



Residential Mortgage-Backed Securities Modeling: A Fundamental Approach

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This article surveys the recent developments in the credit markets paying special attention to the issues surrounding the valuation of residential mortgage-backed securities (RMBS) and related collateralized debt obligations (CDOs). It also offers a modeling framework whose purpose is to provide a robust and transparent approach to the valuation of securities backed by real estate assets. The proposed framework utilizes a stochastic Monte Carlo approach based on econometric analysis of underlying data at the individual loan level paired with accurate reflection of the transactions' financial structure, while accounting for liquidity risk.

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The recent developments in the credit markets have illuminated one very important but often ignored aspect of the financial world – the more than occasional dichotomy between value and price. Or, maybe it is between high-powered academic research and real business applications? Or, perhaps it is between the views of deal execution teams and quantitative researchers in leading financial institutions across the world? Or between underwriting standards and mortgage origination practices? It is all of the above, and we by no means claim for this to be a complete list of issues and facts explaining the credit markets meltdown that has been propagating over the past year and which many believe is only gaining momentum.

While we at RISC do not think we can help financial institutions and investors alleviate all of the above problems, we believe we can be of great value by extending what we have done for other businesses and industries – offer a transparent framework for valuation of credit instruments by focusing on the fundamental drivers of the risk. Not surprisingly, we have started with the most severely affected sector at this stage – the residential mortgage-backed securities (RMBS) and the resulting suite of exotic derivative instruments (collateralized

debt obligations, or CDOs, in all their forms), whose complexity has been singled out as a root cause of the market crash. Of course, we all know that there were many roads leading up to that collapse and the inability to properly value and account for the risk in complex structured finance products was nothing but a crossroad of manifested shortcomings evident in practices and methods. What we offer is an opportunity to leave it just as that – a crossroad, rather than a final destination.

For years we have promoted a simple but powerful framework for risk estimation and valuation – Monte Carlo simulations of underlying drivers based on econometric analysis of the data and processes at hand. When implemented correctly, the data generation processes allow you to sample through the range of potential outcomes and evaluate different financial instrument's relevant cash flows with a great deal of comfort as you are relying upon a scientific framework based on hard, real data. This approach eliminates stress case assumptions and lever toggling based on subjective judgments or reliance upon no-arbitrage financial models that make arbitrageurs smile. Instead, it relies upon relationships tested through time, which in their apparent and powerful simplicity provide the

needed transparency and are accessible to a wide base of investors.

General Trends and Market Developments

The year 2007 marked a dramatic turnaround of what many believed to be a bull market for credit and credit-related structured finance. The credit markets collapsed in the wake of rising delinquencies on subprime mortgages and the liquidation of two high profile hedge funds, which led to the demise of the structured investment vehicles (SIV) market followed by significant write-offs posted by banks. Amidst it all, rating agencies have been called to task for their alleged failure to accurately measure risk. In addition to its short-term intervention, the government is looking at policies to shore up industry practices and to help avoid future crises, adding indirect cost and the threat of increased regulation to the mix.

Credit ratings and traditional methods of valuation of risky debt in highly structured financial instruments, such as CDOs, have come into question and investors are facing the need for more information transparency, with some (we believe far too few) searching for more robust risk analysis and valuation tools.

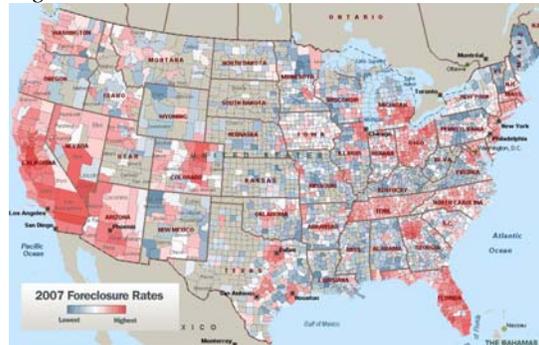
The causes of the residential mortgage crisis that has led to the more general meltdown of the structured finance market go beyond subprime and have their roots in the fundamentals of the housing market cycle.

The United States experienced a real estate boom in the period of 1996-2005, during which the percentage of home-owning households increased from 65.4% to 68.9%, with home prices constantly on the rise, reaching annual growth rates of 11.4% between 2000 and 2005. This rapid expansion, however, has come to a sudden halt. Growth in home prices slowed dramatically in Q1 2006, and in Q1 2007, prices fell for the first time since 1991.¹ The median prices for new and existing homes were down 13.2% and 6.3%, respectively, year-to-

year in October, 2007 (largest decline since 1968).²

These price declines, combined with higher interest rates, led to increased mortgage delinquencies, especially in what has become known as the subprime mortgage market. Based on its December 2007 National Delinquency Survey, the Mortgage Bankers Association reports that the level of delinquencies is at 5.59% of all loans outstanding in Q3 2007, not including the loans already in foreclosure (the highest level since 1986).³ They go on to point out that the percentage of loans in foreclosure stands at 1.69%, the highest level ever recorded. In a January 2008 press release, RealtyTrac® reports that the U.S. foreclosure activity increases by 75% in 2007 (*Figure 1*).⁴

Figure 1



Source: RealtyTrac®

Clearly the market conditions are not painting a very favorable picture – there are signs that the crisis is far from over and the situation is expected to deteriorate even further, but more on that later. First, let's cover some mortgage basics.

Mortgages and Mortgage-Backed Securities

An excellent source for a general introduction to the field is Lucas (2006). We will cover briefly some of the basics for the sake of completeness.

¹ McDonald and Thornton (2008)

² Mortgage Bankers Association (Dec.14, 2007)

³ Mortgage Bankers Association (Dec.6, 2007)

⁴ RealtyTrac® (2008)

A mortgage is a typical loan with real estate serving as collateral. Its basic characteristics include: loan amount, loan term, schedule for repayment, and contracted interest rate. There are many different types of mortgages, mainly depending on how the interest rate enters into the contract:

- Fixed rate, exhibiting fixed monthly payment for the duration of the loan (most common, 70% of total mortgage market),
- Adjustable rate (ARM), where the base rate adjusts periodically based on a benchmark rate (LIBOR, Constant Maturity Treasury, etc). Increased in popularity after 2002,
- Hybrid ARM, where the rate is fixed for an initial period and then switches to adjustable (e.g., 5/1 hybrid ARM, 3/27 hybrid ARM, etc), and
- Interest only (IO), where borrower pays only interest for a number of years. Can be both fixed rate and (hybrid) ARM.

Mortgage loans are financed on a primary and a secondary market basis. Traditionally the primary market has been much larger than the secondary one. With the creation of the Government National Mortgage Association (Ginnie Mae) and the government-sponsored enterprises such as the Federal National Mortgage Association (Fannie Mae) and the Federal Home Loan Mortgage Corporation (Freddie Mac). Aided by growth in these agencies, the secondary market began to expand rapidly in the 1990s and now plays a major role in mortgage finance. This growth was turbo-charged by the increased sophistication of the US and global financial markets, along with the introduction of financial instruments and financial engineering techniques that resulted from increased specialization in mortgage finance. In combination, these factors led to:⁵

- More liquidity in trading the underlying mortgages,
- Greater utilization of capital markets with the development of securitizations, and
- A significant increase in mortgage loan availability to all types of households with lower transaction costs.

⁵ Bernanke (2007)

The loans typically vary in terms of the criteria they satisfy between agencies (to the list of Fannie Mae and Freddie Mac we would have to add the Government National Mortgage Association or Ginnie Mae) and private issuers, with those by private issuers having less stringent underwriting standards.

The exposition would not be complete without addressing some of the common securities backed by residential mortgages (RMBS). The simplest one is a mortgage passthrough security, where the payments from the underlying pool are distributed to investors on a pro-rata basis. The next level is a stripped MBS, where the payments from the underlying pool are directed towards an interest-only class (or IO mortgage strip) and a principal-only class (or PO strip). Once individual loans or pools of passthroughs are tranching into seniority-of-payment tranches, the resulting security is referred to as a collateralized mortgage obligation (or CMO). Further, a diversified pool of collateral comprising one or more of the above structures, results in what is known as a Structured Finance Collateralized Debt Obligation (or SF CDO). Tranches of CDOs themselves, when packaged together, are referred to as CDO² (where the order could be higher than 2). Structured RMBS securities are designed to distill the different risks associated with mortgage portfolios and spread them across the base of investors according to their risk appetite.

Risks

The risks associated with mortgage lending are default risk (that the borrower may default on the mortgage payments) and prepayment risk (the speed of repaying the mortgage, which affects the size and timing of the corresponding cash flows).

Default risk is quite intuitive – in the event of default, the borrower no longer meets the contractual obligations and the cash flows stop. A lender or an investor in a security backed by a pool to which such a mortgage belongs could experience a loss, depending on the amount of collateral coverage. However, in the wake of falling prices, full collateral coverage is hardly the expected norm.

Prepayment risk is essentially reinvestment risk. Prepayments affect the timing of the cash flows and thus, inject uncertainty. Prepayments are a well established risk of mortgages, but occurrence at any rate different than the expected is not a welcome feature in a dynamic environment when interest rates change.

As interest rates fall, borrowers are likely to prepay, which is what lenders and investors in mortgage instruments would like to avoid, because the opportunity set for reinvestment available in the market for comparable investments would have shrunk relative to what was available on the prepaid mortgage. Thus, while the value of the mortgage or the instrument should actually rise with a fall in interest rates, it does so with a percentage gain smaller than the percentage loss for a large rise in interest rates (i.e., there is convexity risk).⁶

As interest rates rise, borrowers are slower at prepaying and this is exactly when the investors would like to see increasing prepayments, as they can invest in instruments yielding higher returns. Thus, the decline in price of the mortgage or the instrument backed by the mortgage is larger (i.e., there is extension risk).

There is a great deal of research addressing the fundamental drivers of the mortgage exposure risk. Metrics such as the FICO⁷ scores, loan size, and loan-to-value ratio (to name a few) have long been recognized as indicators of the likelihood to default or prepay. Other factors affecting the loss severity in the event of a default are the time it takes to foreclose and the then prevailing interest rates, as well as the value of the real estate asset serving as the mortgage collateral (to name a few).

Subprime Mortgage Market

Since there has recently been a great deal of attention in the media stemming from investments in securities backed by subprime mortgages, our discussion would not be

⁶ Lucas (2006)

⁷ FICO scores are developed by the Fair Isaac Corp., see <http://www.fairisaac.com/fic/en>.

complete without focusing on this segment of the market.

Subprime mortgages refer to mortgage loans made to borrowers who usually display previous delinquencies, foreclosure or bankruptcy, have low FICO credit scores, and a ratio of debt service to income of 50% or greater.⁸ The subprime mortgage market offers a wider range of mortgage products than typically found in the prime sectors. It was a new and rapidly growing sector of the mortgage market, which, by expanding the pool of credit to a larger base of borrowers, increases homeownership and the opportunity to create wealth. To give one a sense of the level of growth in this segment: subprime loans categorized as B and C increased from \$65 BN in 1995 to \$332BN in 2003.⁹ The increased securitization of subprime mortgage loans has fueled this growth to a large degree. As the authors of the referenced study note, all the social good that the rapid expansion in this market has brought does not come without a price – they suggest that the probability of default on non-prime mortgages is at least six times higher than for prime loans and that elevated foreclosures adversely impact the value of properties in the affected neighborhoods as a whole.

To put things further in perspective, the market size for subprime mortgages is estimated at \$1.3 trillion outstanding loans (out of \$10.4 trillion of total home mortgages outstanding).¹⁰ Subprime mortgages with adjustable interest rates account for two-thirds of subprime first-lien mortgages or about 9% of total first-lien mortgages outstanding.¹¹ Now, consider the above-mentioned statistic and the fact that 43% of all foreclosures started during Q3 of 2007 belong to subprime mortgages with adjustable rates.¹²

⁸ For an in-depth discussion of the subprime mortgage market, see Chomsisengphet and Pennington-Cross (2006)

⁹ Ibid.

¹⁰ Poole (2007)

¹¹ Bernanke (2007)

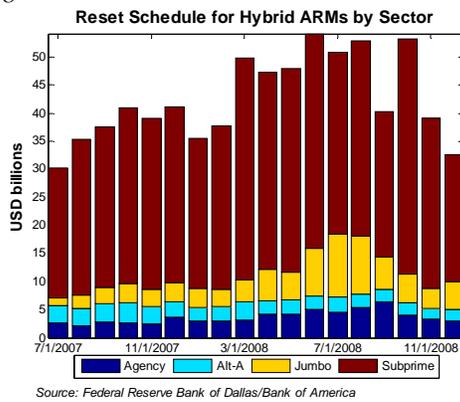
¹² Mortgage Bankers Association (Dec.6, 2007)

How can this happen, you might ask? After all, all years up to 2006 were marked by strong mortgage credit quality and unprecedented growth in the credit markets.

The answer, with the benefit of hindsight, lies in the combination of home price deceleration and a general economic slowdown with a large number of ARMs issued during a period marked by a steep yield curve (2002-2004, suggesting rising short term interest rate expectations).

Add to this the fact that mortgage originators' incentives were influenced by high fees and substantial spreads on non-prime ARMs, not to forget the increased investor appetite for higher securitization yields driving demand for more and more securitizations, and

Figure 2



top it off with the fact that rating agencies' incentives favor pumping more and more volume through the system,¹³ and you have an answer. Better yet, a disaster. So, was it really a surprise that the crisis happened? Moreover, a good number of sources suggest that the worst is yet to come. An economic commentary by David Rosenberg at Merrill Lynch suggests that the ARM resets are just beginning with more than \$170 billion of resets expected in 2008, with 70% of the volume falling into the subprime category.¹⁴ A similar picture is painted by Bank of America (Figure 2)¹⁵.

¹³ Mason and Rosner (2007)

¹⁴ Rosenberg (2007)

¹⁵ DiMartino (2007)

Add to this the deterioration of home prices over the last year and the expectation that they are expected to go down further, and you get a sense of where we might be heading (Figure 3)¹⁶.

Figure 3



Before wrapping up the mortgage market survey, we address the issues surrounding the more exotic products, such as the CDOs. The excessive liquidity in the global financial markets, the spike in the development and use of innovative financial structures, falling interest rates and tightening credit spreads increased the demand for CDOs by investors seeking yield enhancement against a backdrop of relatively low volatility. CDOs outpaced corporate and municipal bond sales with about \$500 billion sold in 2006, up from \$99 billion in 2003.¹⁷ It is reported that almost half of all CDOs sold in the U.S. in 2006 contained subprime debt, with more than \$175 billion in subprime mortgage mezzanine tranches.¹⁸

With the unraveling of the mortgage crisis, investors are realizing that they have no reliable way of quantifying the risk and valuing these complex instruments. The ratings issued by rating agencies have lost credibility as robust indicators of underlying risk. The collapse of the Bear Sterns hedge funds ignited a rash of downgrades on subprime mortgage transactions

¹⁶ Source: S&P Case-Shiller® Index (http://www2.standardandpoors.com/portal/site/sp/en/us/page.topic/indices_csmahp/0,0,0,0,0,0,0,0,0,1,1,0,0,0,0,0.html), adapted from Rosenberg (2007)

¹⁷ Evans (2007)

¹⁸ Ibid.

which, in turn, began a period of panic selling of structured debt with subprime components, as investors fled to safety by moving their holdings to US Treasuries and money market funds. In the meantime, the origination and trading of structured mortgage products has virtually ground to a halt. Inevitably, the rhetorical question arises: what will it take to get another structure with subprime debt rated or placed in the market?

By introducing transparency and fundamental risk drivers into our analysis, we offer a modeling framework to assist in filling the current valuation and risk-assessment vacuum, support ongoing risk transfer activity and restore some of the confidence in RMBS and derivative securities that has been lost in the recent past.

Modeling Aspects

While the preceding discussion covered a lot of ground, we by no means view it as an in-depth analysis of the recent crisis. We do, believe, however, that a few key issues around the current state of modeling rise to the surface:

- Complexity of an unprecedented nature, the often inappropriate use of available data, poor overall transparency (risk, model, data methodology), failure to account for illiquidity,
- Investors' inability to measure their levels of exposure to subprime sector CDOs or the corresponding risk,
- Absence of reliable sources of statistical information with respect to the default rates for many of the CDOs,
- Traditional methodologies and credit ratings that are no longer considered accurate or adequate,
- Rating agencies no longer seen as objective since they play an active role in assembling CDOs,
- Presence of perverse incentives as a substantial portion of the agencies' revenues comes from rating structured finance instruments,
- Rating agencies too slow and opaque in their tackling of the subprime crisis,

- An over-reliance by investors on ratings at the expense of doing their homework,
- Modeling of sudden liquidity withdrawal is critical but missing,
- Data may be unreliable and aggregate / high-level modeling approach inappropriate.

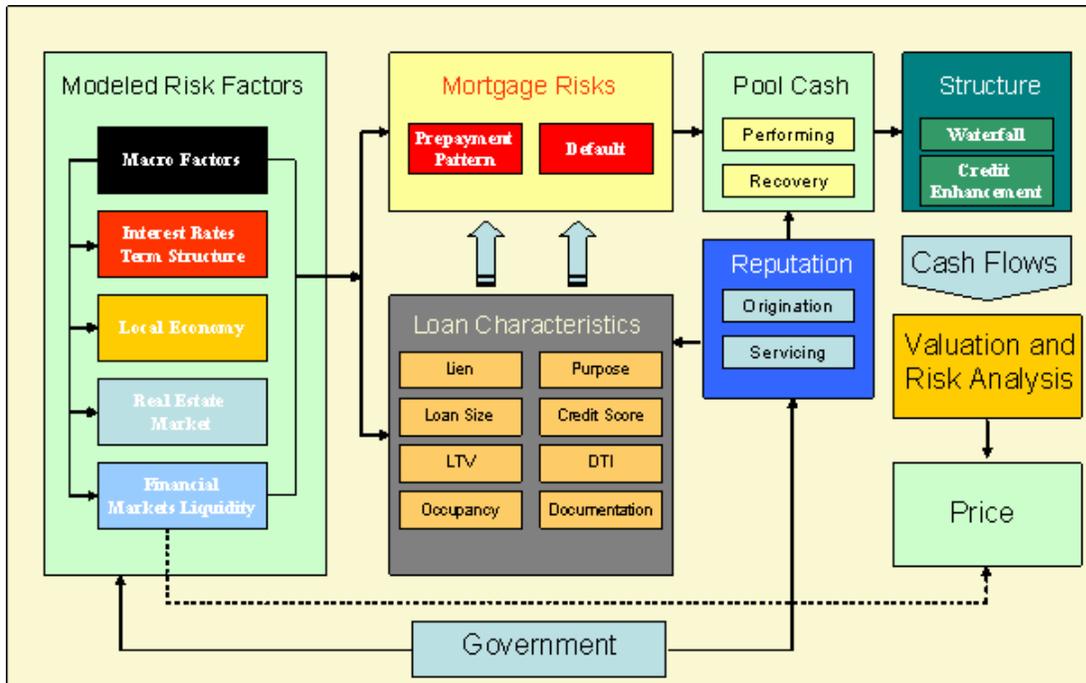
Where this all takes us to is the belief that there is a clear need for independent pricing and valuation based on a transparent and accessible framework, which utilizes analyses derived from reliable and appropriate data (including historical loan and securities performance as well as transaction structures). A framework, in short, that applies robust modeling focused on the underlying asset pools at the individual loan level, allowing for stochastic modeling of the risks, and accounting for the presence of liquidity risk.

RISC RMBS Stochastic Modeling Framework

We believe that the appropriate analysis of RMBS requires a forward-looking stochastic model that combines macroeconomic components (such as US real GDP growth rates and interest rates), industry-specific measurements (such as state-level gross product growth rates and unemployment levels, industrial production concentration), combined with individual loan level analysis. In order to capture the specific aspects of a certain transaction, it is critical to accurately capture its financial structure and corresponding cash-flow dynamics. And, of course, the model has to account for both the originator and servicer practices, as well as market liquidity risk.

The model we are alluding to will produce cash flows generated in a Monte Carlo stochastic simulation environment, which are then flown through the transactional waterfall. As such, it will produce probability distributions of cash flows to each tranche, which, in turn, will give an accurate representation of the risk to each of the corresponding tranches, and produce valuation and risk analysis calculations (expected values, percentiles, etc.)

RISC RMBS Stochastic Modeling Framework



Each of the stochastic components of the models will be based on econometric analysis of historical data sets at the highest level of resolution (such as loan-by-loan historical experiences) and will provide a robust and transparent framework for understanding the analysis assumptions and implications.

Think of this framework as a fully integrated stochastic model, which bases its analyses on scientific analysis of data and provides its users with a full set of analytics, derived from the generated probability distributions filtered through the contractual details of the analyzed transaction. This approach to quantifying risk has worked for us and our clients and we believe it will work for you.

Conclusions

The market needs a new approach when it comes to valuation of residential mortgage-backed securities and the more exotic structured credit products derived from RMBS. We propose a stochastic framework for cash flow generation and risk estimation based on econometric analysis of historical data. The focus is on the loan-level data and the inclusion of key risks (other than default and prepayment) into the framework, such as market liquidity risk.

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