NATIONAL ACCOUNTING FOR THE NEW ECONOMY

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1. INTRODUCTION

It has frequently been suggested – most authoritatively by the Chairman of the Federal Reserve Board (Box 1) - that growth and productivity in the 'new economy' are inadequately recorded in the national accounts. Productivity growth today often leads to improvements in the quality of output, or the introduction of new goods, rather than to changes in the physical volume of output. Innovations – such as those which have occurred in the information and communications technology (ICT) sector - may fail to be recorded properly by measurement techniques that focus on the quantities of goods and services produced. Improvements in the technology of computer manufacture are often reflected in enhancements in model specification, rather than in reductions in nominal prices or in greater output of the same machines.

As Dr Greenspan notes, much investment is now concerned with the acquisition of skills and knowledge rather than the installation of new equipment. Accounting and statistical conventions established in an era when the capital stock consisted mostly of buildings and plant and machinery may understate the real extent of investment and capital formation in modern economies. Current expenditure on software may really be investment in the future productive capabilities of the firm.

Box 1: Alan Greenspan

"These newer technologies and the structure of output they have created have surfaced a set of definitional problems that – although evident in a world of steel, fabrics, and grains – were never on the cutting edge of analysis. I refer, of course, to the age-old problem of defining what we mean by a unit of output and, by extension, what we mean by price. The dollar value of sales or GDP depends, of course, on the specific accounting rules chosen. And while value in that context is uniquely defined, the split between volume change and price change is always approximate".

"But over time, and particularly during the last decade or two, an ever-increasing share of GDP has reflected the value of ideas more than material substance or manual labor input. This ongoing development is imposing significant stress on our statistical systems."

***The challenge of measuring and modelling a dynamic economy,* Alan Greenspan, Chairman of the Federal Reserve Board. At the Washington Economic Policy Conference of the National Association for Business Economics, Washington DC. March 27, 2001**

But to raise these issues – to argue that new technology requires new statistical procedures - is to open a Pandora's box. National income statistics are widely used, not just by economists, but by politicians, business people, and participants in financial markets. Many people in these groups have little knowledge, and little desire to have knowledge, of the bases on which such statistics are compiled. It is necessary to have the needs of such users in mind in deciding how national accounts statistics are presented.

One plausible position is that national statistics offices should attempt to make the best estimates possible of the economic concepts at the basis of calculations This would seem to be the goal to which Dr Greenspan aspires. There are however, real difficulties with this stance, as will emerge in the course of this paper. General agreement on what these underlying economic concepts are would be a prerequisite. And even if such agreement could be obtained, a further problem remains: there is a large degree of subjectivity about relevant economic concepts. The problems this poses are well recognized by commercial accountants. The problems of private sector auditors, and the pressures to which they are subject, are well known.

In an alternative approach, we might take the view that national income is what national income statisticians measure. National income would then be the answer to the question 'what number do I obtain if I follow internationally accepted procedures for the calculation of gross domestic product?"

The argument for such a position is that consistency is as important a virtue as accuracy, and it is a weighty argument. It is an extraordinary achievement that we now have lengthy historic series of national income and output for most countries of the world calculated on a more or less common and consistent basis. In a forceful analogy developed by Paul Krugman[1], we can easily learn to drive safely a car with a faulty speedometer. And, if we have learnt such driving skills, we may drive worse, not better, if the settings of the speedometer are altered – even if the overall effect is to improve its accuracy.

Frequent minor adjustments to statistical series are as likely to do harm as good in their practical effect. It is certainly arguable that the many adjustments to the UK unemployment statistics over the last twenty years – most of them individually entirely defensible – have reduced rather than increased the value of the information provided by destroying their validity as a time series.

It is not my intention in this paper to argue that GDP should be measured differently. That is a question which should properly be the subject of extensive debate and international agreement. Nor shall I argue that the current measurement of GDP is wrong. Rather I begin from the observation that those who measure GDP do not attempt to measure output, or income; they measure GDP. GDP should be regarded as a provisional indicator of output and income, and the calculation of GDP provides an organizing framework for the assessment of trends in output and income rather than a definitive measure of either of these economic concepts.

It allows that statements about output or productivity which are based on movements in GDP should either be described as "GDP output" or "GDP productivity" or, preferably, preceded by careful analysis of the relationship between trends in GDP and changes in output or productivity. This is especially important if it is believed there have been material changes in the structure of the economy -precisely what is claimed by those who emphasise the role of new technology - which might be expected to change the relationship between GDP and output and income. And careful analysis of these relationships is clearly essential if movements in GDP are to be interpreted as shedding light on changes in output or productivity. The question considered here is whether measurements of the growth of GDP understate the growth in output in the 'new economy' conditions described above. The conclusion of this paper is that they do not. The 'new

[1] See http://web.mit.edu/krugman/www/speed.html

economy' has brought about a reduction in asset life and a fall in the price of capital goods relative to consumption goods. As a result the reported growth of GDP overstates, rather than understates, the rate of growth of output. This is probably true worldwide and especially true of the United States.

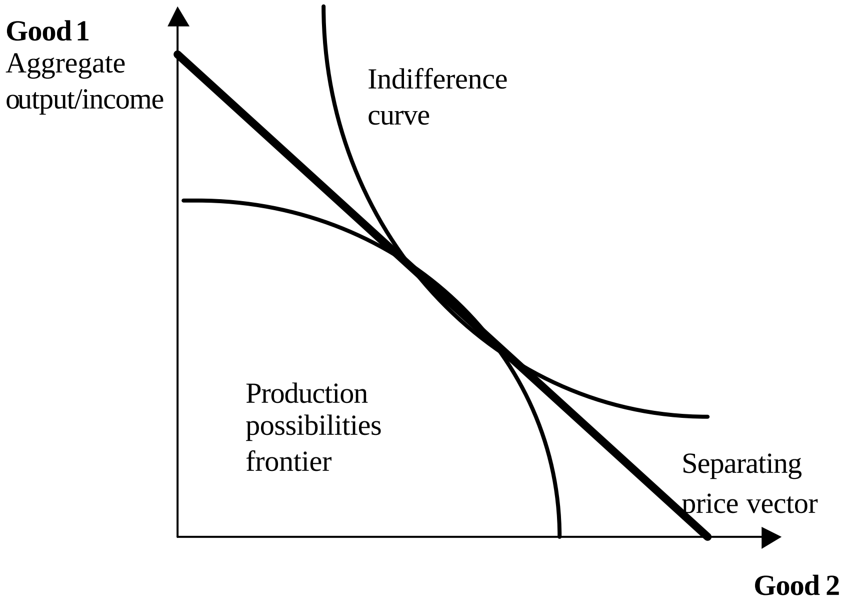
2. THE MEASUREMENT OF INCOME AND OUTPUT

The relationship between economics and accounting centres around a famous definition proposed by Sir John Hicks: Income is 'the maximum value which [a man] can consume during a week, and still expect to be as well off at the end of the week he was at the beginning.' Hicks' definition anticipates a concept which is now described as sustainability. Performance is to be judged in the light of its impact on our ability to maintain that performance in future. The definition requires us to engage in a thought experiment – judging what we could have done and might do, not just what we have done. It follows that income is not immediately observable: it is something that has to be calculated with the aid of subjective judgement. Less obviously, the same is true of the measurement of output.

The practice of national income accounting was developed during the Second World War, in particular by Richard Stone and James Meade under the tutelage of Keynes (Stone, 1986, Weale, 1993). Some aspects of national accounts conventions – particularly the emphasis on gross rather than net measures and the emphasis on the real flows corresponding to the circular flow of income rather than the financial flows important to private sector accounting – seem to be the product of a perspective based on war conditions and Keynesian economics.

The basic theory of national income accounting was set out by Samuelson (1950). Samuelson shows how a separating price vector (Fig.1) establishes the equivalence of the value of income and the value of output. Samuelson's analysis related to a single period, and was mainly concerned with comparisons of national income (or national consumption, which in a one-period model is essentially the same). Importantly, he notes that when the production possibility frontier shifts movements of income and of output are not necessarily the same.

Figure 1: Separating price vector



An intertemporal framework was explicitly developed by Mirrlees (1969), who also emphasizes that marginal rates of transformation (rather than market prices) are required for the evaluation of social income or output. Mirrlees' analysis was extended by Weitzman (1976) and the present paper follows closely the Mirrlees-Weitzman framework, with some clarificatory changes of terminology. In common with Weitzman, I assume a single consumption good but allow multiple capital goods: this assumption is easily relaxed.

Weitzman begins from a definition of net domestic product, v. as $c + \mathbf{p}\dot{\mathbf{k}}$ where c is consumption, $\dot{\mathbf{k}}$ a vector of net investment and $\mathbf{p}$ is a vector of the prices of capital goods with the consumption good as numeraire. For Weitzman, this definition of NDP (which I will call aggregate output) is essentially self-evident. Still, it is worth spelling out the component assumptions:

(a) the output of an enterprise is its value added

(b) national output is the sum of the outputs of enterprises.

These assumptions lead immediately to the conclusion that $v = c + \mathbf{p}\dot{\mathbf{k}}$. Write the value added of an enterprise as

$$v_i = c_i + \mathbf{p}\dot{\mathbf{k}}_i + \mathbf{q}\mathbf{b}_i \qquad (1)$$

where c_i is the output of consumption goods, $\dot{\mathbf{k}}_i$ the net addition to its own stock of investment goods, and $\mathbf{b}_i$ net sales of intermediate goods (including investment goods), with $\mathbf{q}$ price vector of intermediate goods. Since by definition $\sum \mathbf{B}_i = 0$,

$$\sum v_i = \sum c_i + \mathbf{p} \sum \dot{\mathbf{k}}_i \qquad (2)$$

Assumptions (a) and (b) are essentially definitional: it would be possible to define either enterprise output or aggregate output in different ways but these seem to correspond to everyday usage amongst economists. Insistence that output is value added sometimes cause difficulty because of a lingering sense that the measurement of output is fundamentally an engineering question – capable of being resolved by the measurement of physical quantities - rather than one which requires the attention of economists or accountants, (see, for example, Hulten (1992) (Box 2)). But it is immediately clear that this cannot be true in an economy with more than one good.

The question which Weitzman poses is whether any broader interpretation can be given to the concept of aggregate output than its origin as the sum of the outputs of individual firms. Enterprise output has a natural interpretation in terms of the consumption possibilities created by the firm's operations, either directly – through its own output of consumption goods - or indirectly – through its contribution to the output of other firms, valued at prevailing marginal rates of transformation. But this interpretation cannot necessarily be sustained at the level of aggregate output, because marginal rates of transformation will not generally be constant for large changes. It is evident from Fig 1 that aggregate output (measured with the consumption as numeraire) is not equal to the maximum producible output of that consumption good.

Weitzman's contribution is to show that aggregate output, measured as the aggregate of the output of individual firms, equal to aggregate income is for an economy on an efficient (competitive) growth path. Aggregate income is defined by Weitzman as the annuity equivalent level of sustainable consumption. Thus under certain assumptions, the values of aggregate income and aggregate output at prevailing (competitive) prices are equal. Weitzman therefore provides an intertemporal generalization of the separation theorem described by Samuelson

For present purposes, the most important of the assumptions required to demonstrate that equivalence is that of constant technology. This is relaxed in a much more recent paper (Weitzman 1997) which allows for future technological progress. If technological change is anticipated, then aggregate income will be correspondingly higher because future output growth will make a higher level of current consumption sustainable. The investment in capital goods required to sustain any given annuity equivalent level of consumption will be correspondingly lower. While these expectations of future technological change raise national income (what Weitzman calls in this connection Green NDP), such expectations do not raise current output – at least in the way in which the word output is ordinarily used.

Weitzman develops his latter analysis in the context of environmental concerns with sustainability, but the framework has equal significance for the technological progress compiled by the new economy. Expectations of future output growth generated by such technology may increase aggregate income in the current period but do not raise aggregate output in the current period.

Box 2: Gross and net output

Gross and net output

The flavour of Hulten's contribution can be seen in the following paragraph:

> *"While standing at the edge of Robinson's corn field counting the number of bushels harvested, the statistician would observe the gross amount of corn grown during year t, and not the net amount. Alternatively, an observer standing at the door of an*

auto plant would see the gross number of autos rolling off the assembly line, and not the quantity of "net autos", whatever that is. In other words, direct observation of the production process yields information about the total gross output produced in the work place".

Hulten, 1992

There are several confusions here. Statisticians do not in practice stand at the edge of Robinson's corn field counting the number of bushels harvested, and for good reasons: the measurement of agricultural output is normally based on the trading returns of farmers' or agricultural markets. The observer at the automobile factory would indeed correctly record the gross number of autos rolling off the plant. The question which should cause him difficulty is the measurement of the intermediate inputs needed to produce these autos: it is this information which he needs to compute the net output of the automobile factory.

The third statement - "direct observation of the production process yields information about the total gross output produced in the workplace" - is correct if gross output is a list of physical commodities. Aggregation is only possible in an economy with more than one good with the aid of some price vector, which could be inferred from any direct observation of the production process. Anyone who continues to believe that economic output can be measured by the observation of physical quantities should ask themselves what observations of physical quantities could provide answers to the fundamental questions with which this paper began:

- how should improvements in the specification of computers be recorded?
- what part of software expenditure should be treated as investment?

Answers to both questions require analysis of the economic context within which these activities take place.

It is true that the word "output" is often casually used to refer to the aggregate sales or turnover of a firm. But this is a loose usage, most commonly employed in activities where purchased inputs are not a large proportion of the sales of the business. In the case of a retailer, for example, where it is immediately apparent from the nature of activity that there is a substantial difference between the sales and the net output of the enterprise, it would be unusual to refer to the turnover of the retail business as its "output".

3. INCOME AND OUTPUT WHEN CAPITAL GOODS PRICES ARE CHANGING

In Weitzmann's basic model, the relative price of capital and consumption goods can change only as a result of capital accumulation. More generally, this price relative might be affected by technological change. This is a key consequence of the "new economy".

In the framework defined at (1), enterprise income is

$$y_i = c_i + \frac{d}{dt}(\mathbf{pk}_i) + \mathbf{qb}_i - w_i \qquad (3)$$

with w_i labour income paid by the firm and all other notation as before. If $\dot{\mathbf{p}} = 0$ then (3) becomes

$$y_i = c_i + \mathbf{p}\dot{\mathbf{k}}_i + \mathbf{qb}_i - w_i \qquad (4)$$

and hence

$$v_i = y_i + w_i \qquad (5)$$

and

$$\sum v_i = \sum y_i + \sum w_i$$

giving the familiar national accounting relationships.

If $\dot{\mathbf{p}} \neq 0$, then the term $\dot{\mathbf{p}}\mathbf{k}_i$ is a component of enterprise income but not of enterprise output. This is the well-known distinction between financial capital maintenance and physical capital maintenance (as described, for example, in Edwards, Kay and Mayer (1987)). It is argued there that financial capital maintenance is appropriate for the measurement of enterprise income: the value of a business to its shareholders is measured by the value of its assets. For measuring aggregate income, however, it seems likely that physical capital maintenance is more appropriate. Although the aggregate output of a nation is equal to the aggregate of the output of its enterprises, the aggregate wealth of a nation is not equal to the aggregate of the value of the assets of its enterprises: in particular, a fall in the price of capital goods reduces the value of enterprise assets by transferring wealth from owners of enterprises to consumers (who may, of course, be the same people). In the standard framework of national accounts, of course, the identity (5) is maintained by the exclusion of capital gains and financial transactions - and hence $\dot{\mathbf{p}}\mathbf{k}_i$ - from the calculation of enterprise income.

An increase in the productivity of capital goods manufacture would lead to a fall in $\mathbf{p}$. If unanticipated, this reduces enterprise income: the capital loss is the wealth transfer described above. Prospectively, both aggregate income and aggregate output rise, for two reasons

- the existing capital stock can be maintained at lower opportunity cost in terms of consumption
- profitable additions to the capital stock at lower prices contribute more to output than to costs.

If the adjustment to the new level of capital stock is instantaneous, then it follows immediately from Weitzman's theorem that aggregate output and aggregate income are again identical.

It is probably reasonable, however, to suppose that recent increases in the productivity of capital goods manufacture were largely anticipated. If so, then they would lead to an increase in aggregate income at the point at which expectations of such technical progress were formed. There would be no immediate corresponding increase in aggregate output, but output would grow faster than income as expectations of this technical progress were realized. Eventually, as expectations were completely fulfilled (or not) aggregate income and aggregate output would converge, as a result of an increase in output (if the expectations proved justified) or a fall in income (if they did not).

This framework is highly relevant to an account of the development of the new economy. US households believed aggregate income had increased as a result of prospective technological advances. As a result, they increased spending although aggregate output had not yet increased. This caused a balance of payments deficit and a fall in the reported savings rate. Despite this fall in savings net household wealth continued to increase as a result of the capitalization of the value of future technological progress in higher stock prices.

The measurement of both aggregate output and aggregate income requires a measure of net investment, but these measures are not generally the same. In computing aggregate income, the relevant measure of investment is the change in the NPV of future consumption, i.e. the value of additions to the capital stock during the year, with current consumption as numeraire. In computing aggregate output, the relevant measure of investment is the opportunity cost of additions to the capital stock during the year, again with current consumption as numeraire.

If markets are perfectly competitive, and there is no technological change (or new technology is endogenous and the generation of new technology is itself the product of a perfectly competitive process), then aggregate income and aggregate output are the same. If these assumptions do not hold, then the measurement of aggregate income becomes highly speculative – essentially, national income statisticians face the same problem that analysts and investors face in attributing a value to new economy stocks. The measurement of aggregate output, however, which is based on opportunity cost rather than value, is much more robust. It is of course for this reason that practical national income concepts, such as GDP, are much closer to measures of output than to measures of income.

4. THE RELATIONSHIP BETWEEN AGGREGATE INCOME, AGGREGATE OUTPUT AND GDP

Section 3 describes the principles appropriate to the measurement of aggregate income or aggregate output. The standard conventions for reporting GDP do not exactly follow these

GDP is, as its name suggests, reported gross, rather than net. Any intermediate good (whether sold by the firm or retained for own use) whose life extends beyond the current accounting period is categorized as final output, included in GDP, and is not depreciated.

GDP at constant prices is conventionally calculated by deflating each component of current price GDP by a sector specific price index. The measurement of aggregate output, however, requires investment to be recorded in terms of its opportunity cost in terms of current consumption. This implies that the relevant deflator is a consumption price index rather than a measure of the price of capital goods.

The effect of these two factors in creating divergences between GDP growth and output growth is multiplicative. This is particularly clear in relation to the two issues posed at the start of this paper – the appropriate price index for computers, and the division of software expenditure between investment and consumption. In any standard double entry accounting framework, the price basis selected for valuing investment has only a short term impact because subsequent depreciation reverses out the effect of the price assumption. If, however, no such reversal takes place, then the result is very sensitive to the price assumptions made. Similarly, if a current expenditure is reclassified as a short life asset, the effect of the reclassification reverses itself over the – by definition short – life of the asset. If, however, no depreciation allowance is made, the effect of such a recategorisation is much larger.

Box 3 illustrates how large the impact of a recategorisation of software expenditure is on GDP relative to its actual effect on the net present value of output

Box 3: Treatment of software as investment

<u>Treatment of software investment</u>

If annual software expenditure equal to 1% of GDP is reclassified as investment, the effect on GDP is to raise it by 1% in perpetuity.

If the rate of depreciation of software material is 0.33 p.a. and the expenditure is incurred at an even rate, the effect of such reclassification on net output is

Year 1 +0.83% Year 2 0.5% Year 3 0.17% Year 4 and after nil

i.e. the NPV of the whole increase in output is less than 1.5% of GDP

5. THE RELATIONSHIP BETWEEN ALTERNATIVE GDP MEASURES AND OUTPUT IN COMPUTERS IN THE UK

To measure the potential significance of these issues in quantitative terms, I use the data prepared by Oulton (2001), with a view to providing a better assessment of the significance of computer investment to the UK economy. Oulton provides a careful analysis of such expenditure over the last twenty years and draws on US sources to provide appropriate price indices for this series. For present purposes, I assume that the correctness of Oulton's data and show the range of different measures which can be derived from them. I have extended the series to 2000 using my own estimates with assistance from ONS.

Table 1: Investment in computers (£bn)

		1995	1996	1997	1998	1999	2000
1.	Gross investment, current prices	7.7	8.6	8.3	10.2	10.6	10.9
2.	Gross investment, 1995 producer prices	7.7	11.2	14.7	24.8	32.7	36.6
3.	Net investment, current prices	3.9	4.7	4.3	6.4	6.0	4.9
4.	Net investment, 1995 consumer prices	3.9	4.6	4.1	5.8	5.4	4.4
	Differences between 2 and 4 as % of GDP (1995 prices)	0.5%	0.9%	1.4%	2.4%	3.4%	3.9%

Line 1 of Table 1 shows actual gross investment in computers over the period. Spending rises by around 40% and in 2000 amounts to a little more than 1% of GDP. However the price of computers fell very rapidly over the same period, and in 2000 it is estimated that such prices are less than 30% of their 1995 level. Line 2 shows gross investment at 1995 prices. On this basis, actual expenditure in 2000 equates to £6.6 bn at 1995 prices. If the data prepared by Oulton were to be used by the ONS in reporting GDP, this £36.6 bn would represent the contribution of computer investment to GDP in 2000, and it would amount to around 4½ % of GDP.

It is important to note how extraordinary this figure is. It is an estimate of what it would have cost in 1995 to buy computers with the capabilities of the computers which were in fact bought in 2000. However these computers were not bought in 1995, or at 1995 prices, and presumably would not have been bought at 1995 prices. It would in fact have cost only about 2½% of GDP in 2000 to replace the entire capital stock of computers in use at that date.

The analysis of section 3 suggests that the appropriate measure of the contribution of computer investment to output is the opportunity cost of net investment in computers. For the purposes of this calculation, Oulton's data has been used as the basis for a perpetual inventory model of the capital stock of UK computers.

Over the period from 1995 – 2000, the current value of the stock of computers employed in the UK at current prices increased by around 70%, from £13.3 bn to £21.5 bn. On the basis of Oulton's price assumptions, it would have cost £71.8 bn in 1995 to buy a stock of computers with similar capabilities in 1995.

While this is a remarkable figure of the 'believe it or not' variety, it is not apparent that it bears any wider interpretation. In particular, it does not represent a measure of the value of the computers in use in 2000. Nor does it represent a measure of the potential contribution of these computers to output. It is not even clear that it bears its primary interpretation, as the cost of buying the year 2000 stock in 1995. Much of the capital stock of computers in 2000 consists of equipment with capabilities which were not available, at any price, in 1995, and which would in any event not have been useful in 1995 because complementary assets were not them available. While techniques have been established for measuring the effect of quality changes in consumption goods or for valuing new goods by reference to the underlying preference function (e.g. Hausman, 1997), movements in the price of intermediate goods do not carry an analogous interpretation.

Paradoxically, the principal economic requirement for an index of capital goods prices is in the measurement of depreciation (and it is only for this purpose that an index of capital goods prices has been employed in the present paper). A measure of quality improvement is required if the concept of physical capital maintenance is to be used when the composition and characteristics of capital goods are changing. Our understanding of what is happening in the economy would be greater if the energy devoted to debating the price of new computers had been devoted to analyzing the characteristics of the evolving capital stock.

The effect of falling computer prices has been to reduce the cost of capital services to UK enterprises. Table x provides a series for the cost of capital services over the period 1995-2000, assuming a nominal rate of return on net investment of 10%. This figure has been relatively stable in the region of £10 bn p.a. and, is, predictably, not very different in order of magnitude from actual current expenditure on computers.

Table 2: Capital stock of computers (£bn)

	1995	2000
Capital stock at 1995 prices	13.3	71.8
Capital stock at current prices	13.3	21.5
Cost of capital services at current prices	7.9	9.6
Cost of capital services, 1995 consumer prices	7.9	8.6

Over the period, net investment in computers has generally been something over half of gross investment. At 1995 consumer prices, net investment in computers in 2000 was £4.4 bn around ½ % of national income. This figure is very substantially lower than the £36.6 bn estimate of gross investment at 1995 computer prices. If GDP estimates for the UK had been based on Oulton's data, they would have overstated the growth of aggregate output from 1995 – 2000 by around 0.6% per year.

As Table 3 illustrates, the net investment figure is robust to the assumptions used to calculate it. Substantial variations in price or depreciation assumptions have comparatively small impact.

Table 3: Real net investment in computers, year 2000, (1995£bn, CPI deflated)

		Annual price fall (of computers) since 1995		
		10%	**20%**	**30%**
Annual capital depreciation (computers)	**15%**	5.6	6.7	7.5
	30%	3.7	5.0	6.1
	45%	2.7	4.0	5.1

The size of the difference between £36.6 bn and £4.4 bn results from the interacting effect of three factors

- the use of gross rather than net output measures
- the use of sector specific price deflators for capital goods
- the use of 1995 data to provide expenditure weights for the calculation of subsequent output growth

Table 4 illustrates how each of these factors has a significant influence in the final result. It shows the contribution of computer investment to GDP under a variety of alternative assumptions:

- the substitution of net investment at 1995 capital goods prices for gross investment (broadly, the effect of a shift from a GDP to an NDP basis of calculation((line 2)
- the substitution of ONS computer price assumptions for Oulton's assumptions based on US data (line 3)

- the construction of a chain index for the measurement of growth in computer investment in substitution for a series based on 1995 prices (line 4)

Table 4: Investment under different accounting frameworks (£bn)

	1995	1996	1997	1998	1999	2000
Gross investment, 1995 computer prices, Oulton data	7.7	11.2	14.7	24.8	32.7	36.6
Net investment, 1995 computer prices, Oulton data	4.0	6.2	7.8	15.4	18.5	16.5
Gross investment, 1995 computer prices, ONS data	5.7	7.7	9.3	10.8	15.6	18.2
Gross investment, chained series, Oulton data	7.7	11.2	13.9	19.6	22.9	24.2
Net investment, 1995 consumer prices, Oulton data	4.0	4.7	4.2	5.9	5.4	4.4

6. THE RELATIONSHIP BETWEEN GDP AND OUTPUT GROWTH IN ICT EXPENDITURE IN THE US

The analysis of section 5 shows that as a result of the fall in the price of some capital goods and the shortening of the length of life of assets, the gap between recorded GDP and aggregate output in the UK has been increasing. As a result of this, the reported rate of growth of GDP exceeds the rate of growth of output. Over the past five years, this difference has averaged around 0.25% of GDP.

The assumptions made by ONS in respect of the fall in computer prices and the treatment of software expenditure are relatively conservative. In the preparation of the US national accounts, much larger price reductions have been assumed and the proportion of software expenditure that has been capitalized has been considerably greater. As a result, the potential difference between the growth of GDP and the growth of aggregate output is larger.

Table 5: US Investment in ICT, US ($bn)

	1995	1996	1997	1998	1999	2000
Gross investment, current prices	208	232	270	306	344	409
Gross investment, 1996 producer prices	190	232	296	380	478	609
Net investment current prices	80	95	121	142	157	189
Net investment 1996 consumer prices	82	95	118	138	150	176
Difference	126	137	178	242	328	433
Difference as % of GDP (1996 prices)	1.7%	1.8%	2.2%	2.8%	3.7%	4.7%

Table 5 uses the same methodology described in section 5 to produce estimates of the contribution of ICT expenditure to US GDP over the same period. Separate perpetual inventories have been constructed for the three sectors of ICT (computers, software and communications expenditure). The resulting figures are similar to those which appear in the BEA's own calculations of capital stock, since the BEA's own price assumptions are used at similar depreciation assumptions have been made. Table x shows that the difference between the conventional GDP component for such investment (gross investment at constant capital goods prices) and the relevant measure for tracking changes in aggregate output (the opportunity cost of net investment) rises from 1.7% of GDP in 1995 to 4.7% of GDP in 2000. The combined effects of different price assumptions, absence of allowance for depreciation, and the use of base period expenditure weights, are as large in the US as in the UK.

However the degree to which US GDP growth overstates output growth is not as large as Table 5 might suggest. Constant price GDP in the US is computed using a chain index procedure which reduces the extreme figures which are obtained when recent growth is measured using a distant base.

Thus the best method of estimating the difference between GDP growth and output growth in the US which arises from the different treatments of the ICT sector is to substitute net investment data for gross investment data in the BEA growth accounting framework. Over the four years from 1996-2000, the difference in the two growth contributions amounts to 1.75%, equivalent to between 0.4% and 0.5% per year in the reported annual growth rate (Table 6). This figure is still a good deal larger than the comparable difference in the UK and invites the conclusion that a large part of the apparent acceleration is productivity growth in the US may reflect the conventions which are used to calculate GDP rather than any underlying charge in trend in the growth of aggregate output itself.

Table 6: US Contribution of ICT to growth, BEA Growth Accounting framework (% of GDP, Total 1996 – 2000)

	Gross investment	Net investment
Computers	1.77%	1.17%
Software	1.23%	0.48%
Communications equipment	0.81%	0.43%
Total	3.81%	2.06%

7. CONCLUDING REMARKS

(a) It is not only economists and national income statisticians who face problems of measurement. When we measure speed, we know precisely what it is that we are measuring, although instruments may record it imperfectly. When we measure beauty, we recognize that different people might legitimately arrive at different evaluations, because there is only loose agreement on what it is we measure.

But in both cases, we begin with a strong intuitive grasp of what is meant by speed or beauty. No-one has similar intuition about GDP. We do have an intuitive concept of well-being, and of the scale of economic activity (the "size of an economy"). People often talk as though GDP measured these things, although it does not: it is certainly closer to the first than to the second. We also have an intuitive sense of household or personal income, and of enterprise output, and some capacity to visualize aggregates of these. But again, GDP is not a measure of aggregate income or output.

In the light of this, it is disturbing to see financial market practitioners and politicians respond to small movements in reported data. We need to consider what information about the economy they believe is being conveyed by these reports, since the data does not correspond to any of the 'natural kinds' with which they are familiar.

It is also disturbing to see national accounts conventions debated with exclusive reference to other national accounts conventions. Both dialogues become essentially self-referential. GDP matters to markets because markets think GDP matters. National income accountants talk a private language without recognizing that such language has no content unless it relates to objects in the outside world.

(b) although the arguments of this paper are technical, their intuition is entirely straightforward. Computers (and other associated new technologies) are not valued for themselves: they are useful to the extent that they increase the final output of the processes in which they are employed (or substitute for other more costly inputs). It is through their effect of the processes for which they are intermediate goods that the contribution of computers to income or output is recorded.

Under existing GDP conventions, we record not just the effect of computers on non-computer output, but add to that the increased output of computers themselves and treat the fall in the price of computers as a further enhancement of GDP. While there are historic reasons for this multiple counting of the same event there is no corresponding multiple impact on in either the aggregate output or the aggregate income of the economy.

(c) the price of intermediate goods is, in general, irrelevant to the measurement of the volume or value of aggregate income or output. (Computers are in part a consumption good, but domestic use of computers is barely significant relative to business use and most non-business purchases of computers are by government or non-profit bodies). The extensive debate over what has happened to the price of computers is significant to the conventional measurement of GDP, but this is a peculiarity of the method used to compute GDP. The outcome of such debate is not material for the calculation of trends in the productivity of the economy, if such productivity is based on aggregate output.

(d) the price of computers is, however, relevant to the attribution of productivity gains between the computer manufacturing sector and the non-computer manufacturing sector. However this issue, although widely debated (Oliner and Sichel, 2000, Jorgenson and Stiroh, 2000, Gordon, 2000), is not of real significance. Computers have become much more powerful and easier to use. Should this improvement be classified as a gain in productivity by the computer manufacturing sector or by the non-computer sector? The issue could be argued either way. The facts are clear; the only dispute is over how they are described

(e) Similarly, the price of computers may be relevant to the measurement of total factor productivity, because it affects the cost, input and output of capital services. However the question of whether output increases resulting from the better use of computers should be attributed to an increase in the input of computer services or a rise in the total factor productivity of computer users is again a semantic rather than a substantive question.

(f) private sector accounting conventions are based on a principle of conservatism. Examples of this relevant to the issues of this paper include the lower of cost and market rule and the requirement that expenditures can normally be capitalized only when associated with specifically foreseeable revenue streams. Certainly no private sector firm would be allowed to treat computer or software expenditures in the manner in which they are treated in the US national accounts.

A primary reason for such conservatism is that managers of private sector business are likely to be perennially optimistic about asset valuations and future revenue streams, and that auditors need strong supper in resisting client pressure to present an unduly favourable picture of the activities of their clients. It seems to have been believed that this issue did not arise in national income accounting. This assumption may need to be reviewed.

(g) both private sector accounting conventions and national accounting conventions need to be reviewed in the light of the changing structure of the economy. The second paragraph of Dr Greenspan's observations (Box 1) is certainly correct.

One common response has been to expend the concept of capital to include many intangible assets. I am skeptical of the utility of this approach, and this paper demonstrates some of the problems which arise. Attempts to attract monetary values to intellectual capital, or brands, are rarely persuasive. (Stewart, 1997, Srivastava et al., 1998, Sveiby, 1999)

A better approach may be to emphasise the presentation of a vector of physical performance attributes as a measure of the success of the economy in maintaining and developing its productive potential in the broadest sense – essentially on the lines of the "balanced scorecard" which has proved a powerful influence on the evolution of private sector accounting conventions. **(**Johnson and Kaplan, 1987, Kaplan and Norton, 1996) This would fit well with the desire to give increasing attention to social indicators and environmental concerns.

(h) once a connection is made to private sector accounting issues, it is surprising that it should have been expected that the "new economy" would lead quickly to gains in economy wide productivity gains. In a parallel debate, it has been argued that private sector accounting conventions are inappropriate for the new economy. The claim made here was that measures of the current output of firms understate their contribution to income and the creation of value.

Amazon.com, the archetype of new economy businesses, has made operating losses since inception. Its operations reduce economy wide productivity, in the sense that the inputs it uses per unit of output are greater than those required by conventional booksellers. The company's operating losses have been funded by investors who believe, perhaps correctly, that they will be repaid from future growth in output, productivity and profits. On the basis of these beliefs, the activities of the business are aggregate output reducing and aggregate income enhancing. In this it is probably representative of many new economy businesses

REFERENCES

Edwards, J., Kay J.A. and Mayer, C.P., 1987, *The Economic Analysis of Accounting Profitability*, Oxford University Press, Oxford

Gordon, R.J., 2000, 'Does the 'new economy' measure up to the great inventions of the past?', *Journal of Economic Perspectives*, Vol. 14, pp49-74

Hausman, J.A., 1997, 'Valuation of New Goods Under Perfect and Imperfect Competition' in Bresnahan, T. and Gordon, T. (eds.) The 'Economics of New Goods', *Studies in Income and Wealth* 58: 209-237. University of Chicago Press for the National Bureau of Economic Research.

Hulten, C.R., 1992, 'Accounting for the Wealth of Nations: The Net versus Gross Output Controversy and its Ramifications', *Scandinavian Journal of Economics*, 94, 9-24

Johnson, H.T. and Kaplan, R.S., 1987, *Relevance lost: the rise and fall of management accounting*, HBS Press, Boston MA

Jorgenson, D.W. and Stiroh, K.J., 2000, 'Raising the Speed Limit: U.S. Economic Growth in the Information Age', *Brookings Papers on Economic Activity 1*, pp125-211.

Kaplan, R.S., and Norton, D.P., 1996, *The Balanced Scorecard*, HBS Press, Boston MA

Mirrlees, J.A., 1969, 'The Evaluation of National Income in an Imperfect Economy', *Pakistan Development Review*

Oliner, S.D., and Sichel, D.E., 2000, 'The Resurgence of Growth in the 1990s: Is Information Technology the Story?', *Journal of Economic Perspectives*, Vol.14, pp2-22.

Oulton, N., 2001, 'ICT and Productivity Growth in the United Kingdom', *Bank of England working paper series* (available from www.bankofengland.co.uk/workingpapers/index.htm)

Samuelson, P.A., 1950, 'Evaluation of Real National Income', *Oxford Economic Papers*, Vol. 2, pp1-29

Srivastava, R.K., Shervani, T.A., and Fahey, L., 1998, 'Market-Based Assets and Shareholder Value: A Framework for Analysis', Journal of Marketing, Vol. 62, No. 1

Stewart, R.A., 1997, *Intellectual Capital*, Brealey, London

Stone, R., 1986, 'Nobel Memorial Lecture 1984: The Accounts of Society', *Journal of Applied Econometrics*, Vol. 1, Issue 1 (January), pp5-28

Sveiby, K.R., 1999, *The New Organizational Wealth: Managing and Measuring Knowledge Based Assets*, Berrett-Koehler, San Francisco

Weale, M., 1993, 'Fifty Years of National Income Accounting', *Economic Notes*, Vol. 22, No. 2, pp.178-199.

Weitzman, M.L., 1976 (February), 'On the Welfare Significance of National Product in a Dynamic Economy', *Quarterly Journal of Economics*

Weitzman, M.L., 1997 (January), 'Sustainability and Technical Progress', *Scandinavian Journal of Economics*