ICT Deflation and Growth: A Sensitivity Analysis

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Summary of results

There have been a number of studies making use of US-style computer deflators on UK data, to test sensitivity. Because US deflators fall faster, the GDP growth rate calculated is higher. ONS analysts used US computer deflators to illustrate this in the first National Statistics Quality Review on the Short Term Output Indicators (ONS, 2000a). They tried a simple comparison, by applying the US deflator for computers to parts of the Index of Production (IoP). The result of this sensitivity analysis was to raise the index of production by 2-6% in total over 1995-1999. This is equivalent to an annualised growth rate difference in the whole economy of up to 0.3% under the most extreme assumptions.

This simple approach neglects two features:

a. In order to measure changes in real value added, the most rigorous method is to "double deflate" - i.e. to deflate both outputs and inputs to obtain an estimate of real value added as a residual. Adopting this method and using the US deflator to deflate both inputs and outputs will reduce the effect of the US deflator on the growth of value added, as inputs as well as outputs will be increased in real terms.

b. It is also possible to approach measurement of GDP from the expenditure approach, and this entails deflating each component of final expenditure by the appropriate deflator and then subtracting the deflated measure of imports. Again the effect of using the US deflator to deflate components of expenditure such as capital formation will be mitigated by the subtraction of imported ICT goods - this will also be higher in real terms if the US deflate is used to deflate imports.

This study uses the current price supply-use balances underlying the UK national accounts to combine both of the above approaches to produce an approximation to a coherent set of real accounts. The results show that the overall effect of substituting the UK PPI by the US equivalent to test sensitivity has much less effect on the measure of UK GDP than that suggested by the STOIR analysis. The rise of approximately one third percentage points per annum over the period 1995 - 1999 is reduced to about 0.1% for the period 1992-98 in this study.

This study therefore reassures us that in terms of GDP growth, the illustrative use of the US PPI, when taken through the UK accounts, does not result in dramatic revisions to GDP growth as at first suggested by the STOIR results. There does remain the issue that current methods on the output side would generate the changes suggested by the STOIR results, and this can only be resolved through the creation and use of a coherent framework of real indicators underlying the current price supply-use tables - this will not be fully implemented until 2003 when annual chain-linking is also introduced.

However, the recent revision to the UK PPI reflecting improvements to the quotes provided by manufacturers results in a profile for the UK PPI which is much closer to the US deflator. This revision will be incorporated into the short-term growth measured of the national accounts published in September 2001.

Introduction

The rapid quality improvements in information and communication technology (ICT) goods present a number of measurement difficulties in estimating economic growth. In pricing the goods, conventional indices use the matched model approach and rely on pricing the same good each month. However, with ICT goods, there is considerable product change, with products dropping out of the basket. Replacement items often have quite different characteristics to the original item and the differences must be valued when assessing the change in price from the previous item. The UK quality adjusts all its computer price indices. Techniques used to value quality changes have received much attention in recent months as a number of studies have highlighted that differences in price indices impact quite significantly on GDP growth (Eurostat, 1999). The ONS first quality review noted the significant impact of using US computer deflators in deflating the short-term indicator for output of the computer industry (ONS, 2000a).

A second issue raised is to correctly identify where the various ICT goods appear in the national accounts aggregates. UK production of ICT goods such as computers is mostly supplied to capital formation, so that quality improvements increase the expenditure measures of gross domestic product. Work at the Bank of England has highlighted other differences between US and UK measures associated with the computing industry (Wadhwani, 2001). The products of computing services present the most challenging problems of definition. This is a large and growing sector of the economy

and some of its output falls in capital formation, which adds to GDP, and some in intermediate consumption, which does not. The correct allocation between the two categories is necessary to avoid biases on the level and growth of GDP.

This article sets out the results of a sensitivity analysis, showing the impact on UK growth of using different indicator for ICT prices (e.g. UK PPI vs. US Bureau of Economic Analysis deflator). The analysis includes all aspects of the effect of deflators on growth estimates – both double deflation and expenditure components allowing for imports.

The role of ICT in national income

OECD (2000) indicates the industries and products that can be classified as ICT. Using the OECD definition, ICT industries produce approximately 3% of the output measure of gross domestic product, GDP(O), in 1998. Indices of output for these industries show rapid growth during the past few years. A substantial portion of the volume growth is attributable to the fall in prices of the goods produced. For example, the index of production for computers shows the volume of output has risen by 68% in the period 1995-99, with falls in the producer price index contributing over 40% of this growth.

The short-term output indicators use turnover data to approximate the growth in value-added, on the assumption that the production process is constant in the short term, so that changes in turnover are equal to changes in value-added. The short-term output indicators cannot take full account of changes in the intermediate consumption of ICT goods (although some adjustments are made to computer services to try to account for this). Schreyer (2000) notes that the generally positive effect on growth of the fast falling ICT deflators will be countered by the increased volume of ICT goods used as intermediate inputs to the production process. Many ICT intermediate goods, such as semiconductors, are exhibiting price falls greater than those of the products in which they are incorporated. The growth in the output of industries using electronic components ought to deduct this from overall real gross value added, through deflation of both outputs and inputs to the production process (double deflation), transferring the semiconductor quality improvements to the value added by the components industry. To the extent that the components are imported, this would transfer the value added from UK industry to overseas suppliers.

In the expenditure measure of GDP, ICT goods are significant in the UK's gross fixed capital formation. ONS latest figures for 1998 suggest that almost half of UK gross fixed capital formation in plant and machinery can be classified as ICT, equal to 2.9% of GDP (see table 1). Comparisons across countries are problematic because of differences in classification, but work by Didier and Marinez (2000) using an OECD definition of the ICT sector for France and the US suggests that this estimate is reasonable. Also included in the expenditure measure are consumer expenditure and net exports of ICT goods. For the UK, net exports are significant and sometimes negative in some of the ICT goods, particularly electronic components

Measurement of ICT prices for deflation

The traditional price index is a matched model index, using price quotes that track the price of the same good each month. With a product like a computer, changes in products are frequent as old models are withdrawn and new, improved varieties replace these. When this occurs, some splicing factor must be calculated to join the prices of the new items to those of the old item. This is done by comparing the characteristics of the old item with the new one, and valuing the changes. The values for the features can be calculated by a variety of methods. The ONS uses a combination of two methods called option costing and manufacturer costing, with the

Table 1

ICT Gross fixed capital formation 1998

SIC	Products	GFCF (%)	GFCF (£mil)
3000	Office machinery and computers	8	11811
3220	Telegraph and telephone apparatus and equipment, and electronic capital goods	6.2	9204
3230	Television and radio receivers, sound or video recording and reproducing apparatus and associated goods	0.2	307
3320	Instruments and appliances for measuring, checking, testing and navigating and other purposes, except industrial process control equipment	0.1	102
3330	Industrial process control equipment	0.5	767
7220	Computer software, incl. Produced on own account	1.5	2250
	Purchases of capitalised services	1.5	2301
	Total	16.6	24441
	Whole economy	100	147629

Source: ONS, 2000b. Purchases of capitalised services includes some software.

latter more common in the producer price index. Some countries, particularly the United States, use an hedonic regression to estimate the value of the change in characteristics for computers and a number of other goods (see Landefeld and Grimm, 2000). The Annex provides further details of various countries' approaches to quality adjustment. The next section looks at the recent UK work on the use of the different ICT price indices in deflation.

ICT deflators

Quality adjusted ICT deflators generally fall over time. This translates into higher constant price growth rates in the industries producing the ICT goods. However, there is a large degree of variation between countries in the rate at which producer price indices fall for ICT goods (such as computers) . Indices for computers fall annually by as much as 27% a year for the US, 16% for France, 13% for the UK (16% after the revision – see paragraph below) and 6% for Germany over 1995-99 (Schreyer, 2000). Some analysts have argued that most ICT goods are internationally traded so that price falls across countries should not diverge greatly in the medium term and that the divergence might result from difference in quality adjustment method.

However, whilst it is true that different approaches to quality adjustment may significantly impact on ICT deflators, a number of other factors also need to be taken into account. A currency conversion is necessary for international comparisons. Further, the producer prices of each country may reflect a different mix of products produced in each country - e.g. a country may specialise in types of ICT goods experiencing particular price movements. A measurement complication is the handling of discounts and getting reliable, representative up-to-date contributor price quotes. These problems are accentuated for high tech products. Few countries publish a detailed PPI for computers - either due to the difficulties in measurement at the disaggregate level or due to a lack of home producers (or both).

In the UK, as a follow up to the Short Term Output Indicators Review (STOIR), the ONS has conducted a study of some of these factors, working with key manufacturers. An article by Martin Brand details revisions to the UK PPI which are due mainly to the correction of information provided by contributors (Brand, 2001). The effect of these changes is a substantial downwards revision to the UK PPI, bringing it close to the RPI and closer to the US PPI. These changes will be reflected within the National Accounts in September when they will be incorporated into various improvements and revisions within the 2001 Blue Book (see Tse, 2001, for details). The modelling work within this article is therefore based on the pre-revision PPI given that the effect of the revision is yet to be felt within the National Accounts.

Growth Estimates and Deflators

There have been a number of studies making use of US-style deflators on UK data, to test sensitivity. As US deflators fall faster, the GDP growth rate calculated is higher. ONS analysts used US computer deflators to illustrate this in the first National Statistics Quality Review on the Short Term Output Indicators (ONS, 2000a). They tried a simple comparison, by applying the US PPI for personal computers to the relevant parts of the Index of Production (IoP) for computers and other information processing equipment. The results of this simple sensitivity analysis was, under fairly extreme assumptions, to raise the index of production by 6% in total over 1995-1999, equivalent to an annualised growth rate difference in the whole economy of 0.3%. Work at the Bank of England has found similar results (Oulton, 2001) for computers, and explored the issue further looking at telecommunications and electronic components.

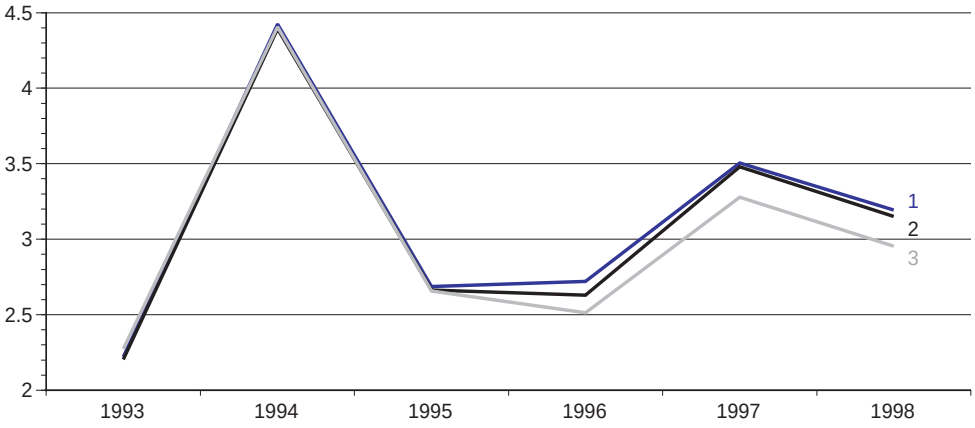
Schreyer (2000) considers the conceptual issues in such studies. He indicates how the overall impact on growth of using faster falling deflators is the sum of a number of different effects, some with a negative impact on growth. A fast falling deflator applied to a good that is part of final consumption and is domestically produced would raise GDP. However, this would be offset if a good is imported and enters production as an input.

Schreyer (2000) indicates the effect of chain-linking constant price estimates where the prices of some goods are falling rapidly. Though the rapidly falling price of computers is accompanied by rising volumes, the impact on total nominal expenditures on computers may be small or negative. Schreyer shows that the effect of chain-linking is then to reduce growth rates in comparison to analyses using base-weighted indices. This finding is borne out in the US research (Landefeld and Grimm, 2000) and UK research (Oulton, 2001). Currently, ONS is implementing a chain-linking project to convert national accounts aggregates from fixed weights to chained weights in 2003.

Results of sensitivity analysis using US ICT deflators on UK growth

The previous two sections have looked at the measurement issues surrounding ICT goods and services. The impact of the difference between ICT deflators on UK GDP is analysed in this section using two alternative techniques, both using US deflators to test the sensitivity of growth. The price indices considered are those for the goods: computers, electronic components and telecommunication equipment. The approach used in the ONS short-term output indicators review did not assess the impact of price falls on intermediate consumption. The first approach used includes the effect of deflating intermediate consumption. The section then looks at an alternative approach using UK expenditure data. It analyses the impact of using US price indices to replace the corresponding UK series

Chart 1
GVA whole economy growth: Output Approach
annual percentage change



Key:
1 – UK GVA growth replacing UK with US deflators for computers and telecomm;

2 – UK GVA growth replacing UK with US deflators for computers, telecomm and components;

3 – UK GVA growth, using UK deflators (ONS published series ABMM).

on the capital formation, consumer expenditure, exports and imports aggregates produced by ONS. Finally, the various approaches are discussed. It should be noted that the analysis uses the PPI for the UK before the revision referred to in Brand (2001), since the effect of the revision is yet to be felt within the national accounts. Further, the full national accounts balancing process takes account of the supply and demand of each product and this is not replicated in this sensitivity work.

Output approach

Output indicators are produced by the ONS monthly for production industries and Distribution industries, and quarterly for the rest of the economy (an experimental monthly index of services is also produced). A sample of firms in the production industries complete monthly production inquiry (MPI) forms. The data for the non-production firms come from a variety of sources. Many non-production sectors are surveyed by the ONS, but some industries are covered in returns made to other government departments, e.g. the construction industry is surveyed by DETR. Most surveyed firms are asked for the turnover of their business during the period. ONS uses this data to produce indices of gross value added (GVA). The turnover data is deflated using appropriate producer price indices (or other deflators) and then aggregated using weights based on value added of the industry in the base year (currently 1995). As part of the annual national accounts balancing process, an agreed annual growth in GDP in current prices is calculated using information from income, output and expenditure sources. The short-term output indicators are then aligned to the growth rate derived from the constant price expenditure measure of GDP.

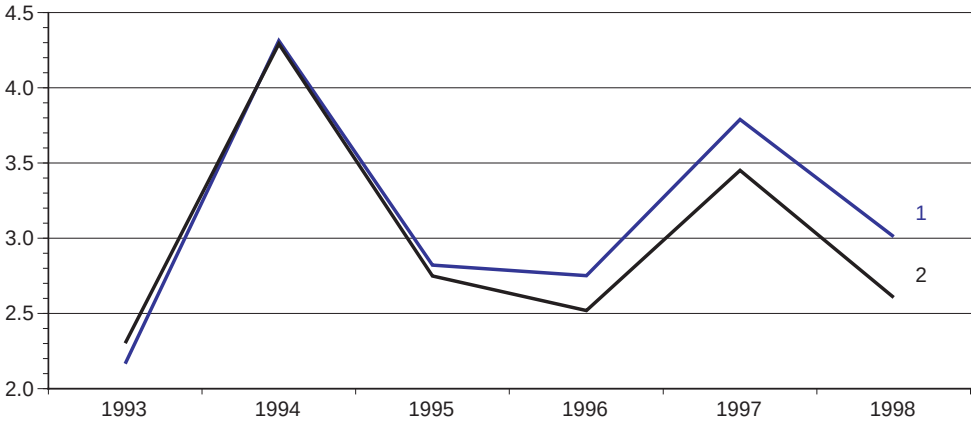
Replacing a deflator with a faster falling one is obviously going to increase growth of a short-term indicator. However, focusing on one sector – the electronic components industry – highlights the difficulty of this technique for assessing the impact of ICT goods on output. The UK is a net importer of electronic components in some years so the volume of imports is raised by the use of US deflators. Further, electronic components are intermediate consumption in the production process. Intuitively, a faster falling deflator would increase the volume of imported electronic components over and above the rise in the volume of UK production. The overall effect on UK growth due to changes in the prices of components should be negative.

This issue can be reconciled using double deflation, where both the output and the inputs of production are deflated, with the difference being a double deflated measure of value added. Currently, the ONS is developing constant price input-output tables where output and inputs are separately deflated. Using constant price input-output tables, output measures can be compared with deflated expenditure measures to give constant price GDP balanced at product and industry level. When analysing ICT goods and services, this disaggregated reconciliation is an ideal basis. The following section explores the change in this measure using US deflators for the ICT goods instead of the UK PPI. This is done at a more disaggregated level, following the double deflation approach.

The methodology used is necessarily a simple one. The domestic output of ICT products in current prices can be found in the supply-use tables. This can be deflated by the UK PPI and the alternative price measure with the difference in the two measures indicating the difference in the volume of domestically produced goods. The effect of changing the deflator on intermediate expenditures on ICT goods can be calculated by using a similar methodology on the total demand for ICT products as intermediates. This sums the value of components used as intermediate consumption across all industries. The constant price change in output less the constant price change in intermediates gives the change in gross value added resulting from the substitution of UK PPI's with the alternative deflators in the sensitivity analysis. This is added to the constant price GVA series. Chart 1 indicates the results.

The growth in the official published GVA series, at 1995 prices, is the lowest line on chart 1; it is compared to graphs of GVA estimates which

Chart 2
GDP Growth: Expenditure Approach
annual percentage change, year end



Key:
1 – UK Whole economy GDP growth using US deflators for computers, telecomm and components;

2 – UK Whole economy GDP growth, ONS published series ABMI.

replace UK PPI with US deflators for computers, and telecommunications equipment. The results prove smaller than that of the STOIR work, with growth raised by very little before 1995, but by 0.23% per annum afterwards. Using a second change series which adjusts for components as well, the change to growth 1995-98 is even more modest – no more than 0.17%. This is mainly because the approach used here can adjust for the imports of ICT goods. What is observed is that the intermediate expenditures on electronic components greatly exceeds the output of electronic components. This is much the same as saying that the UK is a net importer of electronic components as there is very little final consumption or capital formation in the products of that industry. In particular, the growth when only computers and telecomm equipment are deflated using US deflators can be compared to the situation when electronic components are included. Changes in growth are less when components are included.

Two assumptions underlie the results. Firstly, it is assumed that the composition of the intermediate goods is identical to total output. This allows the PPI to be used to deflate intermediate expenditures. This is essentially a weights issue and relies on the weights of industry outputs being similar to those of the intermediates. Generally, industries either produce final output or intermediate consumption goods. Therefore, for example, the output of the components industry is largely going to be used in intermediate consumption. The price movements should be close to the price movements of the components used as intermediates unless the composition of UK imports is very different to domestic production.

A second assumption is necessary on the appropriate treatment of wholesale and retail margins when deflating ICT goods at purchasers rather than producer prices. The current study assumes a deflator for the margin which does not reflect the steep decline of the ICT product price. Some adjustment for margins was made. The ICT margins, as given in the supply tables, were allocated to the UK output in proportion to the domestic share of supply of the good.

Expenditure approach

A common method to analyse the impact of US deflators has been to use the expenditure approach. ICT goods appear primarily in the capital formation and net exports part of final expenditure, though households remain a significant purchaser of computers. The deflation of these expenditures in national accounts is quite complex and the whole procedure is not replicated in this analysis. Instead, we use the supply-use table to deflate product expenditures firstly by the UK indices, then by the US. Some final expenditure – notably that made by consumers – is not deflated by PPI's and the appropriate RPI index has been used in this product. No attempt has been made to replace the RPI index by a US consumer price index. The difference is then added to the Blue Book GDP series (ABMI). The results of this analysis are indicated in chart 2 and indicates a growth rate difference of approximately 0.28% per annum for the period 1995-98 and negligible differences in 1993-95 means a small growth of 0.13% p.a. in the longer period of 1992-98. This is the largest difference of all the measures of impact in the paper. ICT expenditure does form a large portion of total expenditure. In 1995, expenditures on computers, components and telecomm products makes up about 1.9% of final expenditure, net of imports. This represents more than the amount of value added which was deflated using US deflators in the double deflation approach (chart 1) and indicates an explanation for why the expenditure approach gives the largest changes to the growth rate. In the output approach the amount of value added deflated by the ICT PPI's is less.

The explanation for this difference lies in the way the expenditure and output approaches treats the margins of the ICT industry. All expenditures on ICT are at purchaser prices, that is inclusive of retail and wholesale margins. The deflators for ICT goods are therefore applied to both the producer price of the good and the margins. The output approach does not deflate margins in the outputs of the industry. Also, the usage of the PPI

on intermediate expenditures means that the margins for intermediates are deflated by the ICT PPI's lessening the impact of the fast falling ICT deflators. The overall impact, without running a full constant price balancing process, would lie somewhere in the middle, perhaps somewhat closer to the expenditure approach given CPI's and PPI's move very similarly for the goods.

Issues regarding software investment

A number of studies have highlighted differences in the ratio of software to hardware capital expenditures across countries (Oulton 2001; Lequiller, 2001). These papers note that the typical US investment in computer hardware is accompanied by much larger investment in software than in the UK's, and in other major countries', national accounts. The 1995 European System of Accounts (ESA), moved software investment from intermediate consumption to gross capital formation, thus transferring the expenditures from intermediate consumption into value added. The US Bureau of Economic Analysis in the mid-1990s introduced similar changes to their National Income and Product Accounts. Development of software within a firm or organisation is also included in capital formation, with cost of production being a proxy for investment.

While the total output of the Computing services firms can be cross-checked against the total purchases of software, the allocation of purchases between capital and intermediate is more difficult. In the ESA, a good should be capitalised if its cost is greater than five hundred euros and the product lasts more than a year. When individual statistical agencies apply the ESA regulation to their accounts, the precise methodologies used have varied across countries and the implementation has also depended on the accuracy of the data reported by businesses. Overall software expenditures are quite large – in 1997 total demand for Computing services (industry 107 in UK supply-use tables, ONS, 1999) was 1.3% of UK total demand, which includes intermediate consumption. The classification of the expenditures can therefore have a significant impact on the level of GDP.

In the UK, firms now are asked the amount spent on capital goods, including computer software in their capital expenditure returns. They are asked to add the cost of producing software in-house. Telephone surveys in the mid-1990s found that firms had not always followed the instructions on the inclusion of software purchases in their capital expenditure returns (Rizki, 1999). However, own account software development was generally found to be under-reported. Rizki therefore provides details of how a consistent time-series investment is derived, taking account of these findings. An adjustment is then added to the returns made by firms regarding other software spends.

The US measurement technique is different (see Grimm and Parker, 1999). The level of software investment is identified through commodity flow analysis. Rather than exclusively relying on purchase data, the output of the software industry is used to identify capital goods. Within the Computing services industry, products that can be characterised as investment goods (e.g. software applications) can be distinguished from those products that are not (e.g. maintenance and servicing of hardware and software). The US then split the overall software investment figure into three categories:

- Packaged software
- Bespoke software
- Own account software

For the last category, the US uses the cost of production to estimate investment expenditures by valuing the main inputs into in-house software development, mainly labour.

There are some advantages to the US seller survey technique as it consistently identifies the products of computing services. However, there are also some advantages to the capital expenditure inquiry approach. By asking the firm the expenditures which it capitalises, the inquiry is closer to a firm's own valuation of software purchases. A number of complex measurement issues arise when categorising the purchases. The relative merits of the two approaches are currently being researched and this work will use the results of the new ONS surveys. The quarterly Capital Expenditure Surveys are now specifically asking respondents about software investment and the results will be published later in the year. The ONS has also recently surveyed computing services firms about the supply of software.

Conclusions

This paper reports on work following the ONS Quality Review of short-term output indicators. The report highlighted the impact US deflators for computers would have on UK growth as an extreme scenario to test sensitivity to ICT deflators. This paper has provided some results of further work in this area, using pre-revision UK PPI's. On the basis of the assumptions made, the impact on UK growth of using US deflators is about 0.1% per annum in 1992-98. This is much less than the figures indicated in the Short Term Output Indicators Review, and is similar in size to revisions made to GDP due to other methodological changes. The results should also be taken in the light that the US ICT prices are the fastest falling by some margin of all major countries.

The sensitivity of economic growth to the pace of price falls in ICT goods and services is well-known. This paper follows up and extends the results of earlier ONS work and other analysts. One conclusion of such work is very clear. Differences in the methods used for quality adjustment have

the scope to lead to non-trivial differences in growth rate comparisons between countries. ONS is currently engaged in examining quality adjustment methods for computers and some other key products.

A second key issue in this area is the difference between software output identified in capital formation estimates between countries. The UK estimates are about one third of the equivalent figures in the US, and further work is under way to understand the reason for this difference and if necessary to revise the UK estimates. To this end, the UK is currently investigating these issues with its European partners and in international work.

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Annex: Hedonic indexes, option/manufacturer costing and UK deflators

The United Kingdom approach makes quality adjustments in its PPI for improved computer quality - but in a different way to the United States approach. The United Kingdom uses two possible approaches (for all products). The preferred method for producer prices is to ask the manufacturer for an estimate of the cost of upgrading the specification. This amount is fully taken into account in the quality adjustment of the price. If this is not possible, the manufacturer will be asked for the price of the change as an option – this amount is then halved to take into account the economies of scale in production.

In the Retail Price Index, a similar option pricing method is used for computers. The cost of an additional option to the computer is obtained from list prices and a half of this is taken to reflect a situation where some consumers would not necessarily have chosen to purchase the option at the cost given.

Hedonic regressions are used in the US to estimate the value of a change in the characteristics of a product. Landefeld and Grimm (2000) note the increasing use of hedonics in the US – components where hedonics are used account for 18% of GDP. However, while use is widespread, the paper also notes that impact is concentrated in only a few goods (computers and peripherals being the main case). The hedonic approach is based on the general idea that many goods and services can be viewed as bundles of characteristics or features. Statistical techniques are used to estimate the implicit prices of the individual characteristics using data on observed prices in the market place. This is achieved through a regression that estimates the price of a good in terms of its characteristics.

The behaviour of the UK PPI and RPI indices for computers can be compared with the US Bureau of Economic Analysis deflator and a US matched model index regularly weighting together all prices, taken from Aizcorbe et al. (2000). This analysis is complex due to the differences of definition. However, taking 1995 average as 100, by 1999 the US PPI had reached a fifth of this. The matched model price index, by regularly up-dating the basket using quarterly data on both price and quantity, tracks true price movements better. The comparison indicates that the US hedonic index falls in a similar fashion to the matched model. However, more interesting is that the RPI index, which uses option costing for its quality adjustment, tracks the matched model similarly to the US deflator.

UK methods of quality adjustment are considerably less resource intensive than the hedonic method of quality adjusting. It does involve collection of characteristics with each price quote as, when there is a drop-out, the characteristics of the new good need to be compared to the old to value any change in features. However, as the values are determined from list prices or discussions with manufacturers, rather than regression, the number of price quotes used for estimating adjustment values is less. For the hedonic regression in June 1999, the Bureau of Labor Statistics used 685 observations (Holdway, 2000) to determine the adjustment factors for the characteristics of a computer. Such a regression may have to be repeated a number of times in a year because the market prices move so rapidly. The larger data required for the hedonic approach compares to the few dozen value measures needed in the UK method.

Nevertheless, ONS is currently engaged in examining hedonic methods for computers and some other key products. ONS believes that it may need to consider the adoption of such methods (if found reliable and practical) in a European context, to maintain consistency with other countries' national accounts.

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