MARKET INSIGHTS

Floor It:

Market Pricing of the Lower Bound on Interest Rates

May 2019

D E Shaw & Co

Introduction

In the early 2000s, Japan was an anomaly. The Bank of Japan had lowered short-term interest rates to near zero percent, a policy stance that had not been implemented by any other major central bank for more than half a century. But even with that seemingly extreme policy response, the country's inflation stayed at uncomfortably low levels, and its economic growth remained stuck at an anemic pace. The rest of the world watched with concern, but most observers assumed that these challenges were specific to Japan.[1]

Since that time, the limitations faced by the Bank of Japan have become the dominant policy issue confronting major central banks throughout the world. Many of those central banks have spent the past decade probing the lower limits of nominal policy rates, given the difficulties they have faced in generating sufficiently strong economic growth and boosting inflation rates to targeted levels.

To be sure, the past decade was far from ordinary. The global economy suffered a tremendous blow from the financial crisis, and the resulting economic damage propelled central banks around the world into unusually accommodative policy settings. However, there were also important structural changes taking place at the same time that have continued to exert downward pressure on the neutral level of policy rates. Given those structural changes, confronting the lower bound on interest rates likely will be a recurring feature of the monetary policy landscape for many years to come.

Financial markets have failed to account fully for these fundamental changes in the policy environment. Adjusting to this environment is no simple task, since the lower-bound constraint introduces complexities into the determination of interest rates that result in considerably different distributions of rate outcomes than those produced by conventional models. Our analysis reveals that market pricing of interest rate outcomes still has a long way to go. Moreover, the potential implications extend well beyond interest rates, affecting a wider set of assets and the properties of investors' portfolios.

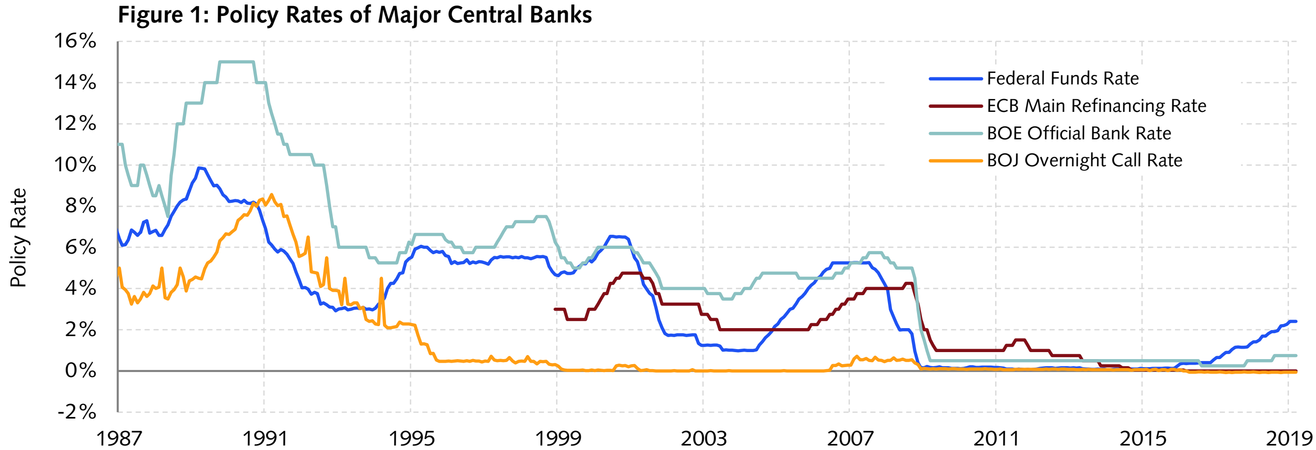
[1] Ben Bernanke, then a governor at the Federal Reserve Board, offered a useful account of the situation and its potential lessons in a well-known 2003 speech titled "Deflation: Making Sure 'It' Doesn't Happen Here."

Policy Challenges at the Lower Bound

Collectively, the policy rates of the Federal Reserve, European Central Bank, Bank of England, and Bank of Japan have spent 85% of the past decade at the effective lower bound ("ELB"), or the lowest policy rate that those banks perceived to be possible at a given time. As shown in Figure 1, this recent pattern contrasts with the history before that period, when only the Bank of Japan was pressed against that boundary for meaningful periods of time.

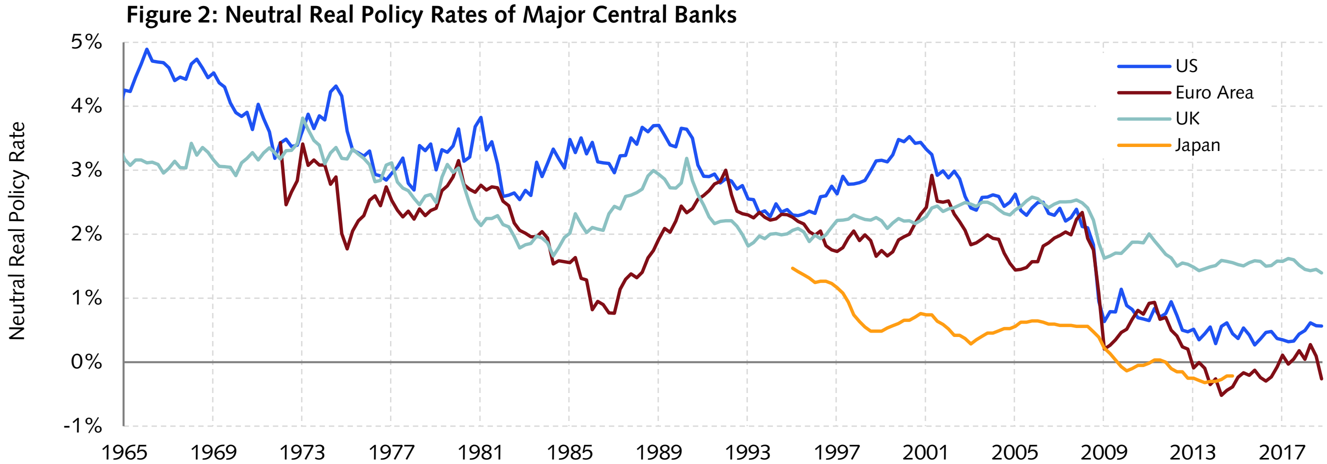
As noted above, the increasing relevance of the ELB constraint in part reflects important structural changes in the global economy. As shown in Figure 2, the neutral levels of inflation-adjusted (*i.e.*, real) policy rates appear to have moved substantially lower—a trend that has been taking place for some time but accelerated after the financial crisis.[2] The causes of the decline in the neutral real interest rate are not entirely understood, but slowing population growth and high savings rates in certain regions have likely contributed to this pattern. The current level of the neutral real policy rate for the United States, at just below 1%, corresponds to a neutral nominal rate of

Figure 1: Policy Rates of Major Central Banks



ECB rate information is shown since the ECB began conducting monetary policy operations in 1999.
Sources: U.S. Federal Reserve, Bank of England, European Central Bank, and Association of Call & Discount Companies/Nikkei.

Figure 2: Neutral Real Policy Rates of Major Central Banks



U.S. rates based on the Laubach-Williams measure; Euro Area and U.K. rates based on the Holston-Laubach-Williams measure; Japan rates based on the Imakubo-Kojima-Nakajima measure for 2-year neutral rate of interest. Japan rates presented with respect to periods of available data only.
Sources: Federal Reserve Bank of New York; Bank of Japan.

[2] The neutral policy rate is defined as the interest rate consistent with an economy at full employment and inflation at its targeted level over the medium term, in the absence of additional shocks to the economy.

just below 3% if we take into account the Federal Reserve's inflation target of 2%.

The implications of the ELB for financial markets will depend critically on the policies that central banks implement in response to these circumstances. One immediate question is obvious: why do central banks not simply push policy rates lower? The answer to this question is not simple, but it stems in part from the public's ability to hold physical currency that earns 0% interest, as well as from the reluctance of the official community to allow retail bank deposit rates to turn negative. Thus, even in the face of economic shocks that might otherwise warrant a deeply negative policy rate, central banks generally have not viewed such a response as feasible.[3]

Central banks therefore have been left looking for other approaches to promote more accommodative financial conditions. The most widely discussed option has been quantitative easing ("QE"), which over the past decade has become an active policy instrument for many central banks. The extent to which QE can substitute for the traditional rate policy instrument is a matter of extensive debate. In any case, it is likely not a perfect substitute, and hence central banks bound by the ELB still face an environment in which they are unable to ease rates sufficiently.

When faced with that scenario, central banks typically compensate for their inability to lower the policy rate further by keeping it at the ELB for a longer period of time and by subsequently maintaining a lower policy rate than they otherwise would. That is, they substitute "longer" for "lower." This substitution turns out to be an effective policy approach in many economic models.

Modeling Alternative Policy Paths at the Lower Bound

To further explore the low-for-longer approach, we introduce an economic model. Our goal is to capture the interactions between economic developments and monetary policy in the United States in a relatively simple structure. Specifically, we consider a model with the following three components:

1) an equation that determines the unemployment gap—the level of the unemployment rate relative to its sustainable level—as a function of the real short-term interest rate, to capture the effects of monetary policy on the business cycle (an investment/savings or "IS" curve, written in terms of the unemployment gap);
2) an equation that determines the rate of inflation as a function of the unemployment gap (a Phillips curve); and
3) an equation that determines the setting of the policy rate in light of the unemployment gap and the inflation rate (a monetary policy reaction function for the Fed).

In specifying these equations, we assume that the U.S. neutral nominal policy rate is just below 3%, consistent with the most recent reading shown in Figure 2. We allow the equations to be subject to shocks that produce the type of fluctuations observed historically for the U.S. economy, including a set of shocks calibrated to match the dynamics observed when the economy entered a recession.

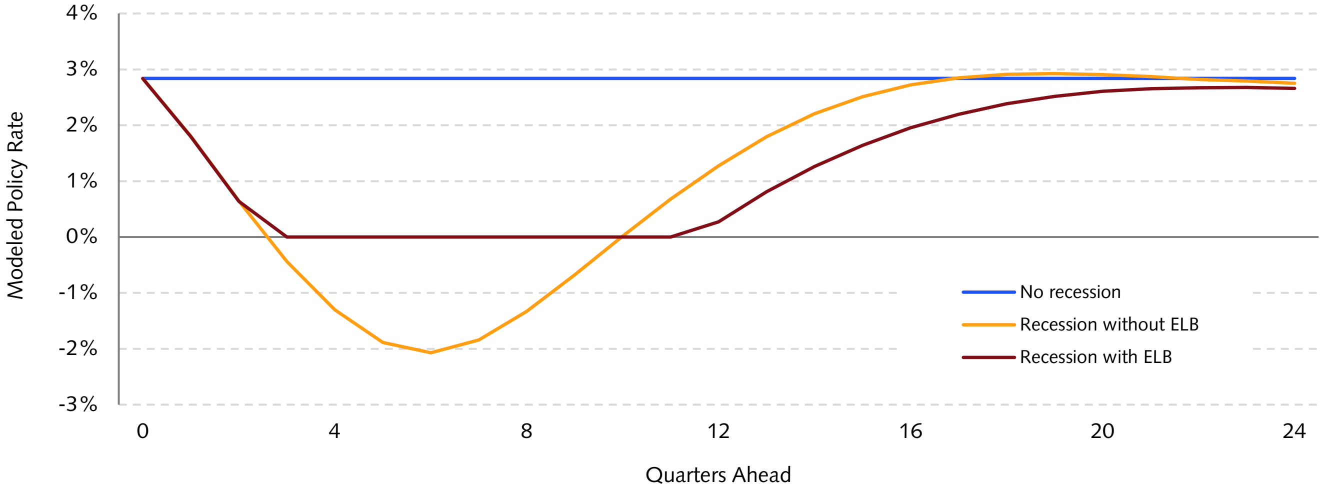
The constraints that arise from the ELB can be seen in this model by looking at how the Federal Reserve tends to respond to the arrival of these "recession shocks." We assume that the economy begins in its steady state—with the unemployment gap at zero, inflation at target, and the policy rate at its neutral level—and is then subject to recession shocks.

Left unconstrained, the standard response of the Fed would be to cut the federal funds rate to -2%, as shown by the orange line in Figure 3. Of course, the central bank cannot follow that path because of the ELB constraint. But an alternative policy path that lowers the policy rate to 0% and keeps it there for longer, as shown by the red line, appears to return the economy to full employment nearly as quickly. This alternative path does not begin to tighten policy until more than a year later than the unconstrained path, and it also maintains a lower rate profile thereafter.

One way to interpret these results is to consider that the integral of the deviation between the policy rate and its

[3] Some central banks have pushed short-term nominal rates into negative territory, but none have solved the ELB problem and reached the deeply negative rates that could prove beneficial in some circumstances. The lowest policy rate setting has been -0.75%, which was implemented by the Swiss National Bank in 2015. A number of proposals have been made to allow interest rates to become deeply negative even in the presence of physical currency (see, for example, Miles Kimball, "Breaking Through the Zero Lower Bound," IMF Working Paper, 2015), but none has been implemented to date.

Figure 3: Modeled Policy Paths for the Fed in Recession Scenarios



The graph above shows hypothetical median policy responses from 100,000 simulations of the economic model described in this section, using the three types of recession assumptions shown. The neutral level shown here is slightly higher than that from Figure 2 because it is conditioned on the realization of shocks that occur during expansions.
Source: The D. E. Shaw group.

neutral level (that is, the area enclosed between the orange or red line and the blue line) is what restores economic activity after a negative shock. Our model indicates that, when confronted with the inability to ease rates to the extent desired in the presence of the ELB, a central bank will instead maintain a lower rate setting for a longer period in order to deliver the same aggregate amount of stimulus to the economy.[4] The results of these simulations suggest that the policy rate will remain at the lower bound for more than two years after recession shocks occur, and possibly longer if additional negative shocks are realized.

Financial Market Pricing of the Lower Bound

This policy approach at the ELB suggests that the probability of short-term interest rates being pinned at the lower bound is sizable—much higher, it turns out, than is currently priced into financial markets.

The dynamics that lead to this outcome are straightforward. When recession shocks are realized, they drive the policy rate to the lower bound and, because of central banks' inability to ease further, the policy rate remains there for several years. As a result, the probability of being at the lower bound at any point in the future is determined by the cumulative probability that recession shocks occurred in any quarter over the preceding several years.

This "accumulation effect" is notable. In order to calibrate it, we need to assume an arrival rate for recession shocks. We think a reasonable starting point is the observed average frequency at which a set of major economies has entered into a recession in a given quarter, conditional on being in an expansion, which has run at a 10% annualized rate since the mid-1980s.

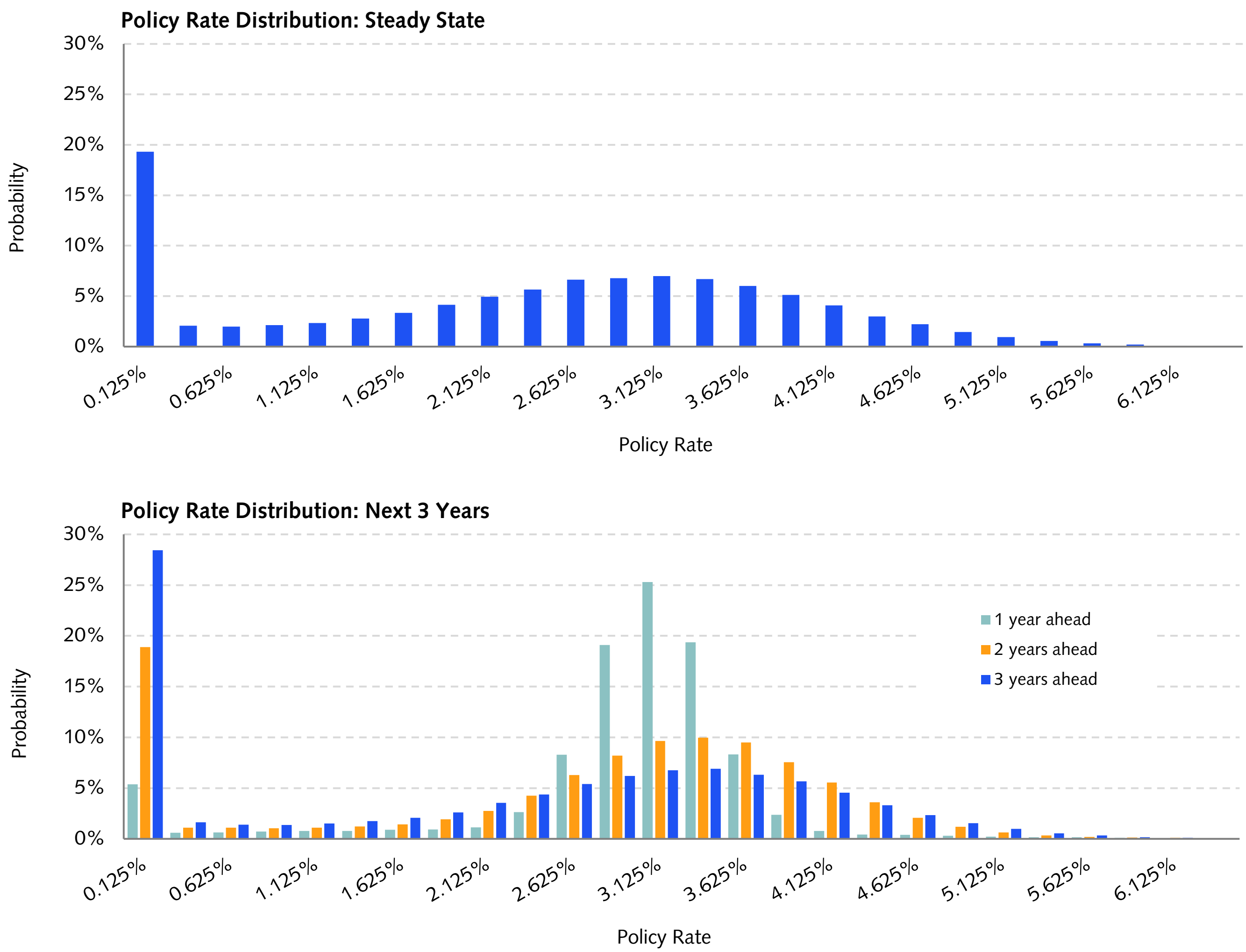
With that arrival rate, the steady-state distribution of policy rate outcomes ends up having significant mass at the lower bound, as shown by the leftmost bar in the upper panel of Figure 4. In fact, under this model, there is a one-in-five chance that the policy rate will be pinned against the lower bound in any given quarter in the future.

[4] The argument for "longer" is even stronger if one takes into account the forward-looking behavior of economic agents. In that case, if a central bank communicates its intentions to keep rates low for a longer period, it can achieve immediate effects on longer-term rates and financial conditions that will deliver stimulus to the economy. This argument is the primary rationale for the use of forward guidance by central banks.

The distribution of outcomes has a strongly bimodal shape, as policy will tend to be near its neutral level (or slightly above it) during non-recession periods and will be stuck at the ELB during recessions and in their wake.[5]

The modeled distribution over the next few years should also incorporate the currently heightened probability of recession perceived by financial market participants. The lower panel of Figure 4 shows policy rate distributions at horizons of one to three years when we calibrate the arrival rate of recession outcomes to match a recent survey.[6] The lower tail at a one-year horizon is relatively small because the accumulation of recession odds does not have long to build, but it quickly grows at horizons of two and three years.

Figure 4: Modeled Distributions of the Policy Rate



The graphs above show hypothetical future policy rate distributions based on 100,000 simulations of the model referenced in this section, incorporating the survey-based arrival rate of recession outcomes described above.
Source: The D. E. Shaw group.

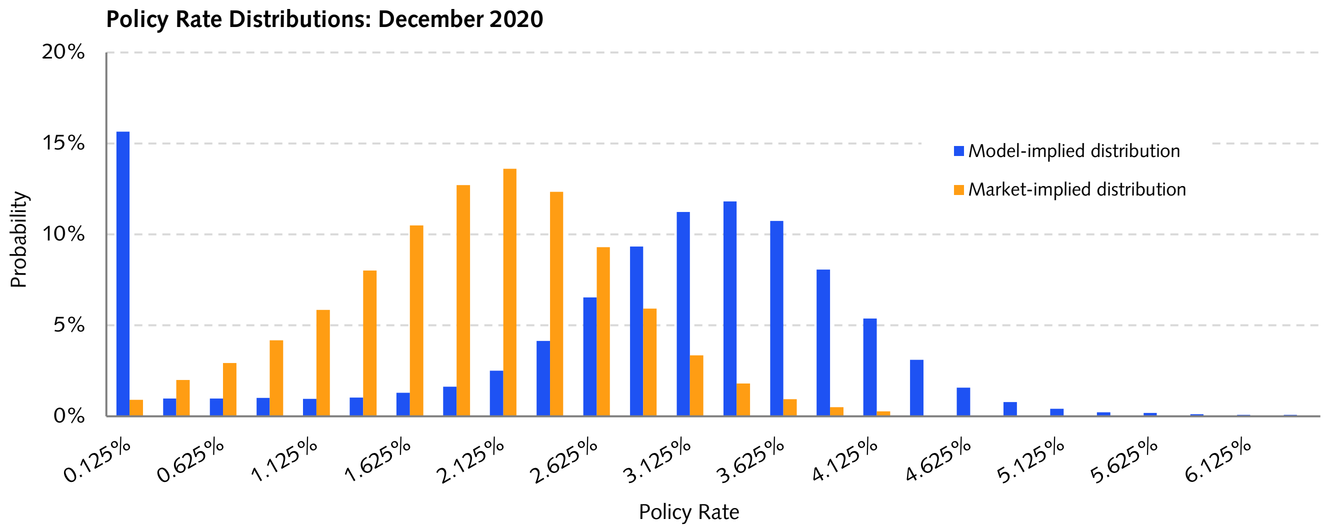
[5] This shape is not specific to the model used here. A similar result is obtained in a paper by Michael Kiley and John Roberts, using two more sophisticated models: the Fed's large-scale economic model (FRB/US) and a dynamic stochastic general equilibrium model. Those two models show that the policy rate under a typical monetary policy rule would spend 32% and 17% of the time at the ELB, respectively, when the neutral real policy rate is 1%. (See Table 2 from "Monetary Policy in a Low Interest Rate World," Brookings Papers on Economic Activity, 2017.)

[6] Specifically, we use the median response for recession probabilities through 2020 from a survey conducted by the National Association of Business Economists (NABE) in March 2019. The perceived probabilities of a recession beginning in 2019 and 2020 were 20% and 15%, respectively. Thereafter, we assume that the arrival rate for recessions steps down to the 10% rate that we assumed in the steady state.

Market pricing does not imply anything close to this bimodal pattern for short-term interest rates. Figure 5 shows the distribution for the policy rate in December 2020 that is implied by swaptions expiring at that time (adjusting for the basis between the swap rate and the policy rate).[7] As shown below, the market appears to be pricing a distribution of outcomes for the short-term rate with a shape much closer to what one might expect when rates are not near the ELB, rather than the bimodal shape that arises in the presence of the ELB constraint, as indicated by our economic model. According to our model, the market is substantially understating the probability of rates ending up at the lower bound.

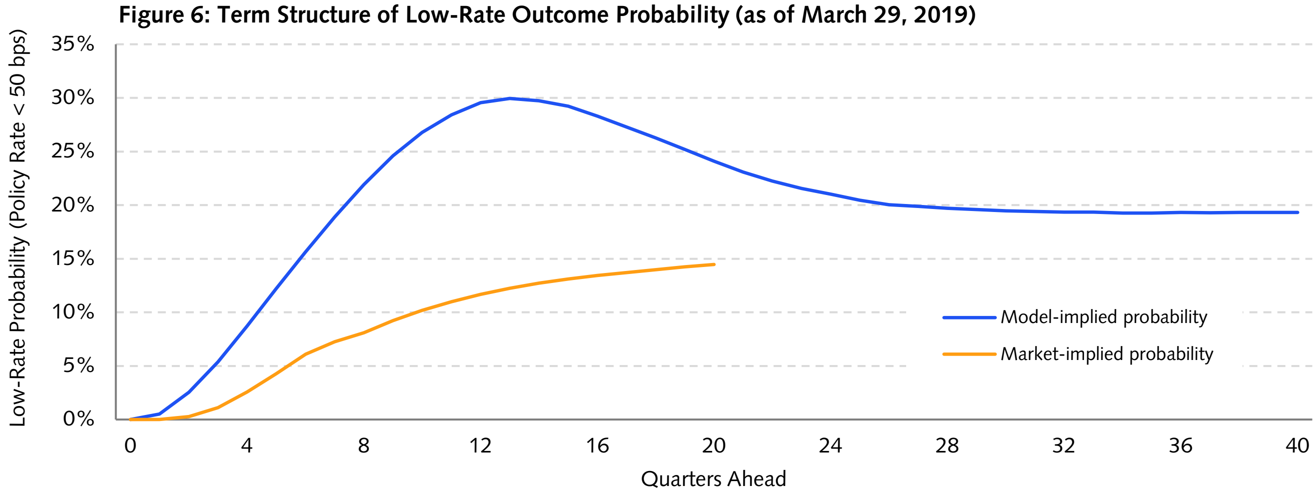
This difference in the probability of low-rate outcomes is apparent across a range of horizons, as shown in Figure 6. The probability of low-rate outcomes in our model (the blue line) rises rapidly as a result of the accumulation effect for recession odds discussed above. This modeled probability reaches relatively high levels over the next several years given the elevated recession probabilities perceived by market participants, before settling to a

Figure 5: Comparison of Model- and Market-Implied Policy Distributions (as of March 29, 2019)



Sources: The D. E. Shaw group; Barclays Capital Inc.; portions used with permission of Bloomberg.

Figure 6: Term Structure of Low-Rate Outcome Probability (as of March 29, 2019)



Sources: The D. E. Shaw group; Barclays Capital Inc.; portions used with permission of Bloomberg.

[7] The calculation is based on swaptions tied to a 1-year LIBOR-based swap rate beginning in December 2020 and assumes risk-neutral pricing.

steady-state level of approximately 20%. In contrast, the market prices a much flatter term structure of low-rate probabilities (the orange line) over the next five years.[8]

Overall, this simple economic model suggests that the distribution of probable policy rate outcomes in the United States looks very different from what would be obtained based on historical norms, given the close proximity of neutral rates to the ELB. That contrast is likely to be even more dramatic for the Euro Area and Japan, as their economies face even lower levels of neutral policy rates and have policy settings that are already pressed against the lower bound.

Broad Implications for Financial Markets

Monetary policy has become a more complicated process, as central banks contend with a significant constraint on their ability to adjust policy. This constraint is a focal point of policy discussions among central banks around the world, and it deserves just as much attention in our analysis of financial markets. The effects on asset prices can be substantial, and a new framework is needed to calibrate them properly.

In our view, markets have not fully adjusted to this new reality. In terms of first-order effects, traditional models that have been used to assess the front end of the yield curve should be discarded, including those that assume that short-term interest rates will have a normal-shaped distribution of outcomes. Instead, market participants should adapt their models in ways that allow for extended periods at the lower bound and the considerable probability of low-rate outcomes at any point in the future.

But the implications of this argument extend well beyond the front end of the yield curve. The path of short-term interest rates determined by a central bank, along with the bank's ability to influence the course of the broader economy, is deeply intertwined with the determination of prices across a broad set of assets.

Tracing the extent of these broader effects is beyond the scope of this paper, but consider the following possibilities:

- Markets may need to price in greater risk of the economy remaining weak and inflation remaining low for long periods after significant downturns in asset prices or economic conditions. That could push the average level of yields lower, by even more than observed to date, if the market sees larger and more persistent effects from those shocks.
- We previously argued that the term premium, especially at shorter maturities, tends to be negative as a result of favorable correlation properties of rates with risky assets.[9] That correlation arises primarily from the policy responses of central banks to shocks to aggregate demand or investor risk preferences. If those responses now extend farther into the future—because the central banks substitute "longer" for "lower"—they could push that negative term premium out to longer maturities.
- The downside risk to equities and other risky assets might be greater than historically observed. The ability to lower policy rates in response to shocks that pressure risky assets provides an important buffer that limits such assets' ultimate movement. To the extent that the capacity to ease is constrained, this buffer is impaired, allowing for sharper declines in those asset prices.
- Currencies could more frequently move in ways that seem counterintuitive. Without the ELB constraint, a shock that weakens an economy and lowers inflation prospects would typically weaken a currency, as the central bank would ease policy in response. However, if the central bank cannot fully respond, real interest rates might actually rise after a negative shock, which could lead the currency to strengthen.

Until we return to an environment in which policy rates can move up and down freely, financial markets will have to adapt to this important constraint. The macroeconomic research community has engaged this topic with vigor, and financial market participants are also paying close attention. Nevertheless, we feel that financial markets are still some distance from pricing in the full extent of the ELB constraint.

[8] This contrast remains stark even though the market's pricing-in of low rates has increased meaningfully over the past several quarters. A similar chart from the middle of 2018 would show an even larger gap between probabilities implied by model results and market pricing.

[9] For a discussion of the negative term premium based on the correlation of rates to equity prices, please see our February 2019 paper, "Positively Negative: Stock-Bond Correlation and Its Implications for Investors."

D E Shaw & Co