# House Price Indexes, Approaches and Methods.

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## Abstract

This paper discusses some methods used in the compilation of quality adjusted house price indices. First there is the repeated sales method, secondly the assessment method, third the stratification method and finally the hedonic method. The Icelandic house price index is described based on present value of sales contracts collected by the Land registry of Iceland. A stratification method is used and a superlative index compiled using geometric estimator. The simple user cost method is also described using annuity method, depreciation and real interest rates.

**Key words:** Assessment method, consumer price index, cost of living index, household expenditure surveys, house price indices, owner occupied housing, real estate price indices, repeated sales method, stratification method, user cost.

**JEL:** C43, C81, D11, E31.

# 1. Approaches to house price indexes

Houses differ widely in quality, they are not homogeneous goods and are often produced as one of a kind; are unique durables (Diewert (2003b) p. 24). Under the matched model method the price changes of the same good is measured between periods. As houses may differ when traded, matching often fails. This is especially the case under housing crises when the volume of trade falls, fewer houses are sold and the quality differ videly. Maintenance and depreciation of houses vary over time so matching is difficult and quality adjustment of some sort is necessary. Houses do not appear on the market in exactly the same condition as they were when last purchased or produced so the matched model methodology fails and a quality adjustment of the house price index is needed.

Sales of houses are random and do not necessarily reflect the value or the composition of the housing stock.

The indices suitable for use in the CPI are usually of the transaction kind but the methods, which are used when the housing stock is valued, are value estimates. The aim of CPI's is to measure price changes and therefore the transaction indices are often used in the CPI compilation.

There are four main methods suggested for constructing constant quality adjusted real estate price indexes (Diewert (2006), p. 6-18).

The *repeated sales method* uses houses that are sold more than once (Baily, Muth and Nourks (1963)). The method has been developed in a weighted form (Palmquist (1980)) and that method can be interpreted as a hedonic method where the characteristic is the house sold. The problem with this method is the risk of bias, e.g. when major renovation or other changes have been made on the house which increase the quality or if the wear of the house has been high causing a decrease in the quality. Such changes are not captured by this method. There are insufficient numbers of repeated sales on the Icelandic housing market in order to calculate such an index.

The *assessment method* is based on a comparison between valuation of a house, often official, and its salesprice. In that case information on housing characteristics is not needed. It is an unweighted transaction index using the arithmetic mean as an estimator. Compared to the repeated sales method all housing transactions are used in the calculations. Examples of such indices are found in New Zealand, Denmark, Sweden and the Netherlands (Wal et. al. (2006) and de Vries et. al. (2008)).

If detailed information on the property characteristics is available, stratification can be used and geometric estimator and superlative weighting could also be applied improving the method.

The quality of this approach depends immensely on the methods used in the house valuation. Those methods should be homogenous and not show systematic difference in quality at the point of valuation. For that purpose the mass apprisal methods used should follow the standard set by the *International Association of Assessing Officers* (International

Association of Assessing Officers (2002 and 2006)). Such mass apprisal methods are used both in Denmark and Netherlands. If there is no in-between revaluation and the valuation quality is good and no crossing at revaluation point this method should be satisfactory for index calculation.

Firstly this method requiers the valuation to be homogeneous – that is the valuation must be done by mass apprisal models where *all* properties are valued at the same time. Often this is not the case. In valuation practice, the proper market value is often dependent on grade and condition of the property, besides size of land and building and in some countries property owner can request a revaluation of his property. The values may be suitable for taxation but not for estimation of price changes over time (Ingvarsson (2006)).

Secondly there is always the risk of systematic difference in the valuation quality, since some types of properties are better valued than others. If you are using the changes in the market value for in a price index there is a need to know much the value of this property type did change at the point of revaluation. In addition changes are often made to the description of the property during revaluation as new inspection lead to changes in sizes or the type of properties valued. It may therefor be very difficult to have access to both the old values and the new values at the time of revaluation (Ingvarsson (2006)).

The *stratification method* sorts information into fixed groups, or strata, in terms of housing characteristics. Then average (Duot) or median sales prices are calculated for each stratum. On the other hand the estimator could just as well be geometric (Jevon). These indexes can be either weighted or unweighted. The method is used in the Icelandic house price index for the calculation of the simple user cost model in the Icelandic CPI. The method is also used in Australia (Olczyk and Neideck (2007)).

The stratification method used in the Icelandic house price index compilation keeps fixity on, category sizes, property types, location in the country and location inside the capital area by the age of the properties. The estimator used in the calculation is geometric and the index is calculated superlatively (Fisher) (Guðnason and Jónsdóttir (2006)).

The *hedonic method* measures the prices of characteristics of houses and in that case the correct functional form is crucial. There is a considerable amount of studies available in this field, (Diewert (2003c), (2003d), (2004), (2005a), (2005b)), (Gouriéroux and Laferrère (2006)), (Haan (2004)), (Li, Prud'homme and Yu (2006)).

## 2. The Icelandic house price index.

The house price index used in the Icelandic CPI is based on market prices for houses obtained from sales contracts that the Land Registry has collected for many years. They are suitable for this purpose because they are standardized throughout the country. Every sales contract contains information on the property, its owners and the sales price, along with precise details on payment terms. Every property has a special, distinctive number which is

used in the register of the Land Registry. These detailed data form a basis for the aggregate real estate value and form the grounds for measuring the market price of real estate in the consumer price index. Since the contracts are gathered through the offices of the District Commissioners upon being registered by the Land Registry, almost every concluded real estate agreement is obtained. It is not only in the interest of buyers that a contract is being registered but also a condition for credit services from the Housing Financing Fund and the commercial banks.

Roughly 8–10 thousand real estate sales contracts are made annually, which means that around 8–10% of all the housing in the country is bought and sold. The price concept is the same as for other price measurements in the CPI as the price used for computation is the one the consumer actually pays for goods and services, the price of the goods in cash. A sales contract details how payments are arranged; in fact, that information enters into figuring its present value. The basic reason for applying the present value is the fact that the value of money paid today is different from the value of money paid in the future.

The housing price index is computed from changes in the present value of real estate as declared in sales contracts. The greater part of the sales contracts serve in producing the imputed rent and are used in calculating the weighted national average since March 2000 and the index was then recalculated back to March 1997. The price changes for real estate is calculated as a three-months moving average, with a one-month delay. April includes contracts from the period January to March, May contracts from the period February to April, and so on.

A stratification method is used in the Icelandic house price index for the calculation of the simple user cost model in the Icelandic CPI. The index is transaction based index weighted superlatively (Fisher) and subindices are produced by this method. The estimator is the geometric mean but keeping fixity on following details:

- Category sizes.
- Types of properties; multi-family housing, single-family housing.
- Location in the country; capital area, outside the capital area.
- Inside the capital area by age of the houses; older/inner and younger/outer. Properties are separated in that way by age/depreciation.

Changes were made to the Icelandic property index in March 2006 aimed at improving the calculation in respect of measuring quality change. They were based on research on housing sales data over the period January 2000 to April 2006. In that period there were 57,200 properties sold, approximately 35,000 multi-family housing nearly 6,500 single-family houses, in the capital city area and 7,700 multi-family housing and 8,000 single-family houses outside the capital city area.

The capital area was split into two strata, an inner/older and an outer/newer where nearly 30% of the single-family houses sold belong to the inner/older area. There are 8 categories for properties size, giving after these changes altogether 18 subindices for housing in the capital city area and 8 indices by size category for property outside the capital city area. From both of

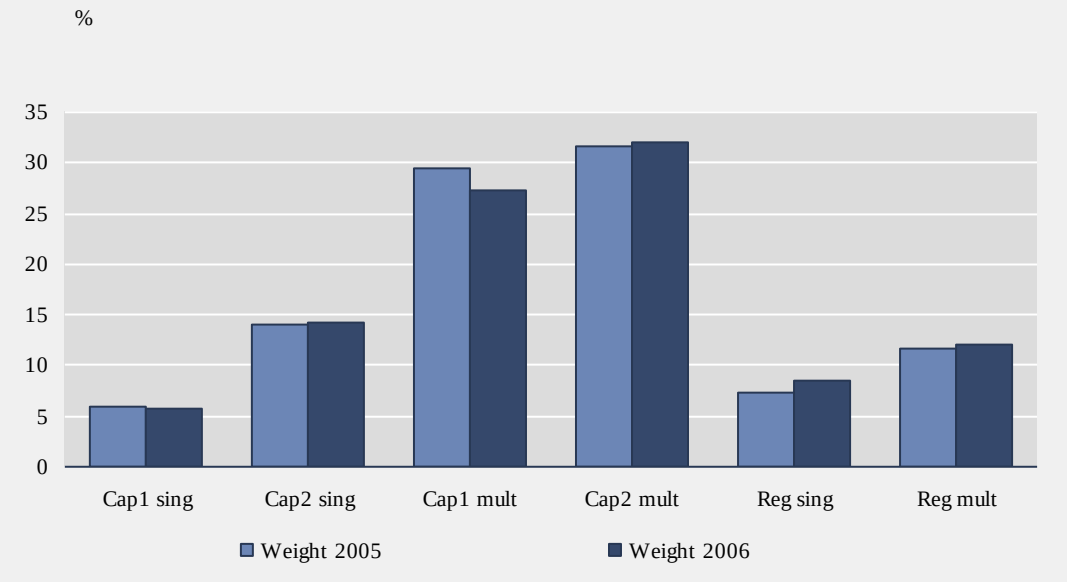
these sets of indices, 4 overall indices are calculated for multi-family housing and single-family houses, inside and outside the capital city area. Hence 30 subindices are used when calculating the aggregate index for real estate prices. Emphasis is placed on comparing price developments within housing categories, not among types of property or among the different regions of Iceland.

Transaction effect the average value of the housing stock which might lead to an increased divergence between quantity and value weights especially in periods of high house price inflation. Value weight are therefore used in the house price index as they better reflect market changes then the number of dwellings sold.

The geometric mean is used when averaging house prices within each stratum at the elementary level. This is in line with the calculation method used at the elementary aggregate level in the Icelandic CPI. The geometric mean is also used in hedonic calculations and the geometric mean is a typical matched model estimator (Diewert (2003b) p. 32 and (2003c) p. 334), (Haan (2005) p. 431).

The house price index is calculated as a superlative index (Fisher) using the values for 2002–2005 as the weight for the Laspeyres index and the values for 2003–2006 to calculate the Paasche index. The weights, which are changed monthly, can be seen in figure 1.

**Figure 1 Weights in the house price index in March 2006**




**Note:** Weight 2005 refers to March 2002-2005, weight 2006 to March 2003-2006. Cap1 is the inner part of the capital city area, Cap2 is the outer part, Reg is housing outside the capital area. Sing are single-flat houses, mult are multi-flat houses.

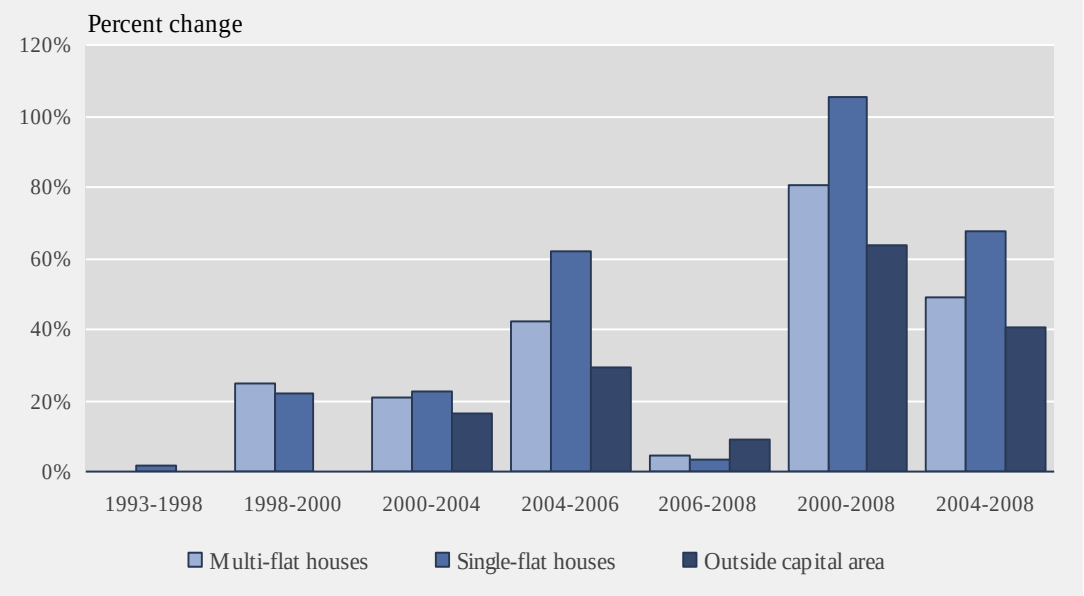
The Land registry is currently developing a new housing sales database, bringing together all register based information about the property with the sales contracts. This database will be an excellent tool for research in the future, paving the way for a hedonic house price index.

## 3. Housing inflation, rentals and interest rates

There has been considerable house price inflation in Iceland in recent years as is shown in figures 2 and 3. In real terms, house prices (deflated by the CPI less housing cost) in the period 2000 to April 2008 have increased by 80% for multi-flat houses and 105% for single-flat houses in the capital area. For houses outside the capital area, the average price change in the same period was 64%. The average price change for the whole country was about 79%.

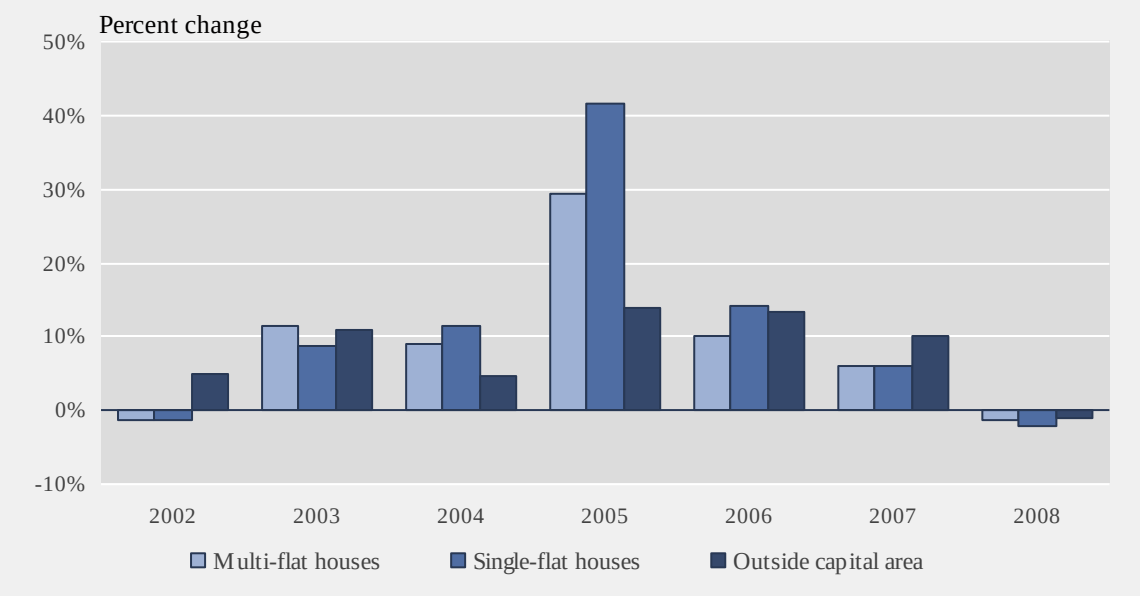
In the period 1993–1998 house prices were stagnant or fell slightly. In the period 1998 to 2000 there was 24% increase in house prices in the capital area in real terms and 17% outside the capital area in the same period. In the period 2000–2004 the average prices in the whole country rose by 20%.

**Figure 2 Changes in real housing prices, deflated by the consumer price index less housing cost, changes over periods of years**




**Note:** Prices outside the capital area were included in the index in March 2000. 2008 refers to April.

**Figure 3 Changes in real housing prices, 2002–2008, deflated by the consumer price index less housing cost.**




**Note:** Prices outside the capital area were included in the index in March 2000. Prices 2008 refer to April, changes from the average 2007.

Following the lowering of real interest rates in the period July–December 2004 and increased supply of loans the real house prices rose on the average from 2004 to April 2008 by nearly 49%.

Rental and housing markets are in theory two sides on the same coin and should therefore move in a similar fashion. But that is not necessarily the case. The composition of the durable stock can differ and there are costs in the rental market that those living in own housing do not face and should therefore not be included in the owners cost (Diewert (2003b), p. 47-50).

Until 2004 rental markets and house prices in Iceland moved in similar fashion. But changes in the loan market and lowering of the real interest rates led to a considerable price increase. Table 1 shows the price changes in the markets 2001–2006.

Rent increased more than imputed rent in the years 2001 to 2003. From 2003 this has changed and in the period 2004 to 2005 housing prices rose by nearly 29%. When the effect of lower real interest rate through the user cost measurement is taken into account the increase in the imputed rent in the same period was nearly 22% and in the period April 2007–2008 housing prices rose by 11% and imputed rent by 17%. In April 2009 the share of imputed rent over rent is 22.5% but market prices are 25.7% higher.

**Table 1 Rent, imputed rent and market prices in the Icelandic CPI 2000-2008.**

| Year | Rent | Imputed rent | Market prices | Imputed/Rent | Market/Rent |
|---|---|---|---|---|---|
| | % | % | % | | |
| 2001 | 9.0 | 6.4 | 6.4 | 1.007 | 0.991 |
| 2002 | 8.7 | 4.8 | 4.8 | 0.971 | 0.956 |
| 2003 | 9.9 | 11.0 | 11.7 | 0.981 | 0.972 |
| 2004 | 7.9 | 9.1 | 10.5 | 0.991 | 0.995 |
| 2005 | 6.2 | 21.9 | 28.5 | 1.138 | 1.204 |
| 2006 | 8.3 | 16.4 | 16.8 | 1.223 | 1.299 |
| 2007 | 10.6 | 13.7 | 9.4 | 1.258 | 1.285 |
| 2008 | 11.0 | 17.1 | 11.3 | 1.225 | 1.257 |

**Note:** March 1997=100. The year 2008 refers to April 2008 and price change is from April 2007.

The average real rates used in the user cost model were 4.0% in July 2004 and were 3.8% in October 2006 and 4.1 percent in April 2008. The effect of real interest rates on the CPI has to be measured separately. In the period April 2004–2005 the effect of changes in interest rate reduced the price change by 0.31% and between 2005 and 2006 interest change lowered th CPI by 0.91%. Because of increase in real interest rates between 2006 and 2008, the Icelandic CPI rose by 0.81% in 2007 and 0.92% to April 2008. Over this period (April 2004–April 2008) the net effect of the increase in the interest rates led to 0.51% rise in the Icelandic CPI.

## 4. Methods for measuring the share of owner occupied housing

Measuring the share of owner-occupied housing in an index has two facets, as housing is used not only for residence but also as an investment, which adheres to its own particular set of rules. For this reason, value measurement of the use of owner-occupied housing has long been a problem when calculating consumer price indices, especially in small rental markets, such as the Icelandic one.

Two main approaches can be considered for computing the use of owner-occupied housing. One takes into consideration the service flow from residence in owner-occupied housing and includes *rental equivalence*, *user cost*, and the newly suggested *opportunity cost approach* (Diewert (2006), p. 27), while the other includes *net acquisition*. What is common to both approaches is that market price is used to measure price changes; however, the approaches to calculating expenditure weights differ.

In countries where rental equivalence is used, information is taken from national accounts, based on rent surveys or housing owners asked what rent they feel would be paid for their apartment if it was rented, and the results obtained are used to derive weights. In cases where simple user cost is calculated, the annuity for the property base is used to

determine the expenditure weight. In the net acquisition approach, on the other hand, the full price of the housing is capitalized in a single expense entry, creating the weight for that approach.

In all these instances, developments in the prices for owner-occupied housing are calculated according to changes in market price. In the case of rental equivalence, the reference is to changes in the market rent paid for comparable housing, while in the case of user cost the reference is to the changes in market prices for bought housing, used as well as new.

The net acquisition approach should theoretically be based on prices for new housing. Real estate prices for new and used properties could easily change in a parallel manner, and then the same real estate index could be applied, in both the user cost and net acquisition approaches. The price measurement is therefore based on market prices independent of the method used for aggregation of weights used under each approach. It could furthermore be the case that prices for old and new houses moved in similar fashion. Then the house price inflation would be the same for both user cost and net acquisition approaches but due to the difference in weight shares the influence on the index results would differ.

According to this, changes in market prices are very important element in these approaches and the development of good and reliable price indices for market prices important.

## 5. Market price methods to calculate the cost of owner occupied housing

The four market price methods the can be used for these two approaches are rental equivalence, user cost, opportunity cost and net acquisition

*Rental equivalence* is computed in many places where rental markets are strong and rental changes can be used for properties in the general market that correspond to owner-occupied housing. The rental equivalent then changes in accordance with the rent for those apartments. A necessary condition for this is:

i) The rental market needs to be large enough for the existence of various types and sizes of properties in the rental market to be comparable to their parallels in owner-occupied housing, and that the market rent rate can be used as an equivalent of rent changes for owner-occupied housing.

ii) The rental market may not be controlled and rent may not be subsidized by authorities or market prices governed in some other way.

iii) That cost born by landlords, but not by tenants or those living in owner-occupied housing, should not be included in price measurements.

The rental equivalence approach is not used in Iceland because of how small the rental market is and also because of the Icelandic market's difference in composition from what

generally applies to owner-occupied housing. The majority of Icelanders, or about 80%, live in owner-occupied housing according to the household expenditures survey.

In instances where the rental market is small, the service flow from owner-occupied housing can be measured in terms of *simple user cost* (Diewert (2002), p. 621 and (2003a) p. 28 and 53) in similar way as in the Icelandic consumer price index. The annuity (imputed rent) is computed from the property's market price, and the imputed housing rent is measured on the basis of certain real interest rates and depreciation. Real interest is the required return on (or opportunity cost of) capital tied up in the property or taken on credit. Property wear is taken into account by basing depreciation on an estimate of the lifetime of the property. Consideration is shown for use of the housing, or residence in it, but the return on the investment is calculated with the real long-term interest rate. Price changes are determined mostly by changes in the market price of all properties sold and to some extent by changes in real interest. The consumer price index measures short-term price changes, providing that there is no substitution between living in owner-occupied housing and renting, in other words that due to the tiny size of the rental market, it is not possible in the short-term to sell the housing and rent other housing instead.

Although several countries calculate the housing in the index as a user cost, none of them use real interest rates for calculating user cost except Iceland. In Iceland longer mortgages are granted in real terms and usually indexed with the CPI. In some countries mortgage profiles are used but they only reflect the life time of the mortgage not the house (durable) and it is often very difficult to separate financing used for housing from other financing. Some countries use market prices of houses to evaluate depreciation or the mortgage rate.

*Opportunity cost approach* to the treatment of owner occupied housing has been suggested recently. In treating problems connected with the flow of services methods using opportunity cost (rental equivalence or user cost) for pricing the services of living in owner occupied housing Erwin Diewert has suggested that the "right" opportunity cost for OOH would be the maximum of what the dwelling could rent for and its user cost.

> "We conclude this section with the following (controversial) observation: perhaps the "correct" opportunity cost of housing for an owner occupier is not his or her internal user cost but the *maximum* of the internal user cost and what the property could rent for on the rental market. After all, the concept of opportunity cost is supposed to represent the *maximum sacrifice* that one makes in order to consume or use some object and so the above point would seem to follow. If this point of view is accepted, then at certain points in the property cycle, user costs would replace market rents as the "correct" pricing concept for owner occupied housing, which would dramatically affect Consumer Price Indexes and the conduct of monetary policy" (Diewert (2006), p. 27).

Housing cost can be valued in reference to *net acquisition.* The net item represents the housing that is built in excess of the housing that is depreciated. When calculating the consumer price index, housing is capitalized at the time of purchase, in the same way as other durables in consumer price index calculations. Price changes are measured

based on the price of new houses, including housing the resident built and housing purchased directly from a builder or real estate broker. Furthermore, apartments bought from the business sector or public parties must be accounted for. This index is to some extent similar to a producer price index for buildings. The amount of new apartment housing built each year varies, depending among other things on the economic situation. The net changes might turn out negative in some years and thereby also the weights for new housing. If this approach is to be used, weights must be calculated as means over several years. Weight fluctuations are greater and relate more closely to economic cycles when the net acquisition approach is used instead of the user cost or rental equivalence approaches; moreover, the weight for owner-occupied housing normally comes out lower (Diewert (2002a), p. 62). The change in house prices used with this method overestimates the house price change when real interest rates falls as their influence on house prices are not taken into account.

Non-market payment method is sometimes used to evaluate owner occupied housing, especially if information is lacking on the market price of housing or on the housing market. By this method, the flow of payments for the purchase of housing is measured without normally giving attention to the funding of consumption when calculating the consumer price index. Attention is however given to payments for housing purchases, instalments, interest, maintenance and housing improvements. This approach is similar to the one used for the Icelandic consumer price index during the period of 1988 to 1992. Nominal interest rates, which partly reflect inflation, are included, but no consideration shown to the distribution of housing use over a longer period.

In some countries, housing is considered chiefly an investment, with the resulting argument that it should not be included in the consumer price index, so that owner-occupied housing is left out of it. In some instances the countries do not have sufficient information on price changes in the property market to be able to apply any of the approaches described above. Owner-occupied housing has still not been included in the harmonized consumer price index calculated for the EEA countries, but there are plans to do so, probably by the net acquisition approach and with a price index for all properties sold.[1]

The methods used for the calculation of owner occupied housing differs as the share of households living in own housing. The methods used in different countries and the share of owner occupiers are as follows (Hansen (2000), Housing Statistics (2004) and Christensen, Dupont, Schreyer (2005)).

*User cost*: Iceland (80), Ireland (78), United Kingdom (69), Canada (66). Finland (64) and Sweden (46).

*Rental equivalence*: Norway (77), United States (68), Japan (60), Denmark (51), Netherlands (54), Germany (45), Switzerland (31).

[1] Eurostat‘s current suggestion includes among other things the following: “A price index for all dwellings purchased by housholds as a self-standing index“. Eurostat (2004), p. 6.

*Net acquisition*: United States until 1983, Australia (70), New Zealand (65), HICP from 2007.

*Excluded*: Italy (78), Spain (81), Greece (74), Luxembourg (67), Portugal (66), Belgium (68), France (56) and Austria (57).

## 6. Simple user cost

Owner occupied housing has two aspects. A house is a place to live in and at the same time an investment. To separate the measurement of the use from that of investment is a difficult problem in CPI calculation, especially where rental market is thin. The flow of service of living in own house is calculated as imputed rent in the Icelandic consumer price index, but the buying of the house is an investment and therefore not taken directly into account in the calculation.

The user cost method converts a part of the expenditure on a durable (such as a house) into flow of services by taking into consideration use of capital, long term financial (opportunity) cost (interest) and the use of the durable (depreciation). With the full user cost approach, capital gains income is also subtracted.[2] This practice is natural in the case of firms as a part of measuring their profit, but there is disagreement regarding the appropriateness of doing this for households.

Conceptually, the Icelandic CPI measures price changes in household expenditures exclusive of changes in households' income. The stated aim is to measure changes in the price level of expenditures without regard for the amount of money needed or available to pay for the expenditures. Hence, capital gains are not taken into account. Two kind of income are connected to owner occupied housing. One is the imputed rent where it is assumed that the owner pays himself for using the housing durable and the other is the capital gain/loss, the income from the price increase of the durable.

There are also hindrances in realising the capital gain income by substituting from own housing into tenancy as is the case in Iceland where the private rental market is very small and considerable difficulties are in finding suitable apartments to rent and very high transaction costs connected with selling a house.

In the case of the simple user cost the long-term real interest used in the calculation shows the return on the investment during the lifetime of the durable in real terms. The real interest is taken to be the required return on (or opportunity cost of) capital tied up in the property or taken on credit. The long term real interest used in the calculation is intended to reflect a real return on the investment over the lifetime of the dwelling. In this regard, the real interest rate does reflect capital gains. The capital gain can in certain periods be higher or lower than the required rate of return.

[2] Research into the use of the full user cost has been interpreted by some as showing that the results are likely to be very volatile. See Gillingham (1980 and 1983) and Garner and Verbrugge (2008). However, the interest rates used in these sudies are nominal, rather than real.

In Iceland, the approach of calculating housing cost as a simple user cost was adopted in November 1992.[3] To begin with price measurements for housing covered only the capital city area; since April 2000, however, they apply to the whole country. The main source when determining a base weight for housing is the official real estate assessment of housing, information on that being available from Household Expenditure Surveys. The Land Registry of Iceland calculates real estate value for all the property in the country. In the middle of the year 2001 the Land Registry revised the estimation method after extensive research, using hedonic regression. The base for the analysis was the capital area and the estimates for other parts of the country were calculated with regional coefficients, (Fasteignamat (2002). p. 9 and p. 17-22), (Ingvarsson (2002), p. 31 and p. 259-270). The value of all properties in the country are measured in a harmonised way based on information about properties sold. This is done with reference to "the law about the measurement of the real estate value says that it should be based on the market price of the property. According the first paragraph. of the law no. 6/2001 the estimated value shall be the discounted market value as estimated last November" (Ingvarsson (2002), p. 260).

The Land Registry of Iceland has collected the sales contracts over a long period of time and the information on market prices of properties is used by them as the base for evaluation of all houses' real estate value. It is also used in the calculation of the simple user cost in the CPI. This basic information is the same as the one used for the price measurement of housing in the CPI and therefore the real estate value is suitable for the user cost calculation.

The simple user cost is calculated in two steps. One is the calculation of the weight by using a real interest rate to measure the long term financial cost and the use of the durable. The other part is the price adjustment of the user cost weight (expenditure) by a house price index. Technically it is done by calculating this cost as an annuity.[4] An annuity is a "sequence of equal payments made at equal intervals of time" (Ayres, p.80). In the index calculation the property value is calculated as an annuity and includes both the real interest rate and depreciation. The annuity formula has the general form:

$$(1) \quad P_H = A_{HV} * \left[\frac{(1+r)^N - 1}{r*(1+r)^N}\right]$$

Where $P_H$ is the present value of the house, $A_{HV}$, the annuity of the house value, $r$ is the real interest rate and $N$ the lifetime of the durable (depreciation is given by an assumed lifetime of 80 years, and no scrap value in the end i.e. 1.25 per cent). The annuity formula (1) is derived from a geometric series and the interest is calculated over the lifetime of the durable and added to the durables value and then converted into equal payments (annuity). By using annuity both the interest rate and the depreciation are calculated from the same base and changes in the same direction when the property value changes. In addition the rent amount is also calculated over the lifetime of the durable. Lower lifetime of the durable (higher depreciation) leads to lower total interest rate.

[3] A similar user cost approach was adopted by the National Economic Institute in the years after 1980, when inflation was very high in Iceland, and used to measure the profitability of domestic fishing and fish processing.
[4] This user cost method is in some ways similar as Steiner (1961) suggested in the Stiegler report. He uses in his user cost model the annuity method to measure depreciation and interest rates but does not use real interest rates.

## 7. Real interest rate

The fact, that a part of the price of using capital is due to factors other than the service price for money, makes the use of interest rates a quality adjustment issue. In order to determine the real interest rate, nominal interest rates must be adjusted for quality according to changes in inflation. Nominal interest rates reflect inflation, as well as risk and expectations; the higher the inflation, the higher the interest rates are.

The quality issue in this case is that inflation is embedded in the interest rates and distorts the real interest value, making a quality adjustment necessary. The real interest rate from this point of view is the quality adjusted nominal interest rate. The quality adjustment is necessary as in the case of every good and service that has a better or worse quality reflected in its price.

In Iceland, real interest is preset, with the subsequent changes in the consumer price index being added to figure the nominal interest.[5]

The relationship between nominal and real interest is often expressed according to Fisher's equation (1896), (Diewert, 2003a, p. 21). The nominal interest rate is denoted $r_t$, the real interest rate $r^*$and the general inflation rate $p_t$. The expression is:

$$(2) \quad r_t = (1 + r^*)(1 + p_t) - 1$$

This means that the real interest rate, when not known, is the difference between the change in the nominal interest rate and the change in consumer inflation and the quality adjustment is expressed by calculating as follows:

$$(3) \quad r^* = \frac{(r_t+1)}{(1+p_t)} - 1$$

There could be a problem in the case of short-term movements. There is an indication that the Fisher effect is not very strong in the short term even if it is so in the longer run (Mishkin 1992). If this is right the use of this method should probably be extended to some kind of average over a longer period of time.

When consumers buy real estate they finance it partly through their equity and partly with credit. The long-term real interest rate unites two leading factors in financing: the share which the buyer needs to finance by borrowing money and the required return on the buyer's equity. In the model for user cost, the share of each factor is based on information from the sales contracts used in price measurements the long-term real interest rate used in the simple user cost model shows the return on investment over the lifetime of the durable.

The real interest rates used in the calculation of the simplified user cost are sticky over the lifetime of the durable but are partly kept variable to reflect short term trends in interest rates. When consumers buy property they finance it with equity and mortages and the average

[5] Indexation is allowed only for financial obligations that are granted for five years or longer.

long-term real interest rate in the model takes into account these two main types of financing. In the simple user cost model the division between these two forms of finance is mainly based on information from the sales contracts used for the house price measurement. As a result the opportunity financial cost covering the lifetime of the durable is estimated by keeping the equity rate fixed but allowing the mortgage real interest share to vary.

The required return on equity, which is constant over the lifetime of the durables, was determined in accordance with the long-term rate of return that pension funds require. When this approach was adopted this rate of return amounted to 3% and been left unchanged for these calculations.[6]

Long-term loans from the Housing Financing Fund were revamped in July 2004 through the introduction of cash loans, so-called ÍLS securities offering a lower real interest rate than before and soon after that commercial and savings banks increased greatly their housing loans at competitive interest rates. The initial fall in mortgage rates was included in the Icelandic CPI in July but as of August 2004 it was decided that the variable real mortgage rates, used in the calculation of the simple user cost of housing, should be calculated as a 60 month's moving average.

This decision was made in anticipation of frequent mortgage rate changes which might give rise to month-to-month volatility in the CPI. The feared volatility of real interest rates on housing credit did not materialized and the rates were stabilized at a substantially lower level than before. Statistics Iceland decided to change the method of averaging real interest rates in the model for owner occupied housing in the CPI as of May 2005 and a 60 month's moving average was replaced by a twelve month moving average. This method has not been changed even if the real interest rates have increased in the last years. This method is reconsidered regularly when the CPI is rebased in March each year.

There are three parts that influence the results of the calculation of the annuity. House prices, interest rates and depreciation. The formula for the annuity is:

$$(4) \quad A_{HV} = P_H * \left[\frac{r*(1+r)^N}{(1+r)^N-1}\right]$$

Factorization of $(1+r)^N$, out of the brackets, reduces the equation to:

$$(4a) \quad A_{HV} = P_H * \left[\frac{r}{1-(1+r)^{-N}}\right]$$

The average real interest rate, measured monthly, has hovered around 4% since 1992 the lowest rate in the period being 3.6 percent in 2004 and the highest 4.3 precent in 2008. When changes in real interest occur, however, they have a direct effect on the annual payment where $A_{FM}$ is the base for the annuity and $P_H$ the present value of the base (the discounted cash value in sales contracts), $r$ the real interest and $N$ the lifetime (in years). Increases in the average

[6] The long-term rate of return of pension funds now lies between 2% and 3.5%. The assessment of long-term claims due to the Damage Compenstaion Act is 3.5%.

real interest rate, in the instance of a long lifetime, increase the annuity (the imputed rent) by just about the same ratio.

The real interest rate also influence the value of the property used as the base for calculating the annuity as lower interest rates normally lead to a higher house prices. In calculating the present value of the sale contracts the loans with fixed interest rates are discounted by rate of return reflecting the change in the real interest rate. A rise in the real interest rate lowers the present value of the property. This fact is in accordance with the economic reality that a higher real interest rate leads to less demand and lower price of housing.

## 8. Depreciation

It is difficult to find a depreciation rate that accurately reflects property wear, and this issue is always subject to considerable uncertainty. Generally speaking, three methods are common in deciding what the depreciation rate should be. The first way to approach this is to find out the property's age and by approximation estimate its lifetime, "*assuming* a depreciation model that seems most appropriate" (Diewert, (2003b), 23), (Diewert et al. (2006)). The second method bases on cross-sectional information to determine the depreciation rate, and the third method regards information on rental rates or the hire purchase of durables. The first method was chosen when the depreciation was decided that entered into computations of the simple user cost. "The first and simplest method is to impose a particular depreciation pattern on the average observed life of structures to derive a depreciation rate." (Malpezzi, Ozanne, Thibodeau, 1987, p. 373)

The depreciation rate used in the user cost calculation was obtained mainly with respect to the housing stock age. According to the Land Registry the stock at the end of the year 2001 has the following age structure: 90 per cent of all property is constructed after the year 1940, more than one third in the period 1960–1980 and one third is constructed later. The depreciation rate seems therefore to be in accordance with age structure.

The depreciation rate was determined chiefly by reference to the construction year of the property base. According to the national registry of real estate from the end of 2001 (Ingvarsson, 2002, p. 261), the division of residential housing by the year of construction shows that about 90% of all properties were built after 1940, more than a third in the period of 1960–1980 and a little less than one-third after that. The premises regarding depreciation therefore seem to accord with the age groupings in the base according to the time of construction. The user cost covers both buildings and the land on which they are built. The depreciation is in fact 1.5% for real estate, which corresponds to a lifetime of about 67 years. Sites are not depreciated, as they do not wear out as time passes, and depreciation should only be calculated on the value of the building; however, the value of the site and the building are never separated in the price information upon which the housing index is founded. For practical reasons, a mean depreciation is calculated for the whole base, both building and site. The depreciation in the index is 1.25% of the real estate value. The value of land is separated

in the real estate value calculated by the Land Registry and is approximately 15% of the total value of the house. In the future Statistics Iceland will consider separation of the value of land from the house value in the calculation of the user cost.

The three most common depreciation methods are:

i) Straight line depreciation when the depreciation is divided into equal shares.
ii) One hoss shay or light bulb depreciation when the durable is depreciated when it falls apart.
iii) Geometric depreciation when the durables value declines by constant percentage rate. The depreciation is usually in the form $(1-\delta)^N$, where $\delta$ is the depreciation rate and $N$ the lifetime of the durable (number of payments). It means that the depreciation is largest in the beginning. According to the geometric method the durable is never fully depreciated.

The form of the annuity formula is an inverted geometric depreciation of the type $(1-\delta)^{-N}$ and it differs from the usual geometric depreciation in that it is small in the beginning but increases as the years go on.

The depreciation is measured as the amortization of the principal (sinking fund), where $N$ equals 80 and reaches the 50 per cent level in the 64th year. In year 73 it covers two thirds of the total depreciation. The interest payment equals the depreciation amount in the 64th year and after that the depreciation amount is larger than the interest. The yearly depreciation measured this way is nearly 0.2 per cent in the beginning and around 4 per cent at the end.

It should be added that unlike the usual geometric depreciation the durable is fully depreciated. It is similar to the one hoss shay method as the depreciation is largest at the end of the durables lifetime and that the durable is fully depreciated but contrary to the one hoss shay method it depreciates over the whole lifetime of the durable.

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