

# QUALITY ADJUSTMENT OF PRICES OF AUDIO-VISUAL GOODS IN THE U.K. R.P.I.

(The use of hedonic techniques for quality adjusting TV prices)

## INTRODUCTION

1. This paper summarises the recent work of Cardiff Business School (CBS) who were commissioned by the Central Statistical Office (CSO) to investigate quality change in the audio-visual sector and to consider options for adjusting prices for quality change. The results of their investigation into the use of hedonic regression for producing quality adjusted TV prices are also included.

## THE AUDIO-VISUAL MARKET

2. Interviews were held with the marketing manager of each of the following organisations :

Dixons-Currys  
Richer Sounds  
Comet  
Radford's Hi-Fi  
Hitachi  
Budd Electrical BREMIA  
Toshiba  
JVC

3. Questions covered product innovation, quality improvement, details of pricing policy, and the identification of market leaders.

## FINDINGS

4. Six major product areas (standard TVs, portable TVs, videos, personal/portable cassette players, mini/midi hi-fi, hi-fi separates) were investigated and the important features of the different markets are summarised in Annex A.

## **Product pricing**

5. The audio-visual market overall is highly competitive and many retailers observed that prices are falling, even without taking quality improvements into account.
6. Most manufacturers operate a 12 month product cycle with trade shows in spring and new products appearing in the shops in April/May, although some model changes do occur in September. Manufacturers recommended prices are usually stable over the product life cycle (12 months), but manufacturers and retailers may use special offer schemes such as cash-back, interest free credit, flexible terms, as alternatives to price cuts.
7. The pattern of manufacturers' price changes suggests that "menu costs" are a feature of the industry. In other words prices do not instantaneously respond to changes in market conditions, rather manufacturers seek to minimise menu costs by increasing prices in a non-continuous manner. Price changes occur irregularly but when they do they compensate for previous periods of constant prices.
8. Since a very large proportion of components are imported, manufacturers' costs are subject to currency fluctuations.
9. Retailers tend to reduce prices in the January and July sales and to clear stocks of old models in April in preparation for the new models. The main periods of price increase are therefore August and February (recovery from sales) and April/May (introduction of new models).
10. An earlier part of this research project involved explanatory discussions with major players in this sector: retailers and manufacturers. This established that in this sector, there is an annual cycle of product developments and marketing initiatives.

## **QUALITY CHANGE IN THE AUDIO-VISUAL SECTOR**

11. The changes made to models as part of the annual product round generally take the form of changes in design (including miniaturisation), added functionality or greater component reliability (fault diagnosis is another new development). These model changes usually hit the market in April/May following trade fairs and product launches. However, manufacturers/retailers often consider many of these changes to be minor and of little interest to the consumer and hence do not usually

advertise them. Thus consumers may be unaware of the full extent of product changes. On the other hand, major innovations such as CD-I and NICAM can occur at any time and are advertised.

## **QUALITY ADJUSTMENT PROCEDURES CURRENTLY USED IN THE RPI**

12. At present, the UK RPI has no provision for linking overlapping prices. Instead, item replacement is dealt with either by assuming no quality change, or by assuming change and imputing a base price.

13. This paper describes work by Cardiff Business School to investigate the use of hedonic techniques for adjusting television prices.

## **HEDONIC REGRESSION ON TV PRICES**

### **Data Source**

14. The data used were the monthly output of GfK for the months of January and July 1993. GfK is an information agency which buys scanner data from retailers, which it then collates and packages for resale, principally to retailers and manufacturers. The scanner data are supplemented with panel surveys, both to provide data on retailers not covered in the main data (usually small, independent outlets) and to provide information about purchasing behaviour.

15. Thus, a scanner data set will in theory contain data on every sale by participating retailers. The main drawback is limited coverage; smaller, independent retailers generally do not use scanner technology. However, GfK data cover approximately 80% of the TV market excluding own-brand (use of own-brand data would breach confidentiality constraints as it would reveal the pricing policy of individual retailers).

16. Scanner databases are particularly useful for hedonic studies as they generally hold a large number of fields for each transaction, often related to physical characteristics. See Annex B for the fields covered by GfK data on televisions.

17. Roughly 375 observations were available each month, covering every model selling more than thirty units in the month. The cut-off of thirty was designed to

exclude sales of models being dumped or sold to specialised markets; most of the models excluded had sales of only one unit.

**The model**

18. The basic model used to estimate the implicit prices of quality characteristics of standard TVs was :

$$\log p_i = a_0 + \sum_{t=1}^n d_t D_t + \sum_{j=1}^m b_j X_{ijt} + \epsilon_{it}$$

for  $i = 1 \dots n$  TV models

where  $j = 1 \dots m$  characteristics (X)

$t = 1 \dots n$  time periods

and D is a time dummy (pooled data for January and July were used).

**NB:** Although  $d_t$  provides an estimate of the quality adjusted price, it should **not** be used alone in this case to give quality adjusted prices, but actual prices should be adjusted by  $b_j$ .

**Characteristics (variables)**

19. The hedonic variables used were all dummies (i.e. could take values of 0 or 1 only) and fell into several categories :

- Features : Flat screen            Fst
- Fasttext             Fxt
- Styling of monitor    Style
- NICAM                NICAM
- Remote control      RC

Manufacturer : 51 tested, 35 showed significant effects

Screen size : 18 tested, 13 showed significant effects

20. The model included dummies for different manufacturers on the basis that, where price leaders exist, make-effects act as proxies for omitted characteristics such as styling, reliability and quality of screen, sound and picture. These “make”

dummy variables were designed so that their coefficients can be interpreted as percentage changes against a "constant" model (Sony 14"). Sony has a substantial mark-up on other makes and the make-effect is generally statistically significant.

21. In addition to the above hedonic characteristics, some additional variables were investigated :

Scale : a variable based on sales data, included to investigate the cost advantages of a model being sold in large quantities.

Stocks : as measured at the end of the period (as a quadratic term), included since, according to economic theory, high stocks are associated with high demand and high prices, and low stocks are associated with low prices (dumping).

Distribution : a variable based on sales and outlet data, included to investigate the distribution advantages of a model being sold in a large number of shops.

## Results

22. Results are given in Annex C for regressions using :

- i. January data only
- ii. July data only
- iii. Pooled January and July data (includes time dummy)
- iv. Full model (Pooled January and July data with extra variables for scale, stocks and distribution)

The models for i. and ii. took the form :

$$\log p_i = \beta_0 + \beta_1 \text{Fst} + \beta_2 \text{style} + \beta_3 \text{NICAM} + \beta_4 \text{Fxt} + \beta_5 \text{RC} + \sum_{j=6}^{40} \beta_j X_j + \sum_{i=41}^{53} \beta_i X_i + \epsilon_i$$

where  $j = 6 \dots\dots\dots 40$  manufacturers  
 $i = 41 \dots\dots\dots 53$  screen sizes

The models for iii. and iv. included a time dummy and the model for iv. included in addition scale, stocks and distribution.

23. The models appear to be well specified. The coefficients on Fst, Fxt and NICAM have the correct sign and are of an appropriate magnitude. All of the

significant make effects are negative compared with Sony, except Bang and Oulfsen. Similarly the screen size coefficients have the correct sign (against a 14") and the coefficients increase appropriately with screen size.

24. The regressions show very high  $R^2$  statistics and no autocorrelation or heteroscedasticity.

25. The additional variables in the full model are significant whereas the time dummy is not. This suggests that the additional variables are explaining the variability accounted for by the time dummy in the simple pooled model. However, it should be noted that these variables are directly related to price and are indicators of market conditions and are **not** hedonic characteristics. The time dummy in the full model is therefore no longer an indicator of quality adjusted price change between January and July.

### **Weighting**

26. The basic hedonic model was refined during this research by the use of a weighting scheme based on sales data. Thus, individual observations were weighted in line with relative sales. This allows an increase in average price due to higher sales of more expensive models to be distinguished from an increase due to genuine price increases.

### **Discussion**

27. This initial hedonics study has been encouraging. It has yielded adjustments which may be applied experimentally to current RPI data and it has also suggested that a similar approach might be used effectively for other commodities similar to TVs.

28. The RPI item specifications already control for TV screen size but hedonic coefficients may be used to adjust prices for any forced changes in make or in any of the physical characteristics used in the regression.

29. As always with hedonic techniques, adjustments cannot be made for characteristics not used in the regressions. Thus the models would need to be regularly updated in an attempt to capture technological innovations.

30. Further work might include :

- investigating the application of the coefficients to existing RPI data,
- investigating further the use of weighted regression,
- repeating the hedonic study on other audio-visual goods or even consumer durables.

## IMPORTANT FEATURES OF THE MAIN MARKETS UNDER INVESTIGATION

### Standard TVs

- dominated by Japanese manufacturers
- brand name is important
- Sony is the market leader
- one year life cycle
- features are important to consumers and therefore a major element in competition (screen size, NICAM, teletext, etc.)

### Portable TVs

- features are not important
- brand name is not important
- competition based almost entirely on price
- margins very thin

### Videos

- similar to standard TVs
- market leaders are Sony and Panasonic

### Personal/portable players

- Sony is market leader for personal stereos
- retailers consider these goods to be different to other audio-visuals and often place them in other departments

### Mini/midi hi-fi

- similar to standard TVs and videos (features, one year cycle, etc.)
- rapidly growing area

### Hi-fi separates

- longer life cycle
- sold in specialist shops rather than electrical retailers
- more expensive than combined units
- features very important



**VARIABLES IN THE GfK TELEVISION DATA**

Brand (manufacturer)

Model number

Flat screen technology

Styling

Screen size

NICAM

Fasttext/teletext

Remote control

Quantity of sales

Market share

Number of purchases

Unit price

Stocks at the end of period

## ANNEX C

	January	July	Pooled	Full Model
Constant	5.316 (113.42)**	5.234 (63.0)**	5.270 (123.3)**	5.623 (47.43)**
Fst	-0.004 (0.17)	0.183 (5.33)**	0.072 (3.75)**	0.114 (5.94)**
Style	-0.021 (1.51)	0.293 (0.01)	-0.011 (0.95)	-0.008 (0.71)
Nicam	0.240 (14.97)**	0.254 (11.69)**	0.249 (18.99)**	0.252 (19.89)**
Fxt	0.061 (4.37)**	0.075 (3.84)**	0.067 (5.85)**	0.067 (6.11)**
RC	0.058 (1.44)	0.051 (0.65)	0.064 (1.67)	0.065 (1.78)
Akai	-0.216 (3.89)**	-0.018 (0.20)	-0.142 (2.84)**	-0.177 (3.58)**
Akura	-0.417 (9.78)**	-0.343 (4.46)**	-0.390 (9.97)**	-0.445 (11.14)**
Alba	-0.446 (7.69)**	-0.349 (3.83)**	-0.409 (8.00)**	-0.479 (9.32)**
Amstrad	-0.261 (3.55)**	-0.138 (1.03)	-0.218 (3.19)**	-0.262 (3.92)**
B&O	0.487 (5.29)**	0.667 (3.27)**	0.517 (5.72)**	0.454 (5.15)**
Bako	-0.252 (4.67)**	-0.194 (3.51)**	-0.240 (6.38)**	-0.331 (8.23)**
Beon	-0.483 (7.38)**	-0.353 (5.60)**	-0.430 (9.90)**	-0.508 (11.49)**
Bush	-0.362 (7.79)**	-0.218 (3.51)**	-0.307 (8.08)**	-0.358 (9.14)**
Crown	-0.127 (0.61)	-0.041 (0.05)	-0.108 (0.48)	-0.180 (0.83)
Dansai	-0.434 (2.43)*	-0.291 (0.75)	-0.375 (2.14)*	-0.456 (2.69)**
Decca	-0.360 (5.75)**	-0.240 (2.02)*	-0.309 (5.27)**	-0.356 (6.17)**
Ferguson	-0.242 (9.16)**	-0.109 (2.94)**	-0.186 (8.48)**	-0.242 (10.07)**
Finlex	0.040 (0.53)	0.050 (0.37)	0.045 (0.65)	-0.12 (0.18)
Goldstar	-0.256 (6.04)**	-0.184 (3.43)**	-0.231 (6.84)**	-0.270 (7.79)**
Grundig	-0.024 (0.35)	0.021 (0.24)	-0.006 (0.10)	-0.061 (1.13)
Harwood	-0.497 (1.70)	-0.335 (2.27)*	-0.402 (3.36)**	-0.435 (3.75)**
Hinari	-0.339 (4.63)**	-0.217 (1.69)	-0.298 (4.42)**	-0.354 (5.33)**
Hitachi	-0.122 (4.86)**	-0.050 (1.38)	-0.096 (4.50)**	-0.117 (5.53)**
ITT	-0.053 (0.86)	0.000 (0.00)	-0.016 (0.23)	-0.062 (0.92)
JVC	-0.108 (3.80)**	-0.045 (1.07)	-0.084 (3.45)**	-0.119 (4.97)**
Mitsubishi	-0.105 (4.34)**	-0.039 (1.18)	-0.080 (3.99)**	-0.094 (4.77)**
NEI	-0.397 (7.75)**	-0.309 (2.81)**	-0.360 (7.21)**	-0.441 (8.38)**
Nikkai	-0.419 (6.11)**	-0.272 (2.43)*	-0.354 (5.82)**	-0.428 (6.81)**
Nokia	-0.034 (0.15)	-0.053 (0.67)	-0.107 (1.63)	-0.145 (2.25)*
Orion	-0.390 (1.60)	-0.140 (2.00)*	-0.206 (3.59)**	-0.274 (4.86)**
Panasonic	-0.07 (2.79)**	0.049 (1.34)	-0.025 (1.14)	-0.043 (2.02)*
Philips	-0.160 (5.78)**	-0.049 (1.18)	-0.116 (4.90)**	-0.144 (5.80)**
Pye	-0.256 (4.89)**	-0.139 (1.13)	-0.205 (3.94)**	-0.244 (4.77)**
Samsung	-0.237 (7.49)**	-0.182 (4.27)**	-0.224 (8.65)**	-0.281 (10.15)**
Sanyo	-0.228 (6.36)**	-0.122 (2.93)**	-0.189 (7.18)**	-0.230 (8.73)**
Sharp	-0.232 (6.62)**	-0.153 (3.22)**	-0.200 (6.89)**	-0.243 (8.08)**
Ssangyong	-0.347 (0.73)	-0.344 (0.24)	-0.329 (0.65)	-0.449 (0.93)
Tatung	-0.130 (3.01)**	-0.039 (0.78)	-0.093 (2.88)**	-0.151 (4.40)**
Toshiba	-0.055 (2.53)*	0.039 (1.30)	-0.016 (0.87)	-0.023 (1.27)
Sbr	-0.407 (7.32)**	-0.138 (0.81)	-0.350 (6.13)**	-0.425 (7.44)**

...../Continued on next page

	January	July	Pooled	Full Model
6 <sup>*</sup>	0.279 (1.79)	- -	0.244 (1.42)	0.239 (1.45)
10 <sup>*</sup>	0.203 (3.91)**	0.140 (1.76)	0.181 (4.02)**	0.197 (4.55)**
15 <sup>*</sup>	0.201 (6.63)**	-0.015 (0.33)	0.112 (4.32)**	0.577 (2.18)*
7 <sup>*</sup>	0.414 (10.69)**	0.281 (5.15)**	0.354 (10.88)**	0.299 (9.15)**
13 <sup>*</sup>	0.495 (5.85)**	0.391 (4.12)**	0.446 (7.07)**	0.441 (7.20)**
20 <sup>*</sup>	0.332 (10.60)**	0.330 (8.45)**	0.322 (13.18)**	0.326 (13.73)**
21 <sup>*</sup>	0.577 (24.97)**	0.378 (11.15)**	0.492 (25.14)**	0.439 (21.73)**
24 <sup>*</sup>	0.785 (29.30)**	0.595 (15.90)**	0.701 (31.67)**	0.651 (28.62)**
25 <sup>*</sup>	0.767 (7.03)**	0.645 (3.55)**	0.700 (7.12)**	0.693 (7.34)**
26 <sup>*</sup>	1.026 (7.38)**	0.905 (17.31)**	0.991 (25.06)**	0.934 (23.90)**
27 <sup>*</sup>	0.930 (23.58)**	0.775 (11.78)**	0.856 (24.50)**	0.817 (23.51)**
28 <sup>*</sup>	1.099 (27.62)**	0.678 (7.24)**	0.987 (25.83)**	0.935 (24.55)**
32 <sup>*</sup>	1.532 (17.35)**	1.394 (11.32)**	1.469 (19.88)**	1.43 (19.92)**
Jun/July			0.023 (2.55)*	0.004 (0.34)
LN (Sales)				-0.060 (2.89)**
Stocks				0.001 (5.57)**
Distribution				-0.002 (3.86)**
(Stocks) <sup>2</sup>				-0.000 (6.87)**
R <sup>2</sup>	0.96	0.92	0.94	0.95
D-W	1.95	1.80	1.90	1.94
F-Statistic	171.78**	86.52**	235.99**	240.64**
Log-Likelihood	192.755	91.90	244.59	281.01
Reset	1.810 (0.145) <sup>†</sup>	1.806(0.146) <sup>†</sup>	1.52 (0.207) <sup>†</sup>	1.91 (0.123)
Breusch-Pagan	0.98 (0.517) <sup>†</sup>	1.23 (0.139) <sup>†</sup>	1.24 (0.117) <sup>†</sup>	0.965 (0.553) <sup>†</sup>
Skewness	-0.41 (0.99) <sup>†</sup>	0.86 (0.97) <sup>†</sup>	0.43 (0.98) <sup>†</sup>	-0.001 (0.992) <sup>†</sup>
Kurtosis	3.43 (0.00) <sup>†</sup>	6.49 (0.00) <sup>†</sup>	5.94 (0.00) <sup>†</sup>	17.27 (0.00) <sup>†</sup>

\* Figures in parentheses are t-statistics - \* and \*\* denotes difference from null of zero is statistically significant at a 0.05 and 0.01 level respectively.

† Figures in parentheses are p-values; all tests are two-tailed