



# The State of Automated Valuation Models in the Age of Big Data

Valuation Analytics Workgroup

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## Abstract

### Highlights:

- I. AVMs are currently constrained in use by regulation and policy; some policies are changing, and the right questions are beginning to be raised.
- II. Nonetheless, AVMs have ridden a wave of increasing data availability and quality to much higher response rates and accuracy; the methods themselves are also evolving, further improving accuracy.
- III. AVMs are subject to comprehensive testing.
- IV. AVMs provide additional statistical information, relative to an appraisal, that is both directly and indirectly valuable to the loan production process and risk management.
- V. AVMs support a rule-based, automated production process that can minimize human bias if properly implemented and supported by policy and processes. Those rules are amenable to oversight.

## Introduction

This paper focuses on the state of automated valuation models (AVMs) in order to provide industry, policymakers and regulators an update on their practicality and effectiveness in valuation. From their inception, they have been used by lenders and investors for evaluating lower loan to value mortgages, qualified refinances, home equity lines of credit (HELOCs), portfolios of collateral and for quality control purposes on mortgages of all types and in all stages of the mortgage value-chain. The Government Sponsored Enterprises (GSEs) are increasingly relying on automated property valuation analytics as a means of risk analysis at loan delivery as well as for appraisal-waiver programs.<sup>1</sup> AVM performance has dramatically improved over the past decade alongside increases in the availability and integrity of real estate data and advances in modeling, database and data-related technologies. Industry stakeholders need to understand the current state and trends of this important valuation tool, if they wish to compete in a more efficient mortgage processing world.

As each real estate cycle reminds us, the valuation of real estate collateral remains central to the underwriting, pricing, and risk management of the mortgage asset. Estimates of residential real estate value at a particular point in time are typically generated by means of an appraisal, AVM

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<sup>1</sup>Current proposals by the FDIC, OCC and GSEs would allow ending manual appraisals for homes sales if \$400,000 and less. See <https://www.housingwire.com/articles/47458-regulators-propose-ending-appraisal-requirement-on-some-home-sales-of-400000-and-below>. Federal Register /Vol. 83, No. 235/Friday, December 7, 2018/Proposed Rules at <https://www.fdic.gov/news/board/2018/2018-11-20-notice-sum-c-fr.pdf>

or broker price opinion (BPO). Traditional appraisals have long been the most widely used method of valuation, especially for origination purposes, in part due to statutory, regulatory and investor requirements. AVMs have also served an important role in the mortgage industry and are increasingly relevant in an age of big data. BPOs leverage the knowledge of the brokerage community to provide yet another perspective on value.

An update on AVMs is particularly timely due to recent changes in both the appraisal and mortgage industries. Supply shortages of appraisal professionals have been fueled by rising education requirements, flat or falling compensation and the aging of the workforce among other factors.<sup>2</sup> Additionally, the mortgage industry is undergoing technological change, steadily progressing towards a fully digital mortgage that is originated in a potentially short period of time, relative to current standards, and which leverages a variety of advances in technology, data and processes to serve consumers. While the idea of a digital mortgage is appealing for lenders as they strive for lower-cost, lower-mistake production, its achievement is also paramount for them to meet increasing consumer demands and expectations.

We conclude that AVMs are an increasingly important and complementary tool alongside appraisals and other valuation alternatives for real estate valuation. The availability, accuracy and performance of these models continue to improve even as certain difficult to value properties remain a challenge for all valuation approaches. AVMs can systematically provide more information than just a valuation estimate, including reliability metrics and other statistics as well as a statistically derived range of estimates. The rule-based system of valuation is also readily amenable to regulatory oversight.

In the next sections, we reprise the important role of real estate collateral valuation in mortgage lending and provide a refresher on the regulatory context within which estimates of value are currently made. Then we describe the nature of AVMs, the evolution of data feeding the models, the requirement of model validation and provide a recent history of AVM performance.

## The role of valuation in the mortgage process

An accurate property valuation is an essential aspect of a mortgage transaction because the property provides collateral to secure the loan (generally resulting in more favorable terms for the borrower than unsecured debt). It is also a critical input to risk management decisions both at origination and during the life of the loan. At origination, the lender, investor and guarantor want an accurate estimate of property value in order to understand the probability and potential severity of a loss resulting from default, foreclosure or real estate owned (REO) distress sale should it occur in the future. The greater the initial equity in the property relative to its value, the

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<sup>2</sup> See, for example, “Interagency Advisory on the Availability of Appraisers” at <https://www.federalreserve.gov/supervisionreg/srletters/sr1704.pdf>, accessed on November 13 2017, noting lender complaints of appraiser shortages, especially in rural areas.

greater the decline in value the property can withstand and still provide sufficient funds for repayment of the mortgage debt should a sale be required. All other factors being equal, the lower the true loan to value (LTV) ratio at the time of origination, the safer the loan is for a lender or mortgage investor.<sup>3</sup> Accurate and independent property valuations are also a very important source of information for consumers who may be making decisions about one of their largest assets.

If the valuation is not correct or reliable, then the LTV is not correct or reliable. For example, suppose a prospective borrower enters into a contract on a property for \$125,000 and takes out an 80 percent LTV mortgage of \$100,000. If the true value of the property is \$100,000, then the true LTV ratio is 100 percent, not 80 percent, and the borrower has no equity in the property. A loan to a borrower with little to no equity carries considerably higher risk for the lender and mortgage investor than a loan to a borrower with 20 percent equity in a property. While most consider property valuation linked primarily to issues of severity given default, some studies suggest accurate valuations are correlated to the likelihood of default as well.<sup>4</sup> It is of the utmost importance that borrowers, lenders and investors in mortgage loans be able to rely on accurate and objective value estimates of all properties underlying mortgage loans.

When a lender's valuation comes in below the proposed purchase price, and assuming it is accurate, there are several options. One option is for the borrower to renegotiate the purchase price with the seller based on the lower valuation. However, data collected from millions of purchase transactions suggests that renegotiations of contract prices due to low appraisals historically have been infrequent.<sup>5</sup>

Another option is for the borrower to put more equity into the deal. For example, suppose that a borrower wants an 80 percent LTV mortgage for a purchase price of \$125,000 (requiring \$25,000 from the borrower), but the appraisal comes in at \$120,000. The lender can provide a loan of 80 percent of the appraisal value, or \$96,000, which is 76.8 percent of the purchase price. The borrower can still close on the loan but must put in \$29,000 which now includes \$4,000 of additional equity. This additional equity protects the integrity of the calculation on the probability of loss in case of foreclosure, since the property can drop in value by 20 percent before it is below the mortgage principal. If the loan is made for \$100,000, then the true LTV is 83.3 percent and the property can drop in value by only 16.7 percent before the value dips below the original mortgage loan. This example shows why lenders and mortgage investors must be able to rely on valuations as accurate sources of information. The equity cushion is even more critical when one

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<sup>3</sup> On an on-going basis, Agarwal, *et. al.* (2015) show that in addition to the mark-to-market value of the property relative to the outstanding mortgage balance, higher amounts of initial equity in the property is also associated with lower default rates.

<sup>4</sup> See "Appraising Home Purchase Appraisals" by Paul S. Calem, Lauren Lambie-Hanson, and Leonard Nakamura No 18-28, Working Papers from Federal Reserve Bank of Philadelphia, July 2017.

<sup>5</sup> See "Systemic Risks in Residential Property Valuations: Perceptions and Reality," Collateral Assessment & Technologies Committee, (June 2005), at 13-14, published in James Kirchmeyer, AVMs 201: A Practical Guide to the Implementation of Automated Valuation Models, at 145-146; and Paul S. Calem, Lauren Lambie-Hanson, and Leonard I. Nakamura, "Information Losses in Home Purchase Appraisals," Working Paper No. 15-11, Research Department, Federal Reserve Bank of Philadelphia, (Mar. 2015), at 3, 29.

considers the significant legal and transaction costs associated with a sale of the property and the potential costs incurred from claims against representations and warranties made to investors.

When appraisals come in above the purchase price, as frequently happens, regulations of banks and thrifts and other lenders require the use of the lower of either the purchase price or the appraisal. In such cases, it is possible that the true equity in the home is higher than dictated by the stated LTV.

Following origination, when a property declines in value such that the borrower has little to no equity in the home or is “underwater” (that is, the outstanding principal on the mortgage debt exceeds the value of the property), financial distress can push the borrower into default. A borrower may also decide to simply walk away from a mortgage that exceeds the value of the property, regardless of ability to pay. It is well established in the academic literature that “underwater” borrowers in the United States are more likely to default, even when they have the income and means to make the mortgage payments.<sup>6,7</sup> Loss-mitigation and loan modification strategies rely on accurate valuation of the property post-origination.

These scenarios represent real world risk decisions lenders, investors and consumers face each day. They illustrate the importance of getting an accurate valuation on a property and the financial consequences of missing the mark.

## The Current State of Property Valuation Regulation

A main source of regulation affecting valuations for residential mortgages (and other real estate transactions, including commercial mortgages) is the Interagency Appraisal and Evaluation Guidelines (Guidelines).<sup>8</sup> While the Guidelines have direct significance for federally regulated institutions, their influence goes beyond those institutions to impact the practices of other companies originating mortgages that will eventually be involved in a transactions with federal agencies or federally regulated institutions. Therefore, non-bank, independent mortgage companies are indirectly governed by these guidelines through their interactions with warehouse lenders, investors and other secondary market actors who are federally-related institutions.

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<sup>6</sup> See for example, “Consumer Ruthlessness and Strategic Default During the 2007-2009 Housing Bust,” Neil Bhutta, Jane Dokko, & Hui Shan, Federal Reserve Board 1, October 26, 2010 or “Loan Loss Severity and Optimal Mortgage Default,” by Vassilis Lekkas, John M. Quigley, and Robert Van Order, *Real Estate Economics*, Dec 1993, 21:4, pp 353-371 or “Strategic Mortgage Default: The Effect of Neighborhood Factors,” by Michael Bradley, Amy Crews Cutts and Wei Liu, *Real Estate Economics* Sept. 2015, 43:2 pp. 271-299.

<sup>7</sup> The rate at which borrowers actually “walked away” in the last cycle when they had negative equity but an (estimated) ability to repay is lower than anecdotally believed – in only about 8-15 percent of the cases meeting those criteria. Bradley et al. (2015)

<sup>8</sup> These agencies include the Office of the Comptroller of the Currency (OCC), the Board of Governors of the Federal Reserve System (FRB), the Federal Deposit Insurance Corporation (FDIC), the Office of Thrift Supervision (OTS), and the National Credit Union Administration (NCUA).

Based on the Guidelines, real estate-related financial transactions require either an *appraisal*, an *evaluation* of market value, or a form of valuation acceptable by a government agency or government-sponsored agency involved in the transaction. An evaluation is not as clearly defined as an appraisal but provides alternative forms of evidence about the collateral's market value. Appraisal exemptions requiring an evaluation include transactions below the appraisal threshold of \$250,000 with a proposal to increase this to \$400,000 on the table or an extension of existing credit which includes some refinancings, subsequent draws or decisions about HELOCs and workouts and modifications.<sup>9</sup> According to the Guidelines, AVMs, along with additional evidence about the physical condition of the property and economic and market conditions, may be a suitable tool for building an evaluation while BPOs are not. Appraisals, however, may still be used even when an exemption exists in the course of safe and sound banking practices or because of investor requirements.

Beyond low value transactions and extensions of existing credit which require an evaluation, appraisal exemptions include loans that are wholly or partially insured or guaranteed by a U.S. government agency or U.S. government-sponsored agency and transactions that qualify for sale to a U.S. government agency or government-sponsored agency.<sup>10,11</sup> More than 70 percent of all originations were insured or guaranteed by a government or government-sponsored agency in the first half of 2017.<sup>12</sup> The regulatory rationale for the exemption from the Guidelines is that these agencies are presumed to have well-developed policies around property valuation that are enforceable against lenders.

With respect to transactions that requires an evaluation, institutions are required to have policies and procedures in place for determining if they should still obtain an appraisal. The decision to use an evaluation when an exemption exists carries risk since the institution is left with a degree of discretion and not granted complete legal protection by virtue of the exemption itself.

Should a lender choose to go the route of an evaluation, AVMs, paired with property inspection (in order to address a property's current physical condition, as required) provide a valid method. For those using AVMs, the Guidelines direct institutions to establish policies and procedures that indicate the appropriate and acceptable use of AVMs and that guide selection of a particular AVM or AVM vendor. Guidelines also require institutions to validate AVM results and evaluate AVM performance on an on-going basis.

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<sup>9</sup> That evaluations are sufficient to support lender decisions to curtail a line of credit is currently being litigated. See <https://www.housingwire.com/articles/47458-regulators-propose-ending-appraisal-requirement-on-some-home-sales-of-400000-and-below> and Federal Register at <https://www.fdic.gov/news/board/2018/2018-11-20-notice-sum-c-fr.pdf>

<sup>10</sup> Opinions differ as to whether a loan that qualifies for sale but is not actually sold to an agency or GSE, is indeed exempt from the requirement of an appraisal.

<sup>11</sup> An exemption also applies to transactions in which the appraisal adheres to GSE appraisal standards for the particular class of real estate for loans that otherwise do not qualify for sale, like non-conforming jumbo loans.

<sup>12</sup> Urban Institute, *Housing Finance at a Glance*, September 2017.



In light of the Guidelines, it is perhaps unsurprising that a recent change in approach to valuation has come from the GSEs. In December of 2016, Fannie Mae issued guidelines that allow for a property inspection waiver (PIW) on refinanced loans when the LTV at origination will be 75 percent or less (or 70 percent or less when cash is being withdrawn) if the loan processor uses the Fannie Mae Desktop Underwriter (DU) product.<sup>13</sup> Freddie Mac followed suit in June of 2017 to allow some waivers for both purchase and non-cash out refinances for loans processed through their Loan Product Advisor system.<sup>14</sup> Fannie added the possibility of waivers for purchase transactions in August of 2017.<sup>15</sup> Appraisal and inspection changes have been motivated by the amount of property data that the GSEs have accumulated over time and their confidence in the accuracy of their proprietary AVMs. The U.S. Department of the Treasury recently acknowledged the benefits of the GSE property valuation reforms:

Treasury supports the GSEs' efforts to implement standardized appraisal reporting, the GSEs' and FHA's adoption of proprietary electronic portals to submit appraisal forms, and the GSEs' limited adoption of appraisal waivers. While Treasury acknowledges that automated valuation engines and appraisal waivers should apply to a defined and limited subset of loans, and that they may compete with traditional appraisers, these innovations offer borrowers upside through lower cost originations and faster closings, without sacrificing accuracy.<sup>16</sup>

Beyond the GSE reliance on AVMs for originations and the role of AVMs in supporting evaluations, AVMs have been used extensively for quality assurance and quality control purposes in origination for over a decade. AVMs have also been frequently used for assessing property values post-origination on HELOCs, loan portfolios, for mark-to-market and for marketing purposes. They also provide a method for the risk-based assignment of appraisals and quality control around appraisals.

This paper sets out to explore and explain the performance of AVMs over time in order to help a variety of actors better understand this critical technique.

## What Is An AVM? How Are They Implemented?

Automated valuation models, or AVMs, are rule-based processes by which real estate values are estimated using statistical modeling and expert systems for data collection and filtering. There are two types of AVMs in the market today, consumer facing AVMs and professional grade AVMs. Examples of consumer facing AVMs are generally found on realtor sites and are typically provided to the user free of charge. This paper focuses on the professional grade AVMs since these types of AVMs are or have the potential to be used in the loan process. Professional grade

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<sup>13</sup> See [https://www.fanniemae.com/content/release\\_notes/du-do-release-notes-12102016.pdf](https://www.fanniemae.com/content/release_notes/du-do-release-notes-12102016.pdf)

<sup>14</sup> See <http://www.freddie.mac.com/singlefamily/guide/bulletins/pdf/bl1708.pdf>

<sup>15</sup> See [https://www.fanniemae.com/content/release\\_notes/du-do-release-notes-08192017.pdf](https://www.fanniemae.com/content/release_notes/du-do-release-notes-08192017.pdf)

<sup>16</sup> U.S. Department of the Treasury, *A Financial System that Creates Economic Opportunities: Nonbank Financials, Fintech and Innovation*, July 2018, p. 106.

AVMs are rigorously tested on massive scales so that their performance, consistency and risk are well known and documented by lenders, investors and third-party stakeholders throughout the mortgage industry.

Consistently available, high-quality data are a critical input, and this is arguably the area in which advances are most rapidly propelling the coverage and performance of AVMs forward. Just as with appraisals, AVMs perform best in the case of houses that are of average quality and size with typical attributes in an area with many sales. If data is scarce then any property valuation is always difficult, and this is particularly true for unique properties, high value properties, distressed properties, and for rural locations.

Many of the fundamental statistical approaches and methods are well-understood. However, new analytics are being developed all the time and bear monitoring. One benefit of using statistical models is that more information is available from AVMs than just an estimate of value, including additional statistics and the ability to create meaningful ranges of value in order to help industry participants assess risk. When paired with well-defined policies and procedures that guide the development of analytic rules, AVMs also produce valuations systematically and without further human input, avoiding biases that may result from ad hoc intervention and decision-making on a case-by-case basis.

AVMs generally make greater use of available data to estimate value as compared to an appraisal. Different models can be evaluated according to their “hit” rates, confidence scoring and accuracy, among other measures. A response rate or “hit” rate refers to the share of homes in a particular group for which an AVM can provide a value estimate (perhaps conditional on the reliability of the estimate). AVM providers include a confidence score as a measure of reliability for value estimates, although the exact nature of the score may vary across providers.

Judgements and measurement of valuation accuracy can vary but typical accuracy statistics for AVMs summarize how close model estimates are to “true” value as measured by actual sale price or other benchmark value, like an appraisal. Testing provides a means of determining model accuracy by using a sample of houses with known values. Because, by definition, we do not know the value of a subject property being valued in real time, confidence scores are effectively a measure of *expected* accuracy for a particular case based on what is known from prior testing of the model. Different data sets and different models will have different hit rates, confidence scores and accuracy metrics, and the metrics can vary over time, across properties and by geographies within a given sample.

The lower the confidence score, the greater the uncertainty of the value of the property, not just for the AVM being used but for any type of appraisal or property valuation. For example, comparable properties may not be very high-quality matches, or they may be few and far between. In fact, many users will assess the overall difficulty of a valuation assignment simply through an evaluation of whether or not multiple AVMs can, at high levels of confidence, value the property.



There are several valuation approaches used by AVMs. The most common are *hedonic models*, which estimate values based on multiple variable regression models. The dependent variable is the sales price and the independent variables – that is, all the factors that might drive the price – size, age, bedrooms, baths, construction types, features (like fireplaces), lot size, location and other market factors.

Another type of AVM is the *appraisal emulation model*. An appraisal emulation model does just that – emulates the process of a manual appraisal, but with the use of statistical analysis. The model identifies several comparable properties (or comps) to the property that the model is valuing (the subject property). The model typically ranks the comparables using a similarity score, which is based on the similarity of the comparable to the subject property, whether in size, number of bedrooms, neighborhood, or other features. Comparable sales that are the least similar are discarded, especially when the amount of property data available for analysis is ample. The comparable sale data is selected so as to be as close to the date of the valuation as possible and as close geographically to the subject property as possible.

The appraisal emulation model then uses sophisticated data analysis, statistical techniques, and weighting to adjust the sales prices of the comps to account for differences in features, size, and to account for historical price trends in the area. The application of statistical tools allows the model to estimate values, and, in particular, specific adjustments for property features, systematically and objectively.

Another type of AVM is based on changes in prices over time. These models are generally referred to as *index models*. In their purest forms, these models assess changes in price in matched sales or sales prices on the same property over different time periods. There are numerous derivatives of index methodologies that quantify various elements of price movement over time.

There are also AVMs that incorporate all of the above-referenced approaches or even create hybrid approaches that leverage advantages of two or more methodologies. These are typically referred to as *blended models*.

Similar to blended models, many users will run AVMs from multiple vendors, often competitors, in what are known as *cascade models*. Current generation cascade models typically work by ranking models according to their accuracy at the county level. The user chooses the top three to five models in each county and a threshold confidence score for each model. To value a property, the top-ranked model is run and if the confidence score exceeds the threshold metric, the value is deemed acceptable. If the confidence score is too low, then the next-ranked model is run, and so on, until either a suitable confidence score is found or it is determined there is no acceptable valuation. The rules that the cascade model uses to rank models and choose confidence score thresholds that comprise the cascade's rules are determined by the user based on periodic AVM validations. Importantly, the rules should be based on statistical accuracy alone.

Cascades may be useful for increasing overall hit rates, coverage and accuracy. However, the increase in performance from cascades is decreasing given the dramatic improvement in individual AVM performance. Nevertheless, AVM cascades are responsible for most of the AVM volume today. It is important to understand that a cascade is only as effective as the validation effort used to create, monitor and update its rules. These validations are sometimes done internally, and sometimes by third party vendors. One source of validation is that the valuations and equity estimates are correlated with subsequent default performance.<sup>17</sup> AVM validation and cascade development also assume a requisite amount of independence in determining appropriate and unbiased selection criteria. Cascades are typically run for an individual transaction but can also be employed on large portfolios.

Cascade methodology and technology is also evolving. Next-generation AVM cascades are being offered today that consider whether the use of an AVM is suitable for a particular property, and if so, identify which AVM from among several models will most accurately value that specific property.

One additional benefit of data driven valuation is that subject property can be assessed for complexity, uniqueness and even comparable data availability prior to valuation. When combined with information on the expected loan-to-value ratio and other underwriting criteria, this allows a determination of whether an AVM is appropriate and could generate a reasonably confident valuation. It also tells a lender how challenging an appraisal will be for manual approaches.

## AVM Data: Growth in Availability Over Time and from Different Sources

One component of AVM performance is the underlying data that fuel the models and their confidence scores. Real property data has significantly improved in terms of geographic coverage, depth and granularity, availability of new information, currency of information, and the overall integrity and accuracy of available data sources. Many of the first AVMs were powered solely on public records data. Public records generally consist of sales transactions and related transfers from the county recorders and tax data from the local county tax assessing authority. Public records can be sourced directly from local county authorities or acquired from regional or national data aggregators. Public records data has improved significantly over the past decade in terms of coverage, currency and integrity.

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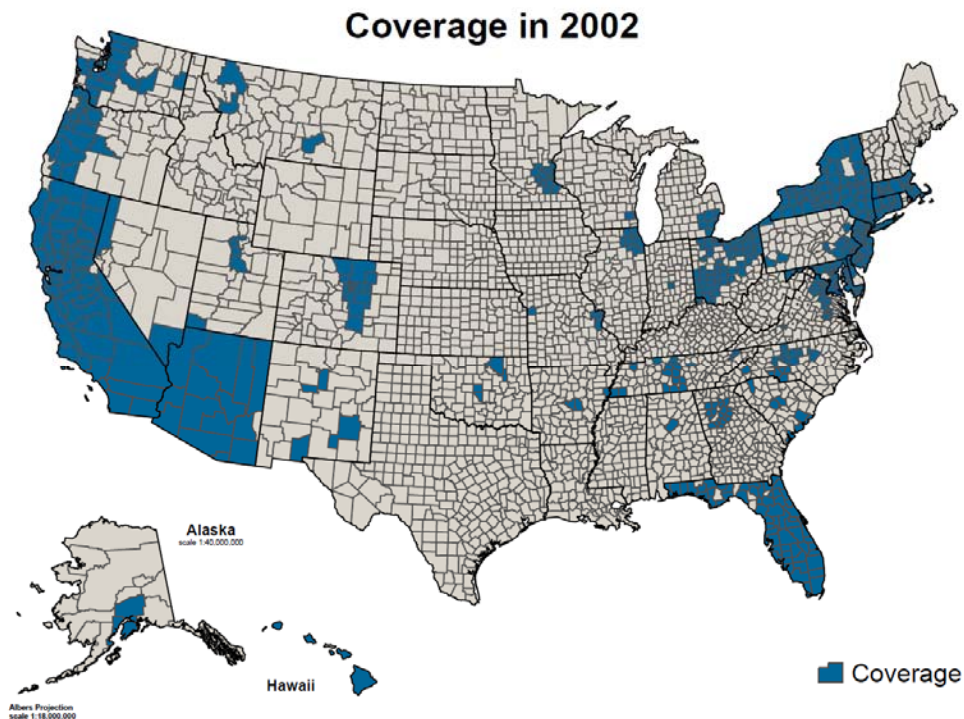
<sup>17</sup> A study covering millions of mortgages from the Federal Reserve Bank of Philadelphia is the strongest evidence to date that additional valuation approaches may be beneficial to the market. Working Paper No. 17-23, Appraising Home Purchase Appraisals, by Paul S. Calem, Laurie Lambie-Hanson, and Leonard Nakamura, July 2017.

Data from multiple listing services (MLS) has become more widely available over the past five to ten years. Many models have incorporated MLS data, driving performance even higher. MLS data helps to fill-in the gaps that may exist in public records jurisdictions while expanding coverage and availability of data, particularly in areas such as non-disclosure states. MLS data further affords modelers new insight into the relationship between list prices and sales prices. Finally, MLS data may provide more current and accurate information on a property’s physical characteristics than is available from public sources, like local tax assessors.

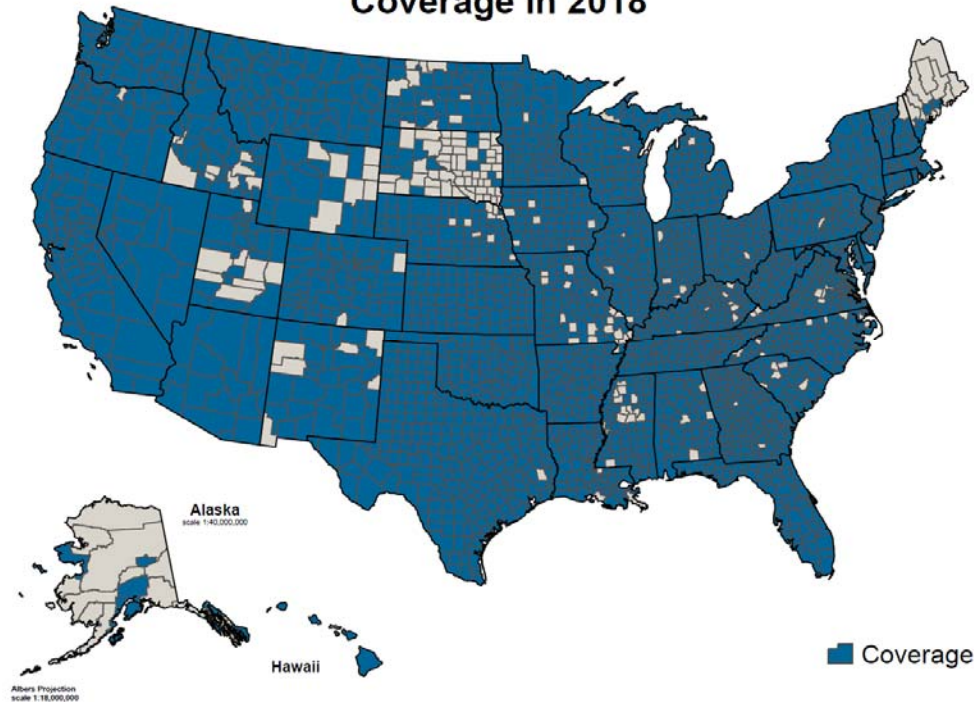
Other data sources available to AVM modelers include appraisal data, tax assessor data, broker-price-opinion (BPO) data, inspection data, building permit data, mapping and geospatial data, transaction data, disaster (fire, flood, earthquake) and other related data sources. The combination of multiple data sources allows model providers to resolve conflicts, provide greater depth and granularity of analysis, expand the number of properties and the number of attributes that may be effectively and appropriately valued (e.g. geographic expansion including more rural areas, new property types, broader price tiers, and the ability to more accurately deal with rapidly changing and challenging markets). As recently noted by the U.S. Department of the Treasury, “AVMs have existed for several decades but their use and accuracy has improved in recent years due to advances in machine learning, database technologies, and the proliferation of large datasets composed of proprietary and public records with detailed property-specific information.”<sup>18</sup>

**The Exhibits (01 and 02) below show the improvement in county level geographic coverage one AVM experienced from 2002 to 2018.**

Exhibit 01



### Coverage in 2018



## Model Validation

AVMs are designed and calibrated based on data from millions of purchase transactions across various geographic markets and over time. When AVMs are tested – whether internally by developers or by outside testing firms or clients – they are run on tens of thousands of purchase and non-purchase transactions from a given market, or hundreds of thousands of transactions nationwide. An AVM developer is typically engaged in multiple, simultaneous AVM test validations at any given point in time. Each test attempts to establish whether the AVM produces value estimates that are close to prices actually observed in the market. The tests are also used to ensure that the confidence metrics that the AVM reports for a particular estimate reflect the model’s actual accuracy. Typical AVM validations are repeated on regular basis, typically monthly or quarterly, to assess the stability of model results.

Because of the highly competitive nature of the AVM industry, the differences in the accuracy of the AVMs offered by the top-tier vendors have narrowed. Further, regulatory and client expectations have materially increased requirements for additional operational controls, model validations, due diligence as well as compliance reporting and audit requirements. Companies who have been unable or unwilling to meet these requirements and performance expectations

<sup>18</sup> U.S. Department of the Treasury, *A Financial System that Creates Economic Opportunities: Nonbank Financials, Fintech and Innovation*, July 2018, pp. 105-106.

do not last long in the space. Models are continually improved to achieve higher accuracy. As early as 2009, the Collateral Assessment & Technologies Committee (CATC) of the Real Estate Information Professionals Association reported that:

*No appraisal or other evaluation product has undergone the rigorous level of testing and scrutiny as AVMs. The performance of AVMs in both appreciating and declining markets has demonstrated their level of accuracy and the unbiased nature of their results when compared to other valuation techniques... Experience has shown that, with all other performance factors held equal, loans underwritten with AVMs have outperformed similar loans underwritten utilizing appraisals or other evaluation methods.*

Similar to the use of any settlement service, effective AVM implementation requires a lender's commitment to the validation and vendor due diligence process. Smaller lenders can face challenges meeting regulatory and compliance expectations. Fortunately, lenders and related organizations of all sizes have numerous resources available to them to meet internal and external expectations for effective risk management. For example, responsible vendor-partners and objective third-party consultants that specialize in the AVM validation process and due diligence can be essential resources.

Regulatory expectations for the validation and implementation of AVMs place the ultimate responsibility for the validation and implementation of AVMs squarely on the lender. Outsourcing AVM validation or use does not relieve the lender from this obligation to understand and support the AVM selection criteria and the production deployment of these tools. These requirements are not unique to AVMs. The same expectations hold true for any settlement service a lender seeks to implement, whether or not such services are outsourced. Responsible service providers work with lender partners to educate, provide internal due diligence metrics, and participate in external due diligence requests, audits and testing in order to help meet regulatory compliance requirements.

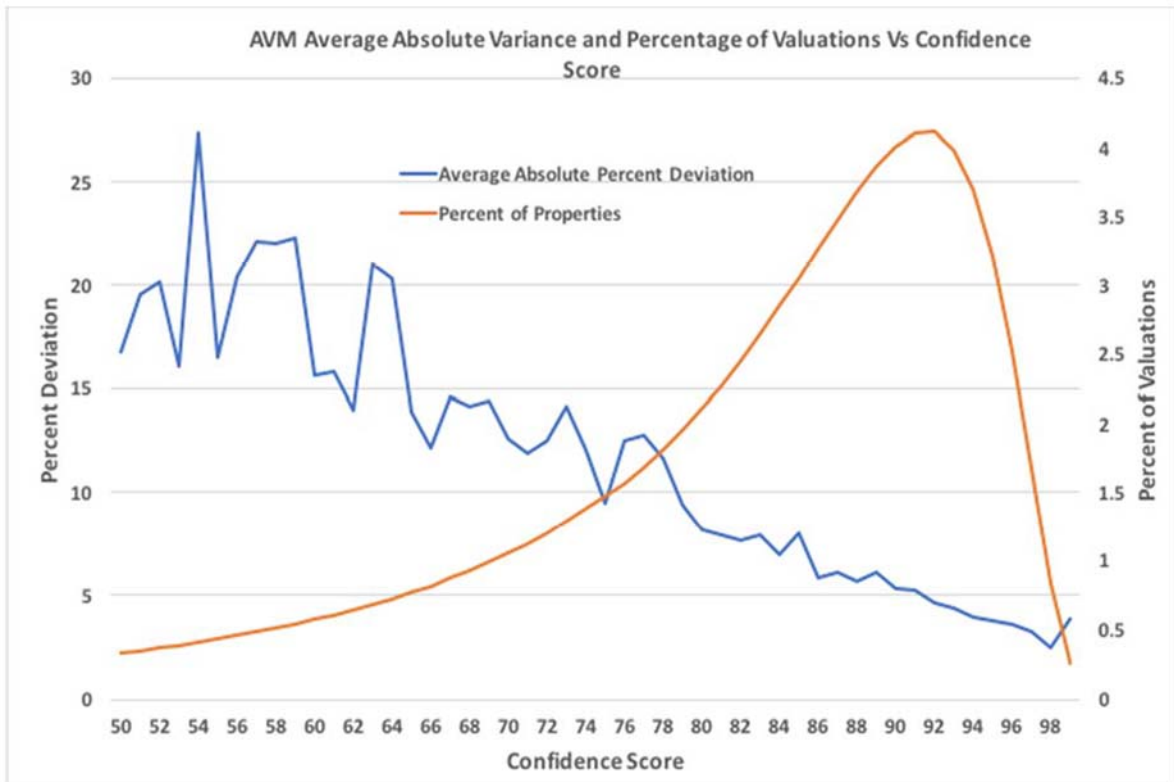
## Trends in AVM Performance

AVM performance is continuing to improve at an extremely rapid pace. Improvements in AVM performance have resulted from increases in the availability of data as well as improvements to the quality and integrity of traditional data sources. Further, material advances in the approach to modeling property values and methods of analyzing massive quantities of data such as advances in Big Data analysis, database technologies and deep machine learning have and will continue to drive performance to new heights.

A confidence score reflects the valuation's expected reliability – that is, how accurate the valuation is expected to be based on prior testing of the model. The average (absolute) percent deviation of a value estimate from a benchmark value, typically a recently observed purchase price, is one way to assess model accuracy. The relationship between confidence scores (for value estimates where the model is blind to the benchmark value) and average absolute percent

deviations of the estimate from the benchmark are shown in Exhibit 03 below for a single AVM. As can be seen in Exhibit 03, the confidence scores are highly correlated with AVM accuracy for a sample of properties with known benchmark valuations. Further, most of the valuations for this single AVM model are delivered at its highest levels of accuracy with more than 80 percent of the sample displaying less than a 10 percent deviation from its benchmark.

Exhibit 03



While there are numerous metrics used to assess valuation accuracy, AVM performance is most typically discussed amongst users as the percentage of values that fall within plus or minus ten-percent of the expected true value or “benchmark” (this is most commonly referred to as “P10”). The number of values that an AVM can produce over a given sample of properties is referred to as the “hit rate.” Typically, there is an inverse correlation between hit rates and reliability in any valuation product.

To illustrate the point, let’s use two extreme examples. If 100 properties are submitted for valuation and a provider delivers 100 values (100 percent hit rate) at very low confidence scores that does not help manage risk. Conversely, if 100 properties are submitted for valuation and a provider delivers one (1) single value (1 percent hit rate) but that single value has very high confidence (i.e. extremely high expected accuracy), this result similarly does not help effectively



manage risk in a meaningful manner. So, in its simplest terms, the goal of an AVM (or any valuation product for that matter), is to deliver the highest percentage of most reliable valuations possible. Model validations will also consider several other aspects of AVM performance including over- and under-valuation risk, extreme outlier performance, performance across different transaction types, property types, price-tiers, and volatility in performance over time.

As a result of advances in technology, the availability of data and the integrity of data over the past ten years, AVM performance has dramatically improved. AVMs are readily and routinely tested on massive scales so that their performance and risk are well known and documented by lenders, investors and third-party stakeholders throughout the mortgage industry.

While it is a costly process for AVM providers to respond to testing requests, the providers are subsequently provided with their own test results as well as the anonymized results of other providers in the test which helps to drive improvements in performance for the industry as a whole. The data produced by this process also provides us an opportunity to track industry progress over time.

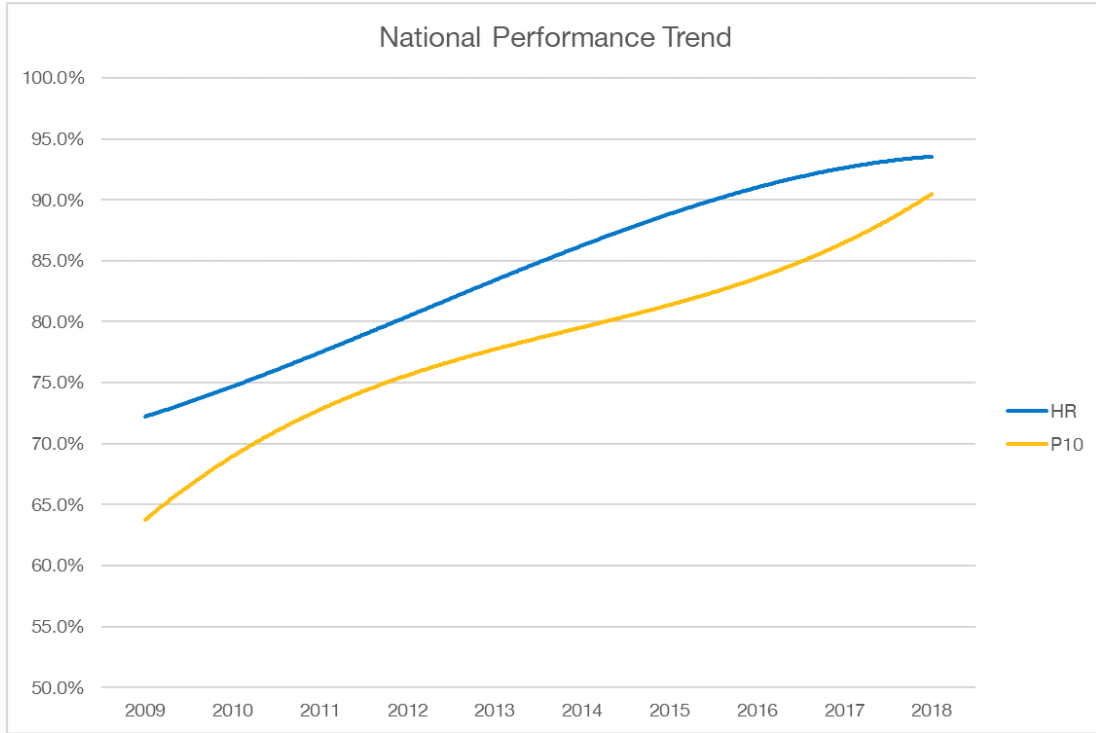
Two of the most comparable statistics across such tests are the gross hit rate and the P10. To provide evidence about the state of AVM performance, AVM providers, lenders and third-party testing and validation companies who have accumulated information on these tests over time aggregated this data on a quarterly basis (this excludes any internal testing done by the providers themselves). Not all providers included in a test are the relevant actors for understanding how performance is trending. Only the best AVMs are typically selected by end users. In addition, we know that cascades and blended models frequently combine the results of different providers in everyday use to maximize hit rates and confidence. Therefore, the P10 for the top 50 percent of providers based on P10 results in each test were averaged. Then the average test scores were averaged again among all independent test results (lender and independent consultants). AVM developer internal due diligence results was excluded. The process was repeated for hit rate and this data was used to generate an industry index of accuracy and hit rates for the industry over the years 2009 to 2018.

Examples of how average hit rates and P10 have advanced over 10 years for the aggregated AVM industry are shown below at the national level. Note how both hit rates and the P10 rates continue to dramatically improve, now approaching 95 percent hit rate and over 90 percent P10. Top-tier individual AVM models and AVM cascades with top-tier AVM models will exceed the performance set forth below.



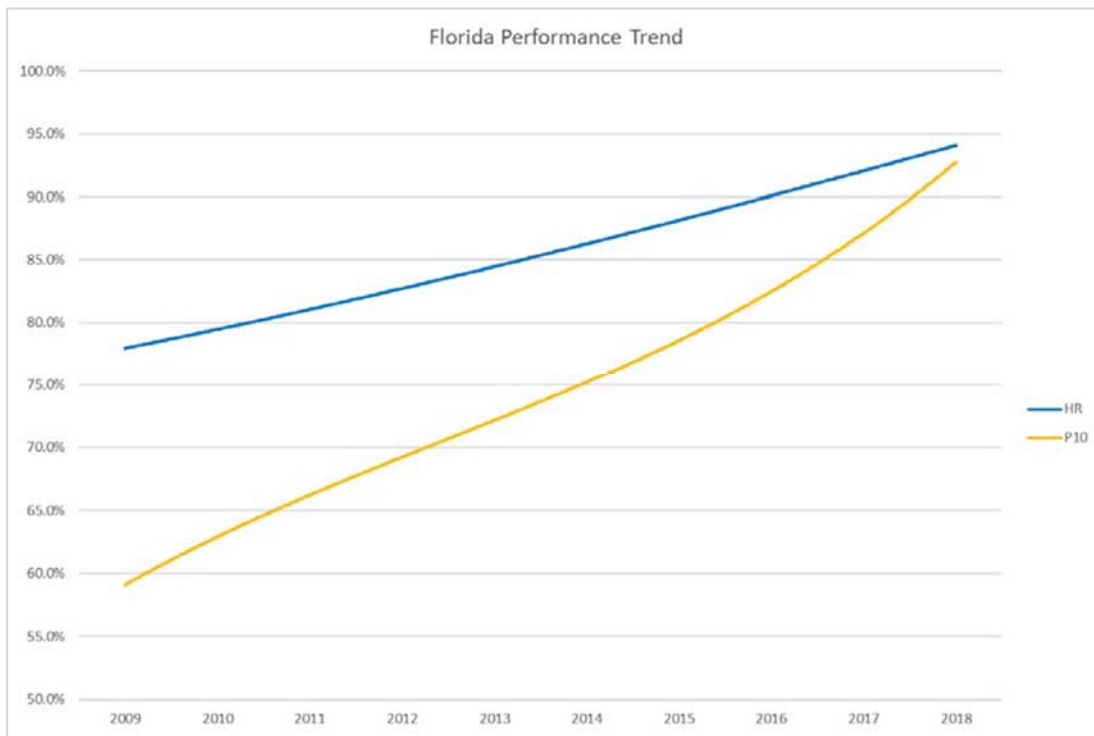
Exhibit 04

Average performance of AVM industry in validations conducted by lenders and third-party consultants

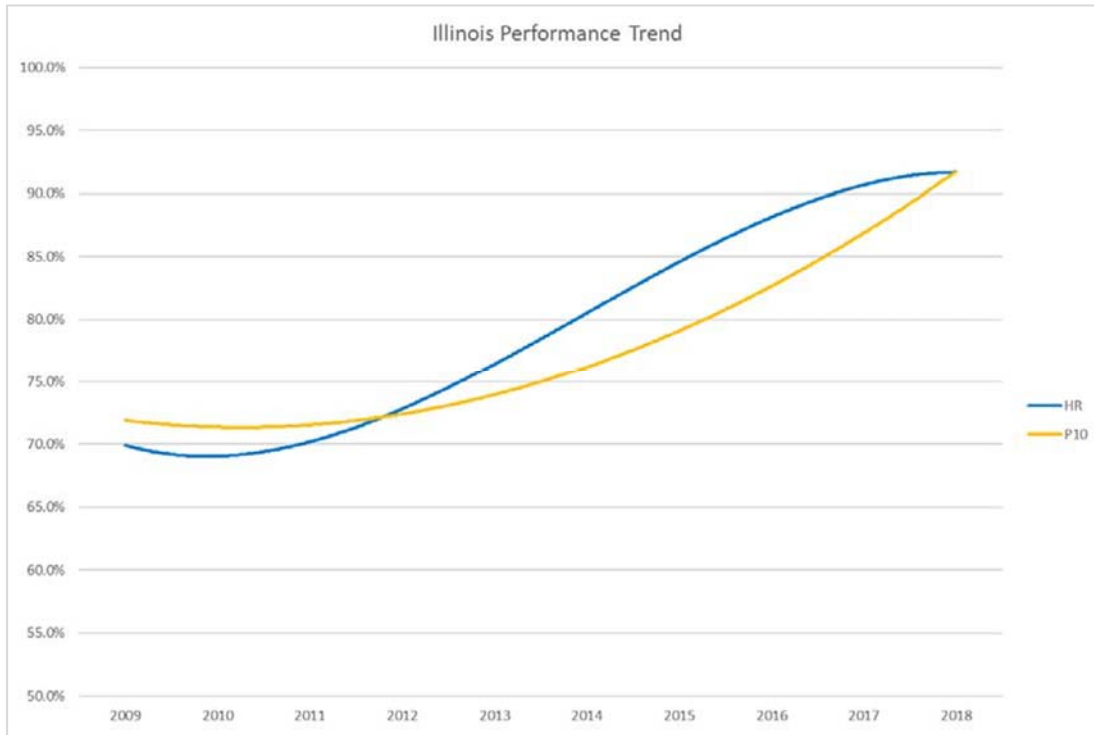


Everyone should know that real estate is local. Home prices and home price movement can and do vary dramatically in different parts of the country. As a result, it can be misleading to only cite national statistics in discussing the performance of any valuation product or service. Relative to AVMs, just as national accuracy has improved dramatically so have individual state results. Below are a few examples of AVM performance in selected states over the same period of time:

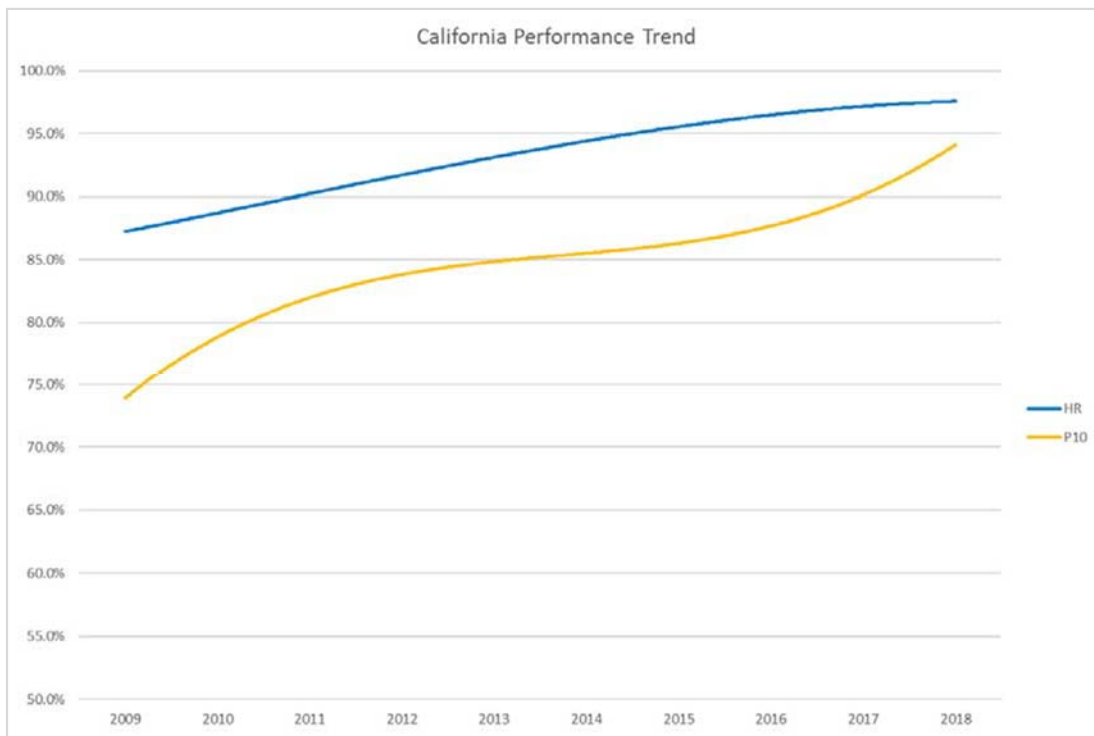
Exhibit 05



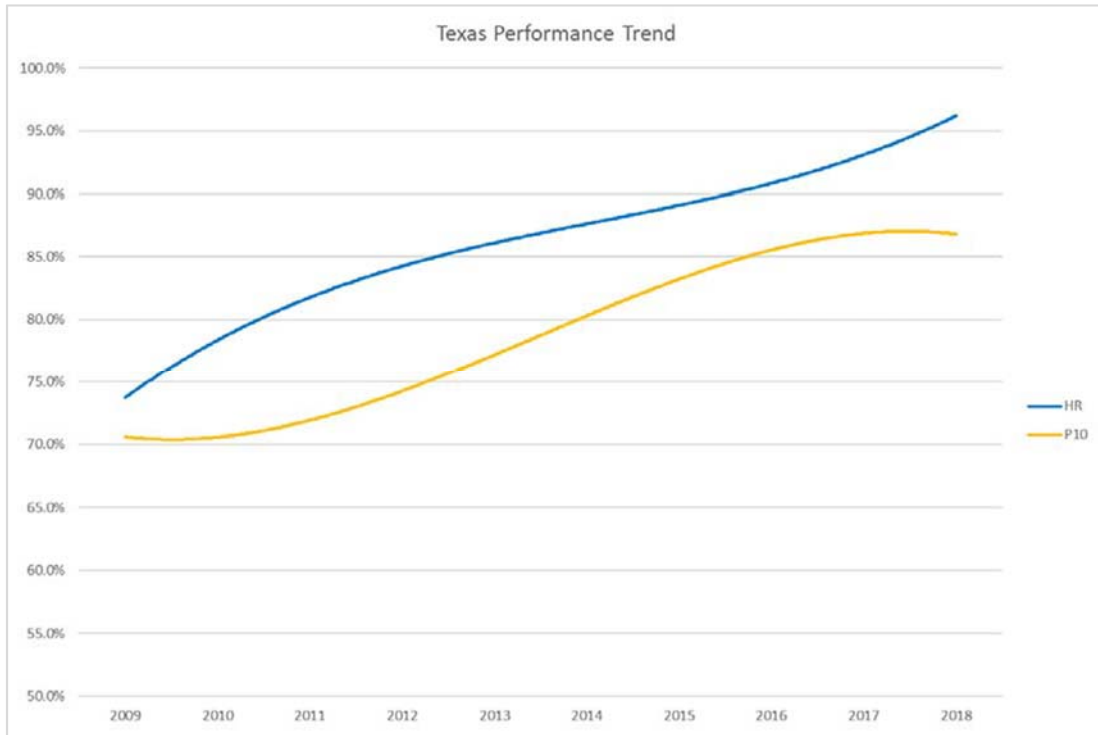
### Exhibit 06



### Exhibit 07



### Exhibit 08



### Exhibit 09

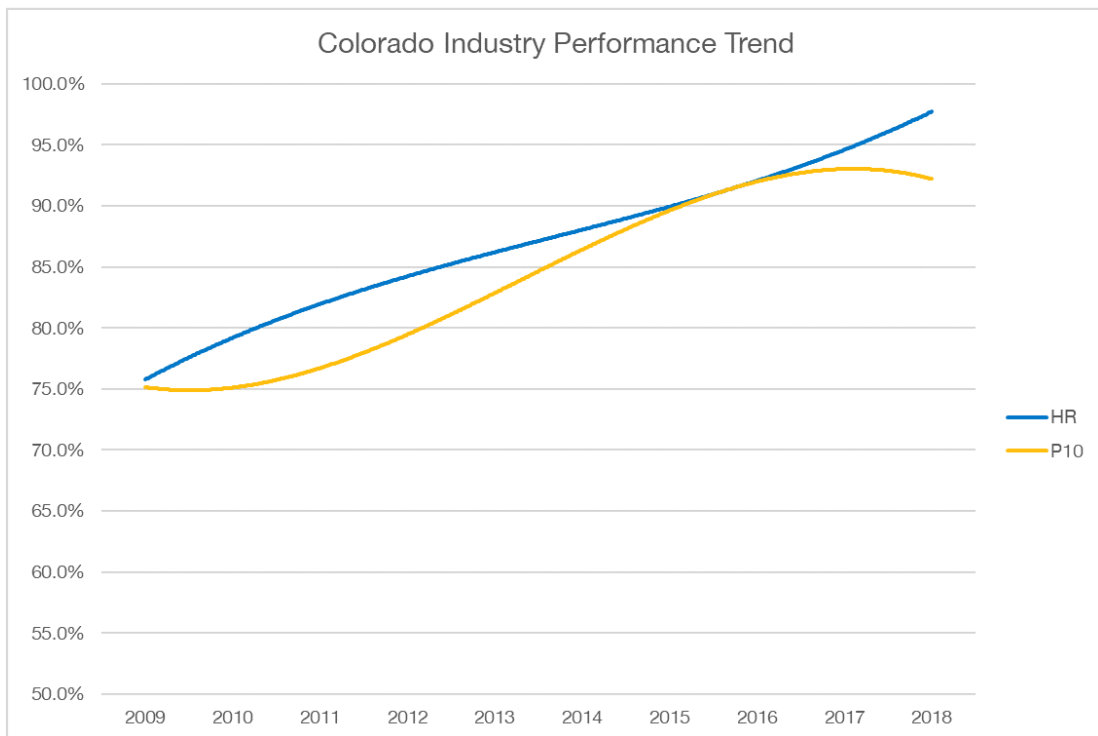


Exhibit 10

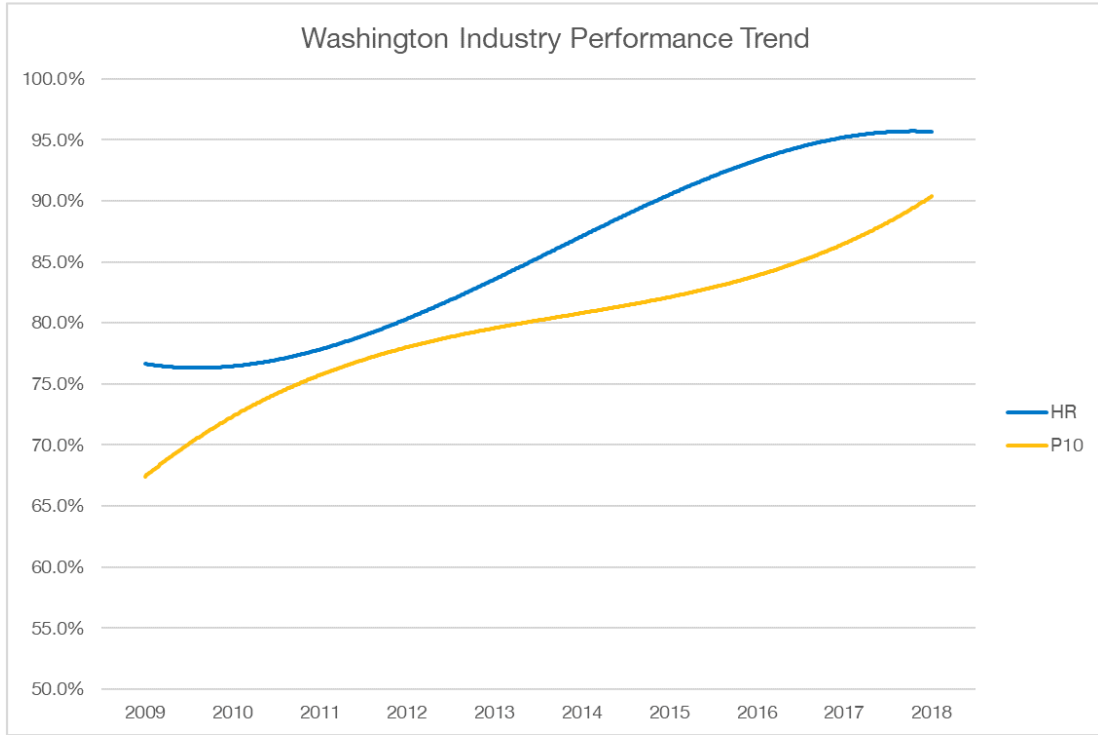
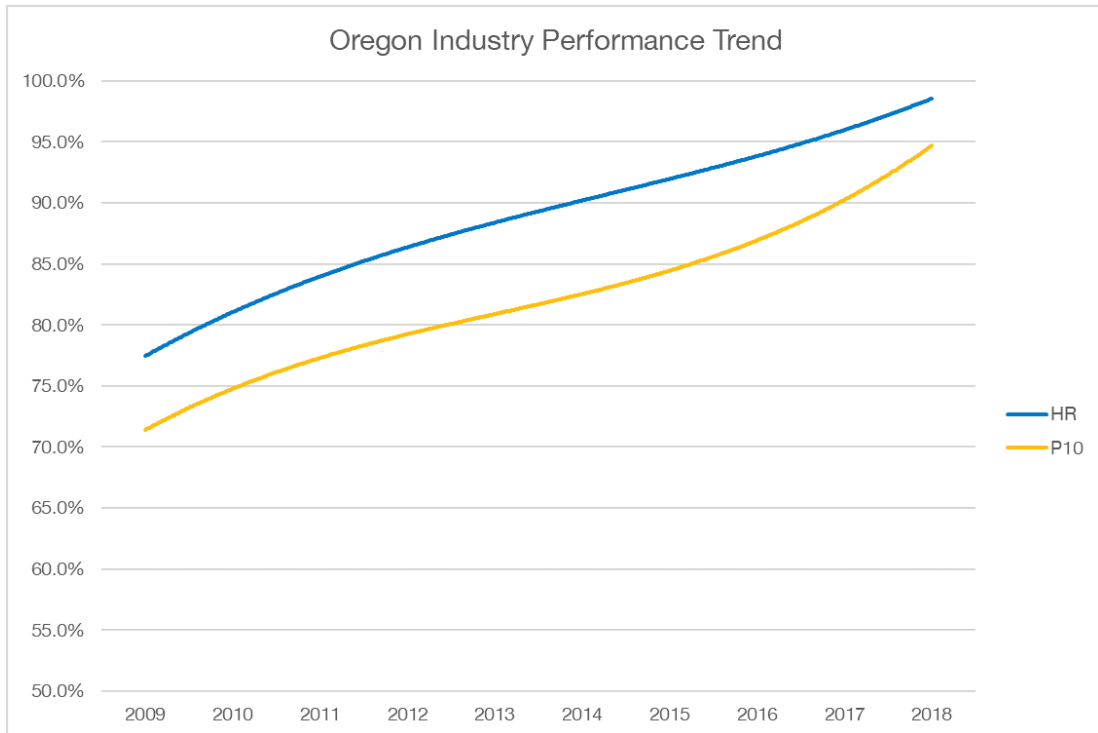


Exhibit 11



Further, AVM performance can be demonstrated at the metro level as well as in regions located in non-disclosure states (these states do not disclose sales prices through public records) with the following examples:

Exhibit 12

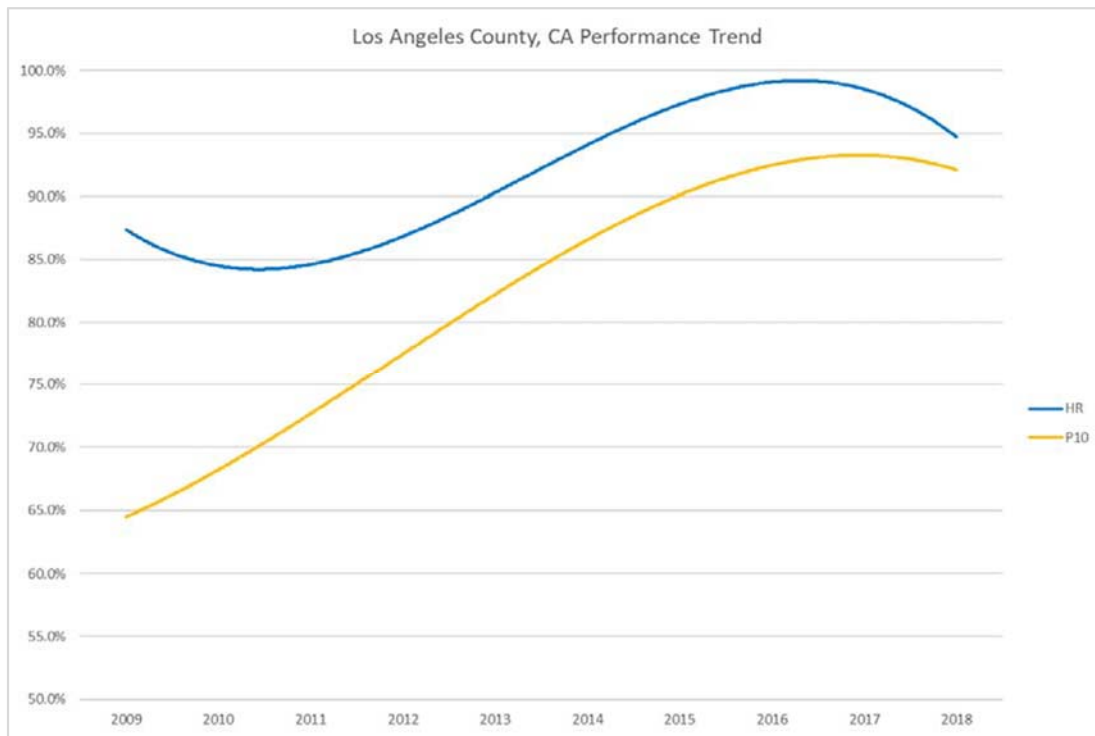


Exhibit 13

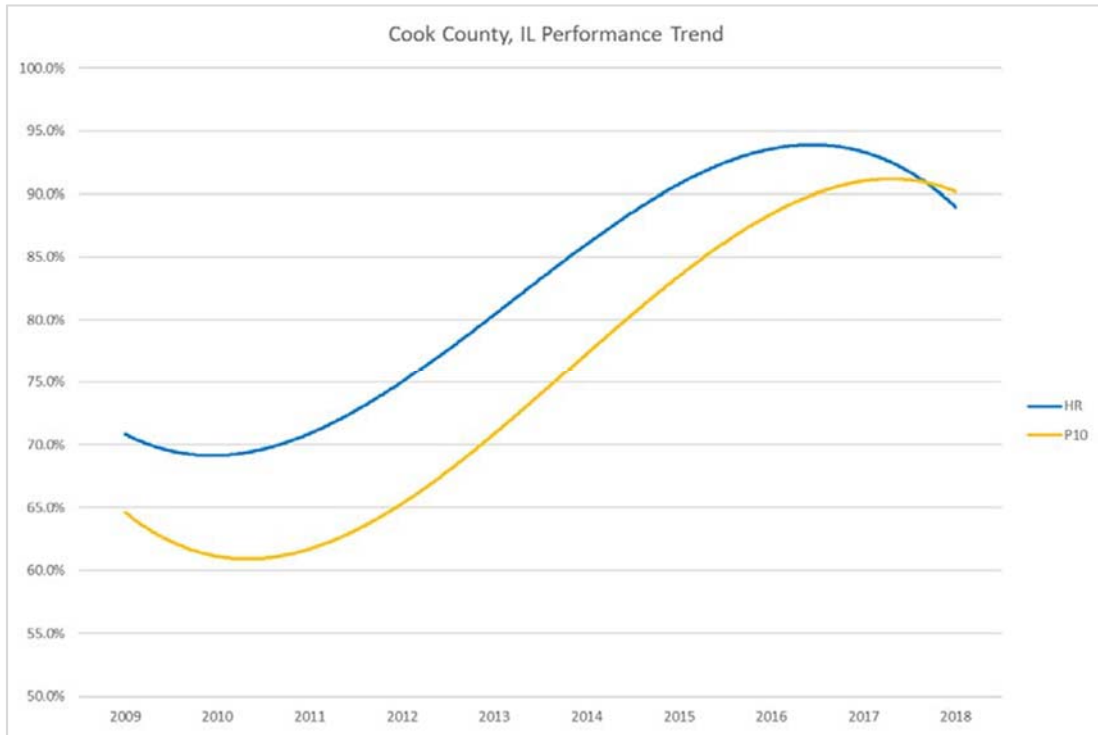
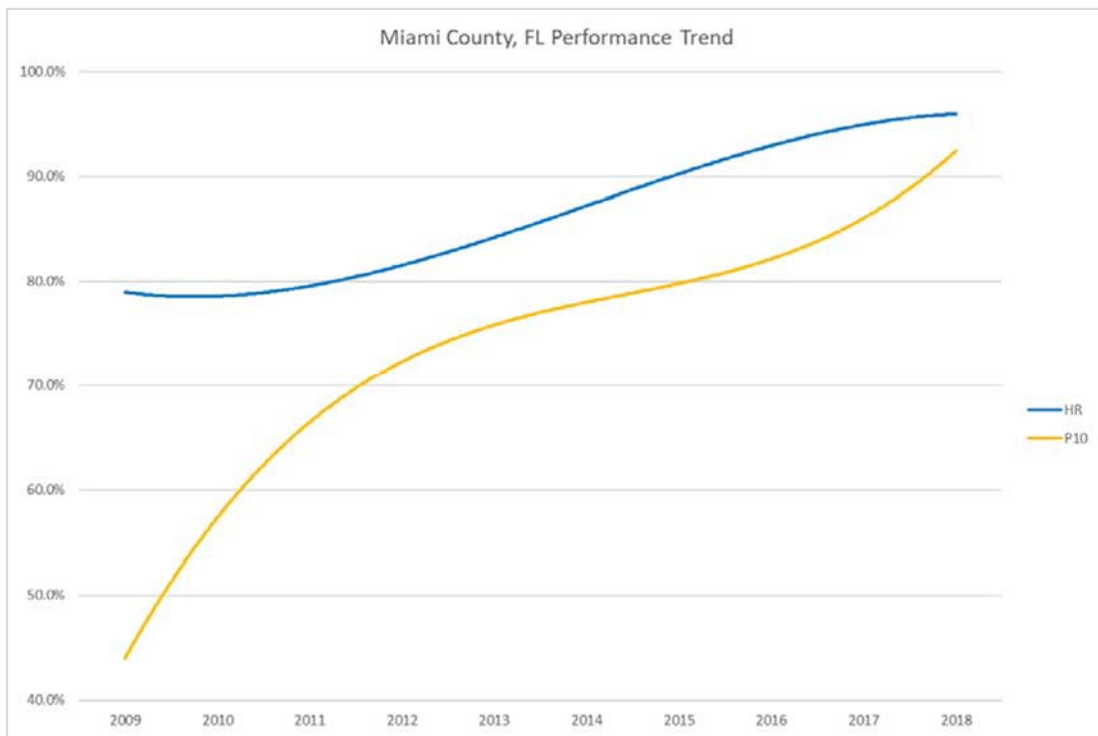
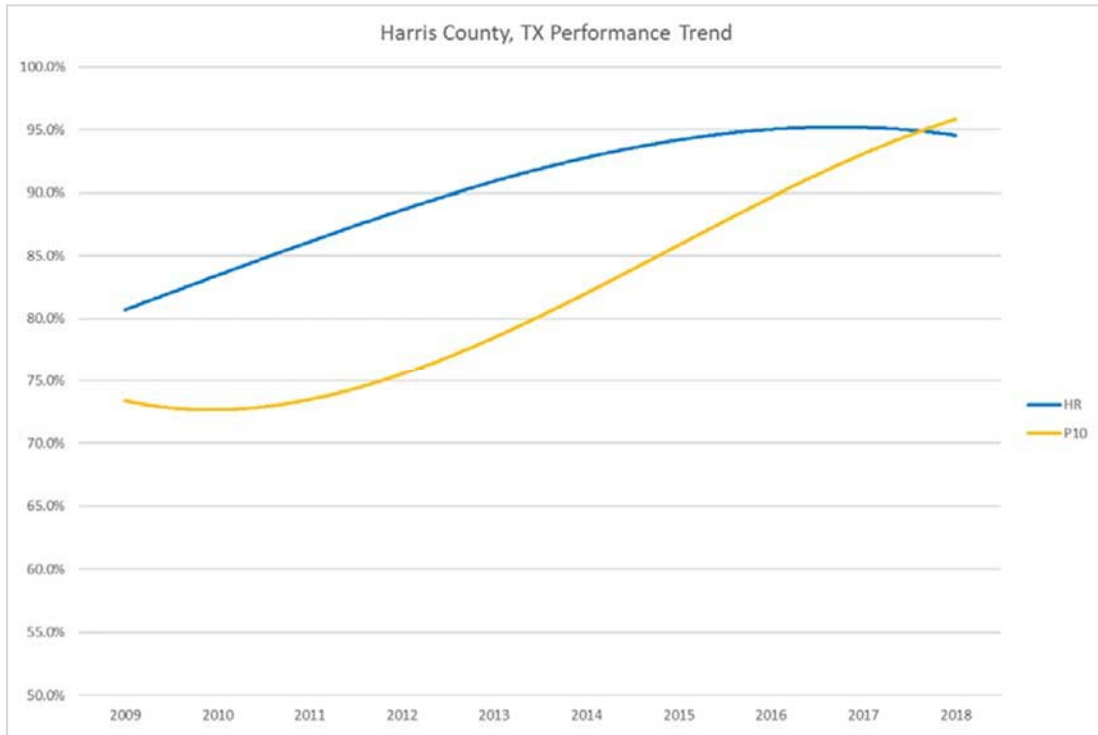


Exhibit 14



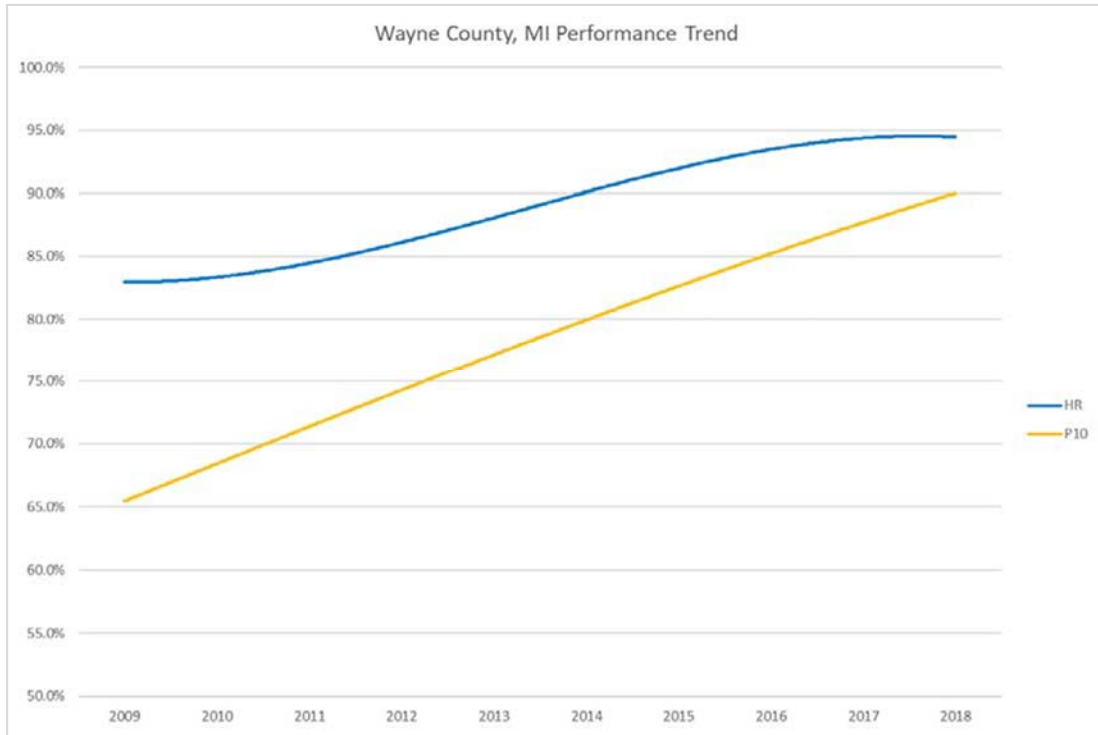


## Exhibit 15



Even areas where lenders have reported challenges with appraisals due to lack of transactions or economically depressed conditions, such as Detroit, MI, AVMs have improved dramatically.

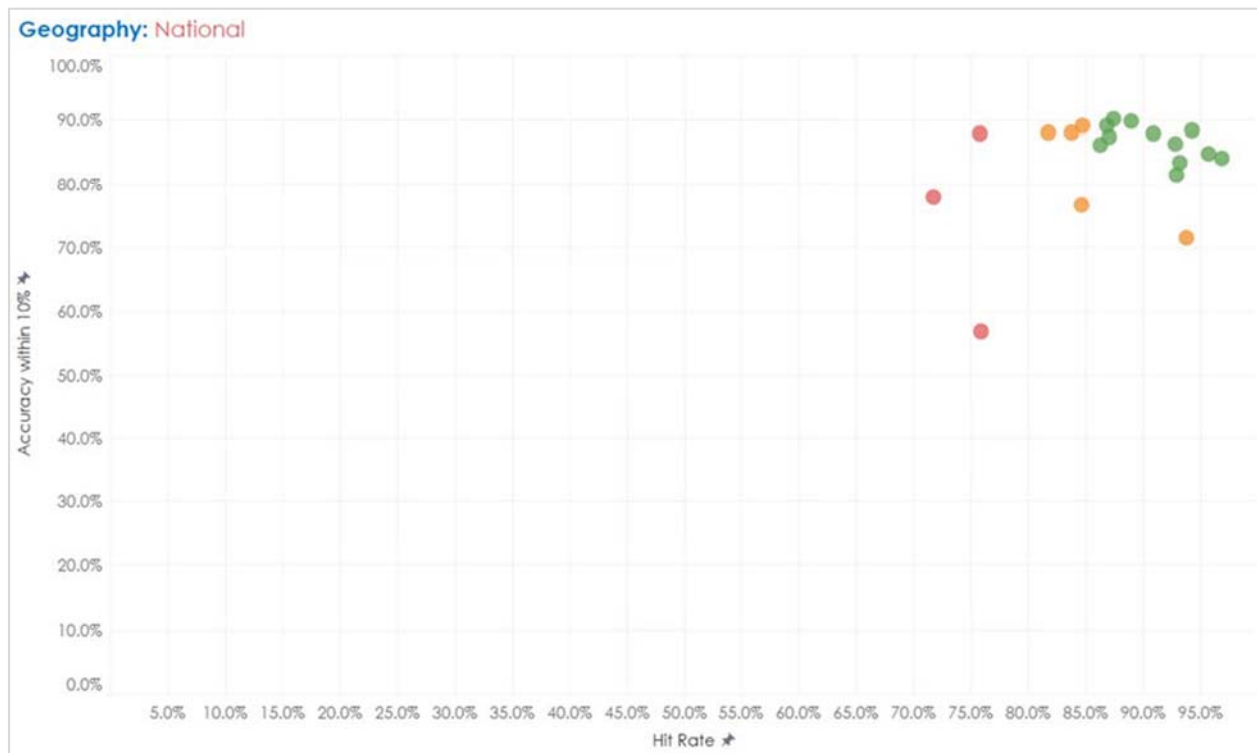
Exhibit 16



However, as noted earlier, the data above represents an index of general industry performance. When studying current individual model performance on a national basis, the dramatic improvement in performance is also readily apparent. As seen in Exhibit 17 below, twelve (12) individual AVMs produce over 80 percent P10 rates while maintaining hit rates in excess of 85 percent (with seven (7) of those AVMs delivering approximately 80 percent P10 rates while maintaining over 90 percent hit rates). All but 1 AVM produce over 70 percent P10 rates while maintaining hit rates in excess of 70 percent.

Exhibit 17

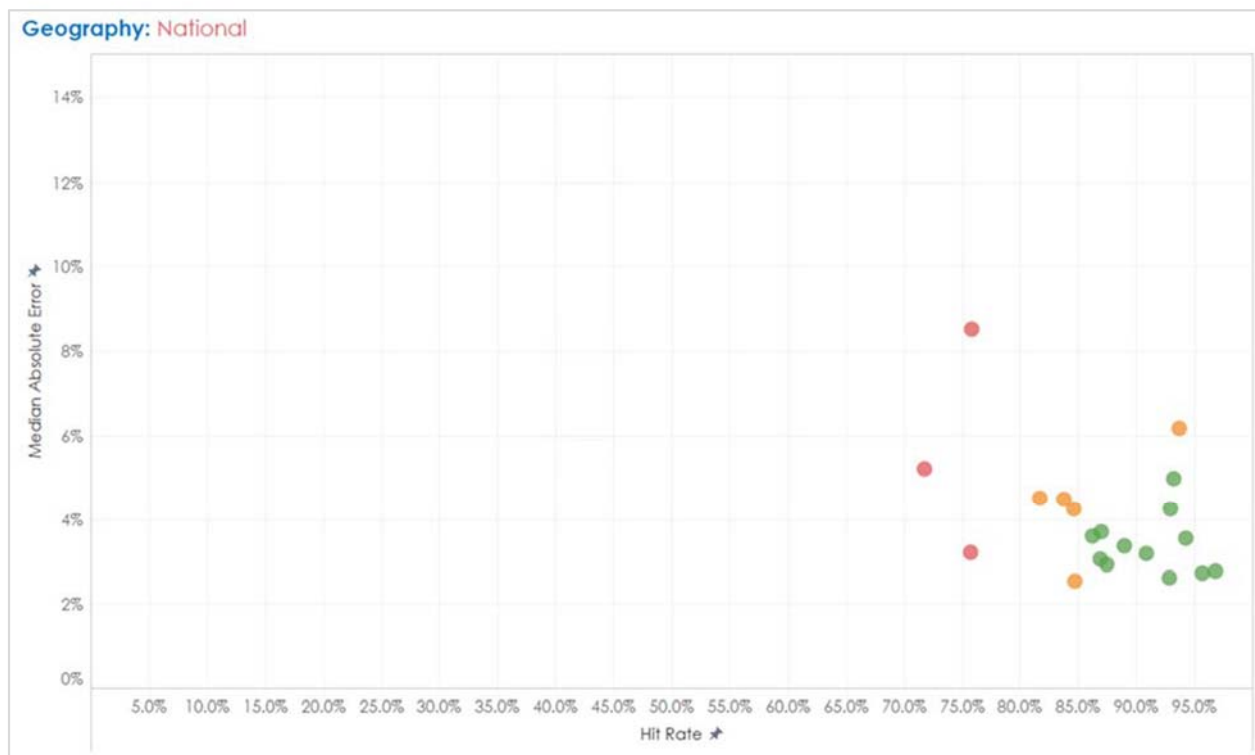
Individual AVM performance in the Third Quarter of 2018 comparing P10 and Hit Rates



Similarly, as seen in Exhibit 18 below, five (5) AVMs produce median absolute error rates less than 4 percent while maintaining hit rates in excess of 90 percent on a national basis. An additional seven (7) AVMs deliver median absolute error rates less than 4 percent while maintaining hit rates greater than 75 percent.

### Exhibit 18

Individual AVM performance in the Third Quarter of 2018 comparing Median Absolute Error and Hit Rates



### Next-Generation AVM Cascades

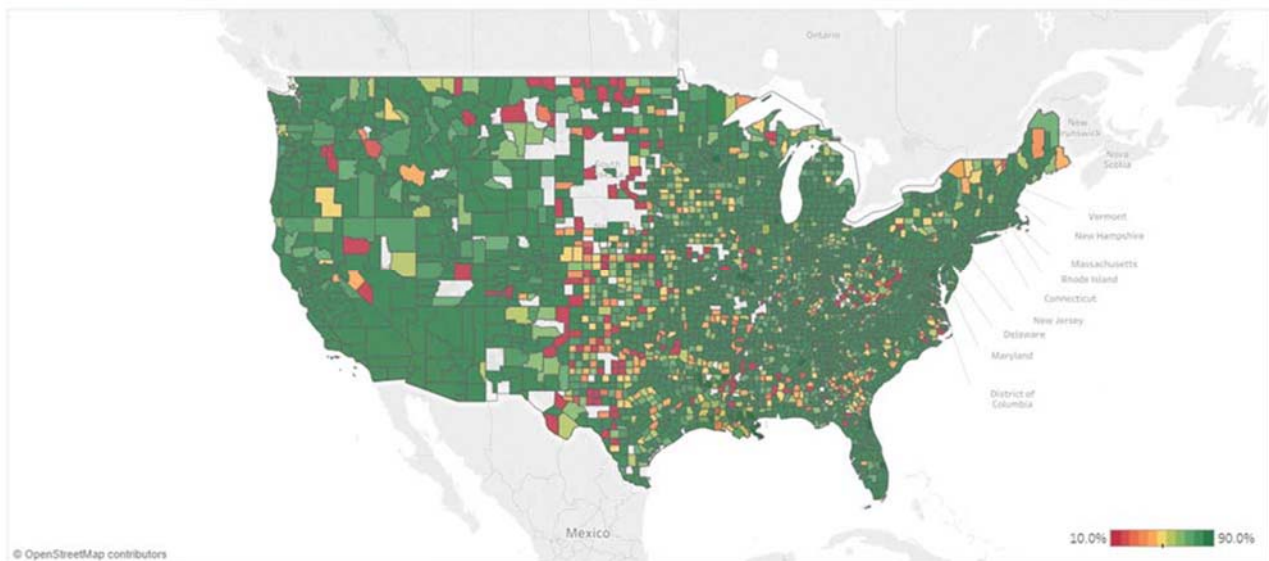
Traditional AVM cascade management identifies top performing AVMs, typically at the county level, and then rank orders them accordingly. New AVM cascades are being introduced at the individual property-level using many of the top performing AVMs in the nation and using deep machine learning and related artificial intelligence methodologies to determine which valuation is the most accurate for that specific property. This drives valuation performance even further as can be seen in Exhibit 19 below and expands high-performing AVM coverage beyond what has

been previously available. Almost all counties in the United States experience P10 rates north of 70 percent with the majority of them (especially in the highest populated areas of the country) realizing P10 rates north of 80-90 percent.

## Exhibit 19

### Sample Property-specific AVM Cascade P10 Rates by County

Leading AVM Performance Nationwide



## Additional Benefit of AVMs

With the vast quantity of data and always expanding computing power, AVMs are not limited to a small number of sales comparison properties and can analyze issues affecting property valuation from a myriad of angles. AVMs balance geographic proximity against recent sales of nearby comparable properties to generate a reasonable sample for model computation. As sale transactions may be limited in some circumstances, AVMs can quickly evaluate significantly more comparable properties over different periods of time and geographic regions in order to generate highly accurate valuations.

AVMs and AVM cascades can also provide unique sources of information and metadata used by mortgage originators and servicers to assess the complexity of a valuation assignment. For example, the inability of multiple high-performing AVMs to provide a reliable valuation on a given property may indicate increased property complexity or risk and drive a higher level of diligence or investigation.

Of course, one of the greatest benefits of a high-performing AVM is the savings in time and costs. “The digitization of this component of the origination process, facilitated through electronic property records, development of large databases capable of holding millions of individual property records, and improvement of advanced valuation algorithms, holds promise to lower cost and expedite closing timelines.”<sup>19</sup>

## AVM Challenges

Similar to any valuation approach (appraisals, broker price opinions, and their derivatives), AVMs have their own brand of strengths and challenges. While these tools deliver unprecedented accuracy as well as significant time and cost savings, users must be aware of the potential for inappropriate use if left unchecked. Just as with appraisals, AVM validation and selection should be independent from the loan production or loss mitigation side of the business. Loan officers should not be permitted to shop or influence appraisers for an appraisal assignment. While the influence factor does not apply to AVMs, that same loan officer should not be permitted to shop AVMs looking for a favorable valuation. Further, an objective and independent AVM validation process is essential to create production results that mirror expectations based on the validation exercise.

AVM validations should be conducted on a repeatable and consistent periodic basis to determine volatility in performance over time. Validations should also be designed to identify performance results and thresholds across transactions types, geography, property types, price tiers and other criteria where performance may materially change. AVM validations should also account for and measure an AVMs confidence score performance to determine appropriate thresholds for individual model implementation and acceptance.

All valuation products and services are essential risk management tools in the loan manufacturing process and loan servicing life cycle. No risk management tool or service should be blindly implemented without first understanding expected performance and risk against identified risk management criteria.

## Risk Management and Valuation Choices: Expanding the Valuation Spectrum

Proven next-generation valuation tools are available today. Through the use of controlled data, automated tools may now be used to complete the property valuation void and expand risk management capabilities. Enhancements to the appraisal process are being introduced and piloted such as the so-called “bifurcated appraisal” which separates the appraiser from the inspection of the property. A property inspection is performed by a third-party which is then

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<sup>19</sup> U.S. Department of the Treasury, *A Financial System that Creates Economic Opportunities: Nonbank Financials, Fintech and Innovation*, July 2018, p. 103.

turned over to the appraiser to complete the appraisal service. As discussed throughout, AVMs are a proven and viable valuation alternative in many, if not most, circumstances. Unlike any other valuation service offering, users know exactly where and in what circumstances an AVM is appropriate and, more importantly, they know with a high degree of reliability what to expect from a risk perspective. Where risk associated with the loan may be greater, AVMs may be combined with property condition reports performed by the same inspection companies referenced for bifurcated appraisals. Further, some stakeholders are evaluating the combination of AVMs with an insurance wrapper to protect against any valuation error. The GSEs have reintroduced appraisal-waiver programs that eliminate the requirement for an appraisal in narrowly defined circumstances. These programs should responsibly expand with greater understanding and acceptance of advances in property valuation technology in our new and expanding Big Data world. Finally, discussions about what is an “appraisal” and moving away from the antiquated notion of a fixed form applicable to all scenarios have begun and provide optimism for the future of property valuation in housing finance.

Implementing these valuation approaches not only speeds up the valuation and loan manufacturing process (streamlined timelines), but also decreases costs and mortgage risk through a more holistic approach to property valuation risk. The traditional appraisal process would benefit from embracing automation as well as available and proven solutions and their derivatives. Enhancements to the traditional appraisal process can improve speed/turn-times, accuracy and data integrity. Inspections can easily be combined with appraisals or AVMs to assure a lender that property condition is appropriately accounted for. In an increasingly automated world, embracing these advances is a logical way to improve the integrity and efficiency of the loan manufacturing. Moreover, qualified appraisers become more productive when embracing digital data capture methods and innovative valuation tools. These same qualified appraisers now have more time to focus on unique and challenging properties. While field appraisals continue to be an important resource for the valuation of high- risk collateral and support for unique or atypical properties, the mortgage industry needs to leverage proven advances in data and technology in order to maintain and grow an efficient, cost-effective, secure and reliable housing finance system.

## Conclusions

The requirements for the valuation of a property in a mortgage transaction set forth in the Financial Institutions Reform, Recovery, and Enforcement Act of 1989 (FIRREA) and its amendments have been left untouched for the better part of a quarter century. During that time, society has witnessed more advances in technology than experienced in the prior 100 years and more. The advent of personal computers and the internet, social media, smartphones, DNA mapping, alternative fuels, electric vehicles, GPS systems, fiber optics, as well as other advances in biotechnology and medicine, energy, transportation, urban planning and civil engineering are all examples of just how dramatically our world has changed in a very short period of time. The

vast increases in the availability of data (as well as the integrity of that data) has been unprecedented and moving at an exponential pace. Most industries have been embracing the application of available data and technology to traditional processes. This paper has set forth the proposition that the time has come to consider expanding the responsible use of established and proven property valuation technology.

This paper does not seek to proffer the notion that appraisals should be replaced. To the contrary, appraisals should be embraced, enhanced and evolved as one part of a growing and proven spectrum of property valuation solutions.

Treasury recommends that Congress revisit Title XI FIRREA appraisal requirements to update them for developments that have occurred in the market during the past thirty years. Recent data has illustrated that approximately 90% of residential mortgage originations are eligible for appraisal exceptions established since the enactment of FIRREA by the designated federal regulatory agencies. An updated appraisal statute should account for the development of automated and hybrid appraisal practices and sanction their use where the characteristics of the transaction and market conditions indicate it is prudent to do so.<sup>20</sup>

AVMs have advanced significantly over the last decade and have reached new heights. The availability (hit rate) of highly-accurate automated property valuations is at an all-time high and continues to push new limits. The responsible validation and production implementation of these tools has been well-established. Mortgage participants know where and when these tools can be most effectively used to significantly lower risk while dramatically shortening the time for a mortgage and at substantially lower costs. Secondary market participants have already introduced appraisal-waiver programs driven on Big Data and automated valuation technology. The U.S. Treasury is recommending that FHA and other federal agencies follow suit.<sup>21</sup> Embracing these proven advances will shepherd the U.S. Housing Finance system into the more established modern age. The beneficiaries of this work will be all mortgage stakeholders including originators, servicers, investors, insurers, government agencies, and most importantly the U.S. consumer and taxpayer.

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<sup>20</sup> U.S. Department of the Treasury, *A Financial System that Creates Economic Opportunities: Nonbank Financials, Fintech and Innovation*, July 2018, p. 106.

<sup>21</sup> U.S. Department of the Treasury, *A Financial System that Creates Economic Opportunities: Nonbank Financials, Fintech and Innovation*, July 2018, pp. 106-107



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