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Pitfalls in the Analysis of Option-Adjusted Spreads

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The option-adjusted spread (OAS) has developed into a popular and powerful tool for portfolio management. The OAS allows the investor to adjust ex ante *yields to a consistent basis for comparison. Valuable as it may be, however, this adjustment has some fundamental flaws.*

The option-adjusted spread (OAS) is derived by positing an array of interest rate paths (using multinomial lattice or simulation techniques) consistent with the current Treasury term structure. These interest rate paths are then used to discount the cash flows from non-Treasury securities to arrive at present values. (We note here that the cash flows may depend upon the level, or even the history, of interest rates.) The present values are averaged to get an expected value, which can be viewed as the theoretically "correct" price of the security.

In the absence of credit risk, any difference between the model-generated price and the market price represents an *apparent* arbitrage. We use the word "apparent" advisedly, because the exact timing and amounts of many cash flows are uncertain, given such events as mortgage-backed securities prepayments and bond calls. Moreover, the liquidity of the security is ignored. Truly riskless arbitrage would require that every possible interest rate path be mapped and that all cash flows be fully determined. In effect, then, the difference between the model and the market price represents a combination of arbitrage opportunity and risk (e.g., of default, illiquidity or uncertain cash flow timing).

To allow valuation of credit, liquidity and payment-timing risks over the underlying Treasury term structure, the model adds a constant spread across each path. This spread is called the OAS. It is the expected interest rate spread over the Treasury curve—inclusive of the impact of any options on the cash flows—averaged over the life of the security.

Mathematically, OAS is obtained by solving the following nonlinear equation:

Eq. 1

Market Price

$$= \frac{1}{S} \sum_{s=1}^{S} \sum_{t=1}^{T} \frac{cf_t^s}{\Pi_{i=1}^{t}(1 + r_t^s + oas)}$$

where S is the number of interest rate paths, cf_t^s is the cash flow in period t under path s, and r_t^s is the short-term discount rate at period t under path s.[1]

Advantages of OAS

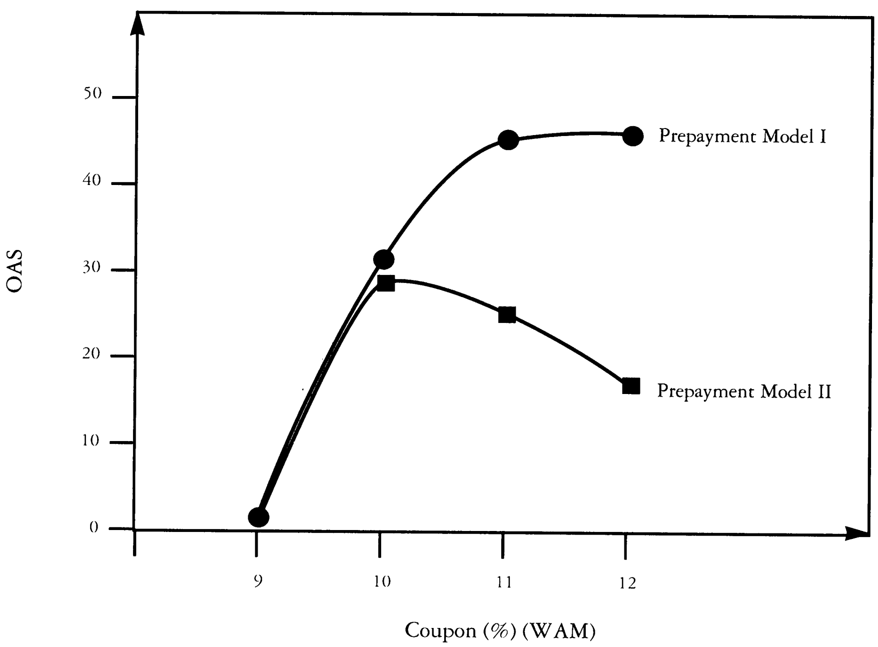
OAS has a number of advantages over conventional yield measures for calculating expected return.[2]

1. OAS takes **interest rate volatility** into account. The model captures this volatility by including a number of interest rate paths and varying their ranges.
2. OAS takes into account any cash flow sensitivities to movements in interest rates. The valuation model explicitly maps future cash flows to interest rates and the paths they follow. In the valuation of mortgage-backed securities, for example, a prepayment model is used to relate the cash flows of the security to the prevailing rates for new mortgages.
3. OAS can be directly tied to assets and liabilities. Asset OASs can be computed as well as liability OASs. Because both spreads are based off the same (implicit) Treasury curve, the net of the two spreads provides a measure of expected profitability.
4. OASs of different securities can be meaningfully compared to give an indication of relative expected return differences. This appears to be the primary reason for the widespread use of the OAS.

Limitations of OAS

Like most financial tools, the OAS measure has several limitations.

Figure A The OAS of Different GNMA Securities under Different Cash Flow Models



We describe these potential pitfalls here and illustrate their effects in terms of the valuation of mortgage-backed securities. We do not always have remedies to propose for these pitfalls, but it is important that investors be aware of them.

First, OAS is **model-dependent**. When measuring OAS, one is therefore, actually invoking the joint hypotheses that the pricing model being used is correct and that, given the pricing model, there is an OAS of x basis points. When we speak of a correct pricing model, we mean that interest rates as well as cash flows are modeled correctly.

Suppose a positive OAS is computed for a given security. Does the positive OAS mean that the market is inefficient, and that the security is underpriced? Or does it mean that the valuation model is inappropriate? We cannot tell. Perhaps we have omitted some important factors in the pricing model; perhaps we included all the important factors, but modeled their behavior poorly; perhaps we misspecified the size and timing of the cash flows.

For example, a four-factor model may best explain the market pricing structure, yet an OAS may be based on fewer factors, or on factors different from those that best explain market prices. While it is true that OAS is applied to the short-rate tree only, other factors may be important in explaining the cash flows or the volatility path of the short rates. These other elements could give rise to a different model price, hence a different OAS.

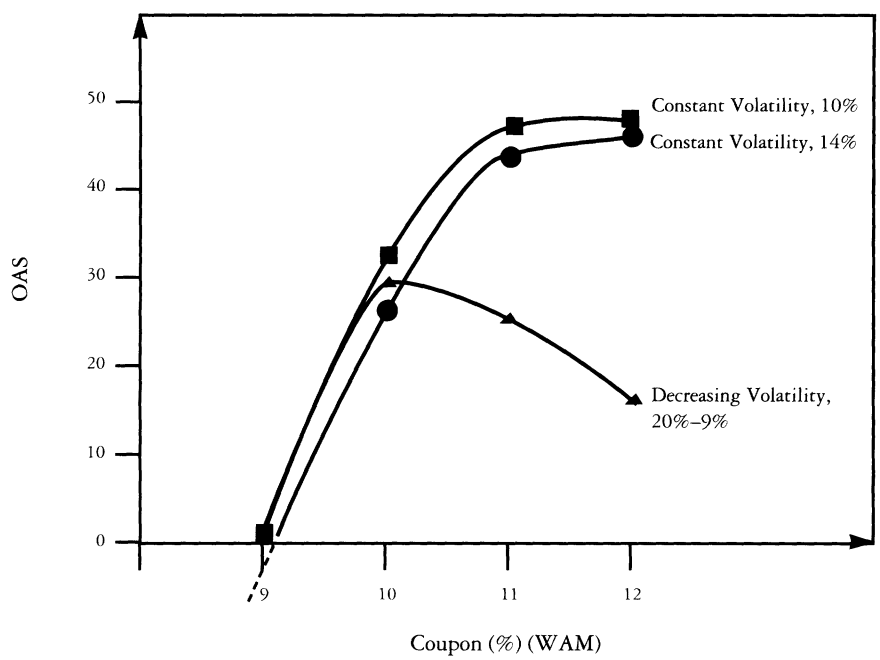
To illustrate the dependence of OAS on model cash flow timing assumptions, we calculated the OASs of GNMA mortgage-backed securities using different models to estimate the prepayment behavior of the mortgage owners.[3] Figure A illustrates the results. What is disconcerting is not so much that the calculated OASs are different under Model I and II, but that the relative attractiveness of the 11% and 12% premium securities has changed. Model I finds the 12% security slightly more attractive than the 11%; Model II finds the 12% security significantly less attractive.

What is an investor to do? Should he resort to the market consensus prepayment rates and perform a **sensitivity analysis**? Unfortunately, the answer is no. The shape of the standardized PSA reveals very little information about the precise timing of prepayments. Investors need to know more information about the structural properties of the prepayment model, and such information is very carefully guarded by the owners of prepayment models.[4]

The second pitfall of the OAS is that the pricing model is usually based on assumptions about interest rate processes that are often chosen for tractability or convenience rather than their ability to capture the richness of reality. For example, it is common practice in the analysis of mortgage-backed securities to use a **Monte Carlo simulation** of a diffusion process.[5] A diffusion process is used to generate both short-term interest rates and mortgage rates. *Ad hoc* adjustments are made to the simulated interest rates to make them consistent with the term structure (i.e., arbitrage-free). These adjustments, rarely disclosed, alter OAS calculations.

Even when the interest rate process is structured in more detail—as in the use of the binomial lattice models of Black, Derman and Toy—substantial differences can emerge depending on the data used to calibrate the process.[6] For example, one analyst may use on-the-run current-coupon Treasuries, while another uses STRIPS or some larger set of Treasury prices. A binomial lattice model is fit to current observations on short-term rates and volatility. While all analysts may have

Figure B The OAS of Different GNMA Securities under Binomial Lattices with Different Volatilities



similar views of the term structure, their estimates of volatility are likely to differ.

To illustrate this point, we calculated the OAS for GNMA securities using three distinct binomial lattices for short-term rates. All were calibrated based on the current term structure of interest rates. However, the first assumed volatilities decreasing gradually from 20% for the first month to 9% after 30 years. The second assumed a constant volatility of 14%, while the third assumed a constant volatility of 10%. Figure B illustrates the results. Again, not only do the absolute values of OAS change, but so do the relative ratings of the securities.[7]

The third problem with the OAS is that it is an averaged number in concept. It averages return both across interest rate paths and also over time up through maturity. An investment may exhibit different spreads across each path, or it may have time-varying spreads, yet it has a single OAS. We know that the true OAS will decline toward zero as a security approaches maturity, for instance, but estimated OAS is assumed to be constant over time. Figures C and D illustrate the (potential) variation of OAS for different interest rate levels at a given point in time and the variation of OAS across time. The precise relation between the OAS and interest rate level, or between the OAS and time to maturity, is an open question.

To further illustrate this point, we calculated the OAS for FNMA 8.00 and FNMA 9.00 under two different assumptions. We first assumed that the OAS is constant across interest rate paths and over time; this estimated OAS is shown as the intercept on the y-axis. We then assumed that the OAS varies over time and also depends on the path. We repeated the calculation for two interest rate scenarios—one obtained from the highest path of a binomial lattice, the other from the lowest path of the lattice. Figure E illustrates the results.

A fourth pitfall arises because a fixed number of basis points is

Glossary

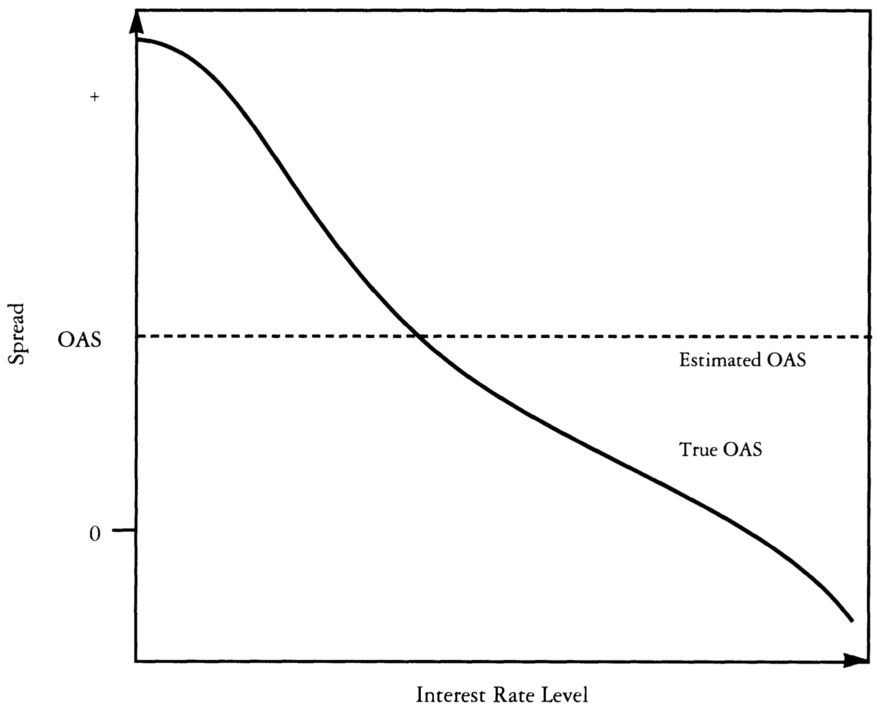
►***Interest Rate Volatility:***
The rate with which interest rates are changing around their mean (i.e., expected) value. It is typically measured by statistical quantities such as the variance. Large variance values indicate high volatility.

►***Model-Dependent:***
When the value of the parameter being measured (in this case, the option-adjusted spread) is critically dependent on the model being used to measure it. The assumptions built into the model may significantly affect its results.

►***Sensitivity Analysis:***
A test to indicate the sensitivity of a model to its assumptions. In particular, sensitivity analysis will indicate whether the outcome of the model changes with changes in the model assumptions or input data.

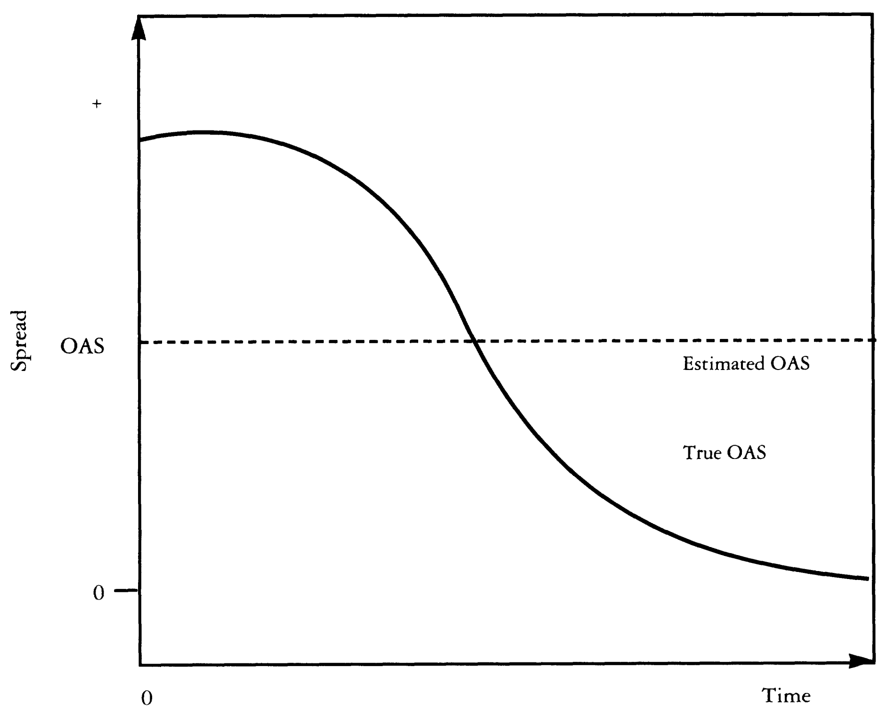
►***Monte Carlo Simulation:***
A technical approach for the generation and measurement of a random process. First the parameters of the process are quantified (e.g., we assume the process follows a normal or lognormal distribution). Then the evolution of the process is described by drawing random numbers with probability distribution identical to the distribution of the process under study. A typical application is the use of random-number generators on a computer to generate a lognormally distributed series. This series is then used to describe the evolution of the term structure of interest rates.

Figure C Point-in-Time Spreads



usually added to each interest rate node in a lattice or each time point in a Monte Carlo simulation to obtain the OAS. But adding a constant spread to the nodes or time points produces an interest rate distribution that is inconsistent with the assumptions of the model. Adding a constant spread to a lognormal lattice, for example, produces an interest rate distribution that loses its lognormality.

Figure D Over-Time Spreads



This difficulty can be eliminated by using a multiplicative option-adjusted premium, computed by solving the following equation for p:

Eq. 2

Market Price

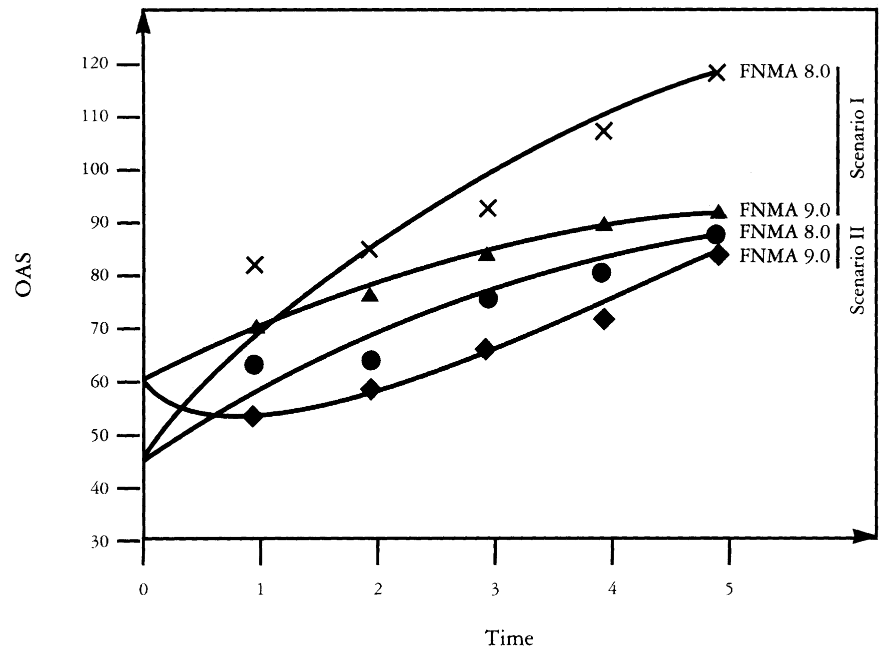
$$= \frac{1}{S} \sum_{s=1}^{S} \sum_{t=1}^{T} \frac{cf_t^s}{\Pi_{i=1}^{t}(1 + r_t^s p)}$$

FNMA is currently using a multiplicative premium in their option-adjusted analysis.

Fifth, the OAS typically ignores some of the options. Most commonly, it ignores the default option. While the OAS technology is in principle capable of accommodating default, prepayment and call options, in practice one or more of these options is subsumed into the OAS.

Sixth, the OAS is subject to common abuse in practice. For example, in calculating OAS for corporate bonds, technicians almost always assume lower interest rate volatilities on the Treasury rates than those used to price the Treasuries. This practice—which is often not disclosed—is clearly inconsistent and imparts a more favorable OAS than would otherwise be the case. Some investment banks, such as Salomon Brothers, Morgan Stanley and Goldman Sachs, disclose the fact that they are using a lower interest rate volatility in pricing corporates. Yet many investors do not fully appreciate the magnitude of the impact that the lower volatility has on OAS. Using an interest rate volatility consistent with Treasury bond prices often results in negative OASs for Aaa and Aa bonds.

Figure E OAS for Two FNMA Securities at Different Times and for Different Interest Rate Paths



When a volatility different from that consistent with pricing Treasuries is used to compute OAS, the analysis is no longer consistent with the meaning intended to be conveyed by the phrase "option-adjusted spread above Treasuries."

Finally, like the yield to maturity, the OAS, when translated into yields, implicitly assumes reinvestment at a constant spread above (or below) the one-period forward rates in the kernel model. Reinvestment at these rates is impossible.

What Can Be Done?

OAS is a powerful tool for comparing securities and structuring optimal asset portfolios. However, it should not be blindly relied upon in selecting assets. Two different valuation models applied to the same security will generate two different OASs. Even a single valuation model can generate multiple OASs for a given security, depending on the parameters chosen and the number of paths used.

The assumptions built into the model by the technicians have to be studied carefully, because they can alter the recommendations of the model substantially. If the same model is used to estimate the prepayment behavior of different mortgage-backed securities, then the ranking of these securities based on OAS may be more reliable because, even if the precise numerical values are subject to model misspecification of prepayment rates, the securities' ranking should not be greatly affected (although relative rankings may change if the term structure differs from the model's, as in Figure B).

The complexities of fixed income securities essentially demand use of the OAS. Financial analysts should be striving for—and investors demanding—OAS models that result in zero OASs for as widely diverse a set of securities as possible (assuming the market is broadly efficient). A complete and consistent model should fully explain the prices of assets in an efficient market and result in zero OASs.[8]

Footnotes

1. *See Asay, Bouyoucos and Marciano, "An Economic Approach to Valuation of Single Premium Deferred Annuities,"* Financial Optimization *(Cambridge: Cambridge University Press, 1992) for applications to insurance products. See S. A. Zenios, "Parallel Running,"* RISK Magazine, *November 1991, for parallel computing applications of this compute-intensive analysis as applied to mortgage-backed securities.*
2. *See L. S. Hayre, "Understanding Options-Adjusted Spreads and Their Use,"* Journal of Portfolio Management, *Summer 1990.*
3. *See P. Kang and S. A. Zenios, "Complete Prepayment Models for Mortgage Backed Securities,"* Interface, *forthcoming.*
4. *Kang and Zenios ("Complete Prepayment,"* op. cit.) *tested both prepayment models against historical data and found Model II to be significantly more accurate.*
5. *See L. Hayre and K. Lauterbach, "Stochastic Valuation of Debt Securities" in F. Fabozzi, ed.,* Managing Institutional Assets *(New York: Harper and Row, 1990).*
6. *F. Black, E. Derman and W. Toy, "A One-Factor Model of Interest Rates and Its Application to Treasury Bond Options,"* Financial Analysts Journal, *January/February 1990.*
7. *Further discussion of the impact of term structure volatility on OAS can be found in M. Koenigsberg, J. L. Showers and J. Streit, "The Term Structure of Volatility and Bond Option Valuation,"* Journal of Fixed Income, *September 1991.*
8. *The research of D. F. Babbel was funded in part by Goldman, Sachs and Co. The research of S. A. Zenios was funded in part by the National Science Foundation, through grant SES-91-00216, and by research awards from Blackstone Financial Management and the Federal National Mortgage Association. The opinions expressed here are those of the authors and not necessarily those of the funding agencies. The authors thank Dr. Martin Holmer of FNMA for bringing to their attention the use of multiplicative option-adjusted premiums.*