EUROPEAN CENTRAL BANK

QUALITY ADJUSTMENT OF EUROPEAN PRICE STATISTICS AND THE ROLE FOR HEDONICS

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C O N T E N T S

ABSTRACT

In this paper we review the well-known problem of how to measure price developments when the quality of the underlying goods and services is changing over time. The importance of appropriate methods to take account of quality change is highlighted from the perspective of monetary policy. In particular, we highlight the need for credible and transparent price indicators. In this context, we review the hedonic approach to calculating quality-adjusted price indices and assess the available information on their effects as well as their potential for improving credibility and comparability. Current practices as regards quality adjustment in the European Union (EU) are also discussed, with particular emphasis on the Harmonised Index of Consumer Prices (HICP). Overall, we give a qualified endorsement of hedonics for specific product categories and make some suggestions about how the work on quality adjustment in the EU can be further developed, focusing in particular on the role of hedonics.

INTRODUCTION

In recent years there has been a renewed interest in the question of how well price statistics measure inflation. This renewed interest in the conceptual problems and practical challenges confronted by those seeking to accurately measure price developments is certainly to be welcomed. Policy-makers rely on the accuracy of price statistics in coming to their assessment of macroeconomic developments and, hence, in setting the course of policy.[1] Top of the list of major issues to be addressed is the problem of ensuring that price statistics accurately account for the dynamism in the quality of the goods and services that are traded in the economy. Although this challenge is not new, it has arguably become more pressing on account of the increased pace of innovation in the economy. Moreover, the need for harmonised price statistics in the EU – first in the run-up to the convergence assessment to Economic and Monetary Union and, since 1999, for the single monetary policy in the euro area – has encouraged the comparison of national practices, and thereby the discussion on quality adjustment methods.

The interest of central banks in quality adjustment stems from the important role that economic statistics, and price indicators in particular, play in helping them to ensure that the objectives of monetary policy are achieved.[2] In the case of the European Central Bank (ECB), the primary objective of monetary policy is the maintenance of price stability. In addition, as recently clarified in May 2003, the ECB's Governing Council has adopted a quantitative definition of price stability in terms of the euro area HICP. According to the Governing Council, price stability shall be defined as a year-on-year increase in the HICP for the euro area of "below but close to 2.0%".[3] In addition, the Governing Council stated that "price stability is to be maintained over the medium term". The definition serves at least two purposes. First, it helps in facilitating public understanding of the primary objective of monetary policy and, hence, of the monetary policy decisions geared towards achieving that objective. Second, the quantitative definition of

price stability can serve as an anchor for medium to long-term price expectations (e.g. in the context of wage negotiations or in settling financial contracts). The definition of price stability reflects the view that the HICP is a sufficiently reliable indicator for the definition to serve these purposes.[4] It was also concluded that "the HICP is the index that most closely approximates the changes over time in the price of a representative basket of consumer goods and services purchased by euro area households".[5] Clearly, however, to the extent that the underlying price measure may be distorted as a result of inadequate quality adjustment procedures, these functions can be undermined. Moreover, in a dynamic economy, where new varieties and new goods and services are being regularly introduced, such reliability cannot be taken for granted.[6] Reflecting on these considerations, the ECB has been an advocate of the need for further work on quality adjustment as an important priority for European price statistics.

In addition to the important role played by the HICP in defining the objectives of monetary policy, the ECB makes use of a wide range of euro area price indicators in its analysis of macroeconomic developments. These indicators include the HICP and its components, indicators of producer price developments at both an aggregate and industry level, export and

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1   Wynne and Rodriguez Palenzuela (2002) discuss some of the main reasons for the renewed interest in price measurement, while Camba Mendez, Gaspar and Wynne (2002) review the conclusions of a joint ECB/CEPR conference entitled "Measurement Issues in European Consumer Price Indices and the Conceptual Framework of the HICP".

2   Issing (2001) reviews the role played by statistics in monetary policy. Domingo Solans (2003) highlights the important role of Eurostat as the provider of euro area statistics for the monetary policy of the ECB.

3   See the ECB Press Release of 8 May 2003 and ECB (2003); the ECB also underlined at that time that the chosen definition also "addresses the issue of the possible presence of a measurement bias in the HICP".

4   See Issing (2001).

5   See ECB (2003).

6   Aside from these general considerations, as discussed in Wynne and Rodriguez Palenzuela (2002) and NRC (2002), such measurement issues become all the more relevant in the current economic context when inflation is low compared with previous episodes of economic history (e.g. the 1970s and 1980s).

import price indicators as well as the national account deflators. These price indicators play a key role in the regular and broadly based assessment of economic developments that is undertaken as part of the ECB's monetary policy strategy.[7] Once again, however, the reliability of this analysis is crucially dependent on the reliability of the underlying price statistics: any mismeasurement of price developments – especially if time-varying and correlated with the economic cycle – resulting from inappropriate quality adjustment or other measurement problems has the potential to cloud the ECB's assessment of macroeconomic developments.

In this paper we will review the challenges posed by the quality adjustment issue and provide some assessment of the role that hedonic methods may play in meeting those challenges. In addition, we try to provide some information and an assessment of current EU quality adjustment practices and suggest some directions for future improvements. In line with its central importance for euro area monetary policy, we mainly focus our discussion on the euro area HICP against the background of the harmonisation work that has been ongoing in the EU for some ten years now, and recent contributions to the discussion on quality adjustment outside the EU, in particular in other OECD countries. We give an overview and evaluation of the discussion and developments in price statistics from a user point of view, but do not attempt to estimate specific hedonic regressions. In particular, we do not attempt to estimate a potential measurement error in euro area HICPs due to perceived quality adjustment problems; this would require – in order to provide meaningful results – a far more detailed knowledge of and access to national data sources and practices.

This paper is structured as follows. In Section 1, the problem of quality change is defined and the enormity of the challenge posed to statisticians is discussed. Section 2 considers what we know about current quality adjustment practices in the EU and provides a preliminary assessment of the scope that may exist for improvements. In Section 3, the hedonic approach to quality adjustment is reviewed and an attempt is made to assess the implications of a more widespread use of hedonic techniques. We conclude with an overall assessment of the role that hedonic techniques should play and make some suggestions about how the quality adjustment agenda in Europe can be taken forward.

7   See ECB (2003).

I THE CHALLENGE POSED BY QUALITY CHANGE

When considering the challenge posed by quality change, it is useful to focus on a particular price index such as the HICP, although in principle most of what follows also applies to any other price index. The HICP is a Laspeyres-type index which attempts to measure the change in the prices of the different goods and services that are purchased by consumers in a given base period, *b*. The HICP can be defined as:

$$HICP_t = \sum_j w_{j,b} \left(\frac{p_{j,t}}{p_{j,b}} \right) \qquad (1)$$

where $w_{j,b}$ is the weight assigned to item *j* determined by the base period consumer expenditure shares and $p_{j,t}$ refers to the price of item *j* in period *t*. The need for quality adjustment arises whenever the mapping between current and base period products is not possible, or when the current period basket reflects new market developments.

One aspect of the HICP that is worth bearing in mind is that the HICP, as a measure of inflation, is conceptually close to a "cost of goods index" (COGI), which seeks to price the changes in a *fixed* basket of goods and services over time.[8] The coverage is defined in terms of the *household final monetary consumption expenditure* and it is updated regularly in each euro area country in order to ensure that it is representative of actual consumer behaviour (in practice at intervals of between one and five years, and with some differences as regards the level of detail at which the weight updates are made). The new price index associated with the current basket is then linked to the indices for earlier periods. The alternative "cost of living index" (COLI) theory was not adopted as the underlying conceptual framework.[9] In particular, the HICP does not aim at measuring the change in costs necessary to maintain a constant standard of living.[10] Another related conceptual feature of the HICP is that the measured prices are based on actual monetary transactions as opposed to using estimated prices to value the implicit price of the services provided by durable goods. Thus it treats durables (e.g. clothing, cars, household appliances) in the same way as non-durables. In contrast, given its focus on consumer welfare, a COLI values the service flow provided to consumers from the stock of durable goods that they are holding. In practice, however, these differences between the COLI and the HICP indices are smaller than might be expected because the flow of services concept is, with the exception of rents, difficult to implement and therefore not often applied.

One way in which the quality issue arises is as a result of *forced* and *non-comparable* replacements of the items included in the sample for the construction of (1) above. In a static world, where the quality of goods and services does not change over time, all of the price relative $p_{j,t}/p_{j,b}$ can and should be directly attributed to a change in price. However, in the actual dynamic environment new and improved varieties are regularly introduced, while old varieties are withdrawn or driven from the market place.[11] Under such circumstances, it is necessary to determine the extent to which the price change between the old variety and the new variety of a particular product is due to its new features rather than representing an actual or pure price change. In other words, the price change between the old (X) and the new variety (Y) must then be decomposed as:

$$P_{Y,t}/P_{X,t-1} = 1 + \pi + q \qquad (2)$$

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8   This labelling for a fixed-weight price index was used in the Report of the Committee on National Statistics (NRC, 2002).
9   See Astin (1999).
10 One implication of COLI theory is that it implies the use of a changing basket to take account of how consumers respond to relative price fluctuations. However, as has already been noted, the baskets for national HICPs are also revised, at intervals varying between one and five years in euro area countries. In addition, the required *annual* review of "critical" weights in national HICPs points to a preference for annual basket revision periods. In this respect, the difference in practice between the HICP and other consumer price indices which aim at measuring a COLI (such as the CPI in the United States) is less significant. For further conceptual discussions see also Triplett (2001) and Diewert (2002b).
11 Such replacements may arise on either a permanent basis (e.g. because the manufacturer has designed a new model and will no longer produce the older version) or a temporary basis (e.g. due to seasonal unavailability).

where π represents the element of pure price change and q represents the contribution of quality change.

In addition to the situation of forced replacements within the sample, quality change can also arise in other forms outside the sample (i.e. in the "universe" of products) and have to be, under certain conditions, reflected in the index.[12] In particular, *supplementary* – rather than replacement – goods may enter the market, which do not completely drive out existing goods.[13] Under such circumstances, the statistical agency could continue to compile a "matched model" price index, which discards the new supplementary good in its sample. However, to the extent that the price dynamics of these supplementary goods may differ from the average dynamics of the goods and services that are included in the index, such a "matched model" approach may mismeasure the actual inflation that consumers face.[14] Another way in which qualitative change can complicate the measurement of inflation is when a fundamentally *new good*, one without any clear predecessor, enters the market and satisfies a consumer need that has not been addressed by any previous good or service. VCRs, mobile phones and vaccines that treat a medical problem for the first time are examples of such "radical innovations".[15] The case of such new goods highlights the link between the issue of quality change and sampling. A regular sample review and replenishment is desirable to ensure a sufficiently representative and up-to-date sample which includes the new goods which have become available to consumers.

Very little data exists as to the severity and frequency of occurrence of the different forms of the quality problem in Europe. Nonetheless, the dynamic nature of modern economies, where differentiating and improving the quality of products and services seems to be a key element underpinning the process of economic growth, suggests that all three forms mentioned above are likely to be prevalent. In addition, the importance of quality change varies depending on the particular good or service in question.

Eurostat (2000) compiled, for selected HICP sub-indices, information on monthly replacement rates as well as on "implicit quality indices" (IQIs), which measure the quality adjustments made to raw price data.[16] Not surprisingly, in eight EU countries the highest average *monthly* replacement rates (between 8 and 14%) and quality adjustment effects were observed for electronic household goods, in particular computers (quality adjustment effect of 31% over a period of one year in seven EU countries). On the other hand, for clothing – and although the replacement rates were high (7%) – the quality adjustment effects were very small (0.1%). In a case study for Eurostat on PCs, Dalén (2002b) provides evidence that the monthly replacements with explicit and implicit quality adjustment vary between 3 and 44% across countries. In addition, replacements that were judged to be "essentially equivalent" and therefore did not lead to a quality adjustment reached up to 81% on average per month. In a simulation for the Netherlands, van Mulligen (2003) showed that between September 1999 and June 2000 monthly replacement rates for computers varied between 35 and 95%. Using scanner data for the UK, Silver and Heravi (2002) show that a matched model may deviate substantially from a model that seeks to maintain its representativeness, thereby implying that the quality issue is quite pervasive and potentially significant.[17] For the

12 Lane (2000) provides a five-fold classification of different types of new goods depending on the extent of the qualitative change and the impact on existing goods and services already in the market.

13 New varieties of breakfast cereals, analysed in Haussman (1997), provide a good example of supplementary goods.

14 Under a matched model approach price collectors record the prices of a sample of models or varieties of selected products existing in a given period and then continue to record the prices of these same products in subsequent periods. In this way a matched model approach can keep constant the qualitative features of the goods included in the price index but only at a potential cost in terms of becoming unrepresentative (see Silver and Heravi, 2002).

15 Lane (2000) suggests this terminology.

16 Note that most of the numbers quoted in what follows refer to replacements within the selected sample, but that information on the changes in the total of all sales is rare.

17 This study gives the example of washing machines where only 53% of the models available in January were still available in December. However, Silver and Heravi (2002) also conclude that such sample turnover is quite pervasive among many household appliances.

United States, the evidence suggests that quality change affects approximately 30% of all items that enter the US CPI in any given year.[18] In line with this evidence, and reflecting the likely variation in the extent of quality change across different goods and services, Gordon and Griliches (1997, p. 84) argue that an overall evaluation of the implications of quality change for price measurement must be conducted "down in the trenches, taking individual categories of consumer expenditure, assessing quality bias for each category and then aggregating using appropriate weights".

I.I QUALITY CHANGE: THE CONSUMER THEORY PERSPECTIVES

In addition to stressing its likely prevalence, the inherent complexity (some might suggest intractability) of undertaking the decomposition in (2) also deserves special note. When considering how to make this decomposition, the concept of efficiency units is of use. This approach helps convert differences in the quality of goods into equivalent differences in quantity. In some instances, this conversion can be made in a very straightforward and objective way. For example, it would be reasonable to claim that a new variety of battery that provides 30% more service life than an old variety was equivalent to 1.30 efficiency units of the old model. However, in many instances the conversion of qualitative aspects into corresponding quantitative units is often neither straightforward nor objective. In particular, the assessment of quality improvement seems inextricably linked to the preferences of consumers and, hence, inevitably contains a degree of subjectivity.[19] For example preferences are also likely to vary across consumers in the euro area and also over time. Moreover, the individual consumer's valuation of quality change may partly depend on whether the good is available widely to other consumers or more scarcely available only to a few. These factors all underline the complexity of the conceptual and practical challenges that the quality problem poses to the measurement of aggregate price statistics.

As mentioned above, the fact that the HICP has not adopted COLI theory as its conceptual basis has some implications for the quality adjustment problem. Three basic cases come to mind. First, the introduction of supplementary goods and new varieties, which expand the available set of choices that consumers can select from, arguably implies *per se* an increase in consumer welfare (and vice versa for reduced choices). A common cited example of this, highlighted by the Boskin Commission in the United States, is the availability of a greater variety of unprocessed foods all year round. COLI theory would seem to imply that this increased welfare due to a more abundant choice set or greater convenience should be taken into account by statisticians, implying a reduction in the measured cost of living *ceteris paribus*. While individually the contribution of such items to overall welfare may be small, when increased varieties across several product categories are considered such small contributions may accumulate and give rise to significant errors in measures of the cost of living.[20] Nonetheless, given that the HICP has not adopted a COLI approach, such overall consumer welfare effects would not seem relevant from its perspective.[21]

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18 See Moulton and Moses (1997). Klenow (2002) reports evidence for the different items included in the US CPI, suggesting that the problem of forced but non-comparable item replacements is highest for durable goods – in particular clothing – as opposed to non-durable goods and services.

19 Consumer theory suggests that the assessment of quality change can be tackled by considering the value that consumers would assign to different varieties. For example, recalling the decomposition in (2), suppose that consumers were indifferent between 1 unit of the new variety and $1+\Theta$ units of the old. Such an equivalence suggests a straightforward way of adjusting the observed price relative for quality change. In particular, when measured in terms of equivalent "efficiency units", the adjusted price of the new variety is given by $[P_{y,t}/(1+\Theta)]$. In principle, using this adjusted price for the new variety, it is relatively straightforward to derive estimates of the pure price change as well as (by default) the implicit contribution of quality. See Hulten (1997) for a further discussion.

20 The Boskin Commission arrived at an estimate of 0.6 percentage point *per annum* for the overstatement of price increases for fresh fruits and vegetables. See Table 1 in Moulton and Moses (1997).

21 Note that this does not imply that newly introduced varieties are not to be included in the HICP. They are to be included in order to ensure the sample representativeness, but their inclusion is not measured as a change in the price index until their transaction prices actually change.

A second implication of COLI theory relates to the introduction of fundamentally new goods which have no predecessor(s). In particular, it has been argued that the correct way to approximate the welfare gain associated with the introduction of a fundamentally new good in period *t* is to estimate the implicit price reduction compared with period *t-1*. Under this approach, the implicit price in period *t-1* is approximated as the price that would have driven demand for the new good to zero in that period.[22] From a COLI perspective, therefore, the exclusion of this implicit price reduction has often been highlighted as a source of upward bias in existing price indices. However, the potential COLI bias associated with the exclusion of these virtual price reductions has another corresponding bias in the form of virtual price increases associated with goods and services exiting the market. A failure to account for the implicit price increases of "exit goods" can give rise to a COLI bias in the index that may operate in the opposite direction to the new goods bias. Again, the incorporation of such "virtual" price changes would not seem consistent with the HICP's conceptual framework, given the focus on final monetary expenditures and measuring price changes for the goods and services in which consumers have actually transacted. Hoven (1999) quotes Walsh (1921) whose views seem to appropriately sum up the spirit of the HICP's approach: "If a commodity exists at one period and not at another, it must be omitted from any comparison of these two periods; for its price has not varied, it has merely appeared or disappeared".[23]

A third relevant implication of COLI theory is that durable goods should not be treated in an identical manner to non-durables. In particular, COLI theory would suggest that durable goods prices should be measured by the cost of *consuming* the good (i.e. their user cost). This reflects the idea that the consumer satisfaction obtained from durable goods can be spread over a period of time. In contrast, in the HICP, durable goods prices are measured by the transaction or purchase price.[24] As a result,

adjustments for a given improvement in quality are made on a one-off basis when the quality improvement has occurred and not distributed over the useful life of the durable good. This last distinction is of particular relevance given that quality improvements are very prevalent for durable goods.

Lastly, while this section has pointed to a number of differences in the prescriptions of the COLI theory for how to deal with quality change compared with what is appropriate for the HICP, it should be added that these differences have, at present, limited practical relevance in explaining differences between existing price statistics. The main reason for this is that the estimation of user cost or the welfare effects from wider consumer choice or new and disappearing goods is notoriously challenging and the results of such estimations are often deemed unreliable. As a result, statistical agencies seeking to approximate a COLI have been very reluctant to implement the prescriptions of consumer theory. There is also academic advice – such as that provided recently for the CPI in the United States (NRC 2002) – which calls for caution when moving towards introducing changes in welfare into price statistics. Barring a significant increase in the use of such estimates (e.g. due to greater confidence in the econometric methods needed to implement them), the *de facto* differences between the HICP and COLI indices will continue to be much less significant than they otherwise would be.

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22 See Haussman(1997).

23 Aside from the conceptual arguments against including virtual price changes in the HICP, there are major practical objections. In particular, for many goods and services the process of estimating the necessary consumer demand systems is data intensive, while the identification of the precise structure of consumer demand is subject to significant uncertainty and may require extensive judgement on the part of the modeller.

24 See Leifer (2001) for a discussion of alternative measurement concepts and arguments in favour of using transaction prices for durable consumer goods in an index used for measuring price stability.

I.2 QUALITY CHANGE AND THE SUPPLY SIDE

In addition to viewing the quality issue from the consumer's perspective, it is also useful to consider the problem from the supply side, i.e. from the firms' perspective.[25] Traditionally, economists like to think of firms as setting prices at a mark-up over marginal costs where the mark-up may fluctuate depending on a number of possible factors such as the degree of competition and/or, possibly, the level of demand. When a firm introduces a new and improved product variety, it is natural to expect that some of the price change compared with the old variety will reflect the added costs of the quality improvement. However, should quality adjustment practices take account of the impact of quality changes on a firm's costs? And, if so, how should these effects be taken into account in the construction of price indices?

Whether or not changes in production costs are relevant for quality adjustment has been a topic that has generated considerable discussion in price index literature. For consumer price indices, in line with the arguments outlined in the previous sub-section, it appears to be widely accepted that quality adjustment should be based on the change in "*user value*" or "*user functionality*" and not on the resource cost of delivering the quality improvement. Taking this view, the quality adjustment necessary for a new printer that is included in the HICP should not be based on estimated changes in its production costs but, rather, on the estimated value to a user from changes in the number of pages it can print in a given time, or any other qualitative changes.

The appropriateness of the user value criterion has also been formalised more generally for the class of input price indices (see Triplett, 1983). Examples of input price indices are estimates of the price of capital or labour inputs used for production, while a consumer price index can be viewed as a special case of an input price index for consumption. The appropriateness of the user value criterion is justified on theoretical grounds. In particular, in order to accurately

measure changes in the price of inputs, Triplett (1983) argues that it is necessary to hold output fixed. Hence, the correct quality adjustment for any input will be exactly equal to the value of the output change that is induced by changing that input's characteristics. By analogy, for a consumer price index such as a COLI, where the standard of living is held fixed, the correct quality adjustment will be exactly equal to the change in the user valuation that is implied by the change in the characteristics of the goods and services that are available to consumers.

In contrast, for the class of output price indices, such as a GDP deflator or a Producer Price Index, it has been shown that the appropriate quality adjustment should be made using the resource cost of the qualitative change. This result reflects the theoretical idea that an output price index requires inputs to be held fixed.[26] In line with this, Hulten (1997) also highlights the importance of measuring the sensitivity of a firm's costs with respect to quality change and argues that the extent of the appropriate quality adjustment will depend on this sensitivity. Hence, both the user value and the resource cost criterion would seem to have some theoretical justification depending on the particular measure of prices that is required.

In a competitive equilibrium, the resource cost and user value criterion should give identical results because market prices will equate with both marginal production costs and user valuation. In practice, in the presence of imperfect markets, the marginal production costs of a given quality change will normally differ from its user valuation. The two criteria would then imply different quality adjustments. This would suggest the need for caution when resource costs are used to proxy the user valuation of qualitative change for consumer price measurement. For example, it is common

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25 See Hulten (1997) and Triplett (1983).
26 See also Triplett (1983). However, according to Diewert (2002c), Triplett's result may be specific to the model of quality change that is chosen. Diewert (2002c) also develops a model of output price measurement under quality change where the appropriate adjustment is based on the user value criterion.

for firms to introduce new varieties at a premium price (high mark-up) that is gradually lowered through the product's life cycle. Under such circumstances, the resource costs of producing the new or improved good at introduction might not provide a reliable proxy for the value that consumers would place on the quality change. Importantly, the divergence between the resource costs and user valuation in practice can also give rise to two different quality adjustments for different sides of the same transaction (e.g. the production and purchase of a printer). This can give rise to inconsistencies in real economic accounts, because GDP from the production and expenditure sides would differ.[27]

The foregoing discussion suggests that the problem posed by quality change is closely linked to the question of how to assess the extent to which consumers value changes in the features of different products. In this regard, the conceptual basis of the HICP, in particular its focus on final monetary expenditures and on the prices of goods and services in which consumers actually transact, places some limits on the extent to which the welfare effects of quality change and new goods are incorporated into the index. This discussion also highlights the relevance of information from the supply side, i.e. changes in resource costs, when measuring output prices. However, in the case of consumer price measurement, there appears to be less theoretical justification for using the resource costs of supplying a given quality change as the relevant quality adjustment. It is also often unlikely to provide an appropriate approximation of user valuation in practice.

27 See Diewert (2002c).

2 QUALITY ADJUSTMENT IN EUROPE: A LOOK AT CURRENT PRACTICES

Notwithstanding the complexity of the task, statistical agencies cannot circumvent the challenge posed by quality change. As a result, a number of quality adjustment procedures exist and are regularly used. In this section we try to summarise what is currently known about quality adjustment practices in the EU and provide some assessment of the scope that exists for improving the current situation.

2.1 OVERVIEW OF QUALITY ADJUSTMENT TECHNIQUES IN PRICE STATISTICS

As a reference for this discussion, Table 1 provides an overview of the main quality adjustment methods, their nomenclature and

underlying assumptions. All of these methods are used in practice, and most of them for the adjustment of certain HICP sub-indices. The methods may be appropriate if their underlying assumptions are met, but they run the risk of mismeasurement if the assumptions are not met. It should be noted that this overview is not exhaustive but rather gives the main methodological categories. Further methods as well as variants of the described methods exist. Moreover, differences in terminology exist within the literature and this sometimes hinders fruitful discussion and analysis of the alternatives.[28] Lastly, in the literature on quality

28 For a more detailed discussion of all quality adjustment methods see Dalén (2002a), NRC (2002) or Triplett (2002).

Table 1 Overview of selected quality adjustment methods

Method	Description	Main assumption
Implicit methods		
Direct price comparison	New and old items directly compared over two adjacent periods	No quality change
Link-to-show-no-price-change	New and old items linked across two adjacent periods	Price change equals quality change
Simple overlap	New item replaces old item in overlap period	Price difference between new and old item equals quality difference; competitive markets
Bridged overlap	New item replaces old item, but price change is inferred from ongoing items	Price changes of ongoing product-offers equal to "hidden" price change of changing offer
Class mean imputation	Variant of the bridged overlap method; only (quality-adjusted) price changes of other non-matched items used	Quality-adjusted price change of other non-matched items equal to those of replaced item
Monthly chaining and re-sampling	Variant of the overlap method; only matched models of two adjacent periods are compared, samples are updated monthly and results linked	Price change of matched models is equal to the true, but unknown, price change of unmatched models.
Explicit methods		
Hedonic regression	Regression analysis of product characteristics and price differentials	Chosen characteristics reflect consumer valuation, no rapid changes in taste; competitive markets
Option costs	New item incorporates features formerly available as option at additional cost	Chosen (fraction of) option cost reflects implicit price in new item, no rapid changes in consumer taste
Price collector or expert adjustment	Decentralised or centralised judgemental adjustment	Judgemental valuation correctly reflects changes in functionality

change, it is common to find references to the matched model method (discussed in the previous section) as a standard practice to deal with quality change. However, the matched model method should not be considered as a quality adjustment technique. Certainly a matched model controls for quality change by only focussing on identical or similar goods through time. However, rather than adjusting for changes in the quality of goods through time, the matched model approach essentially ignores such changes and therefore suffers from being unrepresentative when the characteristics of the underlying goods and services that are being traded in the economy are changing.

Two broad approaches to the problem of quality adjustment exist. One frequently used class of methods seeks to incorporate the new varieties into the index without any explicit attempt to value the new features of the product. These *implicit* quality adjustment methods link the prices of new varieties into the index under various assumptions. In the *direct price comparison method* (comparing prices of the old and the new product over two periods without adjustment) the quality difference is assumed or judged to be zero. Accordingly, the method should be applied mainly when quality differences are insignificant. Bias occurs if this assumption is not met. The opposite assumption is made for the *link-to-show-no-price-change method*; it assumes zero price change from the last to the current period, i.e. the full price difference between old and new products over two periods are assumed to be quality differences. In this case, the potential measurement error arises because some of the observed price difference may not just reflect differences in quality.

Four variants of the *overlap method* are distinguished. They all assume that the quality differences are equal to price differences in the overlapping period. The result of the method therefore depends on the timing of the replacement in the sample. When disappearing products are sold at sales prices, the method

tends to produce a downward bias; when products disappear from the market because they were offered at (overly) high prices, the index is upward biased. The *simple overlap method* links old and new models in the overlap period, but can only be applied if the two products are available in the market simultaneously (which is often not the case). Frequently applied is the *bridged overlap* method. It derives the price change between the old and new item from the observed price change of other items in the sub-index. The quality of this method depends on whether the price change of these other items, i.e. the "bridge products", resembles the price difference between the old and new items. This is not always the case: for example, price increases or decreases may be mainly introduced to the market via product innovation. In this case the *class mean imputation method* may produce better estimates, since it derives the estimate for the quality-adjusted price change from other non-matched items which are either essentially equivalent in quality or which are adjusted for quality change. Finally, the *monthly/frequent chaining and resampling method* (also called "resampling overlap") aims to ensure that one of the conditions for an unbiased result of the overlap method is met, namely the overlapping of new and old prices at "normal" market conditions in which price differentials may be considered as an acceptable estimate of quality differences. This method is resource-intensive because the data requirements for the frequent sample updates are high.

Technical developments such as the existence of scanner data may potentially facilitate the use of overlap methods and make the results more reliable.[29] Since scanner data provides information on a very high number of transactions, if not the "universe" of transactions, it can be used to improve the sampling procedure and to introduce product replacements to the sample at a point in time that satisfies the "normal" market condition assumption. This also points to the fact that, in

29 See Feenstra and Shapiro (2003) for a discussion of scanner data and price indices.

practice, quality adjustment and sampling issues are closely related, since sample update and the use of the overlap method often go together.

The other main class of approaches – which includes hedonic methods – seeks to explicitly evaluate quality changes. *Hedonic methods* use regression analysis to assess the extent to which the observed variability in the price of a product can be explained by variability in the product's characteristics. In other words, hedonic methods confront the quality adjustment problem "head-on", through a rigorous statistical analysis of the extent to which variation in product features can explain changes in the prices of different product varieties. If z_i is a set of characteristics belonging to the i*th* variety of a particular good, and using $p_{i,t}$ to denote the price of the i*th* variety in period *t*, the hedonic function (H_t), applicable in period t, can be written:

$$p_{i,t} = H_t(z_i) \qquad\qquad (3)$$

The hedonic function in (3) can be used to estimate a quality-adjusted price in a variety of ways.[30] In essence, all approaches attempt to use the estimated parameters of the hedonic function in order to put a value on any change in the characteristics between an old and a new model.[31] The data requirements for hedonic methods are often demanding, as very detailed and up-to date information on specific product features is necessary. Potential sources for this information are, in practice, supplier information (e.g. collected via the Internet), information provided by market intelligence companies, and information available from scanner data sources.

Option cost adjustment estimates the value of the quality adjustment for a new product feature on the basis of the market price of that feature observed as a separate option in earlier periods. In practice, option cost adjustment is applied for high-value consumer durables, in particular cars. Since not all consumers decided to buy the option in the past, and since (as a result of economies of scale) the unit price may be expected to decrease when an option is made standard, usually a certain fraction (e.g. 50%) of the option price is used for quality adjustment. The potential measurement error of this method depends on whether or not these assumptions are appropriate.

Judgemental adjustment by price collectors based on guidelines agreed with the statistical agency or *centralised expert judgement* also fall into the category of explicit quality adjustment. These methods are difficult to assess, because they are not formalised. Dalén (2002a) lists some pre-conditions for good results, in particular the selection, instruction and monitoring of price collectors, and the technical and market knowledge of the product expert who is required to value the technical changes. Option cost adjustment, perhaps even judgemental adjustments, may be considered from a conceptual viewpoint as being (cruder or approximate) applications of the basic idea underlying the hedonic approach, namely to value individual product characteristics and adjust prices for changes in these. Moreover, there may be situations where the hedonic approach fails, but where judgemental and option cost adjustment lead to justifiable results.

2.2 EU RULES FOR QUALITY ADJUSTMENT

Given the wide variety of quality adjustment methods that can be applied in practice, since the mid-1990s some efforts have been made at the European level to provide regulatory guidance. The following regulations have been adopted for the HICP:[32]

1. Quality adjustment should be based on *explicit* estimates;

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30 See NRC (2002).
31 In the next section of the paper we provide a more thorough assessment of hedonic methods.
32 European Commission (1997).

2. In the absence of national estimates, national statistical institutes should use estimates provided by Eurostat where available;

3. Where no estimates are available, the *direct price comparison* method shall be used;

4. The *link-to-show-no-price-change method* shall be used only in justified cases;

5. Replacements for sales items should be selected according to the similarity of their utility rather than the similarity of their price.

Although these rules are described as *minimum standards*, they include some rather concrete guidance that deserves discussion. The preference for "*explicit estimates*" could be interpreted as an argument supporting the use of hedonic methods (as well as other explicit methods listed in Table 1). However, there is perhaps some ambiguity since it is possible and commonplace to derive from implicit *methods* (e.g. the bridged overlap method) an explicit *estimate* for price and quality changes of non-matched items. Hence, some further clarification on this point seems necessary. The second rule (Eurostat supplies quality adjustment estimates) has not been applied in practice yet, but it could become more relevant in the future. First, consideration will be given to following-up the work done by Eurostat's European Hedonic Centre (EHC) with the intention of giving methodological and practical support to EU countries for implementing hedonic methods. In addition, Eurostat has been planning for some time to establish a centralised database containing information relevant for HICP quality adjustment that could be used by the Member States (e.g. information about quality adjustment made for new cars). The third rule appears to be problematic, given that explicit estimates are, in practice, often lacking and direct price comparison may lead to bias if the quality change is significant. In such a case, for example, the bridged overlap method appears to be preferable to the direct price comparison method. Finally, the fourth and the

fifth quality adjustment rules are specific requirements aiming to avoid bias which may occur as a result of the frequent use of overlap linking as well as the undesirable replacement of disappearing sales items by items with a low price rather than similar product features.

At present, further guidelines for quality adjustment in HICPs are under discussion between Eurostat and national statistical institutes. They aim at establishing so-called A, B and C methods, i.e. reference methods (A), accepted methods (B) and non-recommended methods (C). Whilst the details are not yet agreed, the discussions appear to converge in two main directions: first, there is agreement that product-specific rules have to be set up (e.g. for PCs, clothing, books, cars); and second, there is a tendency to adopt the hedonic method as a reference method for many of the products under discussion. This would not necessarily imply that the hedonic method should always be used, but the other methods are accepted only if it is proven that their results are not expected to differ systematically from hedonic methods.

Quality adjustment guidelines have also been defined for the EU national accounts, although they are of a rather general nature.[33] In line with the HICP regulations, these express a preference for explicit quality adjustment methods including hedonic methods. For other EU price statistics (i.e. producer and export price indices) quality adjustment requirements either do not exist or are not very specific at EU level. For producer price indices the EU regulation states that "the output price index should take into account quality changes in products", but contains no further details or guidance.[34] However, this does not rule out quite specific guidelines existing at the national level.

The situation described above derives from the fact that euro area and EU price statistics are compiled as a (weighted) average of national

33 Eurostat (2001).
34 European Commission (2001).

price statistics, which follow agreed regulations or guidelines. For these, the approach has been to define at European level the desired *output* ("comparable results") rather than to prescribe the *input* to price statistics, as for example data sources or adjustment techniques. Several years of discussion on quality adjustment harmonisation of HICPs have, however, shown that a pure output harmonisation approach is not sufficient to achieve comparability. A closer co-ordination and harmonisation of the inputs for price statistics therefore seems necessary.

2.3 EU PRACTICES FOR QUALITY ADJUSTMENT AND HEDONIC METHODS

Aside from the regulatory framework, what do we know about the actual application of hedonic quality adjustment methods within the EU and, more particularly, within the euro area?

For the HICP, the available information indicates that hedonic methods are now used by ten EU (seven euro area) countries, although the number of products for which hedonic adjustment is used is still small (see the table in the Annex). However, some countries are studying and, depending on the outcome, plan to implement hedonic methods for selected items. The products concerned may be grouped in four classes. Electronic consumer durables (PCs, washing machines, dishwashers and TVs) are adjusted by hedonic regression in Germany, Spain, France and the United Kingdom. New and/or used cars are adjusted in Germany, the Netherlands, Finland, and Sweden. Hedonics are used for all garments in Sweden and men's shirts in France. Finally, best-seller books are adjusted by hedonic regression in France and Austria. Germany, Spain, Austria and the United Kingdom introduced hedonic adjustment only recently, while in the other countries where it is used hedonic adjustment was introduced between 1987 and 2000. Overall, however, the total weight of all products that are adjusted by hedonic methods in the HICP is still small, accounting for less than 0.5% of the all-item euro area HICP.
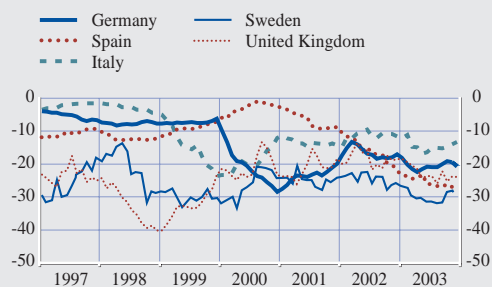
Detailed information on alternative quality adjustment methods used for the adjustment of PCs in HICPs was recently collected by Dalén (2002b). Only two countries (Germany and the UK) are now using hedonic methods for PCs. While some countries use option price methods or judgemental adjustment (i.e. explicit methods), in the majority of cases different variants of the overlap methods are used (implicit adjustment). Four of these countries plan to evaluate and possibly implement hedonic methods for PCs. Although it might be argued that national market and consumption specificities warrant different quality adjustment procedures for some goods, this would not seem likely to apply to PCs given that they are widely traded across national boundaries. Such diversity in the approaches used may instead provide an indication that there is further scope for more harmonisation. A comparison of PC price developments shows large divergences between EU countries (see Chart 1). These divergences were most prominent in the period prior to 1999, but since then, perhaps reflecting changes in sampling and quality adjustment practices, national price data for PCs have converged somewhat.

Clothing is another HICP component where hedonic methods are applied (France, and in particular Sweden). Most other countries probably use either implicit or judgemental methods for clothing quality adjustment. Simulations have shown significant discrepancies between different methods (Eurostat, 2002) and the HICP data appear to confirm this (see Chart 2). Similar to the case of PCs, the spread of the observed price developments is very high and may therefore reflect the chosen quality adjustment method rather than actual price developments.

Apart from the cases reported here in which countries have decided to introduce hedonic methods, it should also be noted that there are cases where tests carried out by statistical institutes did not lead to the adoption of the hedonic method. Germany has tested hedonic methods for new cars, but decided to continue to use cost/option pricing given that this could
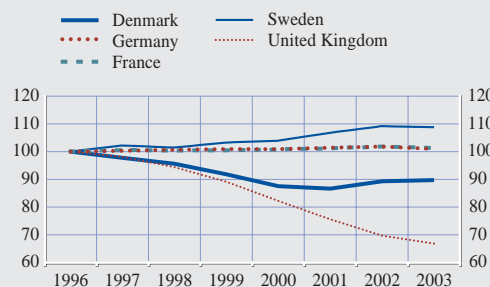
(annual percentage changes, monthly data)

Germany — Sweden
Spain — United Kingdom
Italy

Source: Eurostat.

(1996 = 100, annual averages)

Denmark — Sweden
Germany — United Kingdom
France

Source: Eurostat.

be implemented at lower cost and gives similar results (although hedonic methods have been implemented recently for used cars[35]).
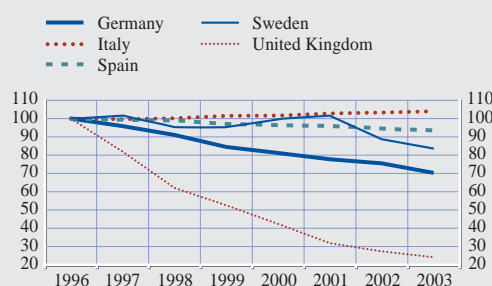
Reflecting the lack of any clear quality adjustment rules and their early stage of harmonisation, very little is known about national practices for producer, export and import price indices (as well as derived national accounts deflators) in the EU. For producer prices, France, Sweden and (since recently) the UK use hedonic adjustment for computers. Germany plans to implement hedonic methods in 2004 for three information technology sub-indices in producer export and import prices. Information on other quality adjustment practices used for PPIs is not available at the European level, a situation which is not

satisfactory. Available results of these indices indicate that discrepancies between national PPIs are no less significant than for consumer price indices (see Chart 3), and the large differences between the CPI, PPI and export and import price indices may also be due to the divergences in quality adjustment practice. In particular, the recent changes to quality adjustment procedures in some CPI sub-indices mentioned previously may have introduced new discrepancies with other related price statistics for which these changes have not been introduced yet. Chart 4 shows this for the example of alternative German price indices for computers, but it should be noted that the situation for other countries is expected to be similar.

35 See Linz (2003).

(1996 = 100, annual averages)

Germany — Sweden
Italy — United Kingdom
Spain

Source: Eurostat.

(1996 = 100, monthly data)

PPI (domestic sales) — Export price index
Import price index — HICP
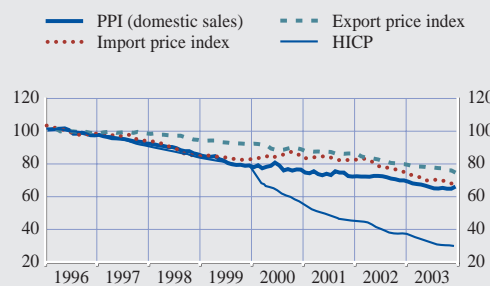
Source: Eurostat, Statistisches Bundesamt.

3 A CRITICAL OVERVIEW OF THE HEDONIC APPROACH FROM A USER POINT OF VIEW

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In recent times, some statistical agencies – particularly in the United States – have increasingly turned to hedonic techniques. As outlined in the previous section, the application of hedonic methods has been less prominent in Europe. This raises the question of whether or not a more widespread application of hedonic methods could be part of the further improvement and harmonisation of quality adjustment practices in the EU. In order to address this question, this section evaluates hedonic methods from the point of view of an intensive user of euro area price statistics. In this evaluation, the main issues raised are: (i) What is the economic rationale for the application of hedonic methods?; (ii) What is the notion of quality implicit in hedonic methods?; (iii) Might the application of hedonic methods change the economic interpretation of existing price indices such as the HICP?; (iv) What do we know at present about the effect of hedonic methods on price indices?; and, lastly (v) Will a more widespread use of hedonic methods improve the objectivity, transparency and comparability of euro area price indicators?

3.1 ECONOMIC RATIONALE

A key advantage of the hedonic approach compared with other quality adjustment techniques is its well-developed underlying economic foundations that provide a framework for understanding and assessing the implications of hedonic analysis. The central economic idea underlying the use of hedonic techniques is that heterogeneous goods can best be thought of as bundles of characteristics.[36] As a result, under the hedonic approach, the economic behaviour of firms and consumers is assumed to relate to these characteristics. Consumers can be thought of as deriving utility not from goods *per se* but rather from the bundle of characteristics that goods provide. Similarly, firms are assumed to make their production decisions with a view to maximising their profits and in terms of the characteristics they attach to their output. Summarising these ideas, Triplett (2002) states "the theory of

hedonic indexes is built on the proposition that the characteristics are the variables that the buyers of the product want, and the characteristics of the product also are costly to produce" (p. 39).

Of course, under normal circumstances, neither firms nor consumers can transact in terms of characteristics and, hence, the price of different characteristics is unobservable.[37] The hedonic function (3) provides a way of disaggregating the bundle of characteristics contained in any given product in order to determine the price of those characteristics. In line with this interpretation, under a number of strong "perfect market" assumptions[38], it can be shown how the hedonic function defines the minimum price associated with a given bundle of characteristics. In other words, the hedonic function can be seen as something akin to the consumer's budget constraint, with the estimated coefficients providing estimates of the unobserved price of the characteristics. Under the assumption of pure competition, these implicit prices will be equal to the marginal value assigned to them by consumers and to the marginal costs of supplying them.[39]

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36 See Triplett (1987).

37 Many "customised" transactions do take place which approximate a situation where firms and consumers transact in terms of characteristics. For example, a consumer purchasing a car is normally presented with a list of optional features, and their prices, from which to choose.

38 In particular, consumers are assumed to have a continuous and large spectrum of characteristic combinations from which they can choose. Consumers are also assumed to have full information about the quality of different goods and their prices. As an alternative to the definition of consumer preferences over any *conceivable* spectrum of characteristics, discrete choice models focus on *existing* product variants when considering consumer behaviour. Jonker (2002) provides a review of discrete choice models and their application to price measurement.

39 See Rosen (1974). In line with this interpretation, Rosen also shows that, except under very specific assumptions, hedonic functions do not allow the identification of the characteristic demand and supply functions. As a result, it is not possible to uncover from an estimated hedonic function the structure of consumers' preferences for different characteristics or the production technology (e.g. cost or profit functions) of firms producing differentiated goods. This seems of practical importance given that the discussion in Section 2 highlighted the relevance of such information for quality adjustment.

Importantly, deviations from these pure competition assumptions – which are likely to be quite important in practice – have implications for the interpretation and application of hedonic techniques.[40] As discussed by a number of authors (e.g. Berndt, 1991 and Diewert, 2002a), a first implication is that the hedonic relationship is likely to be non-linear, thereby complicating the model identification process. Second, under imperfect competition, where firms can have pricing power and can price-discriminate among consumers, the coefficients of the hedonic regression will also include the supplier's profit mark-up. As a result, changes in mark-ups associated with different product life cycle pricing strategies or changes in competitive forces can give rise to unstable coefficients in hedonic regressions. Reflecting these considerations, it has been pointed out that hedonic regression coefficients may require further adjustment in order to measure the precise contribution of quality change.[41] Arguing in this vein, Hobijn (2001) underlines the possible effect of market imperfections: in his example, mark-ups are positively correlated with technical features and, as a result, hedonic methods focusing on technical features run the risk of over-adjusting for quality changes.

3.2 THE HEDONIC NOTION OF QUALITY

A common criticism of hedonic methods is that they imply a somewhat restricted notion of quality. Hedonic methods use observable product characteristics and price differences between products to derive measures of quality differences. The relationship between product characteristics and price is therefore essential. "Relevant" quality characteristics can only be those that, on average, yield price differences. Other factors, which may be perceived by the consumer or by the price collector as important determinants of product quality but which are not in fact associated with price dispersion within the regression sample, will not yield significant hedonic coefficients and, hence, will not have any impact on the measured price

change. For example, the recent extension to two years of the guarantee for consumer electronics and other durables in the EU may be considered as a quality improvement, but this would be very difficult to capture in a hedonic model. Moreover, in the hedonic approach, "relevant" characteristics must be unambiguously identifiable. These are often the technical features of a product such as the performance, colour or availability/non-availability of a certain option. Non-technical features – such as image or taste – which may influence the price-setting of the producer or consumer demand are difficult to measure and are, therefore, regularly excluded from hedonic models or estimated by proxy variables such as brand name. Practical application of the hedonic method using regression analysis normally assumes the separability of the characteristics, which is in practice often not a justified assumption (e.g. the higher speed of a PC only helps if the software and internet connection improves in parallel).

Overall, the focus of hedonic methods on technical characteristics implies that they are used mainly for the adjustment of goods, and hardly ever used for the adjustment of consumer services. However, while pointing to the limits of hedonics, these shortcomings should not be overemphasised, because they also apply to other explicit quality adjustment methods.

3.3 IMPLICATIONS FOR INDEX CONCEPTS

When assessing the role that hedonics should play in the quality adjustment of euro area price data, a further issue is whether or not hedonic methods belong to one or other of the two main particular conceptual groups, i.e. to either the COLI or the HICP (which is closer to a COGI). In considering this question, it is worth

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40 Triplett (2002) gives examples of market imperfections which may affect the interpretation of characteristics and price differentials (e.g. government regulation changing the meaning of resource costs, or pricing on the basis of estimated demand elasticities rather than costs).
41 See Feenstra (1995).

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recalling the discussion in Section 1. Although the COLI theory may have some prescriptions for quality adjustments that would not be appropriate for the HICP (e.g. virtual price changes), the need to adjust for quality change in the event of replacements also exists for the HICP. Hedonic methods offer one possible solution to this need. On this question, the US Committee on National Statistics (NRC, 2002) has also concluded along similar lines (pp. 4-15): "Hedonics essentially replace the price of goods with the price of bundles of characteristics. It is essential to note that hedonic techniques expose a purely empirical relationship between prices and variation among different models of a good. The results of hedonic regressions can be used in either a COGI or a COLI framework". In line with this view, hedonic methods have been implemented both by producers of price statistics aiming to measure a COLI (US) as well as by COGI proponents (DE, UK). Recently, although still not widely implemented, hedonic methods have also been described by Eurostat (2003) as an "a priori default method" (p.10) for quality adjustment in the context of the HICP on the "grounds of a pragmatic valuation of changes or differences in user functionality of product offers serving the same basic purpose". It therefore appears that a broad consensus on the merits of hedonic methods exists across different conceptual "camps" of price indices, a consensus that seems to increase as the experience with hedonic methods grows.

3.4 EVIDENCE OF THE IMPACT OF HEDONIC METHODS ON MEASURED PRICES

Quality adjustment procedures should be selected only on the basis of their theoretical and empirical properties. As a result, the risk that the introduction of a given methodology might result in revisions to inflation data is not a reason to reject it. Nonetheless, for users of price statistics it is also important to know whether or not the use of hedonic methods may have a significant and systematic effect on aggregate inflation data. Moreover, by

comparing the outcome of alternative hedonic calculations one may derive information on whether or not a more widespread use of hedonic methods may – per se – help to improve cross-country comparability, or what the preconditions for such an improvement would be.

In the perceptions of many, hedonic methods are thought to yield lower results than other methods and reduce a perceived upward bias in price indices. Sometimes it is even suggested that the more widespread application of hedonic methods would actually represent the *introduction* of quality adjustment. However, as discussed in Section 2, a number of other procedures are already used extensively. Since such techniques might also over- rather than under-adjust for quality change, it is at least not *a priori* clear whether current euro area price statistics understate the true rate of quality increase. The likely impact of a more widespread use of hedonic methods will therefore depend on whether and to what extent any hedonic quality adjustment differs from the quality adjustment already being performed.

In line with this, the empirical evidence suggests that it may be premature to conclude that a more widespread use of hedonics would necessarily result in a downward "correction" of price data. On the one hand, for those items for which hedonic methods are most intensively used – a few consumer high-tech durables – most early studies showed that hedonic methods resulted in steeper price decreases than traditional indices. However, the differences vary considerably. Using hedonic methods, the UK's statistical office found steeper price decreases for PCs in PPIs and also for HICPs.[42] Dalén (2002b), in a study for Eurostat on PCs, showed strongly varying results for European countries. According to Linz and Eckert (2002), PC prices in the German HICP adjusted with hedonic methods have shown minor differences compared with the option price adjustment applied since 2001. However, significantly

42 See Ball and Allen (2003).

steeper price decreases were observed using hedonic methods than were observed with the matched model method used before (see also Chart 4 above). On the other hand, a recent study for the Dutch CPI concluded that hedonic indices – when applied to the CPI sample – yields higher computer price indices than published.[43]

In addition to this varying evidence relating to PCs, it is important to keep in mind that the extension of hedonic methods to other goods or even services which often have a much higher index weight might have opposite effects. For new cars, the German statistical office found no significant differences between cost-based option pricing and hedonic methods. For used cars, however, the results adjusted by hedonic methods showed significantly higher price increases than the previous quality adjustment method (overlap) and have therefore replaced the old method.[44] This underlines the fact that the effect of a hedonic method depends on the method it replaces. The simulations for Swedish clothing in Statistik Austria (2002) suggest that hedonic methods may avoid a downward bias that is implied by often-used overlap methods, i.e. they would result in an upward correction of clothing prices (see also the Swedish – hedonic adjusted – series in Chart 2 above). For rents, Hoffmann and Kurz (2002) found no evidence of a permanent and substantial quality bias in the German CPI, but did find indications that hedonic methods would give higher inflation rates than official statistics for periods when rent inflation was accelerating. In a study for Eurostat on televisions and dishwashers, the differences between bridged overlap methods and hedonic methods were found to be very small.[45] Finally, for the United States the NRC study concluded that the recent extension of hedonic adjustments in the CPI had had little impact on measured CPI results – with the exception of PCs – because they tend to "wash out" relative to those adjustments used previously (NRC, 2002).

Overall, this suggests that more evidence is needed before making a firm assessment of the directional effect of a more widespread use of hedonic adjustments on aggregate inflation figures. In particular, the likely impact can only be assessed with more knowledge of the effect of the methods that are currently in use. Moreover, other, "secondary" factors should not be disregarded when comparing the outcome of alternative quality adjustment methods. Rather than differences in the quality adjustment methodology, some of the differences between "new" hedonic and "old" non-hedonic adjustments may also reflect differences in data sources and the related sampling and replacement procedures, i.e. in particular the extent and timing of new product entries and old product removals. Importantly, it may be argued that hedonic methods may also bring advantages for these aspects of price measurement because, on account of the required large sample, the required market expertise and thorough assessment of product characteristics, both sampling and quality adjustment practices may improve simultaneously.[46]

3.5 OBJECTIVITY, TRANSPARENCY AND COMPARABILITY

From the perspective of the users of price statistics, an important issue is the extent to which the more widespread use of hedonic methods will improve the credibility of these indicators. If quality adjustment is based on procedures that lack transparency and/or on unsupported subjective judgement rather than

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43 See van Mulligen (2003).
44 See Linz (2003). Although no exact numbers were published for a historical comparison of the two indices, a graphical comparison of the two indices suggests that the index according to the new hedonic method increased by about 3% between mid-2000 and mid-2003, while the index according to the previous method decreased by about 3%.
45 See Eurostat (2002). For the United States, Moulton (2001) mentions sub-indices in the US CPI for which hedonic methods have led to higher price increases (apparel, video recorders) or were even designed to correct for a downward bias (rents).
46 Moulton (2001) confirms that hedonic research has led to improvements in sampling methods and replacement strategies in US price statistics and are considered a useful tool "whether used in the background as a guide to application of the matched model methods, or used directly in making quality adjustments for sample items that are being replaced".

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objective criteria then this has the potential to undermine the credibility of price data. Moreover, from the perspective of euro area price statistics, comparability of the different approaches used to adjust for quality change at a national level represents an additional required feature.

Hedonic methods are often cited as holding out the prospect of better objectivity and transparency – and even reproducibility – of quality adjustment procedures. However, as with many procedures in index compilation, hedonic methods also involve many judgemental elements. These judgements arise in any empirical estimation and concern the sample selection, the choice of the regression function and variables as well as the chosen method for constructing a price index from a given hedonic regression.[47] These choices may be decisive for the results. Some critics of hedonic methods have even suggested that a given dataset, if offered to a technically accomplished set of researchers, may yield a widely differing set of hedonic models with differing implications for measured prices, thereby undermining the potential reliability of hedonically adjusted price indicators.[48] However, notwithstanding this judgemental element, if hedonic methods are applied following agreed and comparable criteria, they may improve rather than diminish the credibility of price statistics.

Another important aspect of ensuring this credibility is the provision of good documentation on the estimated hedonic functions and on the considerations leading to the chosen specification.[49] Revisions associated with the implementation of hedonic methods should be explained to the public. In addition, for EU price statistics some effort should be placed on ensuring a transparent discussion of the results prior to any decision on whether or not to actually implement hedonics for a new class of items. Transparency of the process could also be enhanced through comparison of *implicit quality indices*, showing the extent of the estimated quality change for different goods

and services. To the extent permitted by confidentiality restrictions, it would also be preferable if the underlying datasets used in hedonic research programmes were available.[50]

Finally, the ECB, as a user of euro-area aggregate price statistics, must consider the effect of hedonic adjustment on the comparability of national results. Such comparability implies that differences in measured prices should not reflect errors due to differences in quality adjustment procedures. Although this does not necessarily imply that the same quality adjustment procedures are used in all countries, greater comparability does imply a convergence of national practices in order to minimise any systematic error due to quality change. Importantly, an EU-wide adoption of hedonic methods for selected items would not guarantee completely comparable quality adjustment on account of the inevitable judgemental element in the specification of hedonic models.

This assessment is supported by the results of the recently finalised two-year research project of the European Hedonic Centre (EHC) for Eurostat. The EHC's study refers to quality adjustment for PCs in eight EU countries. It suggests that an unconditional recommendation for hedonic methods alone would not guarantee better comparability. One important condition that could contribute to better comparability is the use of comparable, high-quality data

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47 For a review of these important econometric issues see Berndt (1991). For a discussion of econometric issues together with an application to US car demand, see also Arguea and Hsiao (1993).

48 To confront these perceptions, Ernst Berndt (see Brookings Institute, 2002) proposes commissioning a large number of studies on the same dataset and comparing the results. He suggests that the results would in fact be quite similar, thereby helping to reassure the sceptics about the arbitrariness of hedonics.

49 For the United States, the BLS has played an important role in seeking to ensure that such documentation is publicly available. See, for example, the set of papers constructing hedonic models for a wide class of items available at http:/www.bls.gov.

50 At the same time, users of statistics must accept that full reproducibility of the underlying hedonic regressions may not be possible, given the copyright restrictions of commercial data providers, which are often the suppliers of the datasets required for the application of hedonic methods.

sources that are representative of consumer purchases across countries and over time. This is important, because the available source data for hedonic calculations can differ in terms of market coverage. Second, it seems necessary to specify the criteria used for the identification of the explanatory variables and the choice of the functional form. This is important because alternative hedonic specifications can produce strongly varying results. Third, common practices for revising hedonic functions and parameters are needed because the relation between market price differences and quality features may change, particularly in the case of high-tech consumer durables.[51]

Were these conditions to be met, an EU-wide coordinated application of hedonic methods would, from our point of view, offer the opportunity to achieve greater comparability more quickly than would otherwise be the case. It would also allow Eurostat to publish information on the quality adjustment method used for EU price statistics, and thereby provide users of EU price statistics with information that is similar to that provided by some national statistical agencies and, in particular, by the Bureau of Labour Statistics for the CPI in the United States. In line with this, the EHC concluded: "Since there are considerable differences between the results from different hedonic approaches, a harmonisation of hedonic methods used for quality adjustment is needed. The urgent need for a coordinated and cooperative approach towards a harmonisation of statistics, which has been realized long ago in traditional statistics, is also prevalent when hedonic methods are used".[52]

3.6 A QUALIFIED ENDORSEMENT

While giving a generally positive assessment of hedonic methods, we should note that some final words of caution are justified. Several of these caveats have already been outlined above and are explained in more detail in the recent recommendations of the Committee on National

Statistics for the United States (see NRC, 2002). However, in addition to theoretical and econometric considerations, a number of other practical concerns need to be taken into account before a more extended application of hedonics could be implemented. In particular, it may take statistical agencies some time to build up the required expertise and, given that the application of hedonic methods is resource intensive, the decision to proceed with a more widespread hedonic research agenda must also take account of other existing statistical priorities.

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51 According to the final report of the EHC (Moch et al., 2003), the annual average price change for the period 2000-2002 for PCs in Germany was between -7.9 and -18.5%, and in France between -7.0% and -17.9%, depending on the model chosen. The results for the other six countries studied are similar. Moreover, the study showed faster price declines when the number of explanatory variables was reduced. In a "full specification" the average price decline was -16.1% in Germany and -17.9% in France, but -26.6% and -27.8% when only the three most significant variables were used.

52 See Moch et al. (2003).

4 OVERALL ASSESSMENT AND CONCLUSION

In this paper, we have reviewed the challenge to inflation measurement that results from changes in the quality of the underlying goods and services. In addition, we have tried to describe existing EU quality adjustment practices, particularly for the HICP, and assess the merits of the hedonic approach. A number of general and EU-specific conclusions seem to follow from this analysis.

While the quality adjustment issue raises important conceptual and practical challenges, the important role assigned by macroeconomic policy-makers to price statistics underlines the priority that should be attached to ensuring that price statistics are not distorted by inappropriate quality adjustment procedures. However, there appears to be no universally applicable and superior quality adjustment method. Price statisticians have the difficult task of choosing between different quality adjustment methods for different products and markets. For this choice, there are not only the conceptual properties of the method to be considered, but also the feasibility and resource requirements of the methods.

At present, although only partial information is available on the precise quality adjustment practices at the national level in EU countries, it would seem that for many items a wide variety of different approaches are used and this may have resulted in widely divergent price developments for some individual goods and services. Although the share in consumer expenditure of these individual items is often small, the combined effect may be considerable. Comparability of quality adjustment methods across the EU is still an important objective that needs to be achieved. Hedonic methods are one promising element helping to improve comparability, but they are not the only quality adjustment method capable of producing reliable and comparable results, and they are not sufficient in themselves to achieve comparability.

Most but not all studies indicate that hedonic methods tend to produce steeper price decreases for, in particular, electronic consumer durables compared with other currently employed methods. This is not only due to different quality adjustment methods but also stems from improved data sources and replacement techniques that are implemented along with the introduction of hedonic methods. However, there may be important exceptions depending on the nature of the methods currently used (e.g. option cost adjustment for cars) and sampling (e.g. frequent replenishment and chaining). At least for computers, several EU countries have introduced such changes without adopting hedonic methods, thereby reducing the potential differences due to pure quality adjustment. In addition, the application of hedonic methods to other components of a price index – e.g. clothing, rents – might counterbalance these effects. As a result, an overall assessment of the impact of hedonic methods on aggregate price statistics must therefore be put on hold pending broader-based research. At present, hedonic methods are used for less than 0.5% of the total HICP in terms of expenditure weight, which contrasts with the popularity of the method in applied research. This relatively low use of hedonics is not a concern per se as it does not seem desirable to promote a more extensive use of the hedonic method when there are alternative methods capable of providing reliable and meaningful results and perhaps at a lower cost. However, a major concern is the obvious lack of comparability of quality adjustment methods across EU countries at present. In this context, hedonic methods may offer the potential for improving the objectivity and comparability of quality adjustment methods and, hence, the credibility of price indices.

Given the practical difficulties involved in identifying good hedonic models (e.g. data challenges, econometric judgements and modelling choices), some qualifications are necessary. In particular, hedonic methods may be more reliable for certain goods than for others and they may not have practical application for most services prices which represent a large and growing share of overall consumer expenditure.

In the light of these qualifications, it would seem important for adequate research and discussion of the results of hedonic studies to precede more widespread implementation in the official EU price statistics, in particular since the objective is to improve both the accuracy *and* comparability of practices. It would therefore be useful if statistical agencies would widely publish their research into the application of hedonic techniques and make it available for discussion with academics, product specialists and users. To the extent permitted by confidentiality restrictions, it would also be preferable if the underlying datasets used in hedonic research programmes were publicly available. However, more published documentation is also required for other quality adjustment practices used in EU price statistics, since this is needed for evaluating comparability.

There appears to be a general agreement that quality adjustment is one, if not the highest, priority for the further harmonisation of EU price statistics, in particular HICPs. The question is therefore not to define new priorities for EU price statistics but rather to review why the commonly shared priorities have, for the time being, led to only limited progress. The dominant approach of harmonising European statistics is that of "output" harmonisation, i.e. defining the desirable output, but not the method (input) by which these results are to be achieved. Moreover, at European level this output is often only vaguely defined. This approach has not been successful for the harmonisation of quality adjustment practices. Hedonic methods offer (or even call for) intensified cooperation between statistical agencies and with Eurostat. Without coordinating the input into hedonic methods in national price indices – i.e. the data sources, the sampling techniques, and, of course, the econometric techniques – there is no guarantee that hedonic methods will ensure the comparability of national price statistics. This calls for a critical review of the harmonisation strategy by Eurostat and national index compilers.

Several of the "critical" products are offered and purchased with very similar product characteristics in all European countries (e.g. cars and PCs). Better quality adjustment methods are costly, and resource constraints appear to be the major reason why hedonic methods (or other appropriate techniques) are being introduced only very slowly and for relatively few index items. Progress in quality adjustment methods is still being achieved by relatively independent national research and decisions by individual EU countries. Single European market and resource constraints are further reasons why there should be strong coordination and cooperation for the development of better quality adjustment practices. Practical contributions of Eurostat to quality adjustment development, such as the HICP Quality Adjustment database, or the follow-up to the work of the EHC, should be integrated into the production of price statistics. The latter point is particularly relevant for European harmonisation work, in which many small EU Member States participate, often with very limited resources.

Finally, while it is welcome that absolute priority is being given by Eurostat and national agencies to developing quality adjustment methods for the HICP, which is the primary indicator used by the ECB, quality adjustment methods for other price indicators used in the assessment of price developments by the ECB are also important. Very little is known about quality adjustment in EU output, export and import price indices, as well as in national accounts deflators, but the available results indicate a large potential for harmonisation across countries.

5 ANNEX

Use (current or planned) of hedonic methods for quality adjustment in EU country HICPs[1]				
Euro area countries				
Belgium	Item weight in HICP from index month	No current use or plans.		
Germany	Item weight in HICP from index month	PCs 2.34 June 02	Used cars 4.55 May 03	Washing machines 1.82 Jan. 05	TVs 2.64 Jan. 05
Greece	Item weight in HICP from index month	No current use.	Considered for future use for PCs and other consumer durables (TVs, washing machines), but significant preparations needed.	
Spain	Item weight in HICP from index month	Washing machines confidential Jan. 04	TVs confidential during 2004	Other products studied.	
France	Item weight in HICP from index month	Bestseller books 0.273 Jan. 87	Dishwashers 0.685 Sep. 97	Men's shirts 1.044 Jan. 00	Other products studied.
Ireland	Item weight in HICP from index month	No current use.	Considered for future use for new and used cars.	
Italy	Item weight in HICP from index month	No current use.		
Luxembourg	Item weight in HICP from index month	No current use or plans.		
Netherlands	Item weight in HICP from index month	Used cars 8.07 July 98		
Austria	Item weight in HICP from index month	Bestseller books 1.348 Jan. 03		
Portugal	Item weight in HICP from index month	No current use. Test planned (e.g. for cars)		
Finland	Item weight in HICP from index month	New cars 26.1 Jan. 96	Used cars 30.2 Jan. 96	

Source: Information provided by National Statistical Institutes.
1) The weight is given as in part per 1,000.

Use (current or planned) of hedonic methods for quality adjustment in EU country HICPs (cont')

Other EU countries

Czech Republic	Item weight in HICP from index month	No current use or plans.		
Denmark	Item weight in HICP from index month	No current use.		
Estonia	Item weight in HICP from index month	No current use or plans.		
Cyprus	Item weight in HICP from index month	No current use, but considered for PCs (3.02), TVs (1.98), washing machines (1.42), cars (81.29)		
Latvia	Item weight in HICP from index month	No current use or plans.		
Lithuania	Item weight in HICP from index month	No current use or plans.		
Hungary	Item weight in HICP from index month	No current use or plans.		
Malta	Item weight in HICP from index month	No current use; studies undertaken (e.g. for PCs) but no decision yet.		
Poland	Item weight in HICP from index month	Irons 0.0722 Jan. 06	Books 6.973 Jan. 06	Other household appliances 8.3777 not yet decided
Slovenia	Item weight in HICP from index month	No current use or plans.		
Slovakia	Item weight in HICP from index month	No current use or plans.		
Sweden	Item weight in HICP from index month	Garments 57.7 Jan. 95	Used cars 9.1 Jan. 97	
United Kingdom	Item weight in HICP from index month	PCs 5 Feb. 03	Digital cameras (if tests successful) <1 2004	Laptops (if tests successful) n.a. 2005

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