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## A new consumer price index that incorporates housing

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## A NEW CONSUMER PRICE INDEX THAT INCORPORATES HOUSING

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# **A new consumer price index that incorporates housing**

Anders Klevmarken<sup>1</sup>, Olle Grunewald and Henrik Allansson<sup>2</sup>

November 3, 2009

A long lasting controversy in Sweden as well as internationally is how to best estimate a price on the services of owner occupied housing in a consumer price index. There is no international consensus and different approaches have been adopted. In this paper we use a true cost-of-living index suggested by one of the authors, apply the model to Swedish data and compare the results to the current Swedish CPI. We also show that within the economic model underlying the true cost-of-living index, alternative operationalizations of the index give rather different results. The choice between these alternatives depends upon the primary purpose of the index.

**Keywords:** Price index, cost-of-living index, compensation index, price of housing services

**JEL:** C43, D91

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## 1. Introduction

In many countries housing as a share of private consumption is as much as 25 to 30 percent. The price of housing services is thus a major component of a consumer price index. Depending on country these services are to a large extent generated from owner occupied dwellings for which there is no readily observable price. There is no generally acceptable practice to measure the price of these housing services. In some countries they are represented by an index of rented apartments, in other countries attempts are made to estimate some kind of user cost, and in a few countries there is no index at all for owned housing, which implicitly means that the price of these services is assumed to follow the general CPI.

The literature on price index numbers distinguishes between a few major approaches to measure the price of services from durable goods: the acquisition approach, the rental equivalence approach, the payment approach and the user cost approach. The acquisition approach is used for nondurables but typically also for durables with the exception of owner occupied housing. For most purposes of a CPI one prefers to measure changes in the price of the services derived from a house rather than changes in the price of the house as such. The same argument could have been used for any major durable consumption good, such as vehicles, but the international convention is to use the acquisition approach in this case. The motivation is probably a desire to avoid all the problems with the user cost approach and with weak rental markets. In many countries the rental market for detached houses is very thin, only covering a selected sample of houses. The rental equivalence approach is thus not operational in these countries. In the payments approach one measures cash out-payments for the cost of operating an owner occupied dwelling, but ignores depreciation and the opportunity cost of holding the equity in the owner occupied dwelling.

Many theoretical economists prefer to follow the user cost approach. It recognizes that the purchase of a house is both a consumption and an investment decision. The purchase price can be decomposed into one component which represents the services derived from the house in a given period (depreciation), and another – the end of period value - which is an investment. As an investor the house owner wants a return on his investment, which can be seen as an opportunity cost. The practical implementation of the user cost approach involves the estimation of rather elusive concepts such as; the opportunity cost of the investment, the depreciation of a house, the subjective

interest rate that equalizes amounts in the beginning and the end of a period, purchase prices of constant quality houses, and in some user cost definitions expected future purchase prices. There are many ways to estimate these concepts and incorporate them in an index formula, one not necessarily better than another. The resulting index might depend very much on the specific solution chosen. Typically empirical implementations of the user cost approach result in indices that become rather volatile.

Some practitioners view a consumer price index simply as a weighted mean of price relatives. The problem of computing such an index involves the definition of an index formula, the definition of commodities, finding methods to measure the corresponding prices, and defining the weights. There are obviously infinitely many combinations of these entities which result in indices with different properties. In the so called axiomatic approach a number of plausible properties (axioms) are specified *a priori* and only indices which satisfy these axioms belong to the feasible set of indices. Depending on the axioms chosen and the definitions of the entities there is no guarantee for a nonempty set, nor for a small set. The major problems of this pragmatic approach are, however, that it is completely unrelated to the behavior of consumers and markets, and also to the major uses of a CPI.

The theory of the true cost of living index is an attempt to meet these objections and give index theory a foundation in classical consumer choice theory. In his pioneering work Konüs (1924, 1939) used a simple static model of consumer optimization. This model only includes nondurables, and it must be generalized to accommodate durables and to allow the consumer to optimize over more than one period, before it can become a useful tool to define a true cost of living index that incorporates housing. Klevmarken (2009) has recently suggested a semi dynamic model of consumer behavior that incorporates the demand for housing and is consistent with the general purpose of a consumer price index. He used this model to derive a true cost of living index and showed, given certain assumptions, that there are conventional Laspeyres approximations which can be computed with the information usually collected at a statistical bureau.

Using Swedish data we demonstrate in this paper how Klevmarken's index can be implemented and compare the results to the current Swedish CPI. It turns out that economic theory and the accompanying approximations do not yield a unique index. There is still scope for strategic choices

which become numerically important. We discuss these choices against the background of the most important uses of the Swedish CPI. Our results as well as this discussion raise the issue of revising the current index.

Before reviewing our results we summarize the assumptions and properties of the index proposed in Klevmarken (2009) and discuss alternative variants. These sections draw heavily on Klevmarken (2009). We then continue with a summary of the properties of the current Swedish CPI with a focus on the subindex for housing services. Then follows a description of the practical implementation of Klevmarken's index, i.e. the choice of price and weight data, after which we are ready to present our comparative results and discuss their implications. The empirical implementation draws on Grünewald, Lundin & Allansson (2009).

## 2. A true cost-of-living index

A true cost-of-living index as a basis for a consumer price index should be able to answer a rather simple question: "What income is needed today to compensate for a price change today?" Although economic decisions about housing typically both influence immediate utility as well as future utility, we do not necessarily need a multiperiod optimization model to capture the most important features of this decision situation and at the same time be able to answer the basic CPI question. Klevmarken (2009) assumes that time is discrete and that a time period is homogenous in the sense that prices do not change in a period, only between periods. The consumer is assumed to maximize the following utility function subject to a budget constraint,

$$U(\mathbf{q}, q_h^0 + \lambda q_m, q_h, q_r, g_A(A), g_M(M)); \quad (1)$$

where  $\mathbf{q}$  is a vector of volumes of non-housing commodities,  $q_h^0$  the initial stock of own housing and  $q_m$  the volume of repair and maintenance.  $q_h^0 + \lambda q_m$  then represents the housing stock available for current consumption including any maintenance and repair.  $\lambda$  is a factor that translates maintenance

and repair into house value. A value different from one allows for more or less value enhancing repair and maintenance activities.<sup>3</sup>

In principle one could represent the services the consumer obtains from his own house by the product of a depreciation factor and the stock, but for simplicity this factor is absorbed into the utility function.<sup>4</sup>  $q_h$  is the terminal stock of own housing representing the quantity of house which has a future consumption value. Through the utility function the consumer attaches a current value to the future services a house is expected to provide. There is thus a trade off in utility between using a house today and using it tomorrow.  $q_r$  is the volume of rented housing services. Most consumers will have utility functions with properties such that they will either choose a house or an apartment, but we do not exclude the possibility of having both.

Finally,  $A$  is financial assets at the end of a period, and  $M$  mortgages and loans. Financial assets can in the future be used for consumption and having assets for this reason enhances utility today. Their contribution to utility depends on the expected future real return on assets. The function  $g_A(\cdot)$  represents the consumer's expectations in this respect. Mortgages and loans do not contribute to direct utility, only indirectly through the higher consumption volumes of goods and services they enable. However, higher liabilities increase the consumer's exposure to market risks. He may also become more sensitive to health related risks in the sense that illness and accidents may cause difficulties in satisfying contracted interest payments and payments towards the principal. High multi

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<sup>3</sup> For simplicity in order not to complicate all formulas we also include in  $q_m$  the services and material needed to operate a house such as heating. It is not always easy to make a clear distinction between these goods and services and those used for maintenance. For instance, if a house is not heated in a Nordic climate it will quickly wear down.

<sup>4</sup> In fact, the services obtained from a given house will in general differ from one consumer to another depending on the consumers' preferences. It follows that the services a consumer obtains from a house need not be the same as a market determined depreciation.



period mortgages and loans also constrain future consumption possibilities. In a multi period model future payment to service a loan are, like other expenditures, usually included in the budget constraint, and thus determine the consumer's optimization. The model specified in this paper is not dynamic in this sense, the budget constraint only includes current expenditures – see below. Instead we assume that the consumer evaluates the future budget impact of a loan taken today and translates it into current disutility. There are thus two reasons to include liabilities as an argument in the utility function: the disutility of increased risk and the disutility of future consumption constraints. None of these two effects depend on the nominal size of the loans and mortgages, but rather on a measure relative to collateral, assets owned by the consumer and his earnings capacity. The function  $g_M(\cdot)$  makes this translation into a “real” measure. To simplify and focus on the housing market Klevmarken (2009) assumes that mortgages and loans are primarily or exclusively taken to finance housing. The collateral of a mortgage is then the market value of an owned home, and a natural measure of the risk to which the consumer is exposed is the mortgage share  $M/p_h q_h$ . It is thus assumed that,

$$g_M(M) = M / p_h q_h = \tilde{M} \quad (2)$$

It is further assumed that the consumer expects a future real return  $\tilde{r}$  on financial assets. It then follows that,

$$g_A(A) = A(1 + \tilde{r}) = \tilde{A}; \quad (3)$$

The budget constraint becomes,

$$\begin{aligned}
&\text{beginning of period assets} && A^0 - M^0 + p_h^0 q_h^0 + \\
&\text{money incomes} && y + Ar_A + \\
&\text{change in value of assets} && A^0 r_{AA} + p_h (1 - \delta)(q_h^0 + \lambda q_m) - p_h^0 q_h^0 = \\
&\text{expenditures} && \mathbf{p}'\mathbf{q} + p_m q_m + Mr_M + p_r q_r + \\
&\text{end of period assets} && A - M + p_h q_h; \tag{4}
\end{aligned}$$

where  $Ar_A$  is interest and dividends obtained during the period, and  $Mr_M$  interest paid.  $A^0 r_{AA}$  represents capital gains on financial assets, while the last two terms in front of the equality sign is the nominal capital gain on own home after depreciation, maintenance and repair.

Using the assumptions (2) and (3) the budget constraint (4) can be rewritten in the following way,

$$\begin{aligned}
&y + A^0(1 + r_{AA}) + p_h(1 - \delta)q_h^0 - M^0 = \\
&\mathbf{p}'\mathbf{q} + p_m q_m + p_r q_r + p_h(q_h - (1 - \delta)\lambda q_m) + (r_M - 1)p_h q_h \tilde{M} + \frac{1 - r_A}{1 + \tilde{r}} \tilde{A}; \tag{5}
\end{aligned}$$

The dual to the utility maximization problem is to minimize the expression to the right of the equality sign of (5) with respect to  $\mathbf{q}, q_m, q_r, \tilde{M}$ , and  $\tilde{A}$  for a given level of utility U, prices

$\mathbf{P}^* = \{\mathbf{p}, p_m, p_h, p_r, r_M, r_A\}$ , initial assets  $W^0 = \{A^0, M^0, q_h^0\}$  and expectations about future real return on financial assets. This minimum gives us the net worth the consumer needs to reach utility level U. We might then define a true cost-of-living index as the ratio of two minimum values

corresponding to two different price vectors  $\mathbf{P}^*$ . However, in the consumer price index context we would like to know how much total private consumption (income less savings) will have to change to compensate for a price change, not how much net worth needs to change. A simple rearrangement of the budget constraint *at the minimum* will, however, give us an ideal index which serves our purpose better.

$$y + A^0 r_{AA} + A^* r_A - [(A^* - M^*) - (A^0 - M^0)] = \mathbf{p}' \mathbf{q}^* + p_m q_m^* + p_r q_r^* + p_h (q_h^* - (1 - \delta)(q_h^0 + \lambda q_m^*)) + r_M p_h q_h^* \tilde{M}^*; \quad (6)$$

The entities marked with a star are the values which minimizes the expression to the right of the equality sign of eq. (5) for a given utility level  $U$ , prices  $\mathbf{P}^*$ , initial assets  $\mathbf{W}^0$ , and  $\tilde{r}$ . The expression to the left of the equality sign of expression (6) can be interpreted as “income less (optimal) financial savings”. Income here includes capital incomes, both in the form of interest and dividends, and (net) capital gains. Eq. (6) thus defines a “total consumption” concept for which an ideal price index can be defined that can serve as an ideal target for a consumer price index. Only financial savings, not savings in real assets such as consumer durables and own housing are subtracted from income, because in a consumer price index context one conventionally assumes that durables and own housing are bought primarily for consumption purposes.

Let's denote the expression to the right of the equality sign of eq. (6)  $\mu(\mathbf{Q}^* | U, \mathbf{W}^0, \mathbf{P}^*)$ , where  $\mathbf{Q}^* = \{q^*, q_m^*, q_r^*, q_h^*, \tilde{M}^*\}$ . The corresponding expression for another price vector  $\mathbf{P}^{**}$  yielding a minimum at  $\mathbf{Q}^{**}$  is  $\mu(\mathbf{Q}^{**} | U, \mathbf{W}^0, \mathbf{P}^{**})$ . An ideal cost-of-living index can now be defined as,

$$I(\mathbf{P}^*, \mathbf{P}^{**} | U, W^0) = \frac{\mu(\mathbf{Q}^{**} | U, W^0, \mathbf{P}^{**})}{\mu(\mathbf{Q}^* | U, W^0, \mathbf{P}^*)}; \quad (7)$$

This index tells us how much income, after (optimal) financial savings, must change to maintain the consumer at the utility level  $U$  when prices change from  $\mathbf{P}^*$  to  $\mathbf{P}^{**}$ .

This index will in general be a function not only of the price vectors  $\mathbf{P}^*$  and  $\mathbf{P}^{**}$  but also of the expected future real rate of return on financial assets  $\tilde{r}$ . This implies that even if all commodity prices are constant,  $\mathbf{P}^* = \mathbf{P}^{**}$ , but the expected future real rate of return on financial assets change, the index (7) will not necessarily take the unit value. Because  $\tilde{r}$  is not included in the  $\mathbf{P}$ -vector a conventional (Laspeyres) approximation to (7) would not include  $\tilde{r}$ , and might not be a good approximation to the ideal index (14). However, if all commodities are separable from financial assets in the utility function (6)<sup>5</sup>, or if we look upon the index (7) as a conditional index in the sense of Pollak (1975) – conditional on financial savings, we get indices which have the basic properties of a cost-of-living index (see again Pollak, 1975). The partial index, which relies on the property of separability, will in general be different from the conditional index, which tells us what income change after some fixed financial savings, the consumer will need to maintain a certain level of utility. In the following we will adhere to one of these assumptions. It appears though that both ideal indices have the same operational Laspeyres approximation.

### 3. Laspeyres' approximation

Let  $\mathbf{P}^* = \mathbf{P}^1$ ,  $U = U^1$  (the utility level attained at  $\mathbf{P}^1$ ),  $\mathbf{P}^{**} = \mathbf{P}^2$ , where 1 and 2 are two consecutive time points. The ideal index (7) now becomes an ideal index of Laspeyres-type,

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<sup>5</sup>  $U(\mathbf{q}, q_h^0 + \lambda q_m, q_h, q_r, g_A(A), g_M(M)) = U(V(\mathbf{q}, q_h^0 + \lambda q_m, q_h, q_r, g_M(M)), g_A(A));$

$$I(\mathbf{P}^1, \mathbf{P}^2 | U^1, W^0) = \frac{\mu(\mathbf{Q}^{**} | U^1, W^0, \mathbf{P}^2)}{\mu(\mathbf{Q}^1 | U^1, W^0, \mathbf{P}^1)} \quad (8)$$

$\mathbf{Q}^{**}$  is in general not equal to observable  $\mathbf{Q}^2$ , because  $\mathbf{Q}^{**}$  is an optimum conditional on  $U^1$  and  $W^0$ , while  $\mathbf{Q}^2$  is an optimum conditional on  $U^2$  and  $W^1$ . It is thus not possible to compute this index, but an upper limit is the Laspeyres index,<sup>6</sup>

$$I_L(\mathbf{P}^1, \mathbf{P}^2) = \frac{\mu_L(\mathbf{Q}^1 | \mathbf{P}^2)}{\mu_L(\mathbf{Q}^1 | \mathbf{P}^1)}; \quad (9)$$

Introducing three tax parameters in eq. (6) - a flat rate capital tax  $\tau$  and a real estate tax  $\tau_h$  proportional to a tax assessed value, obtained as the product of the tax parameter  $\beta$  and the market value of the property – and time period top scripts, we can write the numerator of index (9) as follows,

$$\mu_L(\mathbf{Q}^1 | \mathbf{P}^2) = \mathbf{p}^2 \mathbf{q}^1 + p_m^2 q_m^1 + p_r^2 q_r^1 + p_h^2 (q_h^1 - (1 - \delta)(q_h^0 + \lambda q_m^1)) + r_M^2 (1 - \tau^2) p_h^1 \tilde{M}^1 + \tau_h^2 \beta^2 p_h^2 q_h^1; \quad (10)$$

and analogously for  $\mu_L(\mathbf{Q}^1 | \mathbf{P}^1)$ . This index applies to a single consumer. Using the conventional so called plutocratic index it can be shown that the numerator of the Lapeyres index for the whole population of consumers can be written<sup>7</sup>,

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<sup>6</sup> This property of the Laspeyres index holds if the utility function is separable or if the ideal index is a conditional index.

$$\begin{aligned}
\sum_i \mu_{Li}(\mathbf{Q}^1 | \mathbf{P}^2) = & \sum_j \frac{p_j^2}{p_j^1} \sum_i p_j^1 q_{ji}^1 + \frac{p_m^2}{p_m^1} \sum_i p_m^1 q_{mi}^1 + \frac{p_r^2}{p_r^1} \sum_i p_r^1 q_{ri}^1 + \frac{p_h^2}{p_h^1} \sum_i p_h^1 (q_{hi}^1 - (1 - \delta)(q_{hi}^0 + \lambda q_{mi}^1)) + \\
& \frac{r_M^2 (1 - \tau^2)}{r_M^1 (1 - \tau^1)} \frac{p_h^2}{p_h^1} \sum_i r_M^1 (1 - \tau^1) M_i^1 + \frac{\tau_h^2 \beta^2 p_h^2}{\tau_h^1 \beta^1 p_h^1} \sum_i \tau_h^1 \beta^1 p_h^1 q_{hi}^1
\end{aligned} \tag{11}$$

where  $i$  is the summation script for consumers and  $j$  the summation script for non-housing commodities. The first term corresponds to a price index for non-housing commodities, the second to an index for maintenance and repair, the third to an index for rented dwellings, the fourth to an index for investments in new housing, the fifth represents interest payments on mortgages and the last captures the real estate tax. Note that investments in new housing can either be done by buying a new house or by repairing and improving an already existing house. But also note that the market value of houses which exist in both periods will cancel out in the weight sum of the fourth index component. This weight sum will just be the sum of the market values of new built houses less the values of demolished houses.

The index component for interest payments has a price relative which depends on the interest rate, the tax rate and the market price of owned dwellings. If it is not consistent with the purpose of the index to allow for changes in the tax rates one can condition on a certain value of the tax parameter, for instance the value of the base period. The tax parameter then drops out of the price relative, while the weight still is the sum of all interest paid after tax. The market price of owned dwellings comes into the price relative from the assumption that utility is a function of the mortgage share. Increases (decreases) in the market price will *ceteris paribus* decrease (increase) the mortgage share and increase (decrease) utility. The consumer will then in general adjust to this change in market prices, for instance by increasing the mortgage and/or increasing the consumption of other

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<sup>7</sup> See Klevmarken (2009), section 5.

commodities. However, if the change in market price is perceived as temporary, the consumer might not adjust at all. It might be more realistic to assume that the consumer reacts to a more stable long-run trend in real estate prices. The mortgage share should then be defined as the ratio of all mortgages to a weighted mean of past and current prices of the property owned<sup>8</sup>. It then follows that the real estate price ratio in the second last term of eq. (11) is replaced by a ratio of weighted means. The implication is that changes in the market price will not have such a large immediate impact on this index component, and the impact is thus delayed. (See further the discussion of this issue in section 6.)

#### 4. The current Swedish CPI

The history of a Swedish cost-of-living index dates back to 1912, while a monthly consumer price index as we know it today was first computed in 1954.<sup>9</sup> At this time a distinction was made between a short term and a long term index. The index was a monthly chain index, but the weights were kept constant throughout a year (short term index) and only changed in the beginning of January. When the new weights were available at the end of a year the index for the past year was recomputed using this new information. This so called long term index was then used to link the CPI to the next year. In 2005 a new chain index construction was introduced with full year-to-year index links according to the superlative Walsh index formula and Laspeyres year-to-month links.

The theoretical basis of the Swedish CPI is the economic theory for a true cost-of-living index. The CPI is used for many purposes, but the government has decided that computation of the compensation which consumers need to maintain their standard of living when prices change, should be the primary target for the Swedish CPI. This implies that the CPI is used to adjust pensions, social allowances and other income transfers to households from the public sector. It is, however, also

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<sup>8</sup> In practice it might be difficult to know the market price of one's own property if it has not been put on the market. The consumer is then assumed to make an estimate based on the information he can obtain from the market for similar properties.

<sup>9</sup> Statistics Sweden (2001). In the 1930s the so called Myrdal-Bouvin index was computed to cover the period 1830-1914.

used as a target by the Swedish Central bank, although the bank uses alternative indices as well which better serve the purposes of monetary policy.

Housing represents almost 30 percent of the total weight of the CPI. About half of that comprise rented apartments and condominiums and the other half consists of owner-occupied houses. The subindex for rented apartments is relatively uncomplicated. It is based on a questionnaire to landlords covering a relatively large sample of dwellings. Because heating costs, hot and cold water, citygas etc. are typically included in the rent in Sweden, the rental subindex includes these items, while electricity for non-heating purposes is not included, but covered separately. There is no subindex for condominiums, but the price changes of these services are represented by the index for rented apartments.<sup>10</sup>

The design of the subindex for owner-occupied housing (mostly single family houses) originates back to a commission appointed in 1955 to review the principles used to compute the housing subindex. Since then the computations have been adjusted a few times. One might say that Statistics Sweden today uses a modified user-cost approach for owner-occupied housing, however the current model is not theoretically derived from a user-cost model. The following items are included: mortgage interest, depreciation (maintenance and repair), property tax, site lease fees, heating from different sources, electricity, water and sewage and insurance. The subindex which is most interesting to us is that for mortgage interest. It is computed as a product of two separate indices, an interest rate index and a capital stock index.

The interest rate index weighs together changes in rates for mortgages of varying length issued by banks and mortgage institutes. For contracts with a fixed rate for a given period the average rate estimate is a moving average of past and present rates that apply to this kind of contract. For

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<sup>10</sup> Considering that there has been rent control in Sweden since World War II, while the market for condominiums is free and that prices of condominiums has increased about as much as prices of detached houses, at least in the big cities, it is not an ideal solution to allow the subindex for rented apartments to represent the price change in housing services from condominiums. See the comment at the end of the paper.



instance, for mortgages which have a fixed rate for five years, all five years fixed rates in the past 60 months are averaged. Past changes in interest rates will thus influence current inflation.

The capital stock index does not measure changes in the current market value of the stock of owner-occupied dwellings, but rather changes in the purchase values as of the time of purchase. A house that does not change owner contributes the same value to the numerator and denominator of the index, this value is the price at which the house was sold when it last changed owner. A house that was sold in the index period contributes its new price to the numerator and its old price to the denominator. The old price might then date many years back. New built houses enter the numerator with the purchase price and the same price, deflated to the base period by a price index for newly built single-family houses, is used in the denominator.

The logic behind the treatment of interest in combination with the capital stock in this index construct is not straight forward. The background is the following. The 1952 index committee suggested that one should only include interest on borrowed capital. The National Board of Health and Welfare wanted to include interest on both borrowed and own capital at current market values. The 1955 commission accepted that interest should apply to both borrowed and own capital, but did not want to use the current market values. The commission criticized the National Board of Health and Welfare (Chapter IV, section 2b)<sup>11</sup>: “In our view the less convincing arguments of The National Board of Health and Welfare become very clear in their treatment of the cost of interest. That increasing real estate prices through a computed increase in the wealth of house owners would give them increased interest costs and also increased costs of living is in our view an untenable interpretation of the concepts of cost and expenditure in the index context.” The commission instead suggested that the cost of depreciation as well as the cost of interest should be computed against the market value of the house at the time when the present owner once bought his house. The commission also added (Chapter VI, section 2c): “If the cost of building a new house increases, the

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<sup>11</sup> Translated by the authors

costs of depreciation and interest increases for those who build new homes. These changes should influence index. The same is true for the share of owned homes which change owners in a year.”

After the 1955 commission Statistics Sweden has computed a capital stock index from historical transaction prices. The construction of this index thus implies that an increase in the market value of a house that does not change owner does not contribute to increase the capital stock index, while a house which does change owner contributes the price change during the whole period the seller owned the house. The result is that changes in the market price of owner-occupied houses are smoothed and that historical movements in the price will influence the current index link. Another implication is that changes in the turn-over of the housing market will influence the price index. There is no distinction between borrowed and own capital. The index aims at capturing both interest paid and foregone. The weight thus covers both borrowed and own capital, but valued at historical transaction prices.

The treatment of depreciation and maintenance and repair in the current CPI also needs a comment. The weight of the depreciation index is obtained from the assumption that 1.4 percent of the total market value of an owner-occupied home, excluding the land value, is depreciated each year. The price component includes price measures of goods and services used to maintain and repair a house. In addition to the depreciation index there is a subindex for minor maintenance and repair commodities only covering material.

#### 5. Choice of price measures and weight data

We now return to the implementation of Klevmarken’s index. The differences between this index and the current Swedish CPI are found in the treatment of housing, in particular in the index for owner-occupied housing. We thus compute all non-housing items exactly as in the CPI. This also means that we have followed the CPI design used in each period. The computations have been done as if Klevmarken’s approach had been used for the CPI.

The CPI subindex for rent and the corresponding weight were used to compute Klevmarken's index.

We also used CPI data for electricity, heating, citygas to multifamily buildings, water and sewage, and insurance of single family housing.

Table 1 explains the price measures and weights used for owner-occupied housing. Please note that the weight for interest is after tax deductions, while changes in the capital tax do not influence the interest rate subindex. We thus condition on the base year tax rate. In the calculations of the subindex for the real estate tax we follow the current CPI practice and allow changes in the tax rate as well as changes in the tax assessed values to influence both the index and the weight.

Table 1. Price measures and weights used in the implementation of the subindex for owner-occupied housing in Klevmarken's index.

<b>Subindex</b>	<b>Price measures</b>	<b>Weight</b>
Repair	The same price measures for maintenance and repair, goods and services, as in the CPI	The weight is the sum of all expenditures for maintenance and repair. This sum is estimated using HEK and the NA.
New construction of single family housing	The construction price index (BPI) for group built single family houses. The last two years forwarded by the factor price index for group built single family houses.	The weight should be the total market value at the end of the base year of new built houses less the total market value of houses demolished during the base year. The number of demolished single family houses is very small and the total market value is put to zero. The weight is thus the total market value

		of new built houses as obtained from NA
Interest	Price index for interest rates used in the CPI	The total of all interest paid on mortgages after tax deduction.  Source: Housing, construction and building at Statistics Sweden
Real estate price	Real estate price index for single family houses which includes all houses transacted in a year and estimates the price changes of the existing stock of one- and two-dwelling buildings.	See interest
Real estate tax	Real estate tax paid in the base and comparison periods computed for the base period population of house owners by the tax-benefit microsimulation model FASIT	Total real estate taxes paid in the base period by private households
<p>Note: HEK is a sample survey of household finances using both survey and register data.</p> <p>NA is the national accounts. FASIT is a static tax-benefit microsimulation model run by Statistics Sweden.</p>		

We can now summarize the main differences between the current CPI and the index suggested by Klevmarken. The subindex for investments in new housing has no correspondence in the CPI.

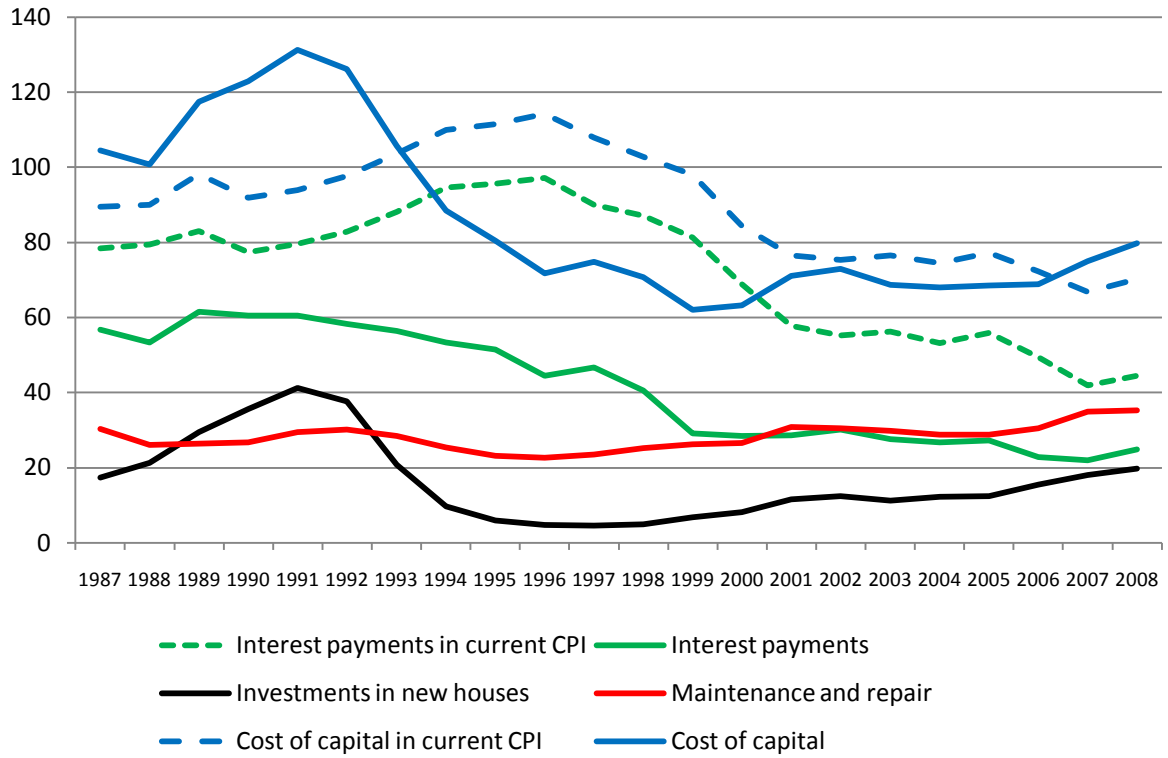
However, the CPI has an item called depreciation where the weight is based on an assumed rate of depreciation, and the price relatives come from goods and services used in maintenance and repair.

Depreciation is a theoretical concept used to capture the wear and tear of the housing stock, but it is not part of the reality of a house owner and thus difficult to measure. The model used in Klevmarken (2009) includes depreciation, it is implicitly part of the item for investment in new housing, but as noted above it is netted out in the aggregation and no specific measure of depreciation is needed. Klevmarken's index rather includes a straight forward subindex of goods and services for maintenance and repair.

The most important difference is found in the subindex for interest. Both the price component and the weight differ. The weight becomes much smaller in Klevmarken's index because it only covers interest paid on borrowed capital after tax deduction, while in the CPI interest is computed for both borrowed and own capital, and without tax deduction. While the interest index is identical, the way changes in real estate prices are accounted for is quite different. As explained above the CPI uses historical purchase values which results in a smoother index compared to the price changes in the market. In Klevmarken's index changes in current market prices determine the price relatives. (See though the discussion of alternative ways of formulating Klevmarken's model at the end of Section 3 and below in Section 6.)

Figure 1 displays the evolution of the weights for the period 1987-2008 in Klevmarken's index and in the CPI. The black curve represents the weight for investments in new houses. After the boom in the beginning of the 1990s and the following recession we see a gradual recovery. The red curve shows the expenditure share for maintenance and repair. The green curve the share for interest payments, the dashed green curve shows the corresponding weight in the CPI. As already noted this weight is much larger. The blue curve represents the weights for the cost of capital in Klevmarken's index. The corresponding curve from the CPI (depreciation, maintenance and repair, and interest) is the dashed blue curve. Both curves show declining trends, primarily a result of declining interest rates. The short term movements are, however, quite different.

Figure 1. Relative weights of the cost of capital and its components 1987-2008 (per mille)



## 6. Alternative ways to model the cost of borrowed capital

Assumption (2) that the consumer's utility depends on his current mortgage share, implies that the consumer will adjust immediately even to temporary changes in the market price of his property. It might be more realistic to assume that the consumer only adjusts to what he perceives as more permanent price changes. Suppose, for instance, that the consumer relates his mortgage to the average of the property prices from the last two periods, i.e.

$$g_M(M) = \frac{M}{(p_h q_h + p_h^{-1} q_h^{-1})/2} = \tilde{M}; \quad (12)$$

The implication is that the second last term of expression (11) becomes,

$$\frac{r_M^2(1-\tau^2) \frac{p_h^2 p_h^1 q_h^1 + p_h^1 p_h^0 q_h^0}{p_h^1 q_h^1 + p_h^0 q_h^0}}{r_M^1(1-\tau^1)} r_M^1(1-\tau^1) M^1. \quad (13)$$

The real estate price now enters as a Laspeyres index of current and past price changes. It is obviously possible to generalize the two expressions above to an arbitrary number of past periods. The issue is, how many? A possible answer is that the consumer tends to smooth prices over a business cycle. To illustrate the sensitivity of our results to the choice of period length, we have chosen to compute indices for periods of both five and ten years.

Our basic assumption (2) as well as assumption (12) and its generalizations imply that an increase in the real estate prices will *ceteris paribus* decrease the mortgage share of house owners with mortgages, and thus also increase their utility. At least some consumers will adjust by increasing their mortgages and in this way liquidize their increased wealth. They will then also have to pay more in interest. However, even if they increase their expenditures for interest, they are certainly better off than before the increase in real estate prices. If one focuses on the compensation uses of the price index, one could argue that a price increase that increases utility should not be compensated, and it should thus not increase our price index. However, consumers who are not house owners, will not experience any utility increase, on the contrary those who are to invest in property will lose in utility because they find this property more expensive and they might chose to take a larger mortgage than they would otherwise have done. There will also be house owners who are about to invest further in property and they may or may not gain in utility from an increase in real estate prices. If we take the compensation issue seriously, we thus find that we should not allow an increase (decrease) in real estate prices to influence the subindex for cost of capital for house owners who are not to make new

investments, while it should for the share of consumers who are to invest in property in the period. In practice it might become difficult to distinguish these groups of consumers. However, if we use a Laspeyres approximation those who do not have any mortgage will not contribute to the subindex for cost of capital, because in a Laspeyres index the weight is proportional to the base period mortgage. In this case the issue then becomes how one can distinguish between those mortgage holders who get a net gain in utility and those who get a net loss.

The compensation issue is primarily a policy issue for the index provider and not a theoretical problem. To illustrate the numerical consequences of focusing on the compensation uses of the price index we have computed an alternative which conditions on the base period real estate price in the sub index for cost of borrowed capital. The change in the real estate price then drops out of this subindex (c f the second last term of expression (11)), and it becomes a simple interest rate index.

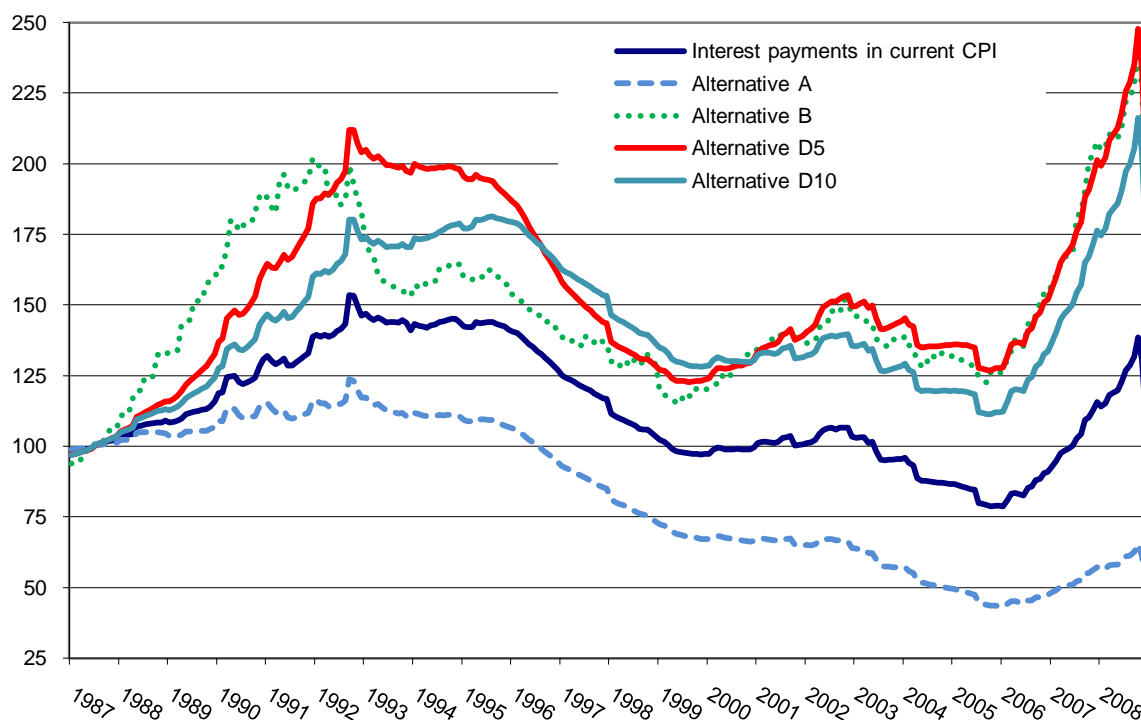
We now have four alternative ways to implement a subindex for the cost of capital: Alternative A conditions on the base period real estate price and is a simple interest rate index, B is our basic model alternative in which the interest index is multiplied with an index for the change in the real estate prices between the base and comparison periods, and D5 and D10 which are similar to B but assume that the consumer bases its decisions on a trend in the real estate prices rather than on the current changes. D5 has a price index of real estate prices based on the last five years of price information, while D10 uses the last 10 years. For the period 1987-2008 Figure 2 displays these four alternatives as well as the corresponding subindex in the current CPI.

Not unexpectedly we find that alternative A distinguishes itself from the other alternatives as it only depends on changes in the interest rates, a trend wise decline. The three alternatives including a property price index all group together in a much higher index path reflecting the general increase in real estate prices. But they differ in their short term behavior. The longer moving average used in the real estate price index, the smoother subindex we get. The current CPI subindex lies in between A and the other alternatives, in this case the rapid increases in real estate prices at the end of the



period are weighted down in favor of historical price changes. The currently used index can be seen as an index with a moving average that extends even longer than in alternative D10.

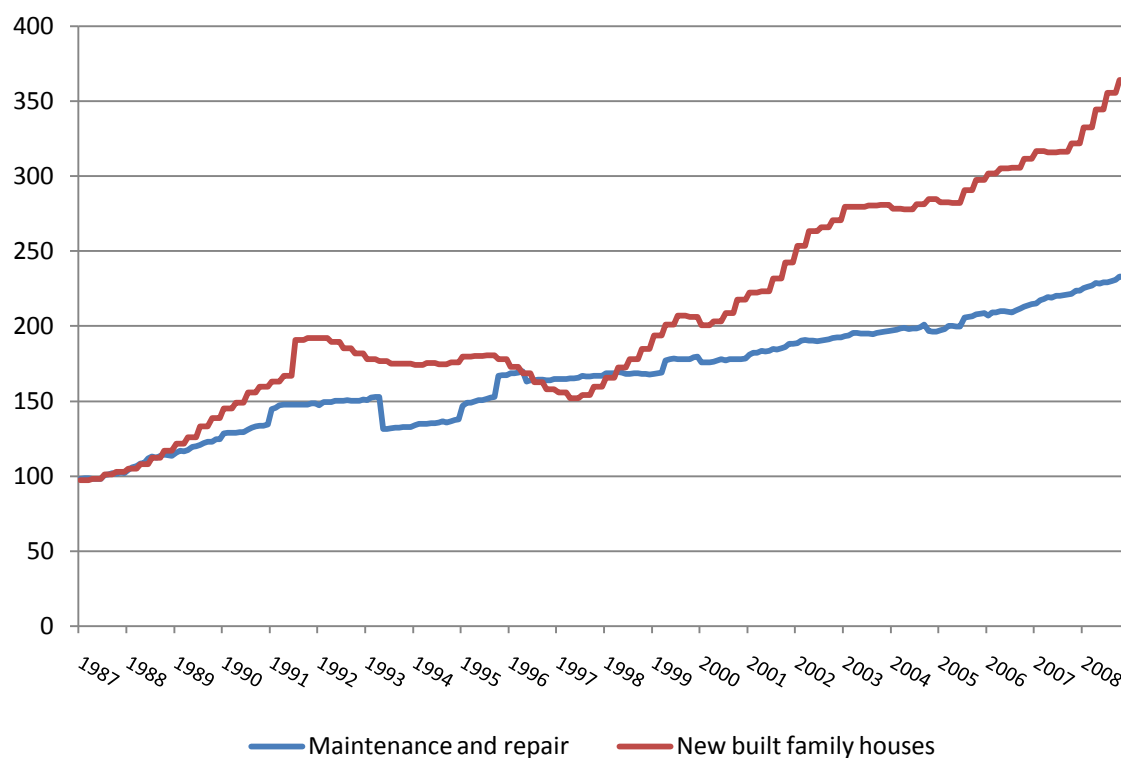
**Figure 2. Alternative subindices for the cost of borrowed capital.**



## 7. Comparison of alternative indices

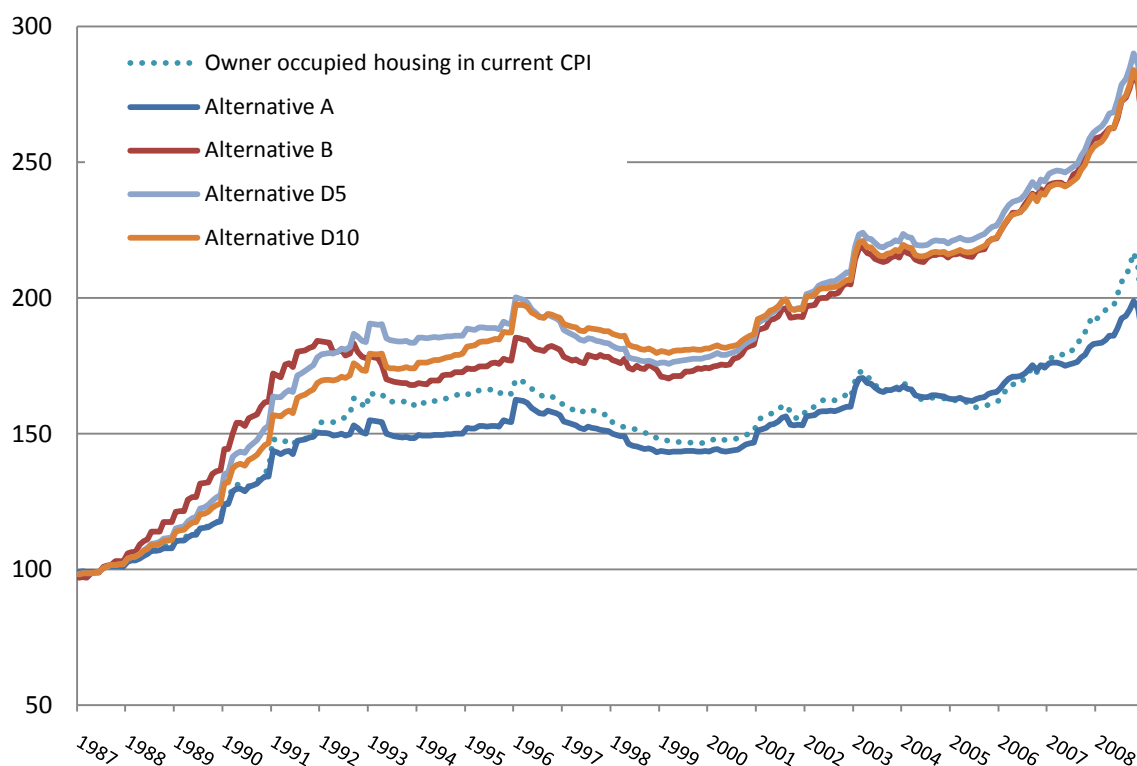
Figure 3 shows the path for two subindices which have no direct correspondence in the current CPI, the price index for new built single family houses and the price index for maintenance and repair. The former index traces the strong increase in real estate prices, in particular in the second half of the period, while the index for the goods and services used in maintenance and repair show a less volatile path and a more modest increase.

Figure 3. Sub-indices for new built single family houses and for maintenance and repair



If we now weight and aggregate all subindices that go into the price index for the services of owner occupied single family houses, we get the results displayed in Figure 4. The current CPI component and alternative A are now very close. The explanation is that the subindices for new built houses and property taxes drive alternative A closer to the currently used index. They still show a more modest increase compared to alternatives B, D5 and D10.

Figure 4. Alternative indices for the price of the services from an owner occupied home 1987-2008



We can also compare the alternatives at the level of total CPI. The results are displayed in Figure 5 and Table 2. All alternatives are now much closer as all commodities but owner occupied homes are identical. There is still, however, a clear difference between the current CPI and alternative A on one side and B, D5 and D10 on the other. The latter increased by almost ten percentage units more than the current CPI and alternative A from 1987 to 2008. Table 2 also gives the corresponding estimates of the average annual rate of inflation and its standard deviation. The current CPI and alternative A had a mean inflation rate of 2.9 percent while alternatives B, D5 and D10 had a rate of about 3.1. The standard deviation is about 3 in all cases. Alternative A comes out as the least volatile alternative as it is least dependent on volatile real estate prices.

Figure 5. Alternative consumer price indices 1987-2008, base year 1987=100

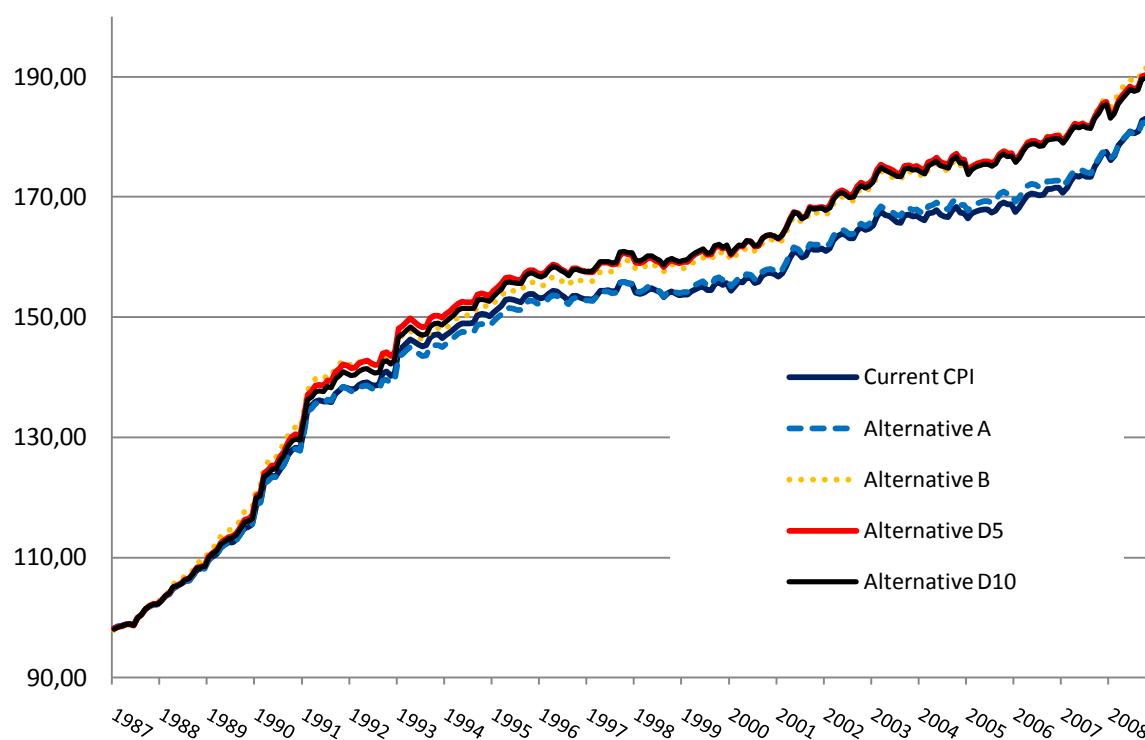


Table 2. Inflation rates and corresponding standard errors from alternative consumer price indices (%)

<i>Statistic</i>	<i>Current CPI</i>	<i>Alternative A</i>	<i>Alternative B</i>	<i>Alternative D5</i>	<i>Alternative D10</i>
<i>Mean</i>	2.88	2.88	3.11	3.08	3.07
<i>Std.</i>	2.94	2.86	3.05	3.09	2.99
<i>Index Dec. 2008 (1987=100)</i>	179.1	179.8	188.5	187.4	186.9

## 8. Conclusions

Even if the average differences between the alternative indices we have analyzed might appear small at the level of a total CPI, annual deviations are certainly large enough to become important both for compensation purposes and in the financial markets. We thus need criteria to choose between these alternatives. All can be accommodated within the model structure we have chosen, so the problem is not theoretical, but rather one related to the uses of the CPI index.

It is interesting to note that the currently used CPI is so close to alternative A. The current index formula can be seen as an attempt by Statistics Sweden to meet the criticism of an index that gives compensation to consumers that become wealthier from increased real estate prices, but at the same time recognize that increasing real estate prices will eventually drive people to increase their mortgages and interest payments. We introduced alternative A just to avoid compensating consumers who increased their housing wealth. If the index provider decides to focus on the compensation uses of the CPI one should choose alternative A or an alternative which is close to A. As discussed above, all home owners might not get a net gain in utility from an increase in the real estate prices.

However, if the compensation issues are considered less important, and one wants an index that approximates a true cost-of-living index, one of the alternatives B, D5 or D10 should be preferred. For long-term price comparisons it does not seem to matter much which of these alternatives is chosen, but in short-term comparisons it becomes important how much one smoothes the influence of variations in real estate prices. We have argued that consumers do not necessarily react immediately to price changes in the real estate market, but try to estimate what they think will become more permanent changes in the price level. This justifies some smoothing, but hardly a time span as long as a decade. The preferred choice should then be an index close to D5.

The theoretical discussion above and the numerical illustrations have focused on owner occupied housing. In principle one can treat the price of services from condominiums and related forms of housing in the same way. If data are available one can also extend the analysis to cover major durables, and treat them as durables rather than non-durables as in the current CPI practice.

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