THC Financial Engineering

How to Simulate Interest Rate Risk Beyond the COVID 19 Crisis

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The COVID 19 crisis has challenged balance sheet managers to re-define interest rate risk and re-examine interest rate models while trying to understand the impact of many unanswered questions.

- What if treasury rates become negative under the weight of the lockdown policies, resulting in a deep recession? Are negative rates a possibility?
- What if the U.S. government relief and stimulus programs lead to unprecedented accelerated inflation? How high can rates rise?

The purpose of this paper is to provide insights into these questions. While COVID 19 is unprecedented in many ways, I propose two approaches to gain insight into Interest Rate Risk in the coming years. In particular, I want to (1) conclude historical experience, (2) extract inferences from the capital market prices.

This paper shows that an interest rate model has to be consistent with the capital market pricing of a broad selection of benchmark securities and derivatives ("arbitrage-free"). Otherwise, simply put, the interest rate model is consistent with market reality: market efficient pricing that aggregates market consensus. As a result, an arbitrage-free model can simulate what-if scenarios and provide an objective forecast yield curve movement.

Historical Treasury Yield Curve Movements

The chart, Figure 1, below depicts the monthly Treasury curves from January 2010 to March 2020. In 2010, the post-2008 financial crisis, short-term rates were low, as the Fed sought to support the economy. However, long term rates remained high, in line with global interest rates, keeping the U.S. yield curve upward sloping.

Short-term rates remained low until 2015; only then did they begin to rise. Today, U.S. rates are low and economic output is depressed by the lockdown. The historical data suggests that the recovery of interest rates will likely take more than six years.

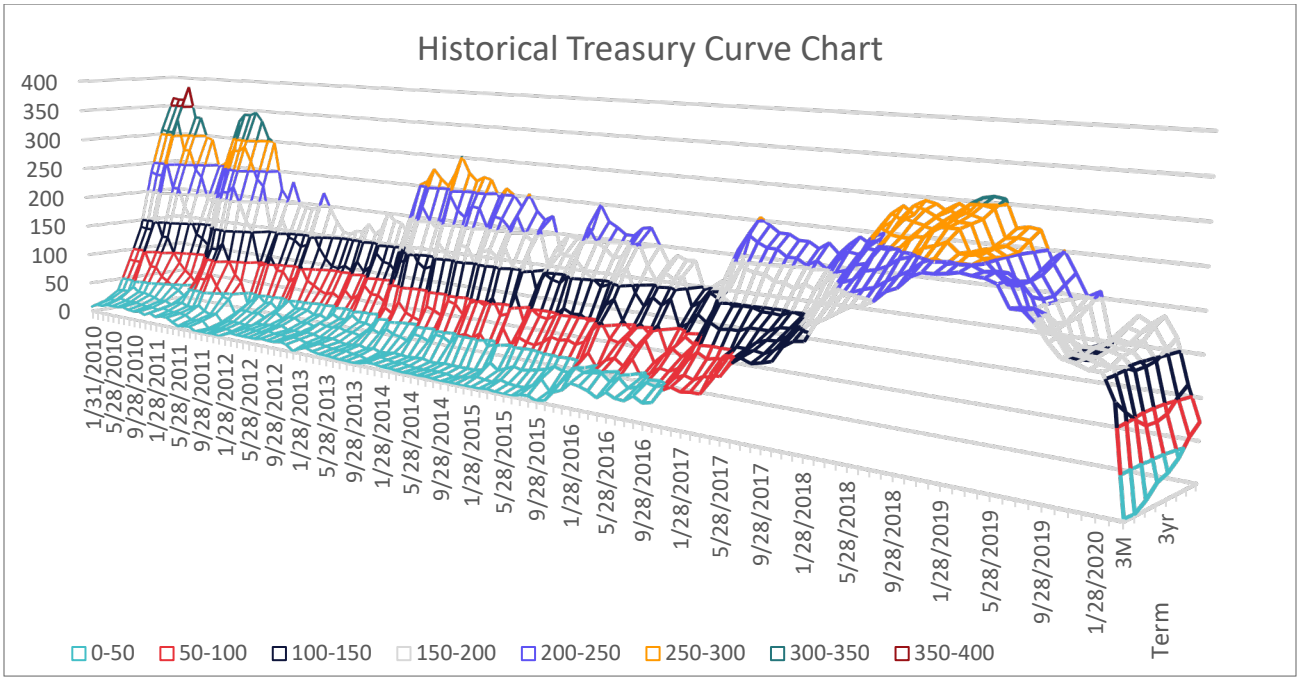
From 2015 to 2019, the U.S. economy continued to grow, resulting in the gradual rise of short-term rates. At times, short-term rates were even higher than the 30-year rates. This period underscores the significance of yield curve risk. While over 75% of the time, the yield curve moved in a parallel way, the U.S. rates are subject to multiple risk drivers. U.S. rates play a significant role in global markets. However, the Fed action impacts short-term rates, and therefore the short- and long- term rates may not move in tandem.

The use of Modern Monetary Policy may create inflation, which may raise long-term rates while the Fed seeks to keep short-term rates low. The yield curve may steepen as exhibited in the years before 2015.

In 2020, short-term rates and long-term rates may uncouple because they may not be perfectly correlated, moving in tandem, subject to different capital market forces. The chart clearly shows that short-term rates are more volatile than long-term rates.

The 2008 financial crisis resulted in the short-rate remaining low for five years; the experience suggests that the yield curve may steepen over time because of inflation, but the short- rates could remain low for more than five years.

Figure 1



While history provides us insight into the yield curve movements, balance sheet management must also be forward-looking, and not based solely on past experiences. The measure of rate volatilities plays an essential role in effective balance sheet management.

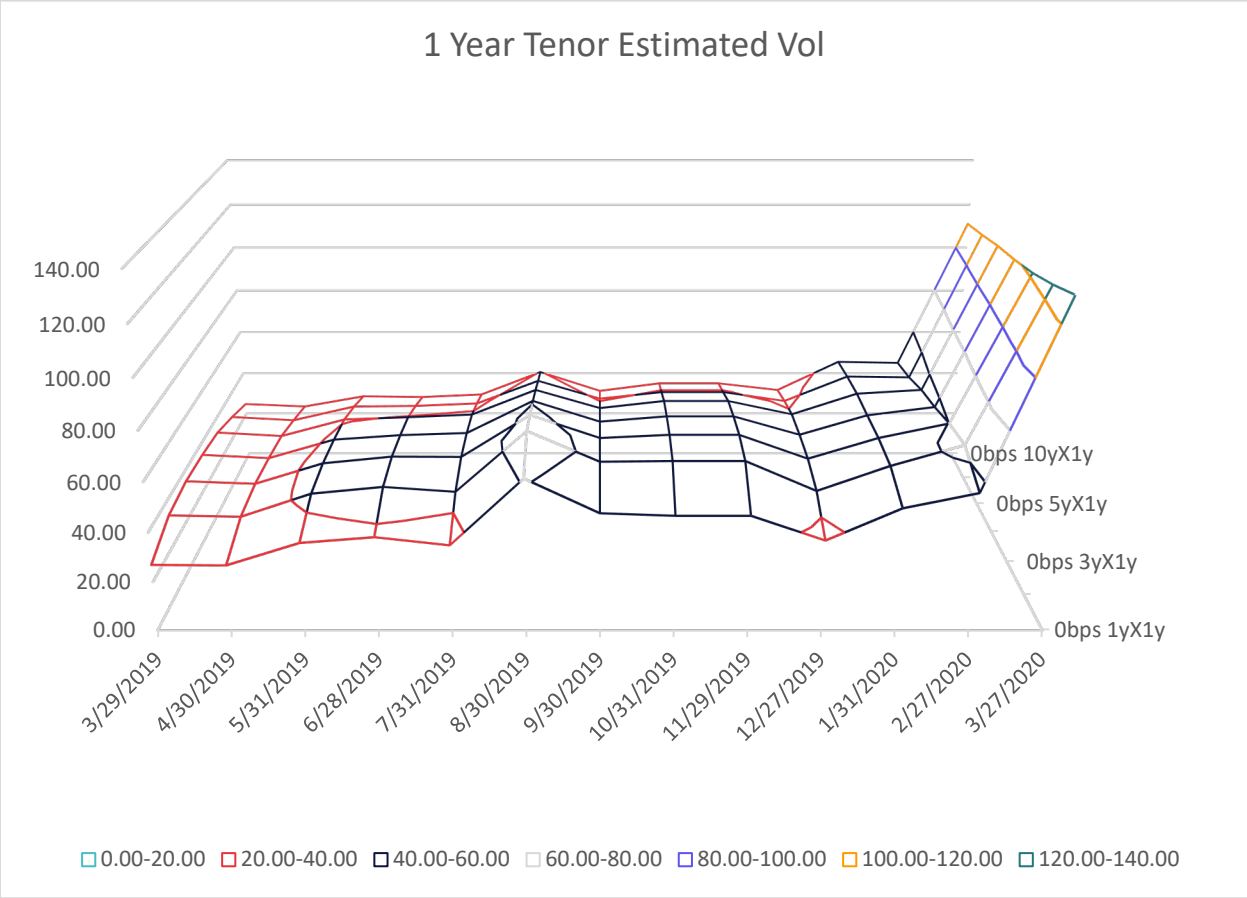
Term Structure of Volatilities

The capital market swaption and cap/floor prices (quoted in perceived percentage change in rates), as shown in Figure 2, provide balance sheet managers the ability to infer the market consensus of interest rate risk. Figure 2 shows the quoted prices of a swaption on the one-year swap rate over a range of time horizons. These prices are available from capital market trading desks.

The capital market consensus on future rate uncertainties is traded at these derivative prices. The higher the perceived uncertainty, the higher the derivative price. Therefore, these derivative prices provide

managers early warning signals via trading activities. The estimates provide transparency of the market participants' perception of interest rate risk.

Figure 2



The key rates of the yield curve have their specific volatilities, and those rates are also correlated. For this reason, Figure 1 is also extended to different key rates, not just the one-year swap rate. The combined prices of a range of terms and tenors is called the volatility surface.

An interest rate model should be specified to capture the market consensus on the perception of rate uncertainties for each key rate over a range of time horizons, such that the model valuation of balance sheet instruments is consistent with these market prices. The following results are based on the THC interest rate model.

The chart, Figure 3, below depicts the "implied volatilities" of the key interest rates, which are the 1, 3, 5, 10-year rates. The values are implied volatilities, as inferred by the THC interest rate models.

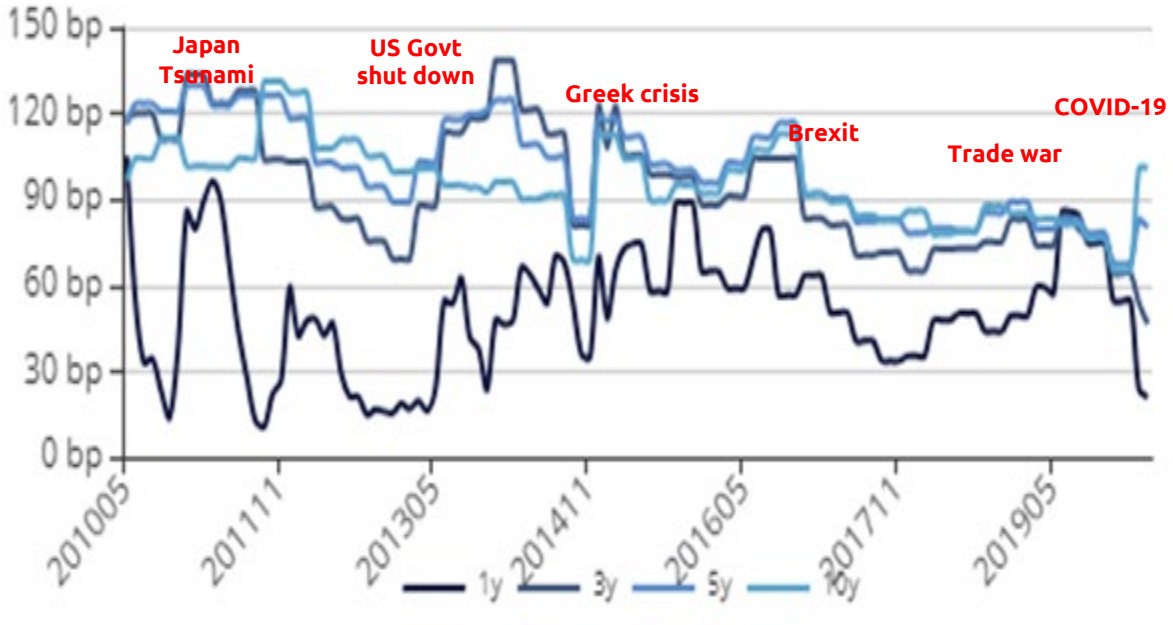
The chart shows that global events can significantly affect the capital market perception of rate uncertainties, demonstrating the usefulness of the implied volatilities model as a forward-looking tool to simulate possible rate shocks to the balance sheet:

- By comparing the one-year volatility trend to that of the ten year, the chart shows that the one-year volatility fluctuates more than that of the ten year. Hence, the 1- year vol is more volatile than the long-term vol. The results show that not only are the short-term rates more volatile (a reference to the chart above), but the vols are also more volatile. While news media often focuses on the uncertainty of global finance, the market considers the economy to be relatively stable in the long run. The Japan tsunami, the U.S. government shut down, the Greek Crisis, Brexit, the Trade War, and the COVID 19 crisis significantly impacted the short-term rates. Still, their impact on the long-term vol is relatively muted. For this reason, the term structure of volatilities (volatility for each key rate), as opposed to focusing on one key rate volatility, is essential to balance sheet management.
- Many balance sheet managers do not "trade" based on a short-term view. In particular, they often use short-dated options to hedge the mortgage prepayment risk. The chart below shows that the "hedge" is not valid on many occasions. Therefore, the Vols can provide valuable insight into the nature of market uncertainties.

The volatility is measured as one standard deviation (or the shift based on 34.1% probability) of the uncertain rate distribution. Consider the COVID 19 impact on market-rate volatilities. The 10-year rate volatility was 100 basis points. That means the chart suggests a 34.1% probability of a 100-basis point rate shift up or down over one year.

Note that the current short-term vols (4/2020) are low, around 27 basis point shift, but the perceived uncertainty can be interpreted as high because the short-term rates were only 20 basis points.

Figure 3



How, then, can "risk" be easily inferred when the risk measures depend on both the interest rate level and the market perception of uncertainties?

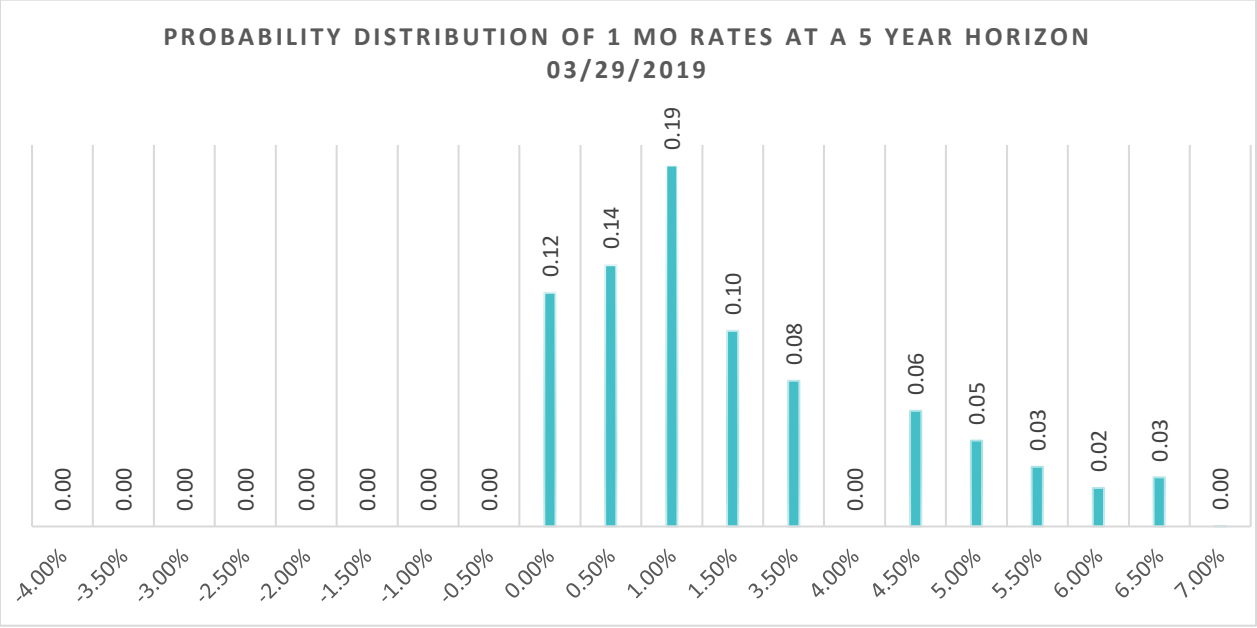
Interest Rate Distributions

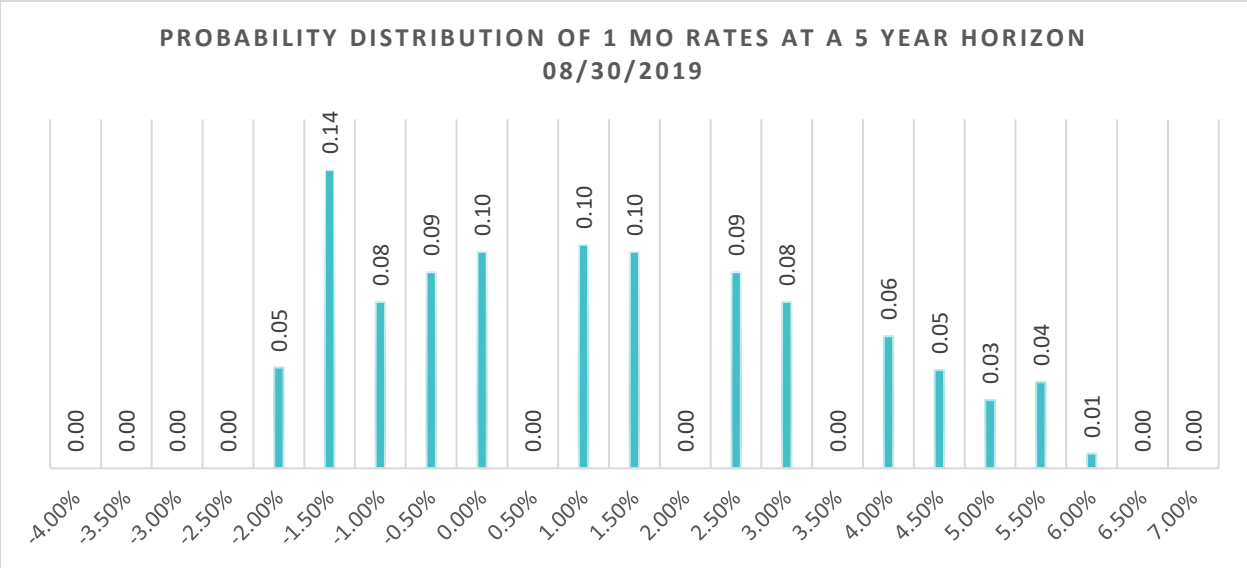
Risk is a probability distribution that should not be measured by volatility (the standard deviation) only. Instead, uncertainties should be described by a probability distribution. The use of a probability distribution to measure interest rate risk is particularly relevant today when rates are low and perceived rate uncertainties are high. What is the probability of rates falling, and how far can the rates fall? If the rates cannot fall too low, must the rates be perceived to rise significantly with a high probability? A complex probability distribution cannot be described solely by the volatility for valuation or risk management.

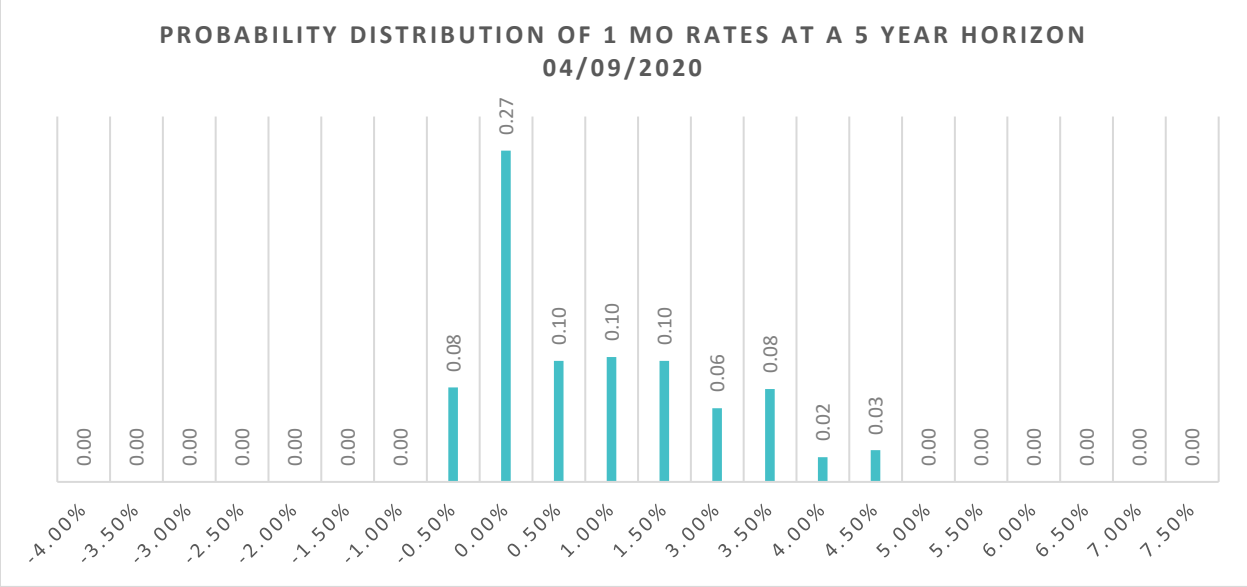
Let me review some of my earlier results, discussed in prior THC White Papers, where I presented some of the rate distributions over the past 12 months. The results show that these distributions, consistent with the prices of swaptions, do not follow any standard distribution. At times, the rates can be negative, but they do not fall too low. I highlight some of the observations below:

- In the last 12 months, including the height of COVID 19 uncertainties, the interest rates did not fall below -2%. The distributions do not gradually fall to -2%, but fall at an accelerated rate, with the left-hand tail of probabilities truncated. The results can be explained by capital market arbitrage. Investors can always deploy capital to alternative investments, such as putting funds in a safe-deposit box or equivalent, when rates are significantly negative.
- Rates can also rise depending on the capital market conditions. If there is a concern about an increase in inflation, then the probability distribution may show a longer tail on the high rate levels, reaching a high level of 6%.

Figure 4



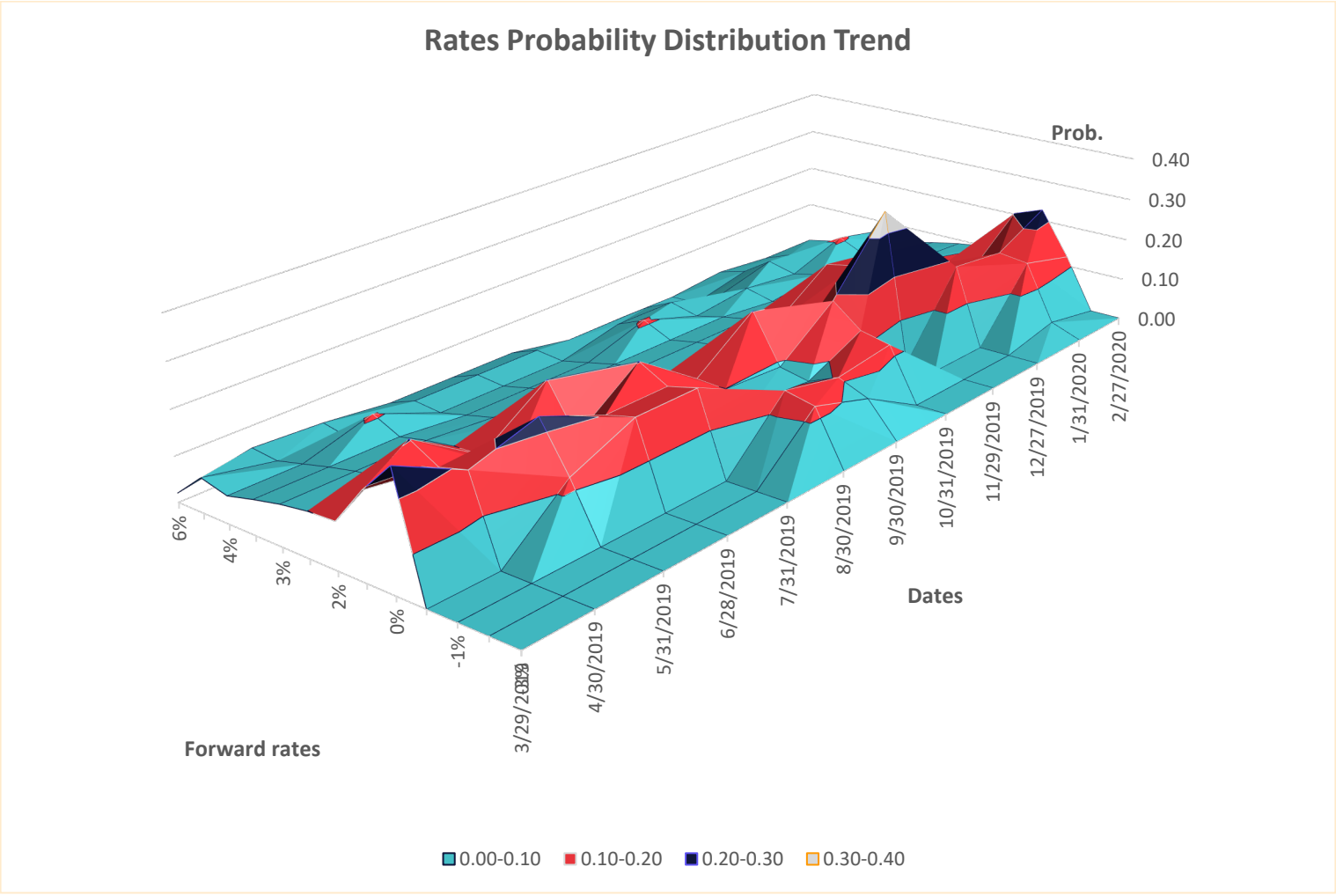




The chart, Figure 5, below depicts the changing shape of the probability distribution of the one-month rate over a 5-year horizon. The chart shows the dynamic nature of the rate probability distribution, which depends on multiple factors, such as the interest rate level, vols, and more.

- The probability distribution shapes continually change.
- Interest rates have not fallen to below -2%, and that is because investors have alternative investments when rates become significantly negative. Meanwhile, interest rates can rise above 6% in this sample period.

Figure 5



Implications

The results have many applications to balance sheet management. This section describes some examples.

- As interest rates have fallen in recent months, many bonds and loans are called or borrowings put. ALCO should anticipate the probability these balance sheet items will require re-investment or re-finance for liquidity, as well as profitability management. ALCO can determine the probability of the rate distribution, and hence the probabilities of involuntary changes in the projected cash flows. Such estimates enable management to manage their liquidity and profitability efficiently. By way of contrast, many community financial institutions tend to hold excess cash for the lack of appropriate cash flow projections.
- Stress testing using instantaneous shocks or determining earnings conditional, a particular set of yield curve movements is standard practice. However, these rate shock approaches fail to

identify the likelihood of the scenario. For example, when interest rates were 6%, a 300 bp shock may seem reasonable. But today, a 300 bp shock to the balance sheet would be overly conservative when interest rates are low. By estimating the rate probability distribution, the stress tests will have systematic guidance on the reasonableness of the size of a rate shock.

Conclusions

Today, the probability distributions of interest rates are dynamic and complex. Interest rate risk cannot be measured by a specific interest rate distribution, such as lognormal or normal. We must re-examine the financial models used today to manage the balance sheet to ensure that they can provide accurate and robust results in the current market conditions.

This paper shows that an interest rate model has to be consistent with the capital market pricing of a broad selection of benchmark securities and derivatives ("an arbitrage-free interest rate model"). Such a model can simulate what-if scenarios and provide an objective forecast of yield curve movements.