Mathematical Modeling For Property Valuation: Automated Valuation Models (AVM)

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Oct 17, 2014

This Talk Will Cover

- ❑ Brief Review: property valuation
- ❑ AVM in general
- ❑ Fannie's AVM
- ❑ Component models in Fannie's AVM
- ❑ Math Modeling for comp model

Take Home Messages

- ❑ Fannie's AVM: tool for property valuation
- ❑ Comp Model: math modeling approach

What Do We Mean By "Property Valuation"?

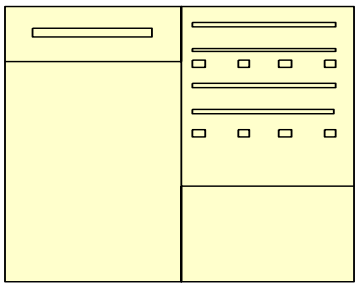
There are many activities in housing and related industries that fall under the rubric of "property valuation".

- Mark-to-market approach: index & transactional data, MTMLTV (fair value), RTI/MTV
- Tax assessment value approach: tax ratio, TAX
- Property characteristic: hedonic, PC
- Comparing the values of similar properties: appraisals, COMP
- Brokers price opinion: real estate or sales agents for a lender
- Income based approach: rental vs sale
- Cost based evaluation: purpose/usage, such as insurance
- CAPM and more

Automated Valuation Model (AVM)

- AVM: tool or application that performs property valuation using mathematical modeling and property databases
  - Property: a home built on a piece of land
  - Value: home sale price estimate of a particular property as of a specific date

\\\\AVM////



Property
Data

Computer Programs
(SAS, shell scripts)
Procedures
Stat/Math Models

Predicted Property
Value at Any Time
(Past or Present)

- Viable tool for providing a fast, accurate, and very economical estimation of Property's value at a specific point in time
- Tech + Modeling + Databases
- Performance Tracking + Cross Business Comparison

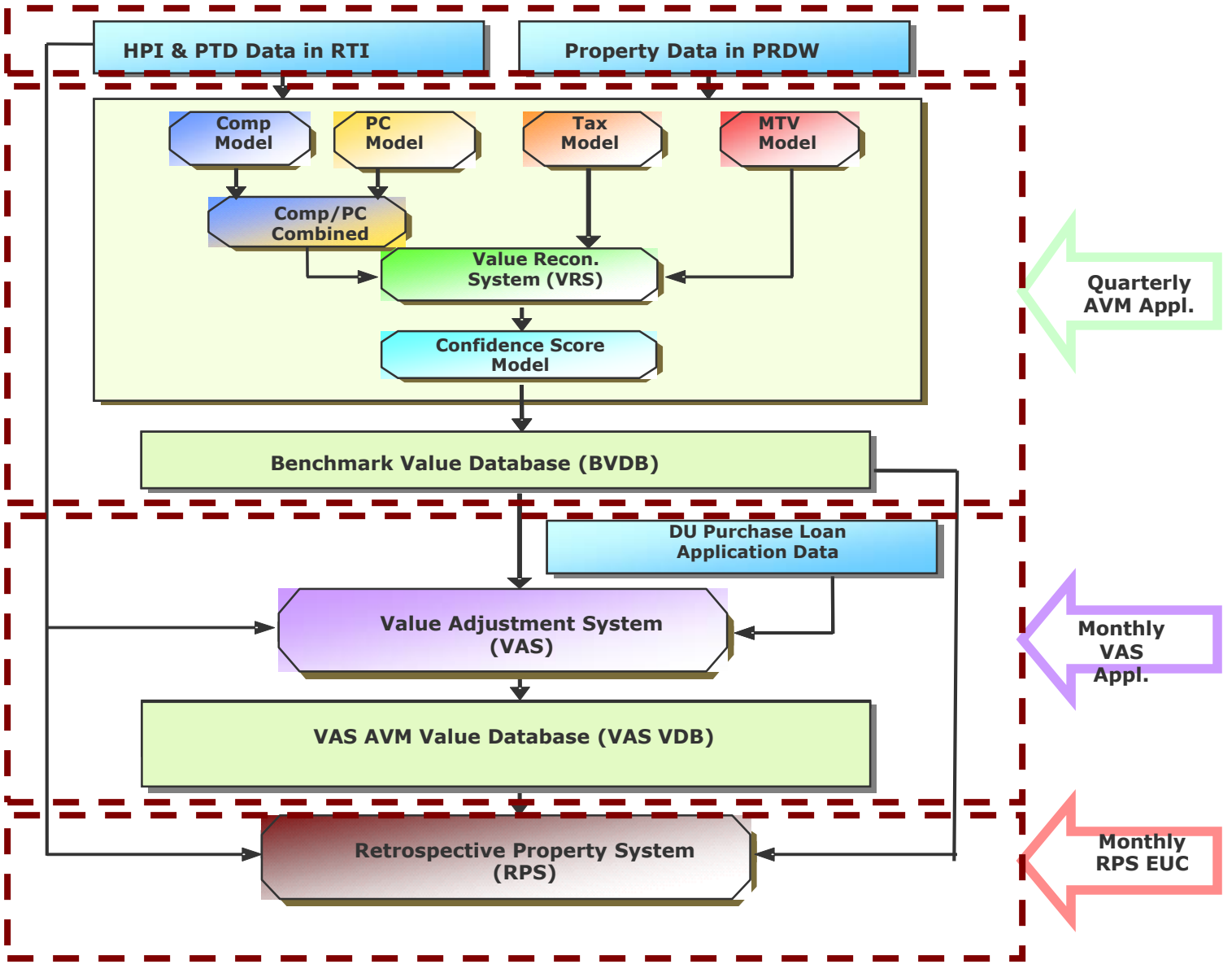
Fannie's AVM

- Residential Databases: PRDW + Property/Past Transaction database (PTD)
- Modeling: MTV + TAX + PC + COMP
- Quarterly Production

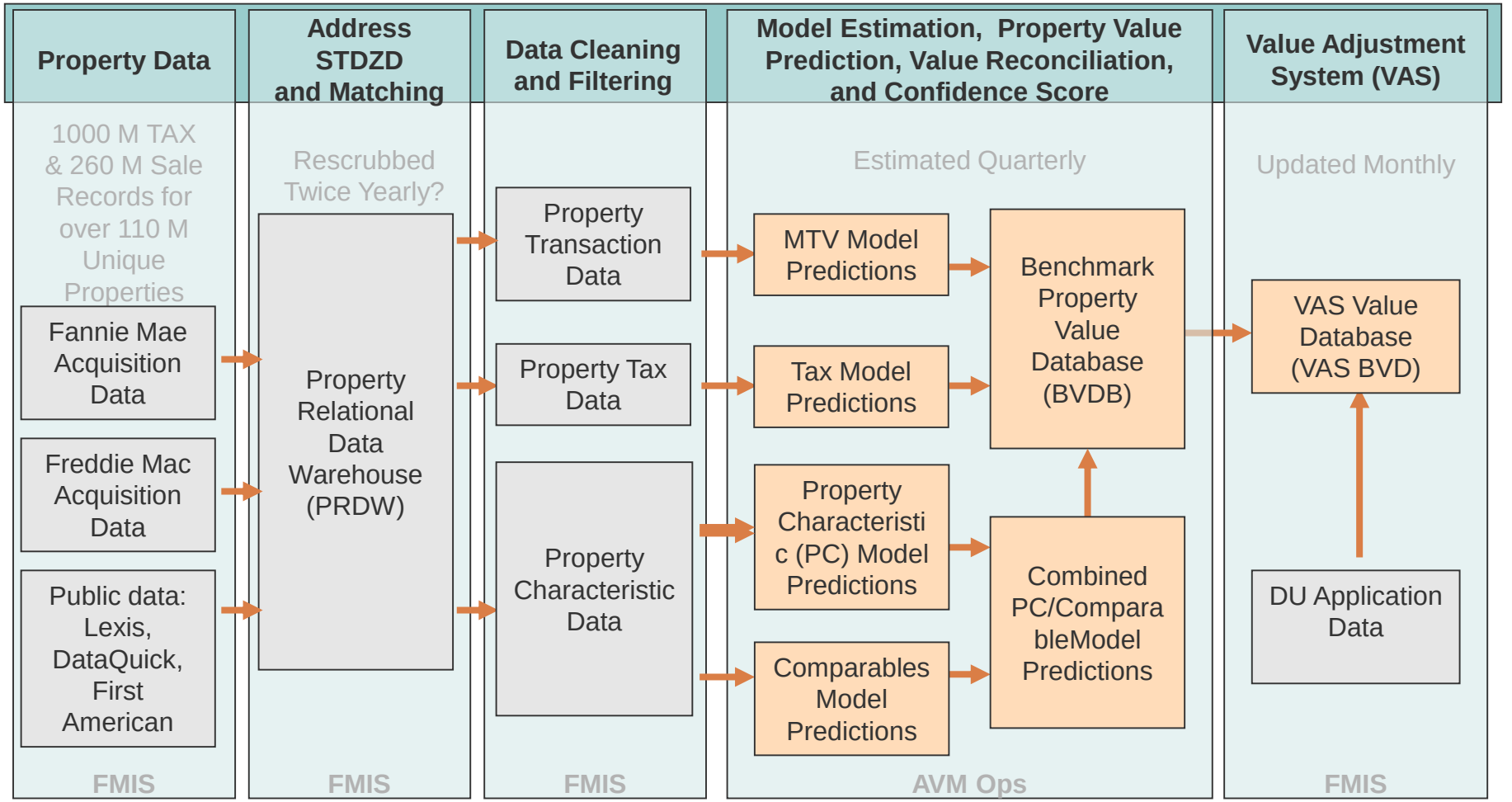
Fannie Mae AVM provides property valuation for over 87 million properties in US (13Q4: 5% CD, 95%SF)

- Applications: LD, FAVM, Deal Factory, DU and more

AVM Model View



The Production View of the AVM



Comparable Sale Model

Comp 1: Sold for $220K on Jan. 1, 2009

Comp 2: Sold for $300K on Jan. 1, 2012

Target Property:Q4 2013 Prediction: $260K

Weight1 X Adjusted Sale Value of Comp 1 + Weight2 X Adjusted Sale Value of Comp 2 = Predicted Property Value

- Weight1: Related to the differences in transaction time, geo distance, and PCs between Comp 1 and target property
- Adjusted Sale Value of Comp 1: Adjusted for differences in property characteristics between Comp 1 and target property
- Weight2: Related to the differences in transaction time, geo distance, and PCs between Comp 2 and target property
- Adjusted Sale Value of Comp 2: Adjusted for differences in property characteristics between Comp 2 and target property

Property Characteristic (PC) Model

Price Effect of 1 Square Foot X Total Square Footage + Price Effect of 1 Bathroom X Total number of bathroom +

Price Effect of 1 Year in house age X House age + Price Effect of 1 Square Foot X Total lot size = Predicted Property Value

All price effects are derived at county level using properties that have sale and all PC information

Multiple Transaction Valuation (MTV or RTI) Model

Jan. 1, 2000 Sale:$135K

MTM

Jan. 1, 2006 Sale:$270K

MTM

Q3 2011 Prediction: $202.5K

Weight1 X MTM Value of Prior Sale 1 + Weight2 X MTM Value of Prior Sale 2 = Predicted Property Value

- Weight1: The smaller the variance of the prediction, the larger the weight
- MTM Value of Prior Sale 1: After refinance bias adjustment
- Weight2: The smaller the variance of the prediction, the larger the weight
- MTM Value of Prior Sale 2: After refinance bias adjustment

TAX Assessment Model

2011 tax Assessment: $200K

Sale to Assessment Ratio= 1.1

$10,000 upward adjustment for that zipcode

Q3 2011 Prediction: $230K

Tax Assessment Value X Ratio of Sale Price to Assessment Value + Location Price Adjustment = Predicted Property Value

- Ratio of Sale Price to Assessment Value: Derived at county level using properties that have both sale and assessment values
- Location Price Adjustment: Derived at zipcode level

Math Modeling for COMP: Four Steps

- STEP 1 - Comparables Selection: potential pool of comps according to location, transaction date, economic value, Others
- STEP 2 - Comparables Adjustment: The sale prices of the "comparable properties" are adjusted to reflect any material differences with the subject property
  - Hedonic Pricing Model, RTI ,TAX, Hybrid
- STEP 3 - Comparables Weighting: defined, based on property similarity, geography, and transaction time
- STEP 4 – Aggregation to Subject Price: weighted sum/average of all comparables

$$p^{Target} = \sum_{C=1}^{N_{COMPS}} w_C \cdot p_{C,Adj}^{Comp} \Big/ \sum_{C=1}^{N_{COMPS}} w_C$$

Example: Comp Model

Simple case: One Target, Property Value p^{Target}

- One comparable: identical $p^{Target} = p_C^{Comp}$

- One comparable: not identical

$$p^{Target} = p_{C,Adj}^{Comp} = p_C^{Comp} \times (\hat{P}^{Target} / \hat{P}_C^{Comp})$$

Example: Adjustment Factor

$$\hat{P}^{Target} / \hat{P}_C^{Comp} = \exp(\log[\hat{P}^{Target} / \hat{P}_C^{Comp}])$$
$$= \exp(\log \hat{P}^{Target} - \log \hat{P}_C^{Comp})$$

$$\ln \widehat{P}_i = \beta_1 \times SF_i + \beta_2 \times building\_age_i + OtherTerms + \varepsilon_i,$$

- β: the incremental contribution to observed price *P* of each property characteristic and fixed effect
- Other Terms: SF, lot size, # bed, Tax, Sale, Hybrid

Example: Weight

- Based on comparables selection, not unique
- Function form: predefined
- Function of geo distance, time distance, economic distance

$$w_C = f(\Delta E_C, \Delta G_C, \Delta T_C)$$

- General Case: two or *N* comparables:

$$p^{Target} = \sum_{C=1}^{N_{comp}} w_C \times p_C^{Comp} \times (\hat{P}^{Target} / \hat{P}_C^{Comp}) / \sum_{C=1}^{N_{comp}} w_C$$

Art vs Science

- It's usually not possible to model all property attributes, only a few main ones are usually directly modeled: computing time and data constraint
- No rock Science for comparable selection & weighting & Adj
- Soft in dealing with geo location effect
- Balancing coverage and accuracy

Appendix: AVM Component Models

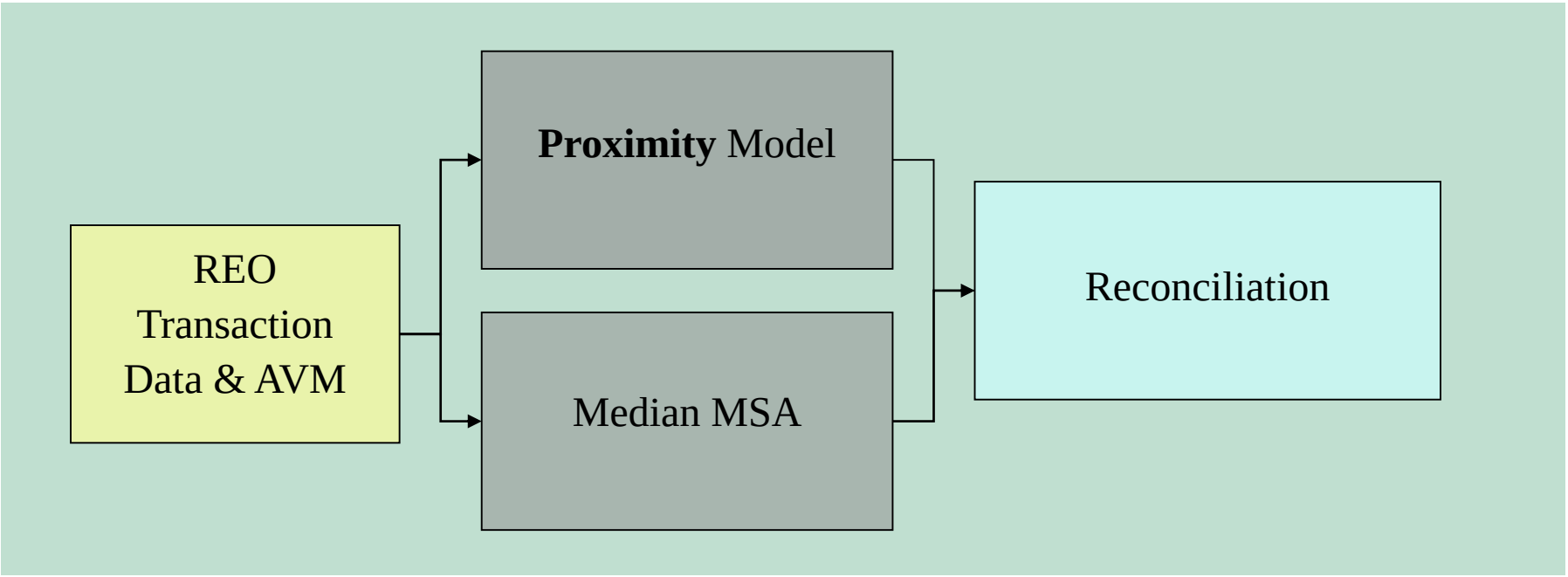
Multiple Transaction Valuation (MTV/RTI)	Use prior transaction values and HPI to predict the current property price.
Tax Assessment (TAX)	Use the county's tax assessment value to predict property price.
Property Characteristic (PC)	Use property characteristics such as lot size, enclosed area, age of the house, # of Bathrooms, etc. to predict property price.
Comparable Sales (CMP)	Use property characteristics and past sales on comparable properties to predict property price.

Appendix: AVM Components: other models

Value Reconciliation Scheme (VRS)	Combine property price predictions from the four component models into a single, final property price prediction.
Confidence Score (CS)	Create a numeric accuracy indicator for predicted property price (1=best, 5=worst, 9=outlier)
Value Adjustment System (VAS)	Use recent transaction data and DU application data to mark quarterly predicted property price to current on a monthly basis
Retrospective Property Valuation Service (RPS)	Use historical sale price or historical quarterly AVM prediction with home price index to predict property price at a point in the past.

Appendix: Fannie's FAVM

- Fannie's FAVM: Uses historical foreclosure disposition prices to predict property price for REO properties
  - Proximity (COMP) + Median MSA
  - PRDW + PTD + TRAX



Appendix: FAVM Modeling-proximity model

$$p^{FAVM} = \sum_{C=1}^{N_{comp}} w_C \times p_C^{REOSale} \times (\hat{P}^{AVM} / \hat{P}_C^{AVM}) / \sum_{C=1}^{N_{comp}} w_C$$

Questions