

Reykjavík, May 17, 2018

To: Taskforce on Reviewing Iceland's Monetary and Currency Policies  
The Prime Minister's Office  
Att. Mrs. Asdis Kristjansdottir  
From: Analytica ehf.  
Yngvi Hardarson, MA, CMT

## **Re: CPI Formulation and Owner-Occupied Housing User Cost**

This note is written at the request of the Taskforce on Reviewing Iceland's Monetary and Currency Policies (Taskforce). The aim is to summarize the treatment of housing costs in the calculation of CPI's for a few countries where the calculation of CPI's is based on a "owner occupied housing user cost approach" and where Central Banks policy is dictated by a pure inflation target.

Three questions have been set forth:

- a. How do the Statistical Bureaus of Sweden and Canada treat "owner-occupied housing user cost" in their CPI estimates? Furthermore, how do their methods compare with the method currently employed with the Statistical Bureau of Iceland?
- b. For those European Countries where Central Banks monetary policy is dictated by a pure inflation target which ones employ the "owner occupied user cost approach" for estimating housing costs within the CPI? Additionally, what method is employed by Statistics New Zealand for estimating housing costs within the CPI?
- c. What is the treatment of housing rental within the CPI of the above countries? Do the countries employ market based rental measures or calculated measures, e.g. derived from property prices?

We base our work on information gathered on our own from the Statistical Bureaus of the respective countries, some OECD studies, information gathered by an Economics research assistant at the Prime ministry during the summer of 2017 and various documents that are referred to in the References section.

### **Summary**

The owner-occupied housing user cost estimates as determined in Canada and Sweden are based on the product of two main components: **(1)** An interest rate index and **(2)** a component estimating the impact of changes in home prices. The second component is here referred to as the capital stock index. The interest rate index reflects interest rates corresponding to the period when a loan was initiated or renegotiated.

The capital stock indices for both countries are constructed such that recent transaction prices weigh in line with the ratio of recent transactions to the total stock. This is in contrast with the Icelandic method where the whole capital stock is re-evaluated in line with recent transaction prices. This is one of the largest contrasts in the methods employed. Also, Iceland employs a real (CPI-linked) rate while the Canada and Sweden employ nominal interest rates. Furthermore, Iceland uses an "annuity method" for estimating user cost.

Apart from Iceland there are three other inflation targeting countries where the user cost approach is employed for estimating owner-occupied housing cost within the CPI. These are Canada, Sweden and Serbia. The Canadian and Swedish cases are studied here.

As regards the treatment of housing rental for calculation of national CPIs then typically a measure of market rent is employed.

### User Cost

The user cost approach to estimating the cost of services generated by a residence concerns the scenario where the landlord and the tenant are the same person. There are three other approaches for estimating the cost of service, i.e. the payment approach, the net acquisition approach and the rental equivalent approach.<sup>1</sup> However, the user cost approach has been adopted by Sweden, Canada and Iceland, more specifically what has been termed a simple (or partial / truncated) user cost approach.

The user cost includes expenses in the form of payments as well as imputed costs. Actual expenses may include items like mortgage interest, renovations and repair as well as taxes. However, it also includes opportunity cost and anticipated capital gain, i.e. the expected price change of the residence over the period in question. In this context it is important to keep in mind that in terms of the CPI the aim is to measure the value of services. Some of the user cost items may not be relevant for that purpose but serve as a measure of investment return.

The user cost measures adopted by Canada, Iceland and Sweden are all referred to as simple user cost. The term simple refers to a simplification of the theoretical concept of user cost where some terms are omitted.

The treatment of owner-occupied housing in the CPI is important as housing generally represents a considerable part of a household's budget. Furthermore, a residence generates service over a long time, much longer than for most other durable goods. However, the impact of owner-occupied housing varies between countries in line with the relative share of owner-occupied housing vs. rental housing.

### Canada, Sweden and Iceland – A Comparison

As stated above Canada, Sweden and Iceland all have implemented a simple user cost approach to valuing the services of owner-occupied housing. However, there are some important methodological differences.

The method adopted by Statistics Canada has recently been documented in reasonable detail.<sup>2</sup> Also, Statistiska centralbyrån (SCB) of Sweden has documented its CPI methodology in detail.<sup>3</sup> The method adopted by Hagstofa Íslands has also been documented in good detail.<sup>4</sup> We base our comparison on the provided documentation in addition to further information provided by the respective statistical bureaus, where needed.

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<sup>1</sup> The purpose of this memorandum is not to describe these various methods but rather to compare the partial user cost approaches of the Statistical Bureaus of Sweden and Canada to the approach adopted by the Statistical Bureau of Iceland. However, it may be noted that the methods employed by Sweden and Canada to estimate mortgage interest cost has a strong resemblance to the payments approach. For the interested reader a brief description of the methods for estimating the cost of service can be found in e.g. Soumare, A. (2017).

<sup>2</sup> Soumare, A. (2017).

<sup>3</sup> Statistiska centralbyrån (2017).

<sup>4</sup> Guðnason, R. (2004a, 2004b).

The simple user cost measures adopted by the respective statistical bureaus include both estimates on actual payments and imputed cost. Estimates on actual payments include utility bills and maintenance and in some cases other items. Typically, the imputed term is detailed separately as based on interest charges and depreciation.

**Table 1. Housing Weights in Canadian, Swedish and Icelandic CPI's**

<b>Canada</b>	
Shelter	26.8%
Rented accommodation	6.4%
Owned accommodation	16.1%
Water, fuel and electricity	4.3%
<b>Sweden</b>	
	Nov. 2017
04 Housing, water, electricity, gas and other fuels	22.6%
04.4 Owner-occupied housing: Electricity, water and dwelling services	1.0%
04.5 Electricity and fuels	4.1%
04.S Rented dwellings: Rent including heating	7.1%
04.x & 04.y Imputed rent for owner occupiers and housing co-ops	10.5%
<b>Iceland</b>	
04 Housing, water, electricity, gas and other fuels	34.3%
041 Actual rentals for housing	5.7%
042 Imputed rentals for housing	20.5%
043 Regular maintenance	3.0%
044 Other serv. relating to the dwelling	1.5%
045 Electricity, gas and other fuels	3.7%

Sources: Statistics Canada (2017), SCB, Hagstofa Íslands Dec. 2017

Table 1 above depicts the relative shares of housing in the Canadian, Swedish and Icelandic CPI's. Part of the difference in weights can be attributed to the large share of owned accommodation in Iceland. This can be seen in table 2.

**Table 2. Share of Owned vs. Rented Accommodation 2016**

	Owner	Rent, market	Rent, reduced
Canada	66.8%	33.2%	-
Sweden	65.2%	34.0%	0.8%
Iceland	78.8%	10.5%	10.7%

Sources: Statistics Canada (2017) 2015 data, Eurostat EU-SILC Survey, Hagstofa Íslands (2017)<sup>5</sup>

### *Canada*

In Canada the housing costs item is referred to a shelter. The shelter term is split into three main items, rented accommodation, owned accommodation and water fuel and electricity. Only the owned accommodation term includes imputed costs. The owned accommodation index covers six components, mortgage interest cost, replacement cost, property taxes, homeowners' home and mortgage insurance, homeowners' maintenance and repairs and other owned accommodation expenses. Note that the index excludes return to homeowners' equity. Also, the capital gain is excluded. Both return on homeowners' equity and capital gains are considered as investment rather than consumption.

<sup>5</sup> Eurostat (2017), "Distribution of population by tenure status, type of household and income group - EU-SILC survey", updated 12.12.17, Statistics Canada (2017), "User Guide for the Survey of Household Spending 2015", Table 7, Jan. 27, 2017, Hagstofa Íslands, EU-SILC (2017)

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The mortgage interest cost index is the product of two components: a component estimating the impact of changing house prices and another measuring the impact of changes in interest rates.

The price associated with a mortgage balance is the average house price in the month of acquisition of the residence. The interest rate corresponds to the period when the loan was initiated or renegotiated. The interest owed on a stock of mortgages during the current month is therefore a function of house prices and interest rates in the current month, as well as those for the previous months, aggregated according to the shares of new and existing mortgages.

“Since the total value of houses purchased during a given period is always a small proportion of the total stock of dwellings, the total amount of mortgage interest owed each month continues to reflect the impact of past changes in house prices for a very long period. In reality, the house prices that enter into the estimation of the mortgage interest cost for each month represent the weighted average house price of the previous 25 years. The weights reflect the distribution of mortgage balances by mortgage vintage, such that older mortgages have a relatively lower weight. This is because newer mortgages generally have a higher principal owing than older mortgages. Past mortgage interest rates also continue to be reflected in the current month index, because new interest rates only affect the index through mortgages newly initiated or renegotiated. These are generally a rather small proportion of the stock of existing mortgages.”<sup>6</sup>

The replacement or depreciation cost faced by the households who own their dwelling. Depreciation is derived from data extracted from the Survey of Household Spending. Respondents are asked how much they would expect to receive for their house if they were to sell it. This amount is multiplied by a “house/property” ratio to obtain an estimate of the value of the house, excluding the land, to which a depreciation rate of 1.5% is applied.

The property tax index measures changes through time in the amount of taxes levied on a constant sample of dwellings in selected municipalities whereas the homeowners’ home and mortgage insurance index measures changes through time in the cost of insuring a fixed stock of dwellings against a specified combination of perils.

It should be stated that the owned accommodation component of the official Canadian CPI was not specifically designed to be an indicator of housing prices inflation.

### *Sweden*

In Sweden owner occupied housing includes directly owned homes as well as beginning in 2017 indirectly owned homes (flats in housing co-operatives).

Imputed rent for housing contains six different items all of which are associated with capital costs (interest cost index, depreciation, building insurance, real estate tax and fee for site-leasehold). Operating costs like heating, refuse collection and water supply are also measured, but are detailed separately.

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<sup>6</sup> See Soumare (2017).

The most important item in terms of imputed rent is the interest cost index which is a product of two sub-indices: the interest rate index and the capital stock index. The interest cost index is a multiple of the two.

The interest rate index employs nominal interest rates and shows the average change of one variable interest rate and several fixed interest rates with different maturity dates. The SCB receives the actual interest rate averages from information providers with the largest banks/lenders being included in the survey.

The capital stock index shows the change of total invested capital in owner occupied housing measured at historical purchase prices irrespective of financing. A model is employed to reflect the change in invested capital. In the model nominal prices are replaced by the real estate price index. (See Appendix I). According to the SCB the capital stock index resembles a 30-year moving average of the real estate price index. Investments in newly produced dwellings are not considered in the model.

As regards interest cost there is no distinction between borrowed capital and equity. The SCB applies the same interest rate for both terms whereby the opportunity cost of capital is assumed equal to the price of borrowed funds. It must also be noted that the acquisition price of both the structure and the land is included. The reason being that land is a prerequisite for housing service.

The index for depreciation is equal to the index for repairs and maintenance. The weighting is calculated as 1.4% of the actual market value of the owner-occupied housing stock.<sup>7</sup>

It may also be relevant in this context that in September 2017, Riksbanken changed the inflation target measure from CPI to CPI-F. The CPI-F is a version of the Swedish CPI where interest rates are being kept fixed.

### *Iceland*

The method of calculation of simple user cost for owner occupied housing in Iceland differs in several important points from the methods employed in Sweden and Canada:<sup>8</sup>

- (1) The user cost is estimated monthly as an annuity which determines both the depreciation term as well as the interest cost.
- (2) Hagstofa Íslands employs a real interest rate for determining the cost of capital based on CPI-linked mortgage rates. A one-year moving average of mortgage rates is employed.<sup>9</sup> The cost of equity is priced at a constant real rate of 3%.
- (3) The full stock of owner occupied dwellings is priced at the most recent available prices or more precisely a three-month moving average thereof.
- (4) The user cost is based on the total value of the structure and the land.
- (5) The price development of both the structure and land is included.

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<sup>7</sup> NIER (2002), p. 34

<sup>8</sup> Additionally, Hagstofa Íslands has summarized some technical differences regarding data collection and calculation in comparing the methods of SCB and Hagstofa in Hagstofa (October 13, 2017).

<sup>9</sup> Earlier a five-year moving average was employed. According to information provided by Hagstofa Íslands the moving average calculation has now been shortened down to one year. Hagstofa Íslands performs a monthly survey of mortgage rates.

- (6) The depreciation term is calculated based on the sum of value of the structure and the land. The depreciation term is included in the annuity which is based on an estimated 67-year lifetime of the average home.<sup>10</sup>

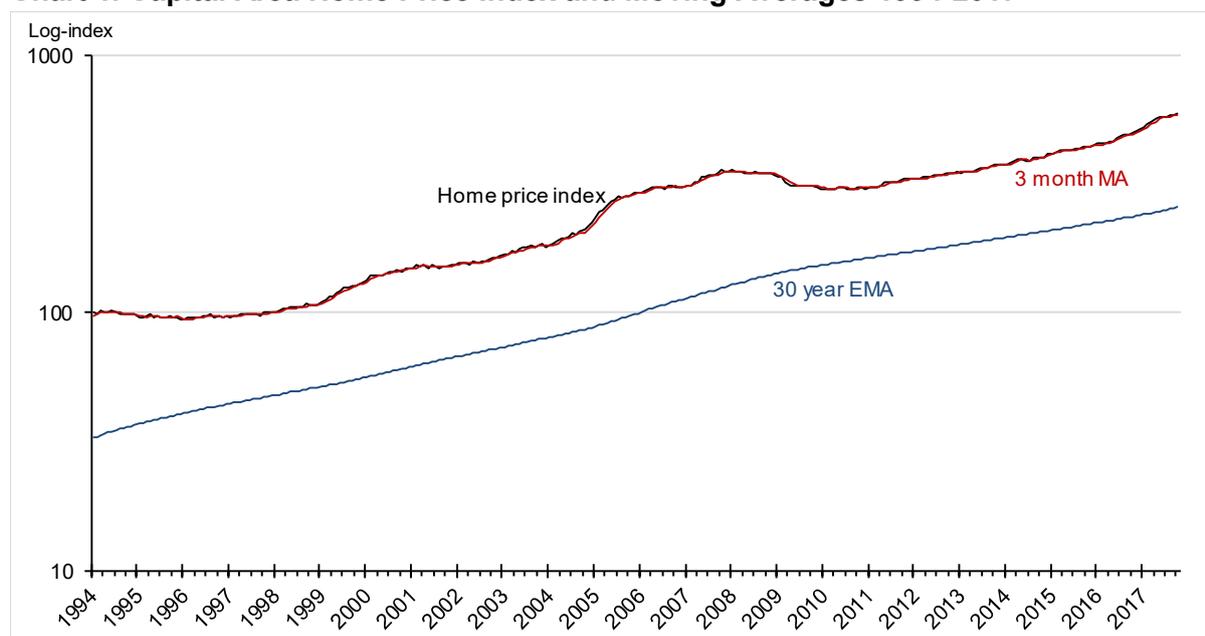
The most significant difference lies in the re-evaluation of the stock of dwellings every month as that makes the Icelandic CPI much more responsive to changes in home prices. This is in contrast with an approximate 30-year moving average process for Sweden and an approximate 25-year moving average process for Canada.

Application of the real interest rate constitutes another major difference as both Canada and Sweden employ nominal rates. The Icelandic real rate is an indexed rate linked to the CPI with a two-month lag. The real rate is applied to the fully marked up stock of dwellings.

As regards the cost of equity then Statistics Canada in effect employs a rate of zero, the SCB applies nominal rates and Hagstofa Íslands employs a 3% CPI-linked rate.

The overall implications of the method employed by Hagstofa Íslands is that: (1) It likely inflates the user cost measure relative to the methods employed by Statistics Canada and the SCB, especially when comparing to the methods of Statistics Canada. (2) The responsiveness of the CPI to changes in home prices is larger in Iceland than for the Canadian and Swedish CPIs.

**Chart 1. Capital Area Home Price Index and Moving Averages 1994-2017<sup>11</sup>**



Source: Registers Iceland, Analytica calculations

One reason for the relatively large user cost measure in Iceland is the use of real interest rates together with the re-evaluated housing stock measure.<sup>12</sup> This involves a relative price change

<sup>10</sup> This does not imply that a depreciation of land is being included in the depreciation term. A lower rate of depreciation is employed to reflect the weight of land in the sum, i.e. a rate of 1.25% is employed to the sum instead of a rate of 1.5% for the structure alone. The value of both the structure and the land is determined by Registers Iceland.

<sup>11</sup> The initial value for the 30-year EMA displayed here is estimated based on a trend regression on the relative price of housing to construction cost. The trend is extrapolated back to 1938, when the construction cost index was first published. The housing price is back-casted based on a multiple of the trend line and the construction cost index. A 30-year simple moving average is calculated in 1968 and from there on a 30-year EMA. The EMA value for December 1993 serves as a starting value of the EMA.

<sup>12</sup> Other explanations may include e.g. higher construction cost in Iceland and possibly larger homes.

of the CPI vs. home prices since home prices have risen relative to the CPI. Another reason involves what’s included in the user cost definition.

A comparison between a 3-month moving average (MA) and a 30-year exponential average is shown in chart 1. The underlying price is the capital area home price index as published by Registers Iceland. Note that this is not the same index as employed by Hagstofa Íslands, but it is highly correlated with the relevant sub-index employed by Hagstofa.

As expected the 3-month moving average is considerably more volatile than the 30-year EMA. The average annual rise of the 3-month average over the whole period amounts to 7.7% whereas the average annual rise of the 30-year EMA amounts to 9%. The underlying exponential trend of the home price index as determined by a linear regression amounts to 8.3% or the average of the two.

**Potential CPI Impact from EMA Based Capital Stock**

Given the above information the Taskforce requested a study of the potential impact on CPI volatility if the current sub-index (042) for owner-occupied housing (OOH), i.e. the imputed rent index, was replaced by an index based on a 30-year EMA of the capital stock. This is thought of as an approximation of the Swedish treatment of the capital stock. The prior expectation was that employing the long term EMA would reduce the CPI volatility. However, this was not so. Volatility and correlation calculations are displayed in Table 3. Home price stands for the Hagstofa home price index.<sup>13</sup>

**Table 3. Annualized Volatilities and Correlation of OOH Cost Sub-Index (042) within CPI**

	CPI	Home price	OOH cost	EMA cost	CPI excl. OOH	CPI w/EMA
<b>CPI</b>	100%					
<b>Home price</b>	3.45%	100%				
<b>OOH cost</b>	11.6%	94.2%	100.0%			
<b>EMA cost</b>	30.0%	-2.7%	28.7%	100%		
<b>CPI excl. OOH</b>	95.3%	-24.7%	-18.4%	20.9%	100%	
<b>CPI w/EMA</b>	96.0%	-24.0%	-14.0%	32.9%	99.2%	100%
<b>St.dev.</b>	1.93%	3.90%	3.96%	1.63%	2.32%	2.04%

Source: Hagstofa Íslands, Analytica calculations based on month on month log changes

The EMA term shown in table 3 is an EMA based OOH Cost Index where the OOH cost term has been replaced by a 30-year EMA<sup>14</sup>. The CPI w/EMA stands for the CPI as modified using an EMA for the capital stock. Due to the negative correlation of the current owner-occupied housing cost sub-index (042) with other sub-indices the current method of encompassing owner-occupied housing costs into the CPI results in lower volatility (standard deviation) relative to the EMA approach. The difference is even clearer when employing quarterly data.

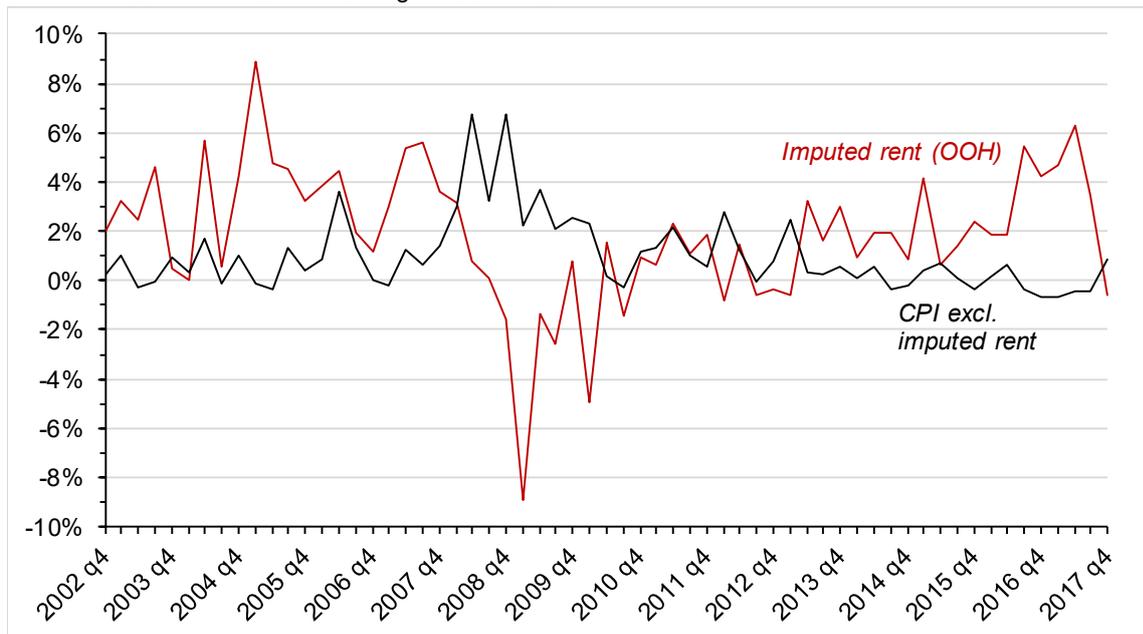
The negative correlation between the Hagstofa Imputed Rent Index (OOH Cost) and the CPI excl. Imputed Rent (OOH) is such that it can be clearly seen in Chart 2 displaying quarterly changes in both indices.

<sup>13</sup> The study covers the period August 2002 through December 2017 and is limited by monthly weights data available on Hagstofa’s portal.

<sup>14</sup> An EMA is employed with L=356.2 (months). This value minimizes the RMSE between a 30-year EMA of the home price index as published by Registers Iceland and a long term EMA of the 3-month average home price index employed by Hagstofa Íslands. The EMA term is then augmented by adding the log difference between changes in the 042 sub-index and PHHI in order to approximate the impact of changes in interest rates.

**Chart 2. Changes in Hagstofa OOH Index and CPI excl. OOH Cost**

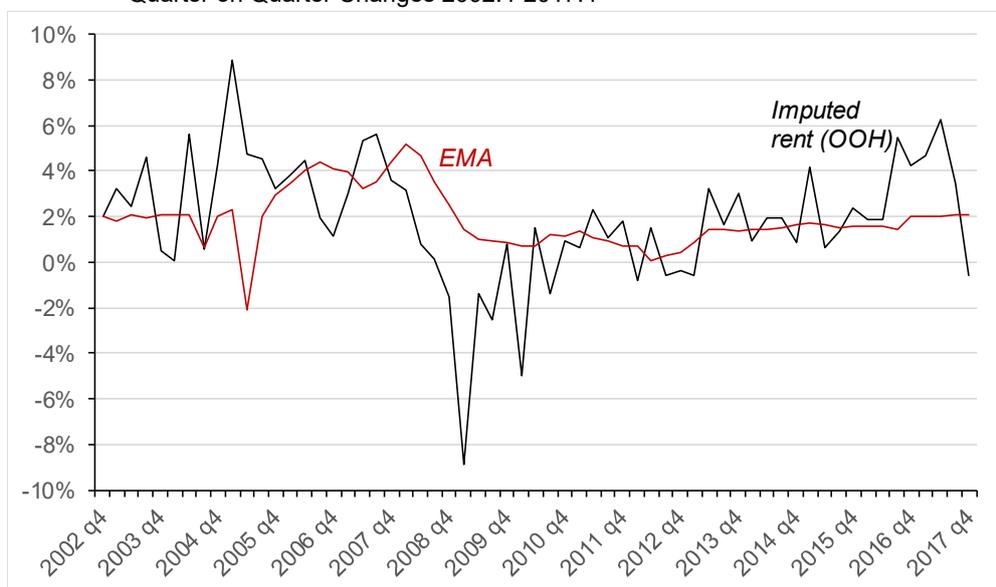
Quarter on Quarter Changes 2002:4-2017:4



The reason for the negative correlation isn't clear but the possibility of it having something to do with Central Bank inflation targeting can't be excluded. Chart 3 depicts the quarter on quarter changes in the Imputed Rent Index (OOH Cost) as compared with the EMA based OOH housing cost index.

**Chart 3. Changes in Hagstofa OOH Cost Index (042) Compared with EMA Based Cost**

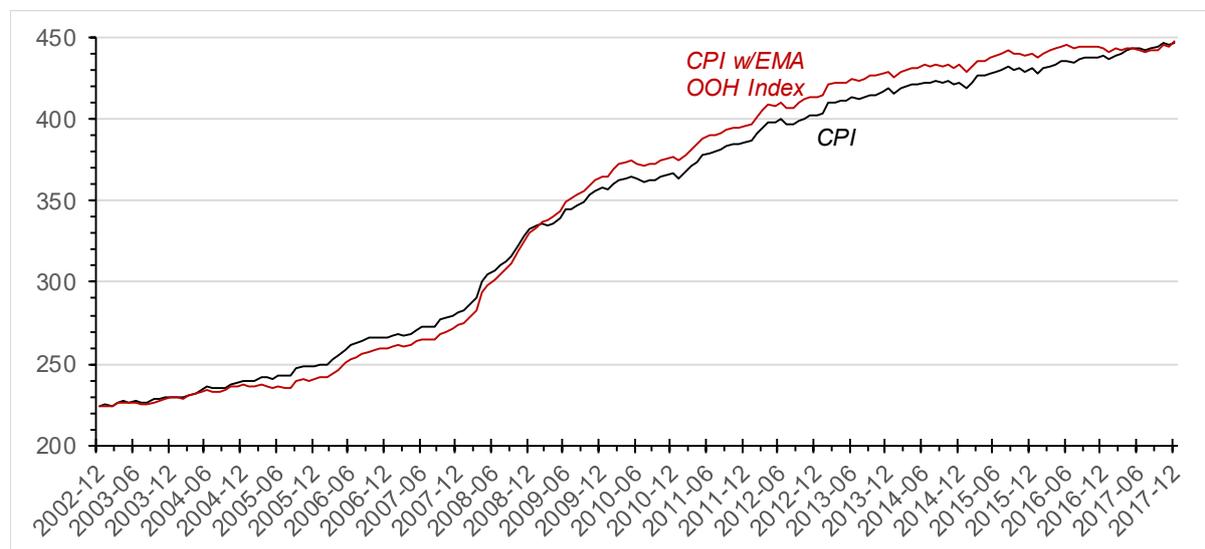
Quarter on Quarter Changes 2002:4-2017:4



Sources: Hagstofa Íslands, Analytica

Chart 4 displays the CPI as compared to a synthetic CPI where the Imputed Rent Index (OOH) is based on an EMA housing stock index. As can be seen there is a variation in the timing of price changes, but it is hard to discern the volatility difference from the chart.

**Chart 4. CPI Compared with a Synthetic CPI based on EMA - Monthly data 2002-2017**



Source: Hagstofa Íslands, Analytica calculations

An attempt was also made to approximate the Canadian method of CPI calculation. This is done by employing a 25-year EMA as an approximation to the housing stock in addition to omitting an estimated average share of land price from the total valuation. The price of land weighs around 17% on average.<sup>15</sup> Furthermore, we omit the cost of equity, based on the assumption that the share of equity funding is around 30%. Omitting the price of land and the cost of equity reduces the weight of imputed rent (OOH cost) by almost 40% or from around 20% for December 2017 to 12.4%.<sup>16</sup> The impact is to reduce the annual inflation measure by around 0.2% or by around 3% in total for the period August 2002 through December 2017. However, the annualized volatility increases to around 2.1% from 1.9%.

One important thing to keep in mind in case a switch is to be made to a measure of housing stock index like the Swedish or Canadian indices. Notably, that such measures resemble a moving average of historical prices. A moving average delays information in line with around half its length. The implication is that care needs to be taken regarding the starting point of the capital stock calculation to avoid the double counting of historical price increases to enter the CPI calculation. One way to avoid this would be to start the capital stock index calculation from the most recent period rather than starting from a historical date.

### **Inflation Targeting in Europe and the User Cost Approach**

The European Central Bank (ECB) targets Eurozone inflation based on the HICP index. The HICP index only includes rented dwellings with the rent measure being market rent as observed by Eurostat and the respective statistical agencies. Also, the Bank of England currently targets inflation based on the UK HICP.

<sup>15</sup> The 17% is an average for all housing on a national basis but not only residential housing. Also, the ratio varies from year to year but seems to have been trending down.

<sup>16</sup> The exact weight reduction varies by period and ranges between 32-38%.

Even though the HICP measures currently exclude owner-occupied housing the EU has published a “Methodological manual referred to in Commission Regulation (EU) No 93/2013 – Owner-Occupied Housing Price Indices – House Price Indices” dated February 2013. According to the manual the EU will adopt the “net acquisition approach” for the measurement of owner-occupied housing rather than the user cost approach.<sup>17</sup> “The weight for the net acquisitions approach are the net purchases of the household sector of dwellings from other institutional sectors in the base period (flows) and not the value of the total housing stock.”<sup>18</sup>

Before moving on to CPI measures and inflation targeting we would like to highlight a principal difference between the HICP and CPI measures. This involves the HICP being a pure inflation measure while the CPI indices in general are considered cost of living indices where consumer substitution effects may play a significant role.

**Table 4. Overview of inflation targeting countries employing user cost (UC) approach**

	Using OOH	Rental eq.	UC	Net acq.
Albania				
Belarus				
Canada	x		x	
Czech Republic	x			x
Euro area				
Hungary	x	x		
Iceland	x		x	
Moldova				
New Zealand	x			x
Norway	x	x		
Poland				
Romania				
Russia				
Serbia	x		x	
Sweden	x		x	
Switzerland	x	x		

Source: IMF (2017), The Prime Minister’s Office, OECD (2002)

As can be seen in table 4 there are four countries in our sample that target inflation and employ the user cost approach to CPI owner-occupied housing (OOH). In addition to Iceland, Canada and Sweden have already been mentioned while little information has been obtained on Serbia. Altogether nine countries take owner-occupied housing into account for their CPI’s.

As concerning New Zealand then Statistics New Zealand has adopted the net acquisitions approach to owner-occupied housing while using actual rentals for rental housing.

### Treatment of rental housing for the CPI’s

Overall a measure of market rent is employed for the calculation of national CPI’s. The use of imputed rent is intended for estimating owner-occupied housing.

<sup>17</sup> European Commission (2013), paragraph 5, p. 3.

<sup>18</sup> European Commission (2013), paragraph 64, p. 19.

## Appendix I – The Swedish Capital Stock Index<sup>19</sup>

In Sweden changes in interest cost are measured by an index calculated as a product of two factors: The interest rate index and the capital stock index. The second factor, i.e. the capital stock index, measures the development of the original investments made by the current owners. Essentially the capital stock index mirrors the development in property prices. The capital stock index valuation is based on the historical acquisition price of homes. This involves an addition to the capital stock in line with the turnover in the market at each point in time. The calculation of the current (year=0) capital stock index is based on the following formula:

$$(1) \quad K_0^m = \left( \frac{\sum_{j=0}^k N_{i-2,B-j} I_{q-j}}{\sum_{j=0}^k N_{i-2,B-j} I_{q-j-4}} \right)^{\frac{m}{12}}$$

$K_0^m$  stands for the capital stock index in month  $m$  of the current year

$N_{i-2,B-j}$  stands for the number of residences in year  $i-2$

$I$  stands for the home price index

$i$  stands for the current year

$i-2$  stands for the reference year of the ownership structure. (Note: Available with a two-year lag). The ownership structure refers to the distribution of the stock of residences according to the length of time the current owner of the residence has owned it. Data on this distribution is obtained from the apartment registry.

$j$  stands for the current owner's holding time since acquisition, counted in number of quarters.

$B$  stands for the fourth quarter of the year  $i-2$  (with quarters continuously numbered for all years in a row)

$q$  stands for the quarter when the latest home price index is published, calculated for month  $m$  (with quarters continuously numbered for all years in a row). (Note: The home price index is available with a 1 to 2 quarter lag.)

$m$  stands for the current month, 1 to 12

$k$  stands for how many quarters the index is calculated. This is calculated from the most recent quarter ( $j=0$ ) and back to the beginning. Statistics on holdings and the home price index go back to 1961.

The formula provides an estimate for the capital which serves as the basis for the calculation of interest cost in month  $m$ , relative to December of the previous year. The calculation reveals the change in the cost of loan financing and the fall in return on capital as home prices change.

It is our interpretation that the above process (1) representing the capital stock index can be approximated by an exponential moving average where the weight of current prices is in line with the turnover of homes relative to the existing stock. Formally this can be written as follows:

$$(2) \quad K_t \approx \lambda_t I_t + (1 - \lambda_t) K_{t-1}$$

<sup>19</sup> See Statistiska centralbyrån, 2017, "Konsumentprisindex (KPI)", p. 27-28.

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where the parameter  $\lambda_t$  represents the turnover of homes relative to the existing stock at time  $t$ ,  $K_t$  represents the capital stock index employed at time  $t$  and  $I_t$  represents transaction prices at time  $t$ . If we define the parameter by:<sup>20</sup>

$$(3) \quad \lambda_t = \frac{2}{L_t + 1}$$

then the exponential moving average resembles a simple moving average of length  $L_t$ . According to Statistics Sweden the process represented by (1) resembles a 30-year moving average. Based on the approximation of (2) and (3) that would imply a relative turnover  $\lambda_t$  of around 6.45% per year. When using monthly data  $L_t$  equals 360 implying a relative turnover  $\lambda_t$  of 0.554% per month.

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<sup>20</sup> Se e.g. Nau, R. (2014), p. 9.

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