Environment and Development Economics 5 (2000): 1–11

Summaries

Green national accounting: why and how?

GEIR B. ASHEIM

During the last decades concern has been expressed for the long-term effects of natural resource depletion and environmental deterioration. This concern has spilled over into an interest in the question of whether national accounting can be 'greened' by taking into account the changes in the stocks of natural and environmental resources. The present paper seeks to give an overview of the *theory* of green national accounting by posing the following two questions: what purposes should green national accounting serve, and what measures are available for these purposes?

There are three purposes that have been mentioned in the literature: (1) measurement of *welfare equivalent income* for the purpose of making comparisons over time (does an economy grow?) and across economies (which of two economies is better off?); (2) measurement of *sustainable income* for the purpose of judging whether actual development is sustainable; or (3) measurement of the desirability of policy changes. Moreover, there are two national accounting measures that have gained attention: (i) *Green Net National Product (NNP)*, being equal to consumption (which is an indicator of well-being that depends also on environmental amenities) + value of net investments (where changes in the stocks of all kinds of man-made and natural capital are taken into account); and (ii) *wealth equivalent income*, being the constant consumption level with the same present value as the actual consumption path.

The paper establishes as a general result that sustainable income $\leq$ wealth equivalent income $\leq$ welfare equivalent income. It also demonstrates how, in principle, wealth equivalent income can be expressed by current prices and quantities only. Practical estimation of such an expression is, however, likely to be informationally demanding.

To establish results concerning Green NNP it is necessary to assume no exogenous technological progress. This is restrictive since (i) it requires that accumulated knowledge is represented by augmented capital stocks, and (ii) it excludes open economies whose 'technology' is changing exogenously due to changing terms of trade. If, in addition, the future is discounted at a constant rate, it is shown that Green NNP $\leq$ welfare equivalent income. No general result appears to be available concerning the relation between Green NNP and sustainable income.

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

Under the assumption of no exogenous technological progress, Green NNP is shown to equal wealth equivalent income if there is a constant interest rate or if consumption is constant.

It is shown that Green NNP can be used to measure the desirability of policy changes only if such changes do not last for more than a period.

The immense practical problems associated with obtaining data to estimate the suggested measures are not discussed here. I abstract from such problems since any practical method of green national accounting needs to be based on theoretical results. The purpose of this paper is to present a survey of such theoretical results.

Sustainability accounting and green accounting

ROBERT D. CAIRNS

Green national accounting has been viewed as a guide for a policy of sustainability. In this paper we first examine the mathematical conditions for sustainability. One condition, Hartwick's rule, asserts that the value (measured using sustainability prices) of net investments in produced capital must exactly compensate for depletion, the value of any deterioration of the environment. This rule is very robust to different types of underlying conditions which may arise in an economy seeking sustainability. However, sustainability accounting using Hartwick's rule would require a completely different approach from the measurement of net national product; market prices would be inappropriate accounting prices. Rather, a qualitatively different optimisation would have to be performed.

Next, we consider a different goal from sustainability, namely the goal of maximising the sum of the consumption levels of future generations, discounted to the present by compound interest. This objective is frequently used in economic theory, but does accord diminished importance to the consumption of future generations, especially in the far future, as compared to the present generation. In this case, a generalisation of net national expenditure is equal to the net interest on the wealth of the economy. An implication is that the 'greening' of the national accounts (by incorporating values for the use of natural resources and the environment) brings net national product closer to being a valid measure of societal well being. Extending the net national product at market prices by using accounting prices arising from this different problem may be the practical way to recognise the value of the environment in social decision making. Following Hartwick's rule using these accounting prices, however, is not a valid policy for achieving sustainability. While a sustainable policy cannot be formulated as an accounting rule using market prices, it is likely that if green NNP increases, so will the quality of the environment.

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

The linearised Hamiltonian as comprehensive NDP

MARTIN L. WEITZMAN

For guidance in determining which items should be included in comprehensive NDP and how they should be included, reference is often made to the linearised Hamiltonian from an optimal growth problem. The paper gives a rigorous interpretation of this procedure in terms of a money-metric utility function linked to familiar elements of standard welfare theory. A key insight is that *the Hamiltonian itself is a quasilinear utility function*, so imposing the money-metric normalisation is simply equivalent to using Marshallian consumer surplus as the appropriate measure of welfare when there are no income effects. The twin concepts of the 'sustainability-equivalence principle' and the 'dynamic welfare-comparison principle' are explained, and it is indicated why these two principles are important for the theory of national income accounting.

Using a 'sustainability-equivalence framework', the paper explains how there is an important connection between the following five core concepts: comprehensive NDP, sustainable-equivalent utility, the completeness of an accounting system, money-metricised utility, dynamic welfare comparisons. One underlying connection is the 'sustainability-equivalence principle', a result which states that comprehensive NDP represents sustainable-equivalent utility whenever, on the one side, the accounting system is perfectly complete, and, on the other side, the utility function has been money metricised to be comparable with national income. The required money-metric normalisation involves exactly the same operations as what is required in static welfare theory to interpret consumer surplus as a base-dollar-denominated true measure of welfare.

The sustainability-equivalence principle is of core importance in the theory of national income accounting because it identifies a strong connection between a comprehensive production-based index of present NDP and a future-oriented sustainability-like measure of overall welfare relative to present consumption. This principle provides a rigorously correct way to understand the heuristic shortcut of 'linearising the Hamiltonian' as representing an intuitive measure of comprehensive NDP—just like using quasilinear utility and a money-metric indirect utility function is a rigorously correct way to understand the heuristic shortcut of 'adding up the area to the left of the demand curve' as an intuitive measure of the welfare effects of a price change.

The sustainability-equivalence principle is a fundamental organising principle for conceptualising the construction of comprehensive national-income accounts. The underlying conceptual linkages, which hold for an ideal world of perfectly complete accounting, are useful as a guide in the

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

real world of incomplete accounting precisely because they indicate *which* items should be included in NDP, and *how* they should be included, if the national accounting system is to be moved in the direction of being a more complete measure of what the future portends.

A second basic result of the sustainability-equivalence framework is the 'dynamic welfare-comparison principle', which lets us compare welfare situations rigorously, yet relying only on currently observable prices and quantities along the present demand function. This isomorphism assures us that it is 'OK' to translate dynamic welfare comparisons into a simple as-if-static story told in terms of conventional consumer-welfare theory. The simple-minded story gives the correct answers to complicated questions that intrinsically involve comparing wealth-like dynamic welfare measures across any two economies differing arbitrarily in technologies or endowments.

Net national product, wealth, and social well-being

PARTHA DASGUPTA and KARL-GÖRAN MÄLER

This paper is about:

- meaning of social well-being
- construction of a *linear index* (NNP) for judging whether a small perturbation (i.e., so small that prices are not affected) of the economy improves well-being in society
- proof that it is generally not possible to interpret this index as sustainable consumption
- proof that, if the sum of the values of the net changes in overall assets is non-negative in the present and in all future time periods, the economy is on a sustainable path

In order to do that, we start with an arbitrary economy, which may be far from an optimal path. The crucial assumption we make is that we can predict the future of the economy from information on the present stock of assets. In the model we restrict ourselves to three assets, real capital, human capital and a natural resource. Such forecasts we call resource allocation mechanisms. For each time period, there is a social utility function which captures the impact on well-being in that period from consumption and labour supply. We can easily extend the model to any number of factors that affect utility in a period, such as environmental damages. Social well-being is defined as the present value of the future flow of utilities. We are then able to show that given a resource allocation mechanism

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

(and some technical assumptions) there are accounting prices (which may or may not be equal to the market prices of the assets) which represent the marginal impact on social well-being from a change in the initial stock of the asset by one unit. Furthermore, we show that if we calculate Net National Product with these prices, we can analyse the effect from a small perturbation or short-term policy reform on social well-being.

It has been claimed in the literature that NNP can also be interpreted as sustainable consumption. We show that this is only true if the utility function is linear, an assumption which violates both ethical mores and empirical observations.

We also show that if the sum of the value of changes in assets is non-negative in the current and in all future time periods, then social well-being will never decline over time. This is then a criterion for sustainable development.

These results depend on the implicit assumption that there are no exogenous changes in the economy, such as autonomous technical changes. In the last part of the paper, we argue that serendipity, unbacked by R&D effort and investment in physical capital, cannot be a continual source of productivity growth. The economy cannot have a 'free lunch' forever. We also point out the possibility that the neglect of changes in natural resources may have introduced a bias in growth accounting exercises which may have led us to believe in autonomous technical change.

Accounting for the distributional impacts of policy in the green accounts

RICHARD D. HORAN, JAMES HRUBOVCAK, JAMES S. SHORTLE and ERWIN H. BULTE

Green income accounts are designed to appropriately value changes in a country's natural resource (natural capital) base. Income accounts that do not incorporate changes in natural capital will mis-represent current economic well-being, provide a distorted representation of the economy's production and substitution possibilities, and fail to inform policy makers about important issues related to economic growth and the use of natural resources. This issue is particularly relevant for developing countries where natural capital is a vital component of economic welfare.

Green NNP is useful as a guide for domestic and international policy only to the extent that it accurately reflects the goals of policy makers. For example, international policy designed to slow natural capital depletion in a developing country is more effective if policy makers recognise the developing country's perceived income effects of the policy. Traditional green accounting models do not satisfy this criterion because they are

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

based on the standard assumption that policies are implemented to maximise the present value of social welfare, defined in terms of utility. This assumption implies that policy makers are either not concerned with the distributional consequences that policies have on various groups, and/or are not limited in the instruments available to them.

An alternative measure of green NNP, denoted political NNP, is derived in this paper to reflect the economic goals of policy makers and their policy options. Economies may be managed to deplete (accumulate) their natural capital stocks in excess of economically efficient rates because this may lead to increased political NNP.

In general, the relation between political NNP and more traditional measures of NNP based on economic efficiency assumptions, denoted sustainable income, is ambiguous. Political NNP may be greater or less than sustainable income, depending on the structure of the objective function used by policy makers in designing policies, production and harvesting technologies, and the structure of the final output and labour markets. Therefore, political income may or may not be correlated with sustainable income. Indeed, sustainable income may provide no indication as to what a country perceives its actual income to be, and may therefore be of limited use in guiding policies.

Valuing mineral stocks and depletion in green national income accounts

GRAHAM A. DAVIS and DAVID J. MOORE

National income accounts are coming under increasing scrutiny as a possible method of assessing the sustainable consumption of a nation. They are at the same time being criticised as not representing the true product of a nation, as they fail to account for the depletion and degradation of natural assets during the production process. A first step in correcting the accounts for these omissions has been to include the value of the stock of minerals and forests in the asset account, and to charge the national product for the depletion of these resources. The result is a set of green national income accounts that some feel are a closer reflection of the health of the economy.

This paper examines the methods by which mineral reserves are valued and included in green national income asset accounts, and the methods by which depletion is calculated and deducted from the green national product accounts. We find that the valuation rules currently used by many income accountants tend to overvalue reserve stocks and overestimate their depletion. We propose that this is because of the restrictive assumptions used when developing these formulas. Our paper presents new stock and depletion valuation formulas that correct for this weakness, and we

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

then empirically calibrate the rules using observed market data. The result is a set of simple, theoretically and empirically sound asset valuation and depletion formulas that provide a practical basis by which to adjust income accounts for mineral stocks and depletion.

Estimating timber depreciation in the Brazilian Amazon

RONALDO SEROA DA MOTTA and CLAUDIO A. FERRAZ DO AMARAL

The importance of incorporating environmental depreciation measures in national accounts is widely recognised. Nevertheless, such a task still faces theoretical as well as methodological controversies. The main literature continues to debate the appropriate method to calculate rent measures that represent the depreciation costs of natural capital. Two main approaches are identified: net price and user cost. The former considers that current net unit prices (deducted of all production costs) could reflect natural capital scarcity whereas the latter indicates that the proper value is the discounted net price which is foregone when the resource is fully used up. Estimates may vary according to which approach is used. On these lines, Vincent and Hartwick (1997) proposed a formulae which generalises depreciation calculation methods and includes the special cases of these two approaches. This approach assumes that extraction of these resource is optimal and, therefore, market prices will reveal scarcity rents.

Applying this generalised approach, our study estimates depreciation values for timber extraction activities in the Brazilian Amazon for 1990 and 1995. Considering the continued large timber stock available in the region, depreciation values were not found to be meaningful. Moreover, taking into account the quasi-open access features of timber exploitation, an important question arises related to the existence and capture of this scarcity rent in the Amazon context. Both high stocks and distorted low prices due to the lack of property rights, are closely related and drive down depreciation estimates. Consequently, the depreciation values reported here are certainly approximations of the real depreciation costs associated with timber extraction in the region.

We conclude that the controversy of methodological approaches covered in the literature, may lose importance when one is considering management policies in regions where the lack of property rights is dominant. Therefore, depreciation charges related to other forest services will be fundamental in making environmental accounting a useful tool for planning in the Amazonian context.

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

Integrating forest resources into the system of national accounts in Maharashtra, India

G.S. HARIPRIYA

Natural resources such as forests have several economic and ecological uses, which go beyond the production boundary of the System of National Accounts (SNA) of a country. In India, the SNA reports only the value of timber, fuelwood and some minor forest products and does not cover other non marketed products of forests, like fodder, pharmaceuticals, etc. Further, when forests are converted to other uses, forest-related benefits are lost but benefits generated by new land uses are gained. The paper adjusts the SNA for the former loss but not the latter gain. The paper attempts to incorporate the value of some of the important goods mentioned above into SNA, compute subsequent depletion of forest capital that occurs during its use by the economy and compute environmentally adjusted state domestic products (ESDP) for the state of Maharashtra. The ESDP is obtained by subtracting the depletion of the forest capital from the Net State Domestic Product (NSDP).

The environmental and resource-related information is made more apparent by desaggregating the current and asset accounts without changing the basic structure. To construct asset accounts, in the first step the physical accounts (volume and area) are constructed for different strata in the state of Maharashtra for the year 1993–4, which contain information on opening stocks, depletion, other volume changes and closing stocks. In the next step, monetary accounts for timber and fuelwood are derived using the net price method. If timber and fuelwood are the only products obtained from forests then the asset value of forest equals the discounted sum of total net rent of timber and fuelwood. As the forest is also a source of other benefits like minor forest products (mfps), fodder and pharmaceuticals (mfps, fodder and pharmaceuticals are together referred to as ntfps), the asset value should also include the discounted value per hectare of these goods. The monetary accounts of ntfps are derived by multiplying the area accounts with the present value per hectare of the products.

The study adjusts the value added by forests to reflect the revised estimate of the value of timber, fuelwood and ntfps. The results show that the contribution of forests is around 3.56 per cent of the adjusted NSDP as against the recorded 1.46 per cent. Further, the difference between the value of the opening stock, other volume changes and the closing stock in forest accounts gives the value of depletion and is found to be 19.8 per cent of the estimated value added. The ESDP, as obtained by adjusting the value of NSDP for the value of depletion, is found to be 99.3 per cent of the estimated NSDP in 1993–4.

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

Improved measure of the contribution of cultivated forests to national income and wealth in South Africa

RASHID M. HASSAN

This study used environmental accounting to adjust current measures of national income and net savings in South Africa (SA) for changes in the value of standing timber stocks, value of the carbon storage benefits and social costs of water abstraction externality of cultivated forests. Results of the analysis indicated that current measures of national income (NI) in SA highly underestimate the contribution of cultivated forests to income and net investment. Omission of the value of net accumulation in standing timber stocks was the biggest source of the underestimation of wealth formation. Contribution of plantation forestry to NI and wealth, in terms of net accumulation in timber stocks was estimated to be more than R800 million on average over the study period. This net contribution was equivalent to 0.54 per cent of NNP, more than 7 per cent of VAD in agriculture and about 1.7 times the VAD generated in primary forestry. The main reason was the fact that standing physical stocks of cultivated forest resources have been steadily rising, indicating that commercial harvesting and natural damage were lower than growth and reforestation over the past 16 years. While net accumulation can be considered a positive gain in welfare, larger stocks of growing trees have several negative and positive impacts on the environment and economic activity. For instance, net growth in cultivated tree stocks increases carbon sequestration and storage capacity. On the other hand, growth in the stocks of water using exotic tree plantations increases water abstraction and reduces stream flow, the opportunity cost of which is expected to be high in a water-scarce country like SA.

Carbon benefits of cultivated forests were estimated at an average of over R52 million over the study period. As net change in carbon storage is proportional to growth in standing stocks, its economic contribution has been steadily rising since 1981 reaching R106 million in 1996. This was equivalent to 0.53 per cent of VAD in agriculture and 8.8 per cent of VAD in forestry. On the other hand, the country lost more than R100 million per annum, on average over the study period, of potential higher VAD in irrigation agriculture as a result of water abstraction by cultivated forest plantations. Like carbon storage this negative externality showed constant growth since 1981 proportional to net accumulation of standing timber stocks to reach R282.6 million in 1995. It is crucial to note, however, that this estimate was based on the opportunity cost of water loss to agriculture, with the maintained hypothesis that agriculture represents the next

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

best user of water compared to alternative land and water use options. The most important limitation of this estimate is the fact that social costs associated with damages to ecosystems' functioning and the consequent loss of their environmental services due to reduced runoff, were not accounted for. Accordingly, the opportunity cost of water loss to agriculture may represent a substantial underestimation of the true value of water abstraction externality of cultivated forests. On the other hand, the contribution of plantations to the total carbon (C) budget of the country is considered to be insignificant. The fact that the potential for future expansions in plantations forestry in very limited due to a number of constraints, suggests a low potential for plantations to be an effective instrument for lowering C balances in SA.

It is also important to remember that the present analysis did not adjust for other positive net contributions of plantation forestry to NI and capital formation as well as for the social costs of other environmental externalities, such as biodiversity loss and soil impacts.

Global macroeconomic sustainability: a dynamic general equilibrium approach

RALPH W. BAILEY and ROSEMARY CLARKE

Empirical studies assessing the sustainability of countries have adopted the weak sustainability indicator (WSI) which measures changes in the stock of physical and natural capital. Results in general relate to individual countries and cover short periods, often as little as one year. An exception is the global study by Proops *et al*. (1999) which uses national income data. We follow their approach and use the same WSI but, whereas other studies have been retrospective, we use a dynamic general equilibrium model to investigate future global sustainability. Data restrictions force us to focus on fossil fuel extraction.

The model enables us to simulate global economic growth, and energy demand and supply over the period 1985–2050. Our standard scenario predicts increasing WSI values suggesting global sustainability in all periods to 2050. The rise in the world oil price, as reserves are depleted, slows economic growth but its impact is softened by the availability of backstop fuels which become available in 2010. A more pessimistic scenario examines possible outcomes in the absence of energy saving technological change and backstop fuels. WSI values still indicate global sustainability, though economic growth is only half that predicted by the more optimistic model and two countries—USA and Brazil—are unsustainable.

While WSI values would be very different if we were able to include

https://doi.org/10.1017/S1355770X00000012 Published online by Cambridge University Press

other forms of natural resource depletion and degradation in our simulations, our study nevertheless illustrates that future country and world sustainability will be greatly affected by the rate of technological progress, the availability of substitutes for natural resources (in our case, backstop fuels) and population trends.

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