

Toward Valuation Engineering Protocols

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Vol. 1, Issue 2 · Fall 2026 · Published October 1, 2026

Version 1.1.0

DOI: [10.67330/7at33590](https://doi.org/10.67330/7at33590)

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Abstract. Professional valuation standards set out ethical obligations, scope of work, recognized approaches, and reporting requirements, but give little guidance on designing, testing, and validating quantitative procedures. This article argues for Valuation Engineering Protocols: a technical layer the Journal intends to develop over time that sits between professional standards and executable valuation analysis. It addresses protocols for the appraisal of an individual property, including statistical models of measured characteristics and the appraiser's assignment of the contributions of latent ones (characteristics, such as condition and quality, that cannot be measured directly); it does not treat mass appraisal, a separate process within the Journal's scope, or automated valuation models, which are outside it. A survey of international standards and national systems finds three levels of requirement. The International Valuation Standards, the RICS Red Book, the European Valuation Standards and USPAP state principles. Spain, Poland and Germany add duties of documentation and justification. Brazil, Colombia and Taiwan set testable statistical requirements. Brazil grades regression models by sample size, significance, extrapolation and precision and requires diagnostic checks; Taiwan has since 2001 prescribed minimum samples, fit and significance thresholds, and caps on adjustments. Even these rules leave model form, out-of-sample validation and the treatment of unmeasured characteristics unaddressed, and none of the systems examined mentions modern methods such as multivariate adaptive regression splines. The article closes by describing how the Journal will develop the protocols openly.

Keywords: valuation engineering, protocols, quantitative valuation methods, valuation standards, model validation, reproducibility

1 The Gap

A central concern of the Journal is the gap between existing professional valuation standards and the detailed technical protocols that modern quantitative valuation requires. Major standards systems generally establish ethical obligations, scope requirements, recognized valuation approaches, reporting requirements, and broad expectations for credible methods. They provide far less specific guidance on how practitioners should design, implement, test, and validate quantitative procedures. This gap defines the Journal's focus: the technical layer between professional standards and analytical execution.

The gap becomes especially apparent in regression analysis, nonlinear modeling, comparable selection, interaction effects, residual analysis, spatial dependence, cross-validation, uncertainty measurement, and model stability. Existing standards may require practitioners to use appropriate methods competently and to produce credible results, yet they provide no sufficiently

detailed procedures for determining whether those requirements have actually been met. These areas mark where broad professional requirements end and technical protocols begin.

2 Valuation Engineering Protocols

The Journal calls the specific instructions for executing valuation tasks that address this gap *Valuation Engineering Protocols*. These protocols address the design, execution, documentation, testing, validation, and reproducibility of valuation methods; this article considers them for the appraisal of an individual property. They do not prescribe a single acceptable algorithm; instead, they establish technically defensible procedures for evaluating competing methods and independently reviewing their results. In this way, they extend professional standards into operational practice without changing the scope of the valuations those standards govern.

Valuation Engineering Protocols may address, among other matters, data quality, market definition, statistical model specification, diagnostic testing, comparable-selection procedures, adjustment derivation, model validation, uncertainty analysis, sensitivity testing, reconciliation, reproducibility, and preservation of an auditable analytical record.

The Journal therefore seeks to develop the technical layer that connects broad professional valuation standards with the actual execution of valuation analysis:

Professional Valuation Standards → Valuation Engineering Protocols
→ Executable Valuation Analysis.

3 What the Protocols Govern

This article considers protocols for the methods an appraiser or valuation engineer develops and applies to appraise an individual property. Mass appraisal, the valuation of many properties as of a date under USPAP Standards 5 and 6, is outside this article's scope though not the Journal's; automated valuation models (AVMs), which are software tools, are outside both. The difference between an appraiser's analysis and an AVM does not reduce to a difference between statistics and judgment.

An appraiser may estimate a statistical model to derive adjustments, just as a hedonic regression estimates the implicit prices of the characteristics included in the model (Craytor 2026c; Craytor 2026b). The appraiser's analysis differs, however: the model estimates the contributions of measured characteristics, and the appraiser then assigns the contributions of latent ones, such as condition, quality and functional utility, which cannot be measured directly. Because they cannot be measured directly, they must be inferred from their effects on observable outcomes (Craytor 2026d).

By contrast, an automated valuation model generally assigns such attributes the expected (average) values for the group of properties that share the subject's measurable characteristics. The appraiser must instead estimate those attributes for the particular property being appraised. The Residual Constraint Approach, for example, performs this task through analysis of the subject property's residual (Craytor 2026e).

4 Where Others Stand

The gap remains, but valuation systems differ substantially in how far they have progressed toward filling it. Their requirements generally fall at three levels. Some systems state only a principle: practitioners must use appropriate methods and produce credible results. Others add duties of documentation and justification, sometimes with a minimum number of comparables: practitioners must explain their data, models, and adjustments. A smaller number impose statistical requirements that can actually be tested, such as specified statistics and thresholds for a model's fit.

Table 1 provides a general indication of these differences. It excludes mass appraisal, which this article does not cover, and automated valuation models.

Table 1: How selected standards and statutory systems address quantitative methods in the appraisal of an individual property

Body or country	Instrument	How far it goes
International Valuation Standards Council (IVSC)	International Valuation Standards 2025	Requires models to be tested; documentation is a “should”; the test is not defined
Royal Institution of Chartered Surveyors (RICS)	Red Book Global Standards 2025	Adopts IVS; requires a model to be “suitable”; mentions validation only as an example
The European Group of Valuers’ Associations (TEGoVA)	European Valuation Standards 2025	States principles only
United States	Uniform Standards of Professional Appraisal Practice (USPAP); Fannie Mae Selling Guide	Requires credible results and market-supported adjustments but specifies no tests
Spain	Orden ECO/805/2003	Requires at least six comparables and justification of methodological choices; specifies no statistical tests
Poland	Regulation of 5 September 2023	Names comparison methods and requires at least three comparables for the pairwise method; specifies no statistical tests
Germany	ImmoWertV 2021 (Real Property Valuation Regulation)	Requires statistical derivation of market data and description of the model; specifies no named test
Colombia	Resolution 941 of 2026 of the Instituto Geográfico Agustín Codazzi (IGAC), Colombia’s national geographic and cadastral agency	Sets a dispersion limit for adopting the mean and requires models to report error metrics, but establishes no error threshold
Brazil	ABNT NBR 14653-2 (Brazilian technical standard); IN SPU 67/2022 (normative instruction of the federal property office)	Grades regression models by sample size, significance levels, extrapolation and confidence-interval width, and requires diagnostic checks; sets no minimum fit; reports must state the grade achieved
Taiwan	Regulations on Real Estate Appraisal	Establishes numerical thresholds for regression models, including a minimum fit, and caps on adjustments; requirements date to 2001; the fit threshold was raised in 2006

The International Valuation Standards now address valuation models more extensively than they once did, but they stop short of specifying how practitioners should judge a model. Valuation models “must be tested to ensure accuracy of the output is appropriate for the intended use”, and practitioners should document their selection, inputs, limitations and quality-control procedures (International Valuation Standards Council 2025, IVS 105). IVS also requires that adjustments to comparables “must be reasonable and the valuer must document the reasons for the adjustments and how they were quantified” (a valuer is an appraiser) (International Valuation Standards Council 2025, IVS 103). Even so, the standards do not define the required test, specify how to measure accuracy, or prescribe how practitioners should derive an adjustment.

The RICS Red Book incorporates those standards yet adds relatively little methodological detail of its own. When a valuer uses a complex or proprietary model, the Red Book requires

the valuer to “make sure the model is suitable for the valuation purpose” and cautions that “the more advanced the model(s), the greater the degree of vigilance needed” (Royal Institution of Chartered Surveyors 2025, VPS 5). It cites model validation once, as an example of a risk technique that documentation should describe (Royal Institution of Chartered Surveyors 2025, VPS 4). It states that a sensitivity analysis “may be judged appropriate” in “some limited circumstances”, but does not require one (Royal Institution of Chartered Surveyors 2025, VPGA 10).

The European Valuation Standards, by contrast, remain largely at the level of principle (TEGoVA 2025). In the United States, USPAP requires credible results (The Appraisal Foundation 2024, Scope of Work Rule; Standards Rule 1-1). Fannie Mae, a principal purchaser of U.S. residential mortgage loans, requires that “the appraiser’s adjustments must reflect the market’s reaction (that is, market based adjustments) to the difference in the properties”, and allows that “the adjustment rates can also be determined through statistical analysis, modeling, paired sales, or other commonly accepted methods” — without specifying how any of that analysis is to be conducted or tested (Fannie Mae 2025).

4.1 Statutory systems that require documentation

Several national systems go further by requiring practitioners to make their methods explicit, although they still stop short of imposing testable statistical standards. For valuations used in mortgage lending and other regulated financial purposes, Spain requires at least six comparables and a reasoned justification of the variables and measures used to adjust them to the subject (Spanish *homogeneización*) (Ministerio de Economía 2025). Poland’s regulation prescribes three comparison methods. The pairwise method, which compares the subject with each comparable in turn (not American paired-sales analysis), requires at least three comparables, and correction of the average price requires *co najmniej kilkanaście* — at least a dozen or so — without fixing a number. The third method, statistical market analysis, serves the valuation of representative properties for the cadastral value (a value set for the property cadastre by mass appraisal, Polish *powszechna taksacja*), which is outside this survey; even there the regulation refers only generally to methods used in statistical analysis (Minister Rozwoju i Technologii 2023, §§ 7–8).

Germany comes closest among these systems to imposing a statistical requirement. Germany’s valuation regulation requires the local expert committees (*Gutachterausschüsse*) that keep the register of purchase prices to derive market data chiefly from that register and from a sufficient number of suitable sales. It further provides that “zur Ermittlung der sonstigen für die Wertermittlung erforderlichen Daten sind geeignete statistische Verfahren heranzuziehen” — that is, suitable statistical methods must be used to derive other data required for valuation (Bundesrepublik Deutschland 2021, § 12). The committees must publish a model description specifying the sample. An appraiser who applies those data must use the same model that produced them (Bundesrepublik Deutschland 2021, §§ 10, 12). Neither duty specifies a method, statistical test, or minimum sample size for the appraiser’s own analysis.

4.2 Systems that set testable requirements

Brazil embeds statistical inference directly into its national valuation standard. NBR 14653-2 grades the statistical support for a comparative valuation on two scales: foundation (*fundamentação*, how well the data support the model) and precision (*precisão*, how narrow the resulting estimate is). It requires the report to state the grade of foundation it achieves (Associação Brasileira de Normas Técnicas 2011, § 9.1.2). For a linear regression model with k independent variables, the three grades of foundation (Grades I, II and III) require at least $3(k + 1)$, $4(k + 1)$ and $6(k + 1)$ market data (sales). They admit a two-tailed significance level of no more than 30%, 20% and 10% for each regressor (explanatory variable). For the model’s F test (a test that the variables together explain price), they admit no more than 5%, 2% and 1%. The

highest grade admits no extrapolation (valuing a property whose characteristics lie outside the range found among the sales), and the lower grades limit it. The grade of precision depends on the width of the 80% confidence interval, as a percentage of the central estimate: no more than 50%, 40% or 30% (Associação Brasileira de Normas Técnicas 2011, Tables 1 and 5). A normative annex requires the appraiser to examine the residuals for constant variance, normality and autocorrelation, to examine collinearity among the variables, and to investigate influential points. It directs attention to the adjusted coefficient of determination (adjusted R^2 , the share of price variation the model explains, corrected for the number of variables) but sets no minimum for it (Associação Brasileira de Normas Técnicas 2011, Annex A). A federal instruction for valuations of federal property likewise requires each report to state the grades it achieves and recommends at least the second grade of foundation when the government intends to sell a property (Secretaria de Coordenação e Governança do Patrimônio da União 2022, art. 34).

Colombia's 2026 resolution sets one numerical threshold: an appraiser may adopt the arithmetic mean of comparable prices only when the coefficient of variation (the standard deviation of the prices divided by their mean) does not exceed 7.5% in urban areas or 10% in rural areas. The resolution also admits econometric, geostatistical, and machine-learning models as complementary tools, provided practitioners document them in an auditable manual and measure their error with verifiable metrics. The same paragraph admits automated valuation models, which lie outside this survey, and it keeps the boundary this Journal keeps: the appraiser must validate the result, and the output of a model may not be presented by itself as a final appraisal. The resolution does not, however, establish a permissible error threshold (Instituto Geográfico Agustín Codazzi 2026, arts. 20 (par. 2) and 21).

Taiwan alone among the systems examined here fixes a minimum goodness of fit and caps the adjustments that may be made to any comparable. The Ministry of the Interior issues the Regulations on Real Estate Appraisal under the Real Estate Appraiser Act, and licensed appraisers must follow those regulations in every report they sign (Legislative Yuan, Republic of China (Taiwan) 2024, art. 19). When an appraiser uses an econometric model, the number of comparables must equal at least five times the number of independent variables, and a regression model's adjusted coefficient of determination may not fall below 0.7. The joint test that all coefficients other than the intercept are zero (the F test) must reject that hypothesis at the 5% level: a test statistic this large or larger may have no more than a 5% probability of arising if those coefficients were all zero. The regulations exclude a comparable if any single location or individual adjustment exceeds 15%, or if all adjustments combined exceed 30%. They also exclude indicated values that continue to differ by 20% or more after review (Ministry of the Interior, Republic of China (Taiwan) 2013, arts. 20, 25–26).

The 2006 revision raised the required fit but relaxed other conditions, as a comparison with the first version shows. The first version of the rules, adopted in 2001, already imposed statistical conditions, although it applied the model differently. At that time, regression valued the subject property directly by entering the property's characteristics into the fitted equation. The rules required at least 30 comparables, a correlation coefficient of at least 0.7, and the same 5% joint significance test. They also applied the 15% cap to condition and date adjustments (Ministry of the Interior, Republic of China (Taiwan) 2001, arts. 19–20, 25).

The 2006 revision shifted the model from directly estimating the subject's value to deriving adjustments applied to comparable properties. It tied the required sample size to the number of variables and replaced the correlation coefficient with the adjusted coefficient of determination. This change raised the statistical threshold substantially, because a correlation coefficient of 0.7 corresponds to a coefficient of determination (R^2) of only 0.49. The revision also introduced the 20% rule for indicated values and allowed a documented waiver of the adjustment caps for unusual properties (Ministry of the Interior, Republic of China (Taiwan) 2006, arts. 19–20, 25–26). The 2013 amendment left these levels unchanged.

Even Taiwan's comparatively detailed rules stop short of constituting a complete protocol.

They do not specify the model form or say whether the model should explain total price, price per square foot, or the logarithm of price. Unlike Brazil’s standard, they require no checks for residual behavior or collinearity among variables; and neither system requires a test of predictive performance on data not used to fit the model. Nor do the rules of either system say how an analysis should treat condition, quality, or other characteristics that cannot be measured directly. Apart from the adjustments ultimately produced, the rules do not require disclosure of the fitted model itself (Ministry of the Interior, Republic of China (Taiwan) [2013](#), art. 27).

4.3 The pattern

Where valuation systems impose checkable requirements, those requirements remain few, scattered, and tied to particular analytical devices: a dispersion limit in one system, a goodness-of-fit threshold in another, a grade that a report must state in a third. None of the systems examined here addresses the analytical problem as a whole — from model specification and validation, through the estimation of contributions from measured and latent characteristics, to the measurement of uncertainty and the reproducibility of the final result. The Journal’s Valuation Engineering Protocols are intended to supply that integrated technical layer.

5 What Comes Next

The Journal’s first issue already pointed to the need. It argued that the only objective way to verify accuracy is “to establish a strict protocol . . . and verify its adherence”, and that standards and protocols should be stringent enough “to ensure that competent valuation engineers will independently arrive at nearly the same value conclusion” (Craytor [2026e](#)).

The need becomes especially acute when appraisers use modern quantitative methods. Multivariate adaptive regression splines (MARS), for example, construct a price model from hinge functions: pieces that are flat on one side of a breakpoint (knot) and rise or fall in a straight line on the other, so that the price change per unit of a characteristic can differ above and below the knot (Friedman [1991](#)). The Journal’s first issue described an interface for fitting such models (Craytor [2026a](#)). Yet none of the systems examined here mentions MARS, and those that set statistical tests (Brazil and Taiwan) wrote them for linear regression.

Taiwan’s rules would appear to admit a MARS model as an econometric model, but their statistical tests were written for a fixed linear equation. It remains unclear, for example, whether the requirement of five comparables per independent variable ought to count the original characteristics or the hinge terms that MARS selects; the two quantities can differ substantially. Because MARS selects those terms from the same data used to fit the model, applying a conventional joint significance test can overstate the model’s evidentiary support. The criterion MARS itself uses to select terms — generalized cross-validation, an estimate of how well the model would predict sales it was not fitted to — appears nowhere in the rules. And because a hinge function produces different adjustments per unit at different points along a characteristic’s range, the adjustment for the same characteristic may satisfy the 15% limit for one comparable yet exceed it for another.

A valuation engineering protocol would need to resolve each of these questions before another analyst could reliably test adjustments derived from a MARS model against the assignment record.

This article does not attempt to establish those protocols. The Journal intends to develop them openly in future issues: proposing individual protocols, publishing them for comment, revising them in light of that review, and releasing them only when their requirements can be checked against the record of an actual valuation assignment. A first procedural draft, Management of Protocols (VE-P1), appears in this issue’s Protocols department for comment; the Journal has not yet released a final protocol, and proposals for the subjects of the first technical protocols are welcome.

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