Revaluations and Capital Gains in the Context of
Natural Resource Accounting

by

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Abstract

Tension exists between national accounting practice (in which capital gains are not counted as part of national income), and the theory of national income definition and interpretation (in which capital gains are often argued to be a component of national income). Much of this theoretical work arises in the context of research into natural resource accounting, where capital gains arise endogenously as natural assets are depleted.

In this paper, the appropriate treatment of capital gains in a variety of circumstances is presented. I argue that views on the inclusion (or not) of capital gains are contingent on the underlying interpretation being applied to national income. Capital gains matter when income is interpreted in sustainability terms, rather than in its traditional guise as a measure of the value of output. Even when income is given a sustainability-related interpretation, different views on gains arise from different presumptions regarding the type of gain (the source of the asset price change). Further disagreements in the literature are shown to turn on the time perspective adopted by the individual analyst. The measurement of capital gains varies with the adoption of a present-value versus a current-value perspective. Using this insight, I resolve a number of conflicting claims in the literature. I also raise the neglected issue of revaluations arising from obsolescence, something hitherto neglected in the context of natural resource accounting.
Revaluations and Capital Gains in Natural Resource Accounting

1. Introduction

The issue of capital gains—and revaluations in general—in the national accounts generally, and natural resource accounting specifically, is a much-discussed and debated topic. A strong tension has developed between national accounting practice and the analytical literature. Results from the literature suggest that in certain contexts capital gains not only matter, but may be part of a more meaningful measure of income than measures that exclude them. Yet conventional national accounting practice, as presented for example in Abraham (1969), is clear: capital gains are excluded from national income (despite typically being regarded as part of personal income, as defined for taxation purposes). However, this convention is not universally endorsed by experts, some of whom argue for at least some consideration of capital gains in measures of national income.¹ Moreover, when considering the possibility of extending the accounts to encompass natural resources, the issue of capital gains and their appropriate treatment becomes even more central since capital gains play a central role in defining the conditions for optimal depletion of a finite resource stock (Solow 1974). Yet, as will be argued in this paper, the literature regarding capital gains in the context of natural resource accounting is a welter of definitional confusion and ambiguity, as well as contradictory claims regarding their interpretation and treatment.

The purpose of this paper is to establish when and why capital gains might matter, and to clarify the arguments for and against their inclusion and to clarify prescriptions for different types of
gains in different circumstances. This is done on several fronts. One is to argue that the differing views regarding how gains should be treated in the accounts are linked to different underlying conceptions of the definition and interpretation of national income, particularly emphasising contrasts in “accounting logic” and “economic logic”. The second looks at how different recommendations about the appropriate treatment of capital gains can arise from different assumptions of how the gains arise in the first place, especially in the context of resource depletion models where gains can be endogenous. The third is to clarify some conflicting claims regarding capital gains in formal models of natural resource accounting and sustainability: I show that these conflicts arise through the choice of time perspective in the modelling framework.

2. Interpretations of National Income

Examining the role of capital gains, or anything else for that matter, in income, requires us to define what we mean by income. This is not a straightforward task, and a detailed treatment of alternative concepts of income is not provided here. It suffices to outline two key ways in which income is presented in the literature.

In the first instance, a “measurement” approach to defining income might involve adding up consumption in a period plus any change in wealth that has occurred during the same period. Alternatively, a “behavioural” or “prescriptive” approach might lead us to think of income as a measure of maximum potential consumption per period for some given time frame, based on current wealth and expectations of future prices and interest rates. This in fact corresponds to the

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1 See, for example, the exchange between Scott, Eisner and Bradford in the Journal of Economic Literature
distinction drawn by Hicks (Hicks 1946, Ch. XIV), and echoed by Bradford (1990), between a measure of *ex ante* income (the latter measure), and *ex post* income (the former). This has led a number of writers on the subject to move between the accounting, or ex post, definition and the economic or ex ante definition, rather casually, referring to either or both as Hicksian income (see again, for example, the exchange between Scott, Eisner and Bradford, 1990).

The national accounts are based upon the backward-looking or *ex post* version of income.\(^2\) They are an exercise in record-keeping as much as anything else, and the job of the national accountant is to classify which items should be included and where the various items should be recorded (in the broad categories of final consumption, capital accumulation, intermediate production and so on). Economists on the other hand tend to instinctively favour variants of the Hicksian version, often attempting to infer a measure of sustainable consumption from historical data describing how current consumption is balanced against growth or depletion of the total capital stock.

Advocates for reform of the national accounts like Scott, or many in the field of natural resource accounting (e.g. Hartwick 1990, Asheim 1994), are attempting to re-align these accounting procedures to produce a more forward-looking measure from historical data. In particular, arguments for extending the accounts to cover (for example) so-called “natural capital” are predicated on the argument that the current measure of total capital is incomplete and needs to be supplemented in order to more safely draw such inferences.

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\(^2\) We admit to being a little loose in our terminology here, in that “change in wealth” and “change in capital” have slightly different interpretations, and implications, in this context, and we gloss over them for now. But the major difference between them concerns capital gains, and the discussion in this paper will be as precise on this score as required.
A distinction needs to be drawn at this point between anticipated (unrealised) and unanticipated capital gains. Standard national accounting practice is to measure unanticipated or “windfall” capital gains (these are not counted as income, but are included as a balancing item in national balance sheets): anticipated, unrealised gains are not recorded as income. In this way, gains are recorded as an item that can reconcile a flow measure (income) with changes in an underlying stock (wealth), but are not themselves a component of national income. At the national level it is growth in the capital stock, not the change in overall wealth, that is added to consumption to construct the national income measure.³

3. Capital Gains and Interpretations of National Income

Why are revaluations not included in national income? And why do many economists continue to argue for their inclusion? To consider the question of the appropriate treatment of revaluations in the national accounts, one must first consider the question of what it is that the national accounts purport to measure—and what purpose they are meant to serve—and proceed from there. As Abraham (1969, p.38) puts it:

“The exclusion of capital gains from the national income accounts is sometimes criticised because it reduces the usefulness of the accounts for certain purposes. Thus, to the extent that economic activity—say, private spending by consumers or investors—is influenced by

³ Note that this is in contrast to measures of personal rather than national income derived from the public finance literature, where total changes in wealth are added to current personal consumption in order to calculate a base for income taxation. Changes in total wealth include revaluations.
capital gains, economic projections based on statistics that do not take them into account will be that much less realistic.”

What “certain purposes” might be expected of the national accounts to serve? In the light of the discussion of the previous section, several possibilities present themselves. Note that here, when we ask about the purpose of the accounts, we are asking about the purpose in a measurement sense: in other contexts we might talk more explicitly about national income and policy, and how growth and fluctuations in national income influenced policy choices (macroeconomic management, resource usage, and so on). For our purposes here, the question is what are we trying to measure?

3.1 Income as a measure of national output

The first and most conventional interpretation is that national income—specifically, gross domestic product (GDP)—is most legitimately regarded as a measure of total output (“product”) of the economy. This is the most standard, and widely accepted, interpretation placed upon the main national accounting aggregates—that “national income measures the income from current production” (Abraham 1969, p.38)—being derived from accounting identities familiar to economists from the circular flow model of introductory macroeconomics.\(^4\)

\(^4\) Several qualifications are needed here. First is that output refers to the total output of final goods and services (capital and consumption), netting out intermediate production, and excluding goods produced and/or traded within the household sector or on black markets. Second and more important for our purposes, it is a gross rather than net measure of output (as the nomenclature suggests) in the sense of not deducting a measure of capital consumption in the overall measure of investment.
A major argument against the inclusion of revaluations in income is that revaluations are not additions to output, but simply a result of price changes within a period. If what we seek is a measure of national output then this is an entirely valid objection to the inclusion of capital gains. The economy’s output has not increased simply because some capital or financial assets within it have increased in value. And to the extent that national accounting principles are designed to provide a measure of output—which they clearly are, more than they are aimed at the alternative two interpretations presented below—the exclusion of capital gains is appropriate. Moreover, these accounting principles require that the value of national output be equivalent (in principle) with actual national income—that is, the value of all final goods and services sold in an economy is identically equal to the total stream of returns to factors (profits, wages, rent, interest) in that economy—and the inclusion of capital gains would violate this equivalence (they do not represent income from current production).

3.2 Income as an indicator of standard of living

Once we move beyond income as a measure of the amount being earned from current output, a second interpretation might be that national income represents a measure of “economic welfare”, and thus a time series of national income serves as an indicator of changes in national (average) standards of living: a long run average increase of (for example) 3% in GDP corresponds with a similar increase in overall national well-being. While more contentious than the first interpretation (GDP was not designed to be a measure of well being per se), many would argue that this is in fact the way many (including politicians and others who make or influence policy) regard national income, with more growth in the index being unquestionably better. It is this interpretation that has provided an impetus for much of the resource accounting and other “national welfare
indicator” work: the perception is that national income is being used as an indicator of social “well-offness” and yet it is, in its present form, poorly equipped to play this role.

This interpretation of income, as a proxy of national well-being, leads to problems of both volatility and aggregation when considering capital gains. Volatility obviously becomes an issue because including all revaluations due to fluctuations in commodity markets or stockmarket activity could result in large swings in income that would make sensibly interpreting a time series hard to do. (For example, is it really the case that a stockmarket crash causes an immediate and major fall in national income, and welfare?) Aggregation becomes an issue because, while any increase in an individual’s wealth is conventionally associated with an increase in today’s income for the individual, it is not clear how well this translates to changes in income at the national level. Scott (1990) notes that “in a closed economy, relative price changes must result in as much gain as loss”; so the question becomes, who was the gain accrued at the expense of? Are gains indicative of increased national consumption possibilities, or of transfers of wealth between citizens?5

6.3.3 Income as consumption potential

Third, we might regard national income as some kind of measure of actual (current) and potential (future) consumption. This contrasts with the “production” emphasis of the first interpretation, and like the second, has welfare/well-being overtones. Now however, the viewpoint is more intertemporal in that future consumption is being explicitly considered: in this sense, we have

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5 Open economy issues will be covered later in the paper.
moved to a forward-looking view of income with a Hicksian flavour, even though its construction is still based on the historical or *ex post* framework. Notwithstanding that this interpretation requires a particular set of assumptions to hold in order to be valid, let us proceed on the basis that we can think of a properly constructed income measure as a first approximation to a Hicksian-type measure. Hicks notes “It seems to follow that any one who seeks to make a statistical calculation of social income is confronted with a dilemma. The income he can calculate is not the true income he seeks; the income he seeks cannot be calculated. From this dilemma there is only one way out; it is of course the way that has to be taken in practice.” (Hicks 1946, p.178.)

That is, the goal is to calculate a measure of *ex post* income that approximates a forward-looking sustainable income measure. For such an interpretation to be at all admissable, a *net* measure of output (deducting any capital consumption) would need to be calculated, and (as Hicks emphasises) any “windfalls” need to be netted out. The second item, windfalls, relates to our topic of capital gains and we deal with this issue throughout the paper. The first of these requires appropriate identification of all capital items (that contribute to future consumption), and accurate measurement and valuation of these items in real terms. This includes appropriate adjustment for depreciation, including, where relevant, environmental degradation and resource depletion (and discovery), which is where the natural resource accounting literature departs from conventional national income accounting practice. How best to do these adjustments is open to debate, both in terms of natural resource accounting, as well as more generally. But Usher (1980), Scott (1989)

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6 See for example the exchange between Scott (1990) and Eisner (1990).
and Nordhaus (1994) are all examples of studies of modifications to major accounting aggregates to derive a measure with an underlying sustainability interpretation.

As stressed by Hicks (1946), windfalls should be excluded from such measures of income. Hartwick (2000), however, argues that the interest of unanticipated capital gains (and losses) is a component of “sustainable income” since an unexpected jump in the price of a capital good would allow the owner to sell that good and invest the proceeds to earn the market rate of return.

But another reason often given for the exclusion of capital gains from income is that, even when capital gains represent actual increases in wealth (rather than transitory fluctuations or the effects of a speculative bubble that will eventually burst), they are not increases in wealth that can be consumed today. That is, capital gains do not represent the actual increases in wealth that can be consumed at any time; instead they represent a capitalised value of an increase in a consumption over time. Bradford (1990, p.1186) puts it as follows:

“I think the traditional objection to inclusion of revaluations...in a measure of national output goes something like: ‘The extra value is not really “output” this year; it is the present value of “output” that will appear in the future.’”

However, this view carries less force when income is viewed as a measure of both actual and potential consumption. If we see national income strictly as an aggregate index of output (as per our first interpretation in this section), a historical accounting measure of market sector economic activity, then as discussed above there are good reasons for excluding revaluations. But in a
broader context, if gains are to be excluded because they cannot be realised immediately\(^7\) then this creates further problems. Why is this? The same could be said to hold true of net physical additions to the capital stock; i.e. of actual investment. Extra “machines” produced today increase physical output today—and are thus entirely appropriate to add to the current production of consumption goods today in a measure of total output—but, once produced, items of machinery for example can no more be *instantaneously* converted to an equivalent value of consumption goods than can the extra wealth that might arise from asset revaluations. In other words, income can be seen as a “wealth-like magnitude” incorporating an intertemporal aspect. That is, it combines a measure of current consumption with a measure (implicitly) of potential future consumption.\(^8\)

This very observation led Martin Weitzman to investigate formally the sense in which a measure of output today also represented a measure of current and future consumption possibilities (Weitzman 1976), with investment representing a capitalised value of additional future consumption. If both physical investment and financial revaluations embody potential future consumption, defined along some optimal path that generates the values (prices) of the assets in question, then why include one “future consumption” item and exclude another?\(^9\) (An alternative approach, as argued by Scott (1990, p.1174), is to implicitly assume that a dollar of investment

\(^7\) That is, if everyone tries to “cash in” their gains at once, the value of those gains will be pushed down.

\(^8\) Note that this is in clear contrast to the standard atemporal perspective of national accounting practice, oriented as it is to measuring current output.

\(^9\) Usher (1994, p.137), in a discussion of Weitzman’s results, refers to the “essential ‘this yearness’” of national income as a rationale for excluding revaluations based on knowledge gleaned (e.g. through revised expectations) about the future. However, Weitzman’s measure is explicitly a “wealth-like magnitude” (forward looking) rather than a current-output measure, meaning that the “this yearness” is now meant to embody capitalised values of “future yearness” in it.
spending can in principle be re-allocated to a dollar’s worth of consumption goods: that is, there is a constant transformation ratio between consumption and investment goods and that this justifies the addition of investment goods to consumption. But if this is applied by assumption to investment spending, why not also to revaluations? Why should realised capital gains be presumed to be subject to diminishing returns but not physical investment?)

The upshot is that to understand conflicting prescriptions regarding the treatment of capital gains, we need to be explicit about the interpretation that is (whether explicitly or implicitly) being placed upon the income measure—the policy and measurement role we hope for it to play—in order to think clearly about the role capital gains might fulfil. Moreover, the nature of the gain itself—a surprise one-off windfall, versus a systematic increase in the value of an asset over time—is also important to consider. The debate about gains in the correspondence between Scott and Eisner is in part about this issue, with Eisner arguing (using an implicit view of income as a guide to prudent consumption, something along Hicksian lines) that consumption in the US has been influenced by some trends in asset inflation and that excluding them misses an important part of the prudent-consumption story. Eisner states that “all this points not to the exclusion of capital gains but rather to clarity in the distinction, in Friedman’s terms, among measured and transitory and permanent components of income, or in the Modigliani life-cycle formulation … between current and expected future income.” (Eisner 1990, p.1180.)

This focus on different types of gain will reappear in our discussion of the different recommendations emerging in the NRA literature.
4. Revaluations in Natural Resource Accounting

4.1 Why Capital Gains Matter for Resource Depletion

The issue of the treatment of capital gains looms large in the literature on resource accounting, particularly the extensive literature on resource-dependent economies (e.g. stylised Kuwait-type economies) in which the main issue is the depletion of—and appropriate accounting for—a fixed stock of a given resource. Capital gains matter in the natural resource context because standard results in optimal resource depletion—now embodied in the so-called Hotelling Rule—are defined on the path of capital gains over time. In a deterministic, optimising model, capital gains (typically labelled “resource rents”) arise purely through the depletion of the existing stock. In particular, depletion in a competitive resource market (with no uncertainty) should be at a rate such that the (net) unit value of the resource appreciates at a rate equal to the market rate of interest (Solow 1974). Faster or slower depletion by the industry means that the resource will be over- or under-performing relative to other assets—since aggregate depletion today affects the resource price tomorrow and hence the capital gain to be had by holding the stock of the resource—leading to arbitrage in asset markets that will restore equilibrium.

In more complex settings, revaluations occur when there are new discoveries, when world market conditions change, when expectations change, when technical progress occurs that affects demand for the resource and so on.

The endogeneity of capital gains in any resource-depletion context is fundamentally important. In traditional market-sector national accounting, revaluations are “incidental” whereas in the context
of natural resource depletion, per-unit revaluations are an intrinsic element of the story. As such, capital gains have received much attention in recent literature on natural resource accounting, with different and often conflicting results and prescriptions. However capital gains can arise for exogenous reasons here too. As we shall see, different opinions as to how to treat capital gains in the natural resource accounting context can turn on what sort of capital gains are being considered, particularly but not only whether they are intrinsic (endogenous) or incidental (exogenous). Moreover, some of the apparent contradiction in the literature can be resolved quite easily once a simple difference in perspective is appreciated.

4.2 Resource Depreciation and Capital Gains

Considering the role of capital gains will first require defining appropriately what we mean by depreciation, and distinguishing depreciation from capital gains. While in general, depreciation is typically argued to arise from a variety of sources, including obsolescence and wear and tear, the focus in resource accounting is typically on resource depletion, and hence depreciation is typically taken to be physical depletion of the stock (valued at its shadow price). Maler (1991) for example draws clearly the distinction between measuring the value of the change in the stock as opposed to the full change in the value of the stock. The full change in value includes both depreciation and capital gains. Denoting the value (of the resource stock) as $V$, the per unit shadow price of the resource as $p$, the quantity of resource extracted as $q$, and the quantity of the resource stock as $Q$, then the change in value is

Abraham (1969) regards capital gains or losses as changes in the value of the capital stock unaccompanied by changes in income from current production. In the natural resource accounting context, gains may arise through deliberate changes to the extraction schedule, which are likely to affect current revenues and profits as well as stock valuations (resource wealth).
\[ \dot{V}(q) = p \dot{Q} + pQ \]

where the first term is the “value of the change” or depreciation (the shadow price times change in quantity), and the second term is the capital gain resulting from depletion.

Maler’s emphasis on resource depreciation as (the economic valuation of) a physical reduction in the natural asset seems to be regarded as standard practice in the resource accounting literature, yet there are alternative conceptual issues/frameworks to consider. One of these alternatives is El Serafy’s “user cost” measure of resource depletion (El Serafy, 1989). Rather than ask “What is the value of the stock reduction being incurred as a result of current production?”, he asks “What is the highest permanent income stream that can be associated with a given level of resource extraction?” He answers this by splitting the resource receipts into two components, one of which, if reinvested, would yield the other amount in perpetuity. The former component is labelled the “user cost”, and the latter component is the income accruing from the depletion.

Despite its popularity in some applications, we confine our focus to the depreciation measure of Maler (1991) and Hartwick (1990) and others, largely by recourse to the result of Hartwick and Hageman (1993) that the two procedures are fundamentally equivalent.\(^{11}\)

Another consideration is that obsolescence (as distinct from physical deterioration) is typically treated as a part of depreciation. However in the context of resource accounting, physical “using
up” of finite natural assets is usually regarded as the major policy problem, and depreciation related to obsolescence is absent from most discussions. There may, however, be circumstances in which accounting for obsolescence is relevant (such as an improvement in a backstop technology, e.g. development of an alternative energy source). We touch upon this in a little more detail in a later section.

4.3 Different Types of Capital Gain in Resource Accounting Models

This leads us to consider a variety of causes of revaluations and consequently a variety of types of capital gain, with different potential implications for how they should be handled within adjusted national accounts. In particular, capital gains may be treated (in any given model) as either endogenous or exogenous—that is, arising either from activities within the resource sector itself (such as depletion) or else from external sources (such as world market conditions in the case of a small open economy, or exogenous technical change). Similarly, it is worth distinguishing between cases where the revaluations are stochastic, and where they are deterministic. Deterministic refers to gains arising from a given depletion path, stable and foreseeable. By understanding the differences in the types of gains being considered, it becomes easier to comprehend differences in the views held by different authors as to the appropriate accounting treatment of capital gains.

A simple taxonomy of revaluations in the NRA literature might thus be as follows.

Case 1: Stochastic and exogenous

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11 This is not to deny that the two procedures may yield significantly different results in practice. See Common
An example would be a small open economy, facing unpredictable swings in commodity prices in the face of (for example) changes in expectations about world supply or demand conditions, or changes in technology. These are the sorts of revaluations considered by Brekke (1997), who argues (in the context of accounting for Norway’s resource wealth) that including such gains as income would be a misleading indicator of that country’s affluence. Another example is the estimates presented in Young (1993) who states that revaluations of mineral stocks swamp all other environmental adjustments in revisions of national income in Australia. Hartwick (2000) proposes that the interest on unanticipated capital gains should be included in a sustainability-related measure of income.

Case 2: Stochastic and endogenous

A simple example might be a closed economy (or the entire world market) in which demand/supply shocks lead to fluctuating resource prices. I am not aware of any studies that have examined natural resource accounting issues in such a context. In national contexts, resource price variability typically arises in international markets; while studies of global economies tend to focus on deterministic scenarios (see the next two cases).

Case 3: Deterministic and exogenous

An example would be a small open economy in the face of a stable world market. The world price might arise from competitive forces and thus be increasing over time in line with Hotelling’s Rule. Alternatively, the trend price might be declining in a smooth fashion in the face of technological...
adjustment. (Asheim 1996, Vincent, Panayotou and Hartwick 1997, Usher 1994, Hartwick 1995.) Several of these papers are explicitly concerned with identifying a constant-consumption path, and advocate the inclusion of capital gains (arising from resource depletion itself) as part of a “constant-consumption” measure of income.

**Case 4: Deterministic and endogenous**

An example would be a closed economy or world market in which stable market forces lead to optimal (or at least predictable) depletion and there are no shocks leading to unexpected revaluations. (Asheim 1996, Hartwick 1995.)

One way of viewing capital gains in the open economy context is as equivalent to terms of trade shifts: as the resource is depleted and its price rises, this is effectively a change in the terms of trade in favour of resource exporters and against consumption good exporters who import the resource.

Different recommendations tend to come from the stochastic/deterministic nature of the gains being considered. The more deterministic they are (in a given model), the more likely the author is to recommend their inclusion.

**5. A Clarification on Deterministic Capital Gains in Resource Accounting Models**

The previous section attempted to clarify different opinions on the status of capital gains in income, based on differences in the types of gains being considered. In this section, a specific
source of conflicting or confusing claims from the literature is resolved. These conflicts are spelled out, and then the source of the misunderstanding is presented.

In the open economy context, several authors have argued that the inclusion of (deterministic) capital gains into measures of income is crucial to the definition and measurement of a “sustainable consumption” concept of income.

“The rise over time in the price of the assets creates an annual capital gain that can be consumed without diminishing the value of the stock in units of consumption goods.” (Usher 1994, p.131)

“(A) concept of NNP which includes capital gains would indicate the maximum allowable level of consumption.” (Asheim 1996, p.421)

To make matters more complex, note also the result of Svensson (1986), who claims that a resource-dependent economy following Hartwick’s Rule (of reinvestment of resource rents) will experience zero capital gains. Further, Hartwick and Hageman (1993) investigate a concept of resource depreciation, for use in adjusting national income, which is explicitly defined as a change in the value of the resource (in contrast to Maler’s preferred “value of the change”) which is thus inclusive of any capital gains; yet they recommend that capital gains not be included in national income. Hartwick (1995) develops a Weitzman-like result wherein income has a “change in wealth” component, rather than the more conventional capital-accumulation term.
Why are there such disparate analyses and prescriptions with respect to the treatment of capital gains? Here, we shall investigate the sources of some of the apparent contradictions. To do so, we shall presume that the economy is competitive, and that the net price of the resource thus obeys Hotelling’s Rule. (Recall that Hotelling’s Rule describes how the returns to a fixed but depletable asset accrue in the form of capital gains at a rate equal to the market rate of return.)

The standard Weitzman-Hartwick-Maler style income measure in the Hamiltonian literature, for a resource-dependent country (the resource being the only form of capital) is given by:

\[ Y = C + p\dot{Q} \]

where \( p\dot{Q} \) is the “value of the change” of the resource, \( Q \) being the resource stock and \( p \) being the appropriate shadow value. By contrast, the measure of income with capital gains is given by:

\[ Y = C + p\dot{Q} + \dot{p}Q. \]

As seen already, the second and third terms here sum to the full “change in value” of the resource, where the third term is the capital gain due to depletion and hence increased scarcity of the resource.

Hotelling’s Rule enables us to link the shadow price terms over time by the expression

\[ \frac{\dot{p}}{p} = r \iff \dot{p} = p r. \]

Thus the capital gain term \( \dot{p}Q \) reduces to \( p r Q \), and the relevant question is what value this takes at any instant along an optimal depletion path.
To investigate this, represent the value of the stock at any point in time as \( p \cdot Q \), and its change over a small interval \( \Delta t \) as \( p_{t+\Delta t} \cdot Q_{t+\Delta t} - p_t \cdot Q_t \). This expression can be expanded to the following, where Hotelling’s Rule is expressed in terms of current values:

\[
(p_{t+\Delta t} - p_t) \cdot Q_{t+\Delta t} + p_t \cdot (Q_{t+\Delta t} - Q_t) \\
= (p_t (1 + r\Delta t) - p_t) \cdot Q_{t+\Delta t} + p_t \cdot (Q_{t+\Delta t} - Q_t) \\
= (p_t r\Delta t) \cdot Q_{t+\Delta t} + p_t \cdot (Q_{t+\Delta t} - Q_t)
\]

Dividing through by \( \Delta t \) and then letting it go to zero, we get \( prQ - pQ^\prime \) — that is, there are instantaneous capital gains in the current value formulation.

However, in present value terms, this result is modified, since

\[
\left( \frac{p_t (1 + r\Delta t)}{1 + r\Delta t} - p_t \right) \cdot Q_{t+\Delta t} + p_t \cdot (Q_{t+\Delta t} - Q_t) \\
= p_t \cdot (Q_{t+\Delta t} - Q_t)
\]

and dividing through by \( \Delta t \) and letting it go to zero leaves us only the \( pQ^\prime \) term: instantaneous capital gains, in present value terms, wash right out. The “value of the change” (economic depreciation of the resource as defined by Hartwick, Maler and others) is equivalent to the full “change in value” of the resource due to depletion. That is, in present value terms, the change in value of the resource stock is given by
\[ \dot{V}(q) = p \dot{Q} + \dot{p} Q = p \dot{Q} \]

The intuition for this result is simple: Hotelling’s Rule defines the change in the marginal value—the capital gain—of a unit of the resource to be equal to the market rate of return. In present value terms, the capital gains are exactly netted out by the act of discounting back into present values. Yet, when using a current value formulation, this “canceling out” does not occur and the capital gains reveal themselves again.

This explains both Svensson’s result that capital gains are zero, and Hartwick and Hageman’s use of a capital-gain inclusive formulation of depreciation even as they argue for capital gain exclusion. Both of them are working in a present-value formulation in which the full “change in wealth” (definitionally incorporating any capital gains) is equivalent to the “value of the change” (excluding capital gains) when viewed from a present value perspective.\(^\text{(12)}\) (Also, discrete-time approaches lend themselves to a present value perspective.) However, the general approach of the Hamiltonian-as-income literature (Hartwick 1990; Usher 1994; Asheim 1996) is to use the current value Hamiltonian, in which instantaneous capital gains will be positive under Hotelling’s Rule.

To conclude, Asheim (1996, p. 420) notes Dasgupta’s comment (Dasgupta 1990) that the result that a cake-eating economy will experience an adjusted income (NNP) of zero in any period is paradoxical. Asheim claims that the resolution lies in the fact that in a trading world, the changing terms of trade facing the resource exporter as a result of the operation of Hotelling’s Rule, imply

\(^{12}\) Eisner (1990) is another who talks of depreciation of an asset in terms of the “change in its value”.
that the economy’s “technology” is changing over time, and capital gains then indicate the sustainable income. While Asheim is correct in noting (as does Usher) that capital gains will change the terms of trade of the resource exporter, I would argue that the “paradox” referred to, and a series of inconsistent claims in the literature, is an artifact of alternative modeling strategies in which capital gains sometimes appear to “matter” and sometimes do not. In present value terms (such as in a discrete time model, or using a present value Hamiltonian or value function), capital gains over an optimal (competitive) depletion path will net out to zero, whether the economy is open or closed. The difference between present and current value perspectives explains a number of anomalous claims in the literature about the role (or existence) of endogenous capital gains in resource depletion models.

6. Capital Maintenance, Depreciation, Obsolescence and Reinvestment

This section represents a slight digression from the topic of capital gains, but is included because revaluations are not only classifiable as capital gains (excluded from national income): depreciation can include an element of revaluation as well as of physical deterioration or reduction.

6.1 Obsolescence and Depreciation

In previous sections, we saw that any change in the economic value of a resource stock could be divided into two components: depreciation and capital gain. In the natural resource accounting

13 This present value “neutrality” result is derived for a constant interest rate. Asheim (1996) goes on to derive a general equilibrium result in which interest rates are driven down as a result of resource depletion. However, in such a deterministic context, as long as the discounting proceeds by using the same instantaneous discount rate as applies to the compounding (for Hotelling’s Rule) then the intuition for the result continues to hold.
literature, depreciation is taken to reflect physical depletion or degradation of a resource stock or environmental asset, while the capital gain refers to any revaluations arising from price changes. This is somewhat understandable: natural resource accounting has been driven by perceptions of increasing natural resource scarcity, and the physical loss or change has been seen as the most important aspect of resource use to incorporate into a revised set of accounts.

However, standard national accounting practice does not treat depreciation as a purely physical process; or, put another way, not all revaluations are regarded as capital gains in the national accounts. Obsolescence is part of the standard-practice approach to depreciation in the national accounts. This perspective derives from business accounting, where, if depreciation is viewed as the measurement of “decline” in a capital asset until it is scrapped, obsolescence due to improved alternative technologies will bring forward the “scraping date” of the asset. Hence, from a business point of view, the amount that needs to be put aside each period to finance the replacement of the asset at the scraping date—the depreciation allowance, in other words—increases with obsolescence.

Two authors who argue for the relative importance of obsolescence in estimates of national depreciation are Scott and Rymes.

“The most important reason why capital goods fall in value over time and are eventually replaced is that they are made obsolete by newer and better capital goods.” (Rymes 1993, p.202)
“(I)t is obsolescence, and not physical decay, which is the principal factor in the depreciation of those business assets that do depreciate.” (Scott 1990, p.1177)

That is, the concept of depreciation used in national accounting is a broader measure than the physical measure emphasised in the natural resource accounting literature. In particular, depreciation is not generally taken to be simply a monetary assessment of physical deterioration; it may have a “value change” component driven by technical progress. Not all commentators approve of this definition. Regarding the issue of obsolescence, Usher (1994, p.136) notes that this “procedure can be perverse in causing national income to fall as a consequence of beneficial technical change”, while Rymes (1993, p.202) asks “Why should we deduct from Gross Product an allowance for depreciation when all that is happening is that the value of capital goods is falling while their productive capacity may be remaining unimpaired?”

In the light of this, Scott, Rymes and Usher all argue for a conceptual distinction between physical change and obsolescence to be reflected in accounting practices, albeit with different authors having different suggestions as to how to implement this. Scott advocates perhaps the most radical departure from the orthodoxy, arguing that depreciation should be confined to a measure of obsolescence; that such depreciation would then be largely a transfer rather than a loss due to “capital consumption”; and that expenditures to physically maintain or restore capital assets should be labelled “maintenance” and treated as intermediate expenditures. Usher is by contrast much more conventional and in keeping with the technical natural resource accounting literature, which, in reviewing, he states: “I think the appropriate procedure for converting gross to net
national product...is to limit the measure of depreciation to the actual deterioration of the capital stock in the course of the year, ignoring obsolescence.” (Usher 1994, p.136)

6.2 Constant Capital, Natural Resources and Reinvestment

The issue of obsolescence has almost entirely been left out of the natural resource accounting literature, in favour of treating depreciation as a consequence of physical change. As we have just seen, several commentators who have thought about obsolescence in this context have advocated maintaining a distinction between obsolescence and “wear and tear”. Scott’s approach diverges from the mainstream in equating depreciation with obsolescence, and labelling expenditures on restoring the effects of “wear and tear” as maintenance. To Scott (see Scott 1990), this has two merits: it both separates physical from financial changes in the capital stock which have hitherto been grouped under the label “depreciation”, and also enables us to disregard the effects of obsolescence as—in his view—the depreciation of capital by obsolescence results in a transfer of wealth (to workers, in the form of real wage increases) rather than a reduction of national productivity. This latter point is quite at odds with conventional wisdom, since Scott argues that depreciation by obsolescence is, to a first approximation, zero. Just how far it is from conventional wisdom is shown by Eisner’s response (Eisner 1990) that depreciating capital would be more likely to be accompanied by real wage falls than the increases Scott claims have occurred.14

14 In Scott’s favour, Eisner appears to be instinctively thinking of depreciation in physical terms: using marginal productivity reasoning, a reduction in the quantity of capital would have such an effect. If capital is being made obsolescent but not losing actual productivity, there is no reason to expect that wages will fall as more productive capital items come onto the market causing existing ones to lose value.
However, despite Scott’s apparent departure from orthodoxy, he and Usher and Rymes all seem to be fairly consistent in emphasising the need to account for physical changes (whether one labels it maintenance or depreciation), and in disregarding obsolescence. Scott (1995) discusses the application of his suggested modifications to accounting practice in terms of environmental sustainability: again the emphasis is on maintenance expenditures to restore the effects of depletion/degradation of natural capital. Regardless of labelling, all three authors seem to support measuring the effects of wear and tear and (largely) ignoring the effects of obsolescence.

These recommendations also seem consistent with some of the sustainability prescriptions emerging from the natural resource accounting literature, such as Hartwick’s Rule prescribing the reinvestment of resource rents into produced capital (see Hartwick 1977, Solow 1986, 1991). Note that Scott does not explicitly outline any Hartwick-type reinvestment rule: he just stresses the need for what he labels maintenance expenditure generally. Presumably in Scott’s schema, such reinvestment would be labelled required maintenance expenditures, since Scott seems to regard maintenance as being those expenditures required to restore the capital stock and maintain consumption possibilities (along Hicksian lines). So far, nothing, bar the labelling, seems out of the ordinary. It is worth noting, though, that Scott disavows any explicit references to a “constant capital” rule. “(I)n my preceding discussion, I did not need to mention any aggregate capital stock, let alone a ‘natural’ one. Even when the concept of economic development is widened, that does not seem necessary.” (Scott 1995, p.87.)

Whether this is simply a pragmatic position—one need not attempt to measure the value of the underlying stock as long as one accounts appropriately for the periodic flows—is not clear, but
seems likely. Scott, like many other authors, seems to work with at least an implicit constant capital rule, even if he states his belief that actually measuring it is an unworthy endeavours.

There are unanswered questions remaining however. The first relates conceptually to the question of optimal resource usage, and particularly applies to (for example) renewable resources. Take the case of agricultural land (“soil”). Soil is both a renewable resource, and one that has a quality as well as a quantity dimension. There remains a debate in the natural resource accounting literature—and the more general literature on sustainability—as to how to best account for changes in the quantity and/or quality of the soil stock due to agricultural production. Some approaches—including the UN SEEA\textsuperscript{15}—recommend a disaggregated capital maintenance rule that would regard the benchmark against which depreciation (or maintenance) should be measured as being constant soil quality/quantity. This contrasts with an economic efficiency criterion; that is, a present-value maximisation rule under which there is an implicit “optimal path” of soil usage (which may involve “mining” the soil over some time frame) that would be the benchmark against which depreciation in the stock of soil would be assessed.\textsuperscript{16} Using the conventional terminology, this affects any calculations of depreciation of such natural resources. In Scott’s terminology, it affects the boundary where maintenance ends and investment begins. Scott’s approach appears consistent with that of the UN, in that any loss of productivity should be matched by equivalent restorative expenditures, labelled maintenance. The contra view, put here

\textsuperscript{15} United Nations’ System of Integrated Economic and Environmental Accounts (United Nations 1993).

\textsuperscript{16} This is an example of a more general point that is important for natural resource accounting. Welfare and sustainability are two obvious benchmarks (fitting our second and third concepts of income earlier) for assessing what income is meant to measure and how well it performs. However, welfare maximising trajectories may violate sustainability conditions (such as non-declining consumption) and vice versa. Measures of depreciation
by Eisner (1990, p.1182), is that “The conventional measure of depreciation, though, is the derivative of the value of an asset with respect to time on the assumption not that maintenance prevents all loss of value due to depreciation but rather that maintenance expenditures are such as to maximize the present value of expected returns net of those maintenance expenditures.”

This does leave unanswered the issue of how to account for changes in the value of a resource stock due to what might be thought of as obsolescence. For example, development of alternative energy sources would be likely to reduce the value of a stock of oil in a way that suggests increased “obsolescence”. Modifying the accounting rules (in particular, the depreciation charges) in the light of such possibilities has received little attention. Scott (1990) notes that obsolescence cannot be counted as a simple within-nation transfer when trade exists, and thus terms-of-trade effects matter. For the sorts of resource-dependent economies under discussion here, such effects are likely to be important.

Some work has been done (e.g. Weitzman 1997) on the topic of technical progress in the formal Hamiltonian framework for green accounting: however, this is mostly aimed at restoring the welfare-interpretation of greened income, rather than determining specific accounting procedures for individual items in response to such technical advances.

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17 With regard to soil issues, Kirby and Blyth (1987) advocate the “efficiency” approach, while Young (1997) advocates the “sustainability” framework.
It may be the case that obsolescence matters with respect to resources and energy, beyond whether the “capital stock” (the natural resource) becomes less valuable through the discovery of substitutes. Fraumeni (1997, p.8) noted that “obsolescence has played a big part in the debate about the impact of the oil embargo on productivity.” In particular, Baily (1981) argued that rapid oil price increases led to obsolescence of particular specific assets, with a consequent decline in the rate of productivity change. A counter-argument has been put by Hulten, Robertson and Wykoff (1989).

Fraumeni (1997) also notes that with respect to the American NIPAs (National Income and Product Accounts), the Bureau of Economic Analysis is moving towards estimating measures of depreciation that separate the effects of obsolescence from those of physical deterioration.

6.3 Discussion

The curious reader might wonder that this section has been devoted to a non-problem: that first I claim that the NRA literature has avoided reference to depreciation by obsolescence (as opposed to depreciation by physical change), and then I claim that those analysts who have paid attention to this issue have advocated against any measurement of depreciation-by-obsolescence anyway.

To respond, the first counter-argument is that depreciation-by-obsolescence is a standard part of national accounting practice and at some stage needs to be explicitly addressed in the literature, even if only to be dismissed. Including obsolescence in depreciation measures is sensible as business practice as it brings forward the date at which it is economic to scrap an existing asset. However, as obsolescence at the national level ought to have (to a first approximation) no
negative effect on national productivity—in fact it should have the reverse effect by dint of the new technologies which render the old ones less valuable!—it is easy to see why Rymes and Scott advocate confining economic depreciation to changes in productivity induced by wear and tear, broadly defined.

The issue of what to measure and what to include, as with the general issue of capital gains in this paper, is one of determining what the aggregate index is intended to measure. A forward-looking income measure that attempts to provide information on long-term consumption prospects is unlikely to be improved by including obsolescence in its depreciation estimates—and a concern for alerting ourselves to possible “limits to growth” suggests the importance of maintaining a focus on the physical where natural resource endowments are concerned—but in turn this requires attention to be paid to the potential “upside” of technological improvements that move us away from reliance on (for example) exhaustible fossil fuels. Rendering those fuels cheaper through technical advance does not lead to the conclusion that we have impoverished ourselves.

7. Conclusions

The conventional wisdom, that capital gains are not part of national income, is brought into question in the natural resource accounting literature. A number of authors argue for the inclusion of gains accruing to natural resource stocks as a result of depletion, for similar reasons as some (such as Eisner and Bradford) have argued for the inclusion of gains in a more general context: that to the extent they embody increases in potential future consumption, they are important to consider as part of income. This of course requires us to view income rather differently than do
national accountants: as a forward-looking measure linked to concepts of sustainability of consumption, rather than simply a measure of income accruing from current production.

The crucial sticking point, if this route is followed, is to distinguish between those gains that are windfalls and those that genuinely represent increases in permanent income. This is not an easy task, and as Brekke (1997) points out, if prices have the potential to vary considerably, then consuming the apparent gains can lead to problems later. Hartwick’s (2000) recommendation to count only the interest accruing to unanticipated gains may be an appropriate compromise.

In terms of anticipated gains, there is increasing support for including them in a sustainability-relevant measure of income (Asheim 1996, Hartwick 2000), although Hartwick argues it is not clear whether gains terms are best accommodated on the income or the product side of the accounts (e.g. Hartwick 2000, p.92).\(^\text{18}\)

It is also important to distinguish who the gains are made at the expense of: typically the NRA models that lead to recommendations of capital-gains-inclusion are open economy models where the capital gains are accrued at the expense of another country (Usher 1994, Hartwick 1995, Asheim 1996). In this context, of course, global capital gains are zero, as gains to one country are offset by losses to another.

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\(^{18}\) Note that in the context of Hartwick’s analysis, the “product side” of the accounts is still in terms of a sustainability-adjusted measure of income, which goes beyond the strict accounting interpretation of a measure of the value of current output.
It was established that some confusion existed about gains, and the distinction between gains and depreciation, in competitive resource depletion models depending on the time perspective of the model employed. The present value of capital gains along a price path following Hotelling’s Rule is zero, although in the current value Hamiltonian framework, those gains “reappear”. Some contradictory claims can be reconciled once this simple point is noted.

Mention was also made of revaluations due to obsolescence, which are conventionally included as part of depreciation rather than as capital loss. This issue has been neglected in favour of a focus on physical depletion in the resource accounting literature; meanwhile, several prominent commentators on income and growth accounting are critical of the blurring between depreciation by wear and tear (physical deterioration) and depreciation by obsolescence. Recommendations as to how to account for these items separately differed—some of this being a difference in labelling—but there was an apparent consensus that they should be accounted for separately. Some tentative comments were offered here about how such concepts might be brought into the resource accounting area.

The ever-present tension between what accountants are trying to measure—how much has the economy produced this year and how much income has been generated by that production?—and what economists would like to infer from such measures—for example, are we better off this year than last year; by how much; and how are we affecting our long term prospects?—looms large in these debates, as the quotes at the start of this section suggest.
If a consensus on a “sustainable consumption” kind of measure is reached, then there is a case for inclusion of capital gains in such a measure. The issues then become largely practical: determining whether anticipated gains are reflecting increases (rather than transfers) in wealth; and then assessing the “reliability” of these estimated gains. Where authors using deterministic models find a clear case for inclusion of gains, the scepticism of others arguing that the practical effect is likely to be serious volatility in measured income, might be allayed by advocating only the interest on unanticipated gains being included.
REFERENCES


