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Introduction to the Special Issue

Green accounting: from theory to practice

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A decade has passed since *Wasting Assets*, a study of Indonesia by Robert Repetto and colleagues at the World Resources Institute, drew widespread attention to the potential divergence between gross and net measures of national income. This was by no means the first 'green accounting' study. Martin Weitzman, John Hartwick, and Partha Dasgupta and Geoffrey Heal had all conducted seminal theoretical work in the 1970s. But the World Resources Institute study demonstrated that data were adequate even in a developing country to estimate adjustments for the depletion of some important forms of natural capital and that the adjustments could be large relative to conventional, gross measures of national product and investment. The adjusted, net measures suggested that a substantial portion of Indonesia's rapid economic growth during the 1970s and 1980s was simply the unsustainable 'cashing in' of the country's natural wealth.

Indonesia is not alone among developing countries in having resource extraction industries that comprise a major share of aggregate economic activity. It is also not unique in suffering high levels of air and water pollution and facing severe threats to its biological resources. Indeed, rates of resource depletion and levels of environmental degradation tend to be higher in developing countries than in the developed world.

If green accounting is policy relevant anywhere, it is therefore likely to be in the developing world—hence, this special issue. The issue is a double one for two reasons. First, the call for papers elicited the strongest response of any special issue so far, and, second, the range of theoretical and empirical issues associated with green accounting could not be fairly represented within the confines of a single issue. The green accounting literature has grown so large that even the ten papers included here do not fully capture the advances that have occurred. Nevertheless, they provide

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a good sampler of the current state of theoretical and empirical research and the relevance of this research for developing countries.

My intention in this introductory essay is to highlight some of the major contributions of the papers and to sketch the connections among them. The title of this introduction connotes three things: the organization of the special issue, the essential role of theory in guiding applied accounting work, and the need for the balance of research on green accounting to shift in an empirical direction. The first two are related, and the third will, I hope, be facilitated by the papers in the special issue.

Comparing consumption-based measures of current and future well-being

Theory brings much-needed precision to an issue as inherently complex and as disparately viewed as sustainability and, by extension, green accounting. For that reason, the special issue begins with five papers that address fundamental accounting issues from a theoretical perspective.

In broad terms, we seek through green accounting to answer the question, 'Will a country be as well-off in the future as in the present?' If national welfare is assumed to equal utility, which at time t is a function of consumption of n different goods and services

$$u = u(c_1(t), c_2(t), \ldots, c_n(t)),$$

then we would ideally like to compare utility in the current period to predicted utility in future periods. Because we do not observe utility, however, we must rely on some more measurable indicator of well-being. A standard measure of current well-being in the national accounts is the aggregate market *value* of consumption of goods and services

$$C(t) = \sum_{i=1}^{n} p_i(t) c_i(t),$$

where p_i is price of the i^{th} good. One aspect of green accounting is the effort to expand the definition, and the measurement, of consumption to include non-market values, in particular ones associated with environmental goods and services.

But even if we can improve this consumption-based measure of current well-being, we still face the greater challenge of constructing a summary measure of future well-being to which we can compare it. We wish to know whether we are living within or beyond our means, but how do we define our 'means' when we are concerned about the implications for all future periods? As Geir Asheim points out in the 'review of results' paper that leads off the special issue,[1] economic theory offers not one, not two, but *three* seemingly reasonable, consumption-based summary measures of future well-being. All three exist, and diverge, even in a textbook two-period model like the one illustrated in his figure 2.

Asheim's frame of reference is an economy with a single, homogeneous

[1] Many of the results reported in Asheim's paper are drawn from previous papers by other authors in the special issue, in particular papers by Partha Dasgupta, Karl-Göran Mäler, and Martin Weitzman.

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consumption good, $c(t)$. Hence, $u = u(c(t))$. He thus abstracts away from aggregation issues in defining consumption; a later paper, by Martin Weitzman, takes up this issue. Given actual consumption levels of $c(1)$ and $c(2)$ in periods 1 and 2, respectively, and a utility discount rate (pure rate of time preference) of δ, one can define 'welfare-equivalent income' as the constant consumption amount, w (for Weitzman), that yields the same discounted sum of utility as the actual consumption path

$$u(w) + u(w)/(1+\delta) = u(c(1)) + u(c(2))/(1+\delta).$$

We can then compare $c(1)$ to w to determine whether current well-being is above or below its long-run 'weighted-average' level.

Alternatively, we can define 'wealth-equivalent income' as the constant consumption amount, h (for Hicksian income), that yields the same discounted sum of consumption—not utility—as the actual consumption path

$$h + h/(1+r) = c(1) + c(2)/(1+r).$$

$c(1)$ and $c(2)$ are the same here as in the definition of w, and we are still assuming $u(t) = u(c(t))$. We are simply using $c(1)$ and $c(2)$ to define a different consumption-based, summary measure of future well-being. Comparing $c(1)$ to this new measure, h, indicates whether current consumption is above or below its long-run 'weighted-average' level. Because wealth-equivalent income is defined in terms of consumption rather than utility, the weights differ from those in welfare-equivalent income: the discount rate is the consumption rate of interest, r, not the utility discount rate.

While easy to conceptualize, both summary measures correspond to hypothetical consumption paths that are not feasible: Asheim's figure 2 shows that both pairs of constant consumption levels in periods 1 and 2, (w, w) and (h, h), are beyond the intertemporal consumption possibilities frontier. This suggests that one might instead want to employ a summary measure defined by the maximum constant consumption level that can actually be sustained over time

Maximize m s.t.: 1. $m = c^m(1) = c^m(2)$
2. $c^m(1), c^m(2)$ are feasible.

Asheim labels m 'sustainable income'. If $c(1)$ exceeds m, consumption must be lower in the future than in the present.

The feasibility of m from a production standpoint makes it a superficially more attractive measure than w or h. But it too involves a strong hypothetical element: $c^m(1)$ and $c^m(2)$ are not the actual levels of current and future consumption, $c(1)$ and $c(2)$. Welfare-equivalent and wealth-equivalent incomes at least have the virtue of being defined in reference to the actual consumption path. This is a point emphasized by Robert Cairns in his article.[2] As he argues, using green accounting procedures to measure the sustainability of actual consumption paths is a fundamentally different

[2] Cairns defines Hicksian income differently than Asheim does. He requires it to be feasible, i.e., on the intertemporal consumption possibilities frontier, and he does not require it to be constant over time. Hence, his figure 1 shows it as smaller than Fisherian income in period 1, in contrast to the depiction in Asheim's figure 2.

undertaking than 'sustainability accounting', which involves calculating the prices whose application would cause consumption to match sustainable income, m (what he calls 'Fisherian income').

Setting aside their diagnostic/prescriptive differences, all three measures have economic meaning and potential policy value. It would be nice if they coincided, but as Asheim demonstrates they instead bear the relationship

$$w \geqslant h \geqslant m.$$

In the textbook, two-period setting of Asheim's figure 2, the relationship is one of strict inequalities. Demonstrating this relationship in a setting with the time horizon running out to infinity,[3] and varying assumptions about such fundamentals as the utility discount rate, returns to scale, and the exogeneity of technological progress, requires more work. It comprises much of the analysis in Asheim's paper.

Suppose that, for whatever reason, a policymaker has selected w, h, or m as the consumption-based summary measure of future well-being. How does she calculate the chosen summary measure? More to the point of this special issue, does green net national product[4] (NNP) correspond to any of the three? The standard definition of green NNP is

$$g(t) \equiv c(t) + Q(t)\dot{k}(t),^{5}$$

where net investment, $\dot{k}(t)$, pertains to all capital stocks, including natural resources, and $Q(t)$ is a vector of prices of capital goods. Alas, as Asheim demonstrates, green NNP does not necessarily coincide with *any* of the three summary measures.

Exogenous technological change is one factor that can cause green NNP to diverge from these measures. This is not surprising, given that green NNP as defined above makes no allowance for changes other than ones that are endogenous to the capital stocks it includes. It cannot measure that which it leaves out. This point is of great practical importance for green accounting in developing countries, most of which are price takers in international commodity markets. Exogenous price changes are one form of exogenous technological progress, and international commodity markets are highly volatile. Salvaging green NNP in the face of exogenous techno-

[3] A multi-period future is really the only setting in which a discussion of w, h, and m is meaningful. If there are only two periods, then we can compare the present to the future simply by comparing $c(1)$ to $c(2)$ (or better, $u(c(1))$ to $u(c(2))$).

[4] Some of the papers in the special issue refer to net national product (NNP), while others refer to net domestic product (NDP). These are conceptually distinct measures: the former includes all income earned by the citizens of a country, regardless of the source of the income (within the country's borders or abroad), while the latter includes only income earned within the country, regardless of who earns it (citizens or non-citizens). The two measures can differ substantially in practice, for example in developing countries with large remittances from abroad. The distinction is not important for the main arguments of the papers, which in effect use the terms interchangeably.

[5] Consumption is the numeraire here.

logical progress requires modifying its definition by adding anticipated capital gains

$$\tilde{g}(t) = c(t) + Q(t)\dot{k}(t) + \dot{Q}(t)k(t).$$

That is, green NNP should reflect changes in the values of capital stocks,[6] not just the value of changes in them (net investment).[7] Adjustments must also be made if the interest rate is not constant. If these adjustments are made, and if the production technology exhibits constant returns to scale, then $\tilde{g}(t) = h(t)$: augmented green NNP equals wealth-equivalent income. A comparison of current consumption to augmented green NNP thus indicates how current consumption compares to the summary measure of future consumption—not the summary measure of future welfare.

Green NNP, welfare comparisons, and policy reforms

As Asheim notes, there is a well-known case when green NNP and welfare-equivalent income coincide:[8] when, in addition to exogenous technological progress being absent and the utility discount rate being constant, utility is linear in consumption. This is the case that Weitzman considered in obtaining his seminal stationary-equivalent results during the 1970s. In their paper in the special issue, and in previous writings, Partha Dasgupta and Karl-Göran Mäler criticize linear utility functions on ethical and empirical grounds. They argue that the theory of green accounting should be based on utility functions that allow for concavity in consumption.

The validity of this criticism is now generally accepted. But it has created an additional challenge to theorists. For several years, the standard procedure for determining which items to include in green NNP has been to express the behaviour of a country's economy as the solution to an optimal control problem and to derive green NNP by linearizing the associated current-value Hamiltonian.[9] If the utility function is linear, then the Hamiltonian itself is already linear and is equivalent in form to green NNP. But, if the utility function is concave, then the Hamiltonian and the *linearized* Hamiltonian are not the same. The Hamiltonian is well understood, but the welfare meaning of the linearized Hamiltonian has remained murky. The latter is certainly a convenient guide for applied work, and it certainly looks like green NNP, but what is its exact welfare basis?

[6] In a stochastic setting—i.e., in the real world—*ex post* adjustments are also needed for *un*anticipated capital gains.

[7] National accountants regularly emphasize that, in their view, the purpose of national accounts is to measure an economy's production, not society's welfare. Consequently, the 'production boundary' is their inviolate criterion for determining whether the accounts should include particular items. If production is the object to be measured, then excluding capital gains, which are not 'produced', from NNP is justified. This is not appropriate when well-being is the object, however, because capital gains can affect future flows of benefits from capital stocks, just as physical changes (net investment) can. 'Net accumulation' is the standard national accounting term used to denote the sum of net investment and capital gains.

[8] They also coincide with wealth-equivalent income in this case.

[9] Linearization replaces $u(c)$ with $u'(c)c$, among other changes.

Weitzman attacks the problem in a setting characterized by optimal production and consumption paths, a constant utility discount rate, and no exogenous technological change (values of capital stocks account fully for all sources of future growth; there is no time-dependent 'residual'). From Asheim's paper, we know that green NNP is less than or equal to welfare-equivalent income in this setting. Weitzman demonstrates that linearizing the Hamiltonian is equivalent to normalizing the utility function, $u(c)$, by choosing the parameters a and b in the transformation

$$v(c) = au(c) + b,$$

so that $v(c(1)) = c(1)$ and $v'(c(1)) = 1$, where $c(1)$ is (optimal) consumption in the current period.[10] In effect, the linearized Hamiltonian scales utility in future periods relative to consumption in the current period. This changes the units from utils to the units of the consumption good,[11] but it does not change the ordering of welfare across periods. Hence, even though green NNP as defined by the linearized Hamiltonian does not necessarily equal welfare-equivalent income, the relative magnitudes of current consumption and green NNP mirror the ordinal relationship between current utility and welfare-equivalent income. Because the difference between green NNP and current consumption is net investment, this is another way of demonstrating the well-known result, reiterated in proposition 4 in the paper by Dasgupta and Mäler, that the discounted sum of utility rises if net investment is positive.

Weitzman's point is not that national accountants need to calculate the parameters a and b, but rather that, if they define green NNP according to guidelines generated by the linearized Hamiltonian, then green NNP will implicitly be scaled correctly for consumption-based comparisons of current and future well-being. He goes on in the paper to generalize this insight to the case of multiple consumption goods. This should provide some reassurance to practitioners, given that the measure of consumption in actual national accounts is a monetary aggregate of multiple goods.

As mentioned above, Weitzman, like Asheim and Cairns, assumes that the economy is on the optimal path. This is a perfectly fine approach for isolating fundamental relationships, but, as Dasgupta and Mäler observe, actual economies often violate this assumption, sometimes grossly. Indeed, attenuated property rights and other types of institutional failures appear to be more the rule than the exception when one empirically examines natural resource and environmental management regimes, especially in developing countries. Dasgupta and Mäler thus investigate the interpretation of green NNP in a setting in which sub-optimal resource use can occur[12] and governments can make policy reforms that alter the paths

[10] Weitzman denotes the current period by 0 instead of 1. I am using 1 here to be consistent with the discussion of Asheim's paper.

[11] In practice, the normalization changes the units to money. Hence, Weitzman refers to it as 'money metricization'.

[12] The literature on green accounting in distorted economies remains relatively small. In addition to the paper by Dasgupta and Mäler published here, the reader is referred to works by Karl-Gustaf Löfgren and Thomas Aronsson.

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of production, consumption, and capital accumulation.[13] They argue that *changes* in green NNP, properly defined and measured, indicate whether policy reforms increase long-run well-being (= the discounted sum of utility from consumption).[14] In effect, the change in green NNP offers a social benefit–cost rule for evaluating the economy-wide impacts of policy reforms.[15]

This result depends on two critical assumptions: (i) local accounting prices—i.e., prices that reflect long-run welfare impacts—are used to calculate green NNP, and (ii) the policy reforms are confined to short intervals ('elementary policy reforms'). The first assumption is one that always applies, or always should apply, to green NNP. It is not evident in the papers by Asheim, Cairns, and Weitzman because they assume optimal economic management. Hence, market prices and local accounting prices are one and the same in their models. By explicitly allowing the economy to be off the optimal path, Dasgupta and Mäler draw attention to this practically important feature of green accounting. For environmental economists, it basically means conducting valuation studies to quantify direct consumption values of the environment and values associated with natural capital stocks. The second assumption is stronger. Citing other recent work, Dasgupta and Mäler report that their result goes through if we augment current green NNP by future changes in consumer surpluses.

Weitzman and Dasgupta and Mäler agree that in the general case we cannot infer changes in the discounted sum of utility over time within a given country from the trend in green NNP. That is, we cannot simply compare $g(t+1)$ to $g(t)$. This follows from Weitzman's interpretation that the linearized Hamiltonian, and thus green NNP, is continually renormalized to current-period consumption and from Dasgupta and Mäler's proposition 5, which likewise identifies relative price changes as the source of the problem with intertemporal NNP comparisons. The two papers present alternative approaches for making welfare comparisons over time and across countries, with Weitzman advocating adding consumer surpluses to the difference in NNP and Dasgupta and Mäler advocating abandoning NNP in favor of wealth-based measures.

The emphasis that Dasgupta and Mäler place on policy reforms leads naturally to consideration of why policymakers make the decisions they do. The paper by Richard Horan *et al.* complements the paper by Dasgupta and Mäler by probing policymakers' objectives. It considers the implica-

[13] With the important exception of their differing assumptions about optimality, Dasgupta and Mäler on the one hand and Weitzman on the other work with models with some basic similarities. In particular, both papers assume that different countries share the same utility function $u(c)$ and the same utility rate of discount.

[14] Asheim reviews some of the results of Dasgupta and Mäler's previous work on NNP as a measure of the welfare impacts of policy reforms.

[15] Dasgupta and Mäler are not proposing that green NNP should replace standard benefit–cost analysis techniques for evaluating individual projects. Their concern is with policy reforms that have impacts at the macroeconomic level and thus are suitable for measurement via entries in the national accounts.

tions of policymakers' 'ends' for the definition of national income, while Dasgupta and Mäler consider the impacts of policymaker's 'means' (policy reforms) on social well-being. When policymakers' goals are to steer benefits toward different groups in society—which Horan *et al*. identify as consumers, firms, and labour—then they implicitly are maximizing a different objective functional than the discounted sum of utility. Horan *et al*. derive this objective functional and identify the differences between a linearized version of it and ordinary green NNP. Their 'political NNP' subsumes ordinary green NNP as a special case. They neatly capture the differences between the two with a set of elasticities that reflect political tradeoffs. Their results suggest that one might be able to recover these elasticities by comparing actual NNP, which is distorted by political objectives, to 'optimal' NNP as predicted by a computable general equilibrium model.

Applying green accounting concepts

The first five papers are to applied green accounting as, say, microeconomic theory is to market analysis: they furnish the economic rationale for the exercise and broad guidelines for conducting it and interpreting its results. Like all good theoretical contributions, however, they abstract from messy aspects of reality that are off the track of the quarry being pursued. While perfectly legitimate for theoreticians, assuming away these messy details can lead practitioners into trouble. It can result in green accounts that are so distorted as to be less useful to policymakers than conventional accounts, whose shortcomings are at least reasonably well understood.

What is needed to avoid this problem is what one might call 'applied theory', which provides rigorous guidance on how to deal with the bedeviling details of real-world interactions between the economy and the environment and limitations in the data describing those interactions. Econometric theory is an example of applied theory that is essential to market analysis. Its green accounting cousin is still in its infancy. The last five papers in the special issue take it a few steps forward.

Most applied green accounting studies have focused on calculating values associated with natural capital stocks: the change in value if one is adjusting NNP or net investment, and total value if one is adjusting national wealth. They have emphasized commercial natural resources like mineral deposits and timber stocks. There is no debate about the definition of the value of such natural assets. It equals the discounted sum of resource rents associated with use of the resource over time:[16]

$$V_t \equiv (p_t q_t - TC_t) + (p_{t+1} q_{t+1} - TC_{t+1})/(1+r) + (p_{t+2} q_{t+2} - TC_{t+2})/(1+r)^2 + \ldots$$

where p is price of a unit of the extracted resource, q is the quantity extracted, TC is total extraction cost, and r is the discount rate. The time horizon could be either finite or infinite, depending on the characteristics

[16] Here and in the rest of the introduction, I switch to subscripts to denote time periods.

of the resource (non-renewable or renewable) and management practices (unsustainable or sustainable). From this expression, it follows that the change in the value of the natural asset is

$$\Delta V_t \equiv V_{t+1} - V_t = rV_{t+1}/(1 + r) - (p_t q_t - TC_t).$$

As they are simply definitions, these two expressions hold regardless of assumptions about the optimality of resource use or future paths of p, TC, or q.

In the case of non-renewable resources, early applied studies assumed, and much current work still assumes, that the change in value equals just the second term in the ΔV_t expression, the negative of current resource rent.[17] They ignored the first term, which is the capital gain (or loss) associated with holding the resource. In effect, they estimated gross, not net, changes in value. They typically estimated current resource rent via the 'net-price method': $(p_t - AC_t)q_t$, where AC_t is average cost.

Early theoretical work did not completely catch this mistake. Because theoreticians were hunting more prized game (in particular, the welfare meaning of green NNP), they made assumptions that kept them on its trail. They typically assumed that resource management problems are fully endogenous (no exogenous shocks to p or TC) and are solved optimally. Under these assumptions, they demonstrated that

$$\Delta V_t = -(p_t - MC_t)q_t,$$

where MC_t is marginal cost. Thus, it appeared that the only problem with the net-price method was that it used average cost instead of marginal cost. Practitioners, it seemed, could continue to estimate the 'change in value' (the left-hand side) by the 'value of the change' (the right-hand side), as long as they used marginal cost in the latter.

Unfortunately, this advice was misguided. This is not to say it was incorrect: it was indeed correct, but only under the strong assumptions underlying it. One would be hard-pressed, however, to imagine a set of assumptions more at odds with the actual characteristics of resource use in most countries than those assumptions: optimal management (many natural resources are in a state of complete or partial open access), endogenous prices (most countries are takers of international prices that fluctuate wildly around mostly downward long-term trends), and endogenous costs (technological advance has driven extraction costs steadily downward). In situations where these assumptions are violated—which is to say most empirical situations—the capital gains term in the definition of ΔV_t becomes important.

It is for such reasons that the 'applied theory' in the paper by Graham Davis and David Moore is welcome. Davis and Moore examine the 'Hotelling valuation principle', which is the analogue to the net-price method for valuing mineral reserves (V_t, not ΔV_t): $(p_t - AC_t)S_t$, where S_t is the physical stock of the resource. They investigate whether this method yields biased estimates of mineral reserve values under alternative assumptions about returns to scale in resource extraction (constant or

[17] Salah El Serafy's work provides the principal exception.

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decreasing), use of MC_t in place of AC_t,[18] and characteristics of mineral reserves (homogeneous or heterogeneous). For countries with market data on sales of mineral reserves, they propose correcting these biases by estimating an econometric relationship between market values and the values predicted by the Hotelling valuation principle. This relationship can then be used to estimate the values of reserves for which transaction data are lacking, including, they propose, reserves in other countries (through a 'valuation transfer' approach).

The paper by Ronaldo Seroa da Motta and Claudio Ferraz complements Davis and Moore's by comparing estimates of ΔV_t from the net-price method (using average cost) to estimates from an alternative, 'user-cost' method that uses information on the number of years until resource exhaustion, the discount rate, and the elasticity of the marginal cost curve.[19] They examine the case of old-growth timber stocks in the Brazilian Amazon, which they argue are a *de facto* non-renewable resource because most logging is associated with land clearing. For both total timber stocks and stocks of just mahogany, they find that the net-price estimates greatly exceed the user-cost estimates under all assumptions. They point out, however, that this comparison is complicated by open-access features of Amazonian logging (their user-cost method assumes optimal resource use). Still, their findings offer evidence that the net-price approach tends to exaggerate the depreciation of non-renewable resource assets,[20] just as Davis and Moore found that it exaggerates the value of such assets.

For mahogany, even the user-cost estimates imply that net value-added in the logging sector is much lower than gross value-added under a wide range of assumptions. The paper by G.S. Haripriya provides additional evidence that green accounting adjustments can be empirically significant. Like Seroa da Motta and Ferraz, she focuses on forest-related values in a sub-national region, Maharashtra state in India. She examines a broader range of forest values: in addition to timber, fuelwood, minor forest products (e.g., bamboo), fodder, and pharmaceuticals. She adjusts state domestic product for both the non-market consumption value of these products and the change in value of their stocks. She finds that the actual (market plus non-market) value-added associated with these products is approximately 150 per cent larger than the sector estimate included in official gross state domestic product. The reduction in value of stocks was also substantial, being equivalent to one-fifth of actual value-added in the sector.

In a third paper on forest resources, Rashid Hassan demonstrates that accounting for non-market values does not necessarily result in upward adjustments to the economic contributions of natural resource sectors. Unlike Seroa da Motta and Ferraz and Haripriya, his concern is industrial

[18] Which is related to the assumptions about returns to scale, since $MC_t = AC_t$ under constant returns to scale.

[19] This method is, in effect, a generalized version of Salah El Serafy's well-known formula. It includes the net-price method as a special case.

[20] I say 'tends to' because the net-price method understates losses in value when capital losses occur instead of capital gains.

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plantations, not natural forests, and he makes adjustments at the national, not regional, level. He considers hydrological externalities, in addition to timber values.[21] He finds that timber plantations have reduced runoff and thus reduced the amount of irrigation water available to downstream farmers. The cost of this negative externality is equivalent to a quarter to a third of value-added in forestry.

Because his physical forestry accounts include information on plantation age, Hassan is able to calculate more precise estimates of the change in the value of timber stocks than is typical for green accounting studies. Theoretical studies typically imply that the change in value of renewable resource stocks is given by the net-depletion expression

$$\Delta V_t = -(p_t - MC_t)q_t - G_t).$$

This is just the marginal-cost version of the net-price method, with growth of the resource (G_t) subtracted from harvest. This expression is valid if newly regenerated resources can be harvested immediately, but this condition holds for few renewable resources, especially not for forests. Hassan compares estimates based on this expression to ones from an expression that takes years to maturity into account. He finds that the net-depletion method yields estimates that are only about half as large as the more accurate ones.

Because the three forestry papers focus on a single resource, they do not generate comprehensive estimates of green NNP. The final paper in the special issue, by Ralph Bailey and Rosemary Clarke, also focuses on a limited set of resources, but they are ones that account for a large share of economic activity in many countries: fossil fuels. Bailey and Clarke use a dynamic computable general equilibrium (CGE) model of the global economy to investigate regional and global sustainability up to 2050. The spatial and temporal scope of their analysis makes it a fitting conclusion to the special issue. They find that net investment, defined as gross investment minus the depreciation of manufactured capital and fossil fuel deposits, is positive at the global level and in most regions in their baseline scenario. Indeed, it rises as a share of gross product over time. As Bailey and Clarke point out, the actual situation is probably even more positive, given that they use total revenue—which exceeds even resource rent—as a proxy for depreciation of fossil fuel reserves. They obtain generally optimistic results even under pessimistic assumptions about prospects for energy-saving technologies and backstop fuels.

The absence from the special issue of papers presenting comprehensive adjustments to the national accounts is perhaps partly a quirk of the specific papers received. It probably also reflects something more fundamental, namely the gap between the considerable progress made toward resolving basic theoretical issues and the lack of agreement on the empirical side about the most appropriate methods for making specific adjustments given specific types of data. Reaching agreement on the latter issue will require generous doses of what I have termed above 'applied theory', combined with repeated testing in different country contexts.

[21] He also estimates the change in value of carbon storage in plantations

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While economists are often critical of green accounting systems proposed by national accountants, we really have not yet drawn fully on the resources of our discipline to offer a coherent, alternative set of operational guidelines. The most important contribution of the papers in the special issue is not so much the advances they report, though these are indeed valuable, but rather the improved position they provide for rising to this challenge.