# Appendix M

with accepted appraisal theory, an advantage to AVMs is the objectivity and efficiency of the resulting value estimates. Of course, sound judgment is required in model development and an appraiser should review the values produced by the model.

## 2.2 Purpose and Use of AVMs

### 2.2.1 General

AVMs are used to provide estimates of market value for a variety of public and private sector purposes. AVM estimates reflect a given time period and should be calibrated to produce market values as of a specific date. Although past market trends can be projected over a short time horizon, the credibility of appraisal estimates increasingly suffers as the projection is lengthened.

AVMs have the advantage of objectivity and consistency, reduced cost, and faster delivery time. It is important, however, that the AVM follow sound statistical and mathematical modeling practices and be tested for accuracy and uniformity before application. Section 8 discusses the important area of model testing and quality assurance and section 9 focuses on reporting of results.

### 2.2.2 Analysis of Impaired Properties

Properties subject to significant defects or that are affected by atypical circumstances impairing market value, including superadequacy or functional obsolescence, cannot be accurately modeled with an AVM. An appraiser may choose to apply the AVM to the property, but the defect or unique circumstance should be noted and a special adjustment made to compensate for the defect or special circumstance.

## 2.3 Steps in AVM Development and Application

The remaining portion of this section outlines the steps to take in development of an AVM. The following sections of this standard provide clarification and details concerning these steps and their application to particular property types.

### 2.3.1 Property Identification

The first step in any appraisal problem is to identify the property to be appraised. In developed economies, identification is normally straightforward, as maps, ownership records, property addresses, and legal descriptions will identify the property and owner. The appraisal assignment will usually require identifying physical characteristics and property rights to be valued as of the appraisal date. When applying an AVM to a particular property, improvements and renovations made before this date should be included in the appraisal; those made subsequent to the appraisal date should not.

The bundle of rights to be appraised generally includes the fee simple interest or full bundle of rights inherent in ownership of property. Nevertheless, the market analyst should make clear what rights are assumed and any limitations to full use or restrictions to transfer of the property.

### 2.3.2 Assumptions

The AVM supporting documentation should state all assumptions, special limiting conditions, extraordinary assumptions, and hypothetical conditions. A key assumption in many AVM applications concerns the assumed use of the property. Most real estate databases contain the actual use of property as of the inspection date. In some property tax systems, current use is stipulated as the basis for valuation. However, comparable market sales reflect the concept of highest and best (most probable) use. Market analysts and users of AVMs need to be aware of these subtleties.

Another key assumption relates to whether or not the fee simple bundle of rights is being appraised. This is generally the case for residential properties, but many commercial appraisals are made to estimate only the leased fee or leasehold interest when there is an existing lease (or leases) on the property.

Government appraisal agencies are responsible for collecting and maintaining property databases, although they often contract with private vendors for this purpose. Commercial AVM providers generally use data maintained by a government agency or third party service. In all cases, it is imperative that AVM market analysts test the reliability of the data and clearly state assumptions concerning its accuracy. If data important to value estimation are missing or the statistical process has shown the data to be inconsistent or unreliable, the AVM provider has a responsibility to not provide a potentially misleading value estimate to the intended user.

### 2.3.3 Data Management and Quality Analysis

The reliability of any appraisal depends on accurate data. Appraisal data fall into two general categories: property data and market data. Property data relate to location, land characteristics, and building features. Market data include sales, income, and cost information. Asking prices and independent appraisals can sometimes be used to supplement sparse sales data.

Computerized statistical tools used to develop AVMs afford the opportunity to screen data for missing or out-of-range occurrences and inconsistencies; examples include homes with more than two fireplaces or a bi-level home with no listed lower level living area.

Geographic information systems (GIS) can also help in data reviews. GIS software is used to maintain computerized maps and provide geographic representations of property attributes and features. It can be used to

highlight properties with impossible, unlikely, or inconsistent data. For example, properties coded as being waterfront can be color-coded, displayed on a map, and reviewed for accuracy.

Only valid, open market sale and income data should be used in model development. (As mentioned, asking prices and independent appraisals can sometimes also be used to bolster sample sizes.)

Since the reliability of an AVM is dependent on the data from which it is generated, the integrity of the database should be monitored on a systematic and ongoing basis.

### 2.3.4 Model Specification

Model specification is the important process of determining the format (model structure) of the AVM. The market analyst must determine the type of model to be employed and specify the variables to be used in the model.

AVMs that employ property features, often characterized as "hedonic" models, can be categorized as additive, multiplicative, or hybrid models (see Section 3 on Specification of AVM Models). Market analysts must also determine the variables to be included in hedonic AVMs. These can represent property characteristics (e.g., square feet of living area and building age), location information, demographic data (e.g., income levels or school quality), or variables derived from property characteristics (e.g., the square root of lot size or living area multiplied by a quality index). The objective is always to include property features important in value determination and to capture actual market relationships. Skilled analysis is required to adequately specify an effective model structure.

Some models that are referred to as AVMs have only a time component; in other words, they merely track changes in property values over time. Where property characteristic information is unavailable or limited, these models can be used to trend a previous sale or value estimate to the target appraisal date.

### 2.3.5 Model Calibration

Calibration is the process of determining the coefficients in an AVM as well as which variables should be retained or deleted due to statistical insignificance. Several statistical tools can be used to calibrate AVM models (see Section 4 on Calibration Techniques). Proper use of these tools requires experience and training in statistical analysis and the software employed.

### 2.3.6 Model Testing and Quality Assurance

An AVM must be tested to ensure that it meets required accuracy standards before being deployed. This is accomplished through statistical diagnostics and a ratio study in which value estimates (e.g., estimated sale price or estimated rent) are compared to actual values (e.g., sale price or reported rent) for the same properties. GIS can be used to display color-coded ratios on maps and help spot groups of under- or over-valued properties. For more information, see Section 8 on Automated Valuation Model Testing and Quality Assurance. Before it is implemented, the AVM also should be tested on a holdout sample, which is a set of properties and their selling prices that were not used in the calibration process.

Properties with unusually large errors, termed "outliers," should be reviewed. It is likely that the sale price (or other value serving as the dependent variable in the model) is not representative, the data are partially incorrect, or the property exhibits atypical features that cannot be adequately accounted for in the model. Except where the data can be corrected, the property should be removed from the sample, and it and similar properties with similar features should not be valued by the AVM alone.

### 2.3.7 Model Application and Value Review

Once tested and validated, the AVM can be applied to estimate the value of other properties of the same type in the area or region where the model applies. These values should be reviewed for reasonableness and consistency with recent sales, either of the subject property itself or of similar properties in the same neighborhood or surrounding area, or where sales are not available, recent asking prices.

It is also good practice to systematically review the generated values for reasonableness and consistency with nearby properties in the same neighborhood. This affords the opportunity to ensure that the data are accurate, and to make individual adjustments to properties with unique features or that are subject to special influences, such as being located at a busy intersection or having a premium or obstructed view.

### 2.3.8 Stratification

Stratification is the process of grouping properties for modeling and analysis. Stratification begins with property type. Properties are delineated into generic use categories such as: single-family residential, condominium (if applicable), multi-family, commercial, and industrial. The number of property types will depend on the size and diversity of the geographic area being analyzed and the number of sales available within the proposed strata.

Residential properties in urban areas are generally stratified into "market areas." Market areas are broad, somewhat homogeneous geoeconomic areas that appeal to buyers in similar economic brackets. One AVM may be developed for each market area, or a regional model may be developed and individually calibrated for each market area. Location within the market area can be handled through neighborhood variables or other variables related to geographic location and desirability. Alternatively, a location value response surface analysis

The market analyst must be able to present the MRA results in an understandable and defensible format that appraisers and AVM clients can easily understand.

To avoid seriously violating assumption of linearity, additivity, and constant variance of the error term, the market analyst must consider the use of transforming variables or other calibration methods described in the standard. A multiplicative, nonlinear, or hybrid model structure is best for measuring interactive effects.

### 4.1.2 Diagnostic Measures of Goodness-of-Fit

Both the market analyst using regression and the user of AVM output must be aware of and understand how the various key statistical measures used in regression relate to the reliability of results. These statistics fall into two categories: overall measures that aid in the interpretation of model performance and individual variable measures that assist in the understanding of how well an individual variable performs in helping to estimate value, as well as keeping the standard error term to a minimum. Primary measures of goodness-of-fit for overall model performance are the coefficient of determination ($R^2$), standard error of the estimate (SEE), COV, and average percent error.

Goodness-of-fit measures for individual variables in a model are produced by most MRA software packages and include the coefficient of correlation (R), T-statistic, F-statistic, and beta coefficients. Each of these measures will provide information about an individual variable's linearity or importance of contribution toward improving predictive success, and relative importance, as variables are compared to each other.

(D'Agostino and Stephens 1986.)

When all the measures are used collectively, along with an understanding of data quality issues, those skilled in developing and using MRA can fully evaluate the credibility of the AVM estimates. Appraisers asked to review AVM results must understand the role that *goodness-of-fit* statistics play in evaluating AVM results. The application of AVM results to a single property may be better evaluated using historical market comparisons selected from a subset of data. Appraisers asked to review AVM results should review the Appraisal Standards Board's *USPAP* Standard and AO-18.

(Appraisal Foundation 2003, 46–56, 180–187; IAAO 1990; D'Agostino and Stephens 1986.)

### 4.1.3 MRA Software, Options and Techniques

MRA is the most widely used method for calibrating models. As such, the availability of MRA software provides users many choices. No one software package is deemed superior to another, as success using MRA is a combination of modeling skills and software familiarity. Variations of a selected MRA technique can be a decisive factor in selecting an MRA and statistical application package. Many MRA techniques have been adopted over the years to help regression take better advantage of its predictive powers. Stepwise, constrained, robust, ridge regression, and others are acceptable techniques used to improve predictive success. Many of the statistical software packages include variable selection routines that aid the market analyst in selection of significant variables.

### 4.1.4 MRA Strengths

1. Goodness-of-fit statistics—gives credence to the validity of results.
2. Software availability—many regression software products are available.
3. Widely-accepted calibration method.
4. Broad education network—MRA is taught at most colleges and universities around the world.
5. Credible values—in the hands of a skilled market analyst, MRA is proven to produce results that meet the test of model performance.

### 4.1.5 MRA Weaknesses

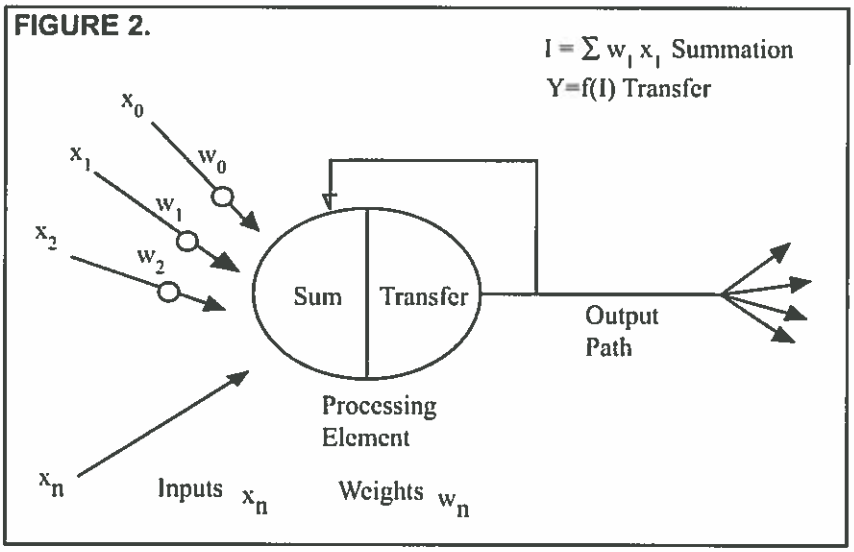
1. Requires a high level of statistical knowledge—market analysts must possess significant background in data analysis and statistical methods.
2. Predictive accuracy is restrained by assumptions.
3. Requires data sets that meet the test of sample size.
4. Interactive and nonlinear market trends are difficult to measure without transforming data.

## 4.2 Calibrating Using Adaptive Estimation Procedure (AEP)

Adaptive Estimation Procedure (AEP) is a calibration technique that was adapted to real estate value in the early 1980s. Also known as feedback, AEP is based on an engineering concept that relies on continual adjustment to coefficients as the calibration engine passes, or tracks, back and forth through the data until convergence, (minimum error is achieved) thus the feedback. For property valuation, the algorithm tracks the sale price as a moving target. It compares property characteristics as variables that measure the change in sale price, and calibrates a coefficient for each variable. The coefficients are used to estimate value that is then compared to sale price. A running tally is kept on the error term as the process continues. Figure 1 depicts the feedback loop.

AEP will make multiple passes through the sales file constantly adjusting coefficients before a final solution is reached. Success using AEP is dependent upon the

**FIGURE 2.**




## 4.4 Time Series Analysis

Time series analyses are a family of techniques that can be used to measure the cyclical movements, random variations, seasonal variations, and secular trends observed over a period of time. In property valuation, these analyses can be used to develop a multiplier or index factor to update existing appraised values or to adjust sales prices for individual properties to the valuation date. Since values can change at different rates in different markets, separate factors should be tested for each property type and market area.

Four methods used to develop time trend factors in the appraisal and assessment industries are: (1) value per-unit analysis, (2) re-sales analysis, (3) sales/assessment ratio trend analysis, and (4) inclusion of time variables in sales comparison models. These methods are summarized below (for a more detailed explanation and discussion, see *Mass Appraisal of Real Property* (Gloudemans 1999, 263-270).

Value per-unit analyses track changes in sale price per unit (e.g., per square foot for residential properties or per unit for apartments) over time. The method is easily understood and lends itself well to graphical representation, as well as to statistical modeling to extract the average rate of change. A downside is that the method does not account for the myriad of other value influences, such as age and construction quality, that impact per-unit values.

Re-sales analysis uses repeat sales occurring over a given time period. Price changes between sales are converted to monthly rates and an average (or median) rate of change is extracted. As can be imagined, the larger the number of repeat sales, the more reliable the estimated rate of change. The method can overestimate rates of change if repeat sales reflect substantial improvements (or other alterations) made to the property since the first sale.

Sales/assessment ratio trend analysis involves tracking changes in the ratio of sales prices to existing assessments made as of a common base date. Increases in the ratios indicate inflation and vice versa. The ratio also provides the index factor required to convert assessed value to a full value estimate. Like value per-unit analysis, the method lends itself well to graphical and statistical analysis. An advantage of the method is that assessments account for most value determinants and thus can isolate time trends better than the value per-unit method. The method assumes that the assessments share a common basis, and its reliability depends partly on the accuracy or uniformity of the assessments.

Time variables can be included directly into AVM models to capture the rate of price change over the period of analysis. This is usually the most accurate of the various methods. However, model developers must be careful that time variables are properly specified so that coefficients developed from the model reflect the desired valuation date.

Once a time trend is established, it can be used to adjust values to any point within the sales period.

Trend factors can be extrapolated for a short period beyond the sales period, but this must be done with caution and grows increasingly unreliable as the time frame is lengthened. If more than several months are involved, the first three methods can be used to calibrate the trend (one would not ordinarily develop time adjustments through use of a modeling approach without recalibrating the entire AVM model).

(The Appraisal Institute 2002, 291.)

## 4.5 Tax Assessed Value Model

Tax assessed value models derive an estimate of value by examining values attributed to properties by the local taxing authorities. As a matter of local law and custom,

known as townhouses, row houses or zero-lot-lines, depending on geographic location throughout the world. All of these uses are residential in nature.

Valuing these various residential properties is somewhat similar to valuing detached single-family structures. All of the same principles apply and all can be modeled and valued using an AVM. In fact, because these properties exhibit a high degree of homogeneity compared to the detached single-family population, sales-based AVMs can produce values that are extremely reliable and accurate. The cost approach can also work well, in some cases, if adjusted to the market, but it is not appropriate for valuating condominium units because depreciated replacement cost will not properly reflect resale values. Data requirements for attached residences will not be the same as with detached residential properties. For example, floor level can be an important value determinant for condominiums, while lot size and yard improvements are irrelevant.

### 5.3 Two- to Four-Family Residential Property

Part of the residential housing market consists of structures built for the purpose of housing more than one family. Improvements designed to accommodate two, three, and four families within their own separate living areas are often referred to as small income-producing properties. A common theme among these property types is that the owner of the property may reside in one of the units. This concept, however, is not a requirement for classifying these structures in the market. Two-unit properties are more likely to be owner-occupied than four-unit properties. The concept to be recognized here is how such properties are treated in the marketplace, because that impacts their price and ultimately the value generated by any AVM. The ability to model the selling price of these small-income properties is reliant on what specific data is available, relating to number of units, age, condition, location and gross income. The motivation of buyers shifts when consideration is given to other property attributes that relate to producing rental income and not just owner occupancy. Direct market models, comparable sales models, and cost models are acceptable methods for valuing these small income-producing properties. With their income-producing potential, the income approach is also a model to be considered. With an adequate sample of gross income values for comparison to sale price, a model of GI * GIM will yield credible results where GI = Gross Income and GIM = Gross Income Multiplier (sale price/gross income). Some AVMs may even be set up to predict GI and the GIM. Each of these indicators can vary with size, age, location, style, and condition of a property.

### 5.4 Manufactured Housing

A manufactured home is a residential structure built in a factory. Construction standards for manufactured housing are controlled and monitored by the Department of Housing and Urban Development in the United States (HUD), and by the Canada Mortgage and Housing Corporation (CMHC) in Canada. While many manufactured homes are built with the same materials as site-built homes, the factory-controlled engineering process helps control cost and quality. The house can be financed as personal or real property on leased land, in a manufactured home community, or on a privately owned site. Buyers who desire to acquire land in conjunction with the home can finance the land and home together. Market conditions and trends will indicate how the manufactured homes compete in the market place. In some communities, zoning only allows manufactured homes in certain areas, confining the market area from which comparables can be derived. Once market conditions for a manufactured home are known, it can be modeled just like any other property type. Consistency is important when using an AVM for manufactured homes. Some manufactured homes are strictly treated in the market as mobile homes (i.e., personal property). An AVM developed to value manufactured homes as real property would give a false value in the case where the home was personal property, and vice versa. AVMs developed to value manufactured personal property homes cannot be used for homes classified as real property. Some manufactured homes compete in the market place with site-built homes. Where this is the case, it is possible that an AVM designed to value detached single-family structures will produce credible results, although the model should include a variable (or variables) to capture any differences between otherwise comparable manufactured and site-built homes.

### 5.5 Time Series Models for Residential Property

Indexed models relate to time-series analysis (see Section 4.4 on Time Series Analysis) as described earlier. Use of these models represents a common method of delivering quick automated value estimates. These models simply measure the average change in value over time and factor the value forward from a benchmark starting-place, such as the average value in a census block or market area. The accuracy of indexed models is inconsistent and less reliable than fully specified models. These models work best in areas of homogeneity where the range of value is close to the average value.

Indexing is a common method used to update cost tables to reflect current cost. As with market models, a benchmark in time is required as a starting point. Cost coefficients are then updated, using a single index factor representing the measurable change since the original cost coefficients were generated. One current method of indexing is to use an economic indicator such as the consumer price index (CPI). In the cost approach, indexed models have no way of adjusting values at the micro level for location and other market influences that impact value. Time adjustments may be developed from