A Simple Alternative House Price Index Method

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Abstract

This paper presents the Sale Price Appraisal Ratio (SPAR) method for constructing house price indexes. The method, which uses ratios of transaction prices and previous appraised values to build up an index, has been applied since the early 1960s to produce semi-annual price indexes for regions and cities in New Zealand. We compare the official New Zealand indexes for three urban areas with repeat sales and hedonic indexes created from the same transactions data, and observe that the SPAR method produces an index very much like those produced by hedonic methods. Given the number of advantages and few disadvantages that we find for the SPAR method relative to the more traditional methods, we maintain that it should be considered by government agencies elsewhere when developing house price indexes.

Key words: house price indexes

1. Introduction

House price indexes are important for numerous reasons. They are crucial inputs for academic research aimed at gaining a better understanding of the housing market (such as analyses of the determinants of house prices and of the efficiency of housing markets), but also for investigations of issues of societal relevance (such as analyses of housing affordability or whether or not housing bubbles exist). Recent research has concluded that housing risk can be hedged, which requires an accurate price index (Englund, Hwang, and Quigley, 2002). Given the importance of housing in households' wealth (more than 50% in many countries), the accurate measurement of house price movements is a vital topic from both academic and practical perspectives.

For the above-mentioned analyses, house price indexes should possess some specific qualities. Despite the fact that median house price indexes are widely available in several countries, they are prone to severe biases due to the heterogeneity of properties. Stated differently, such methods are unable to distinguish between movements in prices and changes in the composition of dwellings sold from one period to the next. Methods that involve some quality control should thus be used. Three such methods exist to date: the hedonic method,

the repeat sales approach, and the hybrid method. The hedonic method controls for quality by using multiple regression models with the properties' attributes as independent variables. With the repeat sales method, quality control is in theory achieved by considering only the subset of properties that have sold repeatedly over a period of time. The hybrid approach combines the hedonic and repeat sales approaches, thus alleviating the specification issues of hedonic models and the sample selection biases of the repeat sales method (Case, Pollakowski, and Wachter, 1991; Clapp and Giaccotto, 1992a).

There is, however, a tradeoff between control for quality – and hence the desired property of constant quality indexes – and ease of construction. Both hedonic and hybrid models lead to constant quality indexes, but such indexes require large databases with detailed sets of property attributes. Moreover, such indexes involve econometric issues that require particular technical skills on the part of the individuals producing the index. In contrast, repeat sales indexes are easy to administer, but do not necessarily produce true constant quality indexes.

The aim of this paper is to present a method that would possess most of the qualities of a hedonic index, but that would be substantially easier to administer. This method is the Sale Price Appraisal Ratio (SPAR) method. It combines information from appraisals and sale prices to construct house price indexes. In contrast to the repeat sales method, the SPAR method relies on all transactions that have occurred in a given housing market, and hence should be less prone to sample selection bias. It is also consistent when data for new time periods are added, which is not the case for the repeat sales method. Finally, the index is constant quality provided that appraisals are adjusted by the value of improvements. We maintain that the advantages and the relatively limited drawbacks of the SPAR method make it an ideal candidate for use by government agencies in developing house price indexes.

The empirical analysis is conducted for three New Zealand cities where such an index has been used for over 40 years. We compare the published indexes to two types of hedonic indexes and two types of repeat sales indexes. These indexes are constructed using a database containing over 165,000 transactions for the period from the second half of 1989 to the second half of 1996. The SPAR method is found to produce an index very much like those produced by hedonic methods, particularly the single equation hedonic method. We argue that hedonic indexes are better benchmarks for the SPAR method than are repeat sales indexes. The latter are in most cases lower than the former because they do not hold age constant, at least not in their basic specification (Gatzlaff and Ling, 1994), and because they usually are geometric rather than arithmetic averages of transaction prices (Shiller, 1991).

The remainder of the paper is organized as follows. In section 2, we review hedonic and repeat sales methods. The SPAR method is described in the following section. Section 4 contains a discussion of the pros and cons of alternative house price index methods, while the results of our empirical analysis are reported in section 5. The final section provides some concluding remarks.

2. Hedonic and Repeat Sales Methods

There are several methods for constructing house price indexes. Some of these methods were created decades ago and numerous variants have been developed since.[1] The easiest way to construct indexes is to refer to a summary measure, such as mean or median price per period. Given the heterogeneity of properties, the median is usually preferred to the mean. Median house prices have been used by several researchers, mostly for comparison purposes (e.g., Mark and Goldberg, 1984; Crone and Voith, 1992; Gatzlaff and Ling, 1994; Wang and Zorn, 1997); however, medians also form the basis of publicly available house price indexes. In the U.S., for instance, the index published by the National Association of Realtors is based on median prices. Such indexes are easy to construct, but they suffer from the fact that little or no control for quality is made (see, e.g., Case and Shiller, 1987).

The hedonic method is a widely used technique to control for the heterogeneous nature of properties when constructing house price indexes. It recognizes that properties are composite products: while attributes are not sold separately, regressing the sale price of properties on their various characteristics yields the marginal contribution of each characteristic. Both structural and location attributes are included in a hedonic regression.

There are two ways of constructing an index using the hedonic method. In the first approach, a separate regression is performed for each time period and the index is constructed by applying the estimated implicit prices to a standardized bundle of attributes. The advantage of this method is that implicit attribute prices are allowed to vary over time. This is not the case with the second approach, in which one overall hedonic regression is performed and time dummy variables are included. The estimated coefficients on the time variables yield the price index. The former type of model is usually preferred (Gatzlaff and Ling, 1994; Knight, Dombrow, and Sirmans, 1995). The hedonic method is used, for example, to construct indexes of single-family houses in the U.K. (Halifax and Nationwide)

[1] Colwell and Dilmore (1999) argue that the first published hedonic study was a 1922 University of Minnesota master's thesis on agricultural land values.

and of various types of residential properties in Switzerland (Informations- und Ausbildungszentrum für Immobilien).

As with all regression analyses, care should be exercised in choosing what variables to include in the model, but also in regard to functional form. Indeed, to obtain unbiased estimates of house price indexes, the regression should be specified correctly with respect to both functional form and independent variables. Many of the attributes that can be expected to influence the price of a property, particularly neighborhood and location variables, are often not available (Case, Pollakowski, and Wachter, 1991). As for functional form, the log-linear form is usually preferred, in particular because coefficients can be more easily interpreted and because it mitigates some statistical problems (Malpezzi, 2003). Recent work on hedonic price indexes has also focused on the impact of spatial effects on hedonic indexes (Gelfand *et al*., 2004).

The repeat sales method is another popular method to control for the heterogeneity of properties when constructing house price indexes. The method, originally developed by Bailey, Muth, and Nourse (1963), holds quality constant by measuring the same asset in two periods and hence there is no need to include the properties' attributes in the model. Specification error should in theory be eliminated. The model to be estimated is a regression of the natural logarithm of the ratio of second sale price to first sale price on a set of time dummy variables that are equal to -1 for the year of the first sale, 1 for year of second sale, and 0 otherwise. The estimated regression coefficients make it possible to construct the repeat sales index.

Two improvements have been suggested to the original model developed by Bailey, Muth, and Nourse (1963). The first is related to the fact that house prices will generally increase over time, which introduces heteroskedasticity. Case and Shiller (1987, 1989) developed the weighted repeat sales method that involves two steps. The first is to estimate the traditional repeat sales equation, while the second uses the residuals from the first step to construct weights that are used to correct for heteroskedasticity using Generalized Least Squares, or GLS (see also Dreiman and Pennington-Cross, 2004). A modified version of the weighted repeat sales method is used by the U.S. Office of Federal Housing Enterprise Oversight to construct quarterly house price indexes for single-family detached properties (Calhoun, 1996).

Another important improvement is the hedonic repeated measure developed by Shiller (1991, 1993), which makes it possible to account for possible changes in house characteristics between first and second sales. The method involves including some hedonic

characteristics in a traditional repeat sales model. Clapp and Giaccotto (1998) advocate using assessed values at time of first and second sales as a parsimonious control for the quality of properties.

To address the bias and inefficiency problems in both the hedonic and repeat sales approaches, several authors have combined both types of models in so-called hybrid models. Case and Quigley (1991) use three stacked equations that are applied to three different groups of transactions. The first equation is a hedonic equation applied to all single sales, the second is a repeat sales equation applied to unchanged repeats, while the third is a repeat sales equation only on those repeats whose quality has changed between both sales.

Several improvements have subsequently been proposed to the hybrid approach. The procedure advocated by Quigley (1995) is based upon an explicit error structure that assumes a random walk in housing prices and a dwelling-unit-specific component of variation. In contrast to Hill, Knight, and Sirmans (1997), who use maximum likelihood techniques, Quigley relies upon robust GLS models to achieve asymptotic efficiency. Knight, Dombrow, and Sirmans (1995) also combine multiple sales observations with single sales transactions while permitting implicit prices from hedonic regressions to vary over time. They use seemingly unrelated regressions as a way of getting more efficient estimates. Finally, Englund, Quigley, and Redfearn (1998) improve hybrid models by distinguishing between the effects of observable and unobservable aspects of quality and between the effects of depreciation and vintage on property prices.

Several authors have used different house price index construction methods on the same data set and compare the resulting indexes. Mark and Goldberg (1984) find that repeat sales indexes tend to exhibit smaller increases than summary and hedonic indexes. Case, Pollakowski, and Wachter (1991) also find that repeat sales indexes increase more slowly than those constructed using other methods. Contrary to Case and Quigley (1991), they do not find any clear efficiency gains from using the hybrid method. Meese and Wallace (1997) find that repeat sales and hybrid methods produce less reliable estimates of price movements than the hedonic approach. The repeat sales method is found to be sensitive to small samples, a result in contrast with that of Crone and Voith (1992) who investigate the predictive accuracy of various methods. Finally, Gatzlaff and Ling (1994) find that house price changes computed from median, hedonic, and repeat sales indexes are highly correlated at the annual frequency, but not at the quarterly frequency. The standard repeat sales index is found to be below the hedonic indexes, but a repeat sales index adjusted for depreciation is not.

3. The Sale Price Appraisal Ratio Method

The Sale Price Appraisal Ratio (SPAR) index is an arithmetic repeat index. The first measure in each pair of repeats is the official government appraisal of the property, while the second measure is an arm's length transaction price. One advantage of using the official appraisal as the first measure in the pair of repeats is that all appraisals for a geographical area are typically as of a particular date, meaning that the properties sold in a given period will usually have valuations in a single base period for comparison purposes. This greatly simplifies the calculation of the index because there is no need to use an estimation technique. The equal-weighted version of the index is calculated as follows:

$$I_{Et} = \left\{ \left[\sum_{j=1}^{n_t} \left(S_{jt} / A_{j0} \right) \Big/ n_t \right] \Big/ \left[\sum_{j=1}^{n_{t-1}} \left(S_{jt-1} / A_{j0} \right) \Big/ n_{t-1} \right] \right\} I_{Et-1} \tag{1}$$

where I_{Et} is the equal-weighted index number for time period t, S_{jt} is the sale price of property j during time period t, A_{j0} is the appraised value of property j as of the base or appraisal time period, and n is the number of sales transactions.

The equal-weighted SPAR index has been calculated for cities and regions in New Zealand since 1982. Between 1961 and 1982, a value-weighted index was calculated:

$$I_{Vt} = \left[\left(\sum_{j=1}^{n_t} S_{jt} \Big/ \sum_{j=1}^{n_t} A_{j0} \right) \Big/ \left(\sum_{j=1}^{n_{t-1}} S_{jt-1} \Big/ \sum_{j=1}^{n_{t-1}} A_{j0} \right) \right] I_{Vt-1} \tag{2}$$

where I_{Vt} is the value-weighted index number for time period t and the other terms are defined as before. When the base appraisal year changes (say, every three years), the index must be spliced. The base appraisal is adjusted for subsequent improvements to the property that require a building permit, thereby controlling for major quality changes.[2]

Table 1 gives a simple example of how the two indexes are calculated. In this case, five houses sold in the current period and four in the previous period. For all of the

[2] We are grateful to Bob Hargreaves of Massey University for verifying this. More subtle improvements that do not require a permit, particularly those taking place inside the house, would not be noticed by the appraisers. However, such improvements tend not to be controlled for by any hedonic or repeat sales methods.

properties, an appraised value was available as of the base time period.[3] For the equal-weighted index, the sale price appraisal ratios are calculated for each property and then averaged; for the current period that average ratio is 1.043. For the value-weighted index, the sale prices and appraisals are first summed and the ratio of the sums is calculated; for the current period, that ratio is 1.034. Then these ratios are divided by the corresponding ratios for the previous time period and multiplied by the index number for the previous period. Setting the previous index number at 100 for each index for the previous period, the current period index number is 104 for the equal-weighted index and 106 for the value-weighted index. The value-weighted index increases at a faster rate in this example because higher-valued properties carry greater weight and higher-valued properties appreciated at a greater rate.

[Table 1]

Shiller (1991) develops both equal-weighted and value-weighted arithmetic repeat sales indexes and notes that the latter are particularly useful for portfolio valuation. However, the main purposes for the New Zealand index (and similar indexes elsewhere) have to do with measuring the affordability of homeownership over time and relative to renting. Thus the choice of the equal-weighted rather than the value-weighted index is appropriate because the aim is to understand average or typical growth rates rather than the overall appreciation rate of the entire portfolio.

There are relatively few examples of the use of appraised values in repeat-type indexes. As noted above, Clapp and Giaccotto (1998) use appraised values as quality-control measures in a repeat sales context, but they do not substitute the appraisals for transaction prices. Clapp and Giaccotto (1992a) use assessed values as the first measure and transaction prices as the second measure in a repeat sales price assessed value model. This is a more general form than the New Zealand approach, because it does not assume that all of the appraised values are as of a particular date. It is more complicated to administer, however, as a regression model must be estimated. Gatzlaff and Ling (1994) employ a variation of the Clapp and Giaccotto method, using sale prices as the first measure and assessed values as the repeat measure. This is apparently because their data provided current assessed values but not prior ones. Both sets of authors find that the assessed value methods produce indexes similar to a standard repeat sales index.

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[3] Note that new houses do not contribute to the SPAR index until after the next official appraisal revision date because they would not have a corresponding appraisal for the relevant base year.

4. Pros and Cons of Alternative Methods

The relative strengths and weaknesses of the various types of indexes are assessed according to four criteria. The first is whether the index method yields a constant quality index. A desirable property of an index is that it should track price changes for a house that has the same characteristics over time. Price changes would only result from changes in the market prices of characteristics, and not from differences in the characteristics of properties that have transacted in the various periods. This is an important feature for any real estate index. Some debate has arisen in the literature as to whether age and to some extent also quality of location should be held constant when constructing an index. It can indeed be argued that if the aim is to measure the return to the typical homeowner, then these should not be controlled for in an index (Case and Shiller, 1987; Clapp and Giaccotto, 1992a). However, house price indexes are often intended to be used to measure affordability and thus should be constant quality with respect to age as well as other characteristics.

The second criterion pertains to whether the subset of properties that form the basis for the construction of the index is representative of the inventory of properties. In other words, the desired property of an index method is that there be no sample selection bias. The third criterion is consistency; that is, whether the historical index values are robust when data for subsequent time periods are added. Lastly, an index should be easy to construct and not require huge databases of transaction prices and property attributes. There may be a tradeoff between the first and fourth criteria. More emphasis on constant quality may require more data.

Table 2 indicates how each of the index construction methods fares with respect to each of the four criteria. We consider six index methods: two hedonic specifications, two repeat sales estimations, the hybrid method, and the SPAR method. The multiple equation hedonic method refers to the estimation of separate equations for each time period, while the single equation hedonic model refers to the estimation of one hedonic regression with time dummy variables. Two types of repeat sales specifications are examined. The first includes all repeat sales that occurred during the period under review, while the other excludes the repeat sales on properties whose quality changed between the first and the second transaction. The hybrid method involves use of both single sales and repeat sales in a system of stacked regressions as discussed in section 2. We do not analyze the characteristics of median or mean house price indexes given their obvious limitations.

[Table 2]

Both hedonic specifications and the hybrid approach make it possible to construct constant quality indexes, while the repeat sales method which uses all repeat sales does not achieve that aim. Any property that has sold repeatedly and whose quality has changed between sales would bias the repeat sales index, but would not bias the hedonic indexes as the property characteristics are included in hedonic models. This drawback of the repeat sales method is often mentioned in the literature (Case, Pollakowski, and Wachter, 1991; Haurin and Hendershott, 1991; Clapp and Giaccotto, 1992a; Gatzlaff and Ling, 1994). The SPAR method is less subject to bias due to changes in the properties' characteristics provided that appraisals are carried out relatively frequently and adjusted when improvements are made.

Several authors screen their sample of repeat sales and eliminate properties whose quality has changed (Case, Pollakowski, and Wachter, 1991; Clapp, Giaccotto, and Tirtiroglu, 1991). In Case, Pollakowski, and Wachter (1991), for instance, the sample of 1,878 repeats included 122 with changed characteristics. Eliminating properties whose quality has changed between the first sale and the second sale enables the index to be constant quality. However, such a screening process requires that the characteristics of properties be known and hence increases the need for large databases. As mentioned above, there may be a tradeoff between the aims of constant quality and ease of administration. There may also be a tradeoff between constant quality and sample selection bias (Case, Pollakowski, and Wachter, 1991).

The second criterion pertains to whether the sample of properties that forms the basis for the construction of the index is representative of the inventory of properties. Indeed, only a small percentage of houses typically sell in any given time period. Gatzlaff and Haurin (1998) show that changing economic conditions affect the statistical composition of the samples of sold properties. Hedonic regression estimates result in estimated house price changes that differ from the true variation in values of the stock. Hence, the evidence contained in Gatzlaff and Haurin (1998) would suggest that the samples used in hedonic analyses probably suffer from sample selection bias. As the hybrid and SPAR methods also rely on samples of transactions they should also be prone to sample selection bias.

With the repeat sales method, not all transactions are used, and the data are limited to those properties that have sold at least twice during a given period of time. Depending on the length of the time span and the state of the market, this will lead to a varying – but in most

cases important – percentage of transactions being discarded.[4] In the samples of Case and Shiller (1987, 1989), for instance, this leads to an average of 92% of transactions being excluded from the analysis for a 16.5 year time period. Repeat sales as a percentage of all transactions is also low (13%) in Case, Pollakowski, and Wachter (1991), but their study spans only 7 years. In the analysis of Clapham *et al*. (2004) for Stockholm, Sweden, however, multiple sales constitute more than half of all transactions over the 1981-1999 period.

The question that arises is whether the sample of repeat sales is even more biased than the sample of all properties sold. Samples of repeat sales may differ from samples of all transactions for the following reasons: (1) properties in repeat sales samples are bought to be repaired or rehabilitated for resale; (2) there may be a higher proportion of lemons in repeat sales samples because properties are repeatedly resold when they do not meet buyer expectations; and (3) starter homes sell repeatedly as owners move to larger and better units (Clapp and Giaccotto, 1992a). One would thus expect dwellings with repeat sales to be in poorer condition (at time of first and second sale for the two latter reasons above, and at time of first sale only for the first reason) and also of lesser value (for the latter two reasons). Clapp and Giaccotto (1992b) find that the prices and assessed values of properties that sell twice are approximately 15% less than those of properties that sell only once (see also Steele and Goy, 1997). Similar results are obtained for properties that sell three or more times. In Meese and Wallace (1997), dwellings that have sold repeatedly are in poorer condition than units with single sales. In terms of the effect of sample selection bias on the repeat sales index, Gatzlaff and Haurin (1997) find that such indexes are biased upward during periods of economic growth and downward during periods of economic weakness.

As mentioned above, the sample selection bias issue is probably exacerbated when repeat sales with changed characteristics are deleted from the sample. Meese and Wallace (1997) report that repeat sales units with changed characteristics tend to be larger and in worse condition than the average of units with single transactions. This could be related to the fact that these larger houses are bought in poor condition to be refurbished and then resold. We conclude that repeat sales indexes suffer from a more severe sample selection bias than do other index types. This is recognized in Table 2 by assigning a double minus to the two repeat sales methods.

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[4] This also means that the repeat sales method is less often usable than the other methods we consider in markets or submarkets with relatively few transactions.

A third desirable property of house price indexes is that they should be consistent when updated. In other words, the historical index numbers should not be altered as data for more recent periods become available. Repeat sales indexes are prone to index revisions. When new sales data become available a subset of these will constitute a match for first sales that occurred previously. Clapp and Giaccotto (1999) find revisions in repeat sales indexes to be large, insensitive to sample size, and systematic (see also Hoesli, Giaccotto, and Favarger, 1997). Revisions are also more likely to be downward than upward. As hybrid models contain a repeat sales component one would also expect them not to be consistent when updated. This should, however, be less of an issue than with repeat sales indexes.

When the index revision issue is investigated for hedonic indexes, each of the two types of hedonic specifications has to be considered separately. When one hedonic regression is performed for each time period, the index should be consistent when updated. This depends, however, on what characteristics are being used for the standard property. If initial weights are used (a Laspeyres index), the index will be insensitive to new data, whereas if current weights are used (a Paasche index), the index will change as new data become available. When a Fisher Ideal index is used, there should also be some impact of the changing characteristics of properties over time.[5] Also, the hedonic model that includes all periods in a single estimation with time dummy variables should be sensitive to new data being added, but to a lesser degree than repeat sales indexes. With respect to consistency when updated, SPAR indexes do not require any historical index revisions when new data are added.

A comparison of index revisions in repeat sales and hedonic indexes is provided by Clapham *et al*. (2004). The average revision in the repeat sales index is -1.7%, while it is -2.4% when changes in characteristics between first and second sales are taken into account. These downward revisions confirm the results of Clapp and Giaccotto (1999). The hedonic index constructed with time dummy variables also exhibits a downward average revision but of lesser magnitude (-1.0%). Finally, the period-by-period Fisher Ideal hedonic index exhibits an average upward revision of only 0.6%. This upward adjustment is potentially due to the fact that the average characteristics of the standard house get tilted towards the characteristics of more recent houses as more recent time periods are added and such houses are presumably of better quality.

The last criterion is ease of administration, suggesting that indexes should be easy to construct and also should not have extensive data requirements. The two types of indexes

[5] The Fisher Ideal index is the geometric average of the Paasche and Laspeyres indexes.

that are easiest to administer are the repeat sales index and the SPAR index. The repeat sales method requires only sale price, date of sale, and some property identifier (to match pairs). As mentioned above, the repeat sales method does not yield a constant quality index. If pairs of sales are screened with the aim of discarding properties whose quality has changed between the time of first sale and the time of second sale, then property attributes are required. This would increase data requirements, but the indexes would still be easy to construct. This is recognized in Table 2 by assigning a single plus to the screened repeat sales. In contrast, hedonic indexes provide constant quality indexes, but require large databases and that various econometric issues be addressed. The implementation of a hybrid model is even more cumbersome. The SPAR method requires the same information as repeat sales plus appraised values and information about the impacts of subsequent improvements on property values.

5. Empirical Analysis

We compare the official New Zealand SPAR index for three urban areas with two types of hedonic indexes and two types of repeat sales indexes, all calculated using the same transactions data. We expect the repeat sales indexes to understate price appreciation relative to the hedonic indexes. One reason is that the repeat sales method is a geometric mean of appreciation rates, which is less than the arithmetic mean unless all of the appreciation rates are the same (Shiller, 1991). A second reason is that the repeat sales method does not control for depreciation, unlike the hedonic method, which typically controls for the age of the house (see, e.g., Case, Pollakowski, and Wachter, 1991; Englund, Quigley, and Redfearn, 1999). On the other hand, houses that are improved between sales may bias the repeat sales index upwards. Thus we calculate two sets of repeat sales indexes. The first index does not screen out properties whose characteristics have changed, while the second does screen out properties whose attributes (other than age) have changed. We also consider the impacts of adjustments to the repeat sales index to correct for the geometric mean, following the method of Wang and Zorn (1997).

The two hedonic indexes are the single equation approach with time dummies and the multiple equation approach. For the latter index, we hold quality constant by defining a standard house to have the average characteristics of the houses in the first period sample. These two approaches should yield broadly similar indexes. The SPAR index, in contrast to the hedonic indexes, does not control for depreciation. As appraisals are carried out every three years, however, the impact of depreciation should be limited and hence the SPAR index

should be close to an index that controls for age. The effects of changes in properties' attributes should also be mitigated with the SPAR method as assessed values get updated whenever improvements requiring a building permit have been made. The SPAR index also does not incorporate information about prices of new houses that do not have a corresponding appraisal. On balance, we expect that the SPAR index should be similar to a hedonic index.

The main source of data for this study is the official database of all real estate transactions in New Zealand.[6] We selected transactions involving residential detached and semi-detached properties in the Auckland region (including five local government areas: Auckland, Manukau, North Shore, Papakura, and Waitakere), the City of Christchurch, and the City of Wellington. We deleted transactions for properties that were classified as subdivisible (because the sale price might represent potential for redevelopment), had floor sizes of less than 30 square meters or greater than 1,000 square meters (probably errors in data entry), or had missing data for any of the variables of interest. We also deleted transactions that were not considered to be "arm's length" by the appraisers.

We calculated two new variables with the help of a geographic information system. Each property was geocoded and assigned coordinates that were used to calculate distance to the central business district (CBD) and distance to the nearest commercial subcenter (for Auckland only). We also constructed a new dummy variable identifying "cross-leased" or "strata-titled" properties. Although a positive land area is provided for a large majority of the transacted properties, a significant percentage have a land area of zero. These properties are generally cross-leased, which means that the land is owned collectively by the owners of dwellings on that site and leased to each owner for a nominal rent. Alternatively, the properties may be condominiums – "strata-titled" in New Zealand terminology.

Because the official New Zealand index is semiannual, we estimated semiannual hedonic and repeat sales indexes. The initial period is the second half of 1989 (1989b) because that is the first period for which the official index was calculated for the newly consolidated local governments. Our final period is the second half of 1996 (1996b), which is the last year available in our database. After deleting questionable transactions and restricting the data to this date range, the total sample across the three urban areas included 167,645 sales. These transactions included 41,827 pairs of repeat sales, of which 36,571 remained in the sample after properties with changed characteristics were deleted. Table 3

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[6] The data were purchased from Quotable Value Ltd by the University of Auckland's Real Estate Research Unit. The authors are grateful to the University of Auckland for providing the data.

gives some statistics for the hedonic and the constant quality repeat sales samples for each geographical area. Consistent with the "lemons" and "starter homes" hypotheses (Clapp and Giaccotto, 1992b), the net (of chattels) mean sale price for the repeat sales samples is lower than for the hedonic sample. The repeat sales samples have smaller land and floor areas, and tend to have smaller percentages of properties with walls and roofs in good condition.

[Table 3]

Figures 1 through 3 compare the official index with the hedonic and repeat sales indexes. In each location, the SPAR index tends to track the two hedonic indexes, and the repeat sales indexes track below the SPAR and hedonic indexes. Price changes computed from the repeat sales indexes are 0.6-1.7 percentage points lower than those computed from other index types (see Table 4). The annual impact of depreciation is thus in the 1.2-3.4 percentage point range, which seems reasonable given the estimated coefficients on the age variable in our hedonic equations (results not reported). Adjusting the all repeat sales index by screening out properties with changed characteristics has a minor effect on that index. As mentioned previously, the lower index values for the repeat sales indexes could be due not only to depreciation, but also to the fact that the index is a geometric mean. Wang and Zorn (1997) show that the arithmetic mean exceeds the geometric mean on average by the following factor:

$$\exp\left(\frac{(n-1)\sigma^2}{2n}\right) \tag{3}$$

which approaches $\exp(\sigma^2/2)$ as $n \to \infty$. This adjustment has a very small impact on the index numbers, increasing the constant-quality repeat sales index numbers by less than 1% in Wellington and Christchurch and only about 1.5% in Auckland. This suggests that most of the gap between the repeat sales and the hedonic indexes is due to depreciation rather than the geometric mean issue.

[Figures 1 through 3]

[Table 4]

The volatility of price changes is roughly similar across the different indexes in Auckland, but is much greater for the multiple equation hedonic method than for other index types in Christchurch and Wellington. This could stem from the smaller sample sizes or other sampling issues for these two cities. Also, the correlations between the SPAR index

price changes and those computed for other index types are high in Auckland. In contrast, for Christchurch and Wellington, the SPAR index is more highly correlated with price changes based on the single equation hedonic specification than with changes based on the other indexes. In general, the SPAR index appears to be more closely related to the hedonic specification with time dummy variables. It reliably tracks house price changes, but exhibits less volatility than index methods that require more parameter estimates.

6. Concluding Remarks

Accurately measuring changes in house prices is an important goal, both from academic and practical perspectives. House price indexes should control for the quality of properties, should be constructed with unbiased samples of properties, and should be robust when data for subsequent periods are added. We maintain that another important trait that indexes should have is ease of administration.

Some of these criteria are conflicting. Increasing the attractiveness of an index according to one criterion may limit its appeal with respect to another. For instance, fully constant quality indexes may require large databases and complex index construction methods. Also, modifying a sample of sold properties to achieve an index that better fulfills the constant quality requirement may introduce more sample selection bias. Hedonic and hybrid indexes lead to truly constant quality indexes but they are cumbersome. In contrast, repeat sales indexes are easy to construct but suffer from other limitations.

As government agencies are (rightly so) often concerned about the cost and difficulty of an index construction method, they often rely on indexes of median house prices. Such indexes, however, can be biased as little or no control is made for the quality of properties. We present an index method that has most of the desired qualities for a house price index, including ease of administration.

As compared to hedonic indexes, the SPAR index fares well with respect to the constant quality criterion. The base appraisal is updated to reflect the value of any subsequent improvements that require building permits. The SPAR index is comparable to multiple equation hedonic indexes in terms of sample selection bias and index revisions. Compared with hedonic indexes, the important feature of the SPAR index is that it is easy to construct and does not require detailed databases of property attributes. Repeat sales indexes share that characteristic of the SPAR index, but suffer with respect to sample bias and consistency.

House price indexes in New Zealand are constructed using the SPAR method and provide for an empirical comparison of index construction methods. We find that the SPAR index tracks house price changes in a manner very similar to the single equation hedonic index. We maintain that government agencies elsewhere should consider the SPAR index as an alternative to other methods.

References

Bailey, M.J., Muth, R.F., Nourse, H.O., 1963. A regression method for real estate price index construction. J. Amer. Stat. Assoc. 58 (304), 933-942.

Calhoun, C.A., 1996. OFHEO house price indexes: HPI technical description. Office of Federal Housing Enterprise Oversight, Washington, DC.

Case, B., Pollakowski, H.O., and Wachter, S.M., 1991. On choosing among house price index methodologies. AREUEA J. 19 (3), 286-307.

Case, B., Quigley, J.M., 1991. The dynamics of real estate prices. Rev. Econ. Stat. 73 (1), 50-58.

Case, K.E., Shiller, R.J., 1987. Prices of single-family homes since 1970: new indexes for four cities. New England Econ. Rev. (September/October), 45-56.

Case, K.E., Shiller, R.J., 1989. The efficiency of the market for single-family homes. Amer. Econ. Rev. 79 (1), 125-137.

Clapham, E., Englund, P., Quigley, J.M., Redfearn, C.L., 2004. Revisiting the past: revision in repeat sales and hedonic indexes of house prices. Working Paper No. W04-005. Fisher Center for Real Estate and Urban Economics, University of California, Berkeley.

Clapp, J.M., Giaccotto, C., 1992a. Estimating price indices for residential property: a comparison of repeat sales and assessed value methods. J. Amer. Stat. Assoc. 87 (418), 300-306.

Clapp, J.M., Giaccotto, C., 1992b. Estimating price trends for residential property: a comparison of repeat sales and assessed value methods. J. Real Estate Fin. Econ. 5 (4), 357-374.

Clapp, J.M., Giaccotto, C., 1998. Price indices based on the hedonic repeat-sale method: application to the housing market. J. Real Estate Fin. Econ. 16 (1), 5-26.

Clapp, J.M., Giaccotto, C., 1999. Revisions in repeat-sales price indexes: here today, gone tomorrow? Real Estate Econ. 27 (1), 79-104.

Clapp, J.M., Giaccotto, C., Tirtiroglu, D., 1991. Housing price indices based on all transactions compared to repeat subsamples. AREUEA J. 19 (3), 270-285.

Colwell, P.F., Dilmore, G., 1999. Who was first? An examination of an early hedonic study. Land Econ. 75 (4), 620-626.

Crone, T.M., Voith, R.P., 1992. Estimating house price appreciation: a comparison of methods. J. Housing Econ. 2 (4), 339-357.

Dreiman, M.H., Pennington-Cross, A., 2004. Alternative methods of increasing the precision of weighted repeat sales house prices indices. J. Real Estate Fin. Econ. 28 (4), 299-317.

Englund, P., Hwang, M., Quigley, J.M., 2002. Hedging housing risk. J. Real Estate Fin. Econ. 24 (1/2), 167-200.

Englund, P., Quigley, J.M., Redfearn, C.L., 1998. Improved price indexes for real estate: measuring the course of Swedish housing prices. J. Urban Econ. 44 (2), 171-196.

Englund, P., Quigley, J.M., Redfearn, C.L., 1999. The choice of methodology for computing housing price indexes: comparisons of temporal aggregation and sample definition. J. Real Estate Fin. Econ. 19 (2), 91-112.

Gatzlaff, D.H., Haurin, D.R., 1997. Sample selection bias and repeat-sales index estimates. J. Real Estate Fin. Econ. 14 (1/2), 33-50.

Gatzlaff, D.H., Haurin, D.R., 1998. Sample selection and biases in local house values indices. J. Urban Econ. 43 (2), 199-222.

Gatzlaff, D.H., Ling, D.C., 1994. Measuring changes in local house prices: an empirical investigation of alternative methodologies. J. Urban Econ. 35 (2), 221-224.

Gelfand, A.E., Ecker, M.D., Knight, J.R., Sirmans, C.F., 2004. The dynamics of location in home price. J. Real Estate Fin. Econ. 29 (2), 149-166.

Haurin, D.R., Hendershott, P.H., 1991. House price indexes: issues and results. AREUEA J. 19 (3), 259-269.

Hill, R.C., Knight, J.R., Sirmans, C.F., 1997. Estimating capital asset price indexes. Rev. Econ. Stat. 79 (2), 226-233.

Hoesli, M., Giaccotto, C., Favarger, P., 1997. Three new real estate price indices for Geneva, Switzerland. J. Real Estate Fin. Econ. 15 (1), 93-109.

Knight, J.R., Dombrow, J., Sirmans, C.F., 1995. A varying parameters approach to constructing house price indexes. Real Estate Econ. 23 (2), 187-205.

Malpezzi, S., 2003. Hedonic pricing models: a selective and applied review. In: O'Sullivan, T., Gibb, K. (eds.), Housing Economics and Public Policy. Blackwell, Malder, MA.

Mark, J.H., Goldberg, M.A., 1984. Alternative housing price indices: an evaluation. AREUEA J. 12 (1), 30-49.

Meese, R.A., Wallace, N.E., 1997. The construction of residential housing price indices: a comparison of repeat-sales, hedonic-regression, and hybrid approaches. J. Real Estate Fin. Econ. 14 (1/2), 51-73.

Quigley, J.M., 1995. A simple hybrid model for estimating real estate price indexes. J. Housing Econ. 4 (1), 1-12.

Shiller, R.J., 1991. Arithmetic repeat sales price estimators. J. Housing Econ. 1 (1), 110-126.

Shiller, R.J., 1993. Measuring asset values for cash settlement in derivative markets: hedonic repeated measures indices and perpetual futures. J. Fin. 48 (3), 911-931.

Steele, M., Goy, R., 1997. Short holds, the distribution of first and second sales, and bias in the repeat-sales price index. J. Real Estate Fin. Econ. 14 (1/2), 133-154.

Wang, F.T., Zorn, P.M., 1997. Estimating house price growth with repeat sales data: what's the aim of the game? J. Housing Econ. 6 (2), 93-118.

Valuation New Zealand, 1995. Urban Property Sales Statistics: Half Year Ended 31 December 1994. Wellington.

Table 1

Calculation of equal-weighted and value-weighted SPAR indexes

Property	1	2	3	4	5	Average	Sum
Current period sales							
Sale price	120,000	125,000	85,000	80,000	110,000		520,000
Appraisal	90,000	118,000	85,000	85,000	125,000		503,000
SPA ratio	1.333	1.059	1.000	0.941	0.880	1.043	1.034
Previous period sales							
Sale price	110,000	120,000	75,000	95,000			400,000
Appraisal	130,000	125,000	65,000	90,000			410,000
SPA ratio	0.846	0.960	1.154	1.056		1.004	0.976

Index numbers	Equal-weighted	Value-weighted
Previous	100	100
Current	104	106

Source: Valuation New Zealand (1995), pp. 2-3.

Table 2

Comparison of alternative methods

Criteria	Multiple hedonic	Single hedonic	All repeats	Constant quality repeats	Hybrid	Sale price appraisal ratio
Constant quality	+ +	+ +	–	+ +	+ +	+ +
No sample selection bias	–	–	– –	– –	–	–
Consistent when updated	+ +	–	– –	– –	–	+ +
Easy to administer	–	–	+ +	+	– –	+

Note: + + indicates that the criterion is satisfied; + indicates that the criterion is partly satisfied; – indicates that the criterion is not satisfied; and – – indicates that the criterion is not satisfied and the problem is more severe than is the case for criteria rated –.

Table 3

Sample means, single equation hedonic and constant quality repeat sales samples, second half 1989 to second half 1996

	Auckland region		*Wellington City*		*Christchurch City*	
Variable	Hedonic sample	Average repeat sale	Hedonic sample	Average repeat sale	Hedonic sample	Average repeat sale
Net sale price (NZ$)	$208,140	$199,904	$175,342	$172,328	$133,985	$128,043
Land area (m^2)	709	677	583	553	611	606
Cross-leased or strata-titled	14%	15%	5%	5%	18%	15%
Distance from CBD (m)	11,233	11,302	5,279	5,221	5,306	5,191
Distance from subcenter (m)	6,220	6,182	NA	NA	NA	NA
Floor area (m^2)	140	136	138	134	131	126
Age	32	33	47	48	37	40
Off-street parking spaces	1.5	1.5	1.0	1.0	1.6	1.5
Wall condition						
Poor	3%	3%	4%	3%	4%	4%
Average	47%	48%	52%	54%	45%	49%
Good	50%	49%	44%	43%	51%	47%
Roof condition						
Poor	3%	3%	5%	5%	5%	6%
Average	48%	48%	48%	50%	45%	47%
Good	49%	49%	47%	45%	50%	47%
Sample size	*93,061*	*19,728*	*19,150*	*3,241*	*55,434*	*13,602*

Note: Repeat sale statistics are the averages of the means for the first and second sales in the constant quality sample (these means are the same except for the net sale price and age). The sample sizes for the repeat sale samples refer to the numbers of pairs rather than the number of transactions. For properties that sold more than twice, data for the same transaction will appear in the repeat sale sample more than once.

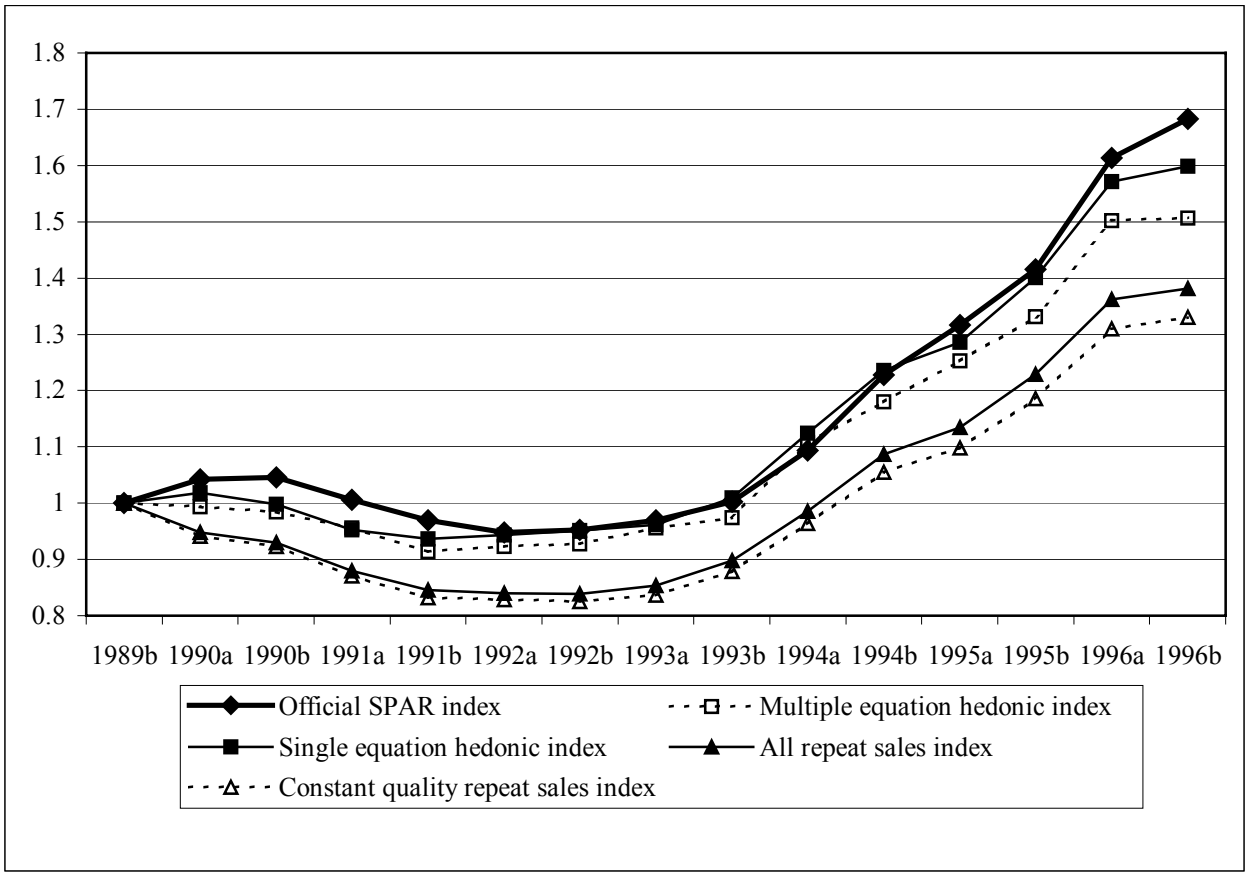
Table 4

Model comparison statistics, semiannual percentage price changes

Index	Mean	Standard deviation	Minimum	Maximum	Correlation with SPAR changes
Auckland region					
Sale price appraisal ratio	3.93	5.58	-3.82	13.99	1.00
Multiple hedonic	3.10	5.42	-4.45	13.70	0.87
Single hedonic	3.53	5.25	-4.54	12.21	0.93
All repeats	2.48	5.74	-5.37	10.83	0.88
Constant quality repeats	2.21	5.72	-5.88	10.51	0.86
Wellington City					
Sale price appraisal ratio	1.30	2.97	-3.75	6.62	1.00
Multiple hedonic	1.07	4.06	-7.78	10.46	0.71
Single hedonic	1.30	3.00	-5.48	6.44	0.85
All repeats	0.45	3.15	-5.53	6.05	0.71
Constant quality repeats	0.46	3.04	-4.88	6.09	0.79
Christchurch City					
Sale price appraisal ratio	3.25	1.99	0.34	7.50	1.00
Multiple hedonic	3.17	3.37	-3.36	8.77	0.47
Single hedonic	3.02	1.67	0.40	6.67	0.89
All repeats	2.30	1.33	0.39	4.60	0.51
Constant quality repeats	2.17	1.34	0.12	4.38	0.55

Figure 1

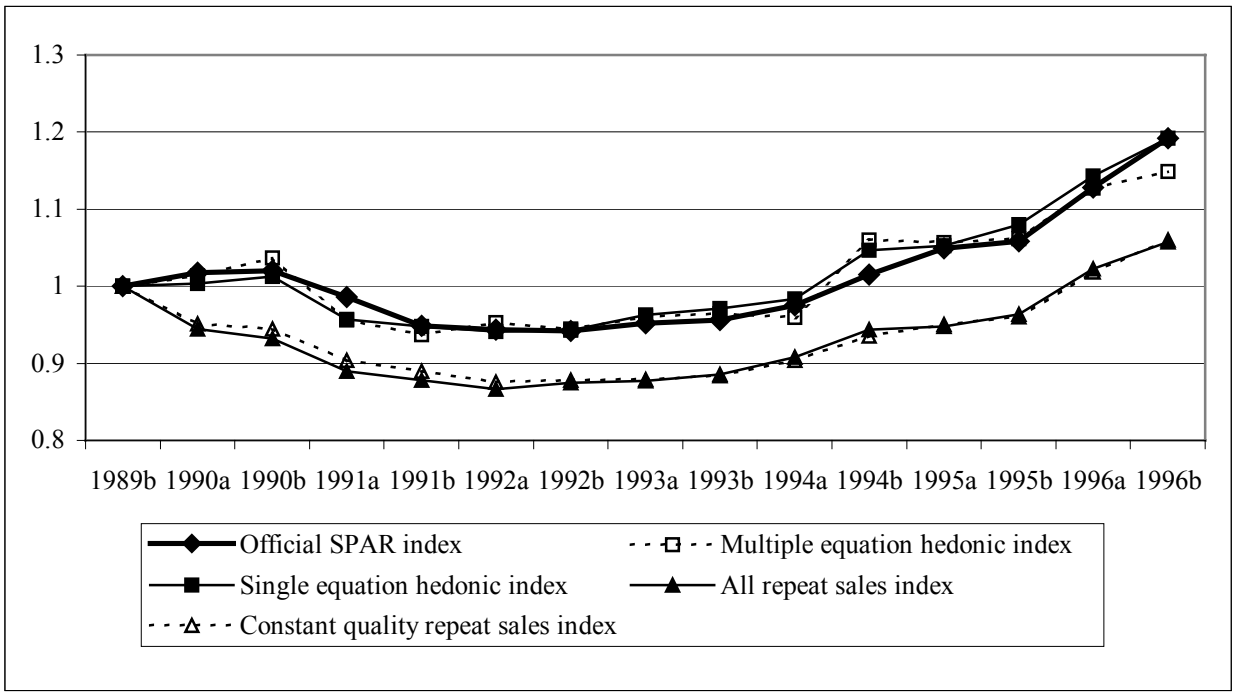
Alternative house price indexes for the Auckland region, second half 1989 to second half 1996



Source: Valuation New Zealand (1995 and other issues) and authors' calculations.

Figure 2

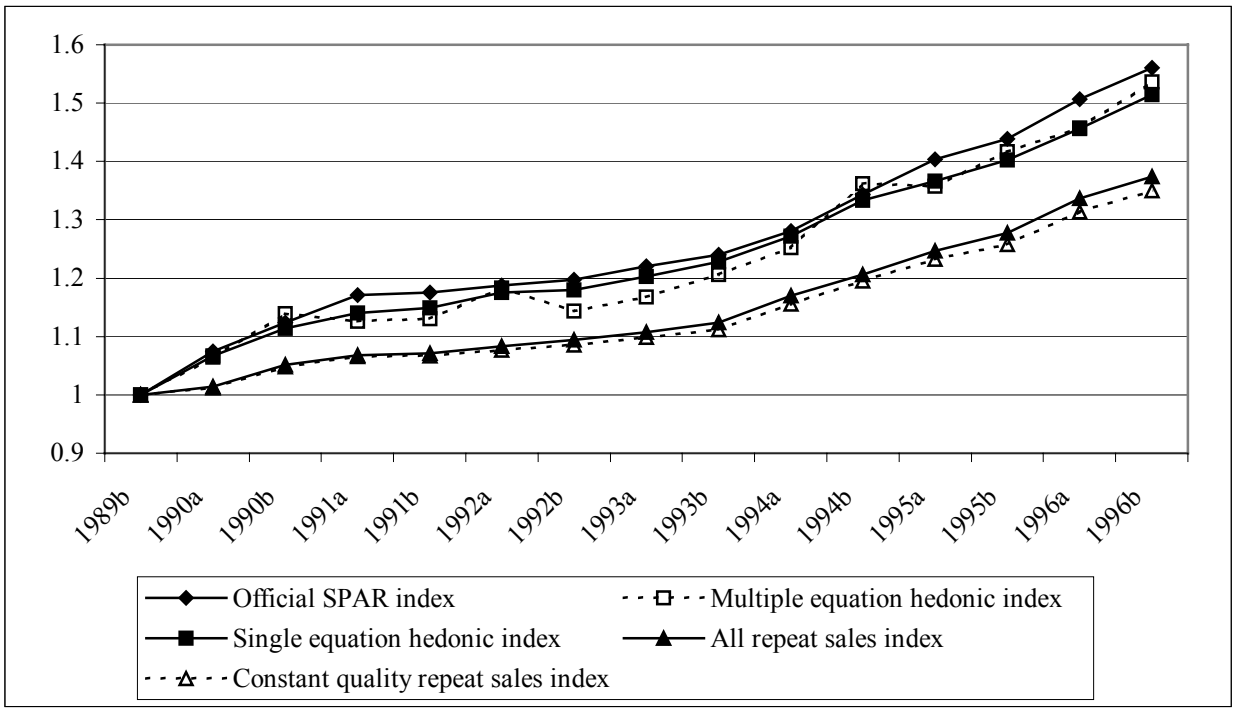
Alternative house price indexes for Wellington City, second half 1989 to second half 1996



Source: Valuation New Zealand (1995 and other issues) and authors' calculations.

Figure 3

Alternative house price indexes for Christchurch City, second half 1989 to second half 1996



Source: Valuation New Zealand (1995 and other issues) and authors' calculations.