3

Elements for a Conceptual Framework

Introduction

3.1 What makes the construction of a residential property price index (RPPI) so challenging? This question was addressed in Chapter 1 of this Handbook but it will be useful to remind readers about the main problems, which are as follows:

- The compilation of price indices typically relies on *matching* the prices for identical items over time. However, in the housing context, each property has a unique location and usually a unique set of structural characteristics. Thus, the matched model methodology will be difficult or impossible to apply.
- Transactions are sporadic.
- The desired index number concept may not be clear, or put another way, there are *several distinct purposes* for which an RPPI is required and, broadly speaking, different purposes require different indices.
- For some purposes, notably the construction of national balance sheets and the estimation of user costs of owner occupied housing, a decomposition of a property price into land and structures components is required but it is unclear how best to accomplish such a decomposition. This issue will be discussed in more detail in Chapter 8 below.

3.2 The first two difficulties are well recognized in the housing measurement literature as the following quotations indicate:

"The price of housing is harder to measure than that of most other goods and assets because of three key distinguishing characteristics. First, and most importantly, dwellings are heterogeneous. No two dwellings are identical, if only because they cannot occupy quite the same location. This means that sampled house prices may be a poor indicator of all house prices because we cannot always reliably predict the sales price of a given dwelling from the price of another." Robert Wood (2005; 213).

"The *fundamental problem* that price statisticians face when attempting to construct a real estate price index is that *exact matching of properties over time is not possible* for two reasons: (i) the property depreciates over time (*the depreciation problem*) and (ii) the property may have had major repairs, additions or remodeling done to it between the two time periods under consideration (*the renovations problem*). Because of the above two problems, constructing constant quality real estate price indices cannot be a straightforward matter; some form of imputation or indirect estimation will be required." Erwin Diewert (2009b; 92).

Such statements indicate that the construction of an RPPI will be much more difficult than the construction of a "normal" price index based on a matched model methodology. It should be recognized at the outset that, because of the difficulties resulting from the uniqueness of each dwelling unit, it would not be possible to construct a "perfect" RPPI; it will only be possible to construct an approximation to the theoretically ideal index for each purpose.

3.3 The question of what is the purpose of an RPPI has been addressed in Chapter 2, where the many uses of an RPPI were considered. This chapter focuses on the uses of RPPIs to fill in gaps in the System of National Accounts and in the construction of a CPI. It is likely that if appropriate RPPIs can be constructed to fill in these gaps, then the resulting family of RPPIs will meet the needs of most users.

3.4 Broadly speaking, two separate RPPIs can be distinguished: 1) a constant quality price index for the *stock* of residential housing at a particular moment in time; and 2) a constant quality price index for residential property *sales* that took place during a particular period of time. The construction of these two types of index will be different; e.g., the weighting associated with the two types will differ. In this chapter, the main approaches to constructing an RPPI will be briefly discussed. Details on these methods will be presented in Chapters 4 to 7.

3.5 A variety of miscellaneous topics will be addressed in the final four sections of this chapter. These topics include the frequency of the RPPI and user needs, the consistency of monthly with quarterly estimates and the consistency of quarterly with annual estimates, revision policies, and seasonal adjustment.

Residential Property Price Indices and the System of National Accounts

3.6 The *System of National Accounts (SNA) 1993* and its recent updating, the *System of National Accounts 2008*,([1]) provide a comprehensive accounting framework for an economy. The SNA partitions the value flows in the economy into various meaningful categories and provides a reconciliation of the flow accounts with the corresponding stock accounts. It is furthermore recommended to decompose the values in the cells of these accounts into price and volume (or quantity) components.

([1]) See Eurostat, IMF, OECD, UN and the World Bank (1993) and (2009).

3.7 There are three passages in the SNA where residential property price indices are required to convert nominal values into volumes or real values:

- the *stock* of residential properties that exist at a particular location in the country at a particular point in time;
- the *sales* of residential properties that were sold in a particular location in the country over a particular time period, and
- the structures part of the *sales* of *new* residential properties that were sold in a particular location in the country over a particular time period.

3.8 A country's stock of residential properties is a component of its national wealth. Hence, a price index is required for residential properties so that balance sheet estimates of *real wealth by component* can be formed.([2]) Balance sheet estimates of national wealth typically distinguish between the structures component of residential property and the land component. If there is a need to provide estimates of the country's real stock of residential structures and the real stock of residential land, it will be necessary to decompose residential property values into separate land and structures components and to construct price indices for each of these components.

3.9 It may not be immediately obvious why a price index for the sales of residential properties is required for national income accounting purposes. It is used to estimate the *real output* of the residential real estate services industry, i.e., the industry that provides services that facilitate residential properties transactions. Some algebra will help understand why having a price index for the sales of residential properties is essential in this area.

3.10 Suppose that the value of real estate agent commissions is V_C^t for some class of property transactions in period t and suppose that the corresponding value of sales for the same group of properties (including the commissions) is V_S^t. Further, suppose that a constant quality price index for this type of sale has been constructed and the period t value of this price index is P_S^t.([3]) An estimate of volume of sales for this class of real estate transactions in period t, say Q_S^t, can be calculated with the following relationship:

$$Q_S^t \equiv V_S^t / P_S^t \tag{3.1}$$

([2]) A price index for the stock of residential properties is also of some use to central bankers who are interested in monitoring property prices for the possibility of bubbles in their countries; see Chapter 2.

([3]) Instead of using a purchaser's price index, it is also possible to use a seller's price index. When constructing a constant quality price index for housing, should the price determining characteristics of the seller or those of the purchaser be used to do quality adjustment? It could be argued that the quality determining characteristics of the purchaser should be used in order to quality adjust prices for residential properties, since if the purchaser does not see enough value in the price of a property, it will not be purchased. This suggests that a purchaser's constant quality price index should be constructed as opposed to a seller's constant quality price index. However, one could also argue that if the selling price of a property (regarded as a function of the characteristics of the property) is not high enough, then producers of new housing units will not build a new unit and thus it is the price determining characteristics of the seller that should count, at least in the context of valuing new housing units. Rosen (1974) discusses these issues. In terms of Rosen's analysis of the determinants of the hedonic surface, for the case of new housing units, it is likely that his Case 1 analysis is relevant, where cost conditions are identical across firms and thus the hedonic surface is determined by the supply side of the market; see Rosen (1974; 50-51).

3.11 The real estate industry can be treated as a retailing or wholesaling industry; i.e., it is a margin industry that can be thought of as buying a property at the pre-commission price and selling it at the post-commission price. The value of the service is equal to the commission revenue, V_C^t, and the quantity of the service is proportional to the volume of the sales, Q_S^t. Thus set the volume of the real estate services, Q_C^t, equal to Q_S^t:

$$Q_C^t \equiv Q_S^t \tag{3.2}$$

3.12 Finally, the price index in period t for the subsector of the real estate industry associated with the property sales, with value V_S^t in period t, is set equal to the value of the corresponding commissions, V_C^t, divided by the corresponding volume, Q_C^t:

$$P_C^t \equiv V_C^t / Q_C^t \tag{3.3}$$

$$= V_C^t / [V_S^t / P_S^t] \quad \text{using (3.1) and (3.2)}$$

$$= [V_C^t / V_S^t] P_S^t$$

$$= m_C^t P_S^t$$

where $m_C^t = V_C^t / V_S^t$ is the period t *margin rate* for this class of real estate transactions; i.e., m_C^t is the ratio of commissions in period t to the corresponding purchaser's total value of the real estate transactions. Thus the period t price index for the output of this segment of the real estate industry is the product of the margin rate m_C^t times the constant quality price index for the properties sold in period t, P_S^t. This demonstration illustrates why constant quality price indices for sales of residential properties are useful for national income accounting purposes.

3.13 The third value cell in the national accounts that requires a housing price deflator is the *value of new housing produced* in various locations in the country over a reference time period. This value flow is part of *gross capital formation* in the country. When a new property is produced in the reference period and if there were no improvements made to the underlying land that the new structure occupies, then the portion of the sale price that can be attributed to the site land should be deducted from the sale price and the residual amount is then part of gross capital formation and also part of the construction industry's output. Thus, an RPPI for the *structure component of the sales of new residential properties* is required in the national accounts. It will be necessary to decompose sales of new residential properties into separate *land and structure components* and to construct a constant quality price index for the structure component in order to serve the needs of the national accounts.

3.14 Recall the above discussion about modeling the output of the real estate industry. Because the sale of a new property will have various transactions costs associated with it (e.g., real estate commissions), this leads to some

complexities in the system of national accounts that have not yet been definitively resolved. From the viewpoint of the construction industry, these transactions costs are not part of the revenues that accrue to the construction sector, so these costs should not be included in the value of the output of the construction industry. However, from the viewpoint of the sector that purchases the new housing unit, these transactions costs are a real cost and they must be accounted for. There are a number of ways that *transactions costs* associated with the purchase of a new housing unit could be treated (from the viewpoint of the purchaser):

- simply attribute all of the costs to the period of purchase and treat the transactions costs as an expenditure by the purchaser ([4]) (which is an acquisitions approach to these costs);
- include transactions costs as part of the structures component of the value of the purchase so that these costs would be amortized over time using the same depreciation rate that was being used to depreciate the structure; or
- separately amortize the transactions costs according to the average length of time a residential property of the type under consideration is being held before it is resold.

Conceptually, the last treatment seems preferable ([5]) but the first and second treatments will lead to a simpler set of accounts. These issues need to be studied further by national accountants with input from the broader economics community.

Residential Property Price Indices and the Consumer Price Index

3.15 Pricing the services of Owner Occupied Housing (OOH) in a Consumer Price Index (CPI) is extensively dealt with in the *Consumer Price Index Manual*. ([6]) There is no universal consensus on the treatment of OOH in a CPI but the CPI manual suggests four possible approaches. ([7]) These approaches treat the unique character of OOH, which involves both the acquisition of a house and the consumption over time of the flow of services of the house, in a different manner.

- The *money outlays* or *payments approach*. In this approach, the out of pocket expenses of home ownership are simply added up. These costs include expenditures on maintenance and repair, mortgage interest costs, insurance premiums, property taxes and condominium charges (if the housing unit is a condominium). Two important types of implicit cost and one important implicit benefit of home ownership are not included. The two omitted costs are depreciation and the opportunity cost of the funds that are tied up in the homeowner's equity in the house; the implicit omitted benefit is any (net) capital gains that may accrue to the owner during the time period under consideration. ([8]) The money outlays approach is useful if an analyst wishes to focus on the disposable income of households. However, it is not particularly useful as a measure of household consumption services (because of the omission of the costs and benefits mentioned above).
- The *(net) acquisitions approach*. ([9]) In this approach, the services of OOH are ignored in the CPI except when a new housing unit is introduced into the market place. The purchase price of the new dwelling unit is charged to the period of purchase so that a purchase of a new house is treated in the same manner as the purchase of a nondurable good or service, i.e. the purchase is treated in the same way as the purchase of other durable goods. A variant of this approach is to decompose the selling price of the newly built residential property into land and structures components and to use just the structures component as the price which will enter into the CPI.
- The *rental equivalence approach*. In this approach, a price is imputed for the shelter cost of the owner occupied housing unit (both for new and existing units), which is equal to the price at which the unit could be rented. ([10])
- The *user cost approach*. In this approach, the financial opportunity cost of owning the house and using its services during the reference period is calculated.

([4]) The price index that could be used to convert the nominal value of transaction charges into a real amount (or volume) is a composite purchase price index for the type of property under consideration which includes both the land and structures components.

([5]) This is the treatment used by the Australian Bureau of Statistics. An unresolved issue is the choice of price deflator in order to form real amortization charges. That is, should a structures price index be used or should a composite structures and land price be used? In the case of real estate the commissions are generally proportional to the overall price of the property (the sum of the land and structures components) so it would be appropriate to use a composite property price index for the deflation of this component of transactions costs. Government transactions taxes or stamp duties may impose different rates on the land and structures components of the sale and so working out an appropriate real price for this component of transactions costs may be rather complicated. Again, it may be acceptable to avoid all of these complexities and just use a composite purchase price index to do the deflation.

([6]) See ILO, IMF, OECD, Eurostat, UN and World Bank (2004), Chapter 23.

([7]) Diewert (2002) (2009a) (2009b) provides more discussion of alternative methods.

([8]) The money outlays concept is explained in some detail in Baldwin, Nakamura and Prud'homme (2010).

([9]) For a comprehensive practical treatment of the net acquisitions approach, see Eurostat's (2012) Technical Manual on Owner Occupied Housing.

([10]) This approach is consistent with the treatment of OOH in National Accounts. In the SNA, OOH is considered a fixed asset, unlike other durables (such as washing machines, furniture, cars etc). The purchase of a house is considered an investment and included in gross fixed capital formation and thus excluded from household final consumption expenditure; the same goes for extensions of the house and major repairs. However, the ownership of a house provides a service which is consumed over time by the owner and the value of this service is included in household final consumption expenditure.

Since the CPI Manual (2004) was written, a fifth concept for pricing the services of OOH has been suggested: ([11])

- The *opportunity cost approach*. In this approach, the price for the services of an owned dwelling unit is set equal to the *maximum* of its rental equivalence and user cost prices.

3.16 The conceptual differences between these approaches should be underlined. The *rental equivalence approach* and the *user cost approach* price the services of an owner occupied dwelling. The *payments approach* measures the out of pocket expenses of home ownership. The *net acquisitions approach* takes a completely different perspective, implicitly allocating all the services of the newly purchased dwelling to the period of purchase.

3.17 In the above approaches except the *payments* and *rental equivalence approaches*, there is a need for constant quality price indices for either newly-built dwelling units or for the existing stock of dwelling units. The *user cost* and *opportunity cost approaches* to pricing the services of a residential housing unit are not entirely straightforward. The Appendix to this chapter outlines the mechanics of these approaches.

3.18 To summarize, RPPIs are needed in the construction of a CPI and to deflate several value flows and stock holdings in the national accounts. For both CPI and national accounts purposes, it will be useful or necessary to have a decomposition of the price indices into structures and land components. More specifically, it would be useful to be able to construct the following set of RPPIs: ([12])

- a price index for the total *stock* of residential housing at a particular moment in time, which is needed for estimating real changes of the economy's stock of residential housing, a component of a nation's real wealth;
- a price index for the *owner occupied stock* of residential housing (a subindex of the index in the bullet point above), which is needed to construct estimates for the value of OOH services based on user cost or opportunity cost principles;
- a price index for residential property *sales* (both newly-built and existing dwelling units) that took place during a given period of time, which is needed for estimating the real output of the residential real estate services sector;
- a price index for the *sales of newly-built residential properties* during a given period of time, which is required if a broadly defined net acquisitions approach is used where both the structures and land components would be included in the purchase;
- a price index for the *structures component of newly-built residential properties* that were sold during a given period of time, which is needed for a narrowly defined net acquisitions approach where only the structures component would be included in the purchase.

([11]) See Diewert (2009b), Diewert and Nakamura (2009) and Diewert, Nakamura and Nakamura (2009).

([12]) Fenwick (2005) (2006) argued that it would be useful to develop a coherent conceptual framework for a family of real estate price indexes. "It can be seen that user needs will vary and that in some instances, more than one measure of house price or real estate inflation may be required. It can also be seen that coherence between different measures and with other economic statistics is important and that achieving this will be especially difficult as statisticians are unlikely to have an ideal set of price indicators available to them." David Fenwick (2006; 8).

Main Methods

3.19 To measure *pure price change*, real estate prices must be adjusted for quality change. In other words, to compile a *constant quality* RPPI, it will be necessary to somehow control for any variations in the amounts of the price determining characteristics of the properties. The most important characteristics are:

- the *area of the structure* (in squared feet or in meters squared);
- the *area of the land* that the structure sits on (in squared feet or meters squared);
- the *location* of the property;
- the *age* of the structure;
- the *type of structure*; the structure can sit entirely in the lot without sharing any walls with an adjacent structure (detached dwelling unit) or share one wall with a neighbouring unit (semi-detached dwelling unit), or the dwelling unit can be a single apartment or unit in a multifamily residence (apartment or condominium building);
- the *materials used* in the construction of the house (primarily wood, brick, concrete or traditional materials; i.e., a shack or shanty), and
- *other price determining characteristics* such as the number of bedrooms, the number of bathrooms, a garage, a swimming pool, air conditioning, distance to amenities, etc.

3.20 Four main methods have been suggested in the literature to control for changes in the amounts of the property characteristics: stratification or mix adjustment, repeat sales methods, hedonic regression methods, and the use of property assessment information. Below, a brief overview of the four methods is provided. More details can be found in Chapters 4-7.

3.21 *Stratification* of transactions according to some of the price determining characteristics is a straightforward and computational simple way to adjust for changes in the quality mix of the samples in different time periods. By defining a number of reasonably homogeneous strata or cells, the average selling price within each cell can be used as a (proxy to a) constant quality price for that type of property. Regular index number theory can then be applied to aggregate up the average prices by cell into an overall index. Such stratification methods are also known as *mix adjustment*

methods. Wood (2005) describes this method in the following way:

"House price observations are grouped into sets or 'cells' of observations on houses with similar location and physical attributes. […..] The mean prices in each cell are weighted together to give a 'mix adjusted' price. A change in the composition of the sample will alter the number of observations in each cell. But if the cells are defined sufficiently precisely, so that all elements of the cell have similar prices and price trends, then such compositional changes will not systematically affect the mix adjusted house price. Robert Wood (2005; 214).

3.22 The *repeat sales method* addresses the quality mix problem by comparing properties that have sold more than once over the sample period. Restricting the comparison to units that have sold repeatedly ensures that the price relatives compare like with like, provided that the quality of the houses remained unchanged. The standard repeat sales method is based on a regression model where the repeat sales data pertaining to all periods are pooled. A potential drawback of this approach is the issue of "revisions": when new periods are added to the sample and the model is re-estimated, the previously estimated price indices will change. An advantage of repeat sales methods is that, because properties are matched at the address level, location, an important factor affecting real estate prices, is held constant.

3.23 One other potential drawback of the repeat sales method is that it does not account for quality changes of the sampled houses; over time a dwelling unit can undergo renovations and be subject to depreciation. Consequently, the quality of the property can vary with time. *Hedonic regression methods* can in principle adjust for such quality changes in addition to changes in the quality mix of the samples. These methods utilize information on the relevant property characteristics to estimate quality adjusted price indices using regression techniques, though it may prove difficult to sufficiently control for location. There are different ways to estimate hedonic price indices. The *time dummy variable method* has been prominent in the real estate literature. This method models the price of a property as a function of its characteristics and a set of time dummy variables. Because the data for all periods are pooled, the resulting indices are subject to revisions like with the repeat sales method. Another drawback of the time dummy method is that it places perhaps unwarranted restrictions on variations in the price of land and structures across time. These difficulties with the time dummy variant of the hedonic regression approach can be avoided by using another variant of the method known as the *hedonic imputation method*.

3.24 Many countries tax real estate property and are likely to have an official property valuation office that provides periodic appraisals of all taxable real estate properties. *Assessment-based methods* combine selling prices with appraisals to compute price relatives (sale price appraisal ratios) and control for quality mix changes. The Sale Price Appraisal Ratio (SPAR) method is based on the matched model methodology. In contrast to the repeat sales method, it relies on all (single and repeat) sales data, and there is no revision of previously estimated indices. Of course the method can only be applied in countries where reliable assessed values of the properties are available.

3.25 If the reference period is a year, all methods will tend to generate similar estimates of the trend in residential property price changes for an entire country. However, as will be seen in the examples presented in Chapters 4-7 and Chapter 11, different methods do generate small but significant differences in trends while for shorter periods they can lead to rather different estimates of price change. The various methods could also produce different signals of turning points.

3.26 As hedonic methods assume that information on the characteristics of the properties sold is known, the samples can be stratified and, if a sufficient number of observations is available, separate indices can be estimated for the strata. In other words, hedonic regression methods can provide a set of constant quality price indices for various types of property. Obviously, if data on some price determining characteristics are available, then repeat sales and assessment-based methods can also be combined with stratification.

3.27 Stratification can also be used to approximate a stock based RPPI. In this case the stratum weights will be based on census data pertaining to the value of the owner occupied housing stock. The stratum price indices will still be based on sample data of properties sold. Within each stratum, the properties traded are now treated as a (random) sample from the stock. Since long time intervals between two censuses is the norm, stock value weights can usually only be updated very infrequently.

3.28 As was discussed previously, for various purposes it is necessary to decompose the overall price of a property into (additive) components that reflect the price of the structure and the price of the land the structure is located on. In Chapter 8 it is shown how hedonic regression techniques can be used to accomplish this decomposition.

The Frequency of the RPPI and User Needs

3.29 For inflation monitoring purposes, most central banks would prefer an RPPI on a monthly or quarterly basis. For national accounts purposes quarterly indices will suffice, while for CPI purposes monthly indices are generally required. Given that the number of observations for a monthly price index will only be approximately one third of the number for a quarterly index, statistical agencies will have to carefully evaluate the tradeoff between publication frequency, timeliness and accuracy. The use of monthly data may lead to rather noisy figures, whatever method used to compile an RPPI. To mitigate the noise, a moving average could be computed but this creates new problems, as will be explained below.([13])

3.30 It is useful to outline some of the tradeoffs that statistical agencies may face when attempting to construct house price indices that meet the needs of users. Before examining the tradeoffs, it will be necessary to review the user needs for a *family of residential property price indices*. The following list of user needs is borrowed from the list compiled by Emily Carless (2011) from the National Statistician's Office of the UK Statistics Authority. The family of RPPIs should:([14])

- be based on the price paid for transacted properties;
- be stratified by region;
- be stratified by type of housing (e.g., detached, row, high rise, type of construction, etc.);
- be computed on a monthly basis;
- aggregate up to a consistent national index;
- be accurate and timely with minimal revisions.

The fifth requirement, that the various sub-indices aggregate up to a consistent national index is not too difficult to satisfy. Whether the first requirement, that the price indices be based on transaction prices, can be met, depends on availability of the data. In many countries, actual selling prices are used to compile RPPIs, but not all statistical agencies may have access to transaction data. Even if transaction data are available, there can be a time lag involved (as will be discussed in Chapter 9), so that in practice the first requirement could be at odds with the sixth requirement, i.e., that the indices should be timely.

3.31 There are also conflicting objectives with some of the other requirements: having many strata and asking for monthly indices may lead to a situation where some strata have only few transactions, resulting in rather volatile and inaccurate sub-indices. Although taking moving averages of the monthly indices can reduce volatility,([15]) such a strategy will not provide timely signals of price change. That is, the resulting average index will be centered in the middle of the time period for the moving average and will not be available until some months have passed.([16]) In particular, this could give a misleading picture of the upswings and downturns in the housing market. So in general, it will not be possible to meet with a single price index all the above listed user needs, and statistical agencies will have to make some compromises in their attempts to meet the different user needs.

Consistency of Monthly with Quarterly Estimates

3.32 How can monthly estimates of real estate price changes be made consistent with quarterly estimates? The answer to this question is reasonably straightforward if the same average price or unit value methodology is applied to the quarterly data as is applied to the monthly data. Suppose that a monthly sales RPPI is constructed using the stratification (or mix adjustment) method. As will be explained in Chapter 4 more thoroughly, the monthly price for a particular cell is the average transaction price or unit value and the corresponding quantity is the total number of properties traded. The quarterly RPPI for that cell would start out by calculating a quarterly unit value, and the corresponding quantity is the quarterly total number of stratum transactions. Some algebra will make clearer the relationship between the quarterly cell price and quantity data to the corresponding monthly data.([17])

3.33 Suppose that there are T quarters of monthly data. Denote the value of quarterly transactions in a particular cell in the stratification scheme by V^t for $t = 1,...,T$. Within each quarter t, the value of first month transactions is denoted by V_1^t, of second month transactions by V_2^t and of third month's transactions by V_3^t. The quarter t *monthly unit value prices* are denoted by P_1^t, P_2^t and P_3^t

([13]) Nevertheless, moving averages are, for example, used in Iceland. It may also be necessary to use slightly out of date information in a monthly CPI context; see Gudnason and Jónsdóttir (2006; 4).

([14]) In addition to the requirements listed, Carless noted that users desire a clear explanation of the methods used to construct the statistics and indicators of the quality of the measures. Also, some users want seasonally adjusted series in addition to the unadjusted series.

([15]) The volatility may also be mitigated by combining some strata, but then users may lose some of the desired geographical detail or type of housing coverage they were expecting. In addition, the new combined strata may not be subject to the same price trend and thus there is the possibility of some resulting unit value bias due to the aggregation of the strata.

([16]) This number is equal to half the window length of the moving average.

([17]) The same type of analysis can be applied to the relationship between an annual (mix adjustment) sales RPPI and the corresponding quarterly estimates.

and the corresponding *monthly number of transactions* are denoted by Q_1^t, Q_2^t and Q_3^t. Note that V_m^t equals $P_m^t Q_m^t$ for $m = 1,2,3$ and $t = 1,...,T$. The value of transactions for quarter t, V^t, is equal to the sum of the monthly transactions within the quarter:

$$V^t = V_1^t + V_2^t + V_3^t = P_1^t Q_1^t + P_2^t Q_2^t + P_3^t Q_3^t \qquad (3.4)$$

$$t = 1,...,T$$

The quarterly quantity series, Q^t, is the sum of the monthly transactions within the quarter and the quarterly price series, P^t, is the quarterly unit value for the cell under consideration; i.e.:

$$Q^t = Q_1^t + Q_2^t + Q_3^t \qquad (3.5)$$

$$t = 1,...,T$$

$$\begin{aligned} P^t &= V^t / Q^t \qquad (3.6) \\ &= [P_1^t Q_1^t + P_2^t Q_2^t + P_3^t Q_3^t] / [Q_1^t + Q_2^t + Q_3^t] \\ &= s_1^t P_1^t + s_2^t P_2^t + s_3^t P_3^t \end{aligned}$$

$$t = 1,...,T$$

where the *month m share of transactions in quarter t*, s_m^t, is defined as

$$s_m^t = Q_m^t / Q^t \qquad (3.7)$$

$$m = 1,2,3\,;\ t = 1,...,T$$

Thus, the quarterly price level for the cell under consideration, P^t, is equal to a transaction share weighted average of the monthly price levels P_m^t for the months m in quarter t.

3.34 For RPPI construction methods other than stratification (hedonic regression, repeat sales, use of appraisal data), the relationship between the quarterly estimates of price change and the corresponding monthly estimates will be more complex. However, in the end, these methods will generate a price index, say P^t for period t, that is associated with a certain group of transactions (or stocks). Generally, the corresponding period t value associated with these stocks, say V^t, will be available and thus a corresponding period t volume, $Q^t = V^t/P^t$, can be defined, so the above algebra can be applied.

Revision Policies

3.35 It would seem that an RPPI for the sales of properties could be constructed without a need for revisions but as it turns out, it is not always easy to gather timely data on property sales. The construction of a stock type RPPI is dependent on census information on housing, which is often subject to long delays. Moreover, when a new census becomes available, it is generally desirable to use this information to retrospectively adjust the stock type RPPI back to the time of the previous housing census. Thus, it will generally be desirable to allow stock RPPIs to be revised. This should not pose any major problems for national accounts purposes, since they are routinely subject to revisions.

3.36 Revisions do cause problems, however, in the context of non-revisable statistics such as the CPI. The treatment of owner occupied housing in a CPI requires a stock type RPPI if either the user cost or opportunity cost approach is used.([18]) It may then be necessary to use preliminary information to compile the RPPI. When additional data become available, a revised CPI could be published as an *analytical series* so that analysts could form some rough estimates of the possible bias in using the unadjusted CPI based on a preliminary estimate of the RPPI for owner occupied housing.

Seasonal Adjustment

3.37 Although the situation may differ somewhat across countries, in general there are substantial seasonal fluctuations in the *quantities* of properties traded over the year. For the construction of an RPPI, the question is whether seasonality in quantities leads to seasonality in *prices*. The empirical evidence is somewhat mixed. Meese and Wallace (1991) find limited seasonality in prices in their econometric study. Prasad and Richards (2008) report that median prices in Australian cities are seasonal, but this seasonality vanishes after controlling for compositional change through stratification. At aggregate levels, and particularly at the nation-wide level, it seems therefore unlikely that RPPI series exhibit strong seasonal fluctuations. However, at lower levels of aggregation it would be useful to check whether any seasonality in prices is present and adjust for this if seasonally adjusted series are required. Some users do want seasonally adjusted series made available to them (in addition to the unadjusted series) if there is evidence of seasonality in prices.

3.38 In Chapter 4, a numerical example is worked out which shows how seasonality can be treated using simple index number techniques. Standard seasonal adjustment methods could also be used.

([18]) The acquisitions approach requires a new house price index which probably should exclude the land component of the selling price of a new dwelling unit. This new house price index could be adequately approximated by a suitable new house construction price index.

Appendix: The Role of House Price Indices in the Construction of User Costs

3.39 This Appendix shows how user costs and opportunity costs can be constructed. The first section discusses how user costs are constructed for durable goods in general. Next, additional difficulties are brought in which arise from the fact that properties are unique goods and are a mixture of land and structures components. Finally, the opportunity cost approach to pricing the services of Owner Occupied Housing (OOH) is discussed.

The Construction of User Costs for Durable Goods in General

3.40 In this section, the elements of user cost theory for a durable consumer good are laid out. The essence of durability is that it provides some sort of service to the purchaser over many time periods. For many purposes (including the valuation of household consumption expenditures on owner occupied housing services) it is not appropriate to apply the entire purchase cost of a durable good to the initial period of purchase; the purchase cost should be spread over its useful life. The question then becomes: how should this intertemporal cost be allocated over time?

3.41 There are two main approaches to pricing the *services* of an owner occupied dwelling unit:([19]) the *rental equivalence approach* and the *user cost approach*. The user cost approach is important in its own right – when only few dwelling units in a country are rented, it is not realistic to value the services of owner occupied housing using the rental equivalence approach – but it also is important as a way to explain how landlords might set their rents for rental dwelling units. However, pricing shelter services is more difficult than pricing the services of, say, a standard model automobile because housing services are more complex.([20]) Therefore, in this section the problems of pricing the services of an *ordinary durable consumer good* (that is available in the same form over many periods) will first be presented before dealing with the complexities associated with housing.

3.42 The user cost approach to the treatment of durable goods is in some ways very simple: it calculates the cost of purchasing the durable good at the beginning of the period, using the services of the durable over many periods and then netting off from these costs the benefits that could be received by selling the durable good at the end of the period, taking into account the interest foregone from having one's capital tied up in purchasing the durable. However, there are several details that are somewhat controversial such as the treatment of depreciation, interest and capital gains or holding gains.

3.43 Another complicating factor with the user cost approach is that it makes a distinction between current period purchases within the period under consideration and the holding of physical stocks of the durable at the beginning and end of the accounting period. Normally in the system of national accounts, all purchases are thought of as taking place at a single point in time, say in the middle of the period under study, and consumption is thought of as taking place within the period as well. Thus, in this case where the commodity is entirely consumed within the purchasing period, there is no need to consider the valuation of stocks of consumer durables that households may have at their disposal. The complexity involved in accounting for stocks and flows are unfamiliar to many price statisticians, so it may be useful to describe these problems in some detail here.

3.44 To determine the net cost of using a particular durable good during say period 0, assume that one unit of the durable good is purchased at the beginning of period 0 at the price P^0. The "used" or "second-hand" durable good can be sold at the end of period 0 at the price P_S^1. It might seem that a reasonable net cost for the use of one unit of the consumer durable during period 0 would be its initial purchase price P^0 less its end of period 0 "scrap value" or market opportunity selling price, P_S^1. However, money received at the end of the period is not as valuable as money received at the beginning of the period. To convert the end of period value into its beginning of the period equivalent value, it is necessary to *discount* the term P_S^1 by the term $1+r^0$ where r^0 is the beginning of period 0 nominal interest rate that the household (or purchaser) faces. Hence, the *period 0 user cost* u^0 for the consumer durable ([21]) is defined as

$$u^0 \equiv P^0 - P_S^1/(1+r^0) \qquad (3.A1)$$

3.45 There is another way to interpret the user cost formula (3.A1): the consumer purchases the durable at the beginning of period 0 at the price P^0 and charges himself or herself the rental price u^0. The remainder of the purchase price, I^0, defined as

$$I^0 \equiv P^0 - u^0 \qquad (3.A2)$$

([19]) The acquisitions approach implicitly allocates all of the services of a newly purchased housing unit to the period of purchase but the System of National Accounts does not recognize this approach as a valid approach to pricing the services of OOH. For other durable goods, the SNA does recognize the acquisitions approach as a valid approach for pricing the services of a durable good.

([20]) In particular, housing services provide the joint services of the structure and the land that the structure sits on and houses are generally unique goods.

([21]) This approach to the derivation of a user cost formula was used by Diewert (1974) who in turn based it on an approach due to Hicks (1946; 326). Note that later, this user cost will be interpreted as a beginning of the period user cost since all costs are discounted to the beginning of the period.

can be regarded as an *investment*, which is to yield the appropriate opportunity cost of capital r^0 the consumer faces. At the end of period 0, this rate of return could be realized provided that I^0, r^0 and the selling price of the durable at the end of the period P_S^1 satisfy

$$I^0(1+r^0) = P_S^1 \qquad (3.A3)$$

Given P_S^1 and r^0, (3.A3) determines I^0, which in turn, given P^0, determines the user cost u^0 via (3.A2).([22])

3.46 From the above it is clear that the user cost approach to pricing the services of a durable good for a period involves an investment aspect. Note that the user cost approach is also a *financial opportunity cost approach*; i.e., the opportunity cost of the financial capital that is tied up in the purchase (or continued holding) of the durable good is taken into account. Finally, note that user costs are not like the prices of nondurables or services because the user cost concept involves pricing the durable at *two* points in time rather than at a single point in time. Because the user cost concept involves prices at two points in time, money received or paid out at the first point in time is more valuable (assuming prices are going up in the economy) than money paid out or received at the second point in time and so *interest rates* filter into the user cost formula.

3.47 Also, because the user cost concept involves prices at two points in time, *expected prices* can be involved if the user cost is calculated at the beginning of the period under consideration instead of at the end. So the price statistician has two options for the choice of P_S^1:

- Use the *expected price* of the durable at the end of the period from the perspective of the beginning of the period, or
- Use the *actual market price* of a similar second hand durable at the end of the period (if such a market price exists).

3.48 The use of an expected price leads to an *ex ante user cost* whereas the use of an actual market price for the used durable at the end of the period leads to an *ex post user cost*. Which concept should be used in practice? In the present context it is reasonable to favour the ex ante concept for two reasons:

- The ex ante user cost concept is likely to be closer to a rental price of the durable good (if it exists),([23]) which many price statisticians would view as a preferred price for the services of the durable during the period, and
- The ex ante user cost is closer to the purchaser's *expected cost* for using the durable good during the period; the purchaser cannot know exactly what the end of period price will be and hence must form expectations about the end of period price of the durable, which leads to the ex ante user cost as the expected cost for using the services of the durable during the period. Thus, the ex ante user cost is likely to be the relevant charge for the services of the durable that motivates consumer behavior.

The issue of how exactly one forms expectations for the selling price of a used durable will be examined later when the pricing of housing services is discussed.

3.49 With all of the above complications, it is understandable that many price statisticians would like to avoid using user costs as a pricing concept. However, the use of user costs may be unavoidable in the context of pricing the services of owned dwellings under certain conditions. The user cost formula (3.A1) can be expressed in a more familiar form using the end of period 0 *depreciation rate* δ^0 and the period 0 *asset inflation rate* i^0. Define the end of period 0 *depreciation rate* δ^0 by

$$(1 - \delta^0) \equiv P_S^1/P^1 \qquad (3.A4)$$

where P_S^1 is the price of a used asset at the end of period 0 and P^1 is the price of a new asset at the end of period 0.([24]) The *period 0 inflation rate* for the new asset, i^0, is defined by

$$1+i^0 \equiv P^1/P^0 \qquad (3.A5)$$

Eliminating P^1 from equations (3.A4) and (3.A5) leads to the following formula for the *end of period 0 used asset price*:

$$P_S^1 = (1 - \delta^0)(1 + i^0)P^0 \qquad (3.A6)$$

Substitution of (3.A6) into (3.A1) yields the following expression for the *period 0 user cost* u^0:

$$u^0 = [(1 + r^0) - (1 - \delta^0)(1 + i^0)]P^0/(1 + r^0) \qquad (3.A7)$$

Note that $r^0 - i^0$ can be interpreted as a period 0 *real interest rate* and that $\delta^0(1+i^0)$ can be interpreted as an *inflation adjusted depreciation rate*.

3.50 In (3.A7), the user cost u^0 is expressed in terms of prices that are discounted to the *beginning* of period 0. However, it is also possible to express the user cost in terms of prices that are "antidiscounted" or "appreciated" to the *end* of period 0.([25]) The *end of period 0 user cost* p^0 is defined as

$$\begin{aligned} p^0 \equiv (1 + r^0)u^0 &= [(1 + r^0) - (1 - \delta^0)(1 + i^0)]P^0 \\ &= [r^0 - i^0 + \delta^0(1 + i^0)]P^0 \end{aligned} \qquad (3.A8)$$

where the second equation follows using (3.A7). If the real interest rate r^{0*} is defined as the nominal interest rate r^0 less

([22]) This derivation for the user cost of a consumer durable was also made by Diewert (1974; 504).

([23]) If a company is in the business of leasing the services of an automobile for a certain period, it has to form expectations about the price of its used autos at the end of the leasing period in order to calculate its schedule of rental or leasing prices for its stock of automobiles.

([24]) If the durable that was purchased (or held) by the household at the beginning of the period was a used durable, then interpret P^1 as the second hand market price of a used durable that is in the same condition as the initially held durable.

([25]) Thus, the beginning of the period user cost u^0 discounts all monetary costs and benefits into their dollar equivalent at the beginning of period 0 whereas p^0 accumulates or appreciates all monetary costs and benefits into their dollar equivalent at the end of period 0. This leaves open how flow transactions that take place within the period should be treated. Following the conventions used in financial accounting suggests that flow transactions taking place within the accounting period be regarded as taking place at the end of the accounting period and hence following this convention, end of period user costs should probably be used by the price statistician. For additional material on beginning and end of period user costs, see Diewert (2005; 485).

the asset inflation rate i^0 and if the generally small term $\delta^0 i^0$ is neglected, then the end of the period user cost defined by (3.A8) reduces to ([26])

$$p^0 = (r^{0*} + \delta^0)P^0 \qquad (3.A9)$$

Abstracting from transactions costs, it can be seen that the end of the period user cost defined by (3.A9) is an *approximate rental cost*; the rental cost for the use of a durable good should equal the (real) opportunity cost of the capital tied up, $r^{0*}P^0$, plus the decline in value of a new asset over the period, $\delta^0 P^0$. Formulae (3.A8) and (3.A9) thus cast some light on the economic determinants of rental or leasing prices for consumer durables.

3.51 If the simplified user cost formula defined by (3.A9) above is used, then forming a price index for the user cost of a durable good is not very much more difficult than forming a price index for the purchase price of the durable good, P^0. The price statistician needs only to

- Make a reasonable assumption as to what an appropriate monthly or quarterly real interest rate r^{0*} should be; ([27])
- Make an assumption as to what a reasonable monthly, quarterly or annual depreciation rate δ^0 should be; ([28])
- Collect purchase prices P^0 for the durable and form the user cost.

3.52 There are some additional difficulties associated with the user cost approach to measuring the services of a consumer durable. The above discussion deals only with the formation of a user cost for a newly purchased consumer durable. It is necessary to extend the analysis to price the services of used units of the consumer durable as well. In order to price out the services of a used durable good, it is necessary to make assumptions about the form of depreciation of the good; does the service flow given to the consumer remain constant throughout the useful life of the durable good or does it decline as the good ages? If the service flow remains constant, then we have *one hoss shay* or *light bulb depreciation* whereas if the service flow declines at a constant linear or geometric rate, then we have *straight line* or *geometric depreciation*. ([29])

3.53 How can one tell whether one hoss shay or geometric depreciation is applicable for a certain consumer durable? The two patterns of depreciation (and user valuation) can be distinguished if *cross sectional information on rentals* of the consumer durable by the age of the rented asset is available. If depreciation is thought to follow that of the one hoss shay, then the rental rates for the consumer durable at a given point in time should be approximately constant for all ages of the durable good whereas if there is geometric depreciation, the rental rates for the good should decline at a geometric rate according to the age of the used durable good. Thus, the various patterns of depreciation can be distinguished if rental markets for used durables exist. In a similar fashion, when *cross sectional information on the prices of used units* of the consumer durable is available, alternative patterns of depreciation can be distinguished. ([30])

The User Cost of Owner Occupied Housing

3.54 An *owner occupied dwelling* is different from a normal consumer durable good because of its unique character. Consequently, it will be difficult to use information on used asset prices in order to determine the pattern of depreciation, which is required to measure a user cost for an owned dwelling unit. As was mentioned in the introduction to this chapter, a particular dwelling unit in a particular country is unique for a number of reasons:

- The *location* of each dwelling unit is unique and location will affect the price of the unit.
- Over time, the dwelling unit *depreciates*; unless there is one hoss shay depreciation, the utility generated by a particular dwelling for the occupying household will tend to decline over time due to the effects of the aging of the structure.
- On the other hand, the effects of depreciation can be offset by *renovation expenditures*, which increase the utility of the dwelling unit.

3.55 For some purposes, it is important to decompose the price of a property into land and structures components. To model the fact that housing is a composite good,

([26]) If one takes the ratio of the approximate rental price for the durable good, p^0, to its asset value, P^0, the rent to value ratio $p^0/P^0 = r^{0*} + \delta^0$ is obtained, which is equal to the sum of the appropriate real interest rate r^{0*} plus the appropriate depreciation rate δ^0. Since real rates of interest and depreciation rates are approximately constant over time, the rent to value ratio will also be approximately constant over time and hence a historical rent to value ratio times a current asset price index will generally give an adequate approximation to an imputed rental rate for the consumer durable. In the housing literature, a rent to value ratio is often called a capitalization rate; e.g., see Garner and Short (2009; 237) or Crone, Nakamura and Voith (2009; 70).

([27]) This is not completely straightforward. It is difficult to determine exactly what the appropriate household nominal opportunity cost of capital should be and even if we come to agreement on this point, there will be difficulties in estimating expected inflation rates. In the end, it may boil down to picking a somewhat arbitrary real interest rate in the 2% to 5% range (for annual rates), depending on the recent experience of the country under consideration.

([28]) The geometric model for depreciation requires only a single monthly or quarterly depreciation rate. Other models of depreciation may require the estimation of a sequence of vintage depreciation rates. If the estimated annual geometric depreciation rate is δ_a, then the corresponding monthly geometric depreciation rate δ can be obtained by solving the equation $(1 - \delta)^{12} = 1 - \delta_a$. Similarly, if the estimated annual real interest rate is r_a^*, then the corresponding monthly real interest rate r^* can be obtained by solving the equation $(1 + r^*)^{12} = 1 + r_a^*$.

([29]) For descriptions of how to construct user costs by the age of the asset for each of these depreciation models, see Diewert and Lawrence (2000) or Diewert (2005; 506-521).

([30]) In the housing context where each house can be regarded as a unique asset, it is necessary to make some additional assumptions in order to identify the form of depreciation. The extra assumptions are of the following type: it is assumed that all housing units in a certain class of structures have a similar pattern of depreciation. Using this type of assumption, empirical evidence suggests that one hoss shay depreciation is unlikely in the housing market since renters are generally willing to pay a rent premium for a new unit over an older unit of the same type. For empirical evidence of this age premium, see Malpezzi, Ozanne and Thibodeau (1987; 378) and Hoffman and Kurz (2002; 19).

consider a particular newly constructed dwelling unit that is purchased at the beginning of period 0. Suppose that the purchase price is V^0. This value can be regarded as the sum of the cost of producing the structure, $P_S^0 Q_S^0$, where Q_S^0 is the number of square meters of floor space in the structure and P_S^0 is the beginning of period 0 price of construction per square meter, and the cost of the land, $P_L^0 Q_L^0$, where Q_L^0 is the number of square meters of the land that the structure sits on and the associated yard and P_L^0 is the beginning of period 0 price of the land per square meter. ([31]) Thus at the beginning of period 0, *the value of the dwelling unit* is V^0 defined as follows:

$$V^0 = P_S^0 Q_S^0 + P_L^0 Q_L^0 \qquad (3.A10)$$

3.56 Suppose that the anticipated price of a unit of a new structure at the beginning of period 1 is P_S^{1a} and that the anticipated price of a unit of land at the beginning of period 1 is P_L^{1a}. Define the *period 0 anticipated inflation rates for new structures and land*, i_S^0 and i_L^0 respectively, as follows:

$$1 + i_S^0 \equiv P_S^{1a}/P_S^0 \qquad (3.A11)$$

$$1 + i_L^0 \equiv P_L^{1a}/P_L^0 \qquad (3.A12)$$

Let δ^0 be the period 0 depreciation rate for the structure. The anticipated beginning of period 1 value for the structure and the associated land is then equal to

$$V^{1a} = P_S^{1a}(1 - \delta^0)Q_S^0 + P_L^{1a}Q_L^0 \qquad (3.A13)$$

So the anticipated value of the dwelling unit at the end of period 1, V^{1a}, equals the anticipated price (per unit of new structure of the same quality) at the end of the period, P_S^{1a}, times one minus the period 0 depreciation rate, $(1 - \delta^0)$, times the quantity of structure purchased at the beginning of period 0, Q_S^0, ([32]) plus the anticipated price of land at the end of period 0, P_L^{1a}, times the quantity of land that the structure associated with the structure, Q_L^0.

3.57 Now calculate the cost (including the imputed opportunity cost of capital r^0) ([33]) of buying the dwelling unit at the beginning of period 0 and (hypothetically) selling it at the end of period 0. The following *end of period 0 user cost or imputed rental cost* R^0 for the dwelling unit is obtained using (3.A11)-(3.A13):

$$R^0 \equiv V^0(1 + r^0) - V^{1a} \qquad (3.A14)$$

$$= [P_S^0 Q_S^0 + P_L^0 Q_L^0](1 + r^0) - [P_S^{1a}(1 - \delta^0)Q_S^0 + P_L^{1a}Q_L^0]$$

$$= [P_S^0 Q_S^0 + P_L^0 Q_L^0](1 + r^0) - [P_S^0(1 + i_S^0)(1 - \delta^0)Q_S^0 + P_L^0(1 + i_L^0)Q_L^0]$$

$$= p_S^0 Q_S^0 + p_L^0 Q_L^0$$

where separate period 0 *user costs of structures and land*, p_S^0 and p_L^0, are defined as follows:

$$p_S^0 = [(1 + r^0) - (1 + i_S^0)(1 - \delta^0)]P_S^0$$
$$= [r^0 - i_S^0 + \delta^0(1 + i_S^0)]P_S^0 \qquad (3.A15)$$

$$p_L^0 = [(1 + r^0) - (1 + i_L^0)]P_L^0 = [r^0 - i_L^0]P_L^0 \qquad (3.A16)$$

Note that the above algebra indicates some of the most important determinants of market rents for rental properties. ([34]) The user cost formulae defined by (3.A15) and (3.A16) can be further simplified if the approximations that were made in the previous section are made here as well (recall equation (3.A9) above); i.e., assume that the terms $r^0 - i_S^0$ and $r^0 - i_L^0$ can be approximated by a real interest rate r^{0*} and neglect the small term δ^0 times i_S^0 in (3.A15). Then the user costs defined by (3.A15) and (3.A16) simplify to

$$p_S^0 = (r^{0*} + \delta^0)P_S^0 \qquad (3.A17)$$

$$p_L^0 = r^{0*}P_L^0 \qquad (3.A18)$$

3.58 The above exposition has neglected two other sources of period 0 cost associated with owning a dwelling unit:

- Various maintenance and insurance costs that are associated with the ownership of a dwelling unit and
- Property taxes that may be payable by the owner to local or state governments.

Assume that period 0 maintenance and insurance costs, M_S^0, are mainly associated with the structure rather than the land under the structure. Suppose that these costs are paid at the end of period 0. These costs can be converted into a *per unit structure charge* μ_S^0 as follows:

$$\mu_S^0 \equiv M_S^0/(P_S^0 Q_S^0) \qquad (3.A19)$$

Suppose the property taxes that fall on the structure, T_S^0, and the property taxes that fall on the land under the structure, T_L^0, are paid at the end of period 0. Then the period 0 structure and land property tax rates, τ_S^0 and τ_L^0, can be defined as follows:

$$\tau_S^0 \equiv T_S^0/(P_S^0 Q_S^0) \text{ and } \tau_L^0 \equiv T_L^0/(P_L^0 Q_L^0) \qquad (3.A20)$$

These additional maintenance and property tax costs need to be added to the imputed rental cost for using the dwelling unit R^0. Thus (3.A14) now becomes:

$$R^0 \equiv V^0(1 + r^0) - V^{1a} + M_S^0 + T_S^0 + T_L^0 \qquad (3.A21)$$

$$= p_S^0 Q_S^0 + p_L^0 Q_L^0$$

([31]) If the dwelling unit is part of a multiple unit structure, then the land associated with it will be the appropriate share of the total land area. This share could be 1 divided by the number of units on the plot or the floor space of the unit divided by the total floor space of the entire structure. Either share allocation could be justified.

([32]) Thus the period 0 depreciation rate δ^0 is an end of period anticipated cross sectional depreciation rate; i.e., δ^0 is defined by the equation $(1-\delta^0) = V_S^{1a}/(P_S^{1a}Q_S^0)$, where V_S^{1a} is the anticipated market value of the (depreciated) structure at the end of period 0 and $P_S^{1a}Q_S^0$ is the anticipated end of period 0 value of a newly constructed structure with floor space area Q_S^0.

([33]) More elaborate discussions on how to choose the appropriate opportunity cost of capital when the owner of a dwelling unit has a mortgage on the unit can be found in Diewert and Nakamura (2009), Diewert, Nakamura and Nakamura (2009) and Garner and Verbrugge (2009b; 176).

([34]) Looking at (3.A16), it can be seen that the land user cost could be negative if the anticipated rate of land price appreciation, i_L^0, is greater than the beginning of the period opportunity cost of capital, r^0. Possible solutions to this complication will be discussed below.

where the new separate period 0 *user costs of structures and land*, p_S^0 and p_L^0, are defined as follows:

$$p_S^0 = [r^0 - i_S^0 + \delta^0(1 + i_S^0) + \mu_S^0 + \tau_S^0]P_S^0 \quad (3.A22)$$

$$p_L^0 = [r^0 - i_L^0 + \tau_L^0]P_L^0 \quad (3.A23)$$

The *imputed rent for a dwelling unit* using the user cost approach to the valuation of housing services is thus made up of six main costs:

- The real opportunity cost of the financial capital tied up in the structure, $(r^0 - i_S^0)P_S^0Q_S^0$;
- The real opportunity cost of the financial capital tied up in the land, $(r^0 - i_L^0)P_L^0Q_L^0$;
- The depreciation cost of the structure, $\delta^0(1 + i_S^0)P_S^0Q_S^0$;
- The maintenance and insurance costs associated with the structure, $\mu_S^0P_S^0Q_S^0$;
- The property taxes associated with the structure, $\tau_S^0P_S^0Q_S^0$, and
- The property taxes associated with the land underneath and surrounding the structure, $\tau_L^0P_L^0Q_L^0$.

3.59 The above user cost approach to pricing the services of a dwelling unit in period 0 can be applied to various *housing strata*, e.g., to detached dwellings, row houses or duplexes or town houses and apartment blocks. For the last two types of dwelling units, the land component for each individual dwelling unit needs to be constructed. For example, if there are 20 dwelling units in an apartment block, then the land share of each individual dwelling unit could be set to 1/20th of the total land area that the apartment block occupies.([35]) Dwelling units can also be grouped according to their construction type, which could be primarily wood, brick, concrete or "traditional".

3.60 If a statistical agency produces national balance sheet estimates, then data on the total value of residential land and residential structures should be available. However, data on the quantity of residential land may not be known. Estimates of the country's total real stock of residential structures can be obtained by deflating the balance sheet estimate of the value of residential housing by the country's corresponding investment price deflator for residential housing.

3.61 There are at least two uses for the above user cost approach to pricing the services of housing:

- The user costs can be compared to market rents for dwelling units that are actually rented during the period under consideration, and
- The user costs can be used to value the services of owner occupied housing.

As will be seen later in this section, it turns out that user costs do approximate market rents (for lower cost housing in the US at least), provided expectations of future inflation in house prices are formed in a certain way.

3.62 As mentioned before, two main methods for valuing the services of owner occupied housing have been suggested for national accounts purposes: the user cost approach just explained and the rental equivalence approach. The rental equivalence approach is straightforward; for owner occupied houses in a certain stratum, we look for similar rented dwelling units and impute the market rental to the corresponding owner occupied house. In many countries, the rental equivalence approach works well, but it does not work well if rental markets are thin or if there are price controls on rents.

3.63 If user costs are used to value the services of owner occupied dwelling units in a country, then the maintenance and insurance rate term μ_S^0 in the user cost of structures formula (3.A22) should be dropped from the formula, since maintenance and insurance expenditures for owner occupied houses will generally be captured elsewhere in the household expenditure accounts.

3.64 The simplified approach to the user cost of housing explained above in equations (3.A17) and (3.A18) can be even further simplified by assuming that the ratio of the quantity of land to structures is fixed and so the aggregate user cost of housing is equal to $[r^{0*} + \delta + \mu + \tau]P_H^0$, where P_H is a quality adjusted price index that is applicable to the country's entire housing stock (including both structures and the underlying land) for the period under consideration and δ, μ and τ are respectively a depreciation rate, a maintenance and insurance rate and a property tax rate that applies to the composite of structures and land. Under this simplified approach to value the services of owner occupied housing, as was seen in the last paragraph above, the term μ should be dropped from the simplified user cost. The resulting *simplified approach* is applied in Iceland; see Gudnason (2004) and Gudnason and Jónsdóttir (2009) ([36]) and in some European countries; see the detailed exposition of the method by Katz (2009).([37]) A variant of this approach is used by the US Bureau of Economic Analysis: Lebow and Rudd (2003; 168) note that the US national accounts imputation for the services of owner occupied housing is obtained by applying *rent to value ratios* for

([35]) It is not completely straightforward to allocate the common land shared by the dwelling units into individual shares; i.e., instead of an equal division of the land, we could use the relative floor spaces of each apartment as the allocator. There are also problems associated with the relative height of the individual apartment units; i.e., an apartment on a higher floor will typically rent for more than an apartment on a lower floor.

([36]) The real interest rate that is used is approximately 4% per year and the combined depreciation rate for land and structures is assumed to equal 1.25% per year. The depreciation rate for structures alone is estimated to be 1.5% per year. Property taxes are accounted for separately in the Icelandic CPI. Housing price information is provided by the State Evaluation Board based on property sales data of both new and old housing. The SEB also estimates the value of the housing stock and land in Iceland, using a hedonic regression model based on property sales data. The value of each household's dwelling is collected in the Household Budget Survey.

([37]) Katz (2009) and Garner and Verbrugge (2009b; 176) give further references to the literature on the simplified user cost method.

tenant occupied housing to the stock of owner occupied housing with the same characteristics as the rented property.([38]) The rent to value ratio can be seen as an estimate of the applicable real interest rate plus the depreciation rate plus a maintenance and insurance rate plus the property tax rate, $r^{0*} + \delta + \mu + \tau$.([39])

3.65 How exactly should the real interest rate, r^{0*}, be estimated? One possible method is to just make a reasonable guess:([40])

"The remaining question was what value of the real rate of return is appropriate? Evidence was presented to the task force that suggested that, at least in Western European countries, the appropriate real rate of return for owner-occupied dwellings was lower than that for other durables, perhaps in the 2.5 to 3.0 percent range. It was the consensus of the task force that given the actual situation in the CCs [Candidate Countries from Eastern Europe], real rates of return on both dwellings and land should be assumed to be 2.5 percent." Arnold J. Katz (2009; 46).

3.66 A second method is to use mortgage interest rates as estimates for the nominal opportunity cost of financial capital tied up in housing and to use econometric forecasting techniques to estimate predicted house price inflation rates (and then the real interest rate can be set equal to the nominal interest rate less the predicted house price inflation rate). Several variants of this second approach were tried by Verbrugge (2008) and Garner and Verbrugge (2009a) (2009b) using US data. However, as these authors show, this approach was not successful in that the resulting user cost estimates were extremely volatile (and frequently negative) and not at all close to corresponding market rents.

3.67 A third approach to the determination of an appropriate real interest rate to be used in a user cost formula for housing services was carried out by Garner and Verbrugge (2009b) using US data. They used applicable mortgage interest rates as estimates for the nominal opportunity cost of financial capital and used current period estimates of consumer price index inflation as their estimate of expected house price appreciation. Much to their surprise, they found that the resulting user costs tracked market rents rather well.([41]) The conclusion is that either making a reasonable guess for the real interest rate or using CPI inflation as a proxy for expected house price inflation gives rise to reasonable user costs that are likely to be fairly similar to market rents, at least for relatively inexpensive housing units.

3.68 It is evident that the main drivers for the user costs of structures and land are price indices for new dwelling construction, P_S^t, and for residential land, P_L^t. Most statistical agencies have a constant quality price index for new residential structures, because this index is required in the national accounts in order to deflate investment expenditures on residential structures. This index could be used as an approximation to P_S^t.([42])

3.69 This completes the overview of the user cost approach to pricing residential housing services. In the following section, another approach to pricing the services of owner occupied housing will be reviewed: the *opportunity cost approach*.

The Opportunity Cost Approach to the Valuation of Owner Occupied Housing Services

3.70 Recall the two main methods for valuing the services of owner occupied housing (OOH): the rental equivalence approach and the user cost approach. In the rental equivalence approach, an owner of a dwelling unit who chooses to live in it (or at least not rent it out to someone else) values the services of the dwelling by the market rent which is foregone. This is a very *direct opportunity cost* of using the dwelling. On the other hand, the user cost approach to valuing dwelling services is basically a *financial opportunity cost* of using the services of the dwelling unit during the period under consideration. It has been suggested that the true opportunity cost of using the services of an owned dwelling unit is the *maximum of the rent foregone and the user cost*:

"We conclude this section with the following (controversial) observation: perhaps the 'correct' opportunity cost of housing for an owner occupier is not his or her internal user cost but the *maximum* of the internal user cost and what the property could rent for on the rental market. After all, the concept of opportunity cost is supposed to represent the *maximum sacrifice* that one makes in order to consume or use some object and so the above point would seem to follow." W. Erwin Diewert (2009b; 113).

Diewert and Nakamura (2009) and Diewert, Nakamura and Nakamura (2009) pursued this opportunity cost approach to the valuation of owner occupied housing services in more detail but it can be seen that this approach seems to be a valid one. Moreover, it has the advantage

([38]) See also Crone, Nakamura and Voith (2009) and Garner and Short (2009; 237) for a description of this capitalization method for determining rental prices for housing units from estimates of the corresponding asset values. It can be seen that this method is actually a method for implementing the rental equivalence approach to valuing the services of owner occupied dwelling units.

([39]) If an owned dwelling unit has the value V^0 and a rented dwelling unit with the same characteristics has the rent to value ratio $\gamma = r^{0*} + \delta + \mu + \tau$, then the imputed rent for the owned dwelling unit is set equal to $(\gamma - \mu)V^0 = (r^{0*} + \delta + \tau)V^0$, since insurance and maintenance expenditures on the owned dwelling will be recorded elsewhere in the System of National Accounts.

([40]) The Australian Bureau of Statistics assumes a constant real interest rate equal to 4% per year when constructing its estimates of capital services.

([41]) Using this approach, Garner and Verbrugge (2009b; 179) also found that there were no negative estimated user costs in their US data set.

([42]) This index may only be an approximation since it covers the construction of rental properties as well as owner occupied dwellings.

of eliminating the problem with the user cost approach: namely, that the user cost approach can generate *negative* user costs if ex post or forecasted housing inflation rates are used in the user cost formula.

3.71 In practice, the opportunity cost approach to pricing OOH services may lead to similar results as the rental equivalence approach provided that expected inflation in the user cost formula is set equal to CPI inflation, since Garner and Verbrugge (2009b) show that for most low end rental properties, the rental equivalence and user cost approaches give much the same answer, at least in the US. However, there is evidence that user costs may be considerably higher than the corresponding market rentals for high end properties. Table 3.1 is taken from Heston and Nakamura (2009a; 113) (2009b; 277) and shows average annual market rent to market value of rental properties in a number of regions; i.e., it shows capitalization ratios as a function of the value of the rental property. Table 3.1 is based on a survey of US federal government employees conducted as part of a Safe Harbor process regarding the Cost of Living Allowance (COLA) program administered by the United States Office of Personnel Management. This program began in 1948 and pays an allowance above the federal salary schedule in three geographic areas (Alaska, the Caribbean and the Pacific) based on prices in these COLA areas relative to the Washington D.C. housing area.([43])

Two facts emerge from the Table 3.1:

- Capitalization ratios differ substantially across regions ([44]), and
- As one moves from inexpensive properties to more expensive properties the capitalization ratio for the high end properties is about one half the ratio for low end properties for all regions.

The second point listed above also emerges from the much more extensive US data on annual rents for the years 2004-2006 as a function of the corresponding home values found in Figure 1 in Garner and Verbrugge (2009b; 178). For a $100 000 home, the corresponding average annual rent was about $10 000 while for a $900 000 home the corresponding average annual rent was about $30 000. Thus the capitalization ratio fell from about 10 % to about 3.3 % as the home value increased from $100 000 to $900 000.

([43]) This program is directed at comparing the costs of living for federal employees in the non-continental United States to Washington D.C. area. Housing is one of the most important and most difficult of the comparisons required under this program. The COLA areas include Alaska, Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands: a very diverse range of climates and housing needs.

([44]) The relatively high capitalization ratios for Alaska may be due to the inclusion of heating services in the rent.

Table 3.1. Estimated Rent to Value Ratios as Percentages (Capitalization Ratios)

	Renter			
	Alaska	Wash D.C.	Carib	Hawaii-Pacific
Value($)	(1)	(2)	(3)	(4)
50 000	13.0	8.9	6.3	6.9
100 000	12.0	8.2	5.8	6.4
200 000	10.2	6.9	4.9	5.4
500 000	6.2	4.3	3.0	3.3

Source: Heston and Nakamura (2009a)

3.72 What factors could explain this dramatic drop in the capitalization ratio as we move from inexpensive properties to more expensive properties? As was indicated previously, the rent to value ratio can be regarded as an estimate of the applicable real interest rate plus the depreciation rate plus the property tax rate, $r^{0*} + \delta + \mu + \tau$, and these rates should not be all that different for properties of differing value. There are at least three possible explanations:

- High value properties may have a much higher proportion of land, hence the depreciation rate δ, regarded as a decline in value of the property due to aging of the structure, will be smaller as the land to structure ratio increases.([45])
- A substantial fraction of a landlord's monitoring, accounting and billing expenses may be in the nature of a fixed cost and hence these costs will drop as a fraction of the rent as the value of the property increases.

([45]) This explanation was suggested by Diewert (2009a; 486) and Garner and Verbrugge (2009b; 182).

- Rentals of high value residential properties are not made on a commercial basis; i.e., they may be made on a temporary basis, with the renters serving as "house sitters" who pay somewhat subsidized rents as compared to the owner's financial opportunity cost.

It seems unlikely that the imperfect determination of the depreciation rate can explain the big decline in capitalization ratios as the value of the property increases; estimates of housing depreciation rates are generally in the 1 to 2% per year range,([46]) and these rates are too low to fully explain the declines in the capitalization ratios. Similarly, the costs of maintaining and insuring a rental property that are collected in the term μ are likely to be relatively small and thus are unlikely to fully explain the phenomenon. Thus it may be that the third explanation is an important explanatory factor. If this is indeed the case, then the opportunity cost approach to the valuation of OOH services would give a much higher valuation to OOH services than the rental equivalence approach.([47])

([46]) Garner and Verbrugge (2009b; 176) and Garner and Short (2009; 244) assume annual depreciation rates (as fractions of the value of the property including both structures and land) of 1% per year.

([47]) Thus the discrepancy between the rental equivalence approach to the valuation of OOH services and the opportunity cost approach may not be very important in the time series context because both measures may move in tandem. But in the context of making international comparisons, this argument will not be applicable due to the fact that the percentage of owner occupied dwelling units differs substantially across countries.