An Options-Based Model for Valuing Commercial Mortgage Loans

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Summary

This white paper provides a non-technical introduction to the Zealand Commercial Mortgage Loan Pricing Model. The accurate valuation of commercial mortgages is a complex and challenging task. The roots of this difficulty are the complex set of interacting options embedded in the structure of these loans. As a result, sophisticated models must be used to correctly price commercial mortgages. The Zealand Commercial Mortgage Loan Pricing Model is a comprehensive and leading edge analytical took that uses the options approach, supported by econometric modeling of underlying property and credit market fundamentals and the extensive use of real estate capital markets data. The model recognizes the fundamental uncertainties inherent in commercial mortgage loans – default, prepayment, and balloon risks – and uses advanced mathematical and statistical techniques to provide rapid and accurate valuations. The Zealand model fully reflects both the range of loan characteristics – tenant and collateral quality, supply and demand trends for the surrounding property markets, call protection, *etc*. – along with the broader economic and capital market factors that influence the relative pricing of commercial real estate debt.

Introduction

Determining the "fair" market price of a commercial mortgage loan has been a longstanding and difficult problem for real estate investors, lenders, traders, and regulators. This difficulty stems from several sources. Unlike residential mortgages, commercial mortgages have loan characteristics that vary enormously from one loan to the next, a reflection of the vast differences in the underlying commercial property collateralizing the loans, the varying credit worthiness of tenants, the financial requirements of borrowers, and the underwriting standards of lenders. Complicating matters further, most commercial mortgages are written in the private market, where disclosure and reporting requirements are minimal (or non-existent). Public market loan information, such as that offered by CMBS, tend to be considerably more standardized than private mortgages. The lack of homogeneity, coupled with the paucity of available data, makes it challenging to establish robust benchmarks of value, since pools of "representative loans" are seldom available.

But there is a more fundamental economic reason why commercial mortgages are relatively difficult to value – namely, the financial self-interest of borrowers. Most commercial mortgages are written on a non-recourse basis. As a result, the lender, not the borrower, bears the ultimate cost of default since a rational borrower may find it financially optimal to simply "walk away" from their loan under certain circumstances, thereby forcing ownership on the (presumably unwilling) lender. Under this interpretation, default is *not* a last resort to be avoided at all costs, but rather the result of a rational, profit-maximizing decision by the borrower. This ability to rationally default can be thought of as an *option* held by the borrower. More precisely, the borrower effectively has a put option on the property, *i.e.*, the borrower can "put" the property back to the lender if it is in their best interest to do so. This characteristic is usually referred to as an *embedded option*, and has been shown to be the key to predicting mortgage defaults and understanding pricing trends (note that prepayment can also be considered a form of embedded option that a borrower may rationally exercise). The problem is that reliably valuing such options – and hence accurately determining the likelihood of loan default at any point in time and ultimately the loan's value -- is a technically demanding problem, requiring the use of complex mathematics and sophisticated numerical computer algorithms.

This white paper introduces a comprehensive and leading edge model developed by Zealand Mortgage Technologies that uses the options-based approach, supported by sophisticated empirical modeling of underlying property and credit market fundamentals and the extensive use of real estate capital markets data. The model recognizes the fundamental uncertainties inherent in commercial mortgage loans – default, prepayment, and balloon risks – and uses sophisticated mathematical and statistical techniques to provide rapid and accurate valuations.

The Zealand model fully reflects both the range of loan characteristics – tenant and collateral quality, supply and demand trends for the surrounding property markets, prepayment terms, etc. – along with the broader economic and capital market factors that influence the relative pricing of commercial real estate debt.

Current Methods of Mortgage Loan Valuation

Given the aforementioned difficulties, investors have been compelled to develop alternative means of loan valuation. Briefly, these methods can be classified into three broad categories. The first, and most prevalent, follows the familiar real estate practice of using "comparables." A recently valued loan that is similar in some important respects to the candidate mortgage is identified and used as a valuation benchmark. This is akin to what appraisers do when using recent comparable sales to value property. From this, a standard discounted cash flow model can be built which reflects the valuation of the comparable loan (or loans), as well as the specific characteristics of the candidate loan, *e.g.*, term, balloon, prepayment restrictions, amortization, interest rate changes, *etc*. While intuitively appealing, this "pricing by analogy" approach is fraught with practical difficulties. Comparable loans may be difficult to find, especially for very seasoned loans or loans secured by unusual collateral. In the case of seasoned loans, terms for newly originated loans will seldom match the terms and credit conditions of older loans. An additional complication is that the selection of key valuation factors, such as discount rates and projections of future asset values, tend to be as much art as science, making the efficient and broad application of this approach very problematic.

The second approach is the so-called "empirical method", in which statistical and econometric analysis is applied to historical loan data in order to estimate a valuation function. This function typically relates loan value or a credit event (like default), to specific loan characteristics, such as term, loan size, amortization schedules, credit characteristics -- especially loan-to-value and debt service coverage -- and a number of broader economic trends. This approach offers the advantage of providing a statistically testable foundation for examining the relative importance of the factors influencing loan value. It also offers a systematic means of predicting and validating value. The drawback, as with the comparable loan approach, is the paucity of data sufficiently rich to permit the reliable estimation of the loan value equation. Much of the data potentially available to an analyst are proprietary to specific lenders and generally not available for independent use. Data that are available run the risk of being biased since underwriting standards vary significantly by lender. Any model estimated using such data will reflect the behavior of the individual lender, but may not be a reliable tool for loans originated by their competitors.

The above sampling issues notwithstanding, there is a more fundamental problem with empirical models. Published models almost always find statistically significant empirical fits for *ex-post* credit events. Defaults are observed in the data and the model is fit to them. Thus the borrower has exercised their embedded option and the default is recorded. However, in the absence of data on the full life history of payments -- the complete record of payments and the explanatory factors over the entire life of the loan -- the value of the embedded options cannot be estimated *ex ante*, that is prior to the default. As the value of these options are the primary determinant of default and prepayment decisions, a model that cannot value these options cannot correctly price loans. In effect these models are "backwards looking" and are not really capable of measuring or pricing default risk -- which is inherently a forward-looking concept -- and this cannot properly value mortgage loans. What is needed is a truly *predictive* model, which values the embedded options based upon expectations of future borrower behavior and capital markets conditions. This leads us to the third methods for loan valuation, the so-called structural model approach.

The structural model[1] approach, of which options models are the most important example, attempt to more rigorously characterize the uncertainty inherent in an investment. In the case of commercial mortgage loans, the predominant sources of uncertainty are the cash flow and market value of the underlying collateral (it may help to think of these as corresponding to debt-service coverage and loan-to-value and debt service coverage). These sources of uncertainty are the variables that ultimately determine the value of the underlying default and prepayment options embedded in a loan. Given these variables, option pricing models are used to derive a precise pricing equation for the investment in reference to other assets (typically interest rates). The Black- Scholes equations for call and put options are perhaps the best known of these models, but the methodology has much broader applications. Structural models attempt to explain the behavior of the option owner (the borrower) as an optimal decision to invest under uncertainty. Structural models also provide a rigorous framework to model the impact of changes in the creditworthiness of the borrower on the value of the mortgage. An additional important benefit of structural models is that capital market information can be easily used to "calibrate" the model, ensuring that the resulting prices (valuations) are consistent with the prevailing prices (valuations) of other risky debt in the market. Thus, changes in market-wide risk premia can be properly reflected in the mortgage valuations.

To summarize, the advantages of structural models are numerous, including: (1) borrower behavior is modeled directly as a function of loan-level and market-

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1. The term "structure" comes from corporate finance, where these models were first developed to value risky corporate-issued debt, especially bonds. In this case, the credit quality of the obligor is linked to it's economic and financial conditions, including it's capital structure. The term structure also has a meaning in econometrics, where it refers to a model of behavior.

level factors; (2) the embedded options are valued explicitly, thereby providing a rational *ex ante* basis for loan pricing ; (3) the model is fully predictive in that the current value of the loan is determined as a function of future market conditions; (4) values corresponding to different economic scenarios are easily calculated, permitting the model to act as a powerful “what if tool”; (5) the model is extremely general and can be extended to a wide range of alternative capital structures and risk environments; and (6) the methodology is consistent with the way capital markets value other risky debt securities, increasing the fungibility of unsecuritized mortgages. Indeed, modern financial research has unequivocally come down on the side of using structural options-based models for modeling debt where possible[2]. The main drawback of this method is that formulating and solving options models is a mathematically and computationally demanding procedure. But recent work in the area of credit derivatives provides the tools tomake the option adjusted valuation of commercial loans both straightforward easy and indeed prudent for originators, investors and servicers. Seemingly small variations in loan structure may require significant changes to the underlying option model, increasing the complexity of the valuation analysis.

The Zealand Loan Valuation Model

A fundamental insight of options pricing theory is that debt secured by commercial real estate assets , can be modeled as a combination of two assets: a risk free bond less the value of any implied put and call options written by the lender to the borrower. That is, the price of a conventional commercial whole loan can be represented as the sum of a risk free bond of equal term and balance, less the value of the embedded default and prepayment options. As a practical matter, an options-based valuation model produces a dollar price or spread that acts as a "floor" on the rational value of the loan. This price is fully consistent with both the terms of the mortgage and the exposure of the loan to default and prepayment risks. A lender would solve the model to get the option price and , then add some additional spread to cover origination costs and profit. An investor would use the model to mark a portfolio to market, while a seller would use the model to determine an appropriate reservation price.

As noted above, an options-based approach is appealing because it reflects the capital structure of the asset and assumes that the borrower exercises his default or prepayment options when it is in their best interest to do so. Structural models clearly identify sources of risk and the exposure present in each loan. Because loan valuations are consistent with the arbitrage- free valuations observed on

2. A possible exception to this involves modeling some extremely complex securities, where the underlying structural models are still not fully developed. In these cases, empirical models are often used as a substitute.

similar traded assets in the market, an options- based model provides values which are consistent with the capital markets and results that can be rigorously generalized over alternative capital structures and risk environments.

The Zealand Mortgage Valuation Model is a proprietary "structural" model that uses modern option pricing theory to model the behavior of borrowers in a world of uncertainty. The Zealand model treats each mortgage as the combination of a riskless bond and a set of embedded options. Typically, these options represent the borrower's right to default or prepay the outstanding balance of the loan at any time prior to and including maturity. The model treats events such as default and prepayment as the rational decision by the borrower to exercise of these embedded options when it is in his or her best interest to do so. Both default and prepayment decisions are treated as "American options" reflecting the fact that the borrower has the right to exercise the option at any point in time from the current period through the maturity date.

The Zealand model has two main parts: (1) a *credit component* based on a structural options model of default risk; and (2) a *prepayment model* driven by interest rates fluctuations. For each of these parts, the model also makes use of capital markets pricing data, taken from a variety of loan and bond transactions, to calibrate some of the input parameters of the model. This ensures that the resulting valuations are consistent with those instruments currently (or recently) trading in the market.

Modeling Credit Risk

In simplest terms, credit risk in the Zealand Model is measured and priced using a "correlated two factor" structural default model. In options parlance, a factor refers to a primary source of uncertainty or risk. For mortgages the primary sources of credit uncertainty flow from changes in the future value of the underlying collateral (the loan-to-value ratio or equity condition) and unexpected changes in the debt service of the loans (debt- service coverage ratio or asset solvency condition). In conjunction with the loan's interest rate, maturity date, amortization schedule, projections of local real estate market conditions, and an estimate of current asset value, this factor determines the current loan- to- value ratio and the evolution of the borrower's equity interest in the asset(s) over the remaining term of the loan. The second factor used in the credit model is a model for asset cash flows. This factor determines the current debt- service coverage ratio and the borrower's on-going solvency through the maturity of the loan. The relationships between the two factors and events such as default and prepayment are shown in Figure 1. These relationships are usually referred to as "boundary conditions" in options modeling.

Figure 1
Two Factor Mortgage Credit Model Boundary Conditions

(1) **Perform to Maturity** • Positive Equity • Cash Flow > Debt Service	(2) **Modify, DPO, or Sale** • Positive Equity • Cash Flow < Debt Service
(3) **Balloon Default** • Negative Equity • Cash Flow > Debt Service	(4) **Immediate Default** • Negative Equity • Cash Flow < Payment

As with any options pricing model, the characteristics of the valuation functional are determined by the boundary conditions. Because the Zealand credit model has two factors, boundary conditions must be defined for each. As shown in Figure 1, the boundary conditions at maturity reflect the borrower's ability and incentives to pay off the remaining balance of the loan. We need to first consider the borrower's rational behavior at maturity and then solve the model recursively back through time. The first factor, the asset value, will determine if the borrower has equity in the asset. If there is positive equity, the borrower will try to pay-off any remaining balance, or sell the asset. If there is negative equity, the non-recourse nature of most commercial mortgages will allow the borrower to walk away from the loan. The borrower's equity (including final period cash flow) will determine whether a balloon default or loan modification is likely at maturity[3].

The second factor, cash flow, determines the solvency of the borrower, or his ability to make contractual payments from asset income. If the borrower has positive equity and cash flow after debt service at maturity, the loan will pay off in full. If cash flow is deficient but the borrower has positive equity, the asset will be sold and the loan repaid from sale proceeds. If there is negative equity but positive cash flow, then the borrower has a "free option" to "sweep cash flow" (that is, keep as much NOI as possible, which includes not making loan payments) until exercising the default option at maturity. If there is both negative equity *and* negative cash flow, the borrower will very likely default.

Given these boundary conditions, the Zealand loan model beings begins with traditional credit analysis to determine the current debt service coverage and loan- to- value ratio and then captures the impact of uncertainty from the two factors over the life of the loan. As is typical for structural credit models, market

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3. By capturing the dynamics of asset valuations, the Zealand model endogenously estimates both the default and recovery rates that are consistent with prevailing market conditions and the important equilibrium condition required in finance that there be no riskless arbitrage opportunities.

data from recent loan originations or secondary market sales are used to estimate the key inputs used by the Zealand model, including volatilities of each of the credit factors. This same data set is used to estimate the correlation of these two factors over time. In more simplistic models, the two factors are either assumed to be perfectly correlated (a world of constant "cap rates" or income yields) or independent (a world of random valuations). The correlation between the two factors helps determine the relative importance of each source of risk in determining a loan's value. Because implied volatilities and correlations are "implied" by recent transactions, loan valuations and risk measures are consistent with prevailing market conditions and can be updated in near real time. In addition, the Zealand model makes extensive use of econometric forecasts of key local market fundamentals, such as rents and occupancies, to help ensure that the options model is fully consistent with current and expected market conditions.

Capturing Capital Markets Influence

A very powerful advantage of the Zealand model is extent to which the model makes use of a broad array of capital markets information to help accurately calibrate the model's key valuation inputs. This is essential to ensure that the resulting loan price and spread are consistent with the market's prevailing pricing for risky debt. In particular, three of our valuation parameters -- the volatility of DSC and LTV, and the correlation of these volatilities -- are not directly observable in the capital markets. Thus in the absence of a substantial historical database of whole loan transactions, these parameters must be estimated[4].

In order to generate estimates of these parameters that provide a meaningful reflection of prevailing credit market conditions, the Zealand model makes extensive use of available loan transactions data, drawn from the new issuance and secondary CMBS markets. From this data we econometrically estimate the distribution of implied volatilities for DSC and LTV (after accounting for loan size and property type), which provides us with a range of LTV and DSC ratios. These ratios, by their very nature, reflect the current market price of credit risk. From these estimated distributions we can then compute a correlation coefficient which also reflects prevailing risk and pricing conditions. Finally, we adjust these estimates, when necessary, to account for loan seasoning. As a result, the Zealand model provides credit (and prepayment)-adjustment pricing and loan spreads that fully reflect both the structure of the underlying mortgage and the capital markets pricing of the mortgage's risk characteristics.

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4. In some liquid credit markets, where trading is sufficiently deep, such as the MBS market, one can attempt to make robust estimates of these three parameters from historical data. This is not the case for commercial mortgages.

Modeling Prepayment Risk

Commercial mortgages – especially seasoned loans – face the additional risk of prepayment (depending of course on what type of call protection is written into the loan). As with residential mortgages, reductions in market interest rates will induce borrowers to refinance the loans. In addition, if collateral values undergo significant appreciation over the life of the loan, borrowers may seek to "cash-out" some of their equity. The Zealand model captures both of these prepayment effects.

Commercial real estate loans are generally prepayable over a portion of their term. To help mitigate balloon maturity defaults, even loans subject to extensive lock-out provisions or defeasance requirements, are generally prepayable during the six-month period prior to maturity (a provision popularized in the CMBS conduit market). When a prepayment occurs, the lender, or current owner of the mortgage loans, is subject to reinvestment risks if the loan coupon differs from the market rate for a mortgage with comparable risk characteristics. More importantly, if the loan was purchased (or currently valued) at a premium dollar price (a price greater than the unpaid principal balance of the loan) and the loan is prepaid at par, then prepayments can result in an immediate loss of investment capital.

These risks are well known in the residential mortgage markets where the vast majority of loans are freely pre-payable. As a result, residential loans and pools of loans are typically priced assuming a prepayment speed consistent with one of the many agency pools of with similar loan characteristics. These static models use prepayment speeds that are typically defined in terms of a Constant Prepayment Rate (the rate of expected exponential decline in principal over the loan's life) or as a multiple of the PSA prepayment curve. Because residential loans do not always prepay when it is in the borrower's financial interest to do so, various empirical models are used to capture the behavioral profile of each pool type (defined by coupon, size, vintage, geography, and loan terms) in response to observable factors such as interest rates, rate volatility, home prices, seasoning and expected burnout rates. These models work because of the homogeneity of residential mortgage loans and the availability of data on agency pools.

With commercial loans, borrowers tend to reflect their economic interests more aggressively than the typical residential borrower. Prepayment, like default, can be regarded as an option that the borrower controls. This option is typically exercised when it is financially optimal to do so. These optimal exercise conditions, however, must reflect the various forms of call protection typically found on most commercial loans. Ultimately, however, optionality explains only part of the prepayment behavior for commercial mortgages and a rigorous prepayment model must reflect other financial and behavioral motivations. It the next few paragraphs we explain how the Zealand loan valuation models account for these factors.

Figure 2
Prepayment Behavior

Financial Incentives of Option

Prepayments <

Behavioral Objectives and Equity Cash-Outs.

For most seasoned pools of commercial mortgages, the prepayment behavior of borrowers are driven by a combination of economic incentives and competing non-pecuniary interests (see Figure 2). As a result, most commercial prepayment models contain both a rational component (to capture the optionality) and an empirical component (to reflect the non option based behavior of borrowers). The factors motivating rational exercise of the call option include: the spread between market rates and loan note rates; the existence of prepayment penalties or lock out provisions; the current risk free rate and volatility of interest rates; and all transaction costs (including penalties) associated with the re-financing. The impact of these factors, however, must be tempered by the borrower's ability to qualify for refinancing. The qualification constraint is closely related to the credit quality of the loan and includes requirements regarding sufficient equity in the asset to meet LTV requirements and sufficient asset cash flows to satisfy debt service coverage requirements.

Like their residential counterpart, not all commercial loans with exercisable call options are prepaid when they are "in the money". Other factors must be considered. For instance, "burnout" models assume the pool is not homogeneous, but rather consists of several sub-pools with different propensities to refinance. As faster pools deplete, mortgage groups with lower prepayment propensities begin to dominate the composition. Not only does the overall refinancing speed of the pool decrease, but the entire structure of response to refinancing incentive changes as well. Other factors are used in the empirical prepayment models include: loan age, equity accumulation (for cash-out refinancing), seasonality and defaults from the credit model (recoveries are treated as involuntary prepayments).

To satisfy the need to analyze multiple types of call protection covenants, the Zealand model offers a variety of prepayment specifications. The simplest static models allow for the user to prove a static prepayment vector (defined in terms of either CPR or number of expected coupons). To simplify this traditional loan pool valuation model we provide a set of reference prepayment speeds that are consistent with the characteristics of the mortgage pool. Pool level cash flows are generated assuming that all loan groups (categorized by prepayment types) pay down at the same CPR. These models are useful in establishing reasonably accurate valuations for commercial loan pools that are consistent with market pricing conventions.

Because commercial loans tend to prepay in their entirety (not at some CPR), we also offer a loan valuation model based on the expected life of the loan. This simple static model is very much like the residential CPR models. It starts with the idea that any premium valued loan could be structured into a par valued mortgage (using the current credit adjusted yield) and an interest- only (IO) strip. The par loan is free of capital risk from prepayments (although interest rate volatility can have a minor impact on values of par loan) and most of the risk to capital is related to the interest only strip. This model is partially dynamic because changes in market coupon rates (derived using the credit model and reflecting interest rate changes) will change the size of the respective par and interest only "bonds." This model causes premium valued mortgage loans to converge to a value cap consistent with the market's willingness to be exposed to IO payment risk. Our model requires the user to specify an estimate of how many payments they expect (or are willing to put capital at risk) to be received and we provide some reference risk durations based on loan characteristics.

For those investors more comfortable with the conventions used to value a residential loan pools, our models can relate the expected number of payments to the CPR which causes the duration of the implied IO strip to equal the expected life of the loan. Actual practices in the secondary market appear to be more closely aligned with the notion of tying the number of periods of capital at risk to the type of loan level call protection. For high coupon pre-payable loans the risk period is roughly 1 year. For modest coupon pre-payable loans with several years of seasoning it is 1 to 2 years. For loans with modest penalties, the risk period is the lesser of half the life of the loan or the number of payments required to justify a price equal to the penalty. For low coupon loans (relative to current mortgage rates), no cap is imposed and the credit modes will yield a discount dollar price (the cap for these in the table below is set to 100%).

Generally, investors in the secondary market for commercial whole loans will not give credit for more than one year of high coupon payments without the documented existence of strong call protection. This will generally limit premium dollar prices on loans to values less than 105. The exception will be for pools with well-documented payment histories and whose collateral resembles other recent pools sold. Moreover, investors will also adjust their valuation of premium bonds to reflect any loan-specific issues which could result in involuntary prepayments related to defaults.

The Zealand loan valuation models provide whole loan investors with several tools to adjust loan prices to reflect prepayment risks associated with each type of loan. For loans with lock out periods, explicit penalties or defeasance provisions we value the mortgage using one of our interest rate models. These loans have call protection provisions which are interest rate options and can be priced using simple derivative pricing techniques. Once the credit model has been used to identify the credit option adjusted spread, a standard interest rate model can be used to price any combination of prepayment penalties, yield maintenance provisions, defeasance clauses, and lock out periods. The model assumes that the borrower rationally exercises these options or the portfolio is marketed to market (in the case of pricing caps), and valuations are consistent with the market practice of pricing loans on a yield to worst basis.

The final set of prepayment models is fully dynamic with respect to interest rate movements. For users requiring a higher degree of accuracy and whose needs are focused on the impact of interest rate risk on loan valuation and hedging, we provide a series of term-structure driving prepayment models. These models combine sophisticated call option models for lock-out period, penalty periods and market-based pricing caps (described above) with empirical models that use hazard functions to estimate non rational behavior. These models use an "aging" variable to reflect burn rates and LTV ratios to capture equity cash outs behavior. To capture the dynamic impact of prepayments on valuation we offer several term structure models. The user can balance the need for accuracy with respect to other contracts (for hedging and arbitrage strategies) against simplicity and ease of use. These models can be used to estimate option adjusted spread (OAS), estimate duration, convexity, and the full range of option "greeks".

Tying It All Together: Translating Value to OAS

As describe above, the model calculates a fair market dollar value for individual whole loans based on their current debt service coverage, loan-to-value ratios, and call protection. Following the tradition of other credit markets, this price can be used to calculate an "option adjusted yield" (OAY). The OAY is simply the IRR calculated using model valuations as the acquisition price and the unadjusted scheduled payments through maturity of the loans. By subtracting the OAY from the appropriate risk free rate one can determine the "Options Adjusted Spread" (OAS) consistent with the model valuations. In similar fashion, by subtracting the appropriate swap yield, one can determine the options adjusted spread-to-swap yields that are often used in the ABS and residential MBS markets.

Option- Based Models as Tools for Risk Management.

Few topics in finance have generated as much interest in recent years as risk management. A host of regulatory changes, including the new Basel II risk-based capital requirements for banks, more stringent compliance and disclosure requirements for investors and issuers, and a heightened sensitivity of the importance of transparency and corporate governance practices have prompted investors and lenders to devote substantial time and resources to establishing formal internal risk management systems. In addition, the increasingly competitive nature of debt markets have produced many innovations in financial products, causing lenders to think more broadly about the types of financial instruments they may wish to originate and trade. While this offers greater opportunities for returns, it also carries with it the added challenge of valuing and managing an increasingly complex spectrum of potential investments. Fortunately options-based models provide an extremely powerful platform for creating robust and consistent measures of risk at both the asset (loan) and portfolio levels.

Investment risk is related to the unpredictable fluctuation of asset values over time. In the standard discounted cash flow approach to valuations, current asset values change to reflect a revised outlook for future cash flows and changes in the discount rates. In the traditional approach, investors had to estimate (*i.e.*, guess) both the future pattern of cash flows and the appropriate discount rate. This by itself is seldom a reliable or practical way to reliably quantify the range of future asset values an investor may face. Empirical models offer an improvement over this approach, but as noted earlier, are also flawed. Empirical models are backward-looking and only accurate for the types of loans and economic conditions that were part of the original data set used to estimate the models[5]. By contrast, option pricing theory provides a much more disciplined and structured way to think about investment risk.

In option pricing theory, the optimal valuation equation that we solve to yield the OAS and prices has certain special properties that allows to consistently calculate the risk exposure of an options-derived loan value to changes in any of the underlying risk factors as well as the key market inputs (such as interest rates). This risk exposure is typically measured by the so-called "Greeks" of option pricing theory. The "Greeks" represent the sensitivity of the options price to changes in various inputs to the pricing equation (the name "Greeks" derives from the fact that mathematicians typically use Greek letters to denote various parts of options pricing equations.) For those mathematically-inclined readers, the Greeks are partial derivatives of the options equation. "Greeks" are also referred to as hedge factors since in principal, one can use their value to create perfect hedges (in theory) for the underlying asset. Of particular importance are the "deltas". Delta hedging (that is, taking a short position in the underlying asset with weight equal to the calculated greek delta value) is both the basis of options pricing theory and a widely deployed took for risk management. Because the Zealand model has two factors, there are two deltas: one for cash flow risk and one for asset value/equity risk. While it may be difficult to implement these hedges in practice (though contracts are now being written on real estate asset

5. Included in this class are the qualitative valuation models of rating agencies which assign letter grades to reflect the credit risk of loans having particular attributes.

performance), the two credit option deltas can be used to derive precise measure of a loans exposure to the two market factors. Beyond the use of risk management as a part of prudent investment practices, these risk measures can also be used to develop rigorous estimates of Value at Risk (VaR) exposure and Basal II compliant risk-based capital requirements. In addition to option deltas, the Zealand models also allows for risk measures that include Gammas (or the second order effects of asset risk including cross correlation effects at the portfolio level), Vegas (the sensitivity of options values to the level of risk), Thetas (the impact of time on options values) and Rhos (the impact of changes in the interest rate). These Greeks are directly comparable across assets (loans), and can be consistently aggregated to a portfolio level.

Extensions to Other Asset Classes

Real estate is not the only asset class characterized by the presence of significant embedded optionality. A voluminous research in finance has demonstrated that virtually *all debt* – from simple corporate bonds to intricate financial derivatives -- can be effectively modeled and priced using options theory. Indeed, today nearly all modern debt and derivative securities are priced using these techniques. This has proven to be one of the most compelling advantages for employing options-based pricing methods over alternative approaches.

With it's structural options framework, the Zealand model can be directly extended to other asset classes involving risky cash flows, including credit cards, auto loans and leases, aircraft lease receivables, student and home equity loans, residential mortgage, and so on. Obviously the workings of the underlying collateral for these sectors differs from real estate, but the fundamental insights yielded by options pricing are remain perfectly valid. For each new sector, the supporting econometric models are modified to reflect available market data and the key economics of the sector, including the estimation of future residual asset values and the calibration of current factor values. The model boundary conditions are modified, where necessary, to account for the specific default and prepayment dynamics of borrower behavior. The resulting model is then solved, yielding options-adjusted prices and spreads for the sector's debt.

Conclusion

The rapid and accurate valuation of commercial mortgages is a complex and challenging task. The roots of this difficulty are the complex set of interacting options embedded in the structure of these loans. As a result, sophisticated models must be used to correctly price commercial mortgages. The Zealand

Commercial Mortgage Loan Pricing Model is a comprehensive and leading edge analytical took that uses the options approach, supported by econometric modeling of underlying real estate and credit market fundamentals. The model recognizes the fundamental uncertainties inherent in commercial mortgage loans – default, prepayment, and balloon risks – and uses advanced mathematical and statistical techniques to provide rapid and accurate valuations. The Zealand model fully reflects both the range of loan characteristics – tenant and collateral quality, supply and demand trends for the surrounding property markets, call protection, *etc.* – along with the broader economic and capital market factors that influence the relative pricing of commercial real estate debt.