

How Do We Measure Inflation?

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Abstract: This paper describes the methods employed in compiling the Icelandic consumer price index, which is a Lowe fixed base index, similar to a cost of living index. The geometric mean is used to correct for substitution, permitting substitution among outlets. Chain weights and quality adjustment were used to adjust for the shopping substitution bias (outlet substitution bias) that followed a significant increase of inflation in 2001. The consumer price index adjustments that were carried out from December 2001 to May 2003 led to a 0.52% lowering of the consumer price index. As a basis for chain weights, the receipts approach greatly facilitates allowing for shifts in shopping behaviour. Owner-occupied housing is calculated as a simple user cost, taking into consideration depreciation and sticky real interest rates. Developments in housing prices are calculated as changes in the price of all real estate sold.

Keywords: Consumer price index, cost of living index, household expenditures survey, shopping substitution bias, outlet substitution bias, quality adjustment, owner-occupied housing, user cost.

JEL: C43, C81, D11, E31

1. Introduction

“A price index is a measure or function which summarizes the change in the prices of many

commodities from one situation 0 (a time period or place) to another situation 1. More specifically, for most practical purposes, a price index can be regarded as a weighted mean of the change in the relative prices of the commodities under consideration in the two situations.” (Diewert, 2004, p. 264).

One of the most common price indices is the consumer price index, which measures the price changes in expenditures for private consumption. However, further price indices can be considered when measuring aggregate price changes, such as of government final consumption and investment or the gross domestic product. The problem for these aggregate measurements of prices is that these indices are either not available or not published soon enough to be of use at any given moment. Thus the consumer price index is most frequently used as a handy indication of inflation.

Inflation is measured by determining changes

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in prices that reflect price trends, and most of the theoretical literature on indices addresses which methods are most suitable for that purpose. Due to the extent of modern business, no overview and complete information can be obtained without great effort. Estimates are therefore necessary for the measurement, which is where indices come in. A basic aspect of index calculations is how the extensive information should be compiled in order to reflect price changes as accurately as possible.

The object of this paper is to deal with some of the price measurement problems encountered. First, the aspects of index theory that directly concern the compilation and calculation of consumer price indices are treated (Chapter 2), followed by an explanation of how these aspects are used in index calculations (Chapter 3). The receipts approach, described in Chapter 4, builds on the utilization of detailed data from the receipts which are gathered in the continuous household expenditures survey which provide a necessary basis for chain weights. Chapter 5 describes shopping substitution bias and its correction, while Chapter 6 describes index calculation methods for owner-occupied housing, by which the flow of service created through residence in one's own housing is estimated as a simple user cost.

2. Methods of calculating price indices

When considering what criteria are significant for selecting index calculation methods, the first point of attention is how the price and quantity of goods and services are related. The test or axiomatic approach, for example, assumes there is no connection between changes in price and in quantity. In contrast, the economic approach presumes that connections exist between price and quantity, thus transferring the task of inflation measurement to the field of economics. "The problem of how to construct an index

number is as much one of economic theory as of statistical technique" (Frisch, 1936, p.1). COLI, cost of living indices,² fall under the economic approach.

A distinction is drawn between the calculating methods for the aggregate index and for the elementary aggregate, which is the index's lowest level. The aggregate index is calculated by adding up the basic headings, which are the lowest level with expenditure weights in elementary index compilations. Generally only actual price information is used for calculations below that level. When quantity information is also available for figuring the base, either fixed base indices or superlative indices are used in the calculations.

The objective of this chapter is to give an account of the theoretical perspectives on which the selection of methods for computing the consumer price index is grounded, above all of the methods used for the index base. The chapter focuses more particularly on the theoretical aspects of choosing calculation methods and formulas. It explains fixed base indices and cost of living indices as well as their difference, then deals with superlative indices which use symmetric information from two periods and touches on problems of chaining. Finally, the chapter discusses the test approach, followed by the indices applied in calculating elementary indices if only price information is available.

2.1 Fixed base indices, cost of living indices, and superlative indices

Theoretically speaking, there are two leading

² In this paper, "cost of living index" refers to an economic cost of living index. The cost of living index concept in Iceland is most often related to the cost of living for individuals or families. Answers to the question of how much it costs to live cannot be discovered through calculating the consumer price index, since that index is for measuring the changes in household expenditures from one period to the next.

types of index calculations: fixed base indices and cost of living indices.

A *fixed base index* is founded on fixing base expenses during the calculation. These indices are most commonly Lowe indices and have the following form:³

$$(2.1) \quad P_{Lo} = \frac{\sum_{i=1}^n p_i^t q_i}{\sum_{i=1}^n p_i^0 q_i}$$

where i = the good(s), 1, ..., n , p_i = price of good i , and q_i = quantity of good i . This index compares the prices of period t to those of a previous period, with respect to a certain quantity. The following indices are special instances of a Lowe index (2.1):

- When $q_i = q_i^0$, a Laspeyres index is obtained.
- When $q_i = q_i^t$, a Paasche index is obtained.

Indices based on weights from the past are named after Laspeyres, while those based on current weights are called Paasche indices. Fixed base indices are sometimes called pure price indices if they are only for measuring price changes based on a fixed quantity.⁴ The computation of fixed base indices does not allow for consumers' switching their selection of products, even if price relatives change, i.e., no substitution is allowed despite such factors. It is most common to use the Laspeyres form for fixed base indices, because older weights are always available, rendering it sufficient to collect price information for the calculation of each index. In the case of the Paasche form, on the other hand, it is constantly necessary not only to acquire price information but also to derive new weights, which involves more complication along with more effort. Yet, no

theoretical arguments call for choosing one option over the other.

If the economic approach is employed, the *cost of living index* is defined as "the ratio of the minimum expenditures required to attain a particular indifference curve under two price regimes" (Pollak, 1989, p. 6). Various factors related to the cost of living index's measurement of utility (living conditions or welfare) cannot be measured by price indices, e.g. the effects of weather, natural catastrophes, acts of terrorism, and plagues. Therefore, a conditional cost of living index is considered which encompasses the area where price measurements can be applied.

The cost of living index relates economically to theories on the true cost of living (Konüs, 1924), according to which consumers maximize their utility and minimize their associated cost. Ordinarily it is presumed that quantity and price are negatively related, so that individuals, in order to maximize their utility, will modify their consumption accordingly if prices go up, purchasing cheaper products or products whose prices rise less than others. When bias is discussed in a cost of living index, an index value is being compared to the value obtained by this theoretically correct cost of living index for two periods. The upper limit of the true cost of living index for the earlier period is a Laspeyres cost of living index, usually lower than a corresponding Laspeyres fixed base index, which is therefore said to be biased upwards. The lower limit of the true cost of living index for the second period, in contrast, is a Paasche cost of living index, which is usually higher than a comparable Paasche fixed base index, so that the latter is said to be biased downwards. One way to reduce the spread between the Laspeyres and Paasche indices is frequently to update the expenditure basis for the consumer price index, since this reduces the difference between the

³ Lowe, in 1823, was the first to suggest that such indices be used. Diewert (1993), p. 34.

⁴ The harmonized index of consumer prices is defined for example as the changes in the monetary expenditures of individuals in reference to a fixed consumption basket.

two former indices and can bring them closer to a true cost of living index. In simple terms, a cost of living index and a pure price index may be defined as the ratio between the expenditures of two periods. While quantity remains constant in a fixed base index, it can evolve in the cost of living index if the price relatives change. In fact, the contrast between the methods used in calculating indices is not as great as it seems on first sight. "In practice, the real problem for all price indexes, whether they are intended to be a measure of inflation or changes in the cost of living, is to get the most appropriate or relevant weights. It should be noted that even when the objective is to measure the changes in the cost of living, the indexes actually calculated in practice are always pure price indexes of one kind or another. When the weights are 'right', it matters little whether the index is intended to be an inflation or a cost of living index." (Hill, 1999, p. 10)

Methods are lacking for measuring the utility of individuals, which renders the measurement of cost of living indices next to impossible. It was therefore a notable discovery to demonstrate that various types of symmetrical indices, called superlative indices,⁵ adequately reflect a true cost of living index, provided that certain criteria respecting the form of the utility function are met (Diewert, 1976). Thus it is possible to calculate a cost of living index by a superlative index, i.e. without direct measurement. Superlative indices are symmetrical, thus taking two periods into account: an older and a more recent one. The problem is that for any given moment information on weights remains unavailable till a later time; therefore, they are difficult to calculate soon enough.

The major superlative indices are as follows:

The best-known of the superlative indices is the *Fisher index*, often called the ideal index. Named after the US economist Irving Fisher (1922), this index is the geometric mean of the Laspeyres and Paasche indices:

$$(2.2) \quad P_F = \sqrt{P_L P_P}$$

Fisher's index is the only superlative index passing every principal test according to the test approach, and it thus corresponds to the geometric mean of elementary indices.

In the *Walsh index* (Walsh, 1901, p. 398, and 1921, p. 97), the weights are the geometric mean of the quantities from two periods. Walsh's formula produces a Lowe price index (2.1), where $q_i = (q_i^t q_i^0)^{1/2}$.

$$(2.3) \quad P_W = \frac{\sum_{i=1}^n p_i^t \sqrt{q_i^t q_i^0}}{\sum_{i=1}^n p_i^0 \sqrt{q_i^t q_i^0}}$$

A third leading superlative index is that of *Törnqvist*, defined as the geometric mean of price relatives weighted by the mean expenditures of both periods.

$$(2.4) \quad P_T = \prod_{i=1}^n \left(\frac{p_i^t}{p_i^0} \right)^{s_i} \quad \text{where } s_i = (w_i^t + w_i^0)/2$$

and w_i is the expenditure weight for product i as a relative of total expenditures, $w_i^j = p_i^j q_i^j / \sum_i p_i^j q_i^j$ where $j = t, 0$.

When indices are chained there is always some risk of their over-measuring price changes at the time of chaining.⁶ Drift may occur in indices if there are major price changes during the month of chaining; moreover, when these changes are reversed the index will not assume the same position as before. Price modifications which have this effect might for instance be seasonal, so this merits special attention whenever chaining is undertaken.

⁵ This concept was first used for categorizing indices by Fisher (1922), p. 247.

⁶ Frish (1936), pp. 8-9; Szulc (1983), pp. 555-556.

2.2 Test approach

The various approaches to calculating indices also yield varying results, which explains the challenge in selecting the most suitable method for any particular index computation. In the test or axiomatic approach,⁷ the various technical qualities of indices are scrutinized in order to observe the conditions the indices meet, without assuming any relationship between developments in price and quantity. Prerequisites are established that the indices must fulfil to be considered favourable for measuring prices, and the indices are tested in those respects. The most suitable method may then be chosen, relying on what test results indicate about the conditions met. Following are a few examples of such tests:⁸

1. Positivity test – neither price nor quantity are permitted to become negative; the indices must contain positive results.
2. Identity test – if the prices of all commodities remain the same for two periods, the index should stay unchanged.
3. Proportionality in current prices – if all the prices for one period are multiplied by the same constant, the new index should be the old index multiplied by this constant.
4. Invariance to exchange in the units of measurement – the index does not change even though the units of measurement are switched.
5. Time reversal test – if the data for two periods are interchanged, the result is the reverse of the original index.
6. Quantity reversal test – if the quantities from two periods are interchanged, the index should remain unchanged.

7. Mean value test for prices – the index result lies between the highest and lowest price relatives.
8. Paasche and Laspeyres bounding test – the resulting price index lies between the Laspeyres and Paasche indices.
9. Monotonicity in current prices – if prices change, the price index changes.
10. Test of permutation or price bouncing – if shops exchange prices between months, with the prices in the latter month related to the prices of the previous month, the index should hold steady. For example, if the price of one product increases from ISK 20 to 25 or by 25% and then decreases from ISK 25 to 20 or by 20%, the mean should remain constant and the index shows no change.
11. Test of transitivity – an index calculated directly between periods should produce the same results upon chaining.

Tests vary in importance, with no rules existing on which of them matters most, so that the conclusions are always subject to assessment. To take an example, the time reversal test determines whether the same result is obtained when an index is calculated forwards and backwards, which is of great consequence in most instances, making this an important test for an index to pass.

2.3 Elementary indices

The elementary aggregate includes weights for both shops and goods, but since weights for individual items are frequently not available, the results are normally calculated using only prices. The index's basic headings have expenditure weights where sub-indices are calculated. A distinction is drawn between the calculation methods used in the elementary aggregate and those used for the aggregation of the index, where its basic headings are added up to obtain an aggregate result. Different methods

⁷ This method is most often associated with Irving Fisher, though Walsh was in fact the first to study the test approach systematically. Diewert (1993), p 39.

⁸ An example of a thorough overview may be found in Diewert (2004), Ch. 16, where he discusses 20 index tests.

may be used for calculating the elementary indices, depending on how the basic data has been itemized; thus it is for example possible to calculate superlative indices if sufficient information is available.

In order to identify the properties of indices calculated in the elementary aggregate, in cases where only prices enter into the computation, price changes can be observed in two ways: either as the average of price relatives or as the relative between the average prices for each period. The main elementary indices calculated by these methods are listed below, where P_i^0 = price observation i for the period 0, P_i^t = price observation i for the period t , and n = number of price observations:

Average of price relatives, associated with Carli

$$(2.5) \quad P_{CAR} = \frac{1}{n} \sum_{i=1}^n \frac{P_i^t}{P_i^0}$$

Relative of average prices, associated with Dutot

$$(2.6) \quad P_{DRA} = \frac{1}{n} \sum_{i=1}^n P_i^t \bigg/ \frac{1}{n} \sum_{i=1}^n P_i^0$$

Geometric mean of price relatives, associated with Jevons

$$(2.7) \quad G_{JAR} = \prod_{i=1}^n \left(\frac{P_i^t}{P_i^0} \right)^{1/n}$$

Relative of geometric mean prices, associated with Jevons

$$(2.8) \quad G_{JRA} = \prod_{i=1}^n (P_i^t)^{1/n} \bigg/ \prod_{i=1}^n (P_i^0)^{1/n}$$

Harmonic mean of price relatives

$$(2.9) \quad H_{AR} = \left(\frac{1}{n} \sum_{i=1}^n \left(\frac{P_i^0}{P_i^t} \right) \right)^{-1}$$

Relative of harmonic mean prices

$$(2.10) \quad H_{RA} = \sum_{i=1}^n \left(\frac{n}{P_i^0} \right) \bigg/ \sum_{i=1}^n \left(\frac{n}{P_i^t} \right)$$

Average of price relatives, Carli and the harmonic mean

$$(2.11) \quad P_{cswd} = \sqrt{P_{car} P_H}$$

There is a relationship between these methods, because the geometric mean is always lower than or equal to the arithmetic means and greater than the harmonic means.

The Carli index (2.5), which is the average of price relatives, is used in some countries for index calculations, but has been used less in recent years. This index has many undesirable properties, as pointed out decades ago: "but we shall see that the simple arithmetic average produces one of the very worst of index numbers. And if this book has no other effect than to lead to the total abandonment of the simple arithmetic type of index number, it will have served a useful purpose." (Fisher, 1922, pp. 29-30). The Carli index does not pass the time reversal test (5), test of transitivity (11), or test of permutation (10) and is therefore unsuitable for chain indices and is considerably upward biased. Its use is prohibited in the harmonised index of consumer prices (Eurostat, 2001, p. 217).

The Dutot index (2.6), which is the relative of average prices, passes every test except for invariance in the units of measurement (4). The effect on results of different packaging sizes can prove a drawback. The index also has indirect weights, since expensive goods exert more effect on the mean than inexpensive ones. The Dutot index is appropriate when goods are homogenous in prices and was employed as the sole method of calculating the Icelandic consumer price index until March 1997.

Since March of 1997, Iceland has used the Jevons index (2.8) for calculating the elementary aggregates of the consumer price index. The geometric mean can be calculated either as the average of price relatives or the

relative of average prices, with both methods yielding the same outcome. The Jevons index passes all major tests and boasts superiority in that respect. Different packaging sizes do not affect results, a quality that is taken advantage of for calculating the Icelandic consumer price index. Moreover, elementary indices may be considered economically, to the extent that they allow for substitution. Observing the elasticity of demand reveals that the elasticity of the geometric mean always equals 1, whereas that of Dutot equals 0. A geometric mean adjusts for substitution on this basis, while an arithmetic mean does not.

The harmonic mean (2.9 and 2.10) can be calculated both as the price relative and as the relative of mean price. A harmonic mean of price relatives is the reverse of Carli (2.5). Passing neither test (10) nor test (11), the harmonic mean is seldom applied to index calculation and is always biased downwards. If the geometric mean (2.5) of Carli and a harmonic mean (2.9 or 2.10) is figured, the result is an elementary index (2.11) with qualities very similar to those of the Jevons index. Fisher was the first to point this out, since when it has received corroboration from others.⁹

3. Calculation of the consumer price index

To begin with when computing an aggregate index, the mean price changes are calculated for each basic heading, after which these are added up to obtain sums for intermediate categories and an overall total. The aggregate index is calculated as a Lowe index (2.1), which is chained annually in March, based on the old and new index results in that month. For example, the elementary aggregates for groceries (perishable

items) in 2002 was derived from the expenditure survey in 2000-2002, whereby expenditures in 2000 and 2001 were calculated from the annual mean for each year to the level of 2002 prices. The 2002 base was then extrapolated to the price level of March 2004. The monthly price changes in the index were calculated from a March 2004 base to the month of calculation. In that month, winter sales are not yet over everywhere, necessitating special caution on account of the risk of drift when adding new goods to the index.

The elementary aggregates include the index weights where the foundation of the index lies. The following five calculation methods are used for the elementary aggregates of the consumer price index:

1. Relative of geometric mean prices (2.8) for calculating almost 39% of the expenditures in the base.
2. The weighted relative of geometric mean prices on groceries (perishable items),¹⁰ extending to nearly 18% of the expenditures.
3. A Lowe (2.1) or relative of average prices (Dutot) (2.6), covering almost 38% of the index.
4. A superlative index (Fisher) (2.2), figuring in over 2% of the expenditures.
5. Indices comprising just under 3% of the index.

There are 696 basic headings in the index. A geometric mean is used to calculate 585 of those, covering more than 57% of the expenditures in the base¹¹, of which 364 headings are for groceries and 221 for numerous other items. There are 99 headings calculated as the relatives

⁹ Fisher (1922), p. 472; Carruthers, Sellwood and Ward (1980), p. 25; Dalén (1992), p. 140.

¹⁰ Goods sold in food store chains.

¹¹ The Norwegian and US consumer price indices have a similar ratio of expenditures calculated through a geometric mean. Dalton, Greenless and Stewart (1998), p. 3, and Johannessen (2001), p. 15.

 The calculations and the price collection in the consumer price index for December 2002

<i>Method of calculation</i>	<i>Basic headings sub-indices</i>	<i>Base, number of weights</i>	<i>Items number</i>	<i>Prices number</i>	<i>Expenditure share</i>
1 Relative of geometric mean prices	221	323	2,083	5,436	39
2 Weighted relative of geometric mean prices	364	4,000	800	10,000	18
3 Lowe or relative of average prices	99	1,509	1,185	2,891	38
4 Superlative index	7	203	75	203	2
5 Indices	5	13	27	27	3
Overall index	696	6,048	4,170	18,557	100

of average prices, while 12 are calculated in another way.

How the elementary aggregates are organized matters greatly, along with the sources used for their compilation. The main source for the index base is the Statistics Iceland survey of household expenditures, whose data are directly used in the calculations for headings which span approximately 64% of index expenditures. When data from the expenditure survey are insufficiently classified, more detailed data are obtained to cover approximately 29% of index base expenditures. These expenditures are for purchases of alcohol and tobacco, medicines, medical service, petrol, bus fares, domestic air fares, communications, swimming pool entrance fees and TV channel subscriptions.

Net weights are calculated for base data amounting to almost 7% of index base expenditures. This is the case for payments on automobiles, insurance and lottery tickets. The expenditure for automobile purchases is figured as the difference in price between a bought automobile and a sold one, which conforms to methods adopted by the harmonized consumer price index and in national accounts. Insurance costs are calculated using net weights which are premium revenue, less claims, though

also taking the capital income of insurance companies into consideration.¹² In a comparable manner, the lottery weights of the index base are determined as the total income of lotteries, less winnings.¹³

The calculation of consumer price indices is a complex process; nor is a single universal method in use. Circumstances and the data dictate how the task is to be solved. Compiling the consumer price index of each year means collecting the prices of up to 220 thousand goods and services, or an average of over 18 thousand per month.¹⁴

3.1 Relative of geometric mean prices for goods and services (2.8)

This method is employed to calculate price changes for almost 39% of the index expenditures. The geometric mean adjusts for

¹² The weight shares are based on a three-year average, which is the approach used for the harmonized consumer price index.

¹³ The price collection covers both the ticket prices and the proportion of winnings.

¹⁴ In addition, an average of approximately 1000 product prices are gathered every month that are not included in compilations. These are for instance goods that have been added to the sample and are gradually included in the index. These have been added following references from price collectors, from the continuous expenditures survey or from scanner data provided by stores.

the effects of substitution which occur when consumers change their consumption due to higher or lower prices on goods. How many prices lie behind each basic heading varies, and price changes are calculated for every good that is available in both periods. The latest price that was measured is taken for goods that are not available when prices are collected.¹⁵ It depends on the nature of the items whether many price quotations are required or whether just a few suffice. When the goods are heterogeneous, the basic heading is not detailed, and price is variable, the calculations gain in reliability with this method. This applies to headings such as automobile parts, toys and books. For homogenous items, a few prices are often sufficient for the measurement to be reliable. Calculating a geometric mean yields a result that is independent of the types and sizes of packaging, enabling goods in different packaging to be grouped under the same basic heading. Through this calculation method, the effects of substitution are measured within a single basic heading, not between headings.

3.2 Weighted relative of geometric mean prices for groceries

This method serves for almost 18% of the base expenditure items. Food stores are divided by conglomerate into four groups, named Hagar, Kaupás, Samkaup and “other stores”. Each group is further divided into chains, of which there are now 11. Operating throughout the country, the chains are the most fundamental units of the groceries index. Specific regional weights are no longer used.¹⁶ Chain weights

¹⁵ If a good is not available for three months, the same rule is applied as in the harmonized index: that it should then be exchanged for a new good.

¹⁶ From March 1997 to March 2002, four regional indices were calculated for groceries in the index, and the total result was weighted together according to the regional weights.

simplify index calculations and make it easier to deal with changes in shopping behaviour, particularly when one store closes and another takes over. One reason for this is ownership concentration in food retailing; today, three groups control a considerable portion of the retail market for groceries. An additional fact is that prices within the shops of any one chain are similar, irrespective of their location.

In order to compile the elementary indices under basic headings for groceries in the consumer price index, the geometric mean (Jevons index) is calculated within a chain for all the product prices that belong under the respective basic heading. The stages in the calculation are that, within product category (basic heading) k , in chain j , an unweighted geometric mean is calculated from a price observation, i :

$$(3.1) P_{jk}^t = \prod_{i=1}^n (p_{ijk}^t)^{1/n}, \text{ for } p_{ijk} > 0$$

where price observation $i = 1, \dots, n$; in chains $j = 1, \dots, m$; and under the basic headings $k = 1, \dots, h$.

In order to make the calculation technically easier, logarithms are taken on both sides, yielding

$$(3.1a) \log P_{jk}^t = \frac{1}{n} \sum_{i=1}^n \log p_{ijk}^t$$

Operations (3.1) and (3.1a) are carried out in the same way for every basic heading, both for the index base time (March of each year) and for the month of calculation.

The first step concludes with the following price tables, P_{jk}^t which is the average price for basic headings k , in chain j during the month of calculation, and P_{jk}^0 , which is the average price for basic headings k in chain j during the base period.

The goods can be of various sizes and types, and specialty goods that are only available in

one chain are also included. Weights are not included in calculations until the next step and the result is weighted together according to the sales shares of the chains for each of the 364 basic headings (subindices) involving groceries. Each chain receives a weight for each basic heading, such that $\sum_{j=1}^m w_{jk} = q_k$. This weight is determined through w_{jk} representing the chain's share in the household expenditures for basic heading k , so that q_k is the expenditure weight in the index base for basic heading k , and $\sum_{k=1}^m q_k$ is the total expenditures on groceries.

Weighted geometric means are calculated for P_{jk}^t and P_{jk}^0

$$(3.2) \quad \bar{P}_k^t = \prod_{j=1}^m (P_{jk}^t)^{w_{jk}} / \sum_{j=1}^m w_{jk}$$

for $P_{jk}^t > 0$. P_{jk}^0 is calculated in the same manner.

Taking the logarithm of the relative of the averages and rearranging the equation

$$\log \bar{P}_k^t - \log \bar{P}_k^0 = \sum_{j=1}^m w_{jk} (\log P_{jk}^t - \log P_{jk}^0)$$

where $\log \bar{P}_k^t - \log \bar{P}_k^0$ is the change in price for basic heading k from the index base period to the month of calculation. This equation is used to calculate the index of any basic heading v_k , and the groceries index is then calculated as $\sum_{k=1}^h q_k^0 \bar{P}_k^t / \sum_{k=1}^h q_k^0 \bar{P}_k^0$ and is thus a Lowe index.

A total of 9–10,000 price quotations are gathered each month. Prices are collected for over 800 goods, with chain weights numbering close to 4000. Approximately 5500 average prices are calculated in the retail chains, and when these have been calculated under the basic headings of each chain they number some 3500. The item *rice* may be viewed for illustration. Prices are gathered for seven rice products, in different-sized packages and of varying types and brands. For these 7 goods, there are 49 average prices in the 11 chains, and these

averages enter into calculations of the average price for the sub-index. Weights relate to the sale of rice in each chain.

If $P_{jk} = 0$ in a chain that has $w_{jk} > 0$, the weight is scaled, which is the equivalent of transferring the respective weight to the other chains. The effect of substitution is therefore such that if a good is not available in one chain, the consumer is expected to start by searching for other items under that basic heading in the same chain. If the good is not available there, the consumer will go elsewhere to buy at the average price in the stores where the good is available. Outlet substitution is therefore permitted.

In the calculations on groceries the averages for all the goods available are calculated and compared with the price of the same goods in the index base.¹⁷ Thus the basket of prices is not the same from one month to the next, nor the average price which is used for price measurement. One of the main advantages of the calculation method is the fact that all the prices available at any given time enter into the index calculation. A fundamental condition for being able to use the method is that the average price for a chain is based on numerous price observations. In order to increase the probability of meeting that condition, price collection includes several outlets in the largest chains.

3.3 Lowe (2.1) or the relative of average prices (2.6)

A Lowe index or relative of average prices is used for items covering almost 38% of index expenditures. These methods are mainly used for calculations where itemized weights are available along with detailed supplemental information. In many instances there are no

¹⁷ This is different when the relative of geometric mean prices is calculated and a good is not available in that particular month. The good is then included in the calculation at its last existing price.

effects of substitution to consider, unlike items calculated as geometric averages. When weights are divided onto individual items, it does not matter whether a geometric average or relative of average prices is used in the calculations. These items include for instance alcohol and tobacco,¹⁸ housing, medical services, cars,¹⁹ fuel, driving lessons, communications, lotteries, package holidays and insurance.²⁰

3.4 Superlative index (2.2)

This concerns headings comprising approximately 2% of expenditure in the index base, and detailed information must be available on their composition for this method to be used. While fixed base indices do not measure the effect of changes in substitution, superlative indices can. If a new weight (Paasche) is available, it is used along with a previous one (Laspeyres), and the result is calculated as a Fisher index. New tariffs for services often involve adjustments and price changes that can lead to considerable alterations in the consumption patterns. The price changes are calculated according to the last available expenditures, together with a new weight, thus taking into account changes due to substitution, which can be considerable. The respective expenditure items are as follows: TV subscriptions, buses, domestic airfare, swimming pool admission, kindergartens, medication, and the services of medical specialists.

3.5 Items calculated through indices

Approximately 3% of index expenditures are calculated by way of indices. Ordinarily adopted for practical reasons, such indices were often originally compiled without any relation to the consumer price index. Housing maintenance is the largest expenditure heading calculated this way, where sub-indices for building material from the building cost index are used. Other headings have been adapted from the wage index, such as work to maintain housing, child minding, domestic and home-care services. The sub-indices of the consumer price index for food, electricity and heating are used to update the cost of boarding. Loan arrangement fees also change in accordance with the consumer price index, whereas stamp duties and commission to real estate agents change in accordance with the housing price index. It is inappropriate to apply the consumer price index to measure its own price changes, and instances thereof are exceptions. When the consumer price index is used for calculating tariffs or changes in the prices of goods and services, it has its own indirect effect on price measurement. Although it is difficult to register exactly the scope of this, rent for housing is probably the largest index item to change in that fashion, because almost half the rental contracts in the sample for rent are indexed to the consumer price index.

4. The receipts approach

Food store chains and other merchants provide their customers with detailed receipts, which Statistics Iceland has taken advantage of in its household expenditure survey. The receipts approach involves collecting this detailed information and applying it systematically for generating statistics. First applied in the household expenditures survey of 1995, the method has since been a part of the continuous household expenditure survey that started

¹⁸ In this case substitution effects do of course enter in, but the weight is highly detailed, down to each bottle or pack of tobacco. Bases are exchanged annually and price comparisons paired within the year.

¹⁹ Although there are substitution effects, the weight is changed every year, according to detailed information on imports.

²⁰ Price changes are measured according to a model of the Icelandic insurance market in which the premiums of all the insurance companies are examined based on residence and the size categories of automobiles.

in 2000. The sample size in the household expenditures survey remains similar during the three-year survey cycle, such as the one starting in 1995. The number of households participating in the survey in 1995 was 1375, while 657 households participated in 2000, 611 in 2001, and 639 in 2002, altogether totalling 1907. Whereas a few other countries also collect receipts in their expenditure surveys, no others to date utilize the information in this manner.²¹ Participants in the survey hand in their receipts in lieu of itemizing purchases in a diary provided for them to record their expenditures in. The idea is that they enter the total purchase amount in the diary and place the receipt in a pocket at the back of the booklet. Originally, the main purpose of this was to make participation easier for households by allowing them to hand in the receipts. A very positive supplemental benefit was the resulting detailed information which has been utilized to introduce chain weights in the consumer price index. Having the receipts enables vastly more accurate estimations of the composition and quantity of goods consumed by households. Nowadays, a great many more stores have adopted the bar code system for checkout than was the case in 1995. This is partly due to the increased concentration of ownership in food retailing, which has led to three groups dominating today's retail market. A general idea of the amount of information appearing on the receipts can be obtained by adding up the entries on the receipts and in the diaries. This involves not only noting the number of entries but also the amounts of expenditure. In the 1995 research, 41% of all entries were read from receipts. This number increased to about 69% in 2000,

reached 74% in 2001 and had climbed to 77% by 2002. In 1995, 53% of the entries for food and beverages were obtained from receipts, in 2000 the proportion was 84%, and in 2001 and 2002 it was 89%. Such receipts spanned 12% of the total expenditures of households in the 1995 research, 26% in 2000, about 31% in 2001, and continued expanding to 36% in 2002. There has been a considerable increase in the scope of this information since 1995, so that it currently accounts for almost a third of the expenditure and nearly 75% of all entries.

A receipt normally provides the following information:

Breakdown of the total amount of the transaction and the number of items sold. As an invoice from a store, a receipt always displays the total amount of the purchase, i.e., what the customer must pay. This is convenient for processing household expenditures, as the data can be balanced upon recording, making the process considerably more secure.²² If necessary, the overall total of transactions can be estimated even before the year's expenditure survey has been completed.

Name of the store: The outlet hands out the receipt, which clarifies the point of sale and makes it possible to assess the share of each store in total household purchases. This information is used as a basis for compiling the groceries base of the consumer price index, e.g. in determining chain weights.

Time and date of the purchase: This information provides an exact account of the particular consumer's consumption pattern, i.e., on what day of the week and at what time of day consumers do their shopping.

Description of each item, their quantity, prices and the total amount: On an ordinary

²¹ The Israelis have long collected receipts, for example in the expenditure surveys of 1986-1987, 1992-1993, and annually since 1997. The Irish came closest to using such data in a comparable manner in their expenditure survey of 1999.

²² This is the first household expenditure survey to exploit this possibility of balancing one-third of household expenditures.

receipt, an itemization of packaging and brands can be observed. Vegetables and fruits are often weighed at the cash register, entering the quantity and unit price, which opens up the possibility of calculating exact quantity weights for these goods and even performing nutritional studies.

Form of payment: Receipts indicate whether a product was paid for in cash or with a debit or credit card or cheque.

Goods were scanned at sale for the first time in 1974 (Hawkes and Smith, 1999, p. 284). Developments have been rapid since then, so that today the majority of retail sales of various stores take place in this manner. When goods are bought in retail outlets, the purchased articles are scanned and the buyer obtains an itemized receipt for the transaction. Information gathered this way is captured in the company's data base and shows its sale of goods. The consumer's paper receipt is a mirror of the company's data. If all the paper receipts were preserved, they would provide the same picture as would be obtained by collecting the data directly from the companies' computer systems. Collecting receipts from consumers provides information on the transactions and who the buyers are. A receipt from a buyer clarifies what was bought and who the purchaser was, which gives such data a certain value over and above that of the data coming from outlets. For example, these data bases include data on purchases by bodies other than households, so that more extensive transactions are involved than covered by the household data.

The receipts approach is one of the greatest advances that has occurred in expenditure survey research for many years, and ushers in new ways of utilizing household expenditure data. Some potentials of the approach worth mentioning include calculating the index for groceries in relation to various types of households,

regularly compiling a superlative index based on such data, using the information on quantities and prices for more detailed quantity weights, and even collecting prices from households on a regular basis.

5. Shopping substitution bias

Consumers must constantly face the fact that store prices for identical or similar goods often vary widely. If consumer price indices are to be correct, they should measure the prices of the goods that households obtain and on that basis measure the price changes in household purchases. Normally, not enough information on shopping behaviour is available to make that possible. The price collection for an index takes place in stores, and the average change in price is most often reckoned from sales information. When households modify their purchasing patterns, the average price of their purchases may change without anything happening in the store; in fact, prices there might even remain unaltered. In order for consumer indices to reflect such developments, store weights must be adjusted and these price changes must be allowed for in the price measurements. If a price change was being measured by household weights, they would be changed for individual stores as household purchasing patterns evolved. The main issue is that the store sample should provide an accurate picture of transactions.

Retail practices are constantly evolving; accordingly, consumers modify their behaviour in consumption. When a store closes down, they are forced to adapt, although if another store opens at the same place as the old one they can keep shopping there. Otherwise, they must search for a new store, whether it has existed before or is brand new. Consumers will respond, and if they buy the same goods elsewhere, at a lower price, this must be accounted for in index calculations, or else shopping substitution

bias will enter the index. Until recently, it was impossible to monitor such changes, because information was lacking, and such a bias is most often called outlet substitution bias. This type of bias has not received much discussion on an international plane, and index adjustments for it have been out of the ordinary.²³

When consumer indices show no consideration for the household shopping substitution that is actually happening, the assumption will be that any price difference between stores stems from differences in the quality of their service, and in this instance, no change will be marked by indices when consumers evolve new shopping behaviour. "When pure price differences exist, a change in market conditions may make it possible for some households to switch from purchasing at higher prices to purchasing at lower prices, for example if new outlets open that offer lower prices. The resulting fall in the average price paid by households counts as a price fall for CPI purposes, even though the price charged by each individual outlet may not change." (Hill, 2004, p. 4).

Underestimating quality change in goods or services leads to overestimating inflation. This risk is most pronounced when inflation increases abruptly and household purchases deviate sharply. The service level in stores deeply influences consumer choice, besides prices on goods. Service level includes every factor affecting the consumer's idea of quality when selecting a place to shop, as well as most elements that characterize the type of store. Such aspects are entailed as the selection of goods, the number of stores in the chain, their location, the number of cash registers, the opening hours and the payment arrangements. Every one of these aspects needs to be accurately reflected in price measurements. Since quality is both subjective

and dependent on the individual, evaluating the service level presents a considerable problem, except for the selection of goods. There has been a reduction in the contrast between low price stores and stores of other kinds in Iceland in regard to the factors indicated above. It is possible to assess a difference in the quality of varying service levels by comparing the assortment of goods, which represents the only factor in service that is measurable. An example would be if one store closed down and another opened at the same location. Various goods that had been available in the previous store would not be offered in the new one, and there would be different packaging and other brands. The consumer would be shopping at the same location as before but in a new type of store. The price difference between the stores for the goods they had in common would be used to measure the price changes.

When buying petrol, consumers may choose between manned and unmanned service stations. At manned service stations, furthermore, they may choose between full service and self-service. Consumers serve themselves at unmanned stations, paying by credit card or cash. Petrol is a homogenous good, with smaller differences in service than before. Self-service stations have become more numerous, and the queues originally forming at unmanned stations are nowadays rare. Consumers spend the same amount of time regardless of whether they receive service or fill the tank themselves; indeed, self-service frequently takes less time. Thus the difference in service quality when getting petrol is actually little or none.

In April of 2001, inflation in Iceland increased substantially, with the consumer price index rising 7.3% from April to the end of the year, leading to a twelve-month change of 9.4%. In 2002, however, price changes slowed down substantially, so that the consumer price index

²³ Reinsdorf (1993); Boskin (1996), pp. 28-29 and 67; BLS (1997), p. 5.

rose between the beginning and end of that year by 1.4%. Simultaneously to the growth of inflation, significant changes appeared in the organisation of Icelandic retail stores and shopping behaviour, especially regarding stores with groceries. Consumers transferred their trade to stores with low prices more often than previously and also bought less expensive petrol more often, by filling up themselves.

One specific development to mention in retail structure is that as of October 2000 customers were allowed to pay at Bónus stores with credit cards, after having been allowed to pay only in cash till then, and the number of stores in the chain increased somewhat. Whereas the chain had 9 stores in early 1999, by midyear the first store outside the capital city area had opened at Ísafjörður, and a Hagkaup store in Kjörgarður, Reykjavík, had been turned into a Bónus store. From the second half of 2000 until the end of 2001, 6 new Bónus stores were opened, of which two were outside the capital city area, at Akureyri and Selfoss. New stores were also opened in or near the shopping malls Kringlan and Smáratorg, towards the end of 2001. During the second half of 2002, two 10-11 stores, at Borgarnes and Egilsstaðir, were switched to Bónus stores, giving a total of 19 Bónus stores. Though much smaller in scope, a comparable development occurred in the Kaupás group during that same period, as their Krónan stores were launched.

The Bónus chain usually prices food lower than other stores, a difference which has been maintained despite a reduced quality gap between them and other stores. A few changes in the Bónus stores may be mentioned, especially in 2001. Originally, the stores occupied simple housing, were located away from shopping malls, offered little variety of goods, purchases had to be paid for in cash, there were few cash registers in each shop, and opening hours were

limited. The new stores, by contrast, are located in spacious housing that is at shopping malls like Kringlan and in Mosfellsbær or near such malls, as by Smáralind. The customers who initially paid for goods with cash may now pay with credit cards. The selection of goods has grown,²⁴ as well as the number of cash registers, and the stores are open every day of the week. Nor are they any longer confined to the capital city area, but are distributed throughout the country: at Ísafjörður in the Northwest, Akureyri in the North, Selfoss in the South, Borgarnes in the West and Egilsstaðir in the East. The selection of goods is more restricted than in other shops so that consumers need to go elsewhere if they want a more diverse selection of goods; also, the selection is often distinct, particularly in regard to package sizes. Of the index's basic headings, only 15 of 364 are not on hand within the chain.²⁵ It has become easier for consumers to shop in the Bónus chain since the number of stores multiplied, and distances are often shorter, which leads to a lower search cost for consumers and has definitely encouraged these far-reaching developments. From 1997 to 2001 six stores in the index's grocery store sample were closed and for each of them a new store was added in its place. The price change was evaluated by comparing the prices of goods common to both establishments, and the level of service between the stores was quality-adjusted in that manner.²⁶ Similar adjustments were made for shifts in

²⁴ In 1999, the food items numbered 1100, but had by 2000 reached 1400. Kaupþing (1999), p. 9; Íslandsbanki (2000), p. 19.

²⁵ For example, no tobacco is sold in the Bónus chain. As far as the basic headings are concerned, it is mostly some types of meat that are unavailable.

²⁶ An example of changes affecting the index was when a Nettó store was opened in Reykjavík in August 1998, replacing a store that was in the sample and thus producing an immediately measured effect. There were indirect effects as well, as other stores lowered their prices when this occurred.

shopping behaviour in 2001. Almost half of the market share increase for low price chains was taken into account as a price reduction and half as a quality adjustment due to differences in their selection of goods. The outcome was introduced in December of 2001 and April of 2002, when chain weights were adopted, since they facilitate changes when new stores are added to the sample in lieu of older ones that drop out. In 2002 there were three instances of such changes. First of all, the Nýkaup store in Kringlan changed hands to Hagkaup in May of 2002²⁷, so that the Nýkaup weight was transferred onto Hagkaup. The KÁ store in Selfoss changed into a Nóatún store at the middle of the year; subsequently, the weight for that chain was moved to the Nóatún chain. In December of 2002, two new Bónus stores started up in place of two 10-11 stores, whose weights were carried over to the Bónus chain. The difference in the variety of goods in these stores is considerable even though the number of basic headings is similar, with the contrast lying to a large extent in different package sizes.²⁸ One of these stores was in the store sample, so that this shift would also have been measured through the older method of calculation. In 2003, such transfers continued, with a correction in May due to stores changing whereby over 1% of the total weight of all food stores in the country was transferred between chains.²⁹ Chain weights have proved their value and greatly facilitate making allowances for abrupt developments in shopping behaviour.

According to data from the Statistics Iceland household expenditure survey, low price stores³⁰

accounted for one-fourth of the total sales of groceries in 2000. This share rose to 31.5% in 2001 and to 38% in 2002. In 2003 the proportion had reached about 41% of total food store turnover. Low price stores saw a significant growth in market share during that period, so that in 2000-2003 some 16% of all grocery sales transferred to the low price stores, clearly demonstrating that consumers had modified their shopping patterns within a short period and had brought their shopping to where prices were lower. This trend varied among household types; thus the purchases of one-person households at such stores rose from 21% in 2000 to 26% in 2002, whereas the purchase share in low price stores of couples with children increased from a quarter to 43%. Clearly, it is of some importance when measuring price change to examine purchases by household type. (Guðnason, 2004a).

Once it became known that such changes had occurred in consumer behaviour, they had to be accounted for in index calculations. There was furthermore a potential for charting the developments through the accurate information on grocery sales and the market share of each chain as read from the receipts collected in the household expenditure survey. Moreover, very detailed information had been gathered from the largest grocery group about the market share of its particular chains, and when compared with the receipts, these references were found to correspond entirely. The store weights and grocery headings were corrected when the index of December 2001 was compiled, which yielded a 1.3% decrease in the food component of the index or a 0.27% decrease in the overall index. On the basis of more precise data from receipts in the household expenditure survey, the effects were evaluated once more in April 2002, resulting in a 0.10% lowering of the index. At the same time, changes in shopping

²⁷ The Hagkaup store in the Kringlan mall had been changed to Nýkaup in June 1998.

²⁸ Approximately half of the 10-11 store goods were also available in the Bónus store.

²⁹ The Hagkaup store in Njarðvík was closed, with a Bónus store replacing it in March 2003. In April of the same year, an 11-11 store in Mosfellsbær closed down, to be replaced by a Krónan store.

³⁰ The low price stores of Iceland are named Bónus, Krónan and Nettó.

behaviour regarding petrol were taken into consideration, according to information from the oil companies on their market shares in petrol sales, whereby the index fell by 0.08%. In May of 2003 changes due to substitution were also introduced, leading to a 0.07% drop in the consumer price index. From December 2001 to May 2003, the total change due to adjustments in household shopping substitution for groceries and petrol amounted to an almost 0.52% drop in the consumer price index.

6. Housing in the consumer price index

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. The majority of Icelanders, or about 80%, live in owner-occupied housing according to the household expenditures survey for 2000-2002.

6.1 Approaches in calculating owner-occupied housing

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* and *user cost*, 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 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 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 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 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.

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 in the first place that the rental market be large enough for there to be types and sizes of properties in the rental market which are comparable to those in owner-occupied housing, and that the market rent rate be used as an equivalent of rent changes for owner-occupied housing. A second condition is that the rental market not be controlled and that rent not be subsidized by the authorities or market prices governed in some other way. The third condition is that cost borne by landlords but not by tenants or those living in owner-occupied housing not be included in price measurements. The rental equivalence approach cannot be 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 approach is however used in Denmark, Germany, the Netherlands, Norway, the USA, Switzerland and Japan (Hansen, 2000).

In instances where the rental market is small, the service flow from owner-occupied housing is measured in terms of *simple user cost*³¹ in the same 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 heading in the index as a user cost, none of them use real interest rates for calculating user cost except Iceland. The countries involved are Finland, Sweden, Iceland, Ireland, Britain and Canada.

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.³² The method was used in the USA until January 1983 and is presently employed in Australia and New Zealand.

A payment method is sometimes used, 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 consumer price index during the period of 1988 to 1992. Nominal interest, which in fact partly reflects inflation, is included, but

³¹ This concept was first used by Diewert (2002), p. 621, and (2003b), pp. 28 and 53.

³² Even about half of what the other methods would indicate. (Diewert 2002a), p. 62.

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. The share of owner-occupied housing differs widely in the countries, which are Greece, Italy, Spain, Portugal, Belgium, Austria, Luxembourg and France.³³

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.³⁴

6.2 Owner-occupied housing in the Icelandic consumer price index

In Iceland, the approach of calculating housing cost as a simple user cost was adopted in November 1992.³⁵ To begin with price measurements for housing covered only the capital city area; since April 2000, however, they apply to the whole country.³⁶ 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. User cost is calculated on the basis of real interest, which is now around 4%, and a depreciation of 1.25% on the official real estate value of the housing. Price measurement occurs monthly according to a price index for sold properties and changes in long-term real interest rates. The expenditure weight is the household's annuity, derived by equation (6.1)

$$(6.1) \quad P_H = A_{FM} \left[\frac{(1+r)^N - 1}{r(1+r)^N} \right]$$

where P_H is the present value of the annuity, r the real interest, N the lifetime (in years) and A_{FM} the base for the annuity.³⁷

The Land Registry of Iceland compiles a real estate value for every property in the country. "The legislation on real estate value indicates clearly that measurement shall be based on the market price of property. According to the first paragraph of Act No. 6/2001, the estimated value of real estate shall be the discounted general market price, for which the property would have sold in the previous month of November" (Ingvarsson, 2002, p. 260). The official real estate value was reviewed in mid-2001, building on extensive statistical research and regression analysis of the explanatory factors for real estate prices. The base for the analysis was the capital city area, while the measurement for other parts of the country was calculated with specific regional coefficients.³⁸ The entire real estate

³³ The ratio of those living in their own housing in these countries is as follows: Greece (75%), Italy (78%), Spain (78%), Portugal (66%), Belgium (65%), Austria (50%), Luxembourg (72%), France (54%). Hansen (2000), p. 12.

³⁴ Eurostat's current suggestion includes among other things the following: "A price index for all dwellings purchased by households as a self-standing index." Eurostat (2004), p. 6.

³⁵ A similar user cost approach was adapted by the National Economic Institute just after 1980, when inflation was high in Iceland, to measure the profitability of domestic fishing and fish processing.

³⁶ In April 2000, an adjustment was made for having over-measured housing price changes on account of this; this adjustment lowered the index by about 0.35%. At the

same time, an adjustment was made for having undervalued housing rents in the index, with the correction for this raising the index by around 0.34%.

³⁷ This method for calculating user cost is similar to that of Steiner (1961), whereby he uses an annuity approach to calculate depreciation and interest. On the other hand, he builds solely on nominal interest rates.

³⁸ Fasteignamat (2002), pp. 17-22, and Ingvarsson (2002), pp. 259-270.

property of Iceland is therefore now valued in a harmonized way through information on the market price of sold properties. The information on which the measurement is based is the same as that used for updating the prices of owner-occupied housing in the consumer price index. The base is therefore well-suited for compiling the user cost of housing.

The relationship between nominal and real interest is often expressed according to Fisher's equation (1896) (Diewert, 2003a, p. 21). Nominal interest is indicated as r^t , real interest as r^* and inflation as p^t . The equation reads as follows:

$$(6.2) \quad r^t = (1 + r^*)(1 + p^t) - 1$$

In Iceland, real interest is preset, with the subsequent changes in the consumer price index being added to figure the nominal interest.³⁹ If only nominal interest rates are known, they have to be adjusted for quality according to changes in inflation in order to determine the real interest rate.

The long-term real interest used in calculating user cost shows the return on investment during the lifetime of the durable. In this way, the real interest rate reflects the capital gain.⁴⁰ 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.

³⁹ Indexation is allowed only for financial obligations that are for five years or longer.

⁴⁰ The capital gain can in certain periods be higher or lower than the required rate of return. The long-term real interest rate is an approximation of capital gain over the lifetime of a durable good.

During computation, the interest on equity is kept fixed, while interest on the borrowed money is variable, in order to estimate by these means the opportunity cost of the capital for the lifetime of the assets. The financing is divided in this way to calculate the real interest rate that is used. The part of the house price paid in cash is considered the buyer's equity.⁴¹ 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.⁴² Approximately two-thirds of real interest rates undergo no change from one month to the next, because they involve returns on the buyers' equity and the interest on existing mortgages that the buyer has taken over. Of other interest rates, the real interest on Housing Financing Fund loans makes up the largest share and has remained similar for the past decade.

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. In its index compilation, Statistics Iceland accounted for the interest rate decrease due at the outset to this structural change, as a lower rate of real interest had in fact resulted.⁴³ Interest in the new loan system is changed monthly, which reduces the stickiness that used to characterize real interest in the index. Because the long-term required return used in

⁴¹ This part is to some extent financed by loans rather than with property.

⁴² 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 Compensation Act is 3.5%.

⁴³ This corresponds with what has been done before in similar circumstances, such as at the end of 1993 when the interest rate on real estate securities fell from 6% to 5% and when, in the first half of 1995, the rate rose from 5% to 5.1%.

the calculation is based on the lifetime of the housing, it is inconvenient for short-term real interest fluctuations to have significant effect on the price measurement of each month. Consequently, it is necessary to base real interest levels on the longer term, and the real interest rate selected for these calculations is based on the rate's average during the previous five years, adjusted monthly by dropping one month and adding a new one. This should ensure that short-term fluctuations in real interest rates on housing loans cause no sharp changes that could lead to considerable surges or declines in the index from one month to the next. On the other hand, it is certain that developments in the real interest rate are reflected in price measurements over the long term.

The average real interest rate, measured monthly, has hovered around 4% since 1992. When changes in real interest occur, however, they have a direct effect on the annual payment. Equation (6.1) may be rewritten as

$$(6.3) \quad A_{FM} = P_H \left[\frac{r}{1 - (1 + r)^{-N}} \right]$$

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

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, p. 23) 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 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.

6.3 Measuring property prices

Market prices are obtained from sales contracts that the Land Registry has collected for many years. They are suitable for this purpose because of being standardized and identical throughout the country. Every sales contract contains

information on the property and 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, almost every concluded real estate agreement is obtained.⁴⁴ About 8,000-10,000 real estate sales contracts are closed annually, so that each year some 8-10% of all the housing in the country is bought and sold.⁴⁵ The price concept is the same as for other price measurements in the index, in that the price taken for computations 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 the weighted national average.⁴⁶ The calculation of price changes for real estate is a three-month moving average, with a one-month delay.⁴⁷ April includes contracts from the period January to March,

May contracts from the period February to April, and so on. Price information is gathered and the price change for imputed housing rent is estimated on the basis of all the sales contracts. This compilation keeps the category sizes fixed, based on what real estate was bought in each category during the last three years. What is measured is the change in price for single-family houses (a 13% weight) and multi-family housing (a 59% weight) in the capital city area (a 72% weight) and for single-family houses (a 15% weight) and multi-family housing (a 13% weight) outside the capital city area (a 28% weight). Emphasis is placed on comparing price developments within housing categories, not among types of property or among the different regions of Iceland. There are 8 categories for property size, giving altogether 9 sub-indices 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 and inside and outside the capital city area. Thus 21 sub-indices are used when calculating the aggregate index for real estate prices.

7. Conclusion

This paper has discussed some factors involved in computing a consumer price index, which in Iceland's case is a Lowe (2.1) fixed base index. Its base is calculated to a large extent like that of a cost of living index, especially in regard to using chain weights for calculating the prices of groceries in the index. Substitution is accounted for in the index in three respects: employing a geometric mean in the base, allowing outlet substitution in calculations on groceries, and using chain weights to correct for household shopping substitution, along with quality adjustment. The item housing is calculated by measuring the service flow from owner-occupied

⁴⁴ It is not only in the interest of buyers that a contract be registered but also a condition for credit services from the Housing Financing Fund.

⁴⁵ Regardless of whether in terms of number or value.

⁴⁶ This has been the case since March 2000. The index for the entire country was then recalculated back to March 1997.

⁴⁷ Contracts from places outside the capital area, however, arrive with a two-month delay.

housing, an approach that is also applied when calculating cost of living indices.

The Icelandic consumer price index may be said to be a Lowe fixed base index, with strong

likenesses to a cost of living index insofar as the approach to substitution and the calculations of service flow from owner-occupied housing are concerned.

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