"What value is Gross Domestic Product?"

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Abstract

Gross Domestic Product (GDP) is a monetary measure of the goods and services annually produced by domestically located factors of production. The contention expressed in this paper is that GDP — in particular, real GDP — is little more than an indicator of the annual volume of national economic activity. GDP is a poor measure of national income; is unable to accurately reveal any qualitative improvements in newly produced goods and services; is an inadequate indicator of sustainable economic welfare; is a less-than-ideal indicator of both the rate of throughput and the environmental pressure exerted by economic activity; and cannot even be used to measure the growth rate of a nation's economy. In sum, we urgently need to abandon GDP and look for alternative indicators of national income, welfare, and environmental pressure. This paper reveals some viable alternatives to GDP.

1. Introduction

Real Gross Domestic Product (GDP) is a macroeconomic indicator used for a variety of purposes. More particularly, real GDP is employed to gauge the growth rate of a national economy, as a measure of national income, and as an indicator of national well-being. In some cases it used as a proxy indicator of resource throughput (e.g., Daly, 1992).

Ecological economists have to some extent highlighted the shortcomings of real GDP as an indicator of national income — at least income in the Hicksian (1946) sense — and national well-being. Less, however, is made of the inability of real GDP to say much at all about the rate of resource throughput, the physical expansion of national economies, and the extent to which economic activity imposes pressure on the natural environment that supports and sustains it. My aim in this paper is to argue that, in terms of measuring anything meaningful, real GDP is of virtually no value at all. Indeed, the sooner we reject real GDP and look elsewhere for key macro indicators to inform policy-makers the better we will be. Hence, as I proceed to demonstrate the paucity of value in real GDP, I shall suggest various indicators to improve our understanding of: (a) economy-envoironment interactions; (b) what is happening to the physical scale of national economies; and (c) what it all means in terms of human well-being.

2. What is GDP?

GDP is a monetary measure of the goods and services annually produced by domestically *located* factors of production (i.e., by the natural and human-made capital located in a particular country).[1] By natural capital, I mean forests, sub-soil assets, fisheries, water resources, and critical ecosystems. Human-made capital, on the other hand, includes the stock of producer goods (e.g., plant, machinery, and equipment) that is used to produce consumer goods and replacement producer goods.

GDP can be measured in *nominal* or *real* values. If GDP is measured in nominal values, it is measured in terms of the prices at the time of production. On the other hand, if GDP is measured in real values, it is measured in terms of the prices of all goods and services in a particular year — often referred to as the base year. In the very simplest of terms, the following is a basic identity to describe a nation's nominal GDP in 2001-02:

$$\text{nominal GDP}_{2001\text{-}02} = P_{2001\text{-}02} \times Q_{2001\text{-}02} \quad (1)$$

where:

- P = the price index of goods and services as at June 2002;
- Q = quantity of goods and services produced during the 2001-02 financial year.

As can be seen from (1), the nominal GDP in 2001-02 involves the multiplication of the quantity of goods and services produced during the 2001-02 financial year and their prices at the time of production. Assume, now, that the 2003-2004 financial year was chosen as the base year to calculate the real GDP in any particular financial year. The real GDP of 2001-02 would subsequently be measured in terms of the prices of all goods and services as at June 2004. It would thus be:

$$\text{real GDP}_{2001\text{-}02} = P_{2003\text{-}04} \times Q_{2001\text{-}02} \quad (2)$$

where:

- P = the price index of goods and services as at June 2004;
- Q = quantity of goods and services produced during the 2001-02 financial year.

Now imagine that we wish to compare the real GDP for each year over a three-year period from 2001-02 to 2003-04. The real GDP for each year would be:

$$\text{real GDP}_{2001\text{-}02} = P_{2003\text{-}04} \times Q_{2001\text{-}02} \qquad (3)$$

$$\text{real GDP}_{2002\text{-}03} = P_{2003\text{-}04} \times Q_{2002\text{-}03} \qquad (4)$$

$$\text{real GDP}_{2003\text{-}04} = P_{2003\text{-}04} \times Q_{2003\text{-}04} \qquad (5)$$

Note that the only 'flexible' variable in each case is the quantity of goods and services produced during the financial year (Q). The prices used to value the goods and services (P) remain constant at $P_{2003\text{-}04}$. By keeping all prices fixed in terms of a base year, annual changes in real GDP reflect differences in the quantity of goods and services produced from year to year. It is for this reason that real GDP is often preferred to nominal GDP in discussions relating to national well-being. It should also be noted that real GDP and nominal GDP are only the same in the base year since, unlike any other year, both are measured in terms of the prices of goods and services during that year.

A more accurate representation of a nation's nominal GDP in 2001-02 is given by a matrix function of the price × quantity relationship on a good-by-good basis. For example:

$$\text{nominal GDP}_{2001\text{-}02} = (P1_{2001\text{-}02} \times Q1_{2001\text{-}02}) + (P2_{2001\text{-}02} \times Q2_{2001\text{-}02}) + \ldots\ldots + (Pn_{2001\text{-}02} \times Qn_{2001\text{-}02}) \qquad (6)$$

As we shall see, this approach negates any possibility of estimating the rate of throughput by way of changes in real GDP over time. However, this does not prevent real GDP from being a reasonable approximation of throughput although, as will be explained later, more precise indicators of resource throughput are best provided by measures other than real GDP.

3. GDP is a poor measure of national income

According to Hicks (1946), income is properly defined as the monetary value of the goods and services that a nation can annually consume without undermining its capacity to sustain the same level of consumption in the future — that is, without impoverishing itself. A central feature of the Hicksian definition of income is the need to keep income-generating capital intact. This calls into question the form in which the maintained capital stock should take. For example, if there is negligible or no substitutability between human-made and natural capital, it is necessary to keep both forms of capital intact rather than a combined form of capital. Given the position of most ecological economists that human-made and natural capital are complements not substitutes (e.g. Georgescu-Roegen, 1971; Daly, 1977 and 1996; Lawn, 2003a), an appropriate measure of Hicksian national income needs to reflect this much stricter capital stock requirement. More on this soon.

The best way to consider whether real GDP is an adequate measure of national income is to ask the following: Could a nation consume its entire GDP in the current year and be in a position to consume the same level of output in the following year? The answer is, of course, no. At the very least, some of the goods produced in any year must be set aside to replace worn out and depreciated producer goods in order to maintain a nation's productive capacity. Hence, a more accurate measure of Hicksian income requires the estimated value of human-made capital depreciation to be subtracted from GDP. This, in turn, enables a measure of Net Domestic Product (NDP) to be obtained as per equation (7):

$$\text{NDP} = \text{GDP} - \text{human-made capital depreciation} \tag{7}$$

For some economists, this depreciation allowance serves as an adequate adjustment to GDP to obtain a proper measure of national income. However, in view of the Hicksian concept of income, a further question remains — that is, could a nation continue to consume its annual NDP without impoverishing itself? Many economists believe not and therefore argue that NDP as well as GDP is not an adequate measure of Hicksian national income.

There are two main reasons why many ecological economists believe NDP is an inadequate measure of Hicksian income:

1. NDP fails to make an allowance for natural capital depreciation (depletion) — it only makes an allowance for human-made capital depreciation. Yet if a nation continued to deplete its natural capital by: (a) extracting renewable resources at a rate exceeding their natural regenerative capacity; (b) failing to invest enough of the proceeds from non-renewable resource depletion to establish renewable resource substitutes; and (c) generating waste levels that exceed the environment's waste assimilative capacity, it could not continue to sustain a level of consumption equal to NDP. Clearly, natural capital depletion of this kind represents the consumption of income-generating capital, not income.
2. NDP includes a range of regrettable defensive and rehabilitative expenditures that are necessary for a nation to defend itself from the unwanted side-effects of economic activity. These such expenditures, and the goods and services produced, enable a nation to maintain its productive capacity over time (e.g., vehicle repairs, medical procedures following industrial accidents, and salt-water interception and evaporation dams on the Murray-Darling Basin). Consumption of the entire NDP would leave nothing for a nation to set aside for defensive and rehabilitative purposes.[2]

Two further adjustments to GDP are therefore required to obtain an adequate measure of Hicksian national income, or what is sometimes referred to as Sustainable Net Domestic Product (SNDP). They are represented in the following identity:

$$SNDP = GDP - HCD - NCD - DRE \quad (8)$$

where:

- SNDP = Sustainable Net Domestic Product;
- GDP = Gross Domestic Product;
- HCD = human-made capital depreciation (producer goods);
- NCD = natural capital depletion;
- DRE = defensive and rehabilitative expenditures.

I mentioned earlier that the subtraction for natural capital depletion depends on whether human-made and natural capital are assumed to be substitutes (weak sustainability) or complements (strong sustainability). A simple but ingenious formula has been put forward by El Serafy (1989) to calculate the portion of the profits generated from resource extraction that must be set aside to establish a replacement capital asset. The set-aside component of depletion profits constitutes the 'user cost' or replacement cost of resource depletion. It is this amount that should be deducted when ascertaining a nation's SNDP.

Significantly, the user cost will differ depending on whether one adopts the weak sustainability or strong sustainability approach to capital maintenance. How? Included in the El Serafy formula is a discount rate that ought to reflect the interest rate generated by the replacement asset. If a weak sustainability approach is adopted, where it is common for the replacement asset to be a form of human-made capital, the chosen interest rate is usually six or seven percent. This will almost certainly be higher than the interest rate used if a natural capital asset is established as per the strong sustainability approach. Indeed, for most renewable resources, the natural regeneration rate is approximately two to three percent and therefore considerably lower than the rate of return on human-made assets (although strong sustainability advocates will point out that the return on a human-made capital asset is entirely dependent on the availability of natural capital, but not vice versa).

Consider, then, a non-renewable resource with a mine life of thirty years. At a discount rate of two percent, the user cost constitutes 54% of depletion profits (i.e., 46% constitutes income in the Hicksian sense). However, at a discount rate of seven percent, the user cost constitutes just 12% of depletion profits (i.e., 88% constitutes income). Clearly, the user cost deducted in the calculation of SNDP will be much higher when the strong sustainability stance is embraced. SNDP will be correspondingly lower.

One of the better known examples of Hicksian income is the study conducted by Repetto et al. (1989) on Indonesia for the period 1971 to 1984.[3] Repetto et al.'s study did not conform entirely to equation (8). There was no subtraction for human-made capital depreciation nor a subtraction for defensive and rehabilitative expenditures. Even the adjustment for natural capital losses was confined to the depletion of petroleum, forestry, and soil assets. This aside, the adjusted income measure grew at an average rate of 4.0% per annum compared to the average 7.1% increase in real GDP over the same period. If further allowances had been made for human-made capital depreciation and defensive and rehabilitative expenditures, the adjusted income of Indonesia would undoubtedly have been much lower, indicating that real GDP greatly overstates a nation's Hicksian or 'true' income.

4. GDP is a poor measure of sustainable economic welfare

Economic welfare is essentially equal to the difference between the benefits and costs of economic activity — i.e., equal to the net benefit of the economic process. Moreover, for economic welfare to be ecologically sustainable, the rate of resource use and waste generation must not exceed the regenerative and waste assimilative capacities of the natural environment. A good measure of a nation's sustainable economic welfare clearly requires the identification, separation, and measurement of the benefits and costs of economic activity as well as the incorporation of any net depletion of resource stocks, waste sinks, and critical ecosystem services.

Unfortunately, real GDP fails miserably as an indicator of sustainable economic welfare. To begin with, it fails to separate and compare the benefits and costs of economic activity. Indeed, real GDP often counts some costs as benefits. It has already been explained in relation to Hicksian income that the cost of natural capital depletion is added in the calculation of GDP when it ought to be subtracted. Another example is the monetary value of vehicle repairs. It too is treated as if it were a benefit despite the fact that: (a) a vehicle, following repair, is merely returned to its pre-accident status, and (b) the resources consumed are diverted from other potentially welfare-enhancing activities. In this sense, the monetary value of all vehicle repairs represents an opportunity cost not a benefit.

Secondly, GDP ignores some benefits such as non-paid household and volunteer labour. Yet it is clear that these forms of work contribute greatly to the welfare of a nation's citizens. Interestingly, if a married couple were to divorce (where the ex-husband is involved in paid employment and the ex-wife engaged in unpaid housework) and the ex-husband decides to employ his ex-wife to do his housework, the value of the housework is included in the measure of GDP whereas it previously wasn't. No additional welfare is generated but GDP suggests there has been. Real GDP also overlooks the benefits yielded by both the stock of existing consumer durables (such as cars, TVs, refrigerators, etc) and publicly-provided assets such as roads, highways, libraries, museums, and art galleries.

Third, real GDP fails to take into account the welfare impact of a change in the distribution of income. The calculation of GDP assumes that an extra dollar of income to the rich adds as much to a nation's economic welfare as an extra dollar of income to the poor. However, the marginal utility of an additional dollar of consumption for a high-income individual is likely to be much less than it is for a low-income person (Robinson, 1962). Consider a hypothetical situation where the real GDP of a nation remains the same from one year to the next and where the income of every individual is also unchanged except for the richest and poorest person. Assume that the former's income has increased by $50 per week and the poorest has fallen by the same amount. The increase in the welfare of the richest person is likely to be negligible. Conversely, the fall in welfare of the poorest individual will be quite dramatic. Overall, the aggregate welfare of the nation will have fallen despite real GDP remaining unchanged.

Other welfare impacts that real GDP overlooks include the changing levels of unemployment and underemployment and the fluctuation in a nation's foreign debt levels. The former have welfare implications similar to the change in the distribution of income, while the latter often leads to ecologically destructive actions such as the liquidation of natural capital in an attempt to repay overseas debt commitments.

It should be pointed out that a Hicksian measure of national income, such as SNDP, is also an inadequate indicator of sustainable economic welfare. This is because it fails many of the above requirements. In addition, Hicksian income merely indicates the maximum quantity of goods and services that can be sustainably consumed over time. However, it is not so much the quantity of goods consumed that contributes to human well-being but the quality of the entire stock of goods available for consumption/use. Fewer high quality goods consumed will contribute more to human well-being than the consumption of many low quality goods. What's more, ongoing production that is needed to keep the stock of benefit-yielding goods intact requires the continued throughput of matter-energy from and back into the natural environment. This results in the inevitable loss of some of the source, sink, and life-support services provided by natural capital — the ultimate cost of economic activity (Daly, 1979; Perrings, 1986).[4] Therefore, SNDP is more or less an index of sustainable cost than an index of sustainable economic welfare. While an indicator of sustainable cost is much preferred to an index of unsustainable cost, such as GDP, this alone does not allow SNDP to qualify as a welfare indicator.

In fact, so much does real GDP depart from the requirements of an economic welfare indicator that the recent attempt to establish an indicator of this type completely overlooks real GDP as a welfare starting point. I am, of course, referring to the Index of Sustainable Economic Welfare (ISEW) or what is commonly referred to as the Genuine Progress Indicator (GPI). Both employ personal consumption expenditure as their foundation item. This may seem at odds with I said above regarding consumption and its relationship with economic welfare, however, the use of consumption as the base item of the GPI does not imply that consumption is a "good" in itself. What it indicates is that consumption is a "necessary evil" in the sense that the benefits provided by the stock of all goods can only be enjoyed as a consequence of their depreciation or "consumption" through use. Because of the way in which the GPI is calculated (see below), a beneficial reduction in the rate of depreciation would necessitate a lower level of production to maintain the stock of human-made capital intact. This, in turn, would lead to a fall in the rate of resource throughput and a decline in the cost of lost natural capital services. Presumably, once a nation's economy surpasses what might be deemed as its optimal macroeconomic scale (i.e., the physical scale that maximises sustainable economic welfare), any fall in the value of consumption (a benefit) ought to be be exceeded by a fall in the cost of sacrificed natural capital services.[5] In such circumstances, the GPI would rise even though real GDP would decline.

To appreciate how the GPI — which is essentially a measure of Fisherian income (Fisher, 1906; Lawn, 2003b) — differs from Hicksian income, consider the following:[6]

$$GDP = CON + INV + NX \tag{9}$$

$$\text{SNDP (Hicksian income)} = CON + INV + NX - DEP(K_P) - DEP(K_N) - DRE \quad (10)$$

$$\text{GPI (Fisherian income)} = CON - ECD + DEP(K_C) - DEP(K_N) - DRE \quad (11)$$

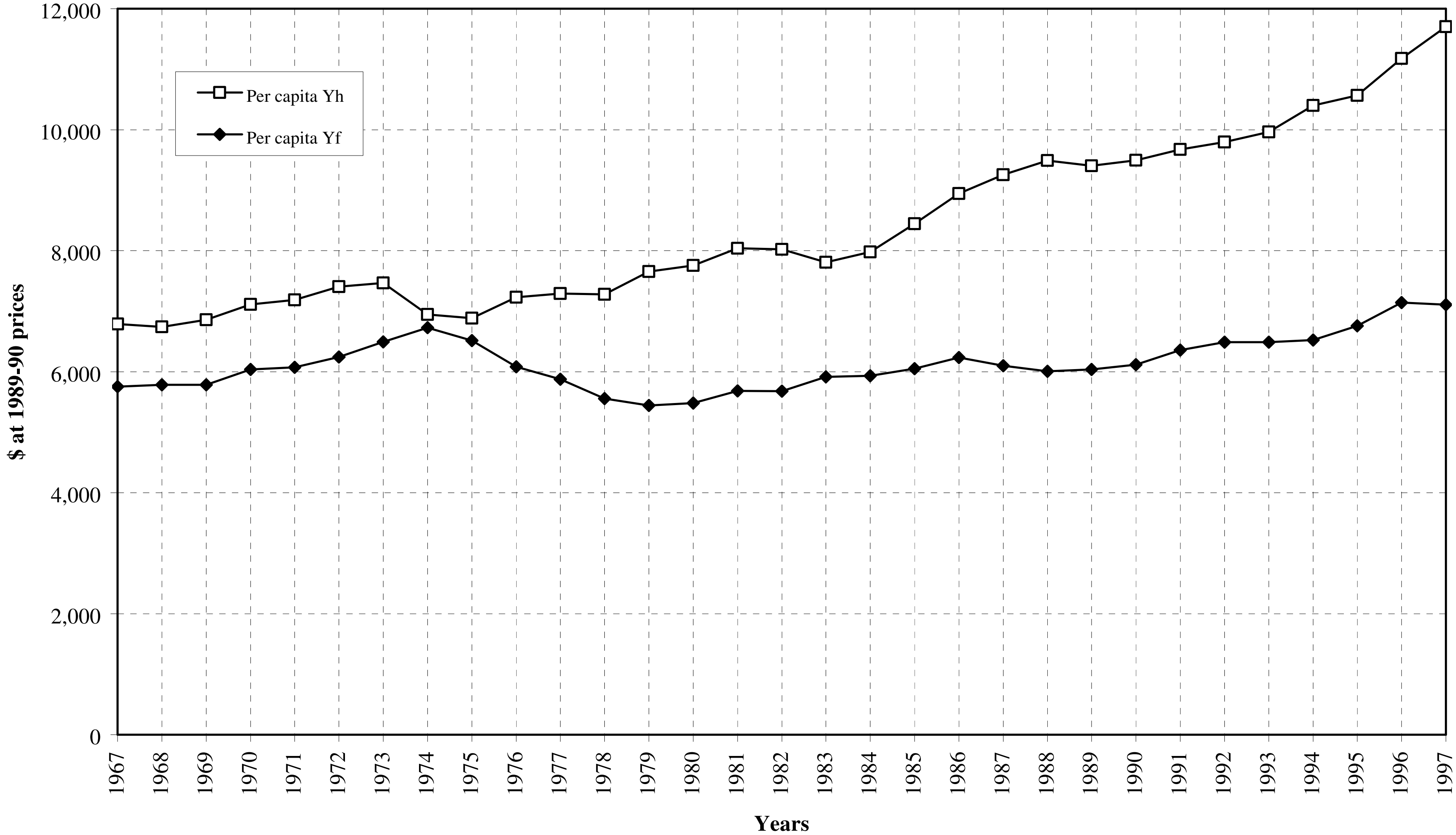
where:

- GDP = Gross Domestic Product;
- SNDP = Sustainable Net Domestic Product;
- GPI = Genuine Progress Indicator;
- CON = private + public consumption expenditure;
- INV = private + public investment expenditure;
- NX = net exports;
- $DEP(K_P)$ = depreciation of producer goods component of human-made capital;
- $DEP(K_C)$ = depreciation of consumer durables component of human-made capital;[7]
- $DEP(K_N)$ = depletion of natural capital;
- ECD = expenditure on consumer durables;
- DRE = defensive and rehabilitative expenditures.

The critical difference between Hicksian and Fisherian income is that the former adds investment in new producer goods (INV) and subtracts the depreciation of existing producer goods ($DEP(K_P)$). The latter, on the other hand, ignores investment altogether and adds the depreciation of existing consumer durables ($DEP(K_C)$). The reason for this is that investment is the antithesis of consumption. Indeed, investment represents consumption forgone to enable the investment of surplus output to maintain a nation's productive capacity. While investment in producer goods is also necessary to sustain economic welfare, the benefit of investment is experienced in future years. Naturally, the welfare benefit of past investment is experienced to some extent in the present, however, it is captured in terms of the consumption item (CON) and the depreciation of existing consumer durables. Expenditure on consumer durables is also subtracted in the case of Fisherian income because it effectively represents an investment in household capital goods. A $2,000 purchase of a TV set, for example, does not represent an immediate $2,000 consumption benefit but a $2,000 increase in household capital. Only as the TV set depreciates in future years through use does the welfare benefit of ownership emerge — which is captured by the DEP(K_C) item.

Figure 1 reveals the per capita Hicksian and Fisherian income for Australia for the period 1967 to 1997.[8] Consistent with ISEW and GPI studies conducted on other developed nations (e.g., Max-Neef, 1995; Jackson and Stymne, 1996), Figure 1 shows that Australia's per capita Fisherian income has barely increased since the mid-1970s. Given that some considerable degree of efficiency-increasing technological progress ought to have taken place over recent decades, Figure 1 indicates that Australia surpassed its optimal macroeconomic scale some thirty years ago. Moreover, and despite the rise in Australia's per capita Hicksian income or sustainable cost throughout most of the study period, Australia would have been far better served by a transition to a steady-state economy with a greater policy focus on qualitative improvement.

Figure 1: Per capita Hicksian income (Yh) and per capita Fisherian income (Yf) for Australia, 1967-1997



5. GDP is a poor indicator of the growth rate of macroeconomic systems

Real GDP is commonly used to ascertain how much a national economy has physically grown. For example, if real GDP has increased by 5% over a financial year, it is often said that the economy has grown by 5% over the same period. However, for an economic system to grow, the magnitude of any additions to the stock of human-made capital (wealth) must exceed the magnitude of any subtractions. Hence, only a balance sheet accounting approach can properly inform us of whether a nation's economy has grown and by how much.

How would one determine if an economic system had physically grown? One would probably adopt the following balance sheet approach (Table 1):

Table 1: Balance Sheet of National Economy

	$	$	$
Existing human-made capital (wealth)			
• privately-owned dwellings (houses, apartments, and business premises)	X		
• publicly-owned assets (roads, highways, offices, government business premises, libraries, schools, universities, etc.)	X		
• consumer durables (cars, TVs, furniture, computers, etc.)	X		
• consumer non-durables (food, drink, clothing, etc.)	X		
Opening balance (as at 1/7/X1)			AAAA
Additions (1/7/X1 to 30/6/X2)			
• production of the above items (+)	Y		
• importation of the above items (+)	Y		
Total additions		+YY	
Subtractions (1/7/X1 to 30/6/X2)			
• consumption of consumer non-durables (–)	Z		
• depreciation of consumer durables (–)	Z		
• depreciation of producer goods (–)	Z		
• exportation of the above items (–)	Z		
Total subtractions		–ZZ	
Net additions/subtractions (1/7/X1 to 30/6/X2)			+/–BB
Closing balance (as at 30/6/X2)			CCCC

The physical growth rate of the economy would be equal to:

$$\frac{Closing\ balance - Opening\ balance}{Opening\ balance} \times 100\% \qquad (12)$$

It is therefore instructive to consider how well real GDP reconciles with this balance sheet approach to measuring a nation's macroeconomic scale. The answer is not very well at all. Why? It should firstly be recognised that real GDP is a flow-based rather than a stock-based measure. Secondly, real GDP conflates various additions and subtractions. For example, it includes such additions as the production of all new goods but also a subtraction item such as the consumption of non-durables. As for exports and imports, real GDP adds the former and subtracts the latter. This, quite naturally, is of value if one wants to measure national income (i.e., net exports are also added in the calculation of SNDP), however, a measurement of macroeconomic scale — as opposed to the scale of the output produced — concerns the eventual ownership of goods, not the location of their production. Thirdly, real GDP ignores the depreciation of all forms of human-made capital.

Even if real GDP was a precise measure of the additions to the stock of domestic wealth it would still be of little value as a growth-in-scale indicator since additions alone constitute one half of the changing stock story. Indeed, to regard real GDP as an indicator of growth is akin to arguing that the growth rate of a population of rabbits can be ascertained simply by knowing the change in the rabbit birth rate while knowing nothing about the rabbit death rate.

There is another means of determining if the economy has physically grown. It involves observing changes in the total stock of human-made capital (durable producer and consumer goods). This can be achieved by calculating net capital investment as per the following:

$$NCI = [INV + ECD] - [DEP(K_P) + DEP(K_C)] \quad (13)$$

where:

- NCI = net capital investment;
- INV = private + public investment expenditure;

- ECD = expenditure on consumer durables (investment in household capital);
- $DEP(K_P)$ = depreciation of producer goods component of human-made capital;
- $DEP(K_C)$ = depreciation of consumer durables component of human-made capital.

Clearly, if NCI is positive, the total stock of human-made capital is expanding. This, in turn, indicates that the economy is physically growing. If NCI is negative, the economy is contracting. A value of NCI = 0 is equivalent to the steady physical state. Both of the above approaches have been used to determine the physical growth rate of the Australian economy. The first, it must be conceded, includes natural capital as well as financial (non-physical) assets and thus equates to a measure of net worth rather than a snaphsot of the physical scale of the Australian economy (ABS, Cat. No. 5241.0.40.001).

The second attempt, essentially a balance sheet approach to the compilation of a human-made capital account (Lawn, 2000), indicates that the Australian economy grew between 1966-67 and 1994-95 in all but the years 1974-75 and 1981-82. It must be said, however, that this example includes labour as part of the stock of human-made capital. Since labour constitutes a significant component of the total stock value, dramatic changes in the unemployment rate greatly influence the fall/rise in the closing account balance. In both 1974-75 and 1981-82, unemployment rose very steeply in Australia.

The third example is based on the NCI approach (Lawn and Clarke, forthcoming). It reveals that the Australian economy grew in every year from 1985-86 to 2002-2003. Apart from a low rate of growth from 1991-92 to 1993-94 ($NCI/DEP < 0.25$), the growth rate of the Australian economy ranged from high to almost rapid ($0.25 \leq NCI/DEP < 0.50$). The interesting aspect of the NCI approach is that the Australian economy grew during a year where real GDP fell (e.g., 1990-91). Furthermore, the Australian economy occasionally grew at a high rate when the growth rate in real GDP was low (e.g., 1986-87), but at a low rate when there was a significant rise in real GDP (e.g., 1993-94). In all, the physical growth rate of the Australian economy does not correlate consistently with the growth rate in real GDP.

6. GDP is a less-than-ideal indicator of throughput and environmental pressure

I mentioned in the introduction that real GDP is sometimes referred to as a proxy for resource throughput, and therefore, as an indicator of environmental pressure (e.g., Daly, 1992). It is often used in this way because the price level is kept constant and thus any increase in real GDP is the consequence of increases in the quantity of output produced. There is, however, a minor flaw in this approach in that it is possible for the quantity of output to rise and the rate of resource throughput to fall if there has been a sufficient increase in resource use efficiency. Of course, this requires the percentage increase in resource use efficiency to exceed the percentage increase in goods and services produced.

There are two main reasons why real GDP has been likened to the rate of resource throughput. Firstly, thermodynamic realities place an inevitable limit on the rate of increase in resource use efficiency. Hence, should resource throughput be declining while real GDP is rising, it is impossible for it to continue in the long-run. To some observers, the continued rise in real GDP represents an inevitable trend in the rate of resource throughput. This in turn, equates to increased environmental stress.

Secondly, as Figure 2 shows, there is a very close correlation between the trend rise/decline in both real GDP and the rate of energy consumption — the latter of which is a better indicator of throughput.[9] While Figure 3 indicates increasing resource use efficiency in Australia after 1991-92, there was a considerable decline in resource use efficiency between 1972-73 and 1981-82. Indeed, the real GDP/energy ratio in 2002-03 of 140.4 was still lower than the 1970-71 peak of 147.3. Both Figure 2 and 3 suggest that while real GDP is not a precise indicator of resource throughput, it is hardly a misleading one.

Figure 2: Index of real GDP and energy consumption
(Australia, 1966-67 to 2002-2003)

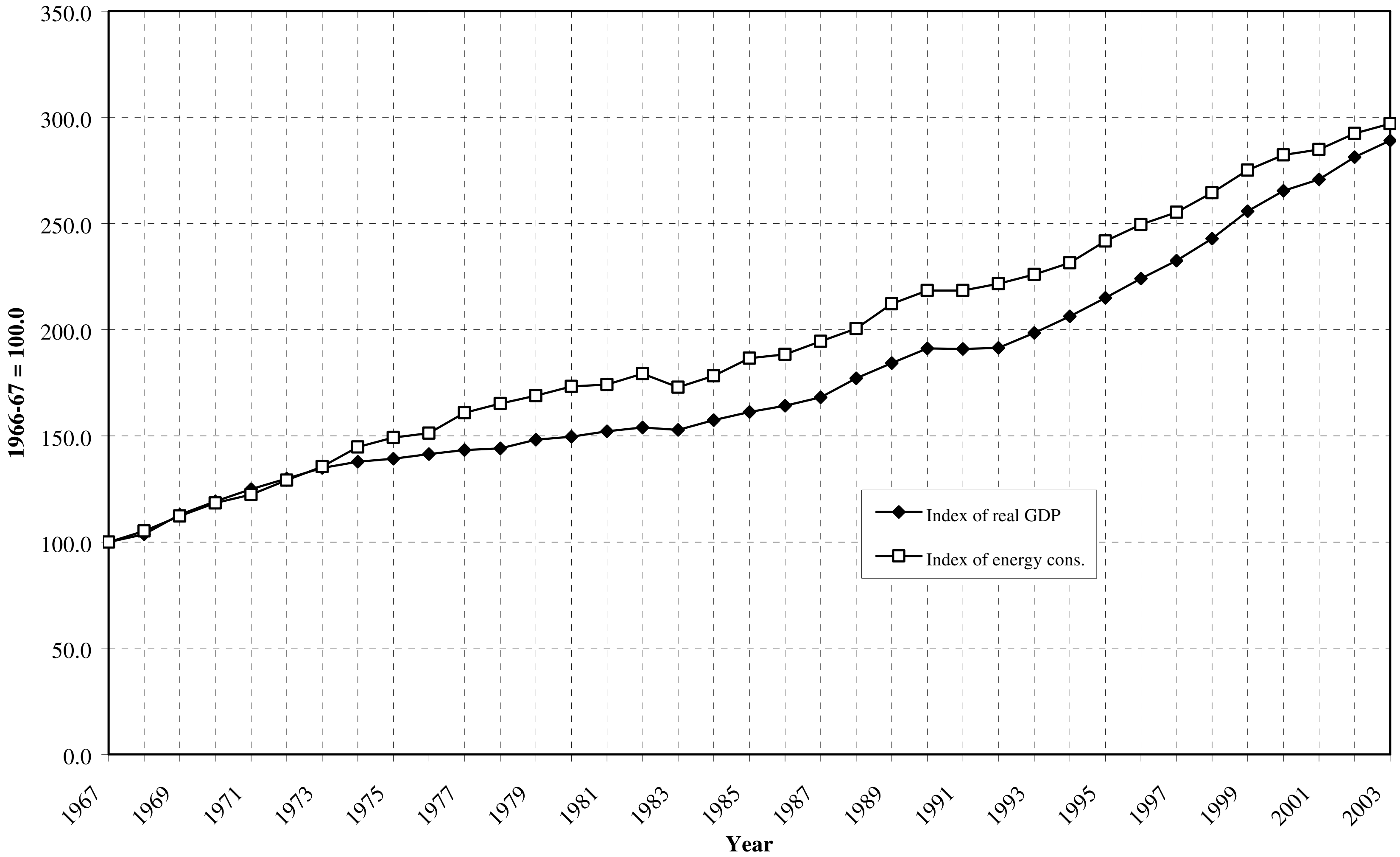
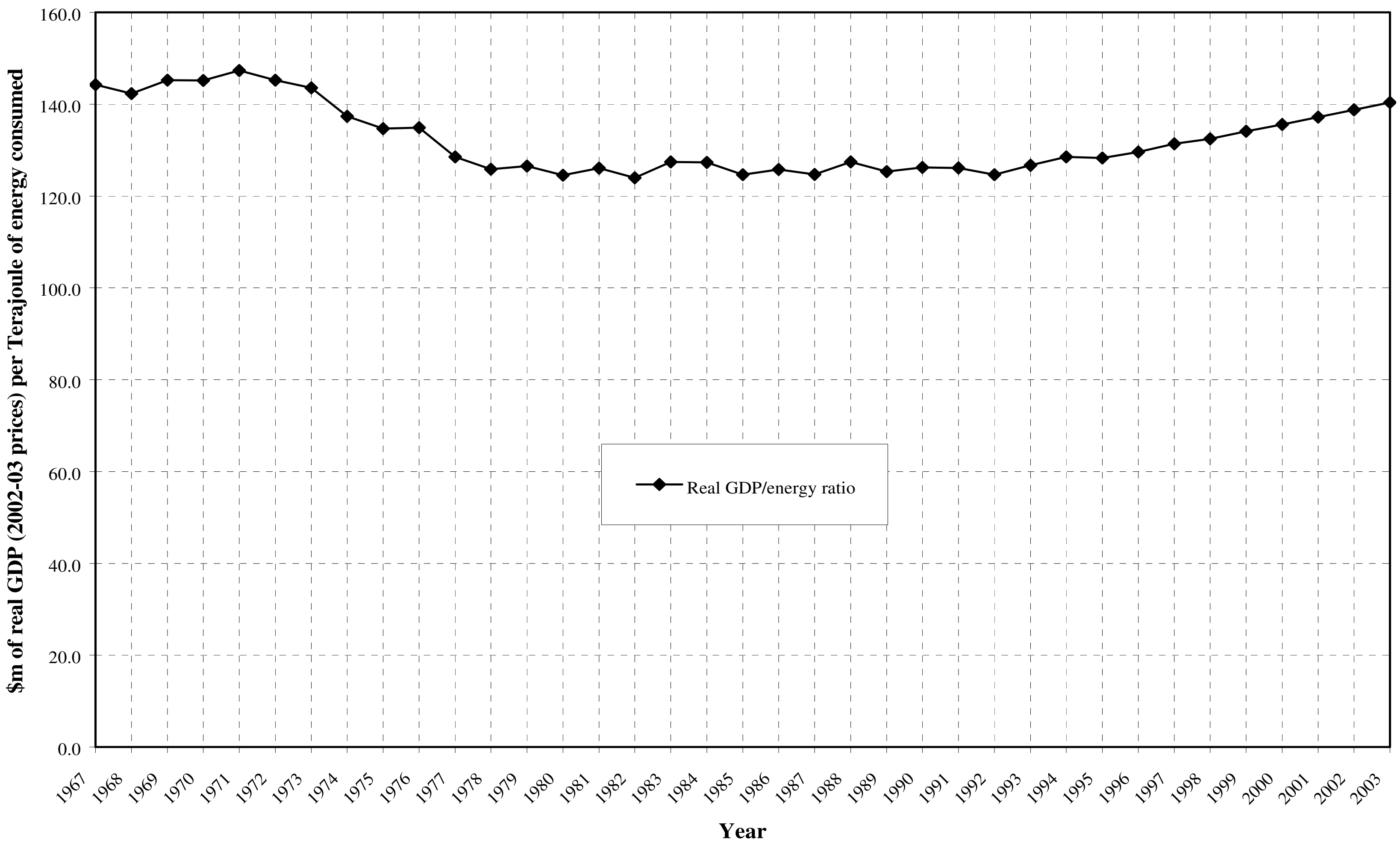


Figure 3: Real GDP/energy ratio (Australia, 1966-67 to 2002-03)



Another popular indicator of throughput and environmental pressure is the Ecological Footprint (EF) (Wackernagel et. al, 1999). A country's EF is the equivalent area of land *required* to both generate the renewable resources and absorb the high entropy wastes needed to sustain economic activity at the current level (Wackernagel and Rees, 1996). To determine whether a nation is depleting its natural capital, the EF is compared with its biocapacity. Biocapacity refers to the amount of *available* land a nation has to generate an on-going supply of renewable resources and to absorb its own and other nation's spillover wastes. Unsustainability occurs if a nation's ecological footprint exceeds its biocapacity.

Table 2 reveals that most of the world's nations have an ecological footprint in excess of their biocapacity (i.e., have an ecological deficit). This is of great concern because it suggests that most national economies have exceeded their maximum sustainable scale. Although trade has been mooted as a possible means of enabling surplus countries to export ecological capacity to deficit countries, Table 2 indicates that the world, as a whole, is in ecological deficit to the tune of –0.7 hectares per person (average global footprint of 2.8 hectares/person compared to the average global biocapacity of 2.1 hectares per person).

Another more recent biophysical indicator initiative involves the identification of specific components of the natural environment that perform critical and irreplaceable functions — what might be called 'critical' natural capital (de Groot et al., 2006).[10] By defining critical natural capital as a set of environmental resources that performs vital environmental functions for which no substitutes currently exist, de Groot et al. have recently developed a "critical natural capital index".[11] The index is now being applied to forests, seas, rivers, and wetlands across the European Union. Since the results of these preliminary studies are still emerging, it is too early to comment on the value of the index as a sustainability indicator.

Table 2: Ecological footprint of 52 nations as at 1997 (35 nations in ecological deficit)

	Ecological footprint (hectare/capita)	Available biocapacity (hectare/capita)	Ecological surplus (+) or deficit (-)
Argentina	3.9	4.6	0.7
Australia	9.0	14.0	5.0
Austria	4.1	3.1	– 1.0
Bangladesh	0.5	0.3	– 0.2
Belgium	5.0	1.2	– 3.8
Brazil	3.1	6.7	3.6
Canada	7.7	9.6	1.9
Chile	2.5	3.2	0.7
China	1.2	0.8	– 0.4
Colombia	2.0	4.1	2.1
Costa Rica	2.5	2.5	0.0
Czech Republic	4.5	4.0	– 0.5
Denmark	5.9	5.2	– 0.7
Egypt	1.2	0.2	– 1.0
Ethiopia	0.8	0.5	– 0.3
Finland	6.0	8.6	2.6
France	4.1	4.2	0.1
Germany	5.3	1.9	– 3.4
Greece	4.1	1.5	– 2.6
Honk Kong	5.1	0.0	– 5.1
Hungary	3.1	2.1	– 1.0
Iceland	7.4	21.7	14.3
India	0.8	0.5	– 0.3
Indonesia	1.4	2.6	1.2
Ireland	5.9	6.5	0.6
Israel	3.4	0.3	– 3.1
Italy	4.2	1.3	– 2.9
Japan	4.3	0.9	– 3.4
Jordan	1.9	0.1	– 1.8
Korean Republic	3.4	0.5	– 2.9
Malaysia	3.3	3.7	0.4
Mexico	2.6	1.4	– 1.2
Netherlands	5.3	1.7	– 3.6
New Zealand	7.6	20.4	12.8
Nigeria	1.5	0.6	– 0.9
Norway	6.2	6.3	0.1
Pakistan	0.8	0.5	– 0.3
Peru	1.6	7.7	6.1
Philippines	1.5	0.9	– 0.6
Poland	4.1	2.0	– 2.1
Portugal	3.8	2.9	– 0.9
Russian Federation	6.0	3.7	– 2.3
Singapore	6.9	0.1	– 6.8
South Africa	3.2	1.3	– 1.9
Spain	3.8	2.2	– 1.6
Sweden	5.9	7.0	1.1
Switzerland	5.0	1.8	– 3.2
Thailand	2.8	1.2	– 1.6
Turkey	2.1	1.3	– 0.8
United Kingdom	5.2	1.7	– 3.5
United States of America	10.3	6.7	– 3.6
Venezuela	3.8	2.7	– 1.1
World	2.8	2.1	– 0.7
	2.8 ÷ 2.1 = 1.3 Earths		

Note: Hectares per capita expressed in terms of world average yield in 1993.

Source: Wackernagel et al. (1999), pp. 386-387.

As with any indicator, there are a number of weaknesses associated with biophysical indicators. The most obvious weakness is their accuracy, or lack of it. The natural environment is a complex system of greater value than the aggregate value contained in its constituent ecosystems and individual resource assets. Because of this complexity, humankind's ignorance regarding the minimum level of biodiversity, etc., to guarantee sustainability is ultimately irreducible (Faber et al., 1992). It stands to reason, therefore, that any biophysical indicator designed to measure sustainability cannot possibly be entirely accurate.[12]

As for the EF concept, it has been widely criticised by practitioners from a variety of disciplines. The most common criticism is that the EF appears to overlook the limiting impact of certain critical resources. For example, in Australia, water is often a critical limiting factor in terms of biophysical productivity. Thus, despite Australia's ecological surplus of 5.0 hectares per person (see Table 2), it is highly probable that Australia's limited water resources, particularly in inland areas, would greatly reduce its capacity to exploit such a surplus. If so, the ecological surplus is potentially misleading.

7. Other GDP issues

In this final section, two remaining GDP issues are raised and discussed. The first relates to the composition of national output and its implications for throughput; the second relates to real GDP and qualitative improvements in production and non-economic activities. In each case, real GDP is again found to be wanting as a useful macro indicator.

7.1 Goods and services, the composition of national output, and throughput

I have already mentioned that variations over time in resource use efficiency can render real GDP as a less-than-perfect indicator of resource throughput. It is also true that compositional change within the basket of goods represented by real GDP (see equation (6)) is likely to be significant over time. It has been suggested that, if the quantity of high resource-intensive activities rises vis-a-vis low resource-intensive activities, it is possible for real GDP to remain unchanged but the throughput demands to have risen sharply.

A couple of points need raising here. Firstly, while a situation of this kind is no doubt feasible, it should not be assumed that a shift towards "services", which are widely regarded as low resource-intensive activities, and away from "goods" will reduce resource throughput. Goods and services are essentially two faces of the same coin — goods are the physical artifacts that yield service; service is the benefit enjoyed as goods are either directly consumed (e.g., food, drink, petrol, etc.) or indirectly consumed as they are worn out through use over time (e.g., consumer durables). The service sector is not "goods free" and, in fact, the direct inputs of the service sector are invariably the outputs of the goods sector. This means that the matter-energy used to produce the goods required for the service sector to function are the indirect inputs of the service sector. Evidence based on embodied energy studies suggests that the combined direct and indirect inputs of the service sector are much the same as the goods sector (Costanza, 1980; Ayres and Ayres, 1999). It is little wonder, therefore, that the shift towards the service sector has had little impact on Australia's real GDP/energy ratio (Figure 3).

Secondly, if real GDP remains largely unchanged despite a relative increase in high resource-intensive activities, this simply indicates that the quantity of goods produced has not changed, only the composition of all goods produced. Yet this is what real GDP is effectively designed to measure. It was never designed to be an indicator of resource throughput and, as has been argued, there are better indicators of throughput available (e.g., the rate of energy consumption).

7.2 Real GDP and qualitative improvements

It is sometimes pointed out that measures of real GDP do not imply the existence of a fixed relationship between service flow (use value) and its physical dimension (goods), particularly in a qualitatively improving society. This, of course, is absolutely true and the arguments I have put forward in this paper in no way suggest that the opposite is the case. However, real GDP, unlike nominal GDP, effectively eliminates the price-altering impact of qualitative change because it is designed to measure the physical volume of goods and services produced. If the rate of throughput is falling as real GDP rises, we might experience a rise in production benefits and a fall in environmental costs. But we may not and, furthermore, real GDP cannot tell us which is occurring. Indeed, a rise in real GDP could be the result of a massive boost in resource throughput, in which case the marginal cost of increased throughput might well be exceeding the marginal benefit of increased goods for consumption purposes. This would lower economic welfare, and is a pattern that appears to be emerging for many developed nations (see Max-Neef, 1995).

Of course, one might argue that it is nominal GDP that we should observing, not real GDP. Unfortunately, while nominal GDP incorporates the price-altering impact of qualitative change, it also includes the price-altering impact of increased scarcity, the increased demand for positional goods, and alterations in tax rates, interest rates, and the quantity of high-powered money. The first of the additional influences represents an increasing cost, not an increasing benefit, while the second involves an individual's relative standing in society, which may or may not lead to increased aggregate welfare. Unless it is possible to identify and isolate the impact on GDP of qualitative changes in economic activity, nominal GDP will be incapable of telling us anything about sustainable economic welfare.

The importance of scarcity-related factors and positional goods is also important if a nation should quantitatively limit the rate of throughput to one consistent with the regenerative and waste assimilative capacities of its natural capital stocks. Assuming, in such circumstances, that the rate of throughput is capped, increases in real GDP must be the consequence of a rise in the quantity of goods produced. In other words, more goods will have been produced from the same rate of throughput that, in turn, must be the consequence of increased resource use efficiency.

Unfortunately, or some would say fortunately, increased resource use efficiency does not constitute the sole form of qualitative change. There are many non-economic factors that also play a key role in a nation's aggregate welfare. Since an increase in real GDP also involves a range of disutility factors, it is possible for the extra consumption benefits arising from increased production efficiency to be more than offset by a rise in psychic disbenefits — another apparent development emerging from ISEW and GPI studies. Also, a capped rate of resource throughput doesn't: (a) ensure that resources are used in the best possible manner from the point of waste generation, and (b) nor does it guarantee that the capped resource flow has been sensitively extracted from the natural environment in the first place (i.e., a capped rate of throughput is just one element of ensuring ecological sustainability).

In all, while real GDP incorporates qualitative improvements, it also includes disutility and environmental degradation factors that cannot be isolated and subtracted without also extracting the impact that qualitative improvements have upon it. Given this, why bother with real GDP when there are other indicators capable of better capturing these changes (e.g., the GPI in terms of qualitative improvements and the EF in terms of reduced throughput)?

8. Concluding comments

The problem with real GDP is not so much what it doesn't capture, but what it does, and moreover, how incongruous its various elements are. As such, real GDP is of little value as a macroeconomic indicator. It fails to indicate much more than the changing physical volume of economic activity. The volume of economic activity may be of some informational significance, but not as an indicator of national income, sustainable economic welfare, or the growth rate of a nation's economy. While it can be of some value as an indicator of throughput, this depends largely on the extent to which the real GDP/energy ratio is varying over time. In Australia's case, the ratio has not increased over the last thirty-five years as much as one would expect. Hence, real GDP has recently been a reasonable indicator of resource throughput and increasing environmental stress. It is, however, time we abandoned real GDP and looked for alternative indicators of national income, welfare, and environmental pressure such as the GPI, the EF, and measures of critical natural capital.

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Endnotes

[1] The is differs slightly to Gross National Product (GNP) which is a monetary measure of the goods and services produced over a financial year by domestically *owned* factors of production.

[2] It should be noted that the category of defensive and rehabilitative expenditures exceeds what is required simply to maintain a nation’s productive capacity. Many such expenditures protect a nation’s welfare without necessarily impacting on productive capacity (e.g., crime prevention measures, private vehicle accident repairs, and cosmetic medical and dental procedures). In the calculation of Hicksian income, these expenditures should not be deducted from GDP.

[3] Surprisingly, very few Hicksian income studies have been undertaken over the last thirty years. Most attention has been given to the concept of green national accounting and the theoretical and valuation issues involved. Hence, there has been more talk about green national accounting than practical action. Other well-known exercises include studies on Mexico (Van Tongeren et al., 1993), Sweden (Skanberg, 2001), USA (Cobb and Cobb, 1994), Taiwan (DGBAS, 2002), China and Japan (Akita and Nakamura, 2000), and Australia (Young, 1990; Hill and Hill, 1999; and ABS, 2002).

[4] The lost source, sink, and life-support services provided by natural capital are regarded as the ultimate cost of the economic process because natural capital is the original source of all economic activity. If one traces the economic process from its final conclusion back to its original source — namely, natural capital — all

transactions cancel out (i.e., the seller receives what the buyer pays). What one is left with is the price paid to have low entropy resources extracted from the natural environment. Should this price reflect all sacrificed natural capital services, it would be equivalent to the uncancelled or ultimate cost of economic activity.

[5] Similarly, an increase in the rate of consumption beyond the economy's optimal scale would result in the rise in consumption benefits being exceeded by the cost of natural capital depletion, in which case the GPI would fall while real GDP would increase in magnitude.

[6] Equations (10) and (11) are variations in equations put forward by Mates (2004) and Lawn (2004a and 2004b).

[7] By including consumer durables in the stock of human-made capital, I am conforming to Fisher's (1906) concept of capital — that is, as the stock of all service-yielding human-made goods capable of ownership.

[8] A number of other slight changes were made to equations (10) and (11) in the calculation of Hicksian and Fisherian income appearing in Figure 1. See Lawn (2004b).

[9] As it is, even Herman Daly, who has long been arguing that real GDP (as $P \times Q$) is good indicator of throughput, concedes that the scale of throughput is probably better measured in terms of embodied energy (Daly, 1992, p. 186).

[10] See the special section on "Identifying critical natural capital" in Volume 44 (2-3) of *Ecological Economics* (2003).

[11] Based on a definition of critical natural capital outlined by Ekins et al. (2003).

[12] This doesn't mean that sustainability indicators are of no value. It simply means it is sensible to operate economies somewhere short of the estimated maximum scale.