5] In this model economy, NNP reflects intertemporal welfare: consumption reflects instantaneous utility, whereas investment reflects how current economic activity contributes to future utility.

Extending conventional income to "green" income is needed if the welfare function has "unconventional" arguments like environmental quality and health (see e.g., Asheim and Buchholz 2004). These arguments can be seen as alternative forms of consumption, not consumption of conventionally produced goods but of natural resource services, health services, etc. Then in a perfect economy, according to the Weitzman principle, green NNP should be calculated as the value of all "consumption" activities that matter for utility plus the value of net investment in all "capital" stocks that matter for production capacity. Both "consumption" and "capital" are broad comprehensive measures

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[3] `The core mathematical result is that in an economics optimal control problem (infinite horizon, only place time enters is through exponentially discounting objective function) the Hamiltonian, which stands for income, equals the discount rate times the value of an optimal program -- a form of the idea that income is the return on wealth' (Weitzman, personal correspondence, July 2006).

[4] The result holds exactly if instantaneous utility is linear in consumption. With a concave utility function, the consumer surplus is not measured, but changes in NNP still reflect changes in welfare, provided the proper consumption price index is used (Asheim and Weitzman, Economics Letters 73, 233-239, 2001).

[5] In practice a correction for consumer price inflation is needed. The sum of the value of consumption and net investment then equals conventional NNP apart from the specific procedure to arrive at constant prices: conventional accounts use both consumption and investment prices to construct the income deflator, while Weitzman argues that –since consumption matters for utility only- investment prices have to be deflated by consumption prices only. See Weitzman (2003).

here, with the former including for example consumption of environmental resource services and the latter including any variable that determines the production capacity for the generation of comprehensive consumption. Accordingly, the relevant capital goods, or assets, include not only physical capital and resource stocks, but also all kind of other state variables like public health (in economies that have a preference for health or in which health determines workers productivity), atmospheric pollution stocks, physical characteristics of the soil determining absorption of pollution and regeneration of nature, institutional capital and social norms subject to erosion and development.

As a special result of the Weitzman principle, the *Hartwick rule* can be derived (Hartwick, 1977). The rule says: if society wants to maintain a constant utility level over time, it has to invest the returns to non-renewable resources in other assets such that total green net investment (the comprehensive measure of investment) is zero. Hence, in accordance with the Weitzman principle, in such an economy, green NNP equals the sustainable level of utility (as well as green consumption, since green net investment is zero). As a result it is a measure of sustainability: comparing two different economies that are both undistorted and maximize maximin preferences, we can say that the country with higher green NNP can maintain indefinitely a higher welfare level than the other.

Caveats

The above results must be interpreted with care and are more limited than might seem at first sight. The important caveat is that an economy with zero green net investment is not necessarily able to maintain a constant utility level for its representative agent over time and can thus be unsustainable (Asheim et al, 2003). This may be the case, for example, in an economy that is dependent on a non-renewable resource and that is maximizing a utilitarian welfare function with constant discount rate rather than a maximin welfare function. Such an economy might *optimally* consume growing amounts initially, but eventually consume declining amounts, which of course is always inefficient for maximin preferences. The key insight from the Hartwick rule is that a necessary, but not sufficient, condition for maintaining constant welfare over time is sufficient investment (Pezzey, 2004).

The Weitzman principle only applies when changes in production capacity depend solely on investment choices. Alternatively, production capacity, i.e. the possibility to generate

consumption, might change over time due to events beyond control of the economy.[6] Three important examples are exogenous technological change, world price changes, and geological or climatic changes. If technology improves over time or the world market price of export goods increases, an economy's welfare can improve even when Green Net Investment (as defined above) is negative. Formally, welfare is now proportional to the sum of comprehensive consumption and net investment, augmented with a term capturing the (properly valued and discounted) benefits from improved technology and world market prices that will accrue to the economy in future (Sefton and Weale, 1996). The latter term can be labelled the "value of time", whereas the sum of green NNP and the value of time is "augmented NNP" (Pezzey and Toman, 2002). In the case of global warming or other negative environmental developments because of purely geological or climatic reasons, there might be a negative time premium and sufficiently positive Green Net Investment is needed to keep welfare constant.

Externalities and sustainable income

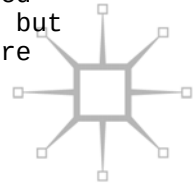
The Weitzman principle is derived for welfare-maximizing economies.[7] How can we measure welfare in economies that do not actually maximize welfare? Similarly, how can we measure sustainable income (consumption) levels in economies that do not actually sustain constant consumption levels?

One theoretically possible way is to construct a hypothetical income figure that represents the level of welfare or sustainable consumption, respectively, that would arise if the economy made the switch from being distorted to being welfare maximizing or sustainable, respectively. This requires a measurement of the total *wealth* of the economy, consisting of all assets valued at their corresponding shadow prices, which depend on the exact welfare function.

The problem when putting this into practice is that actual prices observed in the distorted economy have no direct relation to the

[6] This can be called exogenous time-dependence.

[7] This makes the principle less appealing for practical purposes: the purpose of extending conventional national accounts is to account for environmental degradation and to build a system to evaluate whether a change in policies is needed – in the theoretical construct of welfare-maximizing economies improvements through changes in policy are impossible by construction. A paradox arises within the Weitzman paradigm: if the economy is already welfare maximizing, why would we want to measure welfare or change welfare? One reason can be to compare countries. Pezzey and Toman (2002) refer to the situation (associated with Marglin) in which individuals individually maximize PV welfare but collectively (as a public man) have another –more altruistic- welfare function.



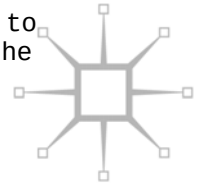
shadow prices needed to calculate wealth. In the presence of externalities, market prices do not reflect certain social costs and benefits, so that the sum of consumption and net investment at market value misses some contributions to welfare. As an alternative to calculating wealth against shadow prices as indicated above, one may augment the market value of comprehensive consumption and net investment with the net present value of the marginal externality along the competitive path (Aronsson et al, 2004).[8] Obviously, such an augmentation term in green accounting is also hard to calculate in practice.[9] [10]

Green national accounting in practice

Given these theoretical results, how feasible is welfare and sustainability measurement in practice? The results suggest that we need (i) comprehensive accounting of consumption and investment activities, (ii) the right (shadow) prices, and (iii) additional forward looking augmentation terms to capture exogenous or uninternalized developments over time. It has been concluded that (ii) and (iii) are insurmountable impediments to practical green accounting: fully correct green accounting is impossible and any method ignoring the problems associated with (ii) and (iii) is bound to produce biased numbers. At the other side of the debate it has been argued that national accounting has always been imperfect and indicative only (Cairns, 2002). According to this view the task is to focus on making national accounts more comprehensive – and satisfy at least requirement (i) – carefully delineating consumption and net investment,[11] and applying corrections to prices where reasonable and feasible. Furthermore, the value of non-marketed activities has to be imputed rather than observed. A host of methods is available to impute prices, which use hedonic pricing, contingent valuation methods, and travel cost approaches.

The resulting practical approaches differ with respect to what to include in national accounts and how to determine values and prices. Among them “Genuine savings” (GS), a comprehensive net investment measure, is best known and closest to theory (Pearce

[8] Alternative adjustments of income to arrive at sustainable income can be formulated in terms of capital gains and interest rate changes, (Asheim, G.B. 1997. Adjusting green NNP to measure sustainability. The Scandinavian Journal of Economics 99, 355-370).
[9] Notice that such a term is very similar to the augmentation term to account for technological progress, changing world market prices or other exogenous effects over time.
[10] See also Arrow, K. Dasgupta, P. and Mãler, K. 2003. Environmental and Resource Economics 26, 647–685.
[11] All consumption and investment needs to be seen as contributions to welfare and production capacity, respectively. This gives rise to the concept of defensive (or regrettable) consumption.



and Atkinson, 1993). Most GS correct conventional measures of investment for consumption of resources,[12] damages from pollution, and investment in education. GS is often found to be positive in Europe and Japan (thanks to high savings and investment in education) and negative for Africa and oil producing countries (due to the depletion of oil reserves).[13] The latter results are quite sensitive to the way resource depletion is accounted for.

GS figures should be interpreted with care: since the GS calculation ignores "value of time" terms and uses market prices rather than shadow prices, GS is not a true measure of welfare increases. Persistent negative rates of GS are likely to result in decreases in welfare (unless exogenous technological change is significant), but with positive rates of GS nothing definitive can be said. So GS can only be used to measure *un*sustainability.

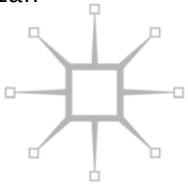
Another well-known indicator is the Index of Sustainable Economic Welfare (ISEW, initiated by Daly and Cobb, 1989). It is an extended measure of Green NNP (and therefore aimed at measuring welfare) that starts from conventional income, adds changes in environmental quality, imputes value of non-marketed activities (particularly household work), subtracts consumption expenditures that do not directly contribute to welfare (e.g. health and pollution abatement expenditures), and weighs on an ad-hoc basis remaining expenditures by a measure of income inequality. For different components different valuation methods are used so that consistency is not always guaranteed. Shadow prices or opportunity costs are rarely used to value damages. The large number of adjustments to NNP also raises the question why certain components are still omitted (e.g. the value of leisure time is not included while household work is, and investment in education and technological change are omitted).

Calculations of ISEW for richer countries show that ISEW has grown considerable slower than conventional NNP over the last decades. This result is not robust, however, for changes in the specific composition of the index and the valuation assumptions (Neumayer, 2003).

Because of the main problem of determining correct prices for non-marketed goods and for dealing with externalities, but also because of the limited substitution between natural resources and conventional man-made inputs, it is often argued that purely

[12] In the closed-economy decentralized Dasgupta-Heal-Solow model following a maximin path, reinvestment of the depleted resource is the responsibility of the resource consumers, not the resource producers. In an international setting, each country should reinvest according to their resource use, not their resource depletion (Asheim 1986 Canadian Journal of Economics).

[13] See Worldbank 2006, Where is the Wealth of Nations - Measuring Capital for the XXI century.



physical indicators are useful to measure the state of the environment and economic welfare and to supplement (rather than adjust) more conventional measures. Since no attempts are made to monetize and the common denominator is missing, different physical indicators cannot be easily aggregated to overall welfare: improvement in one indicator cannot be compared to gains elsewhere and costs of securing improvements cannot be determined.

The *sustainability gap* indicator is an example (Ekins and Simon, 1999). Since welfare is critical dependent on air quality, a minimum level of air quality can be defined that is needed to maintain welfare at a reasonable level, and it can be measured how far society is from this standard; the exercise can be repeated for other critical natural resources.

Another popular example is “ecological footprint”, which measures the amount of land that is needed to generate the consumption of a country, including the land needed to assimilate the waste generated and undo climatic change from carbon dioxide emissions by means of carbon sequestration (Wackernagel and Rees 1996). If for the world as a whole the ecological footprint exceeds available land, the economy is said to be unsustainable. A problem here is how to aggregate over different land uses. Similar measures, with a similar aggregation problem, keep track of varieties of material resource flows.

It is unlikely that the theory of green accounting can in the end be fully applied. Instead, a combination of different indicators and imperfect theory-based measures of welfare could –together with the caveats from theory- provide a useful information system to put conventional national income systems into proper perspective.

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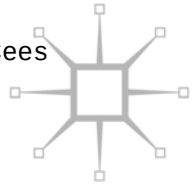

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