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From Average Price to Hedonic Price Indexes : A "Preliminary" Investigation into Various Measures of Trends in Existing House Prices Using MLS® Data for Ottawa

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1- Introduction

The Ottawa Real Estate Board publishes monthly average sale prices for properties sold in the Ottawa-Carleton area, similar to other Canadian real estate boards, which report average or median sale prices as the basis for comparing property values and market trends over time.[1] As with many studies of this kind, the choice of the methodology for measuring trends in house prices is often guides by the nature of the available data. With access to a large and comprehensive database maintained by the Ottawa Real Estate Board, this paper presents preliminary estimates of a hedonic quality-adjusted price index for existing (resale) properties in the Ottawa area using actual sales transactions over the 1996 to 2001 period. The results derived with the hedonic approach are then compared with those using other methodologies such as average prices and median prices. Furthermore, the hedonic price indexes are further compared to the price indexes generated using the repeat-sales approach, and Statistics Canada's New House Price Index.

The distinguishing features of this paper from other research in the field of house price measurement are as follows:

1- It uses MLS data, a source of information that has not been explored to a large extent in Canada for producing quality-adjusted price indexes.

2- The data are for a long enough time period that the results generated from the hedonic approach can be compared with the repeat-sales approach.

3- The results are generated from the hedonic approach are also compared with a (quasi-) matched-model price index, Statistics Canada's New House Price Index for the Ottawa area.

4- The price indexes that are produced using the various approaches are computed on a monthly basis thus opening the door to the possibility of using such information for the purpose of producing short-term economic indicators.

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[1] For the purpose of this study, Ottawa-Carleton will be referred to as simply Ottawa.

(Most research using MLS data in the United States for instance computed annual price indexes.)

Accurately measuring trends in house prices is an important issue for many reasons some of which are presented by Pollakowski (1995):

1- Appreciations rates are considered important indicators of local housing market strengths;

2- Migration and intrametropolitan location decisions depend on house prices;

3- Mortgage lenders and insurers seek to understand differences in house appreciation rates among metropolitan areas to minimize foreclosure and default losses;

4- Potential homeowners and other investors in housing seek properties with good potential for appreciation;

5- Policy analysts need house price information to deal with many issues, including the likely investment return on low- and moderate-income homeownership.

Meese and Wallace (1997) echo Pollakowski but add that accurate measurement of real estate prices is important for our understanding of aggregate wealth and investment bahaviour, and also helps our understanding of the efficiency of the housing market and recent real estate cycles.

Central bankers in various countries and national statistical agencies have also recently voiced their own views with regards to the need for better measures of house prices. For instance, recognizing the paramount role of house prices in the context of financial stability, the International Monetary Fund and the Bank of International Settlements co-sponsored in the Fall of 2003, a conference on Real Estate Indicators and Financial Stability for which one of the objectives was " to promote the development of reliable and timely statistics on real estate prices". [2] In fact, David Dodge (Governor of the Bank of Canada), in last year's speech to the Conference of European Statisticians stated:

> *"Fluctuations in asset markets have become a more prominent feature of modern economies in recent years. Considering that property is by far the world's biggest single asset class, it is not surprising that movements in the real estate market are drawing a lot of attention. In many countries, housing prices, in particular, have been rising rapidly, raising some concerns about a possible sharp correction at some point.*
>
> *Given that investment in housing represents a big chunk of household spending, and that for most people their homes represent their most valuable asset, it is surprising that, in many countries, there are no comprehensive quality-adjusted data on housing prices and rents. In its recent survey of global property markets, The Economist commented that "official statistics offices typically collect more information about the price of shoes or cement than housing, despite its far greater importance."*

Many economists have also convincingly found a strong relationship between trends in house prices and output. For instance, Goodhart (2001) suggests that if the house prices and output are strongly interrelated, central bankers should then be using an asset based measure of inflation, which should include house prices. Compilers of CPIs and national accountants also have a stake in how house prices are measured. According to Turvey (2000), there are three general approaches to the treatment of housing in CPIs: 1) The net acquisition approach; 2) The payments approach; and 3) The user-cost approach. All of these, except for the second, would in theory, make use of accurately measured house prices in their estimate. In practice, however, less-than perfect proxies are often used instead.

This paper is a preliminary investigation into the measurement of trends in house prices and the possibility of using MLS data for this purpose. It uses very detailed data derived from MLS, i.e., sales records of existing houses for the Ottawa-Carleton region. [3]

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[2] See http://www.imf.org/external/np/sta/seminaR-S/2003/fsi/

[3] The Ottawa Real Estate Board was generous enough to provide us with this detailed set of data. In exchange for this information, the authors agreed to provide to the Board a report containing the results and their methodology.

Ottawa was selected for the basis of this study for practical reasons. It was easiest to establish a closer working relationship with the data provider, which was helpful in many ways, notably because of the complexity of the database. Another important reason was because of the authors familiarity with the area.[4] Although the database contains a wealth of information about the properties, some key decision variables such as proximity and quality of the school may be missing. By concentrating this initial study in familiar territory, it is believed that gathering this information would be relatively straightforward. We would then be in a better position to test the statistical significance of the missing information. The paper is divided in the following way: Section 2 presents some of the approaches that can be used for measuring trends in house prices; section 3 explains the data source; section 4 deals with the various models used in this study; section 5 presents the empirical results; section 6 provides a brief discussion of some econometric issues; and concluding remarks and possible future research directions make up the final section.

2- Existing Approaches to Measuring Trends in House Prices

2.1 Average and Median Sales Price

The change in the median (and sometimes average) sale price of existing homes is often used to measure housing appreciation. This statistics is often cited because it is easily understood and available for most geographical areas in Canada through regular releases by an areas real estate board. Such statistics are however misleading indicators of house price appreciation. The problem with using the median to measure housing appreciation is that it is strongly influenced by the composition of homes that have sold in any given period; if more high-end homes sell, the median will rise, regardless of whether the value of any individual home has risen or not. Furthermore, the quality of houses also changes over time.

A house price index that does not control for the changing quality of the units or the composition of the housing stock on the market over time will produce a biased measure of housing prices. Peek and Wilcox (1991) best summarize the issues with averages and

[4] Ottawa is Canada's capital which is where Statistics Canada is located.

medians by stating that measures such as the average or median sales price reflect the combination of shift in prices of houses of constant quality, as well as shifts in the average quality of houses sold. An increase in incomes or a drop in financing costs, for example, would be expected to lead to an increase in the price of houses of a given quality as well as a shift in sales towards houses of higher quality. Given the obvious problems with average and the median measures, this method, except for comparison purposes later in this paper, can safely be rejected if one wants to study accurate rates of appreciation for houses.

2.2 Alternative House Price Appreciation Measures

The literature on quality-adjusted price for existing dwellings usually employs two distinct methods, the hedonic approach and the repeat-sales approach. Both of these methods will be presented here with results. A third method, the hybrid approach will be discussed later but no attempt will be made at present to compute this index.

2.2.1 The Repeat-Sales (R-S) Index

The most significant problem with using median or average sales price as a measure of appreciation is that the variation in the quality of properties sold from period to period is not being accounted for. One approach to avoid this issue is to construct a R-S index, which estimates price trends from pairs of transactions for properties that have sold more than once over the sample period.

The methodology was originally proposed by Baily *et al.* (1963) and later refined by Palmquist (1980) and Case and Shiller (1989). This approach compares the prices of individual houses that are resold over time and controls for differences in housing characteristics across properties in the sample without directly estimating their marginal contribution to total value[5,6]. However, one of the major drawbacks of the R-S method is that by focussing solely on properties that transacted at least twice during the period, it

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[5] In the parlance of price statisticians, the R-S approach would be akin to the "matched sample" approach.
[6] See Calhoun (1996).

discards a large proportion of the sample thus wasting much information.[7] Other criticisms of the R-S approach are[8]:

1) The results are subject to sample selectivity bias (non randomness of the sample). For example, they could be "starter-homes" or they could be houses that have appreciated rapidly thus providing the financial opportunity for current owners to upgrade. Another possibility is that they could be houses with a high default rate, which is typical of houses that are depreciating rapidly. In other words, one cannot legitimately infer that the price indices obtained with the R-S approach are representative of the entire population of properties that sold.

2) It also does not separate house price change from depreciation[9]: increasing age of the structure over time is not being accounted for so that the influence of age is confounded with that of time. Most empirical studies on house prices have determined that age significantly affects the price of a dwelling. (See Case *et al.,* 1991.)

3) Another source of bias is that it does not allow for changes in the implicit price of particular housing attributes over time, in fact, it is likely that each attribute has its own price determined by the demand for and supply of that attribute[10]. Moreover, with the R-S method, it is difficult to control for atypical maintenance or capital improvements made during the period between a sale and a resale of a given property. Thus, quality may not be truly held constant by this method[11].

4) A large number of observations on sales are required before a sufficiently large sample is obtained.

Having presented some of the issues related to the R-S method, the hedonic approach is now discussed.

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[7] Clapp and Giaccotto (1992)
[8] See Haurin and HendeR-Shott (1991)
[9] Case, Pollakowski and Wachter (1991)
[10] Case *et al*. (1991)
[11] Wolverton and Senteza (2000)

2.2.2 The Hedonic Index

An alternative to the R-S methodology in calculating constant-quality price indexes is the hedonic approach. Given one of the major issues with the R-S method, namely that one cannot separate the effect of an average rate of quality improvement (obsolescence) from the average effect of aging (depreciation) (Griliches, 1971), the hedonic approach to measuring trends in house prices has found many supporters. The method is considered data intensive in the sense that very detailed information is required on individual units sold, including their structural and locational characteristics. It would therefore seem well suited for the type of data provided by the MLS. With the hedonic technique, houses are disaggregated into various combinations of a number of characteristics or basic attributes and the implicit (or shadow) prices of such characteristics are then estimated using multiple regression method. The hedonic method is a superior measure to the average or median measures of house price trends because it controls for quality change over time. Depending on data availability, the hedonic approach models the sales price as a function of the various property attributes such as location, lot, structural, and neighbourhood characteristics of the unit, along with time-dummy variables indicating the month of sale. (See Berndt, 1991.) Therefore, the coefficients on the dummy variables will measure changes in the quality-adjusted price over time and are used for constructing the constant quality price indexes.

This approach provides information on the influence of variation in quality characteristics on sale prices and avoids the problem of selecting R-S transactions with the same quality for comparison at different times. With the hedonic method, it is essential that the regression relationship be specified with complete set of explanatory variables and correct functional form be used; however, quality characteristics such as neighbourhood characteristics are numerous and difficult to measure, and very often the data on such characteristics are not available. In addition, other statistical problems such as multicollinearity and instability of housing characteristic coefficients over time may compromise the usefulness of the hedonic method.

2.2.3 The Hybrid Approach

Because of the difficulty of correctly specifying a hedonic price model and the inherent bias and inefficiency of the R-S method, a hybrid procedure introduced by Case and Quigley (1991) combines elements of both the repeat-sales and hedonic regression techniques and yields more efficient estimates. This method includes all available sale information, whether single or repeat transactions, but also incorporates the benefits of repeat sale data by using GLS to estimate a system of equations. The hybrid model yields more precise regression estimates than either hedonic or R-S methods alone because it uses all the available information on all transactions and it also allows the effect of age on property prices to be estimated separately. However, similar to other models, the hybrid model also suffers from potential sources of bias such as omitted explanatory variables, incorrect underlying error structure assumption, sample representativeness, and choice of functional form[12].

2.2.4 In this Study

This study presents estimates of quality-adjusted price indexes for the Ottawa area using the aforementioned approaches. Median and average sales price indexes are compared to price indexes estimated by the more sophisticated R-S and hedonic regression methods. The Hybrid approach for constructing housing price indexes is not examined due to time constraints.

3. Data and Sources

The data used for this study are from the MLS® (Multiple Listing Services®). The Multiple Listing Service® is a Canada-wide co-operative marketing program among maintained for its estate board members. Typically, each real estate board participates in the MLS® and is responsible for providing the required information to the MLS® who ensures maximum exposure of properties to the greatest number of potential buyers. The MLS® has been Canada's most powerful real estate marketing system for over forty

[12] Haurin and HendeR-Shott (1991).

years. It is usually available only to REALTORS and in exceptional cases, such as for this paper, to researchers.

Members access current and historical MLS® information from a computer database. This information allows REALTORS to match buyers with properties and to perform comparative market analysis, critical in valuing a home or other real estate property for sale in the current market.

When a property is listed with a REALTOR on the MLS®, pertinent details about it are automatically published on the Internet at www.mls.ca for potential buyers worldwide. WWW.mls.ca contains approximately 185,000 active listings across the country. For the purpose of this study, only MLS® data for the Ottawa area has been retained. It is estimated that at any given time approximately 90% of non-commercial real estate transactions in Ottawa are reported on the MLS®. A complete list of the information found on a typical MLS® for a single housing unit can be found in Table 1.

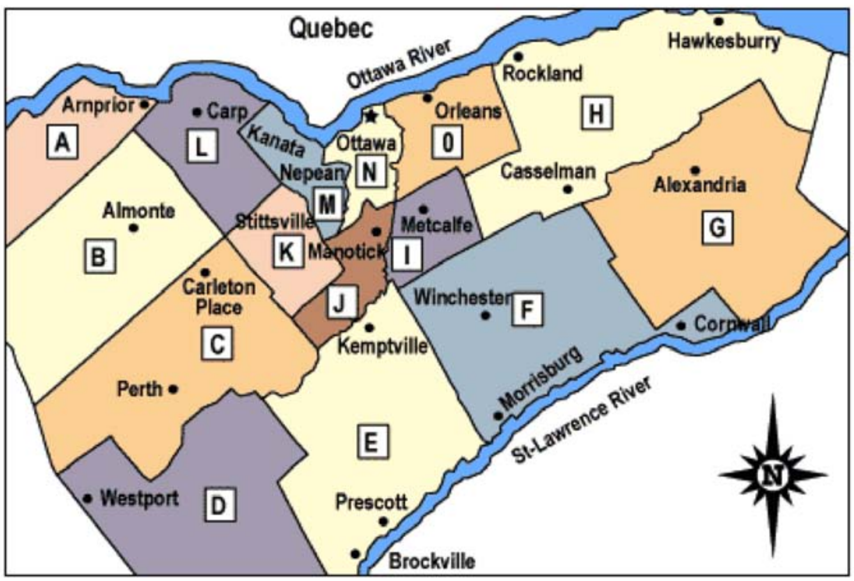
The advantages of using MLS data for tracking trends in house prices are many. First, it provides a consistent set of data for which legitimate methodological comparisons can be made (average prices vs. hedonic indices). Secondly, as is well known, the results of hedonic regressions can be very sensitive to the quality of the data; our MLS data provide, in addition to an extensive number of observations (70, 000 +), a near exhaustive list of detailed characteristics about the housing unit are available, and because the data are used as information for potential buyers these characteristics, we may add, are the ones that are specifically valued (marginal valuation) by potential home purchasers; other studies (e.g. Case *et al.*) have used property assessment to get his information, the number of included characteristics are often not as detailed. Third, MLS data used here are inclusive of transaction price, as opposed to many other studies of house prices, which rely on other source of information for the price variable when it is unavailable, such as custom surveys by the researchers (Cheshire and Sheppard, 1995) or the American Housing Survey data where the current market value of the house is an estimate provided by the owner. Fourth, to the extent that the MLS data reflect almost all transactions (90% +) one could argue that the prices collected represent a universe (or close to) of house prices as opposed to a sample. Lastly, in the case where such data were to be used for the production of timely statistics, they are available on a monthly basis; this is a real benefit for those interested in obtaining an asset based inflation indicator for which timeliness matters, such as for the implementation and monitoring of monetary policy. In all fairness, MLS data do suffer from some weaknesses. According to a personal exchange between one of the authors of this paper and Bradford Case, a leading expert on the measurement of house prices, sample selection bias could be a problem with such data. Smaller, and older, and less-valuable properties may be excluded and real-estate agents may have an incentive to exaggerate the quality and number of attributes of a housing unit. If these issues are indeed true, end they not be, fact remains that these biases are probably systematic in time and therefore should not affect the quality of the results of a temporal price index such as the ones proposed here. Moreover, Case adds:

> *"My general opinion is that the hedonic price model is fairly robust to problems both of data and of functional form. With the amount of data that are included in your MLS databases, it's entirely possible that the problems of sample selection bias and biased regressors would be effectively eliminated (in an empirical sense) by the sheer number of regressors."*

A number of studies in the US have used a combination of transaction- and assessment-type data for measuring quality-adjusted price indexes for measuring housing appreciation.[13] According to Pollakowski (1995), these data suffer from three weaknesses: 1) The data are requires a large amount of cleaning; 2) Assessments are usually carried out on three to five-year cycles; and 3) Reassessments will sometimes miss changes in dwelling quality.

MLS data at the national level in the US have only been used for construction quality-adjusted price indexes for housing in the last 15 years or so. Although such data are considered of high quality for accurately measuring trends in house prices and include all of the same information as the listings in Canada, the US MLS data provided to researchers is too small a sample (500 to 1000 observations per year) at the national level for the purpose of constructing price indexes. MLS data at the local level in the US have however been used by some researchers but in the case of annual estimates. It would appear that this information has not used more frequently for the constructing price indexes because of a lack of machine-readable databases from local real estate boards so the data are only available for short time periods, and the question of the representativity of the data also seems to be an issue.

The database covers the Ottawa and surrounding areas: Ottawa, Orleans, Nepean, Carp, Stittsville, Manotick, Metcalfe, Rockland, Arnprior, Almonte, Carleton Place, Westport, Kemptville, Winchester, Alexandria (see map).



MLS® is an online database with detailed description of the property and listing information. The MLS data base used in this study contains a large volume of information about the location of the house, physical characteristics such as number of bathrooms and bedrooms, total square feet of living area, the type of house, the type of heat, the kind of floors, the age of the house, and the type of foundation and the kind of

[13] Pallakowski (1995) mentions for instance the following: Carroll *et al*. (1992), Case, Pollakowski and Wachter (1995), Crone and Voith (1992), and Meese and Wallace (1991), as studies that have made use of transaction- or assessment-type data.

exterior materials. Additional information is provided on the availability of special or non-standard features of the property such as if appliances are included and which ones, the number of fireplaces and fuel type, air conditioning, fence, deck, swimming pool, whirlpool, central vacuuming, and alarm system. The database also includes some neighbourhood amenities such as closeness to schools, parks, and shopping malls. Other information such as the owner's asking price, property taxes and assessment information, the date that the house was listed, and the selling price together with the date of the transaction are included in the MLS database.

The use of MLS data – available MLS information may not accurately reflect the price of all sales because MLS sales do not represent the universe of all sales. However, according to the Canadian Real Estate Board, "some 90 per cent of all resale homes in Canada go through MLS®".

In the database, only residential properties that are transacted or "sold" are included in the analysis. Properties in "cancelled" or "active" or "expired" status are screened out from the sample. In addition, the types of residential properties examined in this study are single detached or attached houses, condominium houses or apartments; other types such as mobile homes are excluded from the analysis.

4. The Models

4.1 The R-S model

The R-S Method proposed by Case and Shiller[14] where P_{it} is the price of house i at time t is:

$$\ln(P_{it}) = \beta_t + H_{it} + N_{it} \qquad [1]$$

Where β_t is the log of the level of housing prices at time t, H_{it} is a random-walk term whose differences is normally distributed with mean zero, and N_{it} is the normally distributed noise term.

[14] Case and Shiller (1987)

H_{it} represents the drift in individual housing value through time and N_{it} represents the noise specific to each sales transaction. The total percentage change in price for house *i* transacting in time periods *s* and *t* is given by:

$$\ln(P_{it}) - \ln(P_{is}) = \beta_t - \beta_s + H_{it} - H_{is} + N_{it} - N_{is} \qquad [2]$$

The difference in the natural logarithm of the price of house *i* that is observed to transact at any two dates can be expressed more generally by:

$$\ln(P_{it}) - \ln(P_{is}) = \sum \beta_t D_{it} + \varepsilon_i \qquad [3]$$

Where D_{it} is a matrix of monthly dummy variables that takes on the values of -1 in the period of initial sale (period s), +1 in the second period (period t) and 0 in all other periods *(t* = time period January 1996 to June 2002) while ε_I are normally distributed error terms. It is necessary to remove the first period (January 1996) to avoid perfect collinearity among the explanatory variables. The estimated coefficients β_t represent the logarithm of the cumulative price index. That means the anti-logs of the estimated coefficients $\beta_{t,}$ are taken to be the quality-adjusted price index with the first time period as the base period for the index (since the coefficient for the first period is zero, and anti-log of zero equals to 1).

Case and Shiller extended the basic R-S approach by using the Weighted General Least square method to correct for the possibility of time-dependent error variance. So that less weight will be given to highly influential sale pairs that have longer time intervals between sales. The steps for the WRS method is as follow: 1) estimate equation [3] using Ordinary Least Squares by regressing the log price of the second sale minus the log price of the first sale on a set of dummy variables and obtain the residuals; 2) A weighted regression of the squared residuals from the first stage is run on a constant term and the time between sales (the number of days elapsed between two sales). Obtain the fitted values; and 3) A weighted generalized least squares regression is run by first dividing each observation in the first-stage regression by the square root of the fitted values of the second-stage regression and running the stage-one regression again. This weighting procedure acts to diminish the impact on the regression from properties with longer waiting times between repeat transactions by giving less weight to those transactions.[15]

In this study, matches on property address and area code are performed using SAS to identify repeat transactions (more than 90% of the sales are single transactions, so they considered out of scope and thus excluded from the sample). Then by comparing the characteristics of the two sales of the same property to determine if any major renovations or upgrading have taken place between sales (Compare the descriptions or remarks provided by the agent for each sale). Information on property sale prices and transaction dates from both records is retained and written as a single record to a form the R-S data file. This technique is time-consuming and requires extensive cleaning of the database: to identify properties with changes in physical characteristics and then eliminate them from the sample.

Summary of Dataset for the R-S Method:

Repeat transactions:		
Address Matches		13717
Improvements or Upgrading	-974	
Repeat-Sales Regression Dataset		12770
R-S Regression Dataset in PAIRS		6385

An example:

[15] Abraham and Schauman (1991).

R-S Method

	Sold Date	Sold Price
1234 Wellington street	19-May-98	$100,000
1234 Wellington street	25-Nov-00	$120,000
505 George street	01-Aug-97	$86,999
505 George street	23-Jan-99	$113,999

Dependent Variable = $\log(P_i^{\text{2nd sale}}) - \log(P_i^{\text{1st sale}})$

		Monthly Time Dummy Variables						
Repeat Transactions	Dependent Varia2ble	*D96FEB*	*D96MAR…*	*D97AUG…*	*D98MAY…*	*D99JAN…*	*D00NOV…*	*D02JUN*
1234 Wellington street	*log(120000) - log(100000)*	0	0	0	-1	0	+1	0
505 George Street	*log(113999) - log(86999)*	0	*0*	-1	*0*	+1	0	0

4.2 The Hedonic Model

In the hedonic model, the price of a variety *j* at time *t*, $P_{r,t}$, is assumed to be a function of its defining characteristics, $h_t(\chi_{j,t})$, plus a random error term. The hedonic price function specifies how the market price of the commodity varies as the characteristics vary. In the case of estimating a residential housing price index, the hedonic equation is specified as the log of the transaction price of properties as a function of various housing attributes such as structural, dwelling equipment (type of heating, alarm, and air conditioning systems) locational effects and neighbourhood characteristics generated from the MLS database, along with a set of time dummy variables indicating the month and year of sale.

A semi-log form was adopted for the hedonic equations in the study: the logarithm of price was regressed on a number of explanatory variables. Previous studies showed that the semi-log form fits the data better and often reduces heteroscedasticity than the linear functional form.[16] The coefficient of a variable (except the dummy variables) can be interpreted as the percentage change in sale prices due to the inclusion of the variable. The log-linear specification of the hedonic function can be written as[17]:

$$\ln(P) = f(X, Q_1, Q_2, ..., Q_T) + \varepsilon_i \qquad [4]$$

Where P is the sale price of a given property at time t (t = Time period from January 1996 to June 2002), X is a vector of housing characteristics described below, and Q_t is a set of monthly time dummy variables; if the property is sold in period t then Q_t=1, otherwise, = 0. The log-transformed equation is estimated by the Ordinary Least Square method and the Generalized Least square method is used to correct for heteroskedasticity if necessary. The general estimating equation for a hedonic house price model is of the form:

$$\ln(P_t) = \alpha_0 + \beta_1 X_t + ... + \beta_k X_k + \gamma_1 Q_1 + ... + \gamma_t Q_t + \varepsilon_i \qquad [5]$$

In equation [5], $\beta_{1\ to\ k}$ is the vector of linear regression coefficients and they represent the implicit market prices on property characteristics ($X_{1\ to\ k}$). Note that the implicit prices of each housing and locational characteristics are assumed to be constant over time. The regression coefficients on the monthly dummy variables $Q_{1\ to\ t}$ represent changes in the natural logarithm of the price index, while holding other characteristics constant.

The table below shows a list of explanatory variables included in estimating the hedonic house price index. A set of 80 location dummy variables is included in the hedonic equation to model neighbourhood effect on house prices. Each location or township is represented by a separate dummy variable to measure the discount or premium for each location has relative to a central city location (centretown). The township or location dummy variables are identified according to the geographic area breakdown provided by the Ottawa Real Estate Board.

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[16] Based on goodness-of-fit criterion, we also found that semi-log was the superior form.
[17] Clapp, Giacotto and Tirtiroglu (1991).

Summary of the dataset for the Hedonic Model

Original Dataset from the Board			122275
Residential and Condominium properties		106826	
Status = "SOLD"	77360		
Other Deletions			
House type = MOBILE HOMES	-562		
Outside period of observation (<1996)	-1157		
Miscellaneous missing data	-311		
Dataset for Hedonic Analysis			75330

Table 1

Independent variables in hedonic regressions

AGE	Age of the unit in years. If year built is unknown, age equals to 0 and OLDHOUSE equals to 1; if the unit is brand new, age also equals to 0 but NEWHOUSE equals to 1.

AGE^2	*AGE* squared
LIVING_AREA	Total square feet of living area in the unit
BEDROOM	Number of reported bedrooms
BATHROOM	Number of reported bathrooms
OTHER ROOM	Number of rooms other than bedrooms and bathrooms
GARAGE	Number of garage
FIREPLACE	Number of fireplace
NEWHOUSE	If *AGE=0* and the unit is **new** then *NEWHOUSE*=1; otherwise =0
OLDHOUSE	If *AGE=0* and the unit is **old** then *OLDHOUSE*=1; otherwise =0
BIG_LOT	If unit has lot area 1 acre or more then *BIG_LOT*=1; otherwise =0
NO_EQUIP	If unit has no hot water heater then *NO_EQUIP* =1; otherwise =0
APPLIANCES	If unit has appliances then *APPLIANCES*=1; otherwise =0
AIRCON	If unit is air conditioned then *AIRCON* =1; otherwise =0
ENSUITE	If unit has ensuite bath then *ENSUITE* =1; otherwise =0
HARDWOOD	If unit has hardwood floors then *HARDWOOD* =1; otherwise =0
POOL	If unit has indoor or outdoor pool then *POOL* =1; otherwise =0
WHIRLPOOL	If unit has whirlpool or jacuzzi then *WHIRLPOOL* =1; otherwise =0
BASEMENT	If unit has finished basement or recreation room then *BASEMENT*=1; otherwise =0
SECURITY	If unit has security control then *SECURITY*=1; otherwise =0
ALARM	If alarm system is installed in the unit then *ALARM* =1; otherwise =0
SHOPNRB	If shopping center is nearby then *SHOPNRB* =1; otherwise =0
AS-IS	If unit is in as-is condition then AS-IS =1; otherwise =0
BUNGALOW	If housing type is a bungalow
TWO-STOREY	If housing type is a two-storey house

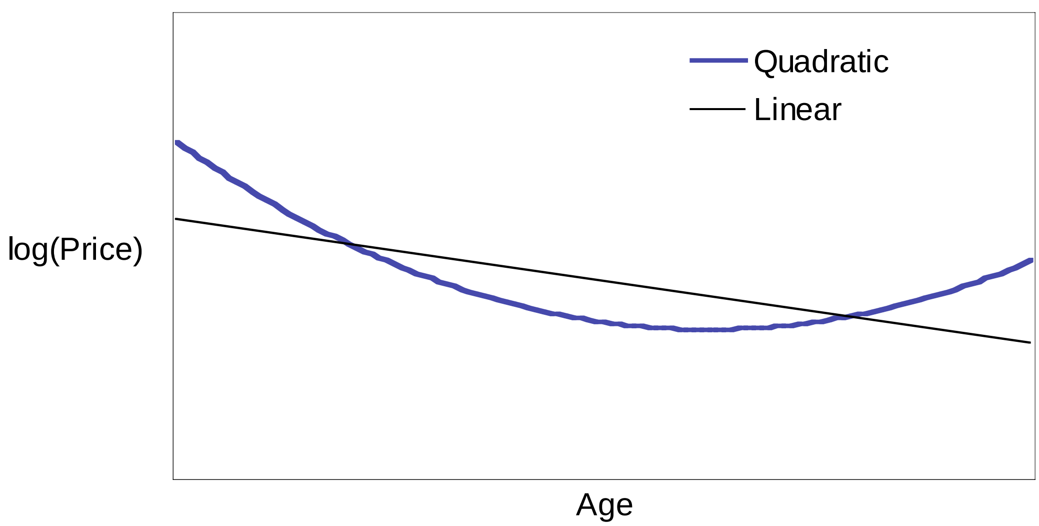
THREE-STOREY	If housing type is a three-storey house
SPLIT	If housing type is a split house
HI-RANCH	If housing type is a hi-ranch
COTTAGE	If housing type is a cottage
GARDEN	If housing type is a garden home
COURT	If housing type is a court home
ROW	If housing type is a row unit
TOWNHOUSE	If housing type is a townhouse
CARRIAGE	If housing type is a carriage
DUPLEX	If housing type is a duplex or double
SEMI	If housing type is a semi-detached
OTHER	If housing type is other
LOCATION DUMMY VARIABLES	See Appendix (Centretown as base category)
MONTHLY TIME DUMMY VARIABLES	January 1996 as base period,
	If unit is sold in February 1996 then *D96FEB* =1; otherwise =0

Age and Age^2

Nonlinearities and interactions between explanatory variables are possible in constructing a hedonic house price index, but in general those terms are not included in the study. For example, diminishing returns to bathrooms and bedrooms may be expected at some point, but this assumption is considered outside the range in the sample. However, the age and its squared are used as separate variables to model the nonlinear relationship between house prices and its age. In Grether and Mieszkowski (1974) study, the effect of age on the value of a house was showed to be nonlinear, with younger houses depreciate more rapidly than older houses and houses continued to lose value until they are around 100 years old. So it is possible that at some point, the age of the house has no effect or even positive effect on house prices because usually older houses are located in more matured neighbourhoods.

log(price) as a quadratic function of Age

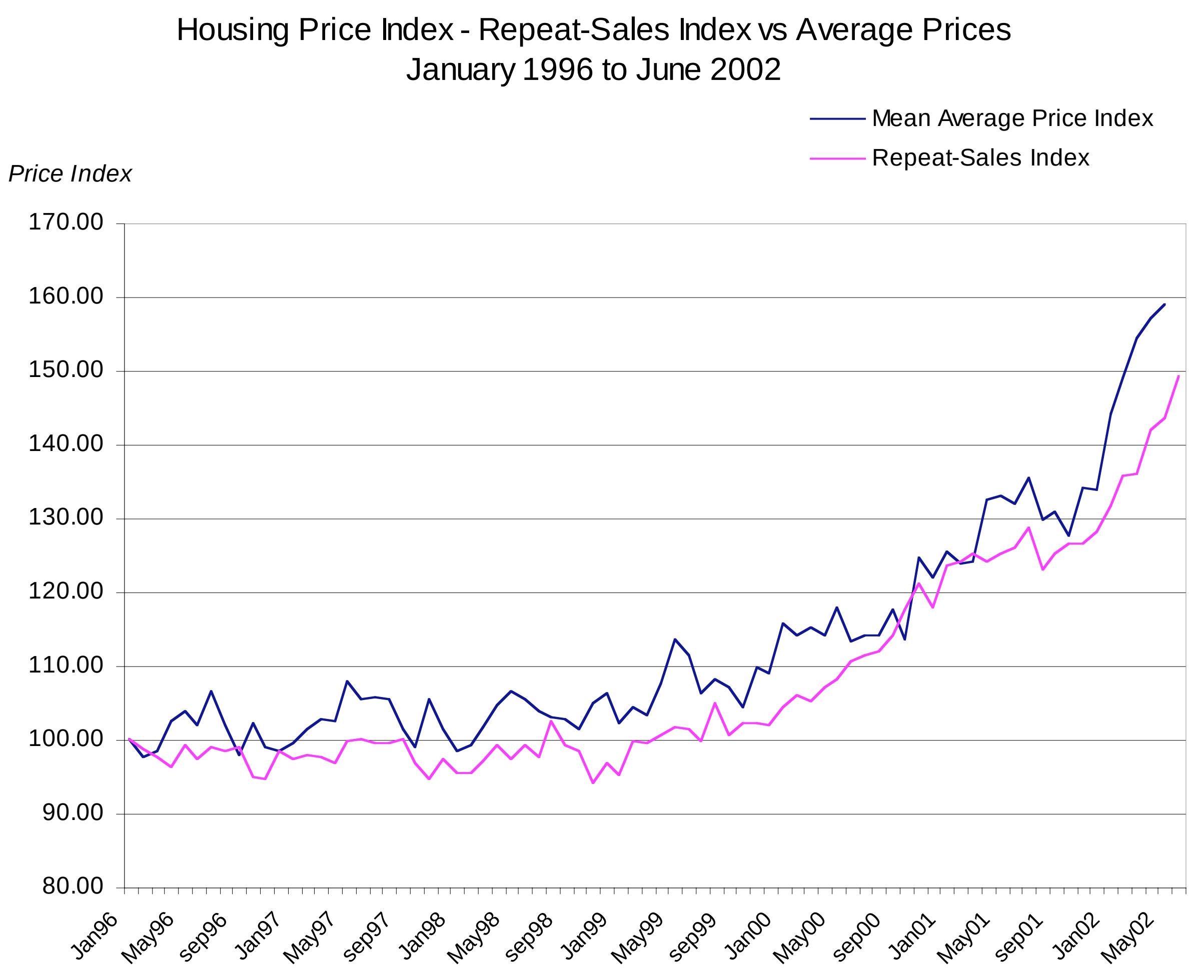
$\log(\text{price}) = b_0 + b_1 \text{ Age} + b_2 \text{ Age}^2$



5. Empirical Results

5.1 The Weighted R-S Index

The results for the estimation of the weighted R-S price index for existing houses for the period from January 1996 to June 2002 are indicated in Appendix A. The R-S model was estimated with 6385 pairs of repeat transactions and 77 monthly time dummy variables; the adjusted R-square obtained is 0.59 with a F-statistics of 119.5. The WRS index is derived by taking the anti-logs of the estimated coefficients of the monthly dummy variables. The following chart compares the Weighted R-S index with the average sales prices of existing houses based on MLS data for the same period of observation.

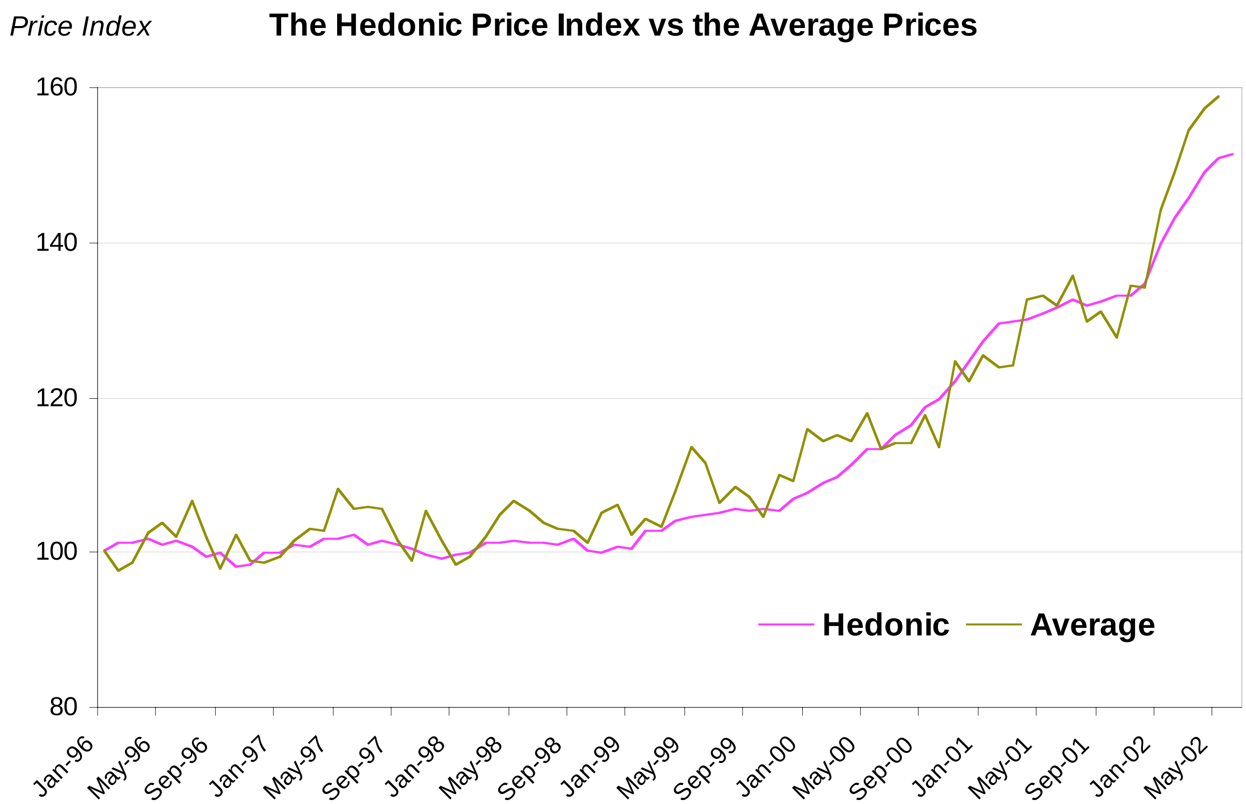


When comparing the results of the Weighed R-S index to the average sales prices, the estimated price index in general is lower than the average sales price index that includes all transactions. The results are consistent with previous studies that show evidence of sample selectivity problem exists - properties that are sold repeatedly are typically of lower quality and might have significantly lower market values compared to properties that are sold less frequently, and thus causes repeat residential sales to be a biased subsample of the entire population of sales.

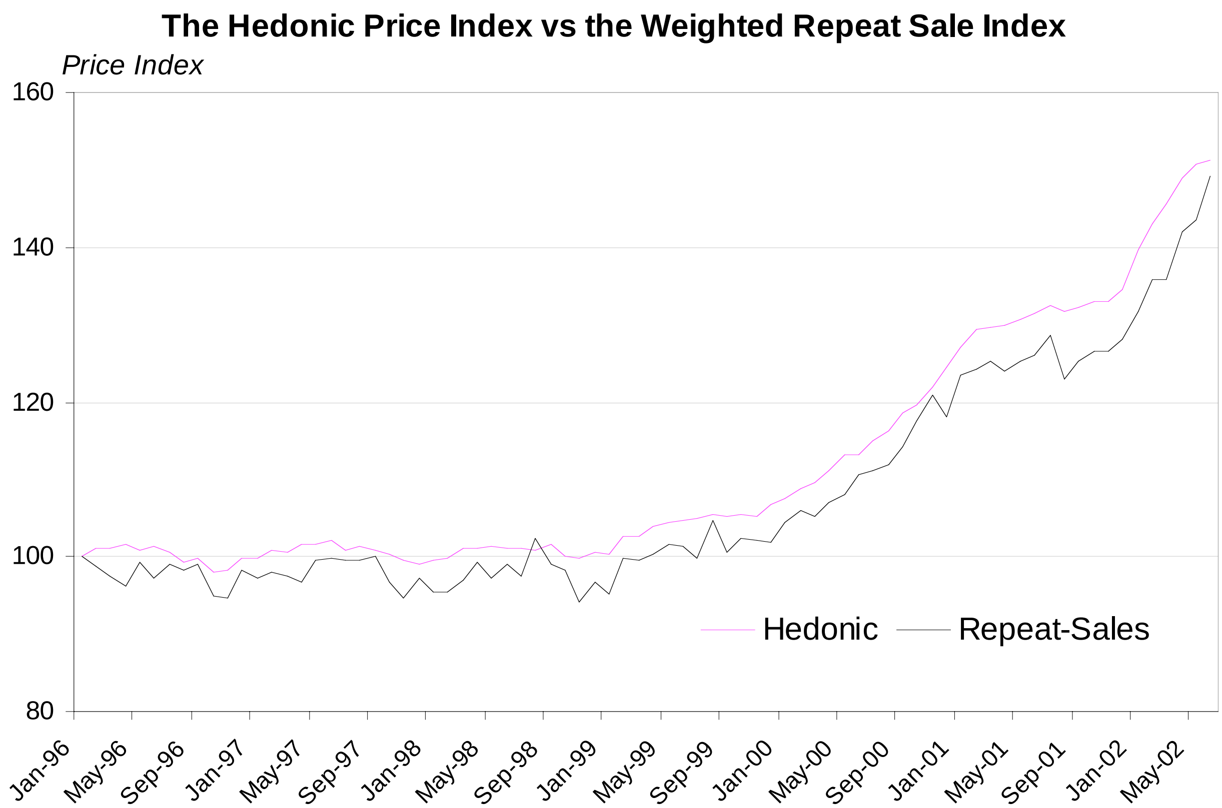
5.2 The Hedonic Price Index

The Bruesch-Pagan test for heteroskedasticity shows that the estimates obtained using the Ordinary Least Squares procedure violates the assumption of homoskedastic error (or equal variance of the error term), so the Feasible Generalized Least Squares procedure is used to correct for heteroskedasticity. The use of FGLS estimates in place of the OLS estimates yields more efficient estimates of the regression parameters and of the variance of the estimators. Thus, the resulting GLS estimators are more reliable than the OLS estimators.

Parameter estimates of the explanatory variables and the monthly time dummy coefficients are presented in appendix B. Overall the results are quite encouraging, with all of the structural and locational variables with the expected signs (except the Basement variable which has a negative sign) and being statistically significant (except neighbourhood dummy for “Carlingwood”). The adjusted R-square obtained is 0.86; the estimated parameters explain at least 86% of the variation in the natural log of sales price.



The results for the quadratic age specification provide support for non-linear effect of age on house prices. The quadratic specification shows the effect of age on the value of house depends on the age of the dwelling. The hedonic estimates of price trend are less volatile then that measured by the average price index.



6. Econometric Issues

6.1 Heteroskedasticity

The presence of heteroskedasticity of the error variance resulting from model misspecification such as omitted variables, incorrect functional form, and structural instability will violate the assumption of constant error variance of the OLS estimator. These problems often arise in estimating hedonic price function since measuring product characteristics and specifying the hedonic model with complete set of regressors could be very difficult. In addition, in studying housing prices, it is possible to notice that the variability in sale price increases as the age of the house increases. This dwelling age heteroskedasticity is likely because older houses generally show greater variation in their condition (renovation vs deterioration), and thus a larger magnitude of error in predicting house prices. The older a house, the more likely the property would undergone major renovations or upgrading and these improvements are usually not recorded in datasets and therefore typically not incorporated in the hedonic specification.[18]

6.2 Autocorrelated Errors

The Durbin-Watson D statistics show no evidence for autocorrelation – the error term is related to the error term of other observation. This is generally more of a problem for time-series analysis.

6.3 Multicollinearity

A common econometric issue in constructing a hedonic price index is the problem of multicollinearity – the explanatory variables are intercorrelated so that the effects of each individual variables upon the dependent variable cannot be separated. By examining the Pearson R correlation coefficients and the Condition Index show that multicollinearity exists. For instance, the correlation coefficient between the number of bedroom and other room with respect to living area is higher than 0.5 since bigger houses usually have more bedrooms and other rooms than houses with smaller living area.

7. Conclusion and Future Research

Price index estimated by the hedonic price function is less volatile than other measures such as median or average prices and because of the inherent difficulties associated with the latter estimates the median and average can be rejected outright as a measure of trends in house prices. The R-S index gives estimates of sale prices that are significantly lower than that of the hedonic price index. This is probably because of the R-S method does not account for the increasing age of the structure over time and therefore their cannot be a pure constant-quality price index. The results support the conclusion of previous studies that R-S are subject to sample selectivity bias. We also believe that the hedonic approach performs better than the R-S method (higher R^2 and because of the issue raised by Griliches). The following chart shows that the hedonic price index for existing houses in Ottawa follow a very similar pattern of that for new houses using

[18] Goodman and Thibodeau, 1995.

Statistics Canada's New House Price Index which reinforces our belief that the results of the hedonic approach are not too far off the mark (or *vice versa*).[19]

The authors have identified the following areas for which some future research could be conducted:

1- Currently, we are negotiating with a neighbouring real estate board (Gatineau) to obtain their MLS data over the same time period. The aim in this case would be to test the data and model in the context of spatial house price comparisons. The unique situation whereby both cities are located in different provinces not to mention the different socio-economic environment could answer some questions on the existing differences in house prices.

2- Given that the hybrid approach is favoured by some researchers because it incorporates the best of both worlds, it would be interesting to see how the results differ using this methodology.

3- Chowhan and Prud'Homme (2004), in order to improve the explanatory power of their spatial hedonic price index model for shelter, merged information from the census database to their initial data source of physical characteristics. The supplementary information added more neighbourhood dimensionality to the existing explanatory variables. A similar exercise could probably be applied to the MLS data.

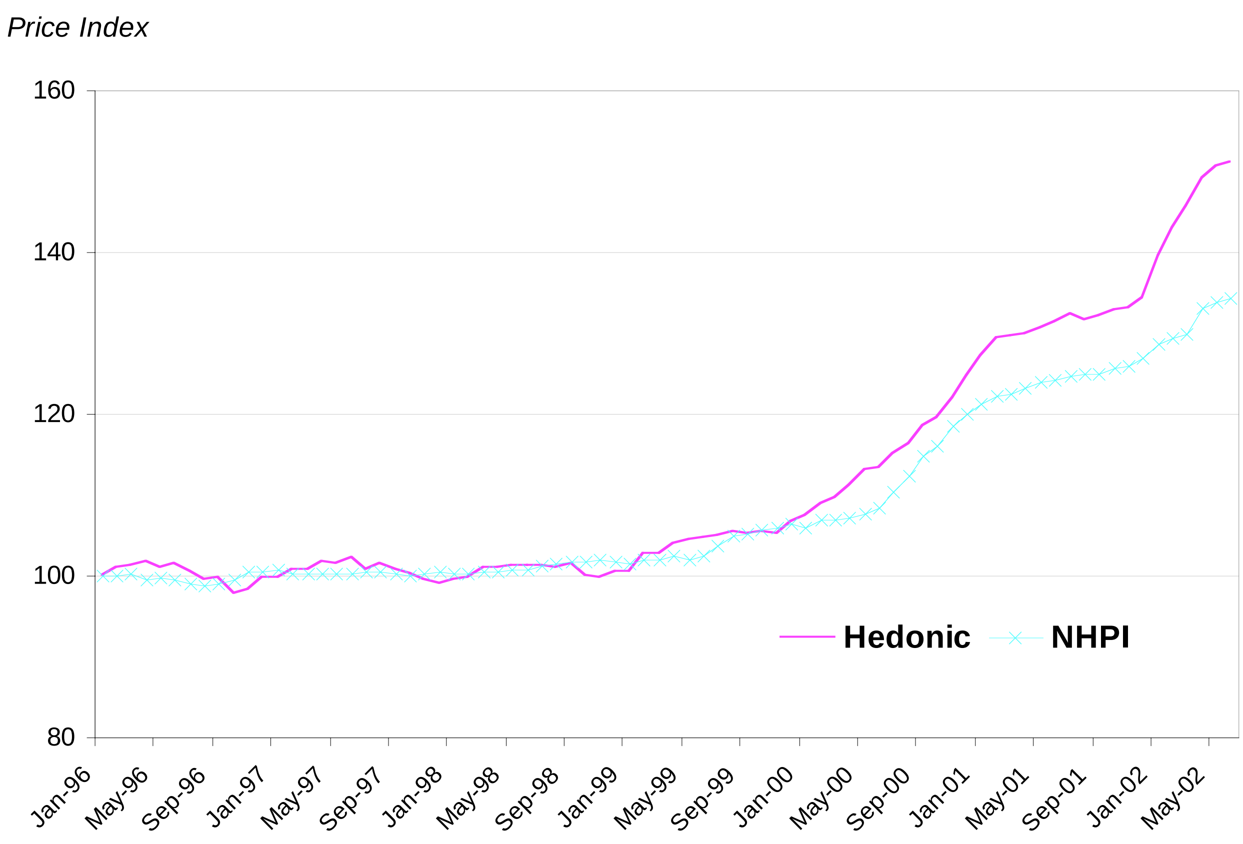
4- So far, our exploratory study was limited to the log and linear functional forms. Other forms could also be tested. Some studies have applied for instance the Box-Cox form because there is evidence to suggest that the linear forms are often confronted with non-normal errors. (See Cheshire and Sheppard, 1995

[19] For residential houses, we have the New House Price Index (NHPI) which is produced by Statistics Canada, which is a monthly series that measures changes over time of the contractor's selling prices of new residential houses, where detailed specifications pertaining to each house remain the same between two consecutive periods. The survey also collects contractors' estimates of the current value of the land for which a land price index is obtained. The resulting series is used for calculating some of the components of the consumer price index for shelter, depreciation to be exact, and for deflating the value of the national housing stock in the national accounts.

and Cropper *et al.*, 1993.) It would seem appropriate to extend the analysis along these lines.

5- Given the largeness of the available characteristics in the MLS database, the issue of which of the explanatory variables to use comes up. A more scientific method for selecting the relevant characteristics has been proposed by Arguea and Hsiao (1993). Most hedonic studies (this one included) will select the characteristics on *a priori grounds*. Arguea and Hsiao favours a conditional index measure to isolate the explanatory variables, a technique pioneered by Belsley, Kuh, and Welsh (1980).

The Hedonic Price Index for Existing Houses vs the New House Price Index (NHPI)



Appendix A: Statistical Results for the Weighted R-S Index

Weighted R-S Model: $\ln(P_{it}) - \ln(P_{is}) = \Sigma\, \beta_t\, D_{it} + \varepsilon_i$

Monthly Time Dummy Variables	Coefficients	Standard Error	Price Index	Monthly Changes	
1996					
1996 January	Base period		100.00		
February	-0.0123	0.0167	98.77	-1.2%	
March	-0.0249	0.0150	97.54	-1.2%	
April	-0.0390	0.0144	96.18	-1.4%	
May	-0.0072	0.0152	99.28	3.2%	
June	-0.0269	0.0165	97.34	-1.9%	
July	-0.0108	0.0158	98.93	1.6%	
August	-0.0163	0.0178	98.39	-0.5%	
September	-0.0108	0.0184	98.92	0.5%	
October	-0.0521	0.0173	94.92	-4.0%	*
November	-0.0542	0.0160	94.73	-0.2%	
December	-0.0176	0.0193	98.26	3.7%	
1997					
January	-0.0273	0.0176	97.31	-1.0%	*
February	-0.0210	0.0158	97.92	0.6%	
March	-0.0250	0.0158	97.53	-0.4%	*
April	-0.0341	0.0143	96.65	-0.9%	*
May	-0.0037	0.0134	99.63	3.1%	*
June	-0.0011	0.0148	99.89	0.3%	
July	-0.0045	0.0144	99.55	-0.3%	
August	-0.0057	0.0162	99.43	-0.1%	*
September	0.0013	0.0171	100.13	0.7%	*
October	-0.0325	0.0168	96.81	-3.3%	*
November	-0.0545	0.0185	94.69	-2.2%	*

December	-0.0278	0.0216	97.26	2.7%	
1998					
January	-0.0479	0.0194	95.33	-2.0%	*
February	-0.0467	0.0163	95.44	0.1%	*
March	-0.0305	0.0147	96.99	1.6%	*
April	-0.0076	0.0142	99.24	2.3%	*
May	-0.0287	0.0141	97.17	-2.1%	*
June	-0.0092	0.0137	99.08	2.0%	
July	-0.0250	0.0145	97.53	-1.6%	
August	0.0244	0.0156	102.47	5.1%	*
September	-0.0087	0.0162	99.14	-3.2%	
October	-0.0177	0.0165	98.24	-0.9%	
November	-0.0604	0.0184	94.14	-4.2%	
December	-0.0338	0.0198	96.68	2.7%	*
1999					
January	-0.0507	0.0182	95.06	-1.7%	
February	-0.0027	0.0153	99.73	4.9%	*
March	-0.0049	0.0142	99.51	-0.2%	
April	0.0043	0.0142	100.43	0.9%	*
May	0.0157	0.0128	101.58	1.1%	*
June	0.0132	0.0139	101.33	-0.2%	*
July	-0.0019	0.0146	99.81	-1.5%	
August	0.0462	0.0145	104.73	4.9%	
September	0.0065	0.0157	100.66	-3.9%	
October	0.0227	0.0159	102.29	1.6%	*
November	0.0219	0.0162	102.21	-0.1%	*
December	0.0179	0.0202	101.80	-0.4%	*
2000					
January	0.0431	0.0153	104.41	2.6%	*
February	0.0572	0.0146	105.88	1.4%	*

March	0.0501	0.0132	105.14	-0.7%	*
April	0.0673	0.0132	106.97	1.7%	
May	0.0778	0.0123	108.09	1.0%	*
June	0.1007	0.0130	110.60	2.3%	*
July	0.1065	0.0136	111.24	0.6%	*
August	0.1119	0.0136	111.84	0.5%	*
September	0.1326	0.0151	114.18	2.1%	
October	0.1626	0.0157	117.66	3.0%	
November	0.1907	0.0161	121.01	2.9%	
December	0.1652	0.0192	117.96	-2.5%	
2001					
January	0.2101	0.0144	123.39	4.6%	
February	0.2164	0.0149	124.16	0.6%	
March	0.2246	0.0135	125.19	0.8%	
April	0.2155	0.0136	124.04	-0.9%	
May	0.2251	0.0127	125.25	1.0%	
June	0.2316	0.0145	126.07	0.7%	
July	0.2515	0.0141	128.59	2.0%	
August	0.2075	0.0141	123.06	-4.3%	
September	0.2247	0.0149	125.20	1.7%	
October	0.2356	0.0144	126.56	1.1%	
November	0.2357	0.0144	126.58	0.0%	
December	0.2472	0.0160	128.05	1.2%	
2002					
January	0.2758	0.0147	131.75	2.9%	
February	0.3058	0.0137	135.76	3.0%	
March	0.3066	0.0126	135.87	0.1%	
April	0.3498	0.0122	141.88	4.4%	
May	0.3610	0.0125	143.47	1.1%	
June	0.4001	0.0244	149.20	4.0%	

* = statistically insignificant at 90% confidence interval

Appendix B: Statistical Results for the Hedonic Price Index

Hedonic Model:

$\log(Pt) = \alpha_0 + \beta_1 Area + \beta_2 Age + \ldots \beta_j X_t + \gamma_1 Q_1 + \gamma_2 Q_2 + \ldots + \gamma_t Q_t + \varepsilon_t$,

where the regression coefficients g_1, g_2, …, g_t represent the constant quality price index estimators for each time period of sale and b1,…bj represent the implicit prices of various characteristics;

P_t = Sale price of a given house at time t, t = Time period from January 1996 to June 2002;

X_{jt} = A vector of housing characteristics;

Q_t = A set of monthly time dummy variables; if the property is sold in period t then Q_t =1 and all other time dummy variables = 0; and

ε_t = Random error with 0 mean and variance s².

Continuous Variables	Coefficients	Standard Error	Interpretation
Total Living Area	0.0001	0.0000	0.01%
Bedrooms	0.0433	0.0010	4.43%
Bathrooms	0.0312	0.0012	3.17%
Other Rooms	0.0113	0.0004	1.14%
Garage	0.0754	0.0010	7.83%
Fireplace	0.0514	0.0011	5.28%
Age	-0.0082	0.0001	-0.81%
Age^2	0.0001	0.0000	0.01%
Dummy Variables			
New House	0.0719	0.0053	7.46%
Old House	-0.2490	0.0029	-22.04%
Big Lot	0.0982	0.0041	10.31%
No Equipment	-0.0089	0.0017	-0.89%
Appliances	0.0209	0.0014	2.11%
Air Conditioned	0.0474	0.0011	4.85%

Ensuite Bath	0.0421	0.0015	4.30%
Hardwood Floor	0.0431	0.0011	4.41%
Pool	0.0271	0.0019	2.74%
Whirlpool	0.0426	0.0021	4.35%
Basement	-0.0272	0.0013	-2.69%
Security	0.0358	0.0061	3.65%
Alarm	0.0378	0.0015	3.85%
Shopping nearby	-0.0131	0.0010	-1.30%
As-is Condition	-0.1144	0.0081	-10.81%
Bungalow	0.4373	0.0040	54.86%
Two-Story	0.4233	0.0039	52.69%
Three-Story	0.4648	0.0078	59.17%
Split	0.4394	0.0044	55.19%
Hi-Ranch	0.4270	0.0047	53.26%
Cottage	0.2921	0.0176	33.92%
Garden homes	0.0373	0.0045	3.80%
Court homes	0.0585	0.0083	6.03%
Row unit	0.2504	0.0039	28.45%
Townhouse	0.0715	0.0040	7.42%
Carriage	0.2942	0.0058	34.20%
Duplex or Double	0.4128	0.0080	51.10%
Semi-detached	0.3066	0.0041	35.87%
Other	0.3100	0.0134	36.34%
Apartment	Omitted as Base category		
Location Dummy Variables			
Downtown Core:			
Sandy Hill	0.0320	0.0080	3.25%
Glebe	0.2290	0.0090	25.73%
Ottawa South	0.1001	0.0090	10.52%

Ottawa East	0.0441	0.0099	4.50%	
			0.00%	
Ottawa West:			0.00%	
Hintonburg	-0.3100	0.0094	-26.65%	
Ottawa West	-0.0612	0.0107	-5.93%	
Civic	0.0597	0.0115	6.15%	
Westboro	-0.1012	0.0096	-9.62%	
Carlington	-0.2762	0.0083	-24.14%	
Ottawa Far West:				
Carlingwood	-0.0039	0.0087	-0.39%	*
Glabar	-0.1603	0.0104	-14.81%	
BelAir	-0.1849	0.0075	-16.88%	
Woodroffe	-0.0948	0.0091	-9.05%	
Britannia	-0.1799	0.0114	-16.46%	
Queensway	-0.2582	0.0075	-22.76%	
Redwood	-0.2960	0.0086	-25.62%	
Ottawa South:				
Cedardale	-0.2952	0.0112	-25.56%	
Blossom Park	-0.3327	0.0074	-28.30%	
Alta Vista	-0.1291	0.0072	-12.11%	
Elmvale	-0.2272	0.0072	-20.33%	
South Keys	-0.3219	0.0063	-27.52%	
Riverside	-0.2212	0.0080	-19.85%	
Carleton	-0.2459	0.0089	-21.80%	
Hunt Club	-0.3148	0.0074	-27.01%	
Ottawa East:				
Manor Park	-0.1390	0.0102	-12.98%	

Rockcliffe	0.5531	0.0160	73.86%
Lindenlea	0.1943	0.0099	21.44%
Vanier	-0.3453	0.0091	-29.20%
Castle Hts	-0.2791	0.0079	-24.35%
Nepean:			
Crystal Beach	-0.1886	0.0087	-17.19%
Skyline	-0.2437	0.0069	-21.63%
Ashdale	-0.2489	0.0086	-22.04%
Craig Henry	-0.2434	0.0066	-21.60%
Barrhaven	-0.3708	0.0061	-30.98%
Bells Corners	-0.3445	0.0074	-29.14%
Kanata:			
Beaverbrook	-0.2685	0.0073	-23.55%
Hazeldean	-0.3404	0.0063	-28.85%
Bridlewood	-0.3590	0.0064	-30.17%
Kanata Lakes	-0.2155	0.0094	-19.38%
Morgan's Grant	-0.3580	0.0077	-30.09%
Orleans:			
Cumberland	-0.3959	0.0061	-32.69%
Chapel Hill	-0.3706	0.0062	-30.97%
Beaconwood	-0.2890	0.0072	-25.10%
Cyrville	-0.3498	0.0071	-29.52%
Blackburn	-0.3193	0.0074	-27.33%
Gloucester	-0.4468	0.0144	-36.03%
Rockland (Area H):			
Russel	-0.5719	0.0076	-43.55%

Casselman	-0.7179	0.0103	-51.22%
Rockland	-0.5918	0.0069	-44.66%
Alfred	-0.7971	0.0130	-54.94%
Metcalfe (Area I):			
Greely	-0.3818	0.0088	-31.74%
Metcalfe	-0.4443	0.0110	-35.87%
Osgoode	-0.4334	0.0091	-35.17%
Vernon	-0.4962	0.0115	-39.12%
Manotick (Area J):			
Manotick	-0.1911	0.0092	-17.39%
Rideau	-0.4422	0.0089	-35.74%
Stittsville (Area K):			
Stittsville	-0.3066	0.0068	-26.41%
Richmond	-0.4095	0.0095	-33.60%
Goulbourn	-0.4469	0.0094	-36.04%
Carp (Area L):			
Carp	-0.3913	0.0089	-32.38%
Woodlawn	-0.4464	0.0092	-36.01%
Fitzroy	-0.5448	0.0136	-42.00%
Arnprior (Area A):			
Arnprior	-0.5707	0.0085	-43.49%
Petawawa	-0.6410	0.0078	-47.32%
Pembroke	-0.6819	0.0088	-49.43%
Renfrew	-0.6799	0.0108	-49.33%
Barry's Bay & Areas	-0.8412	0.0091	-56.88%

Almonte (Area B):				
Almonte	-0.5090	0.0089	-39.89%	
Lanark	-0.7581	0.0203	-53.15%	
Dalhousie	-0.7681	0.0538	-53.61%	
Carleton Place (Area C):				
Carleton Place	-0.5594	0.0070	-42.84%	
Drummond	-0.6132	0.0167	-45.84%	
Westport (Area D):				
Westport	-0.6339	0.0440	-46.95%	
Kemptville (Area E):				
Kemptville	-0.5481	0.0074	-42.20%	
Edwardsburg	-0.7569	0.0175	-53.09%	
Winchester (Area F):				
Williamsburg	-0.8045	0.0178	-55.27%	
Winchester	-0.6941	0.0094	-50.05%	
Finch	-0.8707	0.0227	-58.14%	
Alexandria (Area G):				
Alexandria	-0.8333	0.0465	-56.54%	

Omitted: if area is Centretown (base category).

Time Dummy Variables	Coefficients	Standard Error	Price Index	
Jan 96	Base Period = 0	n/a	100.00	
Feb 96	0.0110	0.0079	101.11	*

Mar 96	0.0120	0.0075	101.21	*
Apr 96	0.0168	0.0075	101.69	
May 96	0.0096	0.0074	100.96	*
Jun 96	0.0140	0.0076	101.41	
Jul 96	0.0052	0.0078	100.52	*
Aug 96	-0.0060	0.0079	99.40	*
Sep 96	-0.0023	0.0083	99.77	*
Oct 96	-0.0214	0.0079	97.88	
Nov 96	-0.0181	0.0076	98.21	
Dec 96	-0.0015	0.0083	99.85	*
Jan 97	-0.0026	0.0084	99.74	*
Feb 97	0.0086	0.0077	100.86	*
Mar 97	0.0062	0.0077	100.62	*
Apr 97	0.0171	0.0074	101.73	
May 97	0.0150	0.0072	101.51	
Jun 97	0.0219	0.0074	102.22	
Jul 97	0.0082	0.0075	100.82	*
Aug 97	0.0135	0.0078	101.36	
Sep 97	0.0074	0.0079	100.74	*
Oct 97	0.0034	0.0082	100.34	*
Nov 97	-0.0042	0.0080	99.58	*
Dec 97	-0.0108	0.0093	98.93	*
Jan 98	-0.0057	0.0090	99.43	*
Feb 98	-0.0029	0.0080	99.71	*
Mar 98	0.0107	0.0074	101.08	*
Apr 98	0.0101	0.0072	101.01	*
May 98	0.0131	0.0072	101.32	
Jun 98	0.0114	0.0072	101.15	*
Jul 98	0.0112	0.0075	101.12	*
Aug 98	0.0086	0.0076	100.87	*

Sep 98	0.0153	0.0080	101.54	
Oct 98	0.0011	0.0082	100.11	*
Nov 98	-0.0014	0.0088	99.86	*
Dec 98	0.0046	0.0095	100.46	*
Jan 99	0.0040	0.0082	100.40	*
Feb 99	0.0260	0.0076	102.63	
Mar 99	0.0258	0.0071	102.61	
Apr 99	0.0397	0.0070	104.05	
May 99	0.0433	0.0070	104.43	
Jun 99	0.0448	0.0071	104.59	
Jul 99	0.0489	0.0072	105.01	
Aug 99	0.0537	0.0074	105.52	
Sep 99	0.0516	0.0077	105.30	
Oct 99	0.0529	0.0076	105.44	
Nov 99	0.0504	0.0080	105.17	
Dec 99	0.0657	0.0091	106.79	
Jan 00	0.0722	0.0080	107.49	
Feb 00	0.0843	0.0073	108.80	
Mar 00	0.0910	0.0072	109.52	
Apr 00	0.1053	0.0070	111.11	
May 00	0.1232	0.0069	113.12	
Jun 00	0.1244	0.0072	113.25	
Jul 00	0.1400	0.0073	115.03	
Aug 00	0.1512	0.0073	116.33	
Sep 00	0.1704	0.0073	118.58	
Oct 00	0.1786	0.0078	119.56	
Nov 00	0.1993	0.0082	122.05	
Dec 00	0.2201	0.0092	124.61	
Jan 01	0.2398	0.0075	127.10	
Feb 01	0.2573	0.0075	129.35	

Mar 01	0.2602	0.0071	129.72
Apr 01	0.2614	0.0071	129.88
May 01	0.2676	0.0070	130.68
Jun 01	0.2737	0.0073	131.48
Jul 01	0.2806	0.0072	132.39
Aug 01	0.2752	0.0074	131.68
Sep 01	0.2791	0.0077	132.19
Oct 01	0.2845	0.0076	132.91
Nov 01	0.2852	0.0073	133.00
Dec 01	0.2959	0.0081	134.43
Jan 02	0.3337	0.0074	139.61
Feb 02	0.3572	0.0074	142.93
Mar 02	0.3755	0.0071	145.57
Apr 02	0.3990	0.0071	149.04
May 02	0.4102	0.0072	150.71
Jun 02	0.4130	0.0105	151.13

* = statistically insignificant at 90% confidence interval

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