Accounting for Depletion in the SNA

by Peter Hill[1]

Introduction

This note is intended as a further contribution to the debate on the treatment of depletion in the SNA. If some natural asset is scarce -- that is, if the total supply of the asset is limited and not sufficient to meet the potential demand for the asset now and in the future -- then there is a cost involved in depleting the asset for purposes of production. From an economic view point, a cost is incurred if the extraction of some natural asset lowers production possibilities in the future. It a matter of fact and not principle how scarce an asset is and whether or not such a cost is incurred. If there is genuine scarcity, then a measure of the cost must be recorded in the Production Account of the SNA and not in some satellite account. Unfortunately, depletion is often regarded as optional extra that can be omitted from the SNA's production account and handled in some related environmental accounts. However, if depletion is actually a cost of production it cannot be relegated to some subsidiary accounting system. Omitting it from the production account implies that the main flow accounts of the SNA, and their balancing items, are seriously distorted and biassed, as many economists and national accountants have stressed.

Natural assets of the kind under consideration here, such as deposits of minerals, ores, natural gas and oil, are different from stocks of both fixed assets and inventories, the most obvious difference being that they have not been produced by processes of production as defined in the SNA. Although they are neither inventories nor fixed assets, they nevertheless have some of the characteristics of inventories and some of the characteristics of fixed assets. One important question is therefore whether their accounting treatment should be modelled on that of inventories or fixed asets.

When accounting for the use of natural assets it is necessary to focus on their economic and not only their physical characteristics. It is argued here that there is a strong generic similarity between natural assets and fixed assets from an economic point of view which implies that their accounting treatment should be similar to that of fixed assets rather than inventories. Depletion has a strong generic similarity with depreciation (i.e., 'consumption of fixed capital' as defined in the SNA), and depletion and depreciation have usually been analysed in parallel in the economic literature on the subject from Hotelling to the present day. It is useful to start, therefore, by examining what are relevant economic similarities between fixed and natural assets.

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The economic similarities between fixed and natural assets

The first and fairly obvious point is that the values of stocks of both fixed and natural assets depend on the contribution they make to production. These value can only be realised if, ultimately, their owners (or some other units to whom they are leased) use them in production. (Of course, owners can also realise the values of stocks by selling off the entire stock at once, but the amounts new owners are prepared to pay depend on their assessment of the benefits to be derived from using them in production.)

The relevant economic characteristic sharedby fixed assets and stocks of natural assets which argues in favour of accounting for them in a similar way is that they are typically not used up in a single year but continue to be used over a long period of time. More fundamentally, there is a constraint on the *rate* at which these assets can be used in production. Obviously, a fixed asset cannot be utilised for more than 24 hours per day, and in practice the maximum is typically much less than this for technological, economic or social reasons. There is also a maximum to the rate at which a natural asset can be extracted, depending on factors such as the location of the deposit and the amount of fixed capital formation which has been undertaken. The entire stock of a natural asset cannot be extracted within 24 hours no matter how much its price rises. There are also economic constraints on the rate at which a natural asset is extracted as the market may only be able to take up a small fraction of the total stock in any one year.

From an economic point of view, these dynamic factors are crucial. Both a fixed asset and the stock of a natural asset can be viewed as delivering a stream of inputs into production over a series of time periods. The value of the asset depends on the stream of receipts associated with this flow of inputs. It is determined not simply by the total value of the stream of receipts but equally importantly by their distribution over time, or time profile. The actual rate at which a fixed or a natural asset is exploited is determined by some planned production schedule which depends on a variety of economic factors and inevitably involves some expectations, implicit or explicit, about the future. Some rate of exploitation and associated stream of receipts must be assumed in order to be able to place a value on an asset and to calculate depletion or depreciation. Production plans are not immutable, of course, and are likely to be revised periodically in response to unforeseen changes in relative prices, technology, information, or other factors. This implies that asset values and estimates of depletion and depreciation may also have to be revised periodically.

Although economists usually write about 'depreciation', the term is often used to mean different things in different contexts. To avoid possible confusion in the context of this paper, the SNA term 'consumption of fixed capital' abbreviated to 'CFC' will be used from here onwards to make clear that this is the intended concept of depreciation.

Valuing stocks of natural assets

It is necessary to distinguish between the price of a natural asset before and after it has been extracted. A unit below ground is an input into the process of extraction whereas a unit above ground is an output. They are different goods. In order to value of stocks of natural assets, it is the price of a unit of the stock in the ground before extraction which is relevant. When the owner and the extractor are different economic units, the payment received by the owner may be described as a 'royalty' which suggests treating it as a form of property income, as in the 1993 SNA. However, as emphasised in the earlier Hill/Harrison paper and also by others, there is a problem about the economic status of a royalty when the owner is actually disposing of the asset and the extractor acquires ownership rights over quantities of the asset extracted. The payment of a royalty looks more like the purchase of an asset from this perspective. The status of a royalty is examined in some detail below.

Because the quantities of a natural asset must be extracted sequentially and cannot all be withdrawn at once from the stock, the value of the stock to its owner is *not* equal to the total quantity of the stock multiplied by the current price of a unit extracted. Quantities which it is planned to withdraw in the future must be valued now at their 'forward' prices where the forward price is the discounted future price. The forward price now of a unit to be extracted in period n is $1/(1 + r)^n$ of the expected real, or relative, price of the asset in period n (which may or may not be equal to the current price). Of course, the effect of discounting is to make the forward prices progressively smaller the further away the extraction date is.

The general SNA principle that quantities should be valued at their current market price is only valid when the quantities in question can be offered for sale on the market at that price. This is not the case for the bulk of the quantities which make up the stock of a natural asset which cannot be extracted all at once because of the constraint on the rate at which they can be extracted. Quantities scheduled to be withdrawn in future periods must be valued at their forward prices so that the *average* price for all the quantities that make up the stock could be considerably lower than the current price. Exceptionally, the entire stock of a natural asset may be offered for the sale, in which case the price paid per unit will reflect the purchaser's estimate of the average of the current and the forward prices. Markets are familiar with forward prices.

Fixed assets are valued in exactly the same way. The quantity of the services that a fixed asset is scheduled to deliver in each future period has to be multiplied by the appropriate forward price to obtain the present value of the service in that period. The total present value of the asset is equal to the sum of the resulting present values over all periods.

On the other hand, when there are no constraints on the rate at which goods can be withdrawn from stocks, they should all be valued at their current market price as they can all be offered for immediate sale at this price. This is typically the case for inventories of goods which have either been purchased by entreprises to use as intermediate inputs or which are held by their producers in the expectation of being sold. As always, the differences between different kinds of stocks may to some extent

be a matter of degree rather than kind as it may be appropriate to value at least some of the goods held in extremely large inventories at forward rather than current prices if it is unrealistic to envisage them all being withdrawn at once. This may be appropriate in the case of strategic stock piles, for example, or butter mountains or wine lakes held under the EU's Common Agricultural Policy. In the vast majority of cases, however, the SNA rule that inventories should be valued at their current market prices seems appropriate.

Consumption of fixed capital (CFC)and depletion

The appropriate economic concept of CFC and depletion was proposed by Hotelling in 1925. Both CFC and depletion may be defined as that part of the change in the value of the asset between the beginning and the end of the period which is attributable to the exploitation of the asset in production. As already noted, the value of a fixed asset or stock of a natural asset is determined by the present, or discounted, value of the stream of receipts to be obtained by using it in production. Both CFC and depletion are therefore measured by the change in the present value of the receipts between the beginning and end of the production period. Denoting CFC or depletion in period t by d_t, it can easily be shown that :

$$d_t, \text{ defined as } (v_t - v_{t+1}), = f_t - rv_t \qquad (1)$$

$$\text{or,} \qquad f_t = d_t + rv_t \qquad (2)$$

where v_t is the present value of the asset at the start of period t,
f_t is the receipt in the period t,
and r is the rate of interest.

This formula, which can also be traced back seventy years (Canning, 1929), has been used extensively by various people including myself in the last twenty years or so. In my paper on *Economic Depreciation in the SNA* present to the 'Canberra Group' on the Capital Stock in March 1997, I argued that explicitly decomposing CFC and depletion into the two elements, f_t and rv_t, ought to provide useful insights into the way in which they should be treated in the SNA. It should be possible to account satisfactorily for all three of the terms, f_t, d_t, and rv_t, in the above equations.

When the owner of the stock of some natural asset and the unit extracting the asset are one and the same unit, accounting for depletion is relatively simple. The value of depletion as defined above should be recorded alongside CFC as a cost of production in the production account. This will be discussed further below. The more interesting case, as explained in the Hill/Harrison paper, is when the extractor is not the owner.

Extraction under a lease

When the unit extracting the asset does so under some kind of lease from the owner, the accounting becomes complicated. To avoid possible possible misunderstanding, it should be noted that leasing extraction rights is not a form of

production. It is analogous to renting land and is different from both financial and operating leasing. Financial leasing is a method of financing the purchase of a fixed asset while operating leasing is a form of production in which the owner of the asset uses it to produce other services which are consumed by other units. The services provided by the fixed asset itself are inputs, together with labour, materials, etc, into the production of outputs of leasing services. The services of the asset and the leasing services must be not be confused with each other.

It is argued here that when the owner of the stock of some natural asset leases out the extraction rights, part of the royalties received constitute property income while the other part constitutes receipts from the disposal, or sale, of the asset. The relative importance of the two components depends entirely on how scarce the asset is. When an asset has become quite scarce, the royalty should be treated mostly, or even entirely, as the sale of the asset. If the asset is relatively abundant, the royalty may be mainly a form of rent. Everything depends on the size of the stock of the asset relatively to current demand and expected future demand. It is useful to approach the problem by considering two limiting and opposite cases.

First, consider the stock of some natural asset for which the quantities are infinitely large and inexhaustible, but to which access is restricted because the stock is owned by some unit, typically the government in practice. This type of situation can occur and is not totally unrealistic. Assume the owner forces units which want to extract some of the asset to pay a fixed charge per unit extracted. Assume also, for convenience, that the owner allows a fixed total quantity to be extracted each period and that the charge remains fixed from period to period. The expected stream of receipts is constant and an infinitely long. Its present value is then equal to f/r where f is constant.

The present value of the stock does not change, however, between the beginning and end of any period under the conditions assumed, which implies that economic depletion as defined by Hotelling is zero. If the stock is inexhausible, extraction does not reduce future production possibilities and no cost is incurred. The asset is not scarce if the supply is infinitely large. Only by being able to restrict access to the stock is the owner able to extort a charge. In practice, the economic units most likely to be able enforce property rights over such an asset and compel other units who wish to extract it to make a payment are, of course, governments. The payments received by the owner have to be a form of rent from an economic point of view. Of course, it may be argued that no natural asset on earth is literally inexhaustible, but the important point is not so much the absolute size of the stock of an asset in a purely physical sense, but its known size in relation to current and expected future demand over the long term, bearing in mind not only the possibility of future discoveries but also of future advances in technology affecting the demand for the asset. There may well be situations in which stocks of certain types of assets are so large that they may be treated as virtually inexhaustible, which is sufficient in the present context.

The way to record this situation in the SNA is presumably to record the payment of royalty by the extractor to the owner as property income in the same way as rent on land. The treatment of royalties proposed in the 1993 SNA seems to be correct in this case (but only in this special case). Reverting to the equations given

above, f is equal to rv_t and d_t is zero. The whole of f_t, the payment received by the owner from the extractor, can be treated as income by the owner. It equals rv_t, the return on the asset received by the owner (which in turn can be identified with Hicksian income). No depletion is to be recorded in the production account, because no cost is incurred if the supply is so large that there is little or no likelihood of future production possibilites being diminished.

(Reverting to the situation in which the owner and extractor are one and the same unit, no cost is incurred in these circumstances so that no charge for depletion needs to be recorded in the owner/extractor's production account. The extractor's value added and operating surplus are the same whether the extractor and the owner are one and the same unit or different units, provided the royalties are treated as property incomes.)

Although this case is a limiting case, it is important from a conceptual point of view. As already argued, there may be situations in which the total deposits or reserves, including unknown ones, of some particular kind of asset may be considered to be so large as to be virtually inexhaustible in practice. In such cases, treating the royalties paid to governments or other owners as property incomes, as proposed in the 1993 SNA, seems to be appropriate. The royalties are payable purely as a consequence of the ability of the owners to enforce their property rights over what is effectively a free good from an economic point of view.

However, it is also important to bear in mind that this is an extreme case and it is not being suggested in this paper that it is the norm : far from it. In order to keep a proper balance it is necessary to turn to examine the other extreme case in which the stock of some natural asset is not only exhaustible but has been depleted to the point at which there is only one period's supply left.

In this case, the value of the stock of the asset at the start of the last period is equal to f_t, the amount to be extracted in that period. The value of the stock at the end of the period (v_{t+1}) is zero. Depletion, d_t, is equal to f_t in this case. The owner has no income, the payment received by the owner being attributable to the extraction and disposal (in effect, the sale) of the entire remaining stock of the asset.

It is also worth noting that this is the special case in which depletion is analagous to withdrawals from inventories. The time constraint on the rate of extraction which was emphasised earlier has gone because, by assumption, the stock of the asset has been depleted to the point at which it is so small that the entire remaining stock can be extracted within a single period. All the quantities extracted in this last period have to be valued at their current price in the same way as goods withdrawn from inventories.

Thus, the economic interpretation to be placed on the term f_t, (*i.e.*, the 'royalty') is totally different between the two extreme cases just considered. In the first case, f_t is equal to rv_t and must be treated entirely as property income, while in the second case f_t is equal to d_t and must be treated entirely as the sale of an asset. It is therefore imappropriate to impose an accounting treatment which assumes that a royalty is a flow whose economic characteristics are the same in all circumstances.

The accounting treatment of general cases between the two extreme cases considered above is now apparent. In general, f_t the royalty payable by the extractor to the owner is made up of two components, one of which, d_t, is a payment for the asset disposed of by the owner while the other, namely rv_t, represents the payment of property income, a special kind of rent, to the owner. Decomposing a flow into two economically different components in this way is commonplace in national accounts. The ratio of one to the other is not fixed, of course, and the proportion that constitutes rent tends to diminish as the stock of the asset becomes smaller and closer to exhaustion. This treatment is strictly analogous to that of CFC, or depreciation, in economic literature and the SNA. The value of the services provided by a fixed asset to production is divided between CFC, or depreciation, and the return to the owner of the asset.

The difficulty from an accounting point of view is that the cost of the depletion appears to be incurred by the owner of the asset whereas the production process is carried out by the extractor. The owner has no production account in which to record the depletion. This is the problem that was addressed in the previous Hill/Harrison paper in which it was suggested that a special depletion account should be created in which to record the depletion incurred by the owner. This solution is somewhat contrived since the owner is not really engaged in some kind of productive activity.

An alternative and more realistic solution, which does not require a depletion account, is as follows.

- First, an amount equal to the term d_t, which seems to be the generally accepted measure of the cost of depletion from an economic point of view, is recorded as the disposal of an asset from the owner to the extractor in the capital accounts of both parties.

- The extractor then uses up the asset just acquired in the course of production. It is therefore recorded as depletion in the extractor's production and capital accounts in the same way as CFC. In effect, the extractor's capital account records both the acquisition of the asset from the owner and its disposal in the form of depletion. Although the two entries cancel out numerically for the extractor, it should be noted that the purchase of the asset is a monetary transaction whereas the depletion, like CFC, is an imputed internal transaction. The two entries need to be kept distinct. The gross value added of the extractor is not reduced by depletion, but net value added is. The accounting is parallel to that for CFC.

- As just explained, the disposal of an asset valued by d_t is recorded in the the owner's capital account. By definition, it is equal to the the decline in the value of the stock of the asset between the owner's opening and closing balance sheets.

- The difference between the total royalty payment, f_t, receivable by the owner and depletion, i.e., the value of the asset disposed of, is recorded as the receipt of property income, a form of rent. The payment and receipt of this property income is recorded in the primary distribution of income accounts of both the extractor and

the owner. It should be classified separately from rent on land and a special category of property income should be created for the purpose. In general, the amount of this income will tend to diminish as the asset becomes scarcer.

As already noted, when the owner and the extractor are one and the same unit, the accounting is greatly simplified. In this case, depletion is recorded in the owner/extractor's production and capital accounts in the same way as CFC. By definition, it equals the decline in the value of the stock of asset between the opening and closing balance sheets. The element which corresponds to the rent on the asset is implicitly included in the net operating surplus. This is strictly analagous to the common situation in which producers own the fixed assets they use in production where the net operating surplus also implicitly includes an element corresponding to the return on the assets. Whether or not the implicit rent should be estimated and separately identified in the production account is an interesting and topical question but it goes beyond the issues addressed in this paper. Similar issues arise with fixed assets and will not be pursued further here.

The implications for GDP and NDP at the level of the economy as a whole are fairly obvious. GDP is unaffected but NDP is reduced by the amount of the depletion. This holds equally whether the owner and the extractor are different units or one and the same unit. It is the same conclusion as was reached in the Hill/Harrison paper. One advantage is that GDP can still be calculated when it is not feasible to make an acceptable estimate of depletion or the share of the royalty that should be counted as depletion. Given that NDP is a much to be preferred to GDP on conceptual and theoretical grounds, this is not a very laudable advantage. However, the SNA has already created a precedent by allowing all the balancing items in the accounts to be recorded gross rather than net if CFC cannot be estimated satisfactorily.

Annex : some further comments

It is suggested in a recent paper by André Vanoli that depletion should be treated as if it were equivalent to withdrawals from inventories rather than CFC. The reason why stocks of natural assets cannot be equated with inventories has already been explained in the first part of this paper. The key difference is the time factor. There is a constraint on the rate at which natural assets can be extracted just as there is a maximum rate at which fixed assets can be used in production. In contrast to inventories, stocks of natural assets cannot be valued by multiplying the total quantity of the assets by current price of a unit extracted. The average price of the natural assets in the ground is not equal to the total quantity times the current price. The opportunity cost of extracting a certain quantity in the current period is also not equal to the quantity times the current price. It is not necessary to repeat all the arguments again.

In any case, intermediate consumption is meant to cover only the costs of consuming goods and services that have been produced by other processes of production in the current period or recent past (allowing for withdrawals from inventories). The economic rationale behind this, which was repeatedly stressed in the early years of national accounting and also today in economic texts, is to avoid double counting the outputs from different productive activities. Gross value added, or GDP,

was intended as unduplicated measure of output. Although natural assets are not produced their inclusion in the value of output does not lead to double counting just as the services provided to production by fixed assets are not double counted. For this reason, it is legitimate to include their value in GDP even though depletion, like CFC, is a genuine cost of production which needs to be subtracted from the value of output together with intermediate consumption in order to arrive at proper measure of *net* value added.

In principle, and despite its widespread use, GDP is not a satisfactory measure of value added when it includes both depletion and CFC.

André Vanoli points out that the term rv_t also equals the increase in the value of the stock remaining in the ground as it comes one period closer to being extracted. I made this same point in my paper to the Canberra Group in March of 1997. André Vanoli now argues that this increase in value should be treated as holding gain, a possibility that I also raised in my Canberra paper but soon rejected. The arguments are spelled out in that paper, but can be summarised as follows.

First, the increase in value is not attributable purely to the passage of time but to the *activity* of extraction. The increase occurs because the stock remaining in the ground becomes more accessible as a result of the activity carried out in the current period. From an economic point of view, the quality of remaining stock is higher than it was at the beginning. A parallel may be drawn with the increase in the value of a bond as it approaches maturity where the increase in value (assuming no change in the interest rate) is an increase in the size, or volume, of the bond and not an increase in its price. There is no nominal holding gain. Terminology can be confusing because it is natural to talk about the 'price' of the bond increasing, whereas the 1993 SNA is correct in treating the increase in the value of the bond as reflecting the reinvestment of the interest accruing on the bond which leads to an increase in the 'size' of the asset.

It is worth noting what happens if the planned extraction schedule is unexpectedly suspended for one year. In that case there is no increase in the value of the stock in the ground over the year because it is no closer to being extracted. The increase in the value occurs when the activity of extraction proceeds according to schedule and is not due to the passage of time in itself.

In any case, nominal holding gains on the stock of the asset remaining in the ground cannot occur unless either the interest rate changes or there is a change in the price of unit extracted during the current period which also changes expectations about the price of the asset in future periods. Changes in the interest rate or in actual or expected prices generate nominal holding gains.

Conversely, it is clear that changes in the total value of the stock due to changes in the planned rate of extraction on the basis of which the stock of the asset was originally valued should be recorded in the 'other change in volume of assets' account. Given a particular interest rate and set of expectations about the price of the asset now and in the future, the total value of the stock depends not only on the total quantity in the stock but also on the distribution of quantities to be extracted over future periods: i.e., on the planned extraction schedule. A change in the schedule,

such as an acceleration in the rate of extraction, increases the present value of the stock just as the discovery that the total stock is larger than expected increases its present value. Neither increase generates a nominal holding gain.

This also provides the clue as to how to treat new discoveries. New discoveries are to be recorded as volume increases in the 'other changes in assets account' to the extent that they change planned extraction schedules, for example by accelerating them or prolonging them. If a new discovery has no effect on the schedules, say because extracting the new stock is not economically viable or because the existing stock is so large that the discovery has a negligible effect on planned rates of extraction, the value of the total stock is scarcely changed and there is nothing, or next to nothing, to be recorded in the 'other changes in volume of assets account'.

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