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Treatment of bias in the Icelandic CPI

The size of bias in the CPI in Iceland is unknown; however the working paper addresses available methods, which have been developed through international co-operation, for minimizing the effect of bias in indices. The working paper discusses four types of biases, their origin and ways to eliminate them. Three types of biases are dependent on consumer behaviour, whereas the fourth is related to the quality of consumed products or services.

This article is a translation of the working paper “Meðhöndlun bjaga í vísitölu neysluverðs á Íslandi” which was published on March 22, 2019 in the Statistical Series “Hagtíðindi” on Statistics Icland’s website.

Introduction

Measurements of price changes, which are systematically too high or too low compared to the accurate result are biased. Measuring correctly and avoiding bias is a constant challenge in all price indices. The Icelandic CPI is no exception. Statistics Iceland takes this challenge seriously and works determinately on minimizing the bias. This working paper addresses the problem but according to Statistics Iceland there is a need for further research in this field.

The bias’s size is unknown, but the bias changes over time, it can increase or decrease, be positive or negative. Various methods are used for treating bias of different origin. This working paper explores the reasons for biases and how they can be treated in the Icelandic CPI. There are four types of different biases described. Three of them are within the scope of consumer behaviour (substitution bias, shopping substitution bias and new goods and services bias). Methods for treating these biases are all in line with economic consumer theory. The fourth type of bias (quality bias) is not connected to consumer behaviour. This bias is rooted in the production characteristics of goods and services. The treatment of this type of bias requires different approaches that are not all related to economic theory.

Statistics Iceland

Substitution bias

The cost of living index relates to consumers that maximize their utility and minimize their associated cost. Ordinarily it is presumed that quantity and price are negatively related. It follows that individuals maximize their utility and modify their consumption by substituting for cheaper or at least relatively cheaper products.

When bias is discussed in a cost of living index, an index value is compared to the value obtained by the theoretically correct cost of living index for two periods. A distinction is drawn between the calculating methods for the aggregate index (upper level) and for the elementary aggregate (lower level), which is the index's lowest level.

> Results for the aggregate index (upper level): Findings for 10 years interval in the Icelandic CPI indicate that this bias is -0.01 per cent to +0.02 per cent on average. The lowest yearly bias is -0.8 per cent and the highest yearly bias +0.9 per cent.
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> Results for the elementary aggregate (lower level): The level of bias is not known. Statistics Iceland applies both geometric mean and superlative indexes to counteract the substitution bias in the CPI. The methods' combined coverage is 77 per cent of the index weights. For this reason this bias is assumed low.

Shopping substitution bias

Consumers constantly face the situation that store prices for identical or similar goods can vary widely. If consumer price indices are to be correct, they should measure the prices of the goods that households obtain to measure the price changes in household purchases. When households modify their purchasing patterns, the average price of their purchases may change without anything happening in the store; in fact, prices might even remain unaltered and if these changes are not corrected there will be shopping substitution. The method for correction in the price measurement is by direct quality adjustment.

Results: Bias is 0 per cent. Shopping substitution bias has been corrected yearly since 2001. The total effect of shopping substitution corrections in 2001-2018 amounts to a -0.75 per cent lowering of the CPI.

New goods and services bias

When new or improved goods and services enter the market they are not taken into account nor the welfare gains for the consumers of their entrance.

Results: The level of new goods and services bias is not known. New goods are systematically incorporated in the CPI. The main method used is overlapping that should ensure that the price history of the good is measured. For this reason this bias is not considered high.

Quality bias

Quality bias arises from the situation where the basket of goods and services is updated without consideration to quality changes of new items. This can occur either because the changes in quality are not noticed or are not properly measured.

Results: The level of quality bias is unknown. Statistics Iceland uses similar methods as other statistical offices, with overlapping the most commonly used method. Many quality adjustments, explicit or implicit, are applied regularly but an overview of its extent is not available. There is an uncertainty of the magnitude of the quality change which is not accounted for in the index.

Elementary aggregate and calculation of the Consumer Price Index (CPI)[1]

In calculating price indices, specialists in statistical offices continually aim to apply the best methods available, so that the outcomes will be as reliable as possible. The elementary aggregate for the Consumer Price Index (CPI) rests on information on household consumption obtained primarily from the *Survey of Household Expenditure*, which is a detailed annual survey of the consumption expenditure of Icelandic households. Its outcomes become part of the CPI expenditure aggregate; the purpose of renewing the aggregate is to have it reflect as closely as possible the actual current private consumption. Participants in the survey keep an expenditure diary for two weeks and also respond to detailed questions on infrequent and/or major expenditures over a three-month period. In order to alleviate the response burden, Statistics Iceland seeks information from third parties on expenditure when individuals give written permission to do so, such as on telecommunications services and insurance. In addition, information is collected from public records, such as tax registers, the National Registry and Property Registry Database.

Each year, 1,222 households are randomly selected for the survey sample. The response rate in the survey has been around 40% in recent years. The results are aggregated for three consecutive years at a time to increase the reliability of the results and reduce temporary fluctuations. The reasons for this are the small size of the annual sample and also the low response rate. The survey has been conducted continuously since 2000. Results for the years 2000 and 2001 were first used in 2002, mainly to review

[1] Translation by Keneva Kunz of the working paper „Meðhöndlun bjaga í vísitölu neysluverðs á Íslandi“ published on 22. March 2019.

the weights for food and beverages. The results of surveys for three years were first utilized in the 2004 rebasing of the index and were mainly based on the expenditure surveys of 2000-2002.

The primary source for the elementary aggregate is Statistics Iceland's Household Expenditure Survey. Its data is used directly in the calculation of items that comprise about 45% of expenditures in the elementary aggregate. When more detailed data is available, or the consumption study does not provide a sufficient breakdown, more accurate data is gathered, covering about 55% of the expenditure weights. This is done, among other things, to reduce the bias in the CPI due to base data.

The index is rebased each year in March. The aggregate index is chain linked to the previous aggregate and the results of the March measurements are used for both the old and new aggregate. The monthly change in the index is calculated from the base in March of the base year to the calculation month. The resulting index is a Lowe price index because its base reflects earlier periods. For example, the elementary aggregate for March 2019 is based on the 2015-2017 expenditure surveys, where expenditures for 2015 and 2016 are price updated from the annual average of each year to the average price level of 2017. The 2017 aggregate is updated to price levels of March 2019. What then is the average age of weights in the CPI base? When the weights are updated to 2017 price levels, that used for 2015 is two years old, for 2016 is one year old and 2017 remains as is. Their average age is therefore one year. In addition, it takes 1.25 years before they are put to use and their average age is therefore 2.25 years when the index is rebased and 2.75 years during the lifetime of the base. The average age of items more recent than the expenditure survey is 0.75 years and that of the total elementary aggregate is therefore about 1.75 years.

Prices of over 240,000 products and services are collected each year for compilation of the CPI, or over 20,000 price measurements per month on average. For the rebasing of the index in April 2016, Statistics Iceland changed its price collection method for groceries and used, for the first time, electronic price data obtained from grocery store scanner systems instead of shelf prices collected through store visits. Price collection was changed but monthly calculation was unchanged.

The stores in the sample provide better coverage, since scanner data is obtained from more stores than before, in addition to which they also facilitate a review of the product basket for rebasing the index, since the sales value of products is available. The electronic data covers more products and stores and will enable Statistics Iceland to use average prices in the price collection week for calculations instead of average prices in stores on the collection days. The number of price measurements in grocery stores every month increases from 9000-10,000 to 120,000-130,000. Electronic data from the store scanner systems make it easier to address substitution bias in the CPI.

What is bias in the CPI?

Bias, or the systematic skewing of measurement, is an under- or over-measurement of the CPI. Bias results from the effects of consumption changes, that occur as economic situation changes, not being accurately measured. Dealing with bias is a constant task of statistical offices because consumers change their consumption as prices change, when stores change and with the advent of new or changed products and services. Bias is usually considered to overstate price changes, but can also understate them, depending on which factors affect them.

Three types of bias are related to household consumption:

Substitution bias

This occurs when the fact that consumers change their consumption choices is not taken into account, for example, buying a product that has decreased relatively in price instead of a product that has increased relatively. This bias affects both the basic headings (upper level) and the elementary aggregate (lower level).

Shopping substitution bias

As new stores appear offering lower prices, shopping behaviour changes. Consumers respond to this and, if they buy the same products as before elsewhere at a lower price, this must be taken into account in the index calculation; if this is not done, shopping substitution bias will occur.

New goods and services bias

This occurs when new or improved products enter the market and neither they nor the consumer benefits of them are taken into account in the index calculation.

Quality bias

Quality bias occurs when products are replaced in the index calculation but changes in their quality are not taken into account. It may be the case that changes in quality are not noticed or that correct adjustments are not made due to changes in quality.

This type of bias is not related to consumer behaviour but rather to the quality of goods and services. The quality of a product is not affected by consumer behaviour but is determined in the production by companies. Quality adjustments therefore cannot be made unless changes in the characteristics of a new product are evaluated. Usually the quality of goods and services increases, but it can also decrease.

Substitution bias

When relative prices change, consumers change their product choices and buy comparable products that are now relatively cheaper than before, thus reducing their cost of living. Cost-of-living indices take into consideration changes due to substitution and make adjustments but in a fixed-base index these changes are generally not taken into account and substitution bias arises. Substitution bias is divided into an upper level and lower level. Bias that affects the basic index headings is part of the upper level, which can be said to be its superstructure, while bias in the lower level applies to the elementary aggregate, which underlies it.

Table 1. Number of groups, subgroups and basic headings at the upper level in the CPI, February 2019

Group	Description	Subgroup	Basic heading
1	Food and non-alcoholic beverages	2	333
2	Alcoholic beverages, tobacco	2	13
3	Clothing and footwear	2	12
4	Housing, water, electricity, gas and other fuels	5	14
5	Furnishing, household equipment etc.	6	35
6	Health	3	17
7	Transport	3	29
8	Communications	1	5
9	Recreation and culture	6	60
10	Educational services	1	3
11	Hotels, cafés and restaurants	2	23
12	Miscellaneous goods and services	3	37
	Total in the CPI	36	581

The aggregate index is calculated based on the average price changes for each basic heading, which are added up and totals for intermediate categories and the aggregate created. At the upper level, the index is calculated as a Lowe fixed-base index with weights based on an older period where changes in composition are not taken into account. In February 2019 the main categories were twelve, intermediate categories 36 and the basic headings 581. Most of the basic headings include food and beverage products (333), information on which is gathered electronically from retail scanner systems.[1] Other basic headings are 248 in number.

Substitution is possible to some extent between basic headings and intermediate categories in each overall category. The main categories are the totals of the intermediate categories; here it is not as clear whether substitution between them is possible. Economic factors other than relative price changes also have an impact. Inflation and exchange rate fluctuations affect the results and the same applies to changes in income that affect demand for the goods and services measured in the index. Calculations of

[1] Sub-indices for food and beverages are calculated for each chain of stores, and their weighted geometric mean, which covers 110 basic headings, is published.

price changes in the elementary aggregate also affect the relative weight of the basic headings during the reference period of the index.

To counteract bias at the upper level, the elementary aggregate is renewed each year and a new combination of basic headings and elementary aggregates is put into effect to better reflect the changes in composition. It is also possible to counteract upper level bias in cost-of-living indices by using superlative indices for calculation, which require extensive timely information on the composition of quantities; such information is not available today.

If the price elasticity is known, then the elasticity coefficient reflects substitution and in such case the index can be corrected for the bias in the Lowe fixed-base index without changing the elementary aggregate. This requires detailed, continuous and timely elasticity data.[1]

Bias in the upper level is, on average, probably insignificant over longer periods in Iceland, although it can vary considerably for individual years.

Bias at lower level affects the elementary aggregate of the index. When a breakdown of weights for individual items is not available the results are calculated only by prices. When information on weights is available, the results are calculated using both weights and prices. For the elementary aggregate, methods are used to counteract bias depending upon the breakdown of basic data. When detailed weights are available, superlative indices can be used for calculation which adjust for substitution. The geometric mean adjusts for the impact of substitution given unit elasticity, but if the elasticity is different this can result in some bias.

Table 2. Divison of expenditures at the lower level in the CPI by method of calculation 2002 and 2019

		Year	
Compilation method	Basic headings Sub-indices 2019	2019	2002
Relative of geometric mean prices	160	29%	39%
Weighted relative of geometric mean prices	367	16%	18%
Superlative index	8	32%	2%
Total of superlative indices and geomean	**535**	**77%**	**59%**
Lowe or relative of average prices	35	20%	38%
Indices	11	3%	3%
Total in the CPI	581	100%	100%

Geometric means are used to calculate price changes for just under 29% of expenditures in the elementary aggregate, which includes over 160 basic headings. Substitution effects are measured only within basic headings and not between them using this calculation method.

1 This has been solved theoretically by using calculation formulas based on constant elasticity of substitution (CES) functions referred to as Lloyd-Moulton (Lloyd, 1975, and Moulton, 1996b).

The weighted relative of geometric mean prices covers almost 16% of expenditure headings in the elementary aggregate and 367 basic headings. The result is calculated using chain weights for the grocery stores, where substitution between stores is allowed. The substitution effect is such that if a product does not exist in a chain, it is assumed that the consumer first searches for another product in the same chain. If the product does not exist there, the consumer will look elsewhere and buy at the average price of the product in other stores where it exists. The geometric mean prices, unweighted or weighted, thus covers 45% of the elementary aggregate and 527 basic headings.

A superlative index is used when detailed new information on composition and quantity exists for headings which cover about 32% of expenditures in the index's elementary aggregate and 8 basic headings. This applies, for example, to automobiles and telephone services. The price changes are calculated according to the expenditure basket that was most recently available and also with a new weight and in so doing taking into account changes due to substitution effects. The quantity used is most often based on the moving average of the last twelve months.

The weighted Lowe or relative of average prices is used for items that cover 20% of the index expenditures for calculations, where there are itemised weights with detailed additional information. In some cases there are no substitution effects, as is the case in most items calculated with a geometric mean.

The greatest part of the calculations in the elementary aggregate of the index is based on the geometric mean, unweighted or weighted, or superlative indices. The calculation methods correct for substitution and include in total about 77% of the expenditures in the elementary aggregate. The result is that the calculation methods mostly correct for substitution and bias in connection with it in the elementary aggregate of the CPI.

Shopping substitution bias

Methods of calculation alone cannot correct bias arising from changes in household shopping. More is needed.

> "Current procedures in the CPI ignore price changes when consumers switch stores. This incorporates into the CPI the implicit assumption that price differentials among outlets entirely reflect differences in service quality." "This shift in market share indicated that many consumers respond to price differentals and do not consider them to be fully offset by differences in service quality." (Boskin et al., 1996, p. 29).
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> "When pure price differences exists, a change in market conditions may make it possible for some households to switch from purchasing at higher prices to purchase at lower prices, for example if new outlets open that offer lower prices. The resulting fall in the average

> prices paid by households counts as a price fall for CPI purposes, even though the prices charged by each indivual outlet may not change.” (Hill, 2004, p. 21).

If no consideration is given to shopping substitution in CPIs, it is assumed that all differences in the price of the same product or product range between stores are due to the fact that their quality of service is different and in such case indices measure no price changes when consumers change their shopping. Product prices and service levels have a major impact on consumer choice. The service level covers all aspects that affect the consumer's idea of quality when choosing a shopping location and most of the factors that determine the type of store. These include items such as product selection, the number of stores in the chain and their location, the number of checkouts, opening hours and payment arrangements. All these factors need to be reflected correctly in the price measurement. Quality is both subjective and dependant on the individual, and evaluating the level of service presents a considerable problem, except for the selection of products. The difference in quality for different service levels can be assessed by comparing a product selection in a store as reflecting the part of the service that can be measured. This applies, for example, if one store closes and another is opened at the same location and various products which were available in the previous store are not in the new one, packages are different and brands are different. The consumer is shopping at the same location as before but in a new type of store. The difference in price levels between stores is not only due to differences in service levels but also to differences in product selection. The difference reflects quality that is the same in common products and they are used in assessing price changes due to changes in household shopping.

When purchasing petrol, consumers can choose between two options. At manned service stations, the choice is between full service and self-service. Petrol is a homogeneous product and at unmanned stations the consumer serves him-/herself and pays by card or cash. Self-service stations have increased in number and queues which formed at unmanned stations at first after they opened are rare today. The consumer spends the same or less time filling the tank him-/herself and usually the self-service is quicker. The quality difference in petrol buying is, in fact, little or none.

In April 2001, inflation in Iceland rose sharply and by the end of the year the CPI had risen by 7.3% and its annual change then reached 9.4%. At the same time as inflation increased, there were significant changes in the system of retail stores and shopping practices in the country, especially in grocery stores, where consumers more often dealt with stores where prices were low and bought cheaper petrol to a greater extent than before by pumping it into their cars themselves.

According to data from Statistics Iceland's expenditure survey, there was a significant increase in the share of low-price retailers in 2000-2003, when about 16% of all grocery sales moved to low-price stores and it was clear that consumers changed their purchasing patterns in a very short time and transferred their shopping to where prices were lower.

As soon as it became clear that such changes had occurred in consumer behaviour, they had to be taken into account in the calculation of the index. The changes could be mapped due to detailed information on grocery sales and market share of the chains, which were obtained from cash register receipts[1] from the survey of household expenditure. In addition, extremely detailed information was obtained from the largest conglomerate on the market share of chains under its auspices; these results were compared with the receipts and both sources were completely consistent.

Adjustments were made with a direct quality adjustment, based on a common product range and service level and the benchmark was products available in both stores or chains of stores. Changes were made to store weights and grocery items when calculating the index in December 2001 which resulted in a 1.3% decrease in the index's food heading and a 0.27% decrease in the overall index. Using more detailed data from the receipts from the consumption survey, the effect was re-assessed in April 2002, resulting in a decrease of 0.10% in the index, while at the same time changes in petrol buying practices were taken into account, based on information on the distribution of petrol sales from the oil companies; that action lowered the index by 0.08 %.[2]

[1] A more detailed description of the receipts method can be found in (Guðnason, R., 2004, pp. 42-43 and 2009, pp.105-110).

[2] A more detailed description of these changes can be found in (Guðnason, R., 2004, pp. 43-46).

Table 3. Correction of shopping substitution bias in the CPI 2001-2018

Timing of Application	Effect on the CPI (%) Grocery Stores	Petrol and Diesel	Total
(i)			
December 2001	-0,27		-0,27
April 2002	-0,1	-0,08	-0,18
April 2003	-0,07		-0,07
April 2004	0		0
April 2005	-0,03		-0,03
April 2006	-0,03		-0,03
April 2007	0		0
April 2008	0		0
April 2009	-0,12		-0,12
April 2010	-0,03		-0,03
April 2011	-0,04		-0,04
April 2012	0		0
April 2013	0,01		0,01
April 2014	0,02		0,02
April 2015	0		0
April 2016	-0,01		-0,01
April 2017	0		0
April 2018	0		0
Total	-0,67	-0,08	-0,75

	Correction of Shopping Bias	Average Yearly correction
(ii)		
2001-2003	-0,52	-0,173
2009-2011	-0,19	-0,063
2001-2018	-0,75	-0,042

The total impact of changes in substitution on household purchases of groceries and petrol was a decrease of 0.75% in the CPI during the years 2001-2018, or just under 0.042% on average annually.

Chain weights were taken into use in calculating the CPI in April 2002. This greatly simplified the process of estimating shopping substitution bias. Grocery stores are divided into four conglomerates. Each conglomerate is divided into chains that are the basic units of the grocery index with operations throughout the country. One of the reasons that chain weights can be used is the concentration of grocery stores, as three conglomerates now control a significant portion of the market for groceries. Prices in stores within a chain are similar, regardless of their location.

Since 2001, or for eighteen years, changes in consumer shopping patterns have been regularly monitored and corrections made if necessary. The method has proven its worth and corrections have been required

for this bias eleven times. Nine times the consumer price index was lowered and twice it was increased, while seven times no effect was measured. The effects have mainly been observed in two periods. In 2001-2003, when the number of low-price retailers increased rapidly, consumers moved in greater numbers than ever before to the stores with lower prices. The effect was a decrease of 0.173% on average per year during this period. Following the financial collapse in 2009-2011, when purchasing power dropped, consumers transferred their business still more to lower-priced stores and the effect on the CPI was a decrease of 0.063% on average per year.

Some changes also occurred to household shopping in 2017 as a result of new stores opening. Statistics Iceland assessed whether there were grounds for making changes to the CPI for this reason. A news release from Statistics Iceland in September 2017 stated that the agency would investigate the effect of changes in household shopping on the CPI as a result of new stores and assess whether this gave cause to make changes to it.

In November 2017, it was reported that an investigation had been conducted, based specifically on receipts with shopping information collected in the household expenditure survey for 2017. In addition, other available sources on shopping were considered, such as data from stores' scanner systems and information on undertakings' turnover. In addition, prices collected were increased and time series were analysed specifically.

> "The conclusion is that Icelandic households have changed their shopping to some extent and shown interest in new stores. At the same time, existing stores in the market have lowered prices for various products to meet increased competition, thus contributing to a new market balance. Making a reliable comparison between the stores presents some problems. For example, it could be pointed out that product selection and package sizes are not fully comparable between stores.
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> A comparison of prices in new stores and older stores, according to the currently available data, indicates that the effect of the changes appears to already be reflected in the CPI." (Statistics Iceland 2017b)

Different factors have had an impact on household purchasing during the period under observation. Firstly, there is a change in shopping habits in 2001-2003, where low price stores increase their market share and consumers quickly change their purchasing habits, as measured in the CPI with a quality adjustment. The next changes in 2009 were domestic, following the financial collapse, when purchasing power declined. Households then shopped to a greater extent than previously in stores with lower prices, resulting in bias which was corrected. In 2017, there were changes in household purchasing with the advent of new stores. On the other hand, the effects of the new stores were partially responded to in the market with price changes in the existing stores that were immediately measured in the CPI. Scanner system data and comparison

of different data sources, together with a quality adjustment, were applied to to obtain a result which was not considered to show shopping substitution bias.

The conclusion that can be drawn from this is that monitoring of what is happening in household shopping and corrections to bias resulting from this is are entirely justified.

New goods and services bias

Such bias arises when new or improved products enter the market and neither they nor the consumer benefits of them are taken into account in the index calculation. Often these are new products that introduce new technology or improvements to existing products resulting from new technology. Products also disappear from the market without being replaced by new ones.

The CPI should assess consumer benefits of new products and services and take this into account in price measurement. This is done using the shadow price of a product, i.e. a price that is sufficiently high so that there will be no demand for the product or service and therefore the expenditure weight is zero. New products are regularly included in the CPI and are closely monitored. Attempts are made to gather price data for them as soon as they enter the market. By doing so, a price history exists when they are included or replaced with another product using bridged overlapping. New goods and services bias is not considered to be great.

Quality bias

This type of bias is not entirely related to consumer behaviour but rather to the quality of goods and services. Product quality is created in the manufacturing process. The concept of quality includes both characteristics of the product and its service life. Quality adjustments cannot be made unless the difference between the characteristics of the old and the new product is assessed. Most often the quality of goods and services that need to be evaluated increases, although the opposite is nonetheless well known.

Quality adjustments are made when newer but comparable products replace older ones. An attempt is made to separate how much of the price change is due to a difference in quality and how much is purely a price change. That part of the price change that is due to a difference in quality is deducted from the price change and the remaining net price change is taken account of in calculation. Changes in product characteristics need to be monitored systematically. Rapid changes in quality and price are especially problematic in the case of products that are technically complex. Products that are included in the price measurement must be comparable, but this can be difficult to monitor because the supply of goods and services is constantly changing.

A quality adjustment can be direct or indirect. For example, a direct method applies when quality change is assessed by Statistics Iceland's experts. An indirect quality change occurs when price changes for

similar products and services are used as the basis. A price change could be due entirely to changes in quality, in which case no price change is measured. If there is considered to be no change in quality, the entire price change could be included.

Direct quality adjustments:

- Assessment by Statistics Iceland's experts based on information about products from vendors.
- Quantity adjustments, based on the number, size, weight of goods/packages.
- Factor cost, or production cost, based on the price of components/units or product or production cost of goods.
- Fixed combination of characteristics, where well-defined characteristics are kept constant.
- Regression analysis, based on the calculated value of assessed characteristics.

Indirect quality adjustments are:

- Bridging, using the price change of products available in both periods. This applies, for example, when the index is rebased.
- The average change for the aggregate or a category is calculated, using price changes for products in the category or price changes for the products most similar to the new product.

When the CPI was rebased in March 1997, there was a change in the policy on quality adjustment. Statistics Iceland then declared that in the future, quality adjustements would be taken into account in the CPI compilation. A direct quality correction was made in June 1999, which covered liability insurance. The insurance price then increased significantly, which was partly due to increased insurance coverage. The assumption was that the insurance coverage resulted in increasing the quality of the insurance and therefore a quality adjustment was required. The conclusion was based on insurance experts' assessment of the quality changes. The price change was evaluated as 36%, the quality correction was 25% and the price increase included in the calculation of the CPI was just over 11%.

Direct quality adjustments are made for:

- Food and beverage products, shopping substitution bias, assuming a common product selection and service level. The benchmark is products that are available in both stores or chains of stores.
- Housing, based on a fixed combination of characteristics such as: size, type of housing (multi-unit dwelling, single-unit dwelling), location in the country (metropolitan area, outside the metropolitan area) and within the metropolitan area, (inner/older, outer/newer).
- Automobiles, based on component costs, cost of additional features, e.g. ABS brakes, air bags, where prices exist, the part considered quality change (40-70%).

Indirect quality corrections are made for clothing and computers by bridging:

- When clothing is replaced exact characteristics are used, as is done in regression analysis, and based on the store where the product is available. More prices are always gathered than are used

in the price measurement, as sales and fashion lead to major changes. Products are often only available at the relevant seasons of the year.

- The prices of most computers sold are collected. Efforts are made to add new products as soon as they come on the market and when a computer ceases to be available, there is a price history of the new product from the time it came on the market and that price change is used in the replacement.

Both direct and indirect quality adjustments are used in the CPI. Bridging is the most common method used in the case of indirect quality adjustment. Assessing bias due to quality changes is difficult and there are no standardised methods for assessing its scope. There is considerable uncertainty as to the extent to which quality changes occur and what their scope is. Both the bias due to quality adjustments and the extent of the quality adjustments made are uncertain.

Discussion of bias in consumption indices

Bias can be said to be linked to theories of a true cost-of-living index, where consumers maximize their utility and minimize costs. In most cases, quantity and price are assumed to be negatively related and, accordingly, individuals change their consumption if price increases occur and buy cheaper products or products that increase less in price than others to maximize their utility. Discussion of bias in the cost-of-living index generally focuses on the final index outcome, which is compared to an outcome obtained according to this theoretically correct cost-of-living index over two periods.

The upper limit of the true cost-of-living index for the former period is the Laspeyres cost-of-living index. This is usually lower than the 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 latter period is the Paasche cost-of-living index, which is usually higher than the Paasche fixed-base index, which is therefore said to be biased downwards. One way to reduce the difference between the Laspeyres and Paasche indices is to change the expenditure base of the consumer price index frequently, which reduces the difference between them and can bring them closer to a true cost-of-living index. Methods are lacking to assess individuals' utility, which makes measurement of cost-of-living indices difficult. Despite this, various types of indices, referred to as superlative indices, adequately reflect a true cost-of-living index, given certain assumptions about the shape of a utility function (Diewert, 1976). This makes it possible to calculate a cost-of-living index using a superlative index, without measuring it directly. Superlative indices are symmetrical and calculated using weights of two periods, older and newer.

Discussion of bias in consumer price indices is often linked to the so-called Boskin report published in 1996. The Boskin Commission was supposed to assess the bias in the consumer price index for the US Senate, in connection with indexation of pensions. The report estimated that the US consumer price index overstated price changes by 1.1% on average per year. It was estimated that bias at the upper level (basic headings) was 0.15%, at the lower level (elementary aggregate) 0.25%, and 0.1% due to shopping substitution bias. The greatest part of the bias was thought to be due to the fact that the quality-adjusted

results of the measurement had not been adequate and that bias due to this was 0.6%. The largest items in the index where price changes due to quality changes were considered to have been overestimated were the items healthcare and housing. It was estimated that 65% of the quality bias was due to these two items.

One of the proposals made by the report authors was that the US consumer price index should be calculated as a cost-of-living index. The commission's estimate of the impacts of bias was made within the framework of a cost-of-living index, where the results of price measurements were compared with price changes measured by a superlative index (Törnquist). The US Bureau of Statistics made significant changes to the methodology following this, most of which had been decided before the report was published. For example, a geometric mean was adopted in the lower level in the January 1999 index. The report's conclusion was reassessed in 2000. It was estimated that bias in the lower level was 0% because using the geometric mean in the lower level had managed to eliminate it. The overall bias was then estimated to be 0.8%.

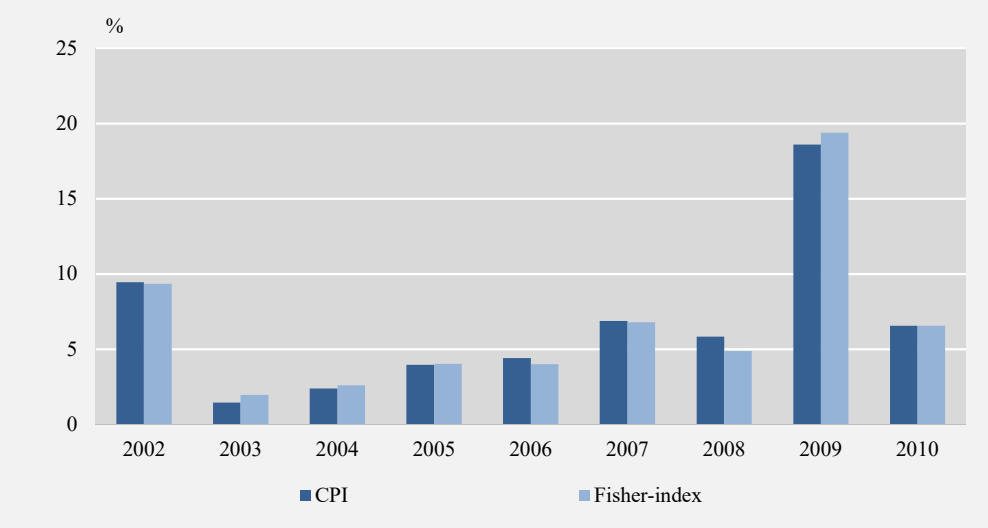
Research on bias in the CPI in Iceland

Two studies have been published dealing with bias in the CPI in Iceland. Both are focused on bias in the basic headings of the index, in its upper level, where the CPI is calculated as a Lowe fixed-base index. One study was by Jónsdóttir, G.R., and Jónasdóttir L.G. (2011) and the other by Halldórsson, B.V., Ottesen, O.Á., and Stefánsdóttir, S.H. (2011). In addition, Joensen, K. (2009) wrote an article dealing extensively with the effects of substitution without investigating the size of bias.

The study by Jónsdóttir and Jónasdóttir (2011, pp. 6-8) was based on theories of a cost-of-living index using a superlative index (Fisher). The results were compared with the CPI results in 2002-2010 (see Figure 1.).

The method has been used in most studies of bias, such as that of the Boskin Commission. Their study used the results of the previous year's household expenditures for the Laspeyres index, and those of the same year for Paasche weights. Figure 1 shows annual inflation based on the CPI in January in 2002–2010 and compares it with inflation as measured by the Fisher index. Price changes of 2002, based on 2001 expenditures, were used in the Laspeyres index while expenditures of 2002 were used in the Paasche index. According to the results the greatest difference was in January 2008 and 2009. In January 2008, the published index rose 0.9% higher than the Fisher index, while in January 2009 the index measured an 0.8% lower price change. The deviation from 2002 to 2010 was, on average, very low or 0.01%.

Figure 1. CPI and Fisher-index, annual rate of change in January 2002-2010



It is generally assumed that the overestimation of fixed-base indices, which are based on the composition of expenditures of past periods, will increase when prices change rapidly, but here the opposite results seems to be obtained. It should be borne in mind that, in the April 2008 index rebasing, the weighting of items such as automobiles, major leisure and electrical equipment was not reduced especially. Their weight was therefore too high compared to what became the reality during the latter half of the year as a result of the financial collapse. In contrast, the weighting of food and beverages was proportionally too low. Price level changes throughout the year varied by category. In January 2009, food and beverage products had risen by 29.8% in twelve months, while travel and transport had only increased by 16.5%. At the same time, the item leisure and culture had risen by 11.6%.

The study by Halldórsson et al. (2011), made an attempt to measure upper-level bias in the CPI. Their conclusion is that substitution bias in the upper level of the CPI on average was 0.3% per year (0.45% in 2/3 of the CPI) from 1997 to March 2006.

The main theory of the authors of the study is that the middle year in the result of each expenditure survey is an unbiased estimator. From the description of their methods, it appears that the relative weights of the index, as published on Statistics Iceland's website for March each year, were used to prepare this "unbiased estimator".

> “We use the weighted average of the weights of these consumption baskets in the proportions ¾ and ¼. In this way, the average age of the consumption basket becomes zero in the middle of the year in which expenditures are measured. For example, for the price

measurement from March 2000 to March 2001, we use the weighted average of weights of consumption baskets of 2003 and 2004." (Halldórsson et al., P. 7) [1]

The main weaknesses in the study are, according to Statistics Iceland:

Firstly, Statistics Iceland updates prices for the consumption baskets in March, before the proportional weights are found, and the proportions may therefore have changed significantly from the year in which the expenditure survey was conducted. The statement that "The weights based on data that are on average 0 years old are almost unbiased estimates of inflation" is correct (taking into account substitution bias at upper level). However, the weights used are not, because due to the price update they are not on average 0 years old[2].

Secondly, it is stated that all expenditures not obtained from the expenditure survey are omitted, but the reality is otherwise. The study does not exclude groceries and alcohol. Statistics Iceland estimated this item each year with new data or other sources (about 15% weight on average). The article states that in three categories bias is significant: category 01 Food and Beverages, 02 Alcohol and Tobacco and 05 Furniture and Home Appliances (Halldórsson et al., p. 9). It is precisely in categories 01 and 02 that newer sources are used for internal weighting for the elementary aggregate of the CPI.

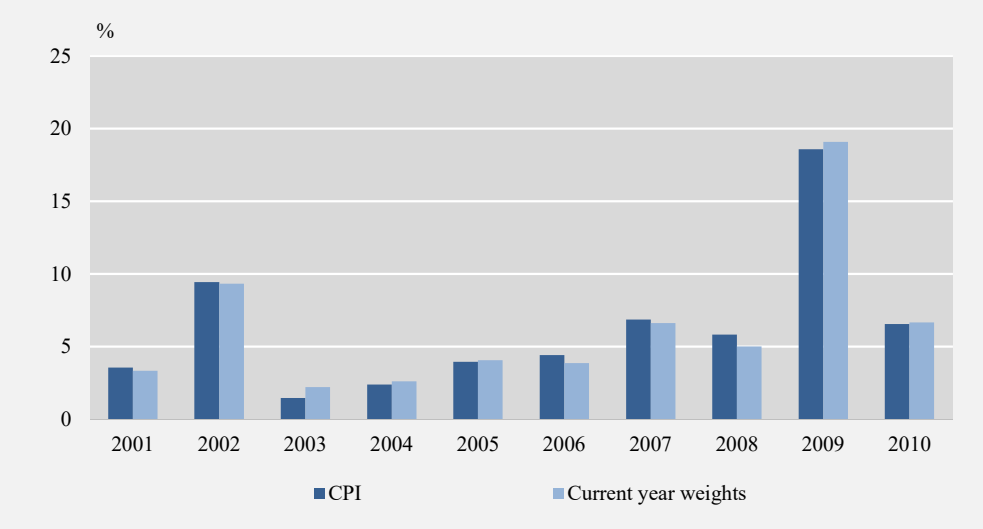
The study by Jónsdóttir and Jónasdóttir (2011, p. 7) examined the result for each year in the expenditure study. This is in actuality a similar comparison to that used in the study by Halldórsson et al. (2011) of bias in the upper level. The CPI is recalculated for the years 2001–2010 and the expenditures survey is used each year as a basis. The calculation is therefore based on actual expenditures for each year. Due to the small size of the sample each year, there are few households underlying the results and the standard error in the sample is high.

Figure 2 shows the results, comparing the measured annual change in the CPI with the calculated result for an index based on the current year weights in January each year. The results of the measurements for both indices are quite similar. The largest differences are in January 2003, when the published index measured 0.8% less than the comparative index, and in January 2008, when the published index measured a 0.8% higher price increase. On average, the difference was +0.02% over the period 2001–2010.

[1] The Marshall and Edgeworth index used in the study, is not a superlative index, because it is not symmetrical (ILO 2004, pp. 266-269 and 348). The fact that the index is not a superlative index does not appear to affect the results of this study.

[2] The survey of household expenditures has been conducted continuously since 2000. Results for the years 2000 and 2001 were first used in 2002, mainly to review the weights for food and beverages. The results of surveys for three years were first utilized in the 2004 rebasing of the index and were mainly based on the expenditure surveys of 2000-2002. In the period 1997-2002, the basis was results of the 1995 expenditure survey, which were price updated every year, while various items were revised according to other sources.

Figure 2. CPI and an index based on current year weights, annual rate of change in January 2001-2010



The article by Joensen (2009, p. 109), discusses the subject in detail, but no special study is made of bias in the upper or lower levels in Iceland.

> "An assessment has been made of substitution effects on the CPI of various countries, and inflation is commonly considered to be overestimated by close to 0.2% annually due to this. It can be concluded that the substitution effect on the CPI in Iceland is the same, or about 0.2% per year on average. Substitution bias is not a fixed figure, but is dependent on factors that vary from one period to the next. The effect of unstable prices is to increase substitution effects and compared to the countries and the studies that were observed in this article, price stability in Iceland is low. On the other hand, the elementary aggregate of the CPI in Iceland is estimated annually, while in many countries such a revaluation is carried out less frequently and with older data. With frequent revisions of the index aggregate, consumption changes can be followed more closely and this reduces substitution effects."

Comparing different countries is always problematic, as circumstances often differ. The same applies to the basic data in the indices, the organization of data and the compilation. All of this has an impact on the results, but the accuracy of the estimation cannot be rejected or confirmed without examining it specifically.

The results of the study by Jónsdóttir and Jónasdóttir of upper level substitution bias over a 10-year period range on average from -0.01% to +0.02%, the lowest annual measurement is -0.8% and the highest is +0.9%.

Estimating bias using a superlative index or based on annual expenditures should show similar results. The study by Jónsdóttir and Jónasdóttir also shows this. There the plus or minus signs of the change each year are practically the same and both methods appear to lead to a similar result.

The conclusion from the study by Halldórsson et al. is that substitution bias in the upper level of the CPI over a 10-year period was 0.3% on average per year (0.45% in 2/3 of the CPI) from 1997 to March 2006. The bias each year is not shown so that it is difficult to interpret the change over the period and compare these results with Jónsdóttir and Jónasdóttir study to see where the difference lies.

One of the reasons why the bias varies from one year to the next is almost certainly the fact that in the Icelandic economy there are large and sharp fluctuations in the exchange rate and inflation. This alters the composition of expenditures changes in the upper level of the CPI, and thus the potential bias. Price changes are not the only reason, as changes in income also have an unequivocal effect on the composition of basic headings in the CPI upper level, where income elasticity is important (Moulton 1996a, p. 165).

In the articles by Halldórsson et al. and Joensen the views are expressed that the economic situation and inflation have an effect in this regard.

> "Inflation has been high in Iceland and changes in relative prices considerable. The ISK exchange rate causes the relative prices of domestic and imported goods to change." (Halldórsson et al., 2011, p. 10).

> "One obvious factor influencing price stability in Iceland is that a large portion of consumer goods is imported and priced in currencies other than ISK. Fluctuations in the exchange rate, therefore, have a considerable effect on prices and for products that have few or no substitute domestic products the exchange rate effects are rapidly visible." (Joensen, p. 107).

The limited research that has been conducted strongly suggests that more detailed study is needed in this area to obtain more reliable results and to be able to understand better what causes underly the bias in order to achieve better results in combating it. The study by Jónsdóttir and Jónasdóttir points out that:

> "The results of this study of distortion or bias in the CPI are noteworthy and give cause for further research. The problem with these investigations is especially that it is difficult to find the right reference for comparison. The indicators used here are based on sample data from relatively few participants each year. It is therefore only to be expected that the deviations may be partly explained by random fluctuations in expenditures and this should be borne in mind when interpreting the results." (Jónsdóttir and Jónasdóttir, p. 8).

These conclusions were timely and can be endorsed wholeheartedly.

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