FEATURE

Volume of capital services: estimates for 1950 to 2006

Gavin Wallis
HM Treasury

Sumit Dey-Chowdhury
Office for National Statistics

SUMMARY

Capital services are the measure of capital input that is suitable for analysing and modelling productivity. This article presents experimental capital services estimates for 1950 to 2006 for the whole economy, for the market sector, and for the non-oil sector. The latter is produced for both the whole economy and the market sector, facilitating macroeconomic analyses. Capital services estimates are also presented by eight asset types, expanded from the previous five asset breakdown, and also by detailed industry. Development work has enabled capital services to be published for purchased software and own-account software for the first time. Key features of the estimates in this article include the strong growth in capital services from computers and software in the late 1990s, the recent divergence of capital services and capital stock measures, and also much stronger growth in the service industries than in the production industries over recent years.

To enhance the understanding of the UK's productivity performance, a framework is needed to analyse the relationship between the inputs and outputs of production. Capital and labour are key factors of production, both contributing to the output of the economy, and accurate measurement of these two inputs is essential for accurate measurement of productivity.

Defining capital and measuring its contribution to production has been a contentious issue for both economists and statisticians for many years. Early work in this area includes Jorgenson (1963), the seminal paper on growth accounting by Jorgenson and Griliches (1967), Hall and Jorgenson (1967) on the cost of capital, and the work of Hulten and Wykoff (1981a, 1981b) on the estimation of depreciation rates. More recently there has been a degree of international agreement about the conceptual issues concerning the stocks and flows of capital. The Organisation for Economic Co-operation and Development (OECD) published a manual in 2001 (OECD 2001) covering the measurement of capital stocks and providing practical guidelines for estimation. Work by Oulton and Srinivasan (2003) has also proposed an integrated framework for measuring capital stocks, capital services and depreciation.

Capital services estimates weight together the growth of the net stock of assets with weights that reflect the relative productivity of the different assets that make up the capital stock. These weights are calculated using estimates of rental prices in contrast to the capital stock estimates in the UK National Accounts, which use asset purchase prices as weights. This difference in weights is important in understanding the difference between the two measures of capital. The capital stock estimates in the National Accounts are wealth estimates of the capital stock while capital services are a flow measure that reflects the input of capital into production. This is the reason why capital services are more suitable for analysing and modelling productivity. By definition, a capital asset generates a stream of services that spans more than one accounting period. Capital services are a measure of this flow of services, so measure the actual contribution of the capital stock of assets to the production process in a given year.

This article presents experimental capital services estimates for 1950 to 2006, extending and revising previously published estimates in Wallis (2007). Developments to the estimates are also described and the additional capital services estimates that have been produced are presented.

An accompanying article in this edition of *Economic & Labour Market Review* (Dey-Chowdhury and Goodridge 2007) describes a published set of official quality-adjusted labour input (QALI) estimates for the UK for 1996 to 2006. Alongside the capital services estimates presented in this article, these form the inputs into the multi-factor productivity (MFP) estimates that are now published annually by the Office for National Statistics (ONS) and are next due

for publication in early 2008.

Asset breakdown for capital services

The main development since Wallis (2007) is the level of asset detail. Previously, capital services were published with a five-asset breakdown (buildings, plant and machinery including purchased software, vehicles, intangibles including own-account software, and computers). In this article, capital services are published for eight assets (see **Table 1** for details). The revision of own-account software in *Blue Book 2007* (see Chamberlin, Clayton and Farooqui (2007) for details) has meant that it is now possible to treat own-account software as a separate asset when estimating capital services. It has also been possible to treat purchased software as a separate asset by separating it from plant and machinery.

Previously capital services estimates were published for the fixed asset intangibles as defined in the UK National Accounts. Sufficient data now exist to publish estimates for the three separate assets that comprise intangibles in the National Accounts: mineral exploration, own-account software and copyright and licence costs for artistic and literary originals (see **Box 1**).

There has been recent literature on how much the UK invests in a more broadly-defined range of intangible assets (see Giorgio Marrano and Haskel (2006) and Giorgio Marrano, Haskel and Wallis (2007) for more details). This work extends the definition of intangible capital asset to include innovative property (including research and development), brand equity, firm-specific human capital, and organisational capital. As these are not yet recognised as produced assets in the System of National Accounts, estimates of capital services are not provided here for these other types of intangibles. Galindo-Rueda (2007) shows some of the work in which ONS is currently involved in incorporating research and development (R&D) as an asset into the UK National Accounts.

Table 1
Developments in the asset breakdown for capital services

UK National Accounts (asset breakdown of raw data used to calculate capital services)	Previous capital services asset breakdown	Current capital services asset breakdown
Buildings	Buildings	Buildings
Vehicles	Vehicles	Vehicles
Intangibles (including own-account software)	Intangibles (including own-account software)	Own-account software Copyright and licence costs for artistic and literary originals Mineral exploration
Plant and machinery including computers and purchased software	Plant and machinery including purchased software Computers	Plant and machinery Purchased software Computers

Box 1
Intangible fixed assets

The National Accounts Concepts, Sources and Methods manual explains that the produced intangible fixed asset category in the UK National Accounts comprises three main asset types. Previously it was not possible to produce estimates for these individual assets but this article does so for the first time. The three types of intangible assets are described below:

- mineral exploration covers the costs of drilling and all related activities (for example, the costs of relevant surveys). The investment in this knowledge asset is independent of whether the outcome of drilling is successful or not
- own-account software refers to software that is developed in-house and not intended for final sale, but for internal use. This is unlike purchased software, for which there is a market transaction. It also includes the creation of software originals intended for subsequent reproduction. Revised estimates of own-account software were included in the UK National Accounts in *Blue Book* 2007
- copyright and licence costs for artistic and literary originals refer to artistic output that is recorded, which encompasses, for example, expenditure on original films, sound recordings, and manuscripts. These expenditures relate to both the physical original and the copyright attached to it

Market sector and non-oil capital services series

The market sector capital services series is published again and is consistent with the definitions used in Marks (2007) and with the experimental market sector labour productivity measures that are now published by ONS. As such, the capital services estimates could be used together with the ONS market sector output data in productivity analysis of the market sector.

In addition, two new series are also included in this article: non-oil capital services for both the whole economy and the market sector. HM Treasury use non-oil gross value added (GVA) as their preferred measure of output in the analysis of the UK economy's trend growth. Although output from the oil and gas sector affects total output, it is considered to have 'little direct impact on the sustainable levels of employment and non-oil economic activity.' The publication of these non-oil capital services estimates should assist with analysis of the UK economy.

Estimation methodology

The four main stages in the estimation of capital services can be summarised as:

- using the Perpetual Inventory Method (PIM) to calculate a net stock series from a history of constant price investment series
- pricing the services from each asset using an estimated rental for each asset
- generating weights, using the estimated rentals and net stock series, which reflect the input of each asset into production, and
- combining the net stock growth using the estimated weights to give capital services growth estimates

The methodology used to estimate capital services is described in detail in Wallis (2005) and in *The ONS Productivity Handbook* (ONS 2007). There have been two changes, the most substantial of which is to allow for a more detailed asset breakdown. A new method has been developed in order to separate both computers and purchased software from the raw plant and machinery data from the National Accounts, which includes these

Box 2
Rental prices

The main difference between the UK National Accounts measure of capital stock and the capital services estimates presented here is how the net stock estimates are weighted. Capital stocks are weighted using asset purchase prices while capital services are weighted using asset rental prices.

The rental price is sometimes referred to as the user cost of capital and essentially measures the price a user would have to pay to hire the asset for one time period. It is estimated in the conventional way using the Hall-Jorgenson formula for the cost of capital:

$$r^{i}_{at} = T_{at}\,[\delta^{i}_{a} \bullet p^{i}_{at} + R_{t}p^{i}_{a,t-1} - (p^{i}_{at} - p^{i}_{a,t-1})]$$

where is r^{i}_{at} the rental price of an asset, T_{at} is the tax-adjustment factor, p is the price of an asset, δ is the rate of depreciation, and R is the rate of return.

The rental price consists of three components:

- depreciation of the asset (the $\delta^{i}_{a} \bullet p^{i}_{at}$ term)
- nominal rate of return (the $R_{t}p^{i}_{a,t-1}$ term), and
- change in the purchase price of the asset (the $(p^{i}_{at} - p^{i}_{a,t-1})$ term)

In addition, an adjustment is made to take account of taxes on profits and subsidies to investment. Depreciation refers to the fact that assets lose value over time, due to wear and tear as well as anticipated obsolescence, and so if an asset is to be leased out, then the rental price will need to cover this loss in value. This is why the rental price is positively related with the depreciation term of the user cost formula. The more the asset depreciates, the greater its rental price will be.

Likewise, a change in the asset price has a direct effect on the rental price an owner of an asset would charge for renting out the asset as it represents a capital gain or loss for the owner. If the market price of the asset has fallen over the year, then the rental price will be higher to compensate the owner of the asset for this price fall (that is, the capital loss). This is the case with computers, where prices have fallen markedly in recent years. In terms of a capital stock measure, it means computers will be given less weight. However, it means that, all other things being equal, the rental price of computers will be higher and hence be given more weight in a capital services measure.

The rate of return is not directly observed and so has to be modelled. It is estimated by assuming that the gross operating surplus (or profit) is completely exhausted by all the produced assets in the economy. It is often interpreted as being equal to the risk-free rate of interest plus some risk premium.

two assets. The method is described in detail below.

The other change is to the calculation of the rental rates (see **Box 2** for more details), and specifically the rate of return component. This is not directly observed and so is modelled endogenously by assuming that the entire operating surplus in the economy is exhausted in remunerating the services from these fixed capital assets (net of the surplus that is attributable to dwellings). Dwellings are not modelled as part of the productive capital stock as they do not represent capital input into the production function. Due to the volatility of the rate of return series, it has been decided that these should be smoothed and so a three-period moving average of the estimated yearly rate of return is used instead.

Data

Before describing the methodology for the separate treatment of computers and purchased software, it is useful to outline the sources being used. The data used to estimate capital services are the same as those underpinning the UK National Accounts capital stock estimates and are consistent with *Blue Book* 2007. The data set consists of a long time series of constant price investment flows, classified by industry, alongside their respective life length means and price deflators.

Maintaining consistency with *Blue Book* 2007 means that the capital services estimates presented here are ideal for MFP work, as they are consistent with the output measures such as GVA in the UK National Accounts.

The asset breakdown of the raw investment series is:

- buildings
- copyright and licence costs for artistic and literary originals
- mineral exploration
- own-account software
- plant and machinery including computers and purchased software
- vehicles

In addition, a series for purchased software is available, based on Chamberlin, Clayton and Farooqui (2007).

In *Blue Book* 2007, own-account software was revised. Previously, the lack of data meant that treating own-account software as a separate asset was not possible. However, current price investment data now are available as well as an accompanying price deflator and life length mean.

In order to treat computers and purchased software as separate assets, they have to be separated from investment in plant and machinery and the associated price deflators have to be adjusted to account for this. It should be noted that, although an appropriate life length is used for computers in the National Accounts (currently assumed to be five years), the capital stock estimates do not separately deflate computers. Purchased software is currently treated as part of plant and machinery in the National Accounts; it is not separately deflated and is subject to the general life length for all plant and machinery.

For all assets, current investment is taken as the starting stock for the first year in which the investment series is available. For buildings, plant and machinery, vehicles, and intangibles, the investment series starts well before 1950 (as early as 1828 for some of the buildings series) and so any initial conditions problems can be ignored. For the other assets for which data start after 1950, sensitivity analysis showed that, except for the first few years, the capital services estimates were insensitive to different methods for calculating the starting stock.

For this reason, the first few years of each series have been dropped.

Treating computers and purchased software as separate assets

Due to the relative price of computers and purchased software falling rapidly, and their economic lives being much shorter than those of most other types of plant and machinery, the treatment of computers and purchased software as separate assets is important. The methodology used to calculate capital services will give more weight to assets for which the rental price is high in relation to the asset price, which will be the case for computers and purchased software.

In order to treat computers as a separate asset, a time series of constant price investment flows is needed, together with an appropriate life length mean and a price deflator. The former is not currently available from the UK National Accounts but is included as part of plant and machinery. The basis for estimating computer investment here is the current price computer investment available in the most recent supply-use analysis. In this case, the supply-use analysis is consistent with *Blue Book* 2006. Capital investment data can be obtained from Table 6 in the supply-use tables, which shows gross fixed capital formation (GFCF) by 57 industries. Current price computer investment can be obtained from here (product 69). As the most recent supply-use tables only cover the period 1992 to 2004, a previous supply-use table for 1984 was used in order to get a series covering the period 1984 to 2006, with the unavailable years being interpolated (and extrapolated for 2005 and 2006).

As noted above, a life length mean for computers is already available in the UK National Accounts and so this is used here, with a double-declining balance method used to give the depreciation rate (see Wallis 2005).

The computers producer price index (PPI) is used as the computer deflator (ONS code PQEK), which is available from 1986. The computer deflator for 1984 and 1985 has been estimated by projecting backwards the 1986 to 1987 growth rate of this PPI. An alternative is to use the growth in the US computer deflator for these two years. This alternative has an insignificant effect on the results presented here. Using the US deflator for the entire period instead of the UK one also has an insignificant impact on the estimates. Combining the current price computer investment, obtained using the supply-use tables, and the computer deflator, constant price computer investment can be generated as required for estimating capital services.

Purchased software investment data are now available back to 1970, making it possible to split out purchased software investment data from the plant and machinery investment data series. However, both series are in current price form and need to be deflated to construct historical constant price investment data. A UK purchased software deflator is not yet incorporated into UK National Accounts; therefore, when producing capital services estimates, a US-based software deflator (Parker and Grimm (2000)) has been used. This deflator is adjusted to take into account price level differences between the US and UK.

The estimation of a purchased software investment series enables plant and machinery excluding computers and purchased software to be derived as a residual. However, these are in current prices, whereas a constant price series is required in order to create the net stock measure needed for capital services.

In order to construct a constant price estimate, an appropriate deflator is required. The plant and machinery deflator in the UK National Accounts has to be adjusted to take account of the treatment of computers and purchased software as separate assets. It is not appropriate to use the existing PPI for plant and machinery which is used in the UK National Accounts, since this includes an element capturing price changes in computers.

An implied deflator was previously inferred using a method that constrains total investment of plant and machinery, computers and purchased software to UK National Accounts totals (in both current and constant prices). However, in producing the estimates shown here, an alternative approach is used. The new method removes the computer deflator (PQEK) from the existing UK National Accounts plant and machinery deflator as it is no longer included in the series to be deflated; this is achieved using available data on the plant and machinery PPI weights. There is currently no PPI for software investment included in the UK National Accounts plant and machinery deflator series; this element therefore does not need to be excluded before deflating the new plant and machinery excluding computers and purchased software series.

Capital services estimates

This section presents capital services estimates for the whole economy, for the market sector, and for the non-oil sector, by eight asset types and also by detailed industry. It provides a 57-industry breakdown, consistent with the most recent supply-use analysis. A six-industry breakdown is also presented that is consistent with the industry breakdown at which the ONS QALI measure is published (Dey-Chowdhury and Goodridge 2007), to enable MFP analyses at this six-industry level.

In most cases, estimates are available for the period 1950 to 2006. Due to space limitations, not all available data are presented here. A full set of results including downloadable data tables is available at www.statistics.gov.uk/statbase/product.asp?vlnk=14205

Capital services in the UK

Wallis (2007) covers in detail the reasons that explain the profile of the growth rate in capital services seen in **Figure 1**. Periods of modest growth coincide with UK recessions (1973 to 1975, 1979 to 1982, the early 1990s) while pick-ups in the growth rate can in part be explained by economic phenomena. For example, the strong growth seen in the 1990s is a result of high levels of investment in information and communications technology (ICT).

Figure 1 also shows annual growth in the net capital stock measures published in the UK National Accounts. The series is the growth in total net stock excluding dwellings, as dwellings are not modelled as part of the productive capital stock. Although measuring different concepts, the close fit of the two series is not surprising since they are both based on the same underlying data sources.

The differences in these two series can be attributed to three main factors:

- the weighting of net stock growth by rental prices in the capital services estimates as opposed to asset prices in the National Accounts estimates
- the separate treatment of computers, purchased software and own-account software for capital services, and
- the use of a geometric depreciation rate when constructing the capital services estimates instead of an arithmetic depreciation rate

It is the use of a geometric rather than an arithmetic depreciation rate that causes

the divergence between the official National Accounts net capital stock measures and the net stock measures used in producing estimates of capital services.

While the growth rates in the stock- and service-based measures of capital both peak in 1998, there is a marked divergence during the late 1990s. This is due to the effect computers, purchased software and own-account software have on the capital services estimates.

Capital services account better for the input contribution of computers, own-account and purchased software than a capital stock estimate. During the 1990s there were large levels of capital investment in ICT assets. The weights used to calculate estimates of capital services are based on two components: the level of net stock and the rental price. The increase in capital investment in computers, own-account and purchased software during this period was reflected in increased levels of net stock for these assets, increasing their share in the whole economy capital services estimates. The other factor driving this divergence is the use of rental prices to weight the net stock. The period of high levels of ICT investment also saw the prices of ICT assets fall sharply. The UK National Accounts measures of capital stock are wealth-based estimates as they are weighted by asset prices, meaning that the fall in prices is reflected in a fall in the weight attributed to ICT assets. However, the rapid fall in prices of computers is reflected in a rise in the rental price for ICT assets (see Box 2). This combination of increased investment in these assets and falling prices makes the share of computers, own-account software and purchased software in the whole economy capital services estimates grow over time and makes capital services grow more rapidly.

An interesting way to look at the divergence of the National Accounts wealth-based measures of capital stock and capital services is as volume indices. **Figure 2** shows that there is a clear divergence between the volume of capital services and the volume of capital stock after 1980, especially after 1990. This divergence is being driven by the shift towards short-lived and more productive assets, such as computers, for which the flow of capital services is high. The standard capital stock measure does not adequately capture this shift and so understates growth in the productive input of capital in the UK economy, especially after 1990.

Figure 1
Annual growth in capital stock and capital services

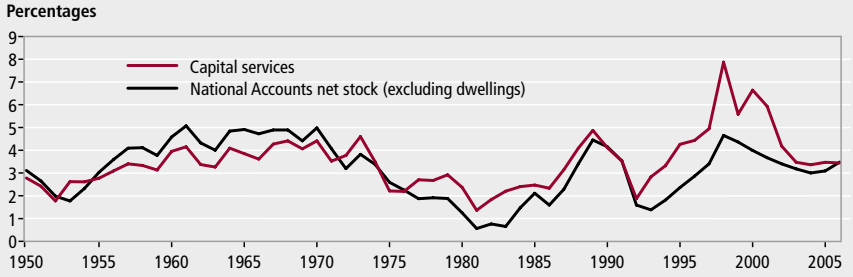


Figure 2
Volume index of capital stock and capital services

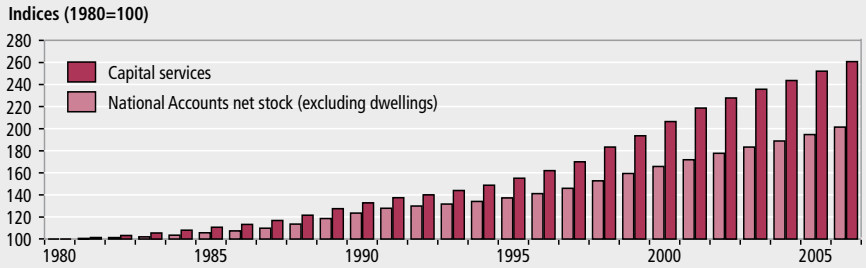
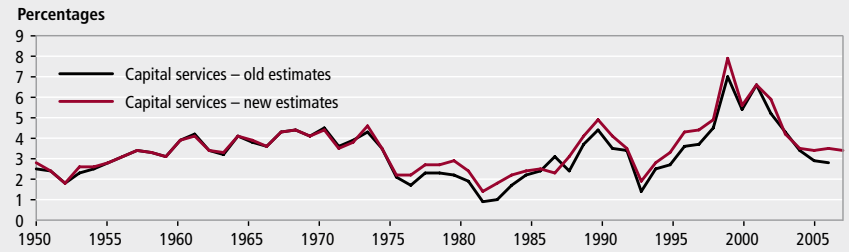


Figure 3
Annual growth in capital services: new and previous estimates



Revisions since previous release

Revisions to capital services estimates since Wallis (2007) are due to a combination of revisions to the underlying constant price investment series and the new methodological changes explained above. A full revisions analysis is not shown here due to the large number of series being presented. However, **Figure 3** shows the new estimates of whole economy capital services growth against the previously published estimates. It can be seen that the revisions are relatively small in magnitude and are predominantly to post-1976 estimates only, when capital services for own-account software are first documented. Estimates of capital services growth for purchased software begin in 1981, which additionally explain the revisions seen post-1981.

Market sector capital services

Productivity and other macroeconomic analyses often focus on the market sector rather than the whole economy. The measurement of the market sector is of importance to policy makers as the market sector better reflects the balance of demand and supply pressures of the UK economy. It also assists making international comparisons of productivity (the US only publishes estimates of market sector productivity), undertaking growth accounting analysis, or when estimating and analysing business cycles. In response to user needs, ONS began publishing experimental estimates of market sector productivity in 2007.

Figure 4 shows the volume of market

sector capital services relative to the whole economy. The market sector here is consistent with the definition of the National Accounts market sector value added measure, making it suitable for use in market sector growth accounting analysis. It is clear that market sector capital services have been growing faster than for the whole economy. The main reason behind this divergence is that the market sector has been investing more heavily in ICT assets than the non-market sector.

Non-oil capital services

This article marks the first time that capital estimates have been published for the non-oil sector. Macroeconomic analysts are interested in examining the non-oil sector, as output from the oil sector is considered to have little direct impact on the sustainable level of employment and non-oil economic activity

Figure 5 plots the annual growth rates in capital services for the non-oil sector and the whole economy. The two growth rates follow each other very closely for the period 1950 to 2006, which reflects that assets in the oil and gas extraction industry are a small part of total assets in the UK economy. There is a slight divergence in the growth rates between 1975 and 1985, where the annual growth rate in non-oil capital services is slower than that observed in the whole economy. This period saw large capital investment in the oil and gas extraction industry as new oil reserves were found in the mid-1970s. These high levels of investment contributed to fast capital services growth in the industry over the period.

Figure 4
Volume index of whole economy and market sector capital services

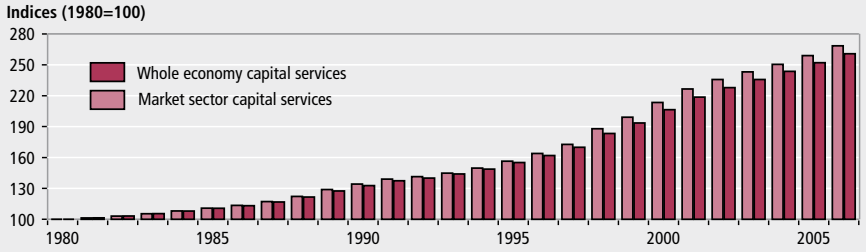


Figure 5
Annual growth of capital services in the non-oil sector

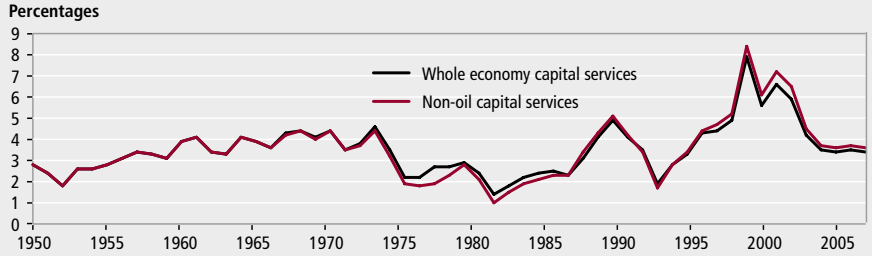
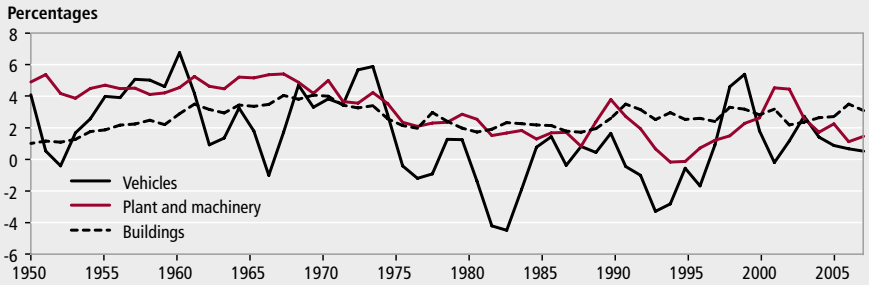


Figure 6
Annual growth in capital services: by asset type



Capital services by asset type

Figure 6 shows annual growth in capital services by asset type for buildings, plant and machinery and vehicles. Growth in capital services for the ICT assets is not shown, as capital services from computers and purchased software grew much faster than other assets, especially in the late 1990s. This is shown in the next subsection. Some of the more interesting analytical points to note are:

- the 1950s and 1960s saw strong and relatively stable growth in capital services for all assets for which data are available
- growth in capital services from buildings is relatively stable over the period in comparison with the growth in capital services for other asset types
- for all assets there is a downturn in capital services growth in the mid-1970s, driven by a fall in the net stock in many industries over this period
- after 1985 there is a clear increase in the variability of the growth rate of capital services
- capital services growth rates are subdued for all assets during the recession in the early 1990s
- negative capital services growth only occurs for vehicles, and the periods of sustained negative capital services growth occur during the period following the oil shocks of the 1970s and the recessions in the early 1980s and the early 1990s

Although not plotted in Figure 6, negative capital services have been observed for mineral exploration since the early 1990s. These capital services data have not been previously published but are interesting as they are the only asset to have experienced a sustained period of negative growth over the last 15 years. This reflects the fact that there have been very low levels of capital investment in mineral exploration, as large amounts of these resources have now been exhausted in the UK.

Figure 7 shows the volume of capital services from computers, own-account software and purchased software relative to the volume of whole economy capital services. The volume index of computers

increases to over 3,000 in 2006 from 100 in 1987, while the volume index of whole economy capital services (all assets) increases to just over 200 by 2006. For purchased software, the volume index has increased to over 2,000 in 2006. This explains the divergence seen in Figure 2 between the wealth-based National Accounts measures of net stock and capital services. The reason that the growth in capital services from computers and purchased software is not driving up whole economy (all assets) capital services more is that these two assets still only account for a 10 per cent share of profits (see **Figure 8**). Growth in own-account software capital services is much less pronounced as, although investment in own-account software has increased quite rapidly, the deflator has not fallen as it has for computers and purchased software. The reason for this is that the deflator is based on the average wage index of software-related employees whose wage has increased over the period. This means that the rental price, all things being equal, is lower for own-account software than it is for computers and purchased software which saw large price falls.

Table 2 summarises capital services growth by asset type for selected periods. The periods chosen are cyclical peak-to-peak and the table shows average annual growth over these periods. Interesting points to note are:

- average annual growth in capital services from buildings is similar in all time periods
- average annual growth in capital services from plant and machinery is similar in all time periods, although slightly subdued in the 1990 to 2000 period
- capital services growth from vehicles has been relatively weak in all periods (although there was a pick-up in growth for the period 2000 to 2006): this is due to weak capital stock growth and possibly reflects the impact of high oil prices and the two oil shocks
- capital services from mineral exploration grew very rapidly in the period 1973 to 1979, reflecting exploration of North Sea oil, and since 1990 has experienced strong negative growth
- capital services growth from computers and purchased software was stronger in the run-up to the millennium than it has been since, possibly reflecting overinvestment in the earlier period in response to the feared 'millennium bug'

The average growth rates presented here for plant and machinery are significantly lower for the period 1979 to 2000 when compared with the results presented in Wallis (2007). It is important to note that in previous articles, the capital services data for plant and machinery included purchased software whereas this has been separated out in these new estimates. This implies that, previously, it was growth in capital services for purchased software driving the growth in plant and machinery (as defined in Wallis (2007)). However, this pattern has reversed for the period 2000 to 2006, illustrating the marked slowdown in capital services growth for purchased software. For the period 1990 to 2000, the average annual growth rate in capital services for purchased software was over 20 per cent. This compares with an average growth rate of around 5 per cent since 2000.

Likewise, it is now possible to understand what was driving the average annual growth rate in intangibles as presented in Wallis (2007). In this previous article, the average annual growth rate for intangibles was weak for the period 1990 to 2005. Table 2 shows that there was relatively strong growth in capital services for both own-account software and artistic and literary originals during this period, but these were offset by the very strong negative growth rate in mineral exploration.

Figure 7
Volume index of whole economy, computers, own-account software and purchased software capital services

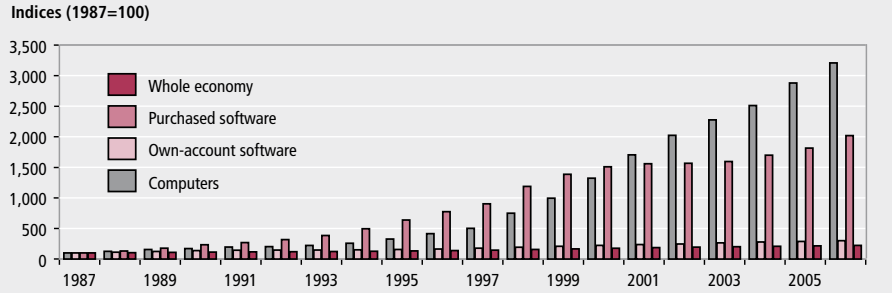


Table 2
Average annual growth rates of capital services: by asset type

Percentages

	1973–79	1979–90	1990–2000	2000–06
Buildings	2.3	2.2	2.9	2.7
Computers	n/a	n/a	23.3	16.1
Copyright and licence costs for artistic and literary originals	11.2	5.5	5.2	3.3
Mineral exploration	12.8	7.0	–5.7	–8.8
Plant and machinery	2.6	2.0	1.5	2.3
Own account software	n/a	10.7	4.9	5.1
Purchased software	n/a	30.1	20.7	5.0
Vehicles	0.5	–0.7	0.3	1.2

Capital services by industry

Capital services estimates have been produced at both 57-industry and six-industry levels. The 57-industry breakdown is consistent with the most recent supply-use analysis. The six-industry breakdown is consistent with the industry breakdown for which the ONS QALI measure is published (Dey-Chowdhury and Goodridge 2007). These are the capital services estimates used in the ONS MFP analysis, which will be next updated in early 2008.

Table 3 shows growth in capital services by industry for selected periods. As in Table 2, the periods chosen are cyclical peak-to-peak and the table shows average annual growth over these periods. Also included are estimates for aggregate production industries and aggregate service industries, as well as medians and 25th and 75th percentiles.

Interesting points to note from Table 3 are:

- in all periods, the average annual growth rate of capital services is higher for aggregate service industries than for aggregate production industries, which is consistent with the fact that GVA growth has been fastest for services
- production industries saw their

strongest growth in capital services in the period 1973 to 1979, and this was followed by much weaker growth in latter periods – as low as 0.3 per cent in the period 2000 to 2006

- average annual growth of capital service in the service industries has been stronger in each period, rising from 2.8 per cent in the period 1973 to 1979 to 6.0 per cent in the period 2000 to 2006
- all service industries saw positive average annual growth in capital services in the periods 1990 to 2000 and 2000 to 2005 while in all periods some production industries saw negative average annual growth in capital services
- the medians and 25th and 75th percentiles show that average annual growth is much more dispersed in the service industries than in the production industries
- over the two most recent periods, computer services and auxiliary financial services saw the strongest growth in capital services, while the agriculture-based industries saw the largest fall in capital services, reflecting the changing nature of the UK economy with a very strong financial sector and a weaker manufacturing and agricultural sector
- industries that are large users of ICT assets, such as computer services and research and development, showed the strongest average annual growth in capital services

Also included in Table 3 are average annual growth rates of GVA for the production and service industries. It is interesting to note that the increase in capital services growth in the service industries over time was matched by stronger growth in service industry GVA, as might be expected, and also that growth in capital services was faster than growth in GVA in all periods. In contrast, production industry GVA growth averaged 1.3 per cent in the first three periods, then declining to negative average annual growth in the latest period.

Table 4 shows annual growth in the volume of capital services for the six industries for which the QALI estimates are published. The data are less informative than in Table 3 as they hide much of the variation across lower levels of industry disaggregation. However, these are the estimates used in the ONS MFP work, as QALI is currently only available at this industry-level breakdown.

Table 3
Average annual growth rates in capital services: by industry

Percentages

Industry	1973–79	1979–90	1990–2000	2000–06
Production industries				
Agriculture	1.3	–0.1	2.9	–1.8
Forestry	1.0	4.8	–1.6	–1.5
Fishing	1.6	–6.7	–6.4	–5.5
Coal extraction	3.1	0.5	–4.4	–4.2
Oil and gas extraction	28.3	5.6	0.7	–2.3
Other mining and quarrying	0.5	–1.5	–1.6	–0.6
Food products and beverages	3.6	2.6	2.0	1.5
Tobacco products	2.6	0.2	2.4	–1.4
Textiles	–0.2	–1.8	–0.1	–3.4
Wearing apparel and fur products	0.6	–0.8	0.7	–3.6
Leather goods and footwear	n/a	n/a	3.1	–2.5
Wood and wood products	2.5	–1.4	0.9	1.8
Pulp, paper and paper products	n/a	19.1	13.0	0.8
Printing and publishing	3.1	2.6	3.0	1.2
Coke, refined petroleum and nuclear fuel	0.2	2.8	0.3	–1.9
Chemicals and chemical products	2.8	2.0	3.3	–0.5
Rubber and plastic products	2.7	2.6	5.0	–1.1
Other non–metallic mineral products	7.2	6.4	2.2	1.3
Basic metals	1.5	–2.9	–0.8	–1.6
Metal products	2.1	0.3	3.0	2.3
Machinery and equipment	3.1	0.3	1.5	–1.0
Office machinery and computers	6.4	9.9	8.4	–1.2
Electrical machinery	2.4	0.0	2.9	–2.3
Radio, TV and communication equipment	n/a	17.8	10.1	–6.6
Medical and precision instruments	4.7	4.5	12.7	3.6
Motor vehicles	3.7	3.2	3.5	0.0
Other transport equipment	1.2	2.4	0.4	5.6
Other manufacturing	3.0	2.0	5.7	3.2
Recycling	n/a	9.2	0.3	7.0
Electricity and gas	–0.1	0.3	0.3	1.5
Water	0.5	3.6	9.5	8.8
Construction	2.2	1.3	2.6	7.6
All production industries	2.7	1.6	2.1	0.3
25th percentile	1.1	0.1	0.3	–2.0
50th percentile	2.4	2.0	2.3	–0.8
75th percentile	3.1	4.0	3.4	1.6
Production industries GVA	1.3	1.3	1.3	–0.8
Service industries				
Motor vehicle distribution and repairs, fuel	n/a	14.9	7.8	8.8
Wholesale distribution	4.9	4.4	7.3	3.9
Retail distribution	4.9	4.9	6.5	6.8
Hotels and restaurants	4.2	5.1	6.3	5.6
Land transport and transport via pipelines	1.1	–0.3	0.9	2.2
Water transport	–4.3	–8.1	7.3	1.2
Air transport	3.0	–3.5	14.4	7.0
Ancillary transport services	2.1	3.1	8.6	12.6
Post and telecommunications	2.5	1.6	9.1	3.7
Financial intermediation	5.2	11.4	4.7	3.2
Insurance and pension funds	10.0	12.2	4.2	2.2
Auxiliary financial services	n/a	n/a	10.7	21.1
Real estate activities	3.2	5.7	4.4	10.8
Renting of machinery, etc.	16.5	9.7	11.3	6.5
Computer services	n/a	25.1	27.6	19.1
Research and development	n/a	17.8	17.7	6.0
Other business services	11.6	15.9	12.8	8.0
Public administration and defence	1.8	2.5	2.7	3.7
Education	1.9	1.2	2.7	7.7
Health and social work	5.3	5.8	4.8	5.4
Sewage and sanitary services	5.7	3.0	3.2	5.8
Membership organisations	n/a	13.9	7.3	7.7
Recreational services	5.1	6.4	7.4	6.8
Other service activities	n/a	15.2	7.1	9.6
All service industries	2.8	3.9	6.1	6.0
25th percentile	2.2	2.8	4.6	3.9
50th percentile	4.5	5.7	7.3	6.6
75th percentile	5.3	13.1	9.5	8.2
Service industries GVA	1.8	2.5	3.2	3.3

Table 4
Annual growth in the volume of the capital services: by aggregate industries

Percentages

Industry		1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Agriculture, hunting, forestry, fishing, mining and quarrying, utilities	A, B, C, E	*0.5*	*0.6*	*–0.7*	*–0.2*	*0.0*	*0.3*	*–0.4*	*0.1*	*–1.1*	*1.0*
Manufacturing	D	*3.9*	*4.5*	*2.1*	*2.0*	*1.9*	*–0.7*	*–0.1*	*–1.1*	*0.0*	*–0.2*
Construction	F	*6.0*	*4.3*	*7.4*	*6.6*	*3.6*	*13.7*	*8.6*	*12.2*	*3.0*	*4.2*
Wholesale and retail trade, hotels and restaurants, transport storage and communication	G, H, I	*9.5*	*11.4*	*8.5*	*10.2*	*10.6*	*7.0*	*4.5*	*2.5*	*3.2*	*3.4*
Financial intermediation, real estate, renting and business activities	J, K	*4.5*	*18.8*	*12.8*	*13.8*	*9.3*	*7.6*	*5.5*	*7.7*	*8.9*	*9.6*
Public administration and defence, education, health and social work, other social and personal services and extra-territorial activities	L, M, N, O, P, Q	*3.7*	*4.1*	*5.1*	*5.9*	*6.5*	*5.8*	*6.6*	*6.4*	*3.7*	*2.4*

The results support the discussion above regarding production versus service industries. The first three industries cover production and, in general, capital services growth is lower than for the last three industries, which cover services. However, the 2006 estimates show stronger growth in agriculture, hunting, forestry, fishing, mining and quarrying, utilities – with annual growth rising to 1.0 per cent from –1.1 per cent in 2005. There was also a pick-up in capital services for construction.

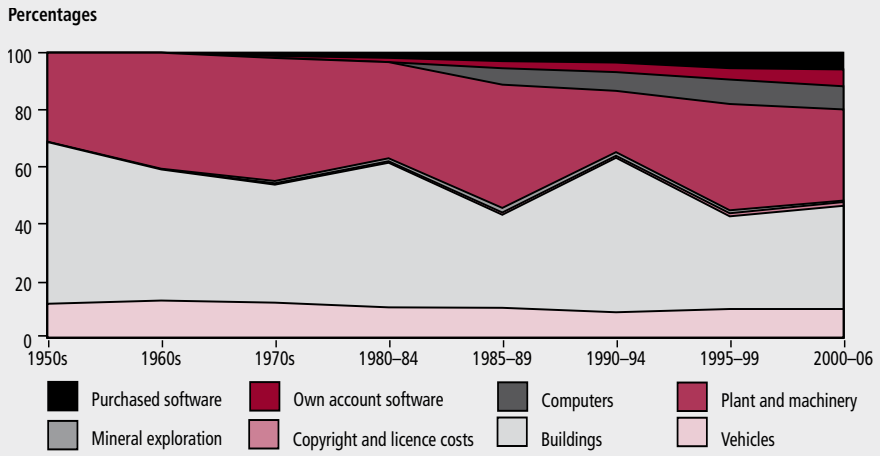
There were also significant upward revisions to the capital services estimates for financial services, reflecting the separate treatment of purchased and own-account software. Financial intermediation, real estate, renting and business activities showed the fastest growth in capital services in Wallis (2007), which reflected the strong growth in investment, with computer investment making up a significant proportion of the total for this industry. The upward revisions presented here are driven by the separate treatment of purchased and own-account software. These data indicate that there has been strong growth in purchased software, in which this industry invested heavily.

Profit shares

The weight of each asset or industry in calculating whole economy capital services is the share of gross operating surplus attributable to each asset or to each industry. These are usually referred to as profit shares. The time profile of the profit shares by asset over the period 1950 to 2006 is shown in Figure 8.

Figure 8 shows that the composition of profit shares has changed substantially since the 1950s. The share of buildings, while still the largest, has fallen, while that of vehicles has remained fairly constant.

Figure 8
Profit shares: by asset, 1950–2006



The share of plant and machinery has been more variable, increasing in the 1960s and 1970s, falling considerably during the period 1990 to 1994, before returning to a level similar to the 1950s by 2000 to 2006. Most interesting is the rise in the profit share of the ICT assets. The profit share of computers has increased each period, culminating in a share of 8 per cent in the period 2000 to 2006. Likewise, the profit shares for own-account and purchased software have steadily increased from the 1970s. The profit shares of both these assets in the period 2000 to 2006 are 6 per cent. The cumulative share of ICT assets (computers, purchased and own-account software) increased to 20 per cent in the period 2000 to 2006 from zero in the 1960s.

Table 5 shows profit shares by industry for selected years. Those shown are 1973, 1979, 1990, 2000 and 2006 for ease of comparison with the capital services growth estimates presented in Table 3.

Interesting points to note from Table 5 are:

- the profit share of production industries falls from 53 per cent in 1973 to 31 per cent in 2006
- in contrast, the profit share of service industries increases from 47 per cent in 1973 to 69 per cent in 2006, reflecting the shift in the UK economy from manufacturing to services
- in 1973, electricity and gas is the industry with the largest profit share (13 per cent), while in 2006 it is public administration and defence (9 per cent)
- industries with the largest increases in profit share include real estate activities, recreational services and other business services
- industries with the largest falls in profit share include electricity and gas, basic metals and agriculture (all production industries).

Conclusion

This article presented experimental estimates of the capital services growth for the whole economy, for the market sector,

Table 5
Profit shares: by industry

Percentages

Industry	1973	1979	1990	2000	2006
Production industries					
Agriculture	4.1	4.7	3.7	3.3	2.1
Forestry	0.0	0.0	0.1	0.1	0.1
Fishing	0.3	0.1	0.1	0.0	0.0
Coal extraction	1.5	1.5	1.5	0.6	0.5
Oil and gas extraction	0.8	3.6	5.8	5.3	4.1
Other mining and quarrying	1.3	1.3	0.7	0.4	0.3
Food products and beverages	3.5	3.3	2.8	2.4	1.9
Tobacco products	0.2	0.2	0.1	0.1	0.1
Textiles	1.9	1.6	0.7	0.7	0.4
Wearing apparel and fur products	0.5	0.4	0.3	0.2	0.1
Leather goods and footwear	0.0	0.0	0.0	0.0	0.0
Wood and wood products	0.5	0.5	0.3	0.3	0.2
Pulp, paper and paper products	0.0	0.1	0.3	0.6	0.3
Printing and publishing	2.1	2.2	2.1	1.9	1.7
Coke, refined petroleum and nuclear fuel	1.4	1.4	1.4	1.0	0.8
Chemicals and chemical products	5.5	5.6	3.4	3.3	2.4
Rubber and plastic products	1.0	1.0	0.7	1.0	0.7
Other non-metallic mineral products	0.5	0.7	0.8	0.6	0.6
Basic metals	3.2	3.3	1.4	1.0	0.8
Metal products	1.5	1.5	1.0	1.0	0.8
Machinery and equipment	2.6	2.8	2.0	1.7	1.2
Office machinery and computers	0.2	0.2	0.3	0.3	0.2
Electrical machinery	1.5	1.9	0.8	0.7	0.5
Radio, TV and communication equipment	0.0	0.4	0.8	1.0	0.5
Medical and precision instruments	0.2	0.3	0.2	0.4	0.3
Motor vehicles	2.5	2.3	1.7	1.8	1.5
Other transport equipment	0.9	0.9	0.8	0.8	0.8
Other manufacturing	0.3	0.3	0.3	0.4	0.3
Recycling	0.0	0.1	0.1	0.1	0.1
Electricity and gas	12.8	9.8	7.2	6.1	4.6
Water	0.3	0.2	0.7	1.1	1.4
Construction	2.1	2.5	1.4	1.3	1.7
All production industries	53.4	54.8	43.7	39.4	30.8
Service industries					
Motor vehicle distribution and repairs, fuel	0.0	0.2	0.5	0.7	1.0
Wholesale distribution	2.2	2.9	2.9	3.2	2.7
Retail distribution	4.2	4.5	4.4	4.5	5.9
Hotels and restaurants	1.4	1.7	1.7	1.9	2.9
Land transport and transport via pipelines	4.7	4.5	4.6	3.3	3.5
Water transport	4.1	2.2	0.6	0.4	0.4
Air transport	1.1	1.0	0.6	1.7	2.1
Ancillary transport services	0.6	0.8	1.5	2.0	3.2
Post and telecommunications	5.7	4.9	5.0	7.6	5.6
Financial intermediation	2.4	2.5	4.4	3.3	3.1
Insurance and pension funds	0.4	0.9	1.8	1.2	2.0
Auxiliary financial services	0.0	0.0	0.4	0.6	0.9
Real estate activities	1.2	2.0	2.4	2.1	5.6
Renting of machinery, etc.	0.7	1.9	1.9	3.3	3.1
Computer services	0.0	0.0	0.4	1.3	1.2
Research and development	0.0	0.0	0.2	0.5	0.5
Other business services	0.6	0.9	3.3	5.0	4.2
Public administration and defence	10.3	6.7	12.2	7.6	9.0
Education	3.3	3.2	1.6	2.3	3.0
Health and social work	1.0	1.1	1.0	2.0	1.9
Sewage and sanitary services	0.5	0.5	1.7	2.0	2.4
Membership organisations	0.0	0.1	0.2	0.2	0.3
Recreational services	1.9	2.5	2.8	3.5	4.2
Other service activities	0.0	0.1	0.3	0.4	0.3
All service industries	46.6	45.2	56.3	60.6	69.2

and for the non-oil sector, by eight asset types and also by detailed industry. The main results include the strong growth in capital services from computers and purchased software and much stronger growth in the service industries than in the production industries over recent years. There has also been a clear shift in the profit share from other assets to ICT assets and also from production industries to service industries.

The divergence between the volume of capital services and the volume of capital stock after 1980, especially after 1990, has also been highlighted. This divergence is being driven by the shift towards shorter-lived and more productive assets such as computers and purchased software, for which the estimated flow of capital services is high. It is important to recognise this divergence when considering UK productivity. Capital services and not capital stock should be used when conducting productivity analysis.

CONTACT

elmr@ons.gsi.gov.uk

REFERENCES

Chamberlin G, Clayton T and Farooqui S (2007) 'New measures of UK private sector software investment', *Economic & Labour Market Review* 1(5), pp 17–28 and at www.statistics.gov.uk/cci/article.asp?id=1798

Dean G (1964) 'The Stock of Fixed Capital in the United Kingdom in 1961', *Journal of the Royal Statistical Society*, Series A (General) Vol. 127, No. 3, pp 327–58.

Dey-Chowdhury S and Goodridge P (2007) 'Quality-adjusted labour input: estimates for 1996 to 2006' *Economic & Labour Market Review* 1(12), pp 48–54 and at www.statistics.gov.uk/cci/article.asp?id=1906

Galindo-Rueda F (2007) 'Developing an R&D satellite account for the UK: a preliminary analysis' *Economic & Labour Market Review* 1(12), pp 18–29 and at www.statistics.gov.uk/cci/article.asp?id=1903

Giorgio Marrano M and Haskel J (2006) 'How Much Does the UK Invest in Intangible Assets?', *CEPR Discussion* Paper No. 6287.

Giorgio Marrano M, Haskel J and Wallis G (2007) 'What Happened to the Knowledge Economy? ICT, Intangible Investment and Britain's Productivity Record Revisited', *Queen Mary College Working Paper*, No. 603 and at www.econ.qmul.ac.uk/papers/doc/wp603.pdf

Goodridge P (2007) 'Multi-factor productivity analysis', *Economic & Labour Market Review*, 1(7), pp 32–8 and at www.statistics.gov.uk/cci/article.asp?id=1826

Griffin T (1975) 'Revised estimates of the consumption and stock of fixed capital', *Economic Trends* 264, pp 126–9. Available on request from elmr@ons.gsi.gov.uk

Hall R E and Jorgenson D W (1967) 'Tax Policy and Investment Behaviour', *American Economic Review* Vol. 57, No. 3, pp 391–414.

Hulten C R and Wykoff F C (1981a) 'The estimate of economic depreciation using vintage asset prices'. *Journal of Econometrics* Vol. 57, pp 367–96.

Hulten C R and Wykoff F C (1981b) 'The measurement of economic depreciation', In Hulten C R (Ed), *Depreciation, inflation and the taxation of income from capital*. The Urban Institute Press.

Jorgenson D W (1963) 'Capital Theory and Investment Behaviour', *American Economic Review* Vol. 53, No. 2, pp 247–59.

Jorgenson D W and Griliches Z (1967) 'The explanation of productivity change', *Review of Economic Studies* Vol. 34, No. 3, pp 249–83.

Marks C (2007) 'Market sector GVA productivity measures', *Economic & Labour Market Review* 1(3), pp 47–53 and at www.statistics.gov.uk/cci/article.asp?id=1742

Office for Economic Co-operation and Development (2001) Measuring Capital - OECD Manual.

Office for National Statistics (2007) *The ONS Productivity Handbook: A Statistical Overview and Guide* at www.statistics.gov.uk/about/data/guides/productivity/default.asp

Oulton N and Srinivasan S (2003) 'Capital stocks, capital services, and depreciation: an integrated framework', *Bank of England Working Paper* No. 192 and at www.bankofengland.co.uk/publications/workingpapers/wp192.pdf

Parker R P and Grimm B T (2000) 'Recognition of Business and Government Expenditures for Software as Investment: Methodology and Quantitative Impacts, 1959-98' and at www.bea.gov/bea/papers/software.pdf

Wallis G (2005) 'Estimates of the volume of capital services', *Economic Trends* 624, pp 42–51 and at www.statistics.gov.uk/cci/article.asp?id=1297

Wallis G (2007) 'Volume of capital services: estimates for 1950 to 2005', *Economic & Labour Market Review* 1(7), pp 39–47 and at www.statistics.gov.uk/cci/article.asp?id=1827