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Towards an Applicable True Cost-of-Living Index that Incorporates Housing

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Abstract

A dynamic model of consumer behavior that incorporates the demand for housing is specified such that it is consistent with the general purpose of a consumer price index. From this model a true cost-of-living index that includes housing is derived. Being an ideal index it cannot be computed without imposing additional assumptions about the behavior of the consumer, but it is possible to draw conclusions about the prices and weights that should be used in conventional approximations to such an ideal index.

Key words: True cost-of-living index, compensation index, price index of housing

JEL classification: C43, D91

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1. Introduction

The design of a price index for housing services within a consumer price index is a long lasting controversy not only among academics but also among national statistical institutes and international organizations. The problem lies in the definition of a price index for the services obtained from owner occupied housing, but in principle it is a more general problem that applies all consumer durables. Conventional index theory that relies on Konus's famous paper (Konüs, 1924, 1939) is static, while a theory that handles consumer durables has to be dynamic. Solutions adopted in practice vary from one country to another. In some countries there is no index at all for owned housing, in others the price changes of these services are represented by the index for rented apartments, and in still others attempts are made to estimate some kind of user-cost. For a critical survey of alternative approaches see Diewert(2003).

There are probably several reasons why this problem has not been solved for more than 60 years. The derivation of an ideal index from a dynamic theory that involves intertemporal utility maximization subject to an inter temporal budget constraint and taking the durability of a house into account easily becomes very complex and difficult to apply in practice. To obtain any useful results additional constraints are needed, either constraints on the behavior of the consumer or constraints on the functioning of the market. The latter approach is usually alien to most index designers who are not used to invoke assumptions about the supply side. A recent exception is Li and Löfgren (2004) who investigate the cost-of-living index problem in a general equilibrium multi-sector growth model. Models that assume a forward looking consumer usually need assumptions about the formation of expectations and the ideal index becomes a function of these expectations that again is alien to most index designers.

The root of the problem is, however, more fundamental. It lies in a rather wide spread misconception about the existence of a true or pure measure of inflation that is model free and independent of what this measure will be used to. It is then easily only becomes a matter of defining a price of a good and plug it into one of our conventional weighting formulas. Thus, it has been a mistake of the past to try to define the price of housing services independently of a model of consumer choice. The attempts to define a user cost of housing rely on investment theory and not on a theory of consumer behavior and generally no attempts have been made to integrate the two. In this approach the underlying model is thus not well-specified and no true cost of living index can be defined.

Any true cost of living index in the Konüs sense must be defined using a model of consumer behavior, but not necessarily the very simple static model he used. Further more, every scientist knows that in general there are many models of human behavior accepted by data and that in scientific work the choice of model within this class is driven by the applications of the model. In our case we would like to have a model that is useful for the purposes of a consumer price index.

In this paper I will first review the standard basic theory of a true cost of living index to fix ideas and introduce notation. I will then argue that it is possible to specify a relatively simple dynamic model to which we can ask the questions we need to ask for an ideal consumer price index that incorporates owner occupied housing. This model is reached in two steps, the first of which is just a marginal extension of the classical static model. Depending on the question we ask the model, alternative ideal indices are derived. Such indices cannot be computed without additional strong assumptions, but the expressions obtained guide as to the prices and weights that should be used in approximations to the ideal index.

2. The standard theory of a true cost of living index

Let p be a vector of n commodity prices and q the corresponding vector of consumed quantities. Assume the consumer's preferences is indexed by a utility function U(q) with standard properties. The consumer is the assumed to maximize U(q) with respect to q, subject to the budget constraint,

$$y = p'q; \tag{1}$$

where y is the consumer's "income". The solution to this problem is an optimal combination of quantities q.

A dual problem, given the price vector p, is to seek the minimal income y=p'q needed to attain a certain utility U, i e

$$\underset{q}{Min}(p'q) \ subject \ to \ U = U(q); \tag{2}$$

The solution to this problem is a vector q*(p,U) and an income y(p,U)=p'q*(p,U). The function y(p,U) is usually referred to as the cost function.

A Konüs index or a true cost of living index is now defined as,

$$I = \frac{y(p_1, U)}{y(p_0, U)} = \frac{p'_1 \, q^*(p_1, U)}{p'_0 \, q^*(p_0, U)}; \tag{3}$$

for given price vectors p_0 and p_1 and utility U. This index thus tells us what income compensation the consumer needs to give him the same utility U when prices are p_1 as when they are p_0. Another name of this index is thus a compensation index. [1]

It is useful to observe that the properties of the cost function depend both on the properties of the utility function and on the budget constraint. For instance, if commodities are close substitutes the compensating income change in general becomes smaller than if they are not. The instrumental importance of the formulation of the budget constraint is immediately seen from the expression after the second equality sign in expression (3). Additional constraints on the behavior of the consumer such as rationing would explicitly influence the cost function and thus also the compensation index.

In practice it is usually not possible to compute the ideal compensation index (3) but we have to seek approximations. If the index (3) is set for the maximum utility obtained when prices are p_0, U_0, then we obtain,

[1] Malmquist (1953) used the terminology "compensation index".

$$I = \frac{y(p_1,U_0)}{y(p_0,U_0)} = \frac{p'_1\, q^*(p_1,U_0)}{p'_0\, q^*(p_0,U_0)} = \frac{p'_1\, q^*(p_0,U_0)}{p'_0\, q_0}; \tag{4}$$

Depending on the shape of the indifference surfaces of the utility function q* is in between q_0 and q_1 in the sense that,

$$p'_0\, q_0 \le p'_1\, q^*(p_1,U_0) \le p'_1\, q_1 \;\; if \;\; p'_0\, q_0 \le p'_1\, q_1 \tag{5a}$$

and

$$p'_0\, q_0 \ge p'_1\, q^*(p_1,U_0) \ge p'_1\, q_1 \;\; if \;\; p'_0\, q_0 \ge p'_1\, q_1 \tag{5b}$$

The well-known property that a Laspeyres index is an upper bound to the ideal index (4) follows immediately. The equally well-known property that a Paasche index is a lower bound to an index conditioned on U_1 can be demonstrated in a similar way.

3. A static model of demand for housing

Assume that a consumer can get housing either by owning a house or by renting an apartment. Also assume that there is a well functioning market both for owner occupied houses and for rented apartments such that it is always possible to buy and sell a house and find an apartment at no transaction costs. Let's also assume that the consumer is myopic and easily switches from one dwelling to another. The consumer's decision problem can then be formulated in the following way,

$$\underset{q,q_h,q_r}{Max}(U(q,q_h,q_r)) \;\; subject \; to \;\; y + p_h^0 q_h^0 = p'q + p_h q_h + p_r q_r; \tag{6}$$

where p_h and p_r are the price of houses and the unit rent of an apartment respectively, and q_h and q_r are the corresponding volumes. p and q are vectors of prices and volumes of all other commodities. $p_h^0 q_h^0$ is the initial value of any house the consumer might own. The properties of the utility function may be such that the consumer only chooses owned housing or a rented apartment, but there is no reason to exclude the possibility both to own and rent. In this model an owned house is an asset that enters the budget constraint, but the durability of a house has no direct consumption value, because the consumer knows that he can always buy a new house at no transaction cost or switch to an apartment. For this reason he is able to behave myopic and treat a house like any other good.

The dual of the maximization problem is to minimize the expression to the right hand of the equality sign of the budget constraint with respect to all the q:s holding utility constant. This yields the ideal index,

$$I = \frac{p^{1\prime} q^*(p^1, p_h^1, p_r^1, U) + p_h^1 q_h^*(p^1, p_h^1, p_r^1, U) + p_r^1 q_r^*(p^1, p_h^1, p_r^1, U)}{p^{0\prime} q^*(p^0, p_h^0, p_r^0, U) + p_h^0 q_h^*(p^0, p_h^0, p_r^0, U) + p_r^0 q_r^*(p^0, p_h^0, p_r^0, U)}; \tag{7}$$

It answers the question how much the consumer's total resources, incomes and assets, must change to maintain the utility U at the two sets of prices. If we would like to know what income change is needed holding assets constant, the answer is,

$$I = \frac{p^{1}{}'q^{*}(p^{1}, p_{h}^{1}, p_{r}^{1}, U) + p_{h}^{1}q_{h}^{*}(p^{1}, p_{h}^{1}, p_{r}^{1}, U) + p_{r}^{1}q_{r}^{*}(p^{1}, p_{h}^{1}, p_{r}^{1}, U) - p_{h}^{0}q_{h}^{0}}{p^{0}{}'q^{*}(p^{0}, p_{h}^{0}, p_{r}^{0}, U) + p_{h}^{0}q_{h}^{*}(p^{0}, p_{h}^{0}, p_{r}^{0}, U) + p_{r}^{0}q_{r}^{*}(p^{0}, p_{h}^{0}, p_{r}^{0}, U) - p_{h}^{0}q_{h}^{0}}; \qquad (8)$$

In this model the consumer treats a house like any good and as a result price changes of houses enter the index. The only difference compared to the previous model is that owning a house is an asset that can be used for consumption purposes including that of buying a new house.

4. A dynamic model of the demand for housing

A truly dynamic model that involves inter temporal utility maximization, forward planning, the formation of expectations and takes depreciation into account does not only add considerably to complexity but also provides answers to more questions than a simple static model. For instance, we can ask what income is needed tomorrow to compensate for a price change today, or what income is needed today to compensate for a price change tomorrow, etc. Given the rather simple minded question we usually ask a consumer price index: "What income is needed today to compensate for a price change today?", we don't really need all that complexity. We need a model that recognizes the depreciation of a house, that there are transactions costs of moving from one dwelling to another which implies that a house does not only represent consumption value today but also tomorrow, and that the consumer borrows and owns assets. Let's now try to specify such a model!

Assume the following utility function,

$$U(q, q_{h}^{0} + \lambda q_{m}, q_{h}^{1}, q_{r}, A^{1} - M^{1}); \qquad (9)$$

q has the same interpretation as before. It represents all commodities but own housing and the services of a rented apartment. q_{h}^{0} is the initial stock of own housing and $q_{h}^{0} + \lambda q_{m}$ represents the current consumption value of an owned house including any maintenance and repair. λ is a factor that translates maintenance and repairs into house value. A value different from one allows for more or less value enhancing repairs and maintenance activities.

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.[2] q_{h}^{1} is the terminal stock of own housing, and it represents the future consumption value of the house as the consumer values it today. There is thus a trade off in utility between using a house today and using it tomorrow. q_r has the same interpretation as before. 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, $A^{1} - M^{1}$ is net financial assets at the end of a period, gross assets less mortgages and loans. They represent the consumption value of the goods these assets can buy in the future as the consumer evaluates it today. In principle one might want to divide net assets by a price index for anticipated price increases in the future. However, each consumer forms his own

[2] 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.

expectations and it is then convenient and reasonable to absorb this factor into the utility function.

The budget constraint becomes,

$$\begin{aligned} & y + A^0 r_A = \\ & p'q + p_m q_m + r_M M^1 + p_r q_r + \\ & (A^1 - A^0) - (M^1 - M^0) + p_h (q_h^1 - (1-\delta)(q_h^0 + \lambda q_m)); \end{aligned} \qquad (10)$$

$A^0 r_A$ to the left of the equality sign should be interpreted as capital income from financial assets including unrealized capital gains. The sum of these incomes and other incomes y (labor incomes) can be used for non housing consumption, maintenance and repairs of own house $p_m q_m$, interest payments on mortgages and loans $r_M M^1$, rent, increase in net financial assets, and to change the consumption of own housing. The last term is the end of period value of the difference between end of period own housing and the beginning of period own housing adjusted for depreciation, maintenance and repairs. δ is a depreciation factor. Moving predetermined entities to the left of the equality sign, the budget constraint is rewritten in the following way,

$$\begin{aligned} & y + A^0(1+r_A) + p_h(1-\delta)q_h^0 - M^0 = \\ & \quad p'q + (p_m - (1-\delta)\lambda p_h)q_m + p_h q_h^1 + p_r q_r + r_M M^1 + (A^1 - M^1); \end{aligned} \qquad (11)$$

The second term to the left of the equality sign is the end of period value of financial assets held in the beginning of the period and including realized and unrealized returns and capital gains during the period. The third term is the end of period value of a house owned in the beginning of the period, but after depreciation during the period.

The dual problem to the maximization of the utility function subject to this budget constraint is the minimization of the expression to the right of the equality sign. The corresponding ideal index is,

$$I = \frac{p^{(1)}{}'q^* + (p_m^{(1)} - (1-\delta)\lambda p_h^{(1)})q_m^* + p_h^{(1)} q_h^{1*} + p_r^{(1)} q_r^* + r_M^{(1)} M^{1*} + (A^{1*} - M^{1*})}{p^{(0)}{}'q^{**} + (p_m^{(0)} - (1-\delta)\lambda p_h^{(0)})q_m^{**} + p_h^{(0)} q_h^{1**} + p_r^{(0)} q_r^{**} + r_M^{(0)} M^{1**} + (A^{1**} - M^{1**})}; \qquad (12)$$

The quantities q* etc are functions of the prices with top symbol (1) while q** etc are functions of the prices with top symbol (0). This index tells us what change in total resources is needed to maintain the same utility U for the two sets of prices

$$\left\{p^{(t)}, p_h^{(t)}, p_r^{(t)}, p_m^{(t)}, r_M^{(t)}\right\} \; for \;\; t = 0,1 \qquad (13)$$

If we would rather know what change in total income is needed, the ideal index becomes,

$$I=\frac{\begin{array}{c}p^{(1)}{}'q^{*}+(p_m^{(1)}-(1-\delta)\lambda p_h^{(1)})q_m^{*}+p_h^{(1)}(q_h^{1*}-(1-\delta)q_h^{0})+p_r^{(1)}q_r^{*}\\ +r_M^{(1)}M^{1*}+(A^{1*}-M^{1*})-(A^{0}-M^{0})\end{array}}{\begin{array}{c}p^{(0)}{}'q^{**}+(p_m^{(0)}-(1-\delta)\lambda p_h^{(0)})q_m^{**}+p_h^{(0)}(q_h^{1**}-(1-\delta)q_h^{0})+p_r^{(0)}q_r^{**}\\ +r_M^{(0)}M^{1**}+(A^{1**}-M^{1**})-(A^{0}-M^{0})\end{array}}; \qquad (14)$$

This expression demonstrates what price changes should go into an index and what kind of weights one should use. We note that price changes on maintenance and repair goods and services should be adjusted for price changes on owned houses. An interpretation of this result is that a consumer's decision to repair and do maintenance is not influenced by a price increase on these goods and services if he is compensated by a comparable increase in the value of the house. Further more we note that the price change on owned houses also should be included in its own right with a weight that is proportional to the change in own housing. Using the conventional non-rigorous transformation from a single individual to an aggregate index the aggregate weight should be proportional to the sum of the value of all newly produced one family houses less demolition and depreciation of the old stock of houses. The change in interest rate on mortgages and loans should only be weighted with a weight proportional to the size of mortgages and loans, not by the value of the housing stock or anything else. This index also includes a variable that represents the change in net financial assets, a variable that we are not used to find in a consumer price index. One possibility to handle this is to constrain the consumer such that his optimization is subject to zero change in net financial assets. This variable then drops out of the index expression above.

Still another question to ask this model is what change in labor income y is needed to compensate for the price changes. An index corresponding to this question is obtained if $r_A A^0$ is subtracted both from the numerator and the denominator of expression (14). Such an index can either condition on a given rate of return r_A, or one can choose to include r_A in the price sets that are compared. In the latter case $r_A^0 A^0$ is subtracted from the denominator of eq. (14) and $r_A^1 A^0$ from the numerator.

Transaction costs were used to motivate that a consumer considers the future consumption value of an owned house, but they were never explicitly introduced in the budget constraint above. This is easily done. All that is needed is to add the term

$$p_T\left[(q_h^1-(1-\delta)(q_h^0+\lambda q_m))\neq 0\right]; \qquad (15)$$

to the right of the equality sign of eq. (10). p_T is the "price of moving" while the expression within brackets is a dummy variable that takes the value one if a consumer sells his house and buys another one.[3] The ideal price indices (12) and (14) will then also include this component. Because we have assumed a unit price of moving, the corresponding aggregate weights will just be the total number of consumers that changed house. A more conventional type of index for this subgroup of services could be obtained if the model would allow for differences in volume and quality of moving services. In practice these services would usually be included among other transport services.

[3] This expression neglects the unlikely case of selling a house and buying another one of exactly the same size and quality and still haing transaction costs.

The model could also be extended to include taxes. Suppose for instance that interest paid on mortgages are deductible against capital incomes that are taxed at a flat rate τ, and that there is a real estate tax τ_h that is applied to a tax base that is proportional (β) to the market value of the house. The budget constraint (10) then becomes,

$$\begin{aligned} & y + A^0 r_A (1-\tau) = \\ & p'q + p_m q_m + r_M (1-\tau) M^1 + p_r q_r + \\ & (A^1 - A^0) - (M^1 - M^0) + p_h (q_h^1 - (q_h^0 - \delta q_h^0 + \lambda q_m)) + \tau_h \beta p_h q_h^1; \end{aligned} \quad (16)$$

It follows that the "prices" that will enter the ideal indices (12) and (14) will change a little. The interest paid on mortgages should be adjusted for any changes in the capital tax rate, and the housing price for any changes in the real estate tax (tax rate and tax base). If compensating for changes in the tax system does not agree with the general purpose of the index, one can condition on a given tax system. The weights of such an index will, however, be different. The mortgage interest rate should be weighted with the sum of all outstanding mortgages multiplied by one minus the tax rate, while the house price should be weighted with the sum of new housing and depreciation net of maintenance and repair plus the sum of real estate taxes paid.

5. Conclusions

A dynamic model of consumer behavior that incorporates the demand for housing was specified such that it is consistent with the general purpose of a consumer price index. From this model it was possible to derive a true cost-of-living index that includes housing. Being an ideal index it cannot be computed without imposing additional assumptions about the behavior of the consumer, but it is possible to draw conclusions about what prices and weights that should be used in conventional approximations to such an ideal index.

We find that:

- House prices should be included with weights proportional to the sum of the value of all newly produced one family houses less demolition and depreciation of the old stock of houses,
- Interest rates on mortgages should be included with weights proportional to the sum of outstanding mortgages. The weights should not include down payments or the non-mortgaged part of the house value.
- The price of value enhancing maintenance and repairs should be adjusted for price changes on houses.
- If there are real estate taxes and the tax system allows for deduction of interest paid, either the price relatives or the weights should be adjusted accordingly. The price relatives should be adjusted if it is desirable to compensate the consumer for tax changes, while only the weights should be adjusted if that is not the case.

These conclusions follow from the model used. Obviously another model could lead to different conclusions. For instance, one might note that although the model is dynamic, it is so in a rather restricted way. It only distinguishes between a current period and the future and expectations about the future are not explicit by absorbed into the utility function. However, given the general purpose of a consumer price index, these assumptions would seem justified.

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