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Measuring the Price of Housing Consumption for Owners in the CPI

Abstract:
Measuring change in the price of housing is an important and notoriously difficult task for national statistical agencies. Different approaches have been attempted, but suffer from known weaknesses. This article suggests dividing housing outlays into consumption and saving. The changes in prices of the consumption component are governed primarily by the purchasing price and the interest rate, and lead us to the construction of a consumption cost index. We show that over the lifespan of the mortgage, under some general assumptions, the price changes most relevant for inflation measurement can be obtained from a housing price index. The main challenge lies in computing weights for the housing consumption index. We demonstrate how this can be done in practice. An empirical example using data from Norway shows that over the 12-month period from June 2003 to June 2004 the official inflation was measured at 1.3%. This did not properly account for a 10.2% increase in house prices. The methodology proposed in this paper estimates the 12-month inflation at 3.4%.

Keywords: asset price inflation, consumer price index, consumption cost, housing prices, inflation measurement, mortgage, rental equivalence, user cost

JEL classification: D1, E3, E5

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1. Introduction

Failing to properly account for changes in the prices of housing services for owner occupied (self-owned) homes in measures of inflation has a number of important economic consequences. First, it can lead to incorrect computations of real income and real interest rates, which economic agents rely upon in their planning. Second, if central banks respond to changes in housing prices that are not part of a formal inflation measure, rule-based monetary policies, such as inflation targeting, may be less effective (Kydland and Prescott (1977)). Finally, it will lead to incorrect measures of the historical development of deflated material standards of living.

This paper proposes a novel method to incorporate the prices of housing services for self-owners into the CPI. Our approach reconciles economic theory and statistical practice. We begin with the plausible notion that economic agents include the price of housing services from self-owned houses into their decision-making process. The impact of including these prices is illustrated using data from Norway. For the period June 2003-June 2004, the official Norwegian CPI shows inflation of 1.3 percent. However, if the CPI is calculated using the methodology proposed in this paper, inflation was in fact 3.4 percent.

We focus on the distinction between consumption and savings in the purchase of self-owned homes. Payments on principal change a household's net equity and are treated as saving. Interest payments do not change a household's net equity and so should be thought of as consumption. Computing the price of this *consumption* is non-trivial because it typically consists of a flow of future prices. This is due to the fact that houses are durables and therefore own-equity financed house purchases involve the opportunity cost of foregone future interest from alternative positions and mortgage-financed house purchases require interest payments in the future. Following Pollak's (1998) advice, we examine the link between the *theoretical* entity "price for housing services for self-owners" which is well identified in consumer theory, and its *empirical* counterpart that ought to be included in a measure of consumer prices.

The question of how to measure the price of housing services for self-owners has a long history. Different ways of answering this question has yielded a patchwork of different measures, with little consensus as to which is most appropriate. For example, the inflation measure employed by the Federal Reserve includes prices of housing services for owners while the Harmonized Index employed by the European Central Bank does not. Alternatively, why consider a single price rather than a vector

of prices? In 2004 the Bank of England increased interest rates when inflation was below its stated target. This may be partially attributable to the rapid rise in prices in the housing market. Implicitly, the Bank of England incorporated house prices into their inflation outlook. Clearly, the role played by housing in measuring inflation needs to be clarified.

Should the prices of housing services for self-owners even be included in the Consumer Price Index (CPI)? One approach is simply to treat houses as assets and exclude them on these grounds. There is an on-going debate as to whether or not asset prices should be included in inflation measurement; see e.g. Goodhart (2001); Bryan, Cecchetti, and Sullivan (2002); and Bean (2004). However, while houses are assets, they also deliver consumption streams to households, and the price of this consumption stream must be included in any measure of consumption prices. Many of the biases in the CPI are by now well known and their magnitudes have been established. We know that substitution, quality improvement, and novel goods contribute to an upward bias. The literature on these errors is excellently surveyed in Lebow and Rudd (2003). Despite the fact that the treatment of housing services is a well-accepted source of bias in the CPI, there have been surprisingly little research into this bias and relatively few attempts to rectify it.

One possible price is the capital cost associated with a purchase of the given durable. In the case of prices for housing services for self-owners, this seems especially appealing since many households, perhaps most, use mortgages to finance the purchase of housing services. However, as will be discussed below, estimating a price, i.e. the implicit capital cost associated with housing consumption, encounters several obstacles. These are not only connected to the durable nature of housing, and the bundle of consumption and saving, but also to the endogeneity of the tenure decision. In practice, due to exit and entry costs, the prices households face when they make their tenure choice, will depend upon previous tenure decisions. This is unfortunate from a CPI perspective since the index is intended to be a comparison between prices at different times. Any attempt to include prices for housing services from self-owned homes will face the confounding of current costs and inter-temporal tenure choices. In addition to some limiting cases, this article presents a solution that involves extending the temporal scope of the purchase decision.

This article stands at the intersection of three strands of the literature. First, there is the approach, which Diewert in ILO (2004) calls the economic approach to indices. This dates back to the work of Laspeyre and Paasche, and continues today with recent work on superlative indices. This literature revolves around conceptual exploration of an index number that is thought to represent many different

prices and many heterogeneous households in a way that preserves a given standard of living or, less ambitiously, the costs of purchasing a given basket of goods. Recent contributions include Abraham, Greenlees, and Moulton (1998); Boskin et al. (1996); Diewert (1998); Hausman (2003); Mankiw and Reis (2003); and Schultze (2003). Second, there is what Diewert calls the axiomatic approach to index number theory, which seeks to construct indices which satisfy certain desirable properties; see for example Crone, Nakamura, and Voith (2000); Gudnason (2003); and the overview in ILO (2004). A third strand of the literature, which motivates our discussion and illustrates the contribution of this paper, is the "Rules vs. Discretion" literature. Monetary theorists have focused attention on the importance of a price level target or a price change target; see e.g. Svensson (2003). These scholars have attempted to develop time-consistent goals for central banks that seek price stability and to develop an apparatus that monetary policy makers can employ to attain those goals. This inflation targeting approach presupposes the existence of something the other two traditions say cannot easily be constructed: a single number that summarizes many prices and the price experiences and expectations of millions of heterogeneous economic agents.

This paper makes three main contributions. First, we separate consumption from saving in the area of housing for self-owners, and focus on the prices of the former and leave out the returns to the latter. Second, we use this separation to derive a formula that under certain conditions imply that the proper index for the prices of self-owned housing services is simply a house price index and under other conditions an interest-rate-ratio-adjusted house price index. Third, we employ the fact that households commit to a long-term consumption plan and financial position, which is longer than the usual CPI consumption period, when they decide to own their home. This allows us to compute the relevant weight by looking at the mean budget share of housing consumption costs during the period.

We now turn our attention to an overview of techniques that are currently used to incorporate the price of housing services in the CPI. We point out the theoretical and practical shortcomings of these approaches. We then propose a consumption cost approach that follows the broad lines sketched above. Subsequently, we present examples of inflation computations that include a price index of housing services for self-owners, and compare these to the official CPI numbers. We discuss the tradeoffs between the benefits of gauge sensitivity and the costs of gauge volatility. The final section concludes, discusses topics of future research, and makes explicit the policy implications of our results.

2. Recent attempts at measuring prices of housing services in the CPI[1]

The durable nature of housing is one of the main challenges to incorporating the prices of housing services for self-owners into the CPI. Durability allows opportunities for capital gains and obscures the role of payments. With the exception of housing, National statistical agencies (NSA) typically attribute all the expenditure on durable goods to the period of the purchase. As a consequence, the transaction price for an ordinary good, e.g. the cost of acquisition, is treated as the full price of the service stream from that good. This leads to an intuitive rationale for the first method of including a price for housing services of self-owners into the CPI: *the acquisition approach.* The acquisition approach simply treats houses like any other good. NSAs compare the prices of purchased (self-owned) homes in the current period to the prices of purchased (self-owned) homes in the previous period. Thus, the sub-index in the CPI that captures the prices of housing services for self-owners is a House Price Index. Weights are computed by calculating the ratio of the average expenditures on home purchases to the sum of average consumption expenditures (on other goods) plus average expenditures on home purchases. The conceptual shortcoming of this approach is that it ignores the inter-temporal nature of a housing purchase, and attributes all expenditures to the period of purchase. Given that households enjoy consumption streams from a house over many periods, implicitly defining the duration of the consumption stream to be a single period seems implausible. From a practical perspective weights computed in this manner may be volatile. In a recession, the acquisition approach will entail large reductions in the weights, as households reduce their purchases of houses. However, this approach is conceptually simple and treats all goods symmetrically.

The *payments approach* measures actual cash outflows on items such as down payments, mortgage payments on principal, and mortgage interest payments. The payments approach has considerable intuitive appeal as it distinguishes between consumption behavior (e.g. interest payments) and saving behavior (e.g. payments on principal). It treats as consumption outlays that do not change own equity and treats as savings outlays that do. The major shortcoming to this approach is that the consumption of a self-owned and completely repaid house does not enter the weight computation because it does not generate an observable cash flow. As a consequence, households that consume services from re-paid self-owned houses are assumed to have zero housing consumption. The question of how to measure the price component is also problematic since agencies need to construct an index that includes variation in house prices and short-term interest rates. Moreover, a question of symmetry arises. Many goods are purchased on the basis of credit and are not treated as more expensive because

[1] ILO (2004) provides a more detailed overview of these methods.

of the additional interest costs. This inconsistency is exacerbated by the fact that many households use mortgages to finance other types of consumption.

The *user cost approach* computes the difference between the purchasing price and the selling price of a house, while accounting for the opportunity cost of capital and depreciation. One advantage of the user cost approach is that it recognizes the durability of housing and allows for the use of a purchased home over multiple periods. The calculation of the net user cost will depend on discount factors and foregone capital gains in other financial markets. A major conceptual difficulty is that user cost may become negative if house price appreciation leads to a higher selling than purchasing price. This admits the peculiar possibility that, while *all* prices in an economy are *increasing*, the CPI could *decrease* due to negative user cost of housing. In essence, the user cost approach confounds consumption prices with returns to equity by treating capital gains as a change in price of consumption rather than a change in wealth or savings.

The fourth approach sidesteps many of the difficulties described above. The basic idea behind the *rental equivalence approach* is that the rental market can be used to infer the price of housing consumption in the owner's market. House ownership and house rentals are assumed to be close substitutes and in the long run should yield comparable prices. There are a number of theoretical and practical objections to the rental equivalence approach. For reasons that are not well understood, the P/E-rate – ratio of dwelling price to annual rent – has varied considerably over time. For our purposes, it is sufficient to notice that this relationship is volatile, and that the computation of the CPI is sensitive in the short run to a choice between using growth in the numerator or denominator in the P/E-rate as a sub-price index. From a central bank's perspective, a volatile P/E-rate may make the equivalence principle ill suited for inflation measurement.[2] Indeed, owning and renting may not be perfect substitutes if the attributes of housing services (including options and liabilities) from a self-owned house are different from the attributes of housing services from a rented house. Moreover, in practice, rental houses and apartments are quite different from owned houses and apartments. Rented

[2] To see why, recall that when monetary policy is especially accommodative, it is likely that monetary stimuli lead to higher prices for houses. If -- in addition -- this economic stimulation does not lead to higher prices for renting, then the rental equivalence approach may lead to serious measurement bias. When credit is easy and money cheap, then consumers in increasing numbers, and with increasing willingness, enter owner's markets with credit. But owner entry is renter exit, and rents fall when renting demand falls. When, in addition, low capital costs entice landlords to lower their rents to attract agents among the diminishing line of renters, and low costs entice new investors to become new landlords, there occurs a substantial downward pressure on rents. Paradoxically, then, under inflation targeting central banks may find themselves easing credit in order to increase inflation, but observe that the actions taken make a large component of inflation -- the rental price sub-index -- actually decrease.

objects are often smaller and found in urban centers, so rental prices involve out-of-sample predictions when they are used to predict rent equivalents from larger, rural self-owned homes[3].

In the next section, we propose a fifth approach for including housing in the CPI, the consumption cost approach, which resolves many of the issues described above.

3. The Consumption Cost Approach

The key conceptual difficulty is that houses are durable goods that simultaneously provide both housing services in the form of shelter and serve as a vehicle for saving. Durability can lead to both depreciation and capital gains. While depreciation can be treated as consumption, capital gains should be thought of as saving since they change a household's equity. In a similar vein, a payment of principal results in a change in equity and ought be classified as saving whereas payments of interest do not change equity and are better classified as consumption. In other words, financial costs may be considered *as* consumption while payments on principal and house appreciation are treated as saving. From a CPI point of view the relevant measure is the cost of housing *consumption*.

Dividing housing outlays into consumption and savings, may appear intractable. However, from a theoretical perspective, the distinction is fairly straightforward and will be illustrated in several stylized examples below.

3.1 Mortgage based self-owned housing

A household H needs to decide upon its housing consumption over the time interval [t, t+1], at time t. It considers two options, purchasing a house at a price A_t (for acquisition price) or renting one for a price B_t, which is defined as the rental price for the time interval [t, t+1]. In the latter case, the housing consumption, C_t, is simply B_t. In the acquisition case, there exist several ways to proceed, as discussed in the previous section. Total outlay TO_t can be written:[4]

(1) $$TO_t = r_{mt} A_t - (A_{t+1} - A_t),$$

[3] The cost of self-owned housing consumption relative to rents may change over time for a number of reasons. Tax-changes that treat tenures differently are expected to change the P/E-rate permanently. In this article, we do not address possible tax related complications, hence we implicitly assume that tax regimes stay fixed from one period to another and may give a level contribution to consumer prices, but -- if accounted for -- permanent level contributions that cancel out when practitioners calculate the index, which in essence is a *ratio* of price levels.

[4] We ignore house depreciation, and other potential current costs apart from capital costs. Note however that physical wear and tear and maintenance could be made explicit by subtracting the outlays from the sales price A_{t+1} .

where r_{mt} is the mortgage interest rate. The first term, e.g. the interest payment $r_{mt} A_t$, is the cost of capital needed to purchase and keep the dwelling, excluding all transaction costs. The second term is the return on the housing investment $(A_{t+1} - A_t) = r_{ht}A_t$, where $r_{ht}=(A_{t+1} - A_t)/ A_t$.

Observe that in this simple model, saving is a function of house appreciation (or depreciation), which in turn gives rise to changes in net equity. Mortgage interest payments do not result in changes in equity. Thus, to remain consistent with our distinction between savings-based equity changes and current costs of consumption, we would define housing consumption as $C_t = r_t A_t$.

3.2 General case: Equity and mortgage based self-owned housing

Let us consider a simple extension of the model described in 3.1. Another household H_2 faces the same options, but possesses positive equity. Let E_t denote the part of the net equity it may decide to use on the housing investment, i.e. $E_t \leq A_t$ if it purchases a house. As noted above, housing consumption in the case of rental is straightforward. Let us examine the acquisition case. The household considers the opportunity cost of capital E_t, $r_{ts}E$, where r_{ts} is the return on a secure asset, government bond or the deposit interest rate.[5] This amounts to setting the current costs of self-owned housing consumption, C_t, equal to $r_{ts}E_t + r_{tm}(A_t - E_t)$ or:

(2) $$C_t = A_t(v_t\, r_{ts} + r_{tm}(1 - v_t)),$$

where $v_t = E_t/A_t$ is the ratio of own equity to the purchasing value. This can be simplified by introducing $d_t = r_{tm} - r_{ts}$ and rewritten:

(3) $$C_t = A_t(r_{tm} - d_t v_t).$$

3.3 The current cost housing index for self-owned housing consumption

In the simplest case of entirely mortgage financed self-owned housing consumption (e.g. when own equity is zero, E=0), the current cost index I_{cc} , which compares current costs at t+1 with current costs at t, is given by the expression in equation (4), which is a valid price index when the quantity and attributes are identical in the two periods:

[5] Note that one option would be to use stock market returns as the opportunity cost of capital. However, these returns are associated with investment risk. Since higher return are thought to be associated with higher risk, using stock market returns would force us conclude that that housing consumption is conditional upon risk premia in other asset markets, which seems implausible.

(4) $I_{cc} = r_{(t+1)m} A_{t+1} / r_{tm} A_t,$

in which A_{t+1} and A_t are interpreted as house price indices at times t+1 and t, to save notation. If the mortgage interest rate is unchanged, i. e. $r_{t+1} = r_t$, the current cost index simplifies to the house price index. The index in the general case is given by taking the corresponding fraction and interpreting A_{t+1} and A_t as house price indexes. The cost ratio becomes a price index when the quantities and attributes are identical in the two periods:

(5) $I_{cc} = C_{t+1}/C_t = (A_{(t+1)}(r_{(t+1)m} - d_{t+1}v_{t+1}))/ (A_t(r_{tm} - d_tv_t)) = I_{hp} (r_{(t+1)m} - d_{t+1}v_{t+1})/ (r_{tm} - d_tv_t),$

where $I_{hp} = A_{t+1} / A_t$ is a house price index. In the case where r_t, d_t, and v_t are unchanged over time, the current cost index again reduces to the house price index. However, in general r_t, d_t, and v_t are likely to change. It should be emphasized that at time t+1, all of the relevant variables can be known and I_{cc} will be simple to compute.

In the important special case where houses appreciate as a result of a drop in interest rates, the actual current cost index will be a rescaled house price index; essentially by the factor $r_{(t+1)m}/ r_{tm}$. This mirrors the situation in which the purchase was financed exclusively by a mortgage (and own equity was zero), but with a correction factor depending on the non-mortgage fraction arising from E > 0.

Lower interest rates can have partially offsetting effects. Lower interest rates may lead to house price appreciation, and thus higher current cost of housing. Note that the effect is less than a house price index would suggest as lower interest rates also yield reduced current costs. However, if house price appreciation changes the ratio of equity-to-mortgage-based financing, this can amplify or mitigate the rate effect, depending on consumer response. To make this effect transparent, consider a first order Taylor expansion of equation (5) in d_tv_t/ r_{tm} which yields:

(6) $I_{cc} = I_{hp}(1 - d_{t+1}v_{t+1} + d_tv_t)= I_{hp} (1 + d(v_t - v_{t+1})),$

where the last equality results from the simplifying assumption $d_{t+1} = d_t = d$. In other words, in a case where the ratio of equity to mortgage in the financing of the home purchase, v_t, is diminishing, using the housing price index for current cost would understate current costs.

The current cost index described above may raise a number of theoretical concerns. First, the current cost is calculated by separating mortgage- and equity-based financing. Implicitly the price of housing becomes conditional on payment plans. This violates the general principle of measuring only market prices and suppressing potential credit costs in a price index. However, as long as NSAs compare two identical payment plans, the price ratio of two such plans can still serve as an index. Indeed, as long as such plans are obtained in a competitive financial market, the market price principle is not violated. Furthermore, it is not immediately obvious that the current cost of housing at a given time will be conditional on the fraction of equity to mortgage; more on this below.

Another concern for NSAs, is the possibility that the relevant interest rate is not a weighted average of mortgage and deposit interest rates, but the current cost of money given by the central bank interest rate, r_{cb}, or other interest rates. In the empirical examples in section 4, we investigate the sensitivity of weights to choice of interest rate.

Indeed, the weights described above may be volatile given that they depend upon relatively volatile short-term interest rates. For obvious reasons, NSAs find weight volatility problematic and central banks are concerned, for reasons of endogeneity, about incorporating short-term interest rates into inflation measures. To rectify this, we now proceed to develop a theory that incorporates long-term contracts and propose weights that employ long-term interest rates.

We now move from a simple model in which households buy and sell homes over a single period to a more realistic situation in which households enter into long-term contracts.[6] This suggests measuring the price of services extracted from a house purchased on the basis of a long-term contract with a bank or on the basis of a long-term financial position of own-equity. Analyzing this type of contract is necessarily more complex than the simple one period model described above. A key challenge is to infer plausibly the value of a contract that stipulates a vector of future payments.

3.4 Path dependence of tenure choice

The current cost method proposed in the previous subsection offers a consistent distinction between investment and consumption. The method is simple to implement as long as we are willing to suppress transaction costs and long-term considerations in contracts. Casual empiricism suggests that both of these can represent important costs of home ownership, especially in countries where transaction costs

[6] Notice, importantly, that public fees and other transaction costs make short-term planning horizons unrealistic and high frequent changes in dwelling attributes expensive.

on purchases (e.g. broker or government fees) are non trivial. House depreciation, normal wear and tear, must also be added to current costs. Transaction costs are likely to induce path dependence in the housing decision. In other words, a household that decides to extract housing consumption from a self-owned house in the time interval [t, t+1], knows that this decision is not independent of consumption decisions in the following period [t+1, t+2]. The decision to switch to or from a rental alternative can result in the household incurring transaction costs that may dwarf other current cost in the given time period.[7] This means that the prices a household faces at t+1 are a function of the household's consumption decision in the previous period. We now examine three different approaches to dealing with this problem.

3.4.1. Strict one period approach

The CPI is a weighted sum of prices of all goods consumed by households in a given time interval [t, t+1]. Under the strong assumption that prices of self-owned housing consumption depend on the present period exclusively, and that the path dependence of tenure is be suppressed, a strict one-period approach can be implemented by including *all* expenses associated with the acquisition and selling of the dwelling in the period. The cost in this case is:

$$C_t = (r_{mt} + r_{dt} + r_{at})A_t \,, \tag{7}$$

where r_{mt} is the mortgage interest rate, r_{dt} the depreciation rate and r_{at} is the rate of exit and entry cost defined by $r_{at} = EN_t/A_t$, in which EN_t is the sum of the entry cost at time t and exit cost at time t+1.

This yields an index in the strict one period approach as given by equation (8):

$$I_{cc} = (r_{m(t+1)} + r_{d(t+1)} + r_{a(t+1)})A_{t+1}/(r_{mt} + r_{dt} + r_{at})A_t, \tag{8}$$

for the simplest case in which a mortgage finances the entire purchase. Bear in mind that most NSAs insist that prices be collected and compared on monthly basis. For such short time frames the entry and exist costs may dominate other costs. The effect of entry and exist costs on (8) is less obvious. When

[7] Thus, a household that anticipates that its housing needs will change in the future may still decide to consume housing from only one object in the whole period. The reason for not tailoring current housing consumption to current needs lies in transaction costs. To see why, consider an example. Typically, changes in needs arise from changes in employment or family composition. A household that plans on increasing its size; for example a couple that plans to have children; some time into the future may decide to over-consume housing for a while in anticipation of its housing needs in the future. It does so because the alternative is too expensive due to the transaction costs in switching from owning one object to owning another one.

these costs change they will evidently influence the index. Over short time periods, any changes in interest rates will swamp the effects of other costs in the index, and make the resulting index volatile. Given that entry and exit costs induce households to take a long-term view of tenure, and that NSAs find volatile indices undesirable, we now propose a framework that incorporates a longer time horizon than is usual in CPI construction.

3.4.2. Housing consumption plan approach

We turn to a framework that explicitly accounts for the long run nature of housing decisions. Define the acquisition price as A and allow the simplifying assumption that the purchase is entirely mortgage financed. Mortgages can be thought of as forced savings plans combined with housing consumption payments. The terms of a mortgage are completely summarized by a series of payments on principal, $A_1, \ldots, A_k$ ($A_0 = 0$, by convention), and interest payments. By definition, the sum of $A_1, \ldots, A_k$ is equal to A. The interest rate r_t may vary over time or be fixed $r_t = r$. In essence, the household commits itself to a plan that consists of two components: a savings plan comprised of k payments on principal, $A_1, \ldots, A_k$, and a plan of k housing consumption (HC) payments $r_0A, r_1(A-A_1), \ldots, r_{k-1}(A-\Sigma_{i=1}^{k-1} A_i)$. The present value of the HC-plan at time of purchase is:

$$(9) \qquad \text{Present value of HC-plan} = \Sigma_{i=0}^{k-1} \delta^i r_i(A - \Sigma_{j=1}^{i} A_j),$$

where δ is a discount rate and subscripts i refer to periods. Because the acquisition price will vary over time, consider the purchase of the same dwelling at time t = 1, for a price of A'. This will result in a mortgage with different from A. This gives rise to another scheme of k saving entries, $A_1', \ldots, A_k'$, and k housing consumption payments, $r_1A', r_2(A'-A_1'), \ldots, r_k(A'- \Sigma_{i=1}^{k-1} A_i')$.[8] The ratio of the present values of these consumption payments is a plausible candidate for measuring price changes in the consumption of housing services in the CPI. A housing consumption price index (I_{hc}) can be written:

$$(10) \qquad I_{hc} = (\Sigma_{i=1}^{k} \delta^{i-1} r_i(A'-\Sigma_{j=1}^{i} A'_j)) / \Sigma_{i=0}^{k-1} \delta^i r_i(A-\Sigma_{j=0}^{i} A_j),$$

where the subscript of the interest rate in the numerator runs from 1 to k and the subscript of the interest rate in the denominator runs from 0 to k-1. If we assume fixed interest rates, and that the principal payment scheme is proportionally similar, then equation (10) reduces to:

[8] Notice that the variable interest rates now apply to different parts of the k payment entries.

(11) $I_{hc} = A'/A$

3.4.3 Limited Commitment approach

The two approaches discussed above are at opposite ends of the spectrum as they relate to the path dependence of tenure choice. A strict one period approach may appear academic as few households buy dwellings with a single period planning horizon. On the other hand, including all interest payments over the lifetime of a mortgage and calculating its present value entails a host of practical difficulties when it comes to incorporating the price sub-index into the overall CPI. The weight of own housing consumption in the overall CPI will depend on future values of the interest rate, which are unknown.

Thus, from a practical perspective one may want to consider a compromise approach. This Limited Commitment consumption cost method strikes a balance between 1-period and the k-period approach. NSAs can weigh the conflicting aims of shortening the time frame in order to comply with CPI conventions and lengthening the time frame in order to capture the inter-temporal nature of housing decisions and to reduce the importance of volatile interest rates and transaction costs. In practice, given that self-owners do tend move on average every 5 to 15 years, a limited period model seems plausible.

Using the notation of section 3.1, assume a household acquires a dwelling at time t. Let entry and exit costs (some function of the transaction price) be b_t and s_{t+n} (for costs associated with "buy" and "sell"), similar to the short-term versions defined in 3.4.1 above. These transaction costs are such that self-owned houses only yield higher inter-temporal utility (relative to say renting) if the dwelling is owned for a minimum of n periods. For simplicity, we assume that the household has perfect foresight and is rational. The household has no incentive for making another tenure choice for the n time periods in question. Under these assumptions, the natural choice of time period for evaluating costs is simply the n time periods in question. The costs consist of exit and entry costs, b_t and s_{t+n}, and interest payments on the mortgage over the n periods: r_tA_t, $r_{t+1}A_t$,… $r_{t+k}A_t$, (suppressing payments on principal). In the case of fixed mortgage interest rates over the n periods, the interest rates are equal $r_t^n = r_t = r_{t+1} = r_{t+n}$. Adopting a finite ownership horizon suggests some simple modifications to the consumer cost approach proposed above.

The simplest approach, over a limited period, is to use the capital costs associated with the acquisition, which consist of a stream of interest payments in the n time periods: r_tA_t, $r_{t+1}A_t$,… $r_{t+k}A_t$, (again suppressing payments on the principal to avoid confounding of consumption and saving). If the

household has entered a contract with a fixed rate mortgage, then interest rates are $r_t^n = r_t = r_{t+1} = r_{t+n}$. For a mortgage with a variable interest rate, a simple approach involves smoothing of consumption over time. This entails computing an average interest rate $r_t^n = (r_t + r_{t+1} + \ldots + r_{t+n})/n$ or another representative interest rate (for example using bond yields for specific maturity dates on given reference dates). This will in turn simplify the computation of weights for the overall CPI. The underlying rationale is that the consumption in one period is equal to total consumption for all periods divided by number of periods, an operation that smoothes the different and potentially volatile interest payments. From this, we obtain the index in the *Limited Commitment* case, when we ignore entry and exit costs:

$$(12) \qquad I_{ls} = r^n_{(t+1)m} A_{t+1} / r^n_{tm} A_t,$$

where the interest rate r^n is a long-term interest rate thought to represent the typical interest level over the period. The formula in equation (12) is viable when the time period is sufficiently long to ignore entry and exit costs. When this is not the case, it is straightforward to update (12) and obtain equation (13), which incorporates these costs:

$$(13) \qquad I_{ls} = (r^n_{(t+1)m} + b_{t+1} + s_{t+n+1}) A_{t+1} / (r^n_{tm} + b_t + s_{t+n}) A_t.$$

In the case of a floating interest rate, there are several possible approaches to partitioning payments into interest and principal. We set $r_t^n = (r_t + r_{t+1} +,\ldots,+ r_{t+n})/n$.

3.5 The weights of self-owners' consumption of housing services

We now turn to the problem of integrating the sub-index proposed above into the overall CPI. In contrast to the payments and acquisition approaches, in which consumption is easily observed, the user cost, rental equivalence, and our proposed consumption cost approaches need to *impute* the consumption of housing services in order to compute weights. This is due to the fact that housing consumption is latent in the model. We need to estimate the level of housing consumption of a household that owns its own dwelling and has paid either the full amount or parts of the principal. A frequently used approach is to estimate each household's implicit housing consumption based on estimated parameters from other surveys. For example, in the rental equivalence approach, the implicit housing consumption attributed to self owned housing is the imputed rent, R_h, of the dwelling. This consumption is added to other consumption C_h which yields a corresponding weight for housing consumption for a given household, $R_h/(C_{h,} + R_h)$. In order to calculate the weight used in the overall

CPI, an average of these individual household weights is used. In most cases, NSAs compute the weight using means, and set the weight w equal to $\Sigma_h R_h/(\Sigma_h C_{h,} + \Sigma_h R_h)$, where we use the ratio of means instead of means of ratios in order to minimize outlier influence.[9] In the empirical example below, weights are calculated in the same manner using imputed current cost as defined above in place of R_h. Hence, the weight, w, is given by equation (10):

$$(14) \qquad w = \Sigma_h iA_h/(\Sigma_h C_{h,} + \Sigma_h iA_h),$$

where i represents a long-term interest rate thought to represent variable interest rate levels over the time period examined (similar to the r^n above), A is the value of a typical self-owned home (based on data from the house price index), C is total other consumption, and subscripts h refer to households.[10] In equation (14), we compute the capital costs for a *given* level of equity.[11] We do this in order to avoid the confounding of consumption and saving that arises when the level of equity is allowed to change.

4. An empirical example

We now turn to an empirical example where we contrast the consumption cost approach with the rental equivalence approach using data from Norway. The computed CPI for recent Norwegian price data is quite sensitive to the choice of price sub-index for housing services of self-owners. If the rental equivalence approach is used the resulting CPI is significantly lower than if the consumption cost approach is employed. This can be explained by the fact that the rental equivalence approach leads to both a smaller weight for self-owners and a price sub-index with a smaller price increase.

Table 1 examines the results of the consumption cost approach for different assumptions concerning the average cost of housing and interest rates[12]. For each house price/ interest rate combination, we

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[9] The reason for not computing the weight using means of households' own budget shares, is this statistic's sensitivity to outliers, as is well known in the literature.

[10] Notice that this treatment is not trivial. To see why, consider two scenarios in which the real interest rate is identical, but in which the nominal interest rate and inflation are different. When nominal interest rates are higher, the computed level of imputed housing consumption is higher, and thus weights become higher. However, using real interest rates in the computation of the imputed housing consumption levels is untenable for the simple reason that real interest rates may become negative, and thus yield negative consumption levels while consumption cannot be negative.

[11] Notice that we have suppressed, for simplicity, tax deductions. However, such deductions may affect weights substantially even if the imputed levels of consumption appears in both the numerator and the denominator. To see why, compare the ratios iH/(iH+C) and iHx/(iHx+C). The latter is smaller if x is below unity, and that is the case when interest payments may be deducted from taxable income; in essence leading to an interest subsidy from the government to owners.

[12] Information on average cost and interest rates allows us to impute capital costs for all households. Hence, practitioners may calculate both the housing price sub-index and the corresponding weight.

compare weights computed for different levels of house prices and interest rates using the formula in equation (14). Observe that for low house values and low long-term interest rates (upper left cell) the weight is 0.20. For high house values and high long-term interest rates (lower right cell) the weight is 0.30. In implementing the approach proposed in this paper NSAs face the usual tension between letting weights represent current consumption patterns and the constructing stable and smooth weights that represent inter-period consumption. This results from the fact that any period is an arbitrary partition of time, and any definition of a period entails the use of means over that period; e.g. means of interest rates or house prices for weeks, months, or years. For the comparisons below between the rental equivalence approach and our consumption cost approach, we use the weight 0.250 tabulated in the middle cell. This reflects the stability of longer-term interest rates that correspond to the inter-period characteristic of long-term contracts.

Table 1. Weights[1] for Housing Services for Self-Owners, Various Interest Rates and House Prices[2]

	House Price		
Interest Rate	**Low, 2003 Mean Value-10% (1 350 836)**	**2003 Mean Value (1 500 929)**	**High, 2003 Mean Value + 10% (1 651 022)**
5%	0.200	0.218	0.234
6%	0.231	0.250	0.269
7%	0.260	0.280	0.300

[1]Weights are computed using equation (14). Mean total consumption excluding housing services for self-owners is NOK 269 828 for the year 2003.
[2]Mean transaction value of 66 726 observed transactions in 2003 is NOK 1 500 929.

Table 2 summarizes the results of constructing a CPI for Norway over the period January 2000-June 2004 using the consumption cost's k-year approach. The official CPI-increase was 8.9% while the consumption cost approach, using the 0.250-weight derived above, yields an overall price increase of 13.3%.

Table 2. CPI Using Alternative Methods and Alternative Weights, Norway, January 2000-June 2004

Measure	Other Goods Index (Weight)[1]	Renters' Price Index (Weight)	Owners' Price Index (Weight)[2]	CPI
Official CPI	1.0735 (0.85)	1.179 (0.03)	1.179 (0.12)	1.0893
Consumption Cost CPI, official weights	1.0735 (0.85)	1.179 (0.03)	1.301 (0.12)	1.1040
Consumption Cost CPI, new weights	1.0735 (0.724[3])	1.179 (0.0256[3])	1.301(0.250[4])	1.133

[1]CPI for the Other Good Index is computed using the simplifying (for transparency) relation 0.85x+0.15*1.179=CPI=1.0893, and solving for x. We use 3 digit precision (includes right zeros, but excludes left zeros).
[2]House price index for 2nd quarter 2000 - 2nd quarter 2004.
[3]Weights obtained by renormalization to 85/88*(1-0.250) and 3/88*(1-0.250).
[4]Weight obtained and procedure explained above. Different weights, using various interest rates and house prices, are shown in Table 1.

The period January 2000-June 2004 hides relatively large inter-period differences. House prices stagnated over the period 2002-2003. In terms of inflation measurement, such short-term price variations may be of substantial interest. Thus, we proceed to examine the one-year period from June 2003 to June 2004. We do this because there is an important difference between the rental equivalence approach and the consumption cost approach in times where increases in rents differ from increases in house prices. Table 3 illustrates the disparity between short-term price increase measurements. In doing so, we also present the differences between our k-year variant and our limited commitment variant.

Table 3. Official Rental Equivalence CPI and Consumption Cost CPI, Norway, June 2003-June 2004

Measure	Other Goods Index (Weight)	Renters' Price Index (Weight)	Owners' Price Index (Weight)	CPI
Official CPI	1.14% (0.85)	1.89% (0.03)	1.89% (0.12)	1.25%
Cons. Cost CPI, K-year	1.14% (0.724)	1.89% (0.0256)	10.2% (0.250)	3.42%
Cons. Cost CPI, Limited Commitment	1.14% (0.724)	1.89% (0.0256)	11.96%[1] (0.250)	3.86%

[1]We compute the ratio r'A'/rA by modifying the house price index A'/A using the factor r'/r. We obtain the interest rate ratio using interest rates with 3 components: the yield on 10-year governmental bonds (June 2004 and June 2003) + three percentage points representing a mortgage mark-up + five percentage points for transaction costs (including a 2.5% public fee). The yields were 4.5% (June 2003) and 4.7% (June 2004) Source: Bank of Norway.

For the 12-month period from June 2003 to June 2004, the official CPI increased 1.25% . Over the same period the rental index increased 1.89%, and the house price index increased 10.16%. Computing the alternative CPI based on the k-year variant of the consumption cost approach

developed above; we find that prices increased 3.42% during the 12 months prior to June 2004. Using the Limited Commitment variant, we modify the house price index A'/A by multiplying with the interest rate ratio r'/r. We obtain interest rates by adding yields on 10-year governmental bonds (obtained for the months inspected), a three percentage point mortgage mark-up, and five percentage points for transaction costs (including a 2.5% public fee). The 10-year governmental yields were 4.5% and 4.7% for June 2003 and June 2004. The increase in the bond yield leads first to an increase in the ratio of interest rates, then to an increase in the computed cost index for self-owners, from 10.2% to 11.96%. This entails an even larger measure of inflation, 3.86%, in this 12-month period compared to the official measure of 1.25%.

5. Discussion

Introducing interest rate ratios to modify the house price index, as we do when we use the Limited Commitment variant instead of the k-year variant, will produce a CPI that is more sensitive to monetary policy, but with a cost: this gauge is more volatile. Thus, this type of inflation gauge may be well suited to pick up changes in costs, but it will also fluctuate more. As a consequence, NSAs and central banks must weigh the benefits of sensitivity against the costs of volatility.

The reason for index volatility lies in the volatility of interest rates. Even 10-year interest rates, or yields on governmental bonds, are quite volatile. Too see how much this volatility influences the indices, and thus to acquire a sense of the need for considering the smoothing features of the k-year variant, let us compute the numbers for Table 3 half year later, from December 2003 to December 2004. In this period, the official CPI rose 1.07%, the rental index increased 1.63%, and the house price index increased 10.5%. However, from December 2003 to December 2004, the yield on 10-year governmental bonds *fell* from 4.8% to 3.9%. Even when the interest rate ratio incorporates constant mortgage mark-ups and includes transaction costs, and thus makes the ratio less sensitive to changes in yields, a reduction in yields from 4.8 to 3.9, gives an increase of 2.77% for the prices of self-owners in contrast to the 10.5% increase of the unmodified house price index.

On the other hand, mortgage rates tend to be less responsive (and volatile) than bond yields. So, if instead practitioners incorporated this tendency by using the mean of bond yields six months prior to the reference month, then the relevant yields change to 4.87% and 4.32%, respectively, and the self-owner's price sub-index changes by 5.78%. These differences highlight the need for NSAs and central banks to contemplate the optimum choice of interest rate ratio and what interest rates suit what

purposes. Longer assumed commitment time n leads to smoother index. As n tends toward k, the self-owners index will tend toward the house price index.

6. Conclusion and Policy Implications

Given the importance of the CPI both in measuring inflation and as a cost of living index, the prices of housing services for self-owners are of interest to central bankers and the public. There is no consensus on how to measure prices for housing services for self-owners. Central bankers are interested in these prices in order to gauge the appropriate level of monetary stimulus. To this end, they need accurate measures of the speed of price increases. The public is interested in these prices because they are central to economic planning. Because of the large budget share of consumption of housing services, prices of these services play a central role in computing real incomes and real interest rates.

How should the price for housing services for self-owners be included in the CPI? Many NSAs prefer the rental equivalence approach, not because it is especially theoretically or computationally compelling, but because it appears to be the least bad approach available. While not without shortcomings, the current consumption approach developed in this paper offers a tractable and intuitively appealing alternative to rental equivalence. Rental equivalence essentially uses the price of one good, rents on dwellings, as the price of another good, self-owned housing. In theory rents and house prices should track each other closely in the long run. In practice, the P/E-rates (house price/annual rent) vary widely over time. From a practical point of view the rental equivalence principle entails computational challenges since rental objects and self owned objects tend to be different with respect to size, physical attributes, and location. Out-of-sample predictions are notoriously hazardous. In addition, renting and owning involve different sets of options, obligations, and liabilities.

The strength of the consumption cost approach is that housing consumption is related directly to housing markets and the capital costs associated with acquisition of self-owned housing. Current costs are defined to be capital costs that depend on interest rates. This paper develops three versions of the consumption cost sub-index: a strict one-period version, a present value long-term version, and a Limited Commitment approach. These differ with respect to which interest rate should be employed for calculation. The strict one-year approach calls for a one-period mortgage or deposit rate, whereas the present value formula involves a 30-year interest rate. One-period interest rates tend to be volatile and the corresponding housing consumption and weights will be volatile. This simple current cost

model does not account for the path dependence of tenure choice. Incorporating the durable nature of housing and the long-term character of housing decisions makes it possible to construct a long-term approach that captures this dependence. We call this the k-year variant, and it entails computing the present value of interest payments for the length of the tenure. This leads to the interesting result that, under some general conditions, the rental index can be substituted with a house price index for the CPI category that examines prices for housing services for self-owners. From a practical standpoint the computations of weight may be difficult. A compromise is the limited commitment approach (including or excluding exit or entry cost), which involves a medium term, say from 5 to 15 years interest rate. This choice not only reflects the path-dependence and inter-temporal nature of self-owned housing consumption but it also reduces fluctuations in weights and prices due to volatility in short term interest rates.

When the consumption cost approach is employed on recent Norwegian data, and when we for illustration purposes reduces the consumption cost approach to its simplest form, the k-year variant when the sub-price index for self-owners is the house price index, the difference between the official CPI and this article's CPI becomes clear. The official CPI for Norway, which is based on the rental equivalence principle, is 1.3% for the period June 2003-June 2004. This article's CPI is 3.4% for the same period. The reason for this difference is two-fold. First, the official CPI uses a weight of 0.12 for self-owners while this article uses a weight of 0.250. Second, the official CPI uses the rental price index with an increase of 1.9% for the prices of self-owners while we use the house price index with an increase of 10.2%.

Which approach is preferred, consumption cost or rental equivalence? Several criteria offer guidance. First, from a theoretical perspective, which is more consistent with economic theory? Second, from a practical perspective, which is easier to compute? Finally, can one model explain phenomena that the alternative cannot? The consumption cost approach compares favorably on all of these criteria. First, separating outlays that lead to equity changes from outlays that do not, gives us a transparent tool that builds on economic theory. Second, the example above illustrated that the consumption cost is no more complicated a procedure than the rental equivalence. Indeed, since the rental equivalence approach relies heavily on out-of-sample predictions, it is potentially more difficult to compute. Third, Røed Larsen (2004) shows that there exists a potential discrepancy between the price experience among households in Norway in the 1990s, revealed by actual behavior, and the official price summary. Estimates on cross-sectional Engel curves uncover a puzzling trend: Households seem to behave as if prices in this period increased faster than official estimates. Estimates in Beatty and Røed

Larsen (2005) may reveal a similar puzzle for recent years in Canada. The approach proposed here may help resolve some of these discrepancies and explain why the official deflators appear to underestimate costs of maintaining a given material standard of living.

These results are important for central bankers. Inflation targeting would be problematic if agents in the economy did not believe that official CPI-numbers allowed them to accurately capture the difference between real and nominal entities. This may be the case if the CPI-numbers do not include, or include sub-optimally, the price for one of the most important services that a household purchases, housing services. If so, central banks may find themselves in the position where they may reach their own targets, but fail to anchor agents' price expectations because agents have started to incorporate the cost of housing services on their own. If this is the case, and anecdotal evidence suggests that it may be, agents will decide upon their inter-temporal consumption in a way that is inconsistent with the inflation measure used by central banks.

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