

# **RangeMark Mortgage Credit Model**

*A Layman's Guide*



RANGEMARK

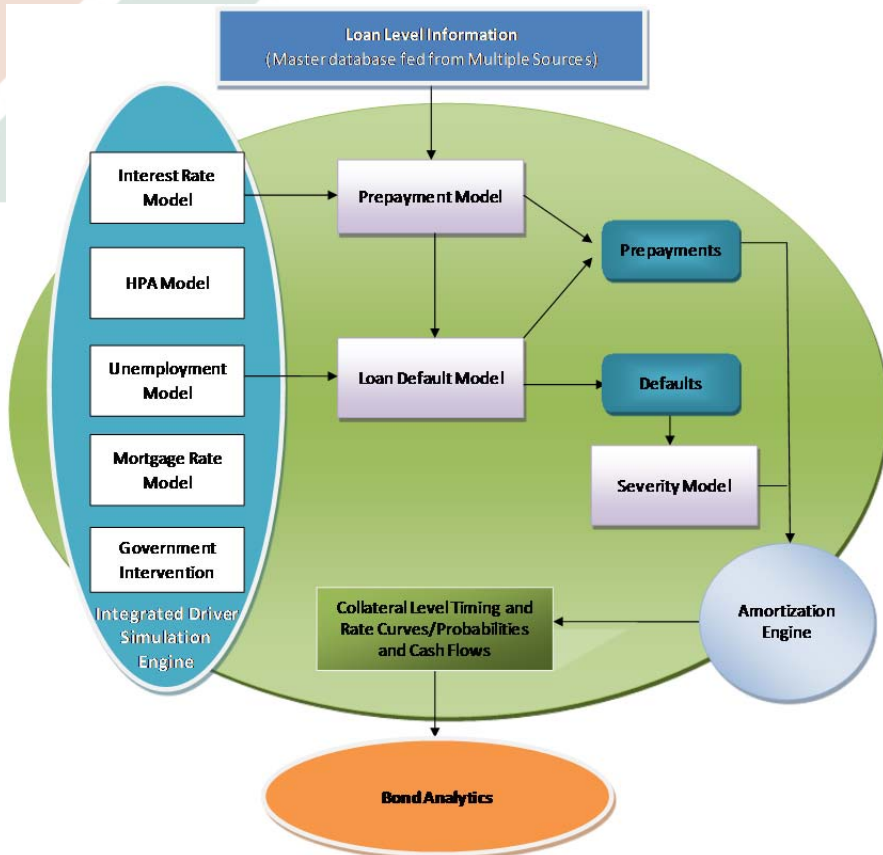
*February 2009*

*Credit Model* is somewhat of a misnomer for the proprietary system developed at RangeMark Solutions for predicting homeowner payment behavior. This is because the RangeMark system is not limited to estimating the propensity of a borrower to continue or cease making contractual interest and principal payments. The borrower may also decide to make an early principal payment...all or part...or instead may decide to make his payments *slowly*. Moreover, modeling challenges do not stop with forecasts of the amount and timing of cash flow associated with mortgage loans; they extend to the measurement of risk and value of securities backed by mortgage loans, and the spectrum of possible loss outcomes to the lender in the event of default.

### INTEGRATED SYSTEM

Predictive Models – The RangeMark Mortgage Credit Model is a system of several *integrated modules*. Borrower payment decisions, subsequent lender action, and the timing and proceeds from the liquidation of foreclosed homes are highly interrelated. These decisions and behaviors are linked by common global factors such as interest rates, local factors such as the economic environment, and housing market conditions. The mathematical functions describing obligor performance and lender behavior -- delinquencies, defaults, severity, prepayments, foreclosure, repossession and loss – then, should also be integrated with projections of key economic variables that shape such behavior.

Dynamic Functions – Because key determining factors are not constant through time, it is sensible to require that behavioral representations evolve dynamically in any modeling projection. Macro and regional economic and demographic factors -- GDP growth, interest rates, and home price movements, housing options and affordability -- effect probabilistic individual borrower behavior through changes in employment and income growth but also affect behavior through changes in obligor monthly payments, and obligor specific combined loan to value (CLTV). These dynamic drivers not only affect the propensity of an obligor to become delinquent or default, they will affect the level of recovery upon foreclosure and hence severity. A non-stationary transition framework is the best framework modeling payment patterns and borrower default timing probabilities. In this report we consider the major types of non-agency mortgage products and introduce the loan default, prepayment and severity model based on transitions.



Loan-Level Analysis – To the greatest possible extent, the foundation of credit analytics should be based on the study and prediction of individual obligor behavior. Often, the goal of the credit analytical process may be the representation of the spectrum of possible cash flows from a security. Various approaches may be considered. Perhaps the easiest approach is to use a credit rating provided by an NRSRO as a starting point and develop a set of metrics based on either the average historical performance for similarly rated assets. The limitations of this approach are now apparent: 1) ratings may be inaccurate, and 2) historical default rates may not be a useful guide to future patterns. Alternatively, one may use average asset pool characteristics to inform an analysis of possible pool cash flows and then work through the implications of those possibilities on the possible cash flows of the security (via roll rates or timing curves). The limitation of this approach is *rep line* information may not be sufficiently rich or sufficiently dynamic to capture critical risk features particularly if the pool is highly heterogeneous in its characteristics. When sufficient information is available, the most effective approach to risk modeling is to incorporate information about individual obligors and assemble the possibilities of pool performance based upon modeled behavior actual obligors.

#### CREDIT MODELING: PERFORMANCE STAGES AND TRANSITIONS

A residential mortgage loan is identified by several transition stages: current, 30-59 delinquent, 60-89 delinquent, 90+ delinquent, foreclosure, REO, prepayment and default. A loan can transit from one stage to another, for example, a 30-59 delinquent loan can be current again if it pays off all amount due.

Loan Delinquencies - Two entities have specified two basic ways of measuring mortgage delinquency: the Mortgage Bankers Association (MBA) and the Office of Thrifts Supervision (OTS). The difference between the two standards to measure mortgage delinquency that they specify is essentially one day. For historical reasons, prime mortgage report delinquencies by MBA standard while subprime mortgages report by OTS standard. What about Alt-A? The problem with Alt-A is that it covers a broad spectrum of mortgages with some being close to prim while others being close to subprime. How trustee or master servicers report Alt-A delinquencies is not uniform.

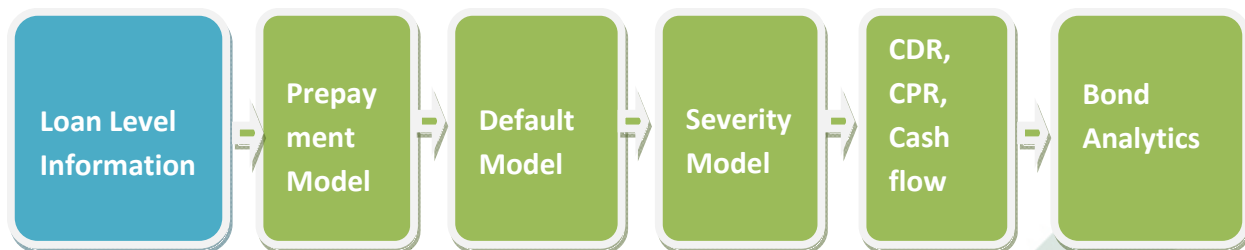
Transition Probabilities - Loans in a certain stage will have a probability to transit to adjacent stages; in the context of the analysis of individual credit decisions, the likelihood of sustaining a current decision or changing to another behavior at each payment date is a transition probability. RangeMark models these probabilities in a form that makes them dynamic and particular to each particular point in time in a projection time path.

	Current	30+	60+	90+	Foreclosure	REO	Prepayment	Default
Current	P(CC)*	P(C3)					P(CP)**	
30+	P(3C)*	P(33)	P(36)				P(3P)**	
60+	P(6C)*	P(63)	P(66)	P(69)	P(6F)		P(6P)**	
90+	P(9C)*		P(96)	P(99)	P(9F)		P(9P)**	P(90)
Foreclosure	P(FC)*			P(F9)	P(FF)	P(FR)	P(FP)**	P(F0)
REO						P(RR)		P(R0)

\* including government program

\*\* including servicer modification program for refinancing

Model Overview - The model uses historical mortgagor payment data for the universe of loans pooled into non-GSE Agency RMBS to derive dynamic, obligor specific transition probabilities using a multinomial logistic specification and maximum likelihood parameter estimation methods. A linear multivariate regression is used to specify dynamic and obligor specific loss severity behavior. Below is a brief description of RangeMark's analytics system.



State Transition Drivers - Certain loan characteristics as well as the specific profile and circumstances of the obligor impact payment performance and timing.

1. *Property Type*: A typical residential mortgage loan will have the following types: single family house, condo, co-op, townhouse, multi-units, PUD, manufactured housing. Generally speaking, some of them will have similar behaviors.
2. *Product Type*: A typical residential mortgage loan will either be fixed rate or adjusted rate, and will have interest rate only period or balloon. Standard ARM is fixed for a period of time, and floats thereafter. In agency, Alt-A, and jumbo lending, the standard ARM is fixed for 3, 5, 7, or 10 years, and resets annually thereafter. During the floating period, the loan is generally indexed to either one-year CMT or one-year LIBOR, these loans are often referred to as hybrid ARMs. Another type of ARM is option ARM, they generally have low initial payments, and payments caps limit the amount the payments can be raised. In subprime, the most common ARMs are 2/28, 3/27. Borrowers taking out ARMs are generally looking to lower their monthly payment. ARM borrowers generally have more risk layering than their fixed rate counterparts, and hence have higher defaults. ARM borrowers have historically prepaid faster than their fixed rate counterparts, as many ARM borrowers have a shorter expected tenure in their home.
3. *Occupancy*: Subprime mortgages tend to have a higher percentage of investor properties than jumbo pools, but less investor properties than Alt-A pools. Occupancy is important in understanding credit performance. Loans with a higher percentage of investor properties tend to default more often, and they also experience higher loss severities when they default. Investor properties also tend to have somewhat more stable prepayment profiles, so as interest rate drop, they are slightly less apt to refinance.
4. *Loan Purpose*: A mortgage can be applied for buying houses, cash-out, or for refinancing purposes. Historically, loan purpose has not been that important in determine the default or prepayment behavior. However in 2004-2006, purchase loans had much more risk layering than did either refi or cashout, because borrowers stretched to buy their homes, and these purchase loans were far more apt to have higher DTI, higher LTV and higher proportions of second mortgage and IO or 40-year mortgages.

5. *Documentation:* Documentation is generally defined as either full documentation or limited documentation. Full documentation generally involves the verification of income and assets. With limited documentation, either income or assets are not verified. Each originator has its own definition of limited documentation. Limited documentation is the key feature in defining Alt-A product. Limited documentation loans tend to have higher default rates than full documentation loans. Moreover, limited documentation tends to be highly correlated with other risk factors (higher LTV, lower FICO, higher DTI).
6. *Lien Type:* Loose underwriting standard in recent years have led to a large number of second lien originations that have performed very poorly. Many lenders were willing to extend loans to risky borrowers with a CLTV of, or even over, 100%. With no equity in their homes, these borrowers have little incentive to make their mortgage payments when home prices are falling. This is evident from the soaring default rates on the second liens, even among otherwise credit-worthy borrowers. In general, the defaults on second liens tend to show up much earlier than the first lien defaults, and the default rates are much steeper. Recoveries are typically zero; in certain cases they may be negative.
7. *Time to Payment Shock:* For a traditional fixed-rate mortgage, the monthly payments are fixed for the term of the loan. However, the majority of loans originated in the subprime market in recent years have been adjustable-rate mortgages (ARMs), where the coupon is fixed for a specified period of time, and then resets periodically at a specified spread (or margin) over a reference index. The initial coupon is typically set below the fully indexed rate (index + margin); hence, the coupon and monthly payment will typically increase at reset, often by substantial amounts. This payment reset acts as a trigger event, with many borrowers unable to make the new higher monthly payment. The result is a spike in delinquencies and defaults after the coupon starts resetting. For many recent loans, the payment shock at reset will be accentuated by an interest-only (IO) period. For many 2/28s, for example, the monthly payment during the first two years consists of interest payments only; hence, the monthly payment after two years will increase because of a higher coupon and because the loan starts amortizing. This double whammy of payment increases is likely to lead to sharply higher default rates after reset for recent vintage subprime ARMs.
8. *Effective LTV:* The effective LTV ratio is the single most important factor determining credit performance on a loan. A high LTV typically indicates that the buyer has stretched to buy a home, and could not put down as much as other borrowers. A high LTV is often associated with a high DTI ratio as well as other weak credit indications. Loans with higher LTV have higher delinquencies and higher loss severities. Those delinquencies and loss severities increase due to home price depreciation. In a lower home price appreciation environment, loans with higher LTV will prepay more slowly, as they have fewer refinancing opportunities.
9. *Change of Monthly LTV:* The change of monthly LTV acts as a proxy to reflect the housing price environment, if the house price is depreciating, the LTV will increase. Decreasing home prices will make it more likely to default since refinance chances are low.

10. *FICO Score*: Credit scores have been used in the consumer finance industry for several decades, they have become an increasingly important part of assessing mortgage credit. FICO scores have been shown to play an important role in determining both delinquencies and prepayment speeds. Lower FICO mortgage default at a much higher rate than their higher FICO counterparts, and exhibit much higher losses. On the prepayment side, it has historically been the case that lower FICO borrowers prepay much faster than higher FICO counterparts. Moreover, lower FICO pools tend to be much less sensitive to changes in interest rate. This reflects the fact that in a refinancing, lower credit borrowers face higher closing costs and points.
11. *Debt to Income Ratio*: While FICO is an indicator of the borrower's willingness to repay the loan, DTI is a measure of borrower's ability to repay it. High DTIs are one more indicator that borrowers stretched to buy their home, and are therefore at a higher risk of default than borrowers with low DTIs.
12. *Mortgage Rate* - Mortgage rate will be an incentive for refinancing behavior. When the prevailing mortgage rate is low, people will tend to refinance their house to profit from the rate difference.
13. *Original Spread*: We have noted that Coupon and Spread at Origination (or, more or less equivalently, WAC on loans from the same origination period) provides important information about the risk of a borrower, beyond that provided by risk factors such as LTV, FICO, and so on. The main reason is that when default risks are higher (due to either high OLTV, low FICO, etc.) or when default risks are not properly understood, lenders charge mortgage interest rate premiums to compensate for the above-normal risk (what is often referred to as risk-based pricing). The higher Spread at Origin (SATO) cohort has markedly higher default rates.
14. *Loan Age*: Loan defaults tend to decline after a peak.
15. *Delinquent History*: Delinquent history is very important for both prepayment and default modeling. If people has delinquent before, he/she is more likely to delinquent again. And delinquent in the past will make it harder to get refinanced.

Macroeconomic Factors - The key macroeconomic and regional economic factors influence mortgage loan performance because they change the circumstances and options of obligors. The primary risk factors are interest rates, HPA, and unemployment levels. Interest rates determine both the presence and degree of payment shock as well as borrowers' the incentive or ability to refinance.

1. *Mortgage Rates*: The prevailing market mortgage rates available will influence the prepayment speed.
2. *Interest Rates*: Changes in market interest rates serving as loan coupon indices change borrowers' payment rates. The amount of payments relative to disposable income is a key performance risk driver. The level of interest rates for new loans, relative to the contractual rate, is the key determinant of the prepayment incentive.

3. *Unemployment Rate*: job loss is a major trigger event for defaults. Ideally, the actual employment status of the obligor would be used to determine credit performance but this information is not available. Instead, as the best practical proxy, we use changes in local unemployment rates to capture the likelihood of a job loss. *Change in Home Prices*: HPA impacts the propensity for loans to default because changes in the value of collateral relative to its loan balance changes such loan's effective LTV.
4. *Change in Home Prices*: HPA impacts the propensity for loans to default because changes in the value of collateral relative to its loan balance changes such loan's effective LTV, thereby changing borrowers' that will influence loan transition probability significantly.

Loan Modification Programs: A loan modification is a permanent change in one or more of the terms of a mortgagor's loan. Loan modifications are generally designed to reduce the borrowers payment or debt burden, reducing the likelihood of default. Loan modifications can consist of any or all of the following:

1. Locking in a fixed rate (e.g., a 3 yr-, 5 yr-, or 30 yr fixed)
2. Reducing interest rate (e.g., 7.25% down to 5.5%)
3. Extending loan term (e.g., 15 year term to 30 year term)
4. Forgiving principal (e.g., decreasing a balance of \$330,000 to \$315,000)

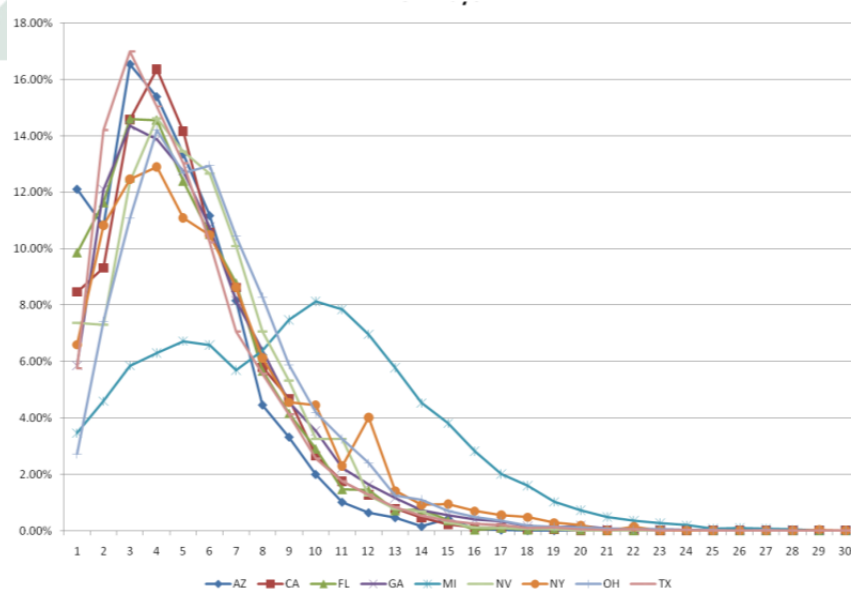
Government Rescue Plan – The Federal, State or Local governments have considered programs designed to mitigate stress within certain markets (housing, capital) buy acquiring troubled or foreclosed loans. The results of such programs would seem like prepayments to investors in securitized pools.

#### DEFAULT MODULE: FORECASTING PAYMENT PERFORMANCE

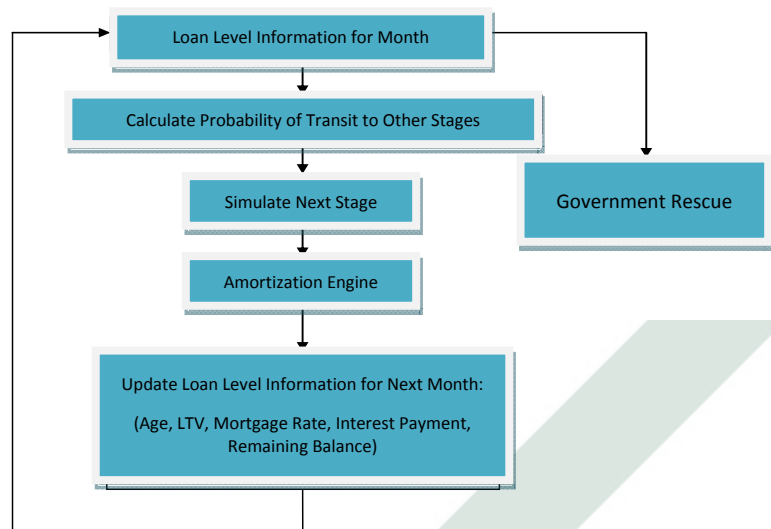
Estimating Transition Coefficients - With the 16 factors identified above, a statistical analysis should be performed, multinomial logistic regression is appropriate and PCA analysis will effectively reduce the dimension of factors.

REO Timing - When a loan is classified as *Other Real-Estate Owned*, new factors and new coefficients for the above factors become relevant. At issue is the timing and liquidation of foreclosed real estate as well as maintenance cost associate with carrying the real estate. Critical to the result is the location of the OREO.

Each state will have a liquidation time-line having a unique projected mean and volatility based on customs, bankruptcy laws and regional economic and demographic factors.



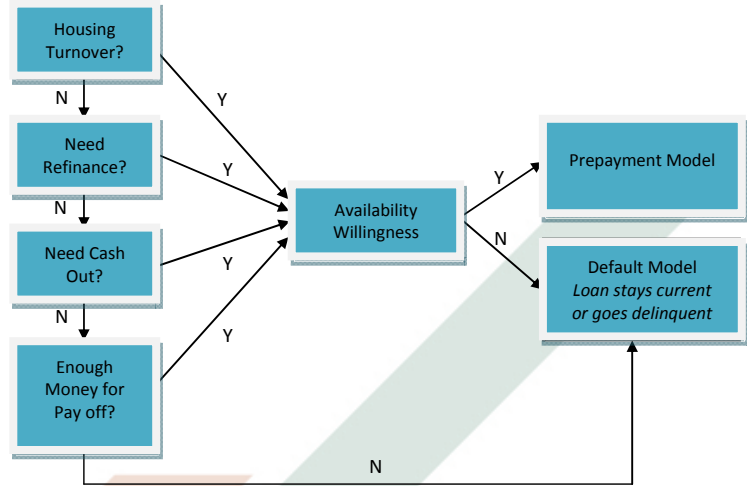
Specification - Loan level information is applied to the transition probability model to evolve the loan stage to the next month, and the relevant loan level information will be adjusted by the evolution. Since the transition probability will differ from loan to loan, month to month and status to status, simulation techniques are applied to get loan evolution.



#### PREPAYMENT MODULE: FORECASTING PRINCIPAL PAYMENT DECISIONS

1. *Housing turnover:* The sale of home would lead to the prepayment of a mortgage. Given data on the number of existing homes sold nationally, we can compute the overall turnover rate — it is the number of existing homes sold as a percentage of the stock. This statistic can be thought of as the overall prepayment rate resulting from home sales. From 1978 to the present, annual turnover rates on existing homes have generally hovered between 5% and 7%, with somewhat lower rates in the early 1980s, when high mortgage rates and a severe recession severely depressed the housing markets.
2. *Refinancing purpose:* This is generally undertaken to take advantage of lower rates. Very high prepayment speeds are the result of refinancing. Housing turnover by itself will rarely lead to prepayment rates above 10%–12% CPR. A refinancing is an economic prepayment and can be thought of as an exercise of a call option on the existing loan. There is no single method that borrowers use to determine whether to refinance. However, a common method, and one that banks and newspaper advice columns encourage, is to determine how many months it will take to recoup the costs of refinancing. Let  $B$  be the current loan balance,  $C$  the coupon on the current mortgage, and  $M$  the effective mortgage rate defined above. Then the annual saving in interest costs is  $B \cdot (C - M)$ . There are both fixed costs of refinancing (e.g., application and attorneys fees), which we assume to be  $F$  (e.g., \$1000), and variable (i.e., proportional to the loan size) costs, such as title insurance, which we assume to be a fraction  $v$  (e.g., 0.75%) of the loan balance. The total cost of refinancing is thus  $F + v \cdot B$ . Finally, we assume that the borrower compares the costs with the savings over some period, say  $H$  years. Hence, the refinancing decision is based on  $H \cdot B \cdot (C - M) - (F + v \cdot B)$ , which we take to be the refinancing incentive.

3. *Cash-out purpose:* Most refinancings are the result of borrowers taking advantage of declines in interest rates to lower their mortgage coupon. However, refinancings can also occur for other reasons. Cash-out refinancings have been popular in the strong housing markets of the past several years. As the name implies, a cash-out refinancing is used to access equity in the home; mortgage debt represents an attractive tax-deductible form of borrowing. While the majority of cash-out refinancings occur for in-the-money loans, and hence are usually accompanied by a lowering of the coupon rate, this is not always the case. Loan-level data from a major lender indicate that some borrowers are willing to accept a higher rate in order to access the equity in their homes. Cash-out refinancings also seem to explain the high speeds on seasoned coupons.

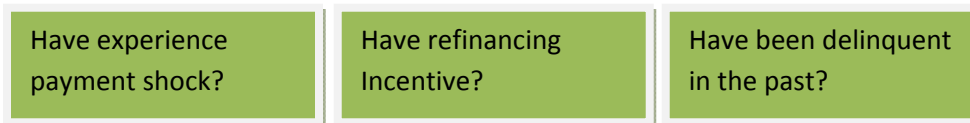


4. *Paid-off or curtails:* When a borrower sends in a monthly payment that is larger than the one due on his level payment mortgage, he is said to “curtail” or partially prepay his mortgage. A borrower may also opt to reduce their mortgage indebtedness completely through a full payoff. By making a partial prepayment, the borrower is effectively shortening the term of the mortgage, leading to the weighted-average maturity (WAM) shortening that is commonly observed in agency pools. Pool WAMs are calculated using the current pool balance and the scheduled monthly payments. Thus, a balance that has been reduced by partial prepayments will, for a fixed monthly payment, be amortized in less time than the nominal remaining term implies.

5. *Seasonality and availability:* Empirical study shows that people prepay faster in the summer.

Specification - Above is a decision-making tree that determines the prepayments. The most important part is refinancing behavior modeling, which is tied to the current mortgage rate available. Availability is different for each originator, but usually the delinquent history and credit profile will be important. Even when the owner of the loan faces large incentive to prepay and refinancing is available, he/she still will not prepay with probability 100%, and thus a probability of prepayment for each category should be identified. People tend to prepay faster in summer, with smaller loan balance outstanding, and when it is close to payment shock.

In the RangeMark Credit Model, loans are classified into the three categories.



Payment shock will determine the likelihood to prepay, since people are more likely to refinance when they are facing a very high monthly payment. If there is no payment shock, but the prevailing mortgage rate is low, the refinancing incentive is calculated, if it is large enough, people will more likely to prepay.

Delinquent history will determine the availability to get refinanced, if a person has very good payment history, he/she will get a new loan much easier. Even people have no payment shock or refinance incentive, he/she will still have chance to pay off all the loans left if he/she has enough money to pay back, which is payoff or curtails.

#### SEVERITY MODULE: FORECASTING LOSS-GIVEN-DEFAULT

Performance Drivers – Long considered a stable rate, the amount of loss realized in the sale of OREO has proven to be nearly as important to performance as default rates.

1. *Property Value*: The lower the property value, the larger the discount. Realtors' fees and the repair costs required to bring foreclosed properties to near-market value tend to be larger in percentage terms for lower priced properties. In addition, because of their likely low returns, they receive the least priority of liquidation from the servicer. Hence, they are typically sold in their current condition and, therefore, are less marketable compared to more expensive properties
2. *Property Type*: Townhouses, multifamily homes, and manufactured homes are found to have the largest discount to foreclosure sale. Following these are single family homes and planned unit developments. Foreclosed condos experienced the least discount relative to other property types (exceptions include certain regions like Florida).
3. *Occupancy*: We have observed that loss severities are significantly higher on investor properties than on owner-occupied (primary residence) or second homes. This would lead one to believe that investor properties experience a significantly higher discount because they are more likely to be neglected than primary residences. However, this is not always the case and does not explain the higher severities. In addition, borrowers (in this case, the investor) have little influence on severities (unless they choose to file for bankruptcy or do not agree to a short sale), and it is the servicer who decides the loss mitigation strategy. In general, loss severities depend primarily on the property value and the outstanding balance at the time of default.
4. *Delinquency Status*: One of the most important factors affecting the discount is the delinquency status at liquidation. A pre-foreclosure or short sale looks like any typical sale to potential buyers, and the discount may be much less than that of similar foreclosed or REO properties. A foreclosed property can be sold in a variety of ways, depending on the foreclosure procedure and laws for the state. For example, the property could be auctioned at a "Sheriff's Sale" or sold at a public auction at an advertised place and location (note that the cost incurred is deducted from the proceeds of the sale). Other possibilities include an attorney's sale or a court-appointed referee's sale. In all cases, potential buyers will expect a significant discount from market value, especially in a weak housing market. REO properties are often in bad condition or in an undesirable location (probably the main reasons why there was not a good offer at the time of foreclosure auction), and the time between delinquency and final property sale can be long. These reasons explain why discounts tend to be highest on REO properties.
5. *Geographical State*: Foreclosure laws and procedure differ from state to state, and these can affect the foreclosure property discount. In states that allow a deficiency judgment, for example, we would expect the borrower to better maintain the property, implying a lower discount.

In states that allow the right of redemption to the borrower, the property may not have a “clean” title, and this could negatively affect the sale price.

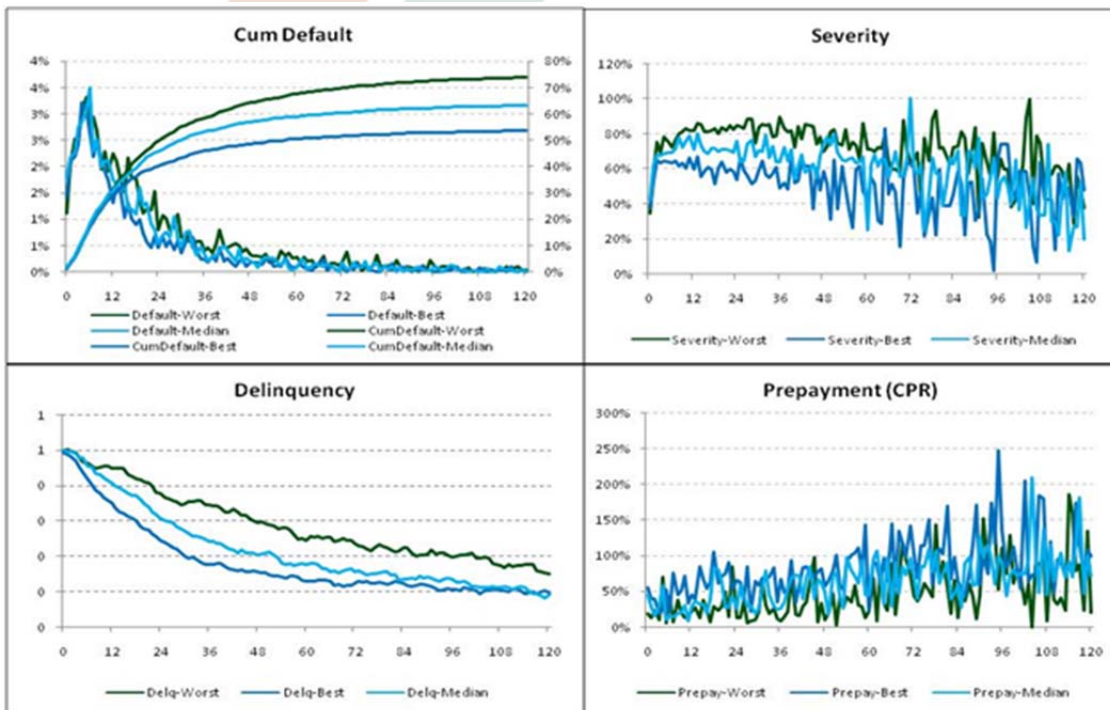
6. *Loan Purpose and Appraisal Inflation:* For loans originated as refinancings or cash-outs, we rely on the appraisal value to estimate the current property value. There is much anecdotal evidence that appraisal values were often inflated during the housing boom of recent years. Hence, use of the given appraisal value may mean overestimating current property values, thus underestimating loss severities.
7. *Loan Age:* Loss severities tend to increase with loan age. One reason for this is that, for the first several years, liquidation time tends to increase with loan age. Longer liquidation times imply greater neglect of the property, as well as higher maintenance and carrying costs. In addition, older loans imply older properties, and older properties may suffer more from neglect, depreciation, and lack of maintenance than newer properties. An age-dependant depreciation factor is included in the model.

Specification - Once the drivers are identified, multivariate regression is applied to historical information to get the relations between those drivers and the severity. The severity for each loan will be calculated based on the relationship identified.

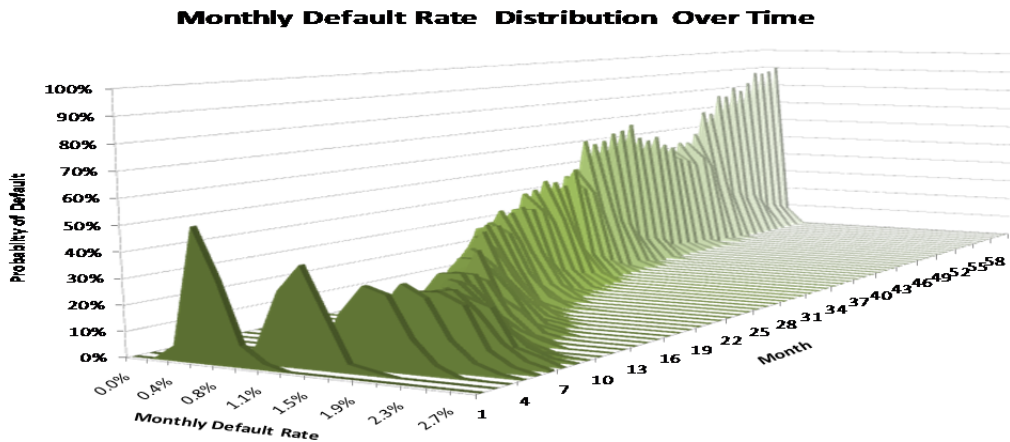
#### DEVELOPING FINANCIAL ANALYTICS

The structure of Mortgage Credit Model enables the generation of robust performance and risk analytics. Analytics are measures that summarize results or metrics that describe risk or value of defined cash flows. The Model’s fundamental and dynamic nature allows for stochastic simulation and analysis, and the development of volatility and time-related analytics.

Example A: Best, worst and median simulated results



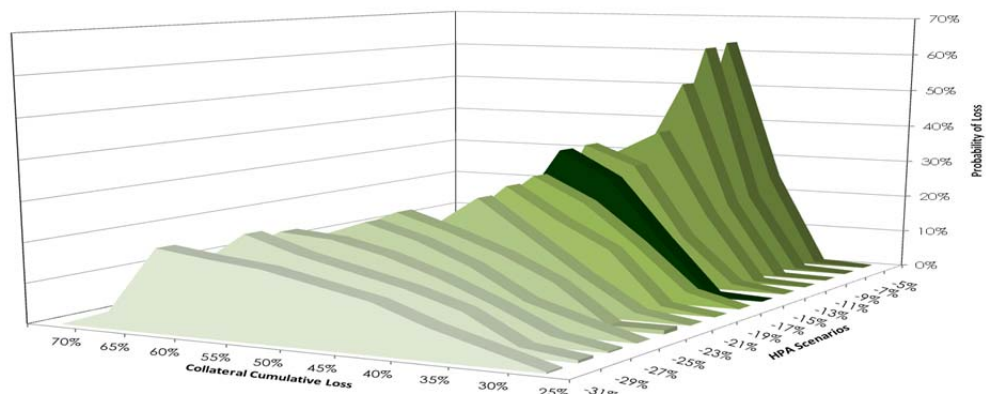
**Example B:** Default distribution of a given loan pool over 60 months (evolves with changes in driver factors, and captures the aging affect on loan performance)



**Example C:** Heat map displays pool's projected performance based on hundreds of simulated scenarios (cumulative losses and prepayments are recorded to show the probability of joint occurrence)

Cum Loss(%)	PREPAY (Life CPR)									
	1	3	5	7	9	11	13	15	17	19
24						0.67%	0.33%			
29		0.33%	0.33%	2.00%	0.67%	0.33%	0.67%		0.33%	
34		1.00%	2.00%	2.00%	2.00%	1.00%	0.67%	0.67%		
39		2.00%	4.00%	5.00%	3.67%	2.00%	0.33%			
44		3.00%	5.67%	5.67%	2.67%	1.33%		0.33%		
49		2.67%	7.33%	6.00%	1.33%	0.67%				
54	0.33%	3.67%	8.33%	3.00%	1.00%	0.67%	0.33%			
59	0.33%	2.00%	3.33%	1.67%	1.00%					
64	0.33%	1.33%	1.00%	1.33%	0.33%					
69		1.00%								
74			0.33%							
79										

**Example D:** Loss distribution of a pool as a function of house price (note that as the HPA scenario becomes more extreme, the loss dispersion and the corresponding tail risk widens dramatically)



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