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THE HALIFAX
HOUSE PRICE INDEX

Technical Details

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Logo

Background

When first introduced in 1984, the Halifax House Price Index represented a major advance in the measurement of house price changes throughout the country. Unlike earlier series, and house price statistics produced by other institutions, the new figures issued by the Halifax were *standardised* rather than based on simple price averages. Given the variety of houses in the United Kingdom, simple averages are not comparable: they do not compare like with like. However, by allowing for the influence of the different characteristics of houses on their prices, using a database especially established by the Halifax for this purpose, the new series placed the measures on a truly comparable footing, thereby providing a more accurate indication of house price movements than was previously possible.

The research work on which the new series of Halifax price index numbers was based was carried out by Professor M C Fleming and Professor J G Nellis. This paper provides a short technical description of the methodology, and presents the results for that first year: 1983.

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1. Introduction

This paper, describing the background to the development of the standardised indices of house prices launched by the Halifax in April 1984, provides a short account of the methodology and presents the series for 1983. The methodology is applied to produce a number of standardised indices covering different categories of houses (all, new and existing) and of buyers (first-time buyers and former owner-occupiers). Future results are to be published in regular monthly bulletins for the United Kingdom and quarterly bulletins giving regional analyses.

The need for "standardisation" arises out of the fact that no two houses are alike: they may differ according to a variety of quantitative and qualitative characteristics relating to the physical attributes of the houses themselves or to their locations. Thus analyses of average house price differences between one region and another, or of changes in average prices over time, are not based on the comparison of like with like if the "characteristics-mix" of houses traded is not standardised. Until recently, little or no attention was paid to this problem: both official and unofficial analyses were based on simple averages of prices and were thus beset by the problem of non-comparability. A review of the problems and of the series available up to 1981 is to be found in Fleming and Nellis (1981).

The problem of comparability cannot be tackled without information about the characteristic, as well as the price, of each house sold. Given the great variety of combinations of characteristics possessed by houses, and given also a desire to measure their influence at regional, as well as at national, levels, it is necessary to establish a data-capturing system large enough to provide representative coverage of all house transactions in each region of the UK. As the country's leading lender it will be appreciated that the Halifax is in an ideal position to obtain large-scale representative data. A comparative study of the Halifax and other building societies*, carried out by the authors, has confirmed that the Halifax data does provide information on price movements that is representative of all transactions financed by building societies in the UK.

*This paper was written prior to the Halifax's conversion to a public limited company in1997. Any references to the Halifax as a building society should now be regarded as the "Company".

The data themselves are described fully in the next section. This is followed in Section 3 by an explanation of the methodology and its application. Section 4 reports the monthly and quarterly results for the different categories of houses and of buyers in 1983.

2. The data on house characteristics

The database established by the Halifax from the beginning of 1983 has two notable merits from the point of view of this study. First, the size of the database is exceptionally large because the number of house-purchase transactions financed by the Halifax each month is very large and all of these are covered in the statistical reporting system. As a consequence, the analytical procedures followed in this study permit much more reliable estimation than would otherwise be the case. Secondly, the scope of the data collected about house characteristics is more extensive than anything available hitherto in the United Kingdom. This again helps to improve the reliability of the statistical analyses. Incidentally, these two facts also mean that the database is larger and more detailed than that obtained in the official *Five Per Cent Sample Survey of Building Society Movements* conducted by the Department of Environment.

Information is obtained about the following house characteristics:

- *Purchase price*
- *Location (region)*
- *Type of property: house, sub-classified according to whether detached, semi-detached or terraced, bungalow, flat*
- *Age*
- *Tenure: freehold, leasehold, feudal*
- *Number of rooms: habitable rooms, bedrooms, living-rooms, bathrooms*
- *Number of separate toilets*
- *Central heating: none, full, partial*
- *Number of garages and garage spaces*
- *Garden*
- *Land area if greater than one acre*
- *Road charge liability*

The use of the information on the characteristics defined above in the analyses undertaken here is explained in the next section dealing with the methodology and its application.

Although one hundred per cent coverage of all house purchase transactions financed by the Halifax is obtained, they are not all allowed to enter the analyses because they do not constitute a fully consistent body of data for the purpose of house price analysis. Therefore, certain properties are excluded, namely those which are not for private occupation and those that are likely to have been sold at prices which may not represent "free" or "normal" market prices, for example, council house sales, sales to sitting tenants, etc. After editing in this way, the database covers over 12,000 house purchase transactions per month.

A final point to note at this stage is that the data refer to mortgage transactions at the time they are approved, rather than completed. This has the disadvantage of covering some cases which may never proceed to completion. On the other hand, it has the important advantage that the price information is more up-to-date as an indicator of price movements and is on a more consistent time-base than completions data given the variable time lags between approval and completion.

3. The methodology and its application

The methodology is based on the "hedonic" approach to price measurement in which goods are valued not for themselves as such but for the set of attributes which they possess (see Lancaster 1966, 1971, Griliches 1971 and Triplett 1971). Thus in the case of housing, prices will reflect the valuation placed by purchasers on the particular *set* of locational and physical attributes (or characteristics) possessed by each house. The difficulty facing the analyst, of course, is that the implicit "price" placed by a purchaser on each characteristic is not observed because transactions take place in terms of a single total price. Therefore, in order to remove that part of price variation due to changes in the mix of house characteristics over time, and so to measure the variation caused by inflationary factors, it is necessary to disaggregate prices into their constituents statistically. This is done using multivariate regression analysis. On this basis it is possible, given data on the prices and the attributes of the houses sold in different time periods, to estimate the change in average price, from one time period to another, on a standardised basis (that is, keeping the mix of housing attributes or characteristics constant). An obvious analogy is with the standard "basket" of goods in the retail price index. It is of interest to note that the technique has been employed by the United States Bureau of the Census in generating a price index of new one-family houses sold each quarter in the USA (see US Department of Commerce, Bureau of the Census 1981).

In relation to the present study, a set of house prices, P_i (i= 1,2, ….n), may be observed in any time period (t) in which each house (i) is sold. Given the supply and demand conditions in the housing market, such houses may be priced differently due to differences in qualitative characteristics (such as the type of property, the availability of certain amenities, the regional location of the property etc), and to differences in quantitative characteristics (such as the age of the property, the number of habitable rooms, garages, bathrooms etc.). Thus, for each house i, we can write P_i as some function of these various characteristics, X_j, together with a group of unmeasured factors (assumed to be randomly distributed) which are specific to each house but for which data are not available, e_i. In general terms the relationship may be expressed as follows:

$$P_i= b_0+b_1X_{1i}+B_2X_{2i}+\ldots..b_jX_{ji}+e_i$$

Where b_1, b_2 …b_j are the regression coefficients corresponding to the qualitative and quantitative variables (X_j).

Given the nature of the data employed in this study, qualitative characteristics can only be represented by "dummy variables" which take the value of one or zero depending upon the presence of absence of a particular attribute. Definitions of the variables for each set of characteristics and the codings used are listed in Table 1 overleaf. The technique of ordinary least squares allows us to estimate the coefficients b_j pertaining to each of the explanatory variables X_j for any set of houses. These coefficients indicate the relative importance of the variables in explaining the variation of house prices in any one time period t.

Table 1

Definitions and Code Names of Variables Included in the Analyses

House Characteristic	*Code*	*Definition*
House Type: Detached Semi-detached Terraced Bungalow Flat	 DH SDH TH BUNG FLAT	Five dummy variables taking the value of 1 if the property corresponds to a particular type. Otherwise 0
Number of bathrooms	NOBATHS	Actual number of bathrooms
Number of separate toilets	NOTOILET	Actual number of separate toilets
Number of garages	NOGARAGE	Actual number of garages
Number of garage spaces	NOGSPACE	Actual number of garage spaces
Presence of a garden	GARDEN	Dummy variable taking the value of 0 if the property has a garden. Otherwise 1.
Number of acres	A1	Dummy variable taking the value of 1 if the property has one acre or more. Otherwise 0.
Central heating; Full None Partial	 CHF CHO CHP	Three dummy variables taking the value of 1 according to central heating provision. Otherwise 0.
Freehold	FH	Dummy variable taking the value of 1 if the property is freehold. Otherwise 0.

Location: (Standardised Statistical Region – formerly Economic Planning Region)		
North Yorkshire & Humberside North West East Midlands West Midlands East Anglia Wales South West South East Greater London Northern Ireland Scotland	EPR1 EPR2 EPR3 EPR4 EPR5 EPR6 EPR7 EPR8 EPR9 EPR10 EPR11 EPR12	Twelve dummy variables taking the value of 1 according to the region in which the property is located. Otherwise 0.
Road Charge Liability	ROADCHRG	Dummy variable taking the value of 1 if the property is liable to a road charge. Other wise 0.
Number of habitable rooms	NOHABS	Actual number of habitable rooms.
Age of property	PROPAGE	Actual age of property in years

Having obtained estimates of the coefficients, b_j, it will be appreciated that the average price of any set or sub-set of houses in any period depends on the number of observations on each characteristic in that period. Therefore, standardisation to allow for the varying mix of characteristics between one time period and another may be accomplished by applying a standard "representative" set of weights corresponding to the numbers of each characteristic observed in a chosen period. It is common to adopt, as a standard, the set of characteristics that pertained in a base period and this is the practice adopted here, the year 1983 being chose for this purpose. Thus the index numbers we calculate represent the movement in average prices for houses possessing the same characteristics as those bought in 1983. The index numbers themselves are computed by comparing the weighted (i.e. mix-adjusted) prices in each current period with the weighted average price in the base period.

Before proceeding to the results of these calculations, however, we would draw attention to the nature of the underlying statistical analysis because the reliability of the results depends upon the reliability of the basic price-estimating equations. We comment briefly on the most important matters here and place a more detailed exposition of the analysis in an Appendix. Two matters demand special attention in establishing the appropriate estimating equations.

Firstly, it is necessary to ensure that the explanatory variables used in the equations are sufficiently independent of one another to allow their relative importance as determinants of prices to be reliably estimated. Although in principle it may be thought desirable to use all the information available about *all* explanatory variables, in practice certain variables may be so correlated one with another that it may be impossible to measure particular coefficients in any one set or sub-set of the data without the problem of "multicollinearity". Where this is severe the regression coefficients for the variables affected reflect not only the relative importance of those variables but also that of other variables with which they are correlated. As a consequence it is necessary to conduct appropriate statistical tests to examine the possible existence of this problem and, if necessary, to take the appropriate remedial action. It will be appreciated that it is not possible to measure all the characteristics that may influence prices or to measure them satisfactorily in every case. In particular, qualitative factors relating to the standards of repair of existing (non-new) houses, the quality of workmanship, the nature of fixtures and fittings, environmental quality of the neighbourhood etc., are not reflected in our equations except in so far as they may be correlated with the variables which ***are*** measured. Consequently it is not possible to explain all of the variation in prices that is observed. However, the characteristics used in the equations in this study generally explain around 70 per cent of this variation in the UK and 55-80 per cent at the regional level, depending on the particular sub groupings of houses. Explanatory power of this order is generally held to be very satisfactory indeed in studies of this kind.

Secondly, it is necessary to determine the appropriate form of the functional relationship between the variables. In this respect the dummy variable technique is particularly useful because it allows the incorporation of variables with which price may be related non-linearly, without the necessity of specifying the nature of the non-linearity. This, of course, is not the case for those variables such as age, number of habitable rooms etc., which are not dichotomous variables and these are incorporated into the estimation procedure as integer values. However, preliminary analyses of polynomial transformations of these variables showed that such transformations provided no significant addition to the explanatory power of the regression equations. But, in contrast, transformation of the dependent variable, price, proved to be statistically significant and this was confirmed by the use of Box-Cox tests (see Appendix): these showed that the semi-logarithmic functional form (with the dependent variable P_i measured in natural logarithms) was to be preferred. The specifications of the final regression equations used to generate the standardised index numbers, are shown in Table 2 overleaf. Reference should be made to the Appendix for a fuller account of these and other matters relating to the statistical analyses.

Table 2

Final Regression Specification (*Dependent Variable Inp$_i$*)

[√] denotes variables included. **[X]**denotes variables excluded.

Table 2

Variables*	**Regression Equations For:** All Houses	New Houses	Exisiting Houses	First Time Buyers	Former Owner Occupiers	All EPRs+
DH*	***Omitted Dummy***					
SDH	√	√	√	√	√	√
TH	√	√	√	√	√	√
BUNG	√	√	√	√	√	√
FLAT	√	√	√	√	√	√
NOBATHS	√	√	√	√	√	√
NOTOILET	√	√	√	√	√	√
NOGARAGE	√	√	√	√	√	√
NOGSPACE	√	√	√	√	√	√
GARDEN	√	**X**	√	√	√	**X**
A1	√	√	√	√	√	√
CHF*	***Omitted Dummy***					
CHO	√	√	√	√	√	√
CHP	√	√	√	√	√	√
FH	√	**X**	√	√	√	**X**
EPR1	√	√	√	√	√	√

EPR2	√	√	√	√	√	√
EPR3	√	√	√	√	√	√
EPR4	√	√	√	√	√	√
EPR5	√	√	√	√	√	√
EPR6	√	√	√	√	√	√
EPR7	√	√	√	√	√	√
EPR8	√	√	√	√	√	√
EPR9∗	***Omitted Dummy***					
EPR10	√	√	√	√	√	√
EPR11	√	√	√	√	√	√
EPR12	√	√	√	√	√	√
ROADCHRG	√	√	**X**	√	√	√
NOHABS	√	√	√	√	√	√
PROPAGE	√	**X**	√	√	√	√

* Variable code names are defined in Table 1.
+ The Regional regressions for new and existing houses only include variables common to both the region and sub-sample specifications.
∗ Variables omitted for computational purposes. One variable from each dummy variable sey must be excluded in order to avoid the problem of indeterminancy of the ordinary least squares normal equations.

We are now in a position to apply the methodology to derive index numbers. The methodology is applied here to produce base-weighted standardised house-price index numbers, whereby a weighted average of the estimated regression coefficients is calculated (each coefficient being regarded as an implicit characteristics-price). It will be appreciated that weights other than those appropriate to the base period may be adopted.

The steps involved may be summarised as follows:

(i) calculate the weights, Q_j1983: the proportions of the qualitative variables and the means of the quantitative variables presenting the chosen base period (i.e 1983);

(ii) with price recorded in natural log form, use the technique of ordinary least squares to estimate the regression coefficients b_j for the j explanatory variables, in both the base period (i.e. b_j1983) and for every subsequent time period t (b_{jt});

(iii) calculate a base-weighted (Laspeyre's type) index for the current period (I_t) as follows:

$$I_t = \frac{\text{antilog} \sum b_{jt}Q_j1983}{\text{antilog} \sum b_j1983Q_j1983} \quad X100$$

Summation is carried out, of course, over all variables included in each regression.

4. Results

For the United Kingdom as a whole, the procedure outlined above is used to compute five monthly series of base-weighted index numbers covering all, new and existing houses, and houses bought by first –time buyers and former owner-occupiers respectively. The results for 1983 are printed in Table 3 overleaf.

The increases over the period from January to December 1983 are always in the range 7 – 8 per cent but with some variation according to house type and house buyer. The index for all houses, based on 1983 = 100, rises from 94.8 in January to 102.2 in December: an increase of 7.8 per cent.

Table 3

Price Movements in the UK by Category of House and Buyer
Monthly Series for 1983

(Index 1983 = 100)

Month	House			Buyer	
	All Houses	New Houses	Existing Houses	First-Time Buyers	Former Owner-Occupiers
January	94.8	96.1	94.7	95.6	94.9
February	95.7	96.3	95.9	96.8	95.5
March	96.9	97.0	97.0	97.4	96.7
April	98.5	99.2	98.4	98.5	98.4
May	100.3	101.1	100.3	99.8	100.3
June	100.9	100.6	100.7	100.5	100.9
July	102.1	100.9	102.2	101.8	102.0
August	102.3	100.4	102.5	101.4	102.6
September	102.2	101.9	102.3	101.6	102.6
October	102.5	102.2	102.7	102.5	102.4
November	102.4	102.4	102.4	102.4	102.2
December	102.2	102.9	101.9	102.8	102.1

In addition, index numbers for each of the twelve standard (statistical) regions for all, new and existing houses are computed quarterly. It should be appreciated that, as the regional analyses are inevitably based on smaller sample sizes than the analyses for the UK, the regional index numbers are subject to larger margins of error. It is for this reason that they are computed on a quarterly rather than a monthly, basis.

The regional results for 1983 are given in Table 4 overleaf. They show that price changes at the regional level during 1983 were much more variable than at the national level, ranging from a low of 2.4 per cent to a high of 10.4 per cent, both relating to existing houses in the West Midlands and in Scotland respectively. For all houses the increases ranged from 3.2 per cent to 9.7 per cent, again in the West Midlands and Scotland respectively. In the case of new houses, the increases ranged from 2.8 per cent (Greater London) to 7.9 per cent (South East).

The UK and regional series are updated in monthly and quarterly bulletins respectively. These are available from the Halifax on request.

Table 4

Regional Price Movements. Quarterly Series for 1983

(Index 1983 = 100)

Region	All Houses				New Houses				Existing Houses			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
North	96.5	98.8	102.4	102.6	96.2	99.8	102.4	100.2	96.6	98.6	102.4	102.9
Yorkshire & Humberside	96.2	100.2	101.7	102.2	96.3	100.7	101.0	102.1	96.3	100.0	101.8	102.1
North West	96.5	100.2	101.8	101.5	96.2	101.7	100.3	101.4	96.8	100.0	102.0	101.4
East Midlands	95.5	100.4	102.5	102.0	95.6	99.5	102.4	102.6	95.6	100.5	102.3	102.1
West Midlands	97.1	101.2	101.7	100.2	97.2	98.0	100.6	104.2	97.1	101.5	102.1	99.4
East Anglia	95.1	99.2	101.7	104.2	95.7	99.2	100.5	103.2	95.2	99.3	102.0	104.1
Wales	96.4	100.8	102.2	100.4	96.4	103.8	98.1	101.9	96.6	100.3	103.0	100.3
South West	96.5	100.2	101.8	101.7	97.7	98.9	102.2	102.0	96.4	100.3	101.6	101.8
South East	95.6	99.2	102.8	103.3	95.9	100.2	101.8	103.5	95.5	99.1	103.0	103.3
Greater London	95.7	99.2	102.6	103.2	97.1	101.9	101.8	99.8	95.7	99.1	102.6	103.3
Northern Ireland	96.3	99.5	102.5	101.4	95.9	101.5	100.8	101.5	96.1	99.0	103.3	102.3
Scotland	94.4	98.9	102.9	103.6	98.0	99.2	100.0	103.3	93.9	99.0	103.4	103.7

Appendix

In regression analysis, four types of interrelated problems are commonplace, and are especially relevant in the present context, namely:

(i) the choice of functional form for the estimating equation,
(ii) the degree of correlation between the explanatory variables themselves (i.e. multicollinearity),
(iii) the possibility of the error term, e_i, exhibiting a non-constant variance (i.e. the presence of heteroskedasticity), and
(iv) errors in the recording of data and the inclusion of extreme or unusual observations ("outliers").

Considerable attention was devoted to each of these subjects in arriving at the estimating equations; we comment on each of them in turn below.

(i) Functional Form

The first step in regression analysis is to determine an appropriate functional form for the estimating equation. A potentially serious source of bias in hedonic price and other regression-based studies may be associated with functional form mis-specification. In principle, many functional forms are possible, but unfortunately there is no theoretical guidance as to which form is the most appropriate to particular models. The solution to this problem, therefore, reduces to an empirical one. Box and Cox (1964) have developed a statistical test for the functional form providing the "best fit" based on likelihood ratio tests and the procedure they suggest is adopted here. The results showed that the semi-logarithmic functional form (with the dependent variable P_i measured in natural logs) was to be preferred. The specifications of the final regression equations which are used to generate the standardised index numbers, are shown in Table 2 above.

(ii) Multicollinearity

Multicollinearity refers to the situation in which some or all of the explanatory variables are very highly correlated and are therefore not independently distributed. The existence of marked interrelationships between explanatory variables can cause problems with respect to the following aspects of regression analysis:

(a) estimated regression coefficients may not be uniquely determined,
(b) estimates of the coefficients from sample to sample may fluctuate markedly, and
(c) less reliability may be placed on the relative importance of variables as indicated by the partial regression coefficients.

It should be appreciated, however, that multicollinearity is inevitably present to some degree in most multiple regression analyses. It can rarely be eliminated completely and the aim of the researcher therefore is to minimise its influence as much as possible.

The procedure adopted for identifying such interrelated variables was partly by examination of the correlation matrices for the explanatory variables but mainly by a stepwise regression procedure in which the relative explanatory power of each variable is determined in turn. At each step of the procedure the interdependence between each variable being considered as a candidate for inclusion is compared against the group of variables already selected. The measure used in this procedure is referred to as the "tolerance" level of a variable, measured by $(1 - R^2_j)$ where R^2_j is the squared multiple correlation when the J^{th} explanatory variable is considered as the dependent variable and the regression equation between it and the other independent variables is calculated. If the variable has a large R^2 – or equivalently a small tolerance – when it is predicted from the other independent variables, then the presence of multicollinearity (to a degree) can be assumed. As a consequence, the variance of the estimators will be inflated and computational problems can occur.

The classic way of dealing with the problem of multicollinearity is to discard variables from the regression analysis. If two variables are very highly correlated, use of either one in the regression (rather than both) can capture the effect of both. This is the approach adopted in the present study. By setting tolerance limits at an acceptable level, as well as gleaning the evidence from the relevant correlation matrix, it is possible to identify the most significant interrelationships between variables. Three alternative variable-selection procedures are possible: "forward selection", "backward elimination" and "stepwise selection". These are described fully in Nie *et al*. (1975), pp 345-347 and Norusis (1982), pp. 118 –121. Each procedure will not necessarily give identical results. In the present study, however, all three methods were employed and they were consistent in leading to particular conclusions concerning the variables that should be included in the final regression specifications.

(iii) Heteroskedasticity

In regression analysis, the error terms, e_i, are assumed to be normally and independently distributed with a mean of 0 and a constant variance of o^{-2}. However, when dealing with data of the kind used in the present study, the constant-variance assumption may be violated, and the appropriate model may in fact be one with a so-called "heteroskedastic" error term – for a detailed discussion of this problem see Kmenta (1971), pp. 249-269.

A simple and direct method of detection is by visual inspection of the residuals (i.e. deviations of observed prices from those estimated from the regression equation) plotted against the estimated values of the dependent variable or against the independent variables. As most of the latter in this study are dichotomous, our attention was focused on the former. If the spread of the residuals increases or decreases with estimated values, it may be taken as an indicator of heteroskedasticity in the data set. The total data set for a sample month was used to test for the existence of this problem and the resultant scatterplot of residuals was observed to be relatively uniform across the range of estimated values. It is concluded therefore that the constant-variance assumption appears not to be seriously violated with respect to the sample data set. There is no reason to believe this should not hold for the data sets relating to other time periods. It should be appreciated, however, that even if heteroskedasticity exists, it would only increase the confidence intervals of the indices; it would not affect their unbiasedness.

(iv) Data-recording (Coding) Errors and Outliers

Cross-tabulations of the date were used to spot potential coding errors and outliers. Examination of the residual plots, referred to above, also helped to identify outliers, as they are cases with very large positive or negative residuals. Particular attention was devoted to the recorded number of habitable rooms (NOHABS) as this is a key variable and it was finally decided to restrict the variable for habitable rooms to the range from one to twenty inclusive, all properties having values outside this range being excluded from any subsequent analyses. Certain restrictions are also placed on other variables.

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