BIAS IN THE COMPILATION OF CONSUMER PRICE INDICES WHEN DIFFERENT MODELS OF AN ITEM COEXIST

Mick Silver
Cardiff Business School
University of Wales, Cardiff
Colum Drive
Cardiff
CF1 3EU UK

Fax: (0)1222 874419
Email: Silver@cardiff.ac.uk

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ABSTRACT

This paper draws attention to a potential bias in the measurement of inflation arising from the coexistence in the market of new and old models of a product. This is a well-recognised problem which has been analysed in the literature in terms of difficulties in estimating quality differences. In this paper it is shown how the bias extends beyond the issue of the technicalities of such quality adjustments, but arises from the very nature of pricing behaviour in this market context. We show why there might be quite different pricing policies for a new and existing model at the time of launch and subsequent to it. Since a price collector can only either continue to monitor the prices of the old model, or switch (with a quality adjustment) to the new model, a bias will arise. A formal model of the nature and extent of the bias is developed and some simulated results are provided. The paper concludes with some practical suggestions.

Keywords: Consumer Price Index; Launch of New Models; Elementary Aggregates; Quality Adjustment.

JEL Classification: C1 D4

1. INTRODUCTION

The purpose of this paper is to identify and illustrate the nature of bias that may arise in the compilation of consumer price indices (CPIs) when new models of a consumer durable are introduced into the market. Much attention has been recently devoted to the nature and extent of different sources of bias in CPI compilation (Lebow, 1994; Advisory Commission, 1995; Shapero and Wilcox, 1996; Moulton, 1996; Diewert, 1996 and Abraham *et al*, 1998). The main categories of bias[1] identified are substitution (or formula) bias; elementary index bias; outlet substitution bias; new goods bias and quality adjustment or linking bias. The problem of new models being introduced is considered in the later category as one of adjusting for quality (or efficiency) changes: "...the new models will be improved in some dimension, but in many cases the Statistical Agency will simply link the new model without an adequate downward adjustment in price to account for the improved efficiency." (Diewert, 1996:13).

A price collector from a Statistical Agency has two options when confronted with the launch of a new model. First, to continue to monitor the price movements of the existing model. Second, to switch, with a quality adjustment, to the new one. It will be argued that the very launch of a new model affects the pricing of the existing and new model. The difference between their prices at the time of launch and subsequent to it is argued to arise from factors other than quality differences. A price collector keeping to the existing model will neglect the price movements experienced by consumers switching to the new (quality-adjusted) one. The situation is reversed if the collector switches to the (quality-adjusted) new model. The resulting bias will arise even if appropriate quality adjustments are made, a contribution of this paper being to identify the nature and extent of this source of bias.

In section 2 we consider the pricing of new and existing models and the bias and factors determining its magnitude. Section 3 provides a formal mathematical model along with estimates for a range of values of its determining variables. Section 4 concludes with some practical recommendations.

2. THE PRICING OF NEW AND EXISTING MODELS

a) The Nature of New Models Bias

The collection of data on prices for the compilation of a CPI is generally based on the *matched models method* which seeks to compare 'like with like'. Price collectors use detailed checklists in an attempt to ensure the same item is repriced from period to period. A new model may be judged to have a significant change in quality, in which case an estimate of the monetary value of the quality change may be attempted. This may be derived from information from the manufacturer or from the coefficients of an hedonic regression (Triplett, 1990 and Liegey, 1994). Alternatively, the method of linking may be used which involves calculating the rate of inflation of a group of similar goods, and then applying this rate to the price change of the model that has been replaced. Any difference between the price change of the old and new models and that of the similar class of goods is implicitly assumed to be due to quality changes. There are many difficulties with these approaches as discussed by Turvey *et al*, (1989), Triplett, (1990), Reinsdorf, Liegey and Stewart (1996) and Moulton (1996). The problem is seen in terms of estimating the quality adjustment between the new and replacement model. As Moulton (1996, p171) argues:

> "Most of the evidence suggests however, that when price changes are relatively small and quality improvements are substantial linking tends to understate the value of quality improvement, from one version to the next.........On the other hand, for goods that do not have substantial quality improvements, the method of linking may attribute too much quality change and too little price changes to the replacement of models.....Recognising the problems associated with linking, the BLS [Bureau of Labor Statistics] has taken steps in recent years to reduce the dependency on linking and increase the use of direct comparisons and direct quality adjustments"

Comparisons of direct estimates of quality adjustment and those by way of linkages show significant differences between the two (for example, Gordon (1990), Berndt *et al* (1995), Griliches and Cockburn (1994) and Reinsdorf *et al*(1996)).

b) The Problem Reconsidered: Some Hypotheses on the Pricing of Consumer Durables

The difficulty with the above approach is that it identifies the problem solely in terms of quality adjustment. A quite distinctive feature of consumer durables is that different vintages can coexist in the market and the launch of an updated version has implications for the pricing of existing vintages. In this section we consider the nature of such markets and develop hypotheses about pricing behaviour. An understanding of the type of bias considered in this paper requires all of this.

For explanatory purposes we use the market for TVs as an illustration, though the bias is general to a wide range of consumer durable goods. For many consumer durables a range of differentiated products are usually available for each brand. For example, Hitachi manufacture a range of television sets (TVs) varying according to their screen size and possession or otherwise of features. Kotler (1991) explains the need for these *branded variants* in terms of meeting heterogeneous consumer tastes. Bergen *et al* (1996) use search cost theory: the more branded variants, the more complex and costly is the consumer search across stores. Thus the likelihood of consumers paying a higher retail price in any store offering such a range is increased. As such there is an incentive for stores to stock many variants. A related phenomenon is the coexistence in the market of different vintages of branded variants as updated models complement rather than replace existing vintage(s). Heterogeneous consumer tastes and search cost theory may also explain the existence of branded variants of difference vintages. The pricing of an updated variant and the effect of the update or launch on the pricing of existing vintage(s) is of specific interest.

It should be stressed that our concern is with updating an existing branded variant, for example, an Hitachi 14" with no special features. As a new version comes on stream we want to know what happens to the prices of the existing vintages of this branded variant. We would expect prices of the different vintages to vary over their life cycles as elasticities vary (Tellis, 1988 and Parker, 1992). We would expect different vintages to coexist since it is common that sales are often low in the early stages of their life cycle (Tellis, 1988). However, here we have a specific effect on the prices of existing vintages outside of the usual life cycle. It is the effect of the firm launching an updated version of that very branded variant and, following this, what happens to their respective prices as they continue to coexist.

It may be argued that different vintages may not coexist, as stores attempt to 'dump' existing models through low prices in order not to spoil the market for the replacement model. In this case the launch of an updated model has a direct effect on the prior pricing of existing vintages which is of interest to estimate. Coexisting vintages may arise from ineffective dumping, as opposed to contributing to meeting heterogeneous tastes and extending branded variates.

Economic theory would argue that branded variants of different vintages may coexist. An updated variant will usually have additional quality characteristics. If the market is in *competitive hedonic equilibrium*, the marginal value users put on the additional quality characteristics is equated with their marginal cost (Triplett, 1990). Some consumers may prefer the older variant, because their valuation of the worth of the features in the new model is lower than the marginal cost of these features. Profit maximising firms may keep models of different vintages on the market to exploit third degree price discrimination (Varian, 1990). Alternatively, Hausman (1997) provides a formal approach for identifying the factors affecting pricing decisions in multiproduct films which may be applied here and will be outlined in the next section.

Table 1 demonstrates the very real phenomenon of coexisting vintages using bar-code (scanner) data from major retailers for seven major makes of 14" television sets in the UK[2]. For sets sold in July 1996 to June 1997 only 35.3% were launched in those calendar years.

We first simplify the terminology since 'vintages of a branded variant' is a little clumsy. TVs can be classified according to variants, for example a 14" screen size without nicam, or any form of teletext facility. We refer to these as 'models' of a TV offered by different manufacturers (*brands)*. *A*, *B* and *C* denote successive vintages of a model.

Figure 1 is an illustrative diagrammatical representation of how the prices of those models of TVs may change over three time periods: period 1 up to T_1; period 2 from T_1 to T_2; and period 3 from T_2 onwards. The lines represent the locus of monthly observations on average prices over the period. In period 1 there is only one version of the model, version *A*, its price path being defined by *A1*. However, at T_1 a new version *B* is launched, its price path over period 2 being defined by *B2*. In period 2 version *B* effectively replaces version *A* and, because of its relatively low sales, its continued price path is not depicted. At T_2 a new version is launched, version *C*, though for period 3 version *B* continues to exist in the market alongside it. With a move from (Model *A* in period *1*) *A1* to (Model *B* in period *2*) *B2* our concern is with the price difference *x*. A similar situation arises at time T_2 since as (Model *B* in period *3*) *B3* is gradually phased out, there will be a need to switch to *C*. Economic theory (Triplett, 1990) shows the price differentials, *x* and *y* may be considered to be a measure of the quality differentials between the new and old models. This requires an assumption that the market is in competitive (hedonic) equilibrium in characteristics with unchanging preferences, where the consumer's marginal valuation of each characteristic is equated to the producer's marginal cost. Thus if, for example, the new model is superior in some characteristic to the old, the marginal cost of the improvement is equal to its marginal value. This assumption may not, however, be valid.

Consider an alternative scenario. New models for televisions contain many features which consumers are unable to properly identify including reliability, screen quality, sound quality and styling. Firms compete in oligopolistic markets for market share through R&D in product and (for reliability) process development in a market where there is evidence of retail collusion (Monopolies and Mergers Commission, forthcoming). This is unlikely to generate the conditions for competitive hedonic equilibrium. It is not just that producers will have difficulty in apportioning marginal costs to individual quality characteristics, nor that the consumers will have difficulty in recognising the marginal values of these gains. It is also that consumers may put a price premium on new models not due to improved efficiency, but the catchet or 'snob' value (Veblen, 1926) of possessing a new model. This would be difficult to disentangle from efficiency changes even if the markets did not have a collusive elements. Given some consumers will attach a higher premium to the new model, a profit-maximising firm will undertake third-degree price discrimination. The result of this, at time T_2, will be an increase in the price of the new model and fall in price of the existing one, the extent of which depending on the elasticities of demand for the two models (Varian, 1990). Note that the very launch of the new model can affect the demand elasticity of the existing one since first, early adopters of new technologies have been found to have higher incomes (Parker, 1992). Second, the marketing literature has substantial evidence of how elasticies increase over the life cycle of a product (Tellis, 1988). Indeed managers are taught through marketing texts to adopt policies of 'price-skimming' at the launch of a new model (Kotker, 1991).

An alternative approach to understanding the effect on pricing of a new model requires recognition that our concern is with a multiproduct firm and that the introduction of a new model, or change in the price of an existing model, may well have an effect on the prices and sales of other models. An economic theory which separately identifies price determination through equating marginal cost with marginal revenue for profit maximisation for each model and vintage in turn would be unrealistic. Hausman (1997) outlines a model for multiproduct firms based on Nash-Betrand pricing under imperfect competition which allows for the required interaction and can be applied to firms selling models of different vintages.

For a firm with $k=1,.....m$ models (including vintages) where s_k is the market share, q_k and p_k the demand and price, mc_k the marginal costs, π is the firm's profits and e_{kj} the cross-price elasticity for any model j, the first-order profit maximising condition for model j's prices is given by Hausman (1997) as

$$\left[\frac{p_j}{\sum_{k=1}^{m} p_k q_k}\right] \frac{\partial \pi}{\partial p_j} = s_j + \sum_{k=1}^{m} \left[\frac{p_k - mc_k}{p_k} s_k\right] e_{kj} = 0 \tag{1}$$

Thus the price change for a model can be seen to be dependent on how close multiproduct firm's models (or vintages) are in terms of their cross-price elasticities. Breshnahan (1997: 224) asks: "what happens if we add a new product, $m+1$?"

> "Two things (1) the summation expression grows larger, by the term
>
> $$\frac{\left(p_{m+1}-mc_{m+1}\right)s_{m+1}}{p_{m+1}}e_{m+1j'}$$
>
> and (2) the firm has a higher marginal revenue for product *j* because it owns *m+1*-shares are held constant...... The offsetting effect is that the terms s_j and s_k are smaller, to the extent that the existing products lose share to the new product. Thus, there are three effects on the existing product *j*'s price. First, there is a new, positive, term in the summation. Second, s_j has fallen because of cannibalization. Third, s_k falls for all the firms' existing products, lowering each term in the summation. The net effect is to either raise or lower equation [1] calling for a new price of product *j* that can either be higher or lower."

The analysis helps us to identify the effect on the price of an existing model (vintage) *j* from the introduction of a new model. The positive effect on model (vintage) *j* arises because the firm can increase its price of existing models (vintages) since when it raises its price part of the demand it loses will go to its own new model, *m+1*. The extent of this will be dictated by the price-cost margin, market share of the new model and cross-price elasticity of the new model with model (vintage) *j* as shown above. The negative effects are due to cannibalization as sales of model (vintage) *j* are picked up by the new model, this fall-off in demand leading to a cut in price. Militating against the aforementioned positive effect on prices will be the fact that the introduction of a new model will lead to a fall in each s_k. In the context of other firms also launching new models there will be little to gain from increasing prices of existing vintages as demand will also spread to competitor's new models. The dominant effect would be one of cannibalization with, *a priori* expectations of a price fall for existing vintages from the introduction of a newer model. All of this leads to three hypotheses, which relate to the differential pricing at T_2 which accords with the example used in Figure 1.

Hypothesis 1: Price Effect at Time of Launch: The average price at T_2 of regime *B2* shifts downwards (to *B'3*) by *z* to help clear the market for *C* and upwards by *y* for the new model.

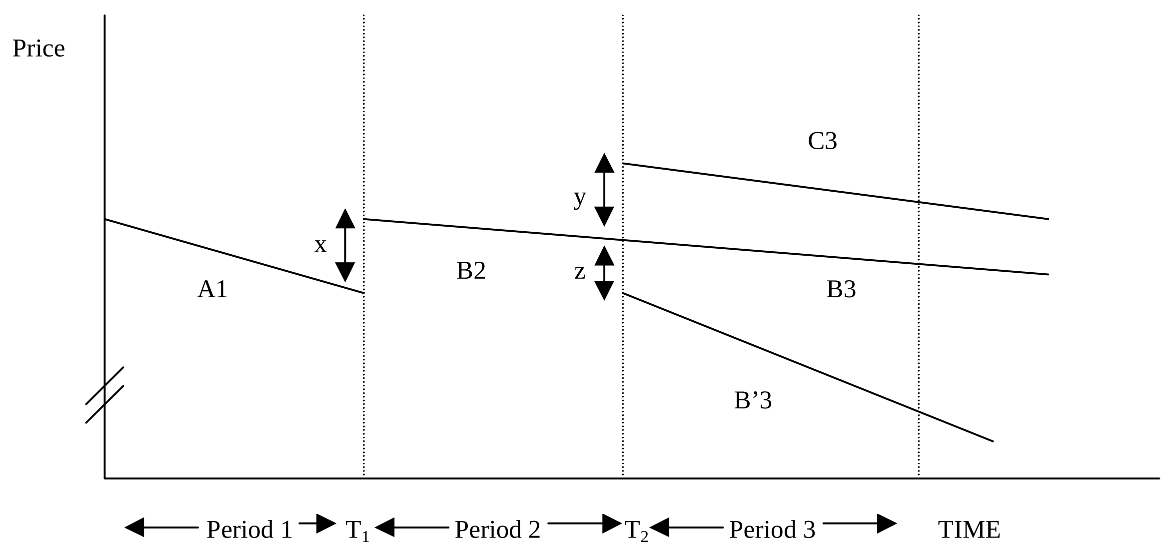
Support for *hypothesis 1* arises from a meta-analysis of price elasticities for branded products over their life cycle by Tellis (1988). He argued that we should expect greater price sensitivity in the latter stages of the life cycle since first, consumers' knowledge of the brand (availability, deals, prices, promotions) has increased and secondly, the temperament of early adopters is likely to be less price sensitive. Robertson (1971) found early adoptors of most products to have relatively high incomes and thus be less sensitive to price changes than later adopters, a feature confirmed by Parker (1992). Kotler (1991) advocated the use of *price skimming* as a strategy to benefit from this. The fall in the price of the existing model over its cycle may not solely be due to deliberate dumping, but a repositioning of the old model. As the market for the new model is formed from those with higher incomes, the market for the existing model is by necessity redefined to meet the needs of consumers with lower incomes, who are likely to have higher elasticities of demand. The hypothesis of prices shifting upwards and downwards as depicted by *y* and *z* in Figure 1 arises from a model of third-degree price discrimination. Support for *hypothesis 1* also arises from the predictions of the approach by Hausman (1997) and Bresnahan (1997) for a multiproduct firm profit maximising under imperfect competition as discussed above. It is worth noting that some empirical support is also available from hedonic regressions of price variability which include vintage or 'age' effects, for example Berndt *et al* (1995).

Hypothesis 2: Price Effect Following Launch: The *rate* at which prices change may be greater (for a price decline) for the new model as even lower prices are needed to clear the (increasingly) more out-of-date model.

Support for *hypothesis* 2 arises from the life-cycle hypothesis as retailers seek to clear old technologies, a manifestation of this being the increasing price sensitivity over the cycle found in Tellis (1988) and Parker (1992). Following Hausman (1997) and Bresnahan (1997) as the existing model ages, its cross-price elasticity with the new model will decline, there being little incentive to raise its price and every incentive to cut price due to increasing cannibalization.

Hypothesis 3: Effect on Price Elasticity: We would expect demand to be relatively inelastic for newer models, compared with older models. *Hypothesis* 3 arises directly from the aforementioned work by Robertson (1971), Tellis (1988) and Parker (1992) and naturally in Hausman (1997) and Bresnahan (1997). We now turn to examine how a bias in index number compilation may arise if these hypotheses hold.

Figure 1, Different Price Regimes for the Launch of New Models



3. NEW MODEL BIAS

Diewert (1996) developed a model for linking or quality change bias where the true price index is given as

$$P_T = (1-s)(1+i) + s(1+i)(1+e)^{-1} \tag{2}$$

and $(1+i) \equiv P_L$ which is the fixed basket Laspeyres index, s is the share of commodities replaced by new models and e the percentage increase in efficiency of new models that is issued when the new model is linked into the index. There are of course practical difficulties in estimating e, though our purpose here is to represent in mathematical terms a type of bias. The bias is thus:

$$B \equiv P_L - P_T = (1+i)se/(1+e) \tag{3}$$

We can use Diewert's (1996) framework for our analysis. The true price change at the micro level is:

$$P_T = (1 - S_C)\, P_B + S_C P_{BC}\, (1 + e)^{-1} \tag{4}$$

where S_C is the share of sales going to the new model C; P_B is the price index for model B between periods T_2 and T_{2-n}, P_{BC} is the price index for the price of C in period T_2 compared with the price of B in period T_{2-n}.

Denote $P_{T_2,C}$ and $P_{T_2,B}$ as the price levels in period T_2 of C and B respectively, then:

$$P_B = \left(\frac{P_{T_2,B}}{P_{2-n,B}}\right);\ P_{BC} = \left(\frac{P_{T_2,C}}{P_{T_2,B}}\right) P_B \text{ and } (1 + e)^{-1} = \left(\frac{P_{T_2,C^*}}{P_{T_2,C}}\right) \tag{5}$$

where P_{T_2,C^*} is the efficiency (quality) adjusted price of C at time T_2.

The price collector has two options: to monitor the prices of B throughout the full period P_B; or to monitor the prices of B up to the introduction of C, and then switch to C (with an efficiency adjustment) in period T_2 and thereafter. The bias in each perspective case is

$$B_{BB} = P_B - \mathrm{P_T} = P_B S_C \left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right] \tag{6}$$

$$B_{BC} = P_{BC}\,(1 + e)^{-1} - P_T = -P_B\,(1 - S_C) \left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right] \tag{7}$$

In both cases

$$\frac{dB}{dS_C} = P_B\left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right] \tag{8}$$

For example, if $P_{2-n,B}$ = 1.00 (for convenience); P_{BC} = 1.40; P_B = 1.20; S_C = 0.4 and P_{T_2,C^*}= 1.30, then B_{BB} = -0.04 and B_{BC} = +0.06. Thus, the absolute value of such bias can be seen from equations (6) and (7) to be determined by the market share of the new model, the current value of the index P_B and the efficiency-adjusted index $P_{BC} = P_B\left(P_{T_2,C^*} / P_{T_2,B}\right)^3$. The bias in relative (to P_T) terms can be derived from equation (6) as
$B_{BB}/P_T = (P_B - P_T)/P_T = x/(1 - x)$
where $x = S_C\left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right]$
Using Taylor's series:

$$B_{BB}/P_T = S_C\left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right] + S_C^2\left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right]^2 + S_C^{\,3}\left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right]^3 + \tag{9}$$

Similarly, using the identities in equation (5) and equation (7):

$$B_{BB}/P_T = \left(P_{BC} - P_T\right) / P_T = -\frac{(1-S_C)}{S_C}\frac{x}{(1-x)} \tag{10}$$

$$= -(1 - S_C)\left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right] - (1-S_C)S_C\left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right]^2 - (1-S_C)S_C^{\,2}\left[1 - \frac{P_{T_2,C^*}}{P_{T_2,B}}\right]^3 + \ldots.$$

Thus only two things matter: the share of sales going to the new vintage and the ratio of the efficiency-adjusted price of *C* to the price of *B at* T_2. It should be borne in mind that

$$P_{T_2,C^*} = P_{T_2,C}\ (1 - e)^{-1} \text{ from (5)} \tag{11}$$

i.e. we take the price of *C* in period T_2 and adjust it for its relative efficiency. Thus any disparity between $P_{T_2,C}(1 + e)^{-1}$ and $P_{T_2,C}$ will lead to bias. It is stressed that this does not mean that the bias is solely dependent on the effectiveness of the efficiency-adjustment. *It also depends on the extent to which firms are pricing their new models above what can be justified by the efficiency difference. Similarly, it also depends on the extent to which firms price the old model below what might be expected if the launch had not occurred.* That is, it depends on *y* and *z* in Figure 1, which under *hypothesis* 1 will exceed zero, this being exacerbated in subsequent periods under *hypotheses* 2 and 3. From our previous example, the relative bias from equations (9) and (10) would be -3.232% and 4.84% respectively. Had S_C = 0.05, then the bias in both cases would be 4.00%.

Note that the bias arises because price collectors collect prices for model B *or* C at the launch or thereafter. It may well be the case that the increased price of C at launch offsets the fall in the price of B, though theory suggest otherwise. However, even if this were true, the bias would remain because the price collector follows only one model. Only under perfect hedonic competitive equilibrium where $\left(P_{T_2,C^*} \,/\, P_{T_2,B}\right)$ = 1 would there be no bias. However, the theory of profit maximising behaviour for multi-product (vintage) firms under imperfect competition, along with marketing strategy and evidence in this context suggest otherwise.

Table 2 provides results on the extent of the bias for different values of the components of equation (9). The bias arise from the price collector continuing to monitor the prices of model B though, as is apparent from equation (10), a similar, converse bias would result from switching to the efficiency-adjusted new model. A number of points arise. First, as the difference between efficiency-adjusted prices of the new model and the price of the old model (hereafter the margin) increases, so too will the bias. The extent of the bias can be substantial; for S_C = 0.05, for example, the bias for a margin of 5% (1.05) would be -2.4%, compared with a bias of -11% against the true index for a margin of 25%.

Second, as S_C increases, the bias from continuing to monitor model B increases. For example, for a margin of 15% (1.15) the bias 'increases' from -1.5% to -10.7% as S_C increases from 0.1 to 0.8. As with the previous relationship, the association is practically linear, the higher order terms in equation (9) having little effect.

Third, there is an interactive effect on the bias for S_C and the margin. A margin of 25% with S_C = 0.75 yields a bias against the true index of about -15%.

Fourth, comparing equations (9) and (10) there is a broadly asymmetric relationship between the bias resulting from continuing to monitor B, against switching to efficiency-adjusted *C*. An important implication of this is that if price collectors in any period adopt a joint strategy of continuing to collect prices for the existing model in some cases, and switching to the new model in others, the respective negative and positive biases will be partially offset. However, this is unlikely since Statistical Agencies re-select their items (and thus new models) at given points in time, such as rebasing. Furthermore, the switching to the new model requires an efficiency adjustment. As such, in practice switching is avoided and may only be undertaken when the existing model is unavailable, or when S_C is relatively large, and the bias high. Finally, the efficiency adjustment is only an estimate and thus is itself a potential source of bias which does not arise if the collector continues to monitor the prices of the existing model. Table 2 helps us to identify the extent of such bias. If the efficiency adjustment, for example, provides a ratio of the efficiency adjusted price of C* to the price of B of 1.15, when in fact it should have been 1.20, then for S_C = 0.5 the bias 'increases' from -7.0% to -9.1%. We therefore have a means by which the effect on bias of error margins from inappropriate quality adjustment can be ascertained.

4. SUMMARY

The above has served to identify the nature of the bias arising from the coexistence of models of different vintages in the market. Previous work has identified such bias in terms of the (in)ability to adjust for the efficiency (quality) of the new model relative to the existing one. We have shown a bias may also arise from factors other than this and outlined its nature. Its rationale arises from hypotheses concerning the pricing behaviour of firms selling models with more than one vintage coexisting in the market.

A number of practical points for Statistical Agencies arise from this.

1 With the launch of a new model the decision by price collectors to continue to monitor the prices of the existing model is not free from bias. The extent of the bias is related to the difference between the price of the existing and the (quality-adjusted) new model, which is intuitively reasonable.

2. Statistical Agencies should seek to identify, through trade and other sources, product markets susceptible to such price differences. Table 2 can be used to identify the level of market share for which the bias is deemed to be serious. In such cases 'partnerships' may be formed whereby price collectors roughly counter balance those items whose prices are switched with those whose are not. Alternatively data on market share at the level of the model is now available from scanner data (Silver 1995). If products prone to such bias can be identified, estimates of the bias via equation (6) and (7) may be used to directly adjust the micro indexes.

3. Because the biases from switching to the new model are potentially offsetting, Statistical Agencies should be wary of policies of switching to new models at a specific date, for example at rebasing. A similar area of concern is when price collectors only switch when the old model is unavailable, i.e. when S_C is relatively high, thus again limiting the extent of any offsetting bias.

4. The switch to the new model leads to further potential bias if the estimate of the quality adjustment is biased in one direction. Hedonic regression coefficients, for example, may suffer from this as they only incorporate identifiable, measurable characteristics as opposed to the 'reliability' of a product. Table 2 can be used to estimate the effect of such inaccurate estimates on overall bias.

5. As should be apparent from equations (9) and (10), the decision, by a price collector, to switch or otherwise to a new model should not be a matter of convenience, but one taken with, at least, an awareness of the potential bias arising from it.

Notes

1. In many European countries the aim of a CPI is to measure price changes of a fixed basket of goods and services, as opposed to providing estimates of a cost-of-living index, as in North America. As such substitution bias, outlet substitution bias are, strictly speaking, of no concern to such Statistical Offices, while quality adjustment and linking bias and new goods bias remain as problems.

2. The scanner data is compiled from the bar-code readings of transactions by GfK Marketing Services. The coverage of retailers is over 90% of the market. Sales transactions can be linked via the bar-code to the model number, which in turn is linked to a file on the characteristics of the model including its year of launch.

3. Of note however is that the bias may be more serious than revealed by equation (5). In maintaining B we are implicitly considering a fixed basket of models at a time when there may be a substitution to the new models. The nature of the substitution bias would in this case be unusual as falling prices coexist with *lower* sales. A bias would, however, still exist. The maintenance of a fixed basket of old models to avoid estimating e would not take into account consumers substituting away from the old model to new models with quite different price regimes.

Table 1 Number of Models and Sales of 14" TV Sets by Year When First Launched (vintage) for Sets Sold Between July 1996 and June 1997

Vintage(a)	Number of Models	Percent of Models	Number of Sales	Percent of Sales
1996/7	371	17.1	386,898	35.3
1995	603	27.6	409,910	37.5
1994	364	16.7	186,306	17.0
1993	331	15.2	75,719	6.9
1992	274	12.6	20,762	1.9
1991	104	4.8	5,369	0.5
1990	73	3.3	6549	0.2
Earlier	62	2.7	2,597	

(a) Calendar years

Table 2, Simulated bias (B_{BB}/P_T)

Market Share(S_C)	Ratio of the adjusted price C to the price of B at T_2 ($P_{T2,C*}/P_{T2,B}$) 1.01	1.05	1.1	1.15	1.2	1.25	1.5
0.10	-.001	-,005	-.010	-.015	-.020	-.024	-.048
0.15	-.001	-.007	-.015	-.022	-.029	-.036	-.070
0.20	-.002	-.010	-.020	-.029	-.038	..048	-.091
0.25	-.002	-.012	-.024	-.036	-.048	-.059	-.111
0.30	-.003	-.015	-.029	-.043	-.057	-.070	-.130
0.35	-.003	-.017	-.034	-.050	-.065	-.080	-.149
0.40	-.004	-.020	-.038	-.057	-.074	-.091	-.168
0.45	-.004	-.022	-.043	-.063	-.083	-.101	-.183
0.50	-.005	-.024	-.048	-.070	-.091	-.111	-.199
0.55	-.005	-.027	-.052	-.076	-.099	-.121	-.214
0.60	.006	-.029	-.057	-.083	-.107	-.130	-.229
0.65	-.006	-.031	-.061	-.089	-.115	-.140	-.243
0.70	-.007	-.034	-.065	-.095	-.123	-.149	-.255
0.75	-.007	-.036	-.070	-.101	-.130	-.158	-.267
0.80	..008	-.038	-.074	-.107	-.138	-.166	-.278
0.85	.008	-.041	-.078	-.113	-.145	-.175	-.289
0.90	-.009	-.043	-.083	-.119	-.152	-.183	-.298
0.95	-.009	-.045	-.087	-.125	-.159	-.191	-.306
1.00	-.010	-.048	-.091	-.130	-.166	-.199	-.313

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