Property Valuation Methods and Data in the United States

by Charles A. Calhoun

INTRODUCTION

Residential property valuation is a subject that permeates social, political, and economic life in the United States. Property valuation serves as an endless topic of discussion among neighbors, but also provides the impetus for major property tax reforms and other public policy measures. Some say that the two most common shared experiences of American daily life are the duration of your commute to work and how much your house has appreciated in the past year. That discussion is increasingly well informed, as the availability of broad-based house price indexes (HPIs) and automated valuation models (AVMs) has evolved rapidly in recent years.[1] This paper aims to provide a survey of the basic statistical methods, historical developments, and recent innovations in house price indexes and property valuation models in the United States, and to give a preliminary assessment of the requirements and prospects for applying similar approaches in other countries.

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A common thread throughout the discussion is the need for more and better data, and the innovative solutions that have emerged to exploit information from a variety of sources, including government surveys, tax assessments, real estate listings, appraisals, mortgage originations, and actual sales transactions. Data gaps and statistical uncertainties persist, and to a certain extent are unavoidable given the relative infrequency and idiosyncratic nature of real property transactions. However, one can also see a steady trend toward more complete geographic coverage, and information that is more readily accessible to homeowners, lenders, brokers, investors, and government regulators, with definite advantages for the efficient operation of the housing finance system.

Applications of HPIs and AVMs

Applications of HPIs and AVMs are almost as varied as the methods and data underlying them. House price indexes are used to track the national, regional, and local performance of residential real estate. Periodic HPI publications represent the most readily available source of information on the economic performance of the most important financial asset for a majority of U.S. households. At their most basic level, HPIs represent an attempt to estimate the rates of appreciation or depreciation in housing values over time periods when a relative minority of properties are actually traded. Thus, in one important sense, HPIs attempt to create data where none existed. HPIs are an important data input into a wide range of academic, financial, and regulatory models concerned with the financial performance of housing and mortgage markets. As discussed in greater detail below, HPIs also comprise an essential component of many large-scale commercial AVMs in the United States.

The United States may be unique in terms of the number of applications of HPIs to housing policy and financial regulation at the national level. For example, a house price index is used to determine increases in the conforming loan limits for eligibility for purchase or securitization of residential mortgages by the Federal National Mortgage Association (also known as Fannie Mae) or the Federal Home Loan Mortgage Corporation (also known as Freddie Mac).[2] The Office of Federal Housing Enterprise Oversight

(OFHEO), the financial safety and soundness regulator for Fannie Mae and Freddie Mac, has proposed a risk-based capital model under specific statutory requirements for the use of HPIs when projecting the financial performance of the enterprises under conditions of economic stress. Loan limits for first-time homebuyers under the Federal Housing Administration (FHA) single-family program are currently tied to loan limits for Fannie Mae and Freddie Mac.[3] Efforts are currently underway to develop local house price indexes from multiple data sources with potential application to setting FHA loan eligibility requirements.

AVM models are an increasingly important tool for use by mortgage lenders and servicers in the United States. A recent study by Pricewaterhouse Coopers indicates that AVMs are used on between 5% and 25% of purchase and refinance loans as a supplemental estimate of value.[4] Although they are rarely used as the only estimate of value for purchase or refinance loans, AVMs are used on 35% to 55% of home equity loans as the only estimate of value.

Ross and Nattagh (1996) describe four primary applications for which AVM models or systems are likely to be adopted, including: mortgage quality control or appraisal review, loss mitigation analysis, portfolio valuation, and appraisal process redesign. Mortgage quality control entails validation or verification of appraisals conducted to determine the market values of collateral properties securing purchase money or refinance loans. Conventional quality control methods typically entail manual review of a random sample of completed appraisals. Application of an AVM to this process offers the advantages of increased speed and reduced subjectivity, limiting the need for manual review to cases identified by the AVM as exceptional.

In loss-mitigation analysis, AVMs can be applied to estimate the current loan-to-value ratio on nonperforming loans to assist the lender or guarantor in determining optimal foreclosure strategies. Lenders may be more eager to provide alternatives to foreclosure and to avoid booking an accounting loss when the proceeds from a foreclosure sale are not likely to cover the outstanding mortgage principal. In this case, better information may benefit both borrowers and lenders.[5]

Portfolio valuation is a natural application of AVM technology, providing an efficient means of marking-to-market a large number of property values, and is most closely aligned with the underlying statistical methods.[6] And, as this application illustrates, AVMs can be applied to both case-by-case valuations and batch processing of thousands of properties.

The fourth application mentioned by Ross and Nattagh, appraisal process redesign, foresees the simultaneous application of an AVM model in conjunction with the efforts of professional appraisers. The automation features of the AVM can reduce the need for manual data collection and manipulation by the appraiser, while simultaneously providing an independent estimate of value. The role of the appraiser would be to evaluate the findings from the AVM in light of his/her own physical inspection of the property, verification of comparables, and knowledge of local market conditions.

The next section provides a brief introduction to the statistical methods underlying the various house price indexes and large-scale automated property valuation systems currently in use in the United States. This is followed by a broad outline of historical developments in the production of residential house price indexes and property valuation models. Discussion of the various data sources occurs throughout the paper, as data availability tends to drive the selection of methods.

Our goal is to give the reader a sense for how analysts, agencies, and firms in the United States have been able to overcome various methodological hurdles and data deficiencies to reach the point where automated valuation systems now represent a viable alternative to manual valuations by professional appraisers. At the same time, we wish to emphasize that no ideal method or data source currently exists, and all of the major asset valuation models currently in use in the United States depend on the application of more than one methodological approach and data source. An important conclusion of the paper is that a similarly eclectic approach is likely to be required when attempting to apply knowledge gained from the U.S. experience to property valuation in other countries.

INDEX AND VALUATION METHODS

A number of statistical methods have been applied to index estimation and property valuation in the United States. Selection of a particular methodology has depended largely on the available data, and as data quantity and quality have improved so have the estimates. This section briefly reviews the methods that have had or gained widespread acceptance in recent years, including: sales comparisons, mean or median transaction prices, hedonic estimation, repeat-sales estimation, hybrid repeat-sales/hedonic methods, rules-based artificial intelligence or expert systems, and artificial neural networks. As discussed in the introduction, the selection of particular methods or combinations of methods depends on the intended applications, which may range from appraising collateral properties securing mortgage loans and valuing real estate portfolios, to production of house price indexes for a variety of financial and regulatory applications.

Sales Comparisons

The traditional method of valuing residential properties has been through the use of pro-

fessional appraisers. Appraisers follow established state and national guidelines in producing estimates of the current market value of a property, relying primarily on comparison with houses recently sold or listed for sale and knowledge of neighborhood trends.[7] Appraisers observe the values of comparable properties, and make numerical adjustments to the prices of the comparables to align them with the features of the subject property and arrive at an estimate of value.

This approach is still the most widely used technique to obtain appraisal values on collateral properties securing residential mortgages and as the basis for periodic real estate assessments by local tax authorities. Professional appraisers in the United States operate under established guidelines, such as the Uniform Standards of Professional Appraisal Practice, or USPAP.[8] The USPAP standards generally refer to minimum standards that must be attained. Appraisers are also subject to various underwriting guidelines that may exceed the requirements of USPAP, such as those imposed by secondary market institutions like Fannie Mae and Freddie Mac, private mortgage insurance companies like PMI Mortgage Insurance Co. and Mortgage Guaranty Insurance Corp., or by government agencies like the Department of Housing and Urban Development or the Federal Home Loan Bank Board.[9]

The primary criticism of the comparative sales approach is that it is subjective, both in terms of selecting comparable sales and with regard to the types of adjustments that are made to determine value. In practice, the number of comparables is usually limited to three or four properties, and separate adjustments are made for specific property characteristics.

Mean or Median Transaction Prices

As with many economic and financial indicators, year-to-year changes in mean or median values continue to be of interest to market participants. This type of index is simple to compute and provides easy to understand summaries of sales activity within relatively localized areas such as ZIP codes. One widely recognized shortcoming is the failure to control for differences in the composition of the sample and the relative quality of the properties transacting from period to period. This makes it difficult to separate out differences in prices that occur because of actual appreciation in housing values from differences in the characteristics of the properties that are being sold. This has lead to a search for "constant quality" house price indexes based on hedonic and repeat-sales methods.

Hedonic Methods

The hedonic method of property valuation recognizes that housing is a composite good, and defines value as a mathematical function of its characteristics.[10] Hedonic methods employ multiple regression techniques to estimate the contribution to total value of specific property characteristics, such as: number of bedrooms, number of bathrooms, number of fireplaces, parking facilities, living area, and lot size. The main strength of hedonic methods is that they control for the characteristics of properties, thereby allowing the analyst to distinguish the impact of changing sample composition from actual property appreciation.

Hedonic methods can be applied to estimate the value of new or existing homes, and observations on value may be actual sales prices, listing prices, appraisal values, or even owners' estimates of housing values. Given an estimated equation expressing property value as a function of housing characteristics, one simply enters the values of the subject property characteristics to predict the total value. Constant-quality house price indexes can be generated, either by including the valuation date (e.g., month, quarter, or year) in the multiple regression, or estimating separate regressions for each time period. A standard bundle of characteristics can be used in the equation(s) to project changes in the value of an "average" house over time.

The main difficulty with the hedonic method is the requirement for detailed information on property characteristics. Even when data on property characteristics are available, these may not be ideal measures of the attributes of houses over which consumer preferences are defined. Also, the available hedonic characteristics tend to be limited to the features of individual houses, and may not provide adequate measures of important differences in neighborhoods and other environmental factors or externalities affecting the market value of a property.

Repeat-Sales Methods

Repeat-sales methods use the observed sales prices of the same properties at different points in time to create a sample of price differentials that can be used to estimate the appreciation rates of houses. If one can assume that the properties in the repeat-sales sample have not undergone significant physical improvements or deterioration between the observed sales, then using price differentials for the same properties automatically controls for the impact of quality on the estimated index of appreciation. Multiple regression methods are used to account for the fact that not all the properties in the sample are sold or re-sold at the same dates, but the only data required are the transaction prices and dates.

Bailey, Muth, and Nourse (1963) first proposed the application of multiple regression methods to the estimation of repeat-sales indexes. Case and Shiller (1987, 1989) extended their approach by accounting for differences in the sampling distributions of price changes observed over different

lengths of time between repeat sales. They proposed a weighted-repeat-sales (WRS) model based on a generalized least squares regression to account for this source of heteroscedasticity in the errors.[11]

Hybrid Methods

Various attempts have been made to improve on both the hedonic and repeat-sales methods of house price index construction. For example, Case, Pollakowski, and Wachter (1991) investigate a hybrid of the hedonic and repeat-sales methods, utilizing repeat transactions when available, but otherwise using hedonic information to control for differences in quality and to confirm that no significant physical changes have occurred for properties with repeat observations. Various other hybrid methods have been proposed that introduce a spatial dimension, such as the distance-weighted repeat-sales (DWRS) method advanced by Goetzmann and Spiegel (1995, 1997). The spatial dimension in this case does not necessarily refer to location per se; rather it corresponds to the correlation among appreciation rates for individual properties that may be closer or farther apart in either geographic space or "characteristic" space. Distance-based methods have been found to improve the accuracy of indexes for smaller areas such as neighborhoods.[12]

AUTOMATED PROPERTY VALUATION METHODS

Computer Assisted Assessments and Appraisals

With the advent of computer technology and computerized databases, regional authorities in the United States were the first to implement computer assisted valuation methods.[13] Some of the earlier applications of computers to the assessment or appraisal of real property are referred to in the literature under such names as Computer Assisted Mass Assessments (CAMA), Computer Assisted Review Appraisals (CARA), and Computer Assisted Real Estate Appraisal System (CAREAS).[14] These systems are essentially automated versions of traditional valuation methods such as the comparative sales approach. While some systems focused mainly on the automation of standard forms and record keeping, others provide early examples of the application of multivariate regression models to the task of valuation.

Rules-Based Artificial Intelligence

Rules-based artificial intelligence (AI) methods, also called expert systems, attempt to apply or emulate, via computer programs, established principles and guidelines, such as those contained in standard texts on practices and standards for real estate appraisal, or comprising professional standards, such as the Uniform Standards of Professional Appraisal Practice, or USPAP.[15] One advantage that rules-based methods have over "black box" approaches such as multiple regression models or artificial neural networks (discussed below) is that it may be easier to explain why a particular result was obtained. On the other hand, rules-based systems depend critically on the efficient selection of the sample of comparable properties to be used as the basis for estimating the value of the subject property. This is another potential source of error since the existence of recent sales is itself a statistical process subject to its own sources of variation and bias.[16]

Valuations based on expert systems can be used to supplement or replace human appraisals. In this case, the perceived accuracy of the results may also depend on the extent to which human appraisals are actually consistent with the theory or quantifiable standards underlying the system.[17] While there is consensus that appraisal standards and practices have improved over the past 10 years, there remains a general perception that valuations based on arms-length sales transactions provide more accurate and meaningful representations of market value.[18] Current directions point to rules-based expert systems calibrated using actual sales transactions, and this should lead to more accurate and robust estimates of market value.

Artificial Neural Networks

Artificial neural networks attempt to emulate the process by which the human brain converts external stimuli (inputs) into specific responses (outputs) via neurons and synapses. In this sense an artificial neural network is a type of AI model that replicates the learning process that occurs in the brain. In the case of an artificial neural network, mathematical functions called "nodes" are used to represent the neurons and are connected to each other in processing layers corresponding to the input layer, hidden layer or layers, and the output layer.

Worzla, Lenk, and Silva (1995) provide a summary of the neural network approach to real estate valuation and a comparison with multiple regression models.[19] When applied to property valuation, the inputs are the explanatory or independent variables, such as location and property characteristics, and the output is the dependent variable, in this case the property value. The hidden layers are generally nonlinear mathematical functions that assign weights to the inputs as they pass through the nodes of the hidden layer to the output layer. The ultimate goal of the neural network is to determine the weights that will result in a response like that which really exists between the independent variables and the output or dependent variable. Typically, one subset of data is used to "train" the model through repeated iterations until some objective function is satisfied, and then the model is tested for accuracy on another subset of

data by letting it predict outputs based on a new set of inputs.

HISTORICAL DEVELOPMENTS

This section of the paper provides a brief history of the evolution of HPIs and AVMs in the United States. Once again, the development and application of alternative methods largely reflects data content and availability.

Commerce Constant Quality Index

Since the 1960s, the U.S. Department of Commerce has issued constant-quality house prices indexes for new homes sold and listed for sale. The Commerce Constant Quality Index (CCQI) is a hedonic house price index based on data from the Housing Sales Survey conducted by the Bureau of the Census.[20] The sample used to estimate the CCQI comprises approximately 13,000 new houses sold or listed for sale each year. Information on the physical characteristics and sales prices of new one-family houses are obtained through interviews with a nationally representative sample of builders and owners. A national price index is derived from five separate price models: four for detached houses in each of the Census regions, and one model for attached houses. Each model is "designed to measure changes over time in the sales price of new one-family houses which are the same with respect to many important physical characteristics." House characteristics included in all five models are: floor area, geographic division within the region, inside or outside a metropolitan statistical area (MSA), number of fireplaces, number of bathrooms, type of parking facility, and type of foundation. The national index is a weighted average of the five indexes for detached and attached houses, and the weights are defined using various combinations of housing characteristics. The price index is computed from actual transaction prices, which include the value of the developed lot. However, land costs are not explicitly accounted for in the hedonic estimation and weighting procedures.

Other Research on Hedonic Indexes

A number of academic researchers have developed hedonic house price indexes, primarily from periodic surveys like the American Housing Survey (AHS).[21] The AHS includes data on both new and existing properties, and provides information on the physical attributes of properties and neighborhoods and the demographics of occupants. A unique aspect of AHS data is that for many years the only source of information on housing values was owner's valuations. Kiel and Zabel (1999) provide a summary of research on the accuracy of owners' estimates of housing value for a number of data sources, including the AHS.[22] These studies generally find that owners tend to overestimate their property values when compared with appraisals, estimates from hedonic regressions, or actual sales prices. Kiel and Zabel develop a more complete model that includes some earlier models as special cases and find that owners do overestimate their property values by about 5% on average, but that the differences are not related to particular occupant, house, or neighborhood characteristics. This implies that owners' valuations remain fairly reliable for measuring changes in housing prices over time.

NAR Existing House Price Series

The first large-scale effort to provide purchase price indexes of existing houses was undertaken by the National Association of Realtors (NAR), utilizing multiple listing service (MLS) data from local member offices.[23] The NAR continues to publish monthly and annual house prices series showing the mean and median prices of houses listed for sale.

Case-Shiller Repeat-Sales Indexes

Renewed interest in constant quality indexes for existing homes was stimulated in the late 1980s by the work of Case and Shiller (1987, 1989). Case and Shiller began by utilizing multiple listing service (MLS) data obtained from local real estate organizations in four U.S. cities (Atlanta, Chicago, Dallas, and Oakland) to estimate repeat-sales house price indexes. Case and Shiller subsequently expanded their original research into a national data collection effort and established a commercial business marketing house price indexes and an online property valuation service.

Agency Repeat-Transactions Indexes

Government-sponsored enterprises (GSEs) Fannie Mae and Freddie Mac have developed repeat-transactions indexes utilizing the sales prices or appraisal values of residential properties securing loans sold into the secondary mortgage market in the United States. The GSEs now publish an index series based on their combined data under the name Conventional Mortgage Home Price Index (CMHPI).[24]

OFHEO, the financial safety and soundness regulator for Fannie Mae and Freddie Mac, produces and publishes an official government house price index series based on data submitted each quarter by the GSEs and employing essentially the same statistical methodology for repeat transactions. The OFHEO HPI was developed to meet certain regulatory requirements for the use of house price indexes in projecting the financial performance of the GSEs under stressful economic scenarios.[25] Since 1995, OFHEO has published quarterly index series for the nation, the nine Census divisions, and the 50 states and the District of Columbia. OFHEO has recently undertaken to release quarterly indexes for 329 metropolitan areas. A key aspect of the OFHEO HPI is its unrestricted

public availability, which has enabled other parties to substitute the OFHEO indexes for regions and time periods on which their own data may be insufficient.[26]

Large-Scale Electronic Asset Valuation Models

Consolidation of the mortgage market and automation in the mortgage origination process have led to the emergence of several large-scale property data and property evaluation systems in the United States. Primary sources of data for many of these systems are the real estate transactions documented in county records and tax assessment rolls in local jurisdictions. These data include information on both sales transactions and the terms of any mortgages issued using the property as security collateral. In most cases the records also include information on property characteristics, and these are updated over time as improvements in the property are assessed and recorded for tax purposes. Local jurisdictions vary in terms of whether their tax and recording data are automated. As a result, commercial data vendors involved in the acquisition and sale of these data often obtain only printed copies or scanned images that must be converted to a machine-readable format for use in their automated systems.

Given the large-scale data collection effort involved, there is extensive cooperation and partnering among commercial data vendors engaged in the collection and resale of data on a national scale. As a result, many automated valuation systems ultimately use some of the same original property information, although there may still be significant differences in how the data are used. For example, a single large data provider, DataQuick®, has provided or shared data simultaneously with Countrywide Home Loans, First American Real Estate Solutions, and Freddie Mac, each of which offers some form of automated property valuation system. Each of these firms has also been able to supplement the data obtained from DataQuick with their own data.

Existing large-scale electronic AVMs generally utilize some combination of hedonic and repeat-sales house price indexes, neural networks, and rules-based artificial intelligence to generate estimates of property value. In some cases the systems generate estimates by more than one method and then report the estimate believed to have the smallest error. Some systems are based entirely on statistical models for house price indexes, while others utilize house price indexes primarily to obtain starting values for an artificial neural network or rules-based system, or when information on property characteristics is unavailable.

Parallel to the consolidation that has occurred at the institutional level, there has been considerable consolidation among AVM vendors and products, making it difficult to trace the exact lineage of specific systems or components of systems. Following are some examples of the major large-scale automated property valuation systems currently in use in the United States:

Case-Shiller-Weiss, Inc.—CASA™ (Characteristics and Sales Analysis) system employs repeat-sales house price indexes and data on more than 90 million historical sales transactions. CSW has arrangements with multiple local data providers in each state originally selected through a process of data quality verification. Characteristics data are used when available to confirm that properties included in the index estimation have not undergone significant physical improvements between transactions. Comparables within the local area are used to confirm and validate recent house price performance as an additional check on the model assumptions.

First American RES – AREAS™ (Automated Real Estate Analysis System) is based on a combination of hedonic and repeat-sales house price indexes and artificial neural network models. First American RES combined with Transamerica's Intellitech real estate information business in July 2000 to acquire AREAS™. Data sources include First American's own proprietary data, formerly marketed as REDI, TRW REDI and Experian RES; and previous versions of the AREAS product included property transactions obtained through DataQuick. Coverage includes approximately 1,300 counties in 48 states, plus the District of Columbia and the U.S. Virgin Islands. First American's ValuePoint® utilizes data on comparable sales to perform property-specific, rules-based appraiser emulation. The system identifies and evaluates comparables and then makes adjustments to sales comparables using USPAP guidelines. First American's HPI™ provides monthly repeat-sales house price indexes down to the ZIP+4 level. First American RES also provides an AVM (Assessed Value Model) based on statistical analysis of property assessments with adjustments to reflect market value. This model is applied mainly in nondisclosure states.

Countrywide Home Loans—CAPES™ (Countrywide Automated Property Evaluation System) utilizes a combination of hedonic and repeat-sales HPIs with a rules-based adjustment model that aims to follow the practices of appraisers.[27] The adjustment model estimates market values by comparison of a subject property to nearby properties for which recent sales data is available. Regional home price indexes are used when historic sales prices and transaction dates are available. The system accesses property data from DataQuick® and Countrywide's own proprietary databases. Missing data on characteristics are represented as special values and treated appropriately to avoid loss of information on other characteristics. Statistical and heuristic constraints are used to evaluate the model results and to select among alternative

estimates for the same property. Measures of statistical confidence are provided along with the estimated valuations.

Freddie Mac—HVE™ (Home Value Explorer) utilizes a combination of repeat-sales and hedonic index methods to produce estimated valuations. Valuations are statistically based and confidence scores are provided along with the estimated valuations. Data sources include DataQuick® and Freddie Mac proprietary mortgage origination data. Coverage includes approximately 2,800 counties in 50 states and the District of Columbia.

AVM PERFORMANCE

Criteria for evaluating AVM performance include coverage and accuracy. Coverage relates to the percentage of properties submitted for which an AVM will return an estimate of value. Accuracy refers to how close the AVM estimate of property value is to the observed market value or other standard, such as a manual appraisal. For example, a standard approach to evaluating the accuracy of an AVM is ex post comparisons with actual sales prices, such as the proportion of estimates that are within plus or minus 5% of the actual selling price of a property. However, this type of calculation typically does not include outcomes where a value conclusion could not be obtained from the model, either because of the lack of comparables or missing data items for the subject property. Even in states such as California, with relatively high quality data available from public sources, value conclusions may not be attained for a significant number of subject properties.[28]

In a recent study by Pricewaterhouse Coopers, a sample of 5,000 properties from the largest U.S. metropolitan areas was submitted to eight different AVM vendors, which resulted in property value estimates from 11 types of AVMs.[29] The results were analyzed in terms of coverage ratios and the accuracy of the valuations compared with standard appraisals. Coverage was defined in terms of "hit rates" for the percent of properties for which the AVM was able to provide a value estimate, and "adjusted hit rates" for the percent of properties in a geographic area that the AVM covers for which it was able to provide a valuation. Hit rates for each AVM ranges between 4% and 73%, with a median hit rate of 48%; while adjusted hit rates ranged between 16% and 79% with a median hit rate of 69%. Hit rates were much better in urban than in rural areas. The median adjusted hit rate for properties in urban areas was 72% versus 41% for properties located in rural areas.

The same study examined the accuracy of the AVM valuations utilizing the median absolute error rate (MAE).[30] The estimates of MAE for the vendor AVMs ranged from 8.1% to 20.9%, with a median MAE of 9.9%. Accuracy also varied between urban and rural areas, with valuations in urban areas being slightly more accurate.

HPIs and AVMs Outside the U.S.

There are relatively few examples of broad-based HPIs or large-scale AVMs in other countries. In the United Kingdom, the Halifax Group and the Nationwide Building Society both provide online access to hedonic valuation models based on their respective proprietary data; but to my knowledge neither institution currently offers mass appraisal or other commercial valuation services based on their internal models.[31] In terms of public sources of property value data in the United Kingdom: Inland Revenue offers online tabulations of property transactions by property type, price, region, type of seller, and type of buyer; and the Land Registry reports average transaction prices for regions, counties, and local authorities, down to the postcode sector (neighborhood) level.[32] U.S.-based Countrywide Credit Industries recently announced the formation of a joint venture with several U.K. lenders, called UK Valuation, to provide automated valuation services utilizing Countrywide's proprietary valuation system.[33]

In Switzerland, the CIFI (Centre d'Information et de Formation Immobilières) has produced hedonic indexes based on multiple regression methods since 1997, and has provided online access to valuations based on their models since 1999. Building on the work of Swiss academics, the CIFI indexes have been developed through a joint effort of Swiss universities, banks, pension funds, and insurance firms.

In Thailand, the AREA (Agency for Real Estate Affairs), a Bangkok-based commercial venture, offers valuations based on market comparables and modeling for mass appraisals.[34]

In Hong Kong, the AVS (Automated Valuation System) has been produced by the Hong Kong Mortgage Corporation Ltd. (HKMC), utilizing land registry transaction records for the past seven years. The primary applications of the AVS are portfolio valuation and determining the need for warranties on loans with high loan-to-value ratios. The AVS utilizes sales comparisons, data on prices per square foot, and residential house price indexes. HKMC residential house price indexes are based on a hybrid repeat-sales/hedonic model applied to average price-per-square-foot (PPSF) data for residential estates.

While there are numerous other examples of national statistical agencies or commercial outlets that report basic house price data or indexes, these sources do not provide the types of models that can be used for mass appraisals or to value individual properties in real time.

With the exception of Countrywide's early efforts to apply their valuation system to U.K.

data, I found no examples of large-scale multi-method AVMs outside the United States. However, it is clear that the technologies utilized by the U.S. vendors are being adopted, and adapted, to the specific market and data requirements of other countries.

Lessons Learned From the U.S. Experience

Data quality and quantity are critical to the successful development of an HPI or AVM model. Whereas well-developed statistical methods abound, the evolution of HPIs and AVMs in the United States has been determined largely by data availability and quality. Adequate coverage must exist across both time periods and physical locations, and there must be sufficient detail about property characteristics to support selection of comparables and estimation of hedonic models. Some collective effort or data-sharing mechanism, whether commercial or public, is likely to be required to attain sufficient geographic and temporal coverage.

Data standardization has proved difficult in the United States, as the original data come largely from tax rolls or municipal records across thousands of jurisdictions. It is unlikely that any one private institution can be the sole source of data for a large-scale property valuation system, and virtually every HPI and AVM we have considered depends in some way on a mix of public or quasi-public information. In the case of large-scale AVM systems, the efforts of commercial data vendors have been required to extract and standardize this information. This situation may be less severe in countries that have more centralized recording of mortgage and property transactions, but there may be other legal or administrative limits on data access. In most areas of the United States, municipal records of residential mortgage and property transactions are publicly available to anyone who wishes to view them. Some jurisdictions have developed machine-readable data and on-line access to this information, while in others manual extraction of data is required.[35]

The U.S. experience demonstrates quite clearly that the perfect index or valuation scheme is an elusive concept. Given the varied sources of data and range of potential applications, adoption of more than one valuation method will be required. None of the major commercial providers of AVMs relies entirely on a single methodology, and many have found value in offering valuations based on a combination of approaches. Even in cases where model-based HPIs and AVMs are highly accurate, the system may still need to offer accurate statistical simulation or rules-based emulation of standard appraisal practices, as long as professional appraisals are required by law to meet the underwriting guidelines of the secondary market.

Institutional barriers to entry may hinder or preclude development of similar systems in other countries.[36] There is also a natural tension between traditional appraisers and the proponents of large scale AVMs.[37] While few would claim that manual property valuation is a precise science, it is somewhat ironic that as raw information and computational capacity multiply, skepticism regarding statistical models of property valuation and appreciation seems to persist. Statistical models may be perceived as less accurate because they quantify, and thereby highlight, their potential inaccuracies. Conversely, the perceived accuracy of appraisals based on a handful of comparative sales may simply reflect post-sale justifications of observed purchase prices. Existing multi-method models should be capable of testing the relative accuracy of the different approaches. Realistically, we are not likely to obtain a clear resolution of this question given the predominance of a small number of proprietary HPIs and AVMs.[38]

At present, a variety of statistical criteria are used to evaluate and justify one approach over another, and few of these could be considered to be measuring the underlying theoretical statistical properties of the estimators. Ex post measures of goodness-of-it are useful, and perhaps convincing, but may be specific to the times and conditions under which they were estimated. Attention should be given to the sensitivity of the estimates and their accuracy to data availability and varying economic circumstances.[39] For example, the selection of comparables is itself a rather complex sampling problem with its own impact on the ultimate statistical properties of the valuation estimates.[40] Some model errors may have no material significance and should not be given the same weight as errors associated with potentially significant financial losses. That is, an appropriate loss function should be applied when evaluating the acceptability of estimates from a particular valuation model.[41]

Some level of statistical error is inevitable and must be accommodated, as every transaction represents another draw from a joint distribution of properties, buyers, sellers, brokers, locations, and time periods, each with their own idiosyncratic contributions to the final price. Given that real property transactions can only occur so often within the vicinity of a particular location, we may already be approaching the maximum for statistical precision in valuing individual properties. This should not be interpreted to discourage efforts to develop new HPIs or large-scale multi-method AVM models in other countries, but both producers and consumers should proceed fully aware of the benefits and limitations of the different approaches. Notwithstanding the difficulties outlined here, AVMs have tremendous potential for enhancing the informational efficiency of housing and mortgage markets with significant benefits to all concerned.

NOTES

[1] AVMs are sometimes referred to as automated property valuation (APV) models.

[2] The statutory maximum single-family mortgage loan eligible for purchase by Fannie Mae or Freddie Mac for 2001 is $270,000 and will increase to $300,700 for 2002 (50% higher in Alaska and Hawaii). Increases in the conforming loan limit are based on an annual (October-to-October) appreciation index produced by the Federal Housing Finance Board (FHFB) using data from their monthly interest rate survey (MIRS). Interestingly, the statute containing the formula for increases in the conforming loan limit includes no provisions for reductions in the limits, and Fannie Mae and Freddie Mac have held the limits constant rather than reduce them in cases where the FHFB index declined.

[3] FHA lending limits for one-unit properties range from $132,000 for an FHA-insured mortgage loan in a standard area to $239,250 in high-cost areas. As of 1998, FHA minimum loan amounts are limited to 48% of the Fannie Mae/Freddie Mac conforming loan limit, while the FHA maximum loan amounts are set at 87% of the Fannie Mae/Freddie Mac conforming loan limit. In high-cost areas, the FHA limit is equal to 95% of the area median house price, but no higher than 87% of the Fannie Mae/Freddie Mac limit (also 50% higher in Alaska and Hawaii).

[4] These figures are based on Robertson (2001).

[5] The potential downside to better information is that borrowers will know when their mortgages are underwater, and may be more likely to exercise their option to default.

[6] In other words, just as we know that statistical estimates based on large samples of property transactions will be more precise through the averaging out of random differences across many properties, estimates of total or average values should have smaller relative errors than valuations of individual properties.

[7] The focus of this paper is the valuation of single-family residential properties. Valuations of multifamily, commercial, and other nonresidential properties often employ alternative methods based on construction costs, replacement costs, income and discounted cash flow analysis, or residual value analysis that are not considered in this paper.

[8] The USPAP were developed in the mid-1980s by The Appraisal Foundation (TAF), which had been formed by eight leading professional appraisal organizations in the United States, along with the Appraisal Institute of Canada (Rayburn et al., 1993). Adherence to the USPAP was codified in the Financial Institutions Reform and Recovery Act of 1989 (FIRREA). See Dennis (1992).

[9] See Lennhoff and Horsley (1988).

[10] Classic papers on econometric models for hedonic valuation are Griliches (1971) and Rosen (1974). A recent paper by Wallace (1996) examines the various aspects of hedonic indexes for residential housing.

[11] Standard multiple regression methods, such as ordinary least squares (OLS), assume that the model errors or disturbances are independently and identically distributed with mean zero. This implies that each pair of repeat transactions is assumed to come from a random distribution with the same variance as any other repeat pair in the sample. It is reasonable to assume, however, that the longer the time between observed transactions for the same property, the greater the likelihood of intervening factors that add to the variation in price differences. Thus, the error variance will be proportional to the length of time between transactions. This situation is referred to in the econometrics literature as heteroscedasticity, and a standard solution is to estimate a generalized least squares (GLS) model to account for these differences in the error variances.

[12] Goetzmann and Spiegel (1977) apply the DWRS methology to estimate indexes for ZIP codes in the San Francisco Bay area over the period 1980-1994.

[13] See, for example, the discussion in Adair and McGreal (1988) in which they cite earlier work by Pendelton (1965) on the application of multiple regression techniques to property appraisals and assessments.

[14] See McCluskey and Adair (1997), Detweiler and Radigan (1996), and Eckert et al., (1993).

[15] An early paper on the application of AI to real estate appraisal is given that of Dreyer (1989).

[16] The papers by Vandell (1991), Gau, et al. (1992), and Lai and Wang (1994) develop rigorous methods for selecting and weighting comparables for use in the market comparison approach to valuation.

[17] Smith (1986), Dotzour (1988), and Diaz (1990) have examined inconsistencies arising from appraisal practices and misapplication of human appraisals.

[18] Questions have also arisen with regard to the independence of appraisals provided in conjunction with mortgage purchase money applications. Ferguson (1988) finds that appraisers make estimates at or above contract prices, and concludes that these constitute something in the nature of post-sale justifications rather than independent estimates of market value.

[19] Other published studies that have applied neural network analysis to residential real estate appraisals are Borst (1992), Do and Grudnitski (1992, 1993), Tay and Ho (1992), and Evans et al. (1991).

[20] The CCQI is issued by the U.S. Department of Commerce under Series C27, Price Index of New One-Family Houses Sold.

[21] See Thibodeau (1989) and Kiel and Zabel (1997).

[22] These include studies by Kish and Lansing (1954, using 1950 Survey of Consumer Finance), Kain and Quigley (1972, using 1967 St. Louis sample), Robins and West (1977, using 1971 Seattle Income Maintenance Experiment), Ihlandfeldt and Martinez-Vazquez (1986, using 1978 Atlanta AHS), Goodman and Ittner (1992, using 1985, 1987 National AHS), and DiPasquale and Somerville (1995, 1978-1991 National and Metropolitan AHS).

[23] Multiple listing services are computerized databases of properties currently listed for sale. Properties are listed on an MLS when a seller retains a real estate agent to sell their property, or owner-sellers may subscribe on a fee-for-service basis.

[24] Development of the first Freddie Mac repeat sales index is documented in the paper by Abraham and Schauman (1991). Details of the development of the CMHPI are provided in Stephens, et al. (1995).

[25] A technical description of the OFHEO HPI is provided by Calhoun (1996), and is available at the OFHEO web site. The application of the OFHEO HPI in OFHEO's regulatory risk-based capital model for the GSEs is summarized in OFHEO's final risk-based capital regulation (OFHEO, 2001), also available at OFHEO's web site.

[26] OFHEO also publishes the estimated volatility parameters associated with each of its index models. These volatility estimates are based on estimates of the error variances obtained as part of the WRS procedure described previously. This information can be used to gain some understanding of the distribution of errors in the index and the uncertainty associated with updated housing values that are computed using the index and a previously observed sales price.

[27] See Hulthage and Stobie (1998).

[28] See the discussion of model coverage and accuracy in Ross and Nattagh (1996).

[29] See Robertson (2001).

[30] The error rate of an AVM estimate is the difference between the AVM estimate and the appraisal value as a percentage of the appraisal value. The MAE is the midpoint of the absolute values for the error rates.

[31] Both of these hedonic house price models are based on the research of Fleming and Nellis (1985).

[32] Novelli and Procter (1992) provide a comparison of traditional appraisal practices in the United States and the United Kingdom. Their analysis reveals more similarities than differences, with generally positive implications for the globalization of appraisal and valuation services.

[33] See the earlier discussion of the Countrywide CAPES system. The U.K. lenders participating in the joint venture with Countrywide are: Abbey National, Woolwich, Alliance and Leicester, Bradford and Bingley, and Bristol and West.

[34] This firm also offers valuations of multifamily properties and non-residential properties using cost, income, and discounted cash flow analyses.

[35] The United States includes what are called disclosure and nondisclosure states. In nondisclosure states it is illegal for local jurisdictions or mortgage lenders to disclose sales price information. Data vendors usually seek this information from real estate multiple listing services (MLS). The six nondisclosure states are Indiana, Kansas, New Mexico, Texas, Wyoming, and Utah.

[36] Although there are more fundamental institutional differences between U.S. and European Union mortgage markets, the lack of broad-based house price indexes and property valuation models has been mentioned as a handicap to secondary market activity in European mortgage markets. See Coles and Hardt (2000).

[37] See O'Rourke (1998).

[38] While there is increasing competition among various commercial models, independent evaluations are practically nonexistent given the proprietary nature of the data and models. Whether market forces will ultimately identify the most successful methodologies depends in part on the ability of consumers of these models to undertake their own validations.

[39] Diaz (1991) discusses valuation during volatile time periods.

[40] See Vandell (1991).

[41] For example, in the case of loss mitigation strategies for nonperforming loans, overestimating the underlying property value may lead directly to a financial loss if a lender incorrectly forecloses based on this information. Whereas, delaying foreclosure because the model underestimates the property value may add little to the ultimate foreclosure costs, and may allow the borrower and lender to avoid foreclosure entirely.

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