CDIAC

CALIFORNIA DEBT AND INVESTMENT ADVISORY COMMISSION

Issue Brief: Benefits and Limitations of Option-Adjusted Spread Analysis

INTRODUCTION

Public fund managers want to ensure that their investment practices are consistent with their investment policy, and accomplish the main objectives of optimizing safety, liquidity, and return on agency assets. These goals charge public agencies with thoughtfully choosing investments that mitigate risk, ensure sufficient liquid- ity to meet ongoing obligations, and also generate income for the portfolio over budgetary and economic cycles. These dif- ferent objectives often come into conten- tion with one another, as assets considered the safest usually produce the smallest re- turns and assets with higher returns also tend to have more risk.

Yield spread is an important indicator that investors consider when acquiring investments for their portfolios, as it measures additional return for an asset above a risk-free rate. Absolute yield spread for a bond is calculated by subtracting the yield of a "risk-free" bond[1] from the yield of that bond. Although the yield spread for a bond provides important information about the return on the investment, it does not account for embedded redemption structures, such as call options, which allow the issuer to redeem, or call, the bond prior to maturity.

Option-adjusted spread (OAS) is a measure of yield spread for a bond that accounts for embedded redemption structures. OAS is an improvement on the standard calculation of yield spread for a bond because it accounts for the possibility of a change in the bond's cash flows due to changes in interest rates. This issue brief discusses what OAS is, how to interpret OAS values, modeling assumptions, and the limitations of applications of OAS in public portfolio management.[2]

WHAT IS OAS?

OAS is a measure of yield spread that accounts for embedded call options in the valuation of bonds. The OAS for a bond is computed using price and projections of interest rate volatility to account for the possibility of early redemption. The OAS value is interpreted as the constant spread that can be earned on the asset compared to the risk-free option. Most commonly, the OAS is expressed as a spread over the Treasury curve.[3]

The main benefit and purpose of OAS is that it allows for comparability between bonds with different redemption structures. For the majority of public agencies, the most common application of OAS relates to agency investments in callable bonds. For example, an agency might want to compare the yield for a callable bond with the yield for a noncallable, or bullet, bond. Without OAS, an investor can only compare the nominal rate of return for each bond without being able to consider a potential lower return in cases where the callable bond is redeemed before maturity. When used correctly, OAS can help investors make more informed decisions about which assets to include in their portfolios that balance their different investment objectives of safety, liquidity, and return.

EFFECTIVE DURATION

Additional benefits of OAS include applications to calculating duration for a bond in a way that accounts for an embedded option. Duration is a measure of estimating the price (market value) change in a bond given a change in interest rates. Effective duration is a byproduct of the option models that produce OAS and it accounts for ways that changes in interest rates have the potential to change a bond's cash flows. Similar to how OAS is an improved measure of yield spread, effective duration is an improvement over modified duration, as it is a more reliable indicator of a callable bond's price sensitivity to changes in interest rates.

INVESTMENT RISKS OF CALLABLE BONDS

Callable bonds have an embedded option for early redemption, which is associated with additional investment risks. For example, one of the main risks of investing in callable bonds is the possibility that the bond could be redeemed, or "called," earlier than its

[1] A common benchmark security for calculating yield spread is an on-the-run Treasury issue with the same maturity as the bond being compared.

[2] This issue brief is meant to be used as general guidance about what OAS is and how to interpret OAS values. It is not intended to be used as investment advice.

[3] Robert Ingenito, Kelly Joy, and Kevin Webb, "Issue Brief: Investing in Callable Securities – September 2020 Update," California Debt and Investment Advisory Commission, 5, Published September 2020, Accessed September 23, 2020, www.treasurer.ca.gov/cdiac/publications/issue-brief/2020/20-07.pdf.

maturity date. This is most likely to happen when interest rates decrease to a level that allows the issuer to refinance their bond for interest savings while taking into consideration the costs to the issuer of executing the call option. In this case, the investor will be investing the funds from the called bond in a lower interest rate environment with fewer possibilities to earn a comparable yield. This is known as reinvestment risk.

Another risk of investing in callable bonds is uncertainty in the cash flow stream from investment proceeds. The cash inflow from callable bonds is often dependent on market conditions and can be more difficult to predict. This uncertainty can affect liquidity planning in the invest- ment portfolio, making it more difficult to match cash inflows with projected outflows. The decision to redeem a callable bond prior to its maturity date is always made by the issuer, so investments with call options place the investor at a disadvantage. Volatility in interest rates can also lead to "duration drift" in cases where investors have significant proportions of callable bonds in a portfolio.

To compensate the investor for the additional risks, callable bonds offer higher yields than non-callables with the same maturity and credit rating. Investors need to be able to determine if the higher yield is worth the risk that the investment will be called. Investors can use OAS to compare the expected return of the callable bond to other securities that have different options or no embedded redemption options.

COMPARISONS WITH OTHER METHODS OF YIELD CALCULATION

There are multiple methods used to calculate yield for bonds, including yield- to-maturity (YTM), yield-to-call (YTC), and yield-to-worst (YTW) calculations. YTM assumes that the bond is redeemed only on the final maturity date and pro- vides the internal rate of return to that date. YTC is the internal rate of return of the bond to the next call date, whether or not the bond is actually called on that date. The YTW calculation is the lowest yield based on all the internal rates of re- turn (yields) for all possible redemption dates (call dates and final maturity). YTW is the measure that a public fund investor should ask to see on all bond purchases, whether callable or not.

The YTM and YTC calculations are both based on yield for a bond at a specific point in time. Although the YTW calculation takes multiple possible redemption possibilities into account, the value of the YTW calculation is still based on yield at a specific point in time, as it is the minimum yield of all calculations derived using the other methods for yield estimation. Whereas yield calculations essentially measure yield by attempting to predict, or at least reflect, a redemption date, OAS treats provisions for early redemption as options on cash flows of the bond.[4] The OAS measure considers many possible redemption dates and interest rate paths and uses an averaging approach to calculate the expected yield for the bond.[5]

INTERPRETING OAS VALUES

Like the measurement of absolute yield spread, OAS is a measurement of the spread above risk-free rates.[6] OAS differs from traditional yield spread in the way it is calculated and how it is interpreted. The OAS for a callable bond is computed by using interest rate volatility and the bond's price to calculate the valuation of the bond over many different interest rate paths.[7] The cash flows of a callable bond will depend on whether the bond is redeemed early or held until maturity, which are mostly dependent on the interest rate environment.

OAS is similar to yield spread in that it is also measured in basis points; however, the

CALLABLE BONDS

Investors consider many factors when deciding whether to invest in callable bonds. For a more detailed discussion about callable bonds, refer to the CDIAC publication "Investing in Callable Securities – September 2020 Update": **www.treasurer.ca.gov/cdiac/publications/issue-brief/2020/20-07.pdf**

CONVEXITY

Whereas duration is an estimate of the change in price of a bond when interest rates change, convexity is an estimate of the change in duration given a change in interest rates. Effective convexity is another byproduct of the option models that produce OAS, and it accounts for ways that changes in interest rates have the potential to change a bond's cash flows. Similar to how effective duration is an improved measure of modified duration, effective convexity is an improvement over standard convexity calculations, as it is a more reliable indicator of a callable bond's change in effective duration given changes in interest rates.

[4] Tom Miller and Tom Windas, *Introduction to Option-Adjusted Spread Analysis*, (New York: Bloomberg Press, 2007), Kindle edition, 14.

[5] Robert W. Kopprasch, "Option-Adjusted Spread Analysis: Going Down the Wrong Path?" *Financial Analysts Journal*, 50, no. 3 (1994): 43, **https://beedie.sfu.ca/homes/poitras/417_pitfalls2.pdf**.

[6] Frank J. Fabozzi, *Fixed Income Analysis (CFA Institute Investment Series)*, (Hoboken: John Wiley & Sons, Inc., 2007), 493.

[7] For more information on the statistical distribution and binomial interest rate trees used in calculations of OAS, see Tom Miller and Tom Windas, Introduction to Option-Adjusted Spread Analysis, (New York: Bloomberg Press, 2007), Kindle edition, 57.

values are interpreted as the spread to all of the potential redemption dates for the bond. This approach is in direct contrast to the other methods of yield calculation described above, which are based on yield spreads if the bond is redeemed at a specific point in time.

The OAS for a callable bond will typically be lower than the general value of yield spread because the OAS accounts for investor uncertainty due to the embedded call option. For example, a callable bond that has an absolute yield spread of 40 basis points may have an OAS of 15 basis points. Since non-callable bonds do not have an embedded call option, the OAS value should approximate the absolute yield spread for a non-callable bond.

OAS values can be positive or negative. A negative OAS for a callable bond signifies that, after taking the redemption option into account, the bond has a lower expected return than the risk-free option. All things being equal, an investor would prefer a higher OAS over a lower OAS.

ASSUMPTIONS FOR CALCULATING OAS

OAS is subject to a number of underlying assumptions, some of which can significantly alter the OAS value for a bond. For example, the underlying model and curve used to compute the OAS as well as the value used for the volatility parameter all have significant characteristics that form fundamental assumptions when calculating OAS.

Model Dependency

OAS can be computed using different models and the OAS value for any particular bond will depend on which model is used. For example, a Bloomberg terminal gives the option of selecting from various models (lognormal, normal with mean reverting, lognormal with mean reverting, Black swaption, or Linear Gauss Markov) when computing an OAS value. Figure 1 shows a Bloomberg terminal screen with an example of a five-year bond with a call option after one year.

When using a lognormal model for the bond in the example above, the OAS value is calculated at 10.52 basis points. If the lognormal with mean reverting model were used instead for this same bond, the OAS changes to 13.30 basis points. (See Figure 2.) This change in OAS is due to changing only the model and keeping every other factor constant.

The dependency of OAS estimates on the underlying model has implications on investor decision-making. If an investor is using OAS when deciding which investments to purchase, those purchasing decisions could be affected by the underly- ing model used by the investor. Figure 3

FIGURE 1

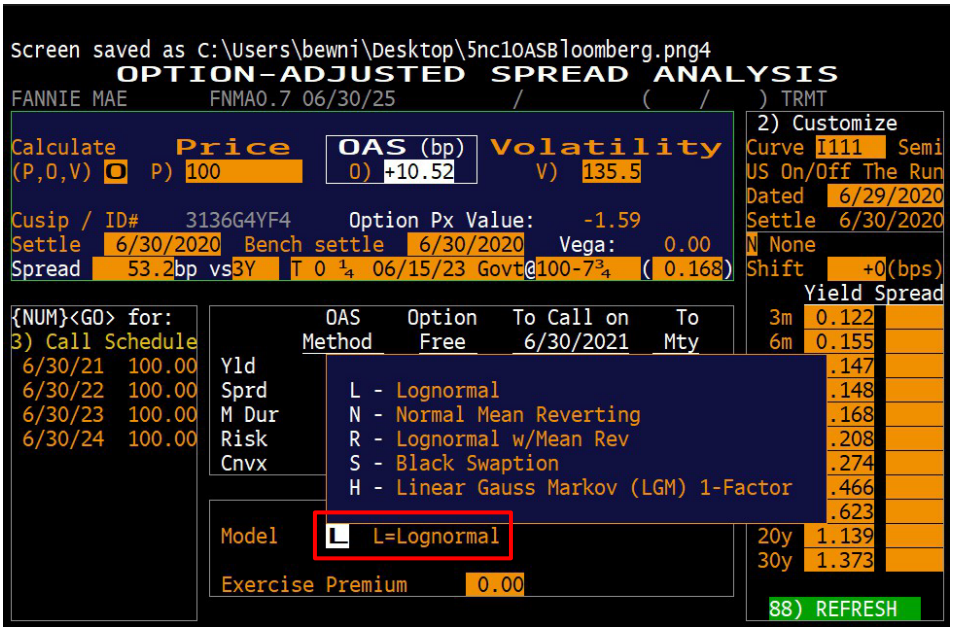

FIGURE 2

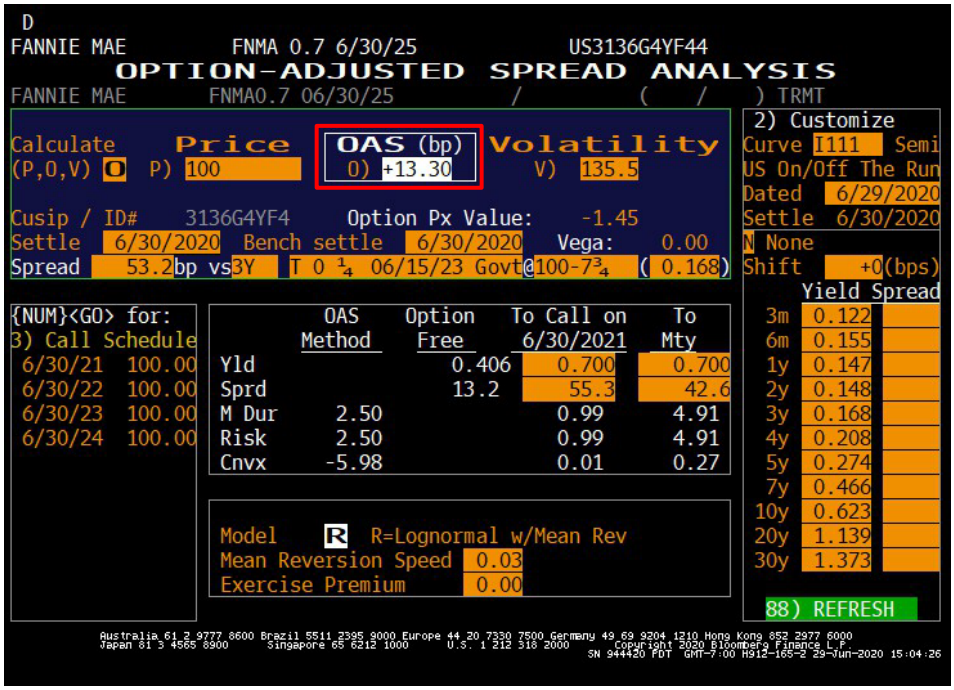

FIGURE 3

OAS VALUES FOR SECURITIES USING DIFFERENT MODELS

SECURITY	LOGNORMAL	LOGNORMAL WITH MEAN REVERSION	LINEAR GAUSS MARKOV
1.5-NC6MCONT	-1.17	-1.05	-2.92
2-NC1 BERM	0.14	0.34	0.38
2.75-NC1BERM	2.13	2.62	2.34
2.75-NC3MCON	-12.39	-11.19	-7.06
3-NC1 CONT	-0.70	-0.08	-1.03
3-NC1.5 BERM	6.96	7.32	5.92
3-NC2 BERM	9.47	9.63	8.18
3-NC3MO CONT	-10.18	-8.70	-4.23
3.5-NC1 BERM	4.72	5.71	4.85
3.5-NC6MBERM	-1.22	0.25	-1.13
4-NC2 1X	7.09	7.76	6.39
4-NC2 CONT	7.60	8.20	5.42
4-NC3MO CONT	-16.22	-13.17	-8.05
4.5-NC1.BERM	5.67	7.10	4.77
4.5-NC6MBERM	-2.69	0.24	-2.08
4.25-NC2 1X	6.25	6.98	5.64
4.75-NC1BERM	-0.49	1.96	-0.14
5-NC1 1X	1.93	4.08	2.92
5-NC2 BERM	12.89	14.27	10.31
5-NC6MO CONT	-6.54	-2.68	-5.35
6-NC6MO BERM	-15.07	-8.94	-9.93
7-NC2 BERM	-0.52	3.68	-2.77
15-NC1 BERM	-34.78	-13.44	-44.83
20-NC1 CONT	-26.66	3.61	-61.02

shows a table of a sample of bonds with OAS values calculated using three different models: lognormal, lognormal with mean reversion, and Linear Gauss Markov. Values in blue cells reflect a higher OAS, while values in orange cells correspond to a lower (and negative) OAS.

The bonds included in the table above feature a range of call types and maturity dates. In all of these cases, the OAS value varies for each bond, sometimes to a large degree. Some bonds have a higher OAS using the lognormal model rather than the Linear Gauss Markov model, for example, whereas the opposite is true for others.

Because OAS values vary depending on the underlying model, it is important to consider how each of the models available in the Bloomberg terminal for OAS computations has its own characteristics and limitations. The default model that is most commonly used on Bloomberg is the lognormal model. The main differences between the models are related to how the model accounts for the level and distribution of interest rates that discount the cash flows and determine OAS.[8] Understanding that there are differences between the underlying models is more important than fully comprehending what those technical differences are. What is most fundamental is making sure that comparisons between bonds are done in a way that maintains consistency and commensurability.

Curve Assumption

The underlying curve used when computing the OAS for a bond is another important input that can change OAS values. The OAS value will represent the spread over the curve that is selected for the model. In Figures 1 and 2, the I111 curve is used, which corresponds to a standard yield curve for U.S. Treasuries. A Treasury curve is most commonly used because Treasuries are assumed to be the risk-free rate, and it also allows for consistent comparisons across issuers, structures, and sectors. Figure 4 shows which curve is selected for the calculation of OAS values in a Bloomberg terminal.

Volatility Assumption

To calculate OAS for a particular bond, values need to be given for two other variables: price of the bond and volatility. The volatility measure helps account for the possibility of changes to interest rates. A higher volatility, all things being equal, will lead to a lower OAS value because volatility in interest rates can lead to an increased likelihood of issuers exercising call options.

The volatility parameter used to calculate OAS for a bond accounts for the expected fluctuation of interest rates over a given period of time.[9] Volatility measures will depend on both the time period and the type of security. For example, volatility values associated with a 5-year bond callable after one year were typically within a range of 23 to 68 in 2019. A 2-year bond callable after one year had a volatility range of 18 to 65 in the same year. In 2020, volatility has been especially elevated due to market conditions resulting from the coronavirus pandemic. For example, volatility has ranged from about 80 to 180 since March 2020 for the 5-year callable bond mentioned in the previous example. (See Figure 5.)

[8] Fabozzi, *Fixed Income Analysis (CFA Institute Investment Series)*, 146.

[9] Ingenito, Joy, and Webb, "Issue Brief: Investing in Callable Securities – September 2020 Update," 5.

FIGURE 4

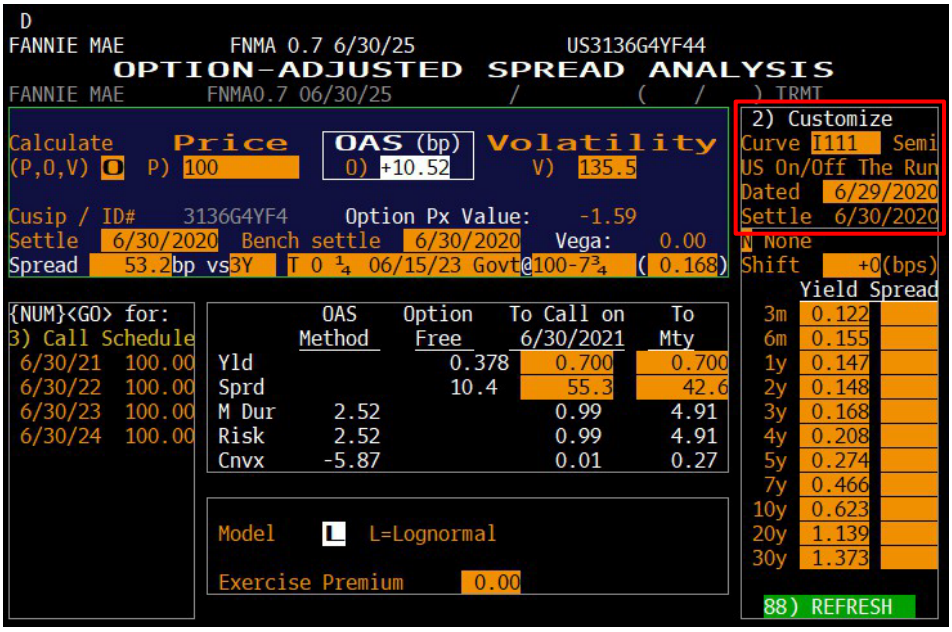

FIGURE 5

The volatility parameter used in Bloomberg or another similar software package is a forecast of future possible volatility measurements based on historical patterns of volatility.

Although Bloomberg has a default setting for volatility, industry practices used by broker-dealers and investment advisors over several years have led to a convention of consistently overwriting the volatility value to 14 when pricing and selling bonds.[10] Although the default value for volatility varies over time depending on conditions in the market, actual volatility measurements have consistently been significantly higher than 14 for the past several decades. As mentioned above, the volatility range for the two bonds in the previous example were always higher than 14. In 2020, there have been multiple periods since March where the volatility measure has been more than 10 times higher than a value of 14. Using a volatility value of 14 (or any arbitrary value that tends to be lower than current volatility levels) will therefore consistently *overestimate* the OAS for a callable bond. Figure 6 shows the same bonds as the table in Figure 4 side by side with OAS values for the same models using a measure of 14 for volatility.

Changing the volatility value to 14 lessens the variance between the different mod- els for the bonds. This can be seen in the table with more consistent coloring for each of the columns using a volatility of 14. An even more important implication of set- ting the volatility parameter to 14 is that OAS values for all of the bonds are inflated when compared to those in Figure 4. This is visually represented in the table by the color change to more blue fields, which correspond to more positive OAS values. For example, there are no longer any negative OAS values for bonds when using a value of 14 for volatility. For investors and fund managers making decisions on callable bonds based on a volatility parameter of 14, investments in callable bonds appear much more attractive than they do using the default volatility setting.

[10] More information about default volatility settings in Bloomberg can be found in Appendix A.

FIGURE 6

OAS VALUES FOR SECURITIES USING DIFFERENT MODELS, VOLATILITY PARAMETER SET TO 14

SECURITY	LOGNORMAL	LOGNORMAL WITH VOLATILITY OF 14	LOGNORMAL WITH MEAN REVERSION	LOGNORMAL WITH MEAN REVERSION AND VOLATILITY OF 14	LINEAR GAUSS MARKOV	LINEAR GAUSS MARKOV WITH VOLATILITY OF 14
1.5-NC6MCONT	-1.17	3.46	-1.05	3.47	-2.92	3.41
2-NC1 BERM	0.14	6.25	0.34	6.26	0.38	6.19
2.75-NC1BERM	2.13	13.66	2.62	13.68	2.34	13.39
2.75-NC3MCON	-12.39	10.35	-11.19	10.39	-7.06	9.96
3-NC1 CONT	-0.70	13.09	-0.08	13.11	-1.03	12.80
3-NC1.5 BERM	6.96	16.15	7.32	16.17	5.92	15.90
3-NC2 BERM	9.47	15.23	9.63	15.24	8.18	15.07
3-NC3MO CONT	-10.18	15.77	-8.70	15.82	-4.23	15.13
3.5-NC1 BERM	4.72	22.74	5.71	22.78	4.85	22.21
3.5-NC6MBERM	-1.22	20.51	0.25	20.58	-1.13	19.82
4-NC2 1X	7.09	18.62	7.76	18.64	6.39	18.41
4-NC2 CONT	7.60	20.61	8.20	20.63	5.42	20.34
4-NC3MO CONT	-16.22	22.98	-13.17	23.09	-8.05	21.95
4.5-NC1.BERM	5.67	25.58	7.10	25.63	4.77	25.10
4.5-NC6MBERM	-2.69	30.13	0.24	30.25	-2.08	28.97
4.25-NC2 1X	6.25	19.14	6.98	19.17	5.64	18.92
4.75-NC1BERM	-0.49	29.04	1.96	29.13	-0.14	28.17
5-NC1 1X	1.93	22.60	4.08	22.69	2.92	22.15
5-NC2 BERM	12.89	32.80	14.27	32.85	10.31	32.20
5-NC6MO CONT	-6.54	33.15	-2.68	33.32	-5.35	31.72
6-NC6MO BERM	-15.07	37.97	-8.94	38.26	-9.93	36.26
7-NC2 BERM	-0.52	34.67	3.68	34.86	-2.77	33.71
15-NC1 BERM	-34.78	56.99	-13.44	60.09	-44.83	50.21
20-NC1 CONT	-26.66	79.03	3.61	85.24	-61.02	65.77

LIMITATIONS OF OAS

Although OAS is a useful and important tool when comparing bonds with different redemption structures, there are limitations to its uses and benefits. Some of these limitations include the assumptions used when calculating OAS, limitations in scope, and exogenous uncertainty.

Limitations Based on Assumptions

There are underlying assumptions when calculating OAS for a bond that result in limitations to its applications. For example, because each of the OAS models available in the Bloomberg terminal has its own characteristics and limitations, the computed OAS values can fluctuate based on the model used and can lead to different purchasing decisions.

There are also serious limitations to current industry practices used by broker-dealers and investment advisors when computing OAS for different investments. Setting the measurement for volatility at 14 has been a standard industry practice for the past several decades, despite the fact that actual measurements for volatility have consistently been higher. Although using a constant value for volatility removes concerns regarding standardization, there are serious limitations when using OAS values computed using an assumed value of 14 for volatility. When the volatility parameter is set at 14, it is not reflective of current market conditions and also overestimates the OAS value. This problem is especially notable in today's environment of low interest rates where volatility levels are especially elevated.

In each of these cases, the assumptions used when calculating the OAS can lead to different OAS values for the same bond. This is a serious limitation if OAS is being used as a means for determining the relative value of bonds. In order to mitigate this limitation, investors can make sure they have a full understanding of the assumptions used in the reported OAS calculations. In addition, it is important to treat OAS as one of several factors to consider when selecting investments and valuing investments in a portfolio.

Limitations from the Scope of OAS

OAS accounts for embedded redemption options for a bond, as well as ways that changes in interest rates may affect the potential return on the investment. However, there are other important factors that can affect the value of the bond that do not factor into OAS calculations. One notable example is the creditworthiness of the issuer and the repayment source. OAS does not account for risk other than volatility in the market related to changing interest rates. An issuer's creditworthiness will usually be reflected in the price and yield of the bond when it is issued, but OAS does not factor in other potential risks, such as changes to credit ratings.

Limitations Due to Uncertainty

OAS captures some of the uncertainty caused by future potential changes in interest rates, and is therefore a valuable tool when comparing yields from bonds with embedded redemption options ver- sus those of other securities. That said, OAS is not a predictive model, and it has major limitations when used in a forecast- ing setting. OAS estimates yield spread for many potential future states using historical data that may or may not reflect what will actually happen. OAS takes into account potential yield differences due to the possibility of changing interest rates in the future; however, OAS cannot predict when interest rates will rise or fall. Changes to interest rates often happen exogenously due to monetary policy decisions from the Federal Reserve Board, for example. The actual yield of a call- able bond can vary widely depending on which interest rate path occurs and it is extremely unlikely for the bond to yield its calculated OAS value.[11]

CONCLUSION

Option-adjusted spread (OAS) is an important improvement on traditional yield spread analysis that allows investors to consider how embedded redemption options may affect the balance of risk, liquidity, and return in their investment portfolios. The OAS for a bond is computed using its price and projections of interest rate volatility, and its value is interpreted as the constant spread that can be earned on the asset compared to the risk-free option.

OAS analysis is a valuable tool when used in the right context, but OAS also has significant assumptions that can limit its effectiveness. OAS values can fluctuate depending on the underlying models and volatility parameters used, all of which can be set, or overwritten, by an investor or a broker-dealer. For example, setting the volatility parameter at 14 is a common convention that is not reflective of recent market conditions and will actually overestimate the OAS value of a callable bond.

Public agency investors that use OAS can consider some important principles to maximize the effectiveness of OAS when evaluating bonds in a portfolio, for example:

- Use a consistent model when comparing the OAS values for different bonds.
- Be mindful of market trends, such as exogenous changes to interest rates from the Federal Reserve, that will affect the likelihood of redemption for callable bonds.
- Make sure that the volatility parameter used to calculate the OAS for a callable bond will not overestimate the expected return of the bond.
- Consider OAS as one of several factors when evaluating investments.

Knowing and understanding how OAS works can ultimately empower public agencies to make the optimal decisions for meeting their investment goals.

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REFERENCES

Fabozzi, Frank J. *Fixed Income Analysis (CFA Institute Investment Series)*. (Hoboken: John Wiley & Sons, Inc., 2007).

Ingenito, Robert, Kelly Joy, and Kevin Webb. "Issue Brief: Investing in Callable Securities – September 2020 Update." California Debt and Investment Advisory Commission. September 2020. **www.treasurer.ca.gov/cdiac/publications/issue-brief/2020/20-07.pdf**.

Kopprasch, Robert W. "Option-Adjusted Spread Analysis: Going Down the Wrong Path?" *Financial Analysts Journal*, 50, no. 3 (1994): 42-47. **https://beedie.sfu.ca/homes/poitras/417_pitfalls2.pdf**.

Miller, Tom and Tom Windas. *Introduction to Option-Adjusted Spread Analysis*. (New York: Bloomberg Press, 2007). Kindle edition.

[11] Kopprasch, "Option-Adjusted Spread Analysis: Going Down the Wrong Path?" 43.

Appendix A: Default Bloomberg Terminal Settings

To be sure that your Bloomberg terminal and/or the terminal of the user that is providing you with OAS is set to use the volatility appropriate for each call- able structure, use function OASD on the Bloomberg terminal. If there are any numbers (for example, 14) in the Custom Volatility column, then the terminal is set to use a constant volatility assumption.

If you do not have access to a Bloomberg terminal, ask your broker-dealer and/or investment advisor to see the OAS User Defaults screen below, and confirm that the custom volatility column is blank.