Did Quantitative Easing Work?

Did QE lower yields and stimulate the economy? What about risks? Weighing the evidence requires a bit of theory.

BY EDISON YU

As the economy began to falter amid the financial crisis in the fall of 2007, the Federal Reserve responded in the usual fashion by lowering its short-term interest rate target. But by the end of 2008, with short-term rates down to virtually zero and the economy and financial system still in trouble, the Federal Reserve adopted an unorthodox program known as quantitative easing (QE) that sought to directly lower long-term interest rates and thus stimulate the economy. To carry out QE, the Fed embarked on three rounds of purchases of long-term securities that increased its balance sheet more than fourfold, to about $4.5 trillion in 2015. As we will see, economic theory tells us that long-term rates are mainly determined by what investors expect short-term rates to be in the future. So why did policymakers think they had a shot at lowering long-term rates when short-term rates were already as low as they could go? As former Fed Chairman Ben Bernanke quipped in 2012, "Well, the problem with QE is it works in practice, but it doesn't work in theory." So what is the theoretical reasoning behind QE? Did QE lower long-term yields? Did it actually stimulate the economy? And what does the evidence so far say about the costs of the Fed's unprecedented accumulation of assets?

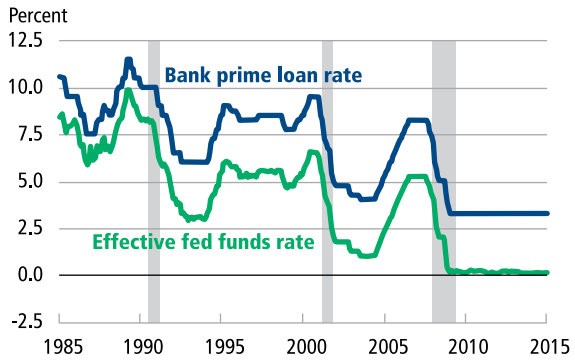
WHY QE?

The federal funds rate — what banks pay each other to borrow funds overnight — is the conventional tool that the Fed uses to conduct monetary policy. The Fed typically raises it to prevent the economy from expanding so quickly that it stokes inflation and lowers it when the economy is weak. A lower federal funds rate reduces banks' costs, which then leads other market interest rates, such as bank prime lending rates and mortgage rates, to fall as well, which lowers the cost of capital for firms and households and thus stimulates borrowing and hence the economy (Figure 1).

FIGURE 1

Lower Funds Rate Lets Lenders Charge Less

Federal funds rate and bank prime rate over time.



Source: Federal Reserve Board of Governors.

But when the federal funds rate hits what economists call the *zero lower bound*, the Federal Reserve cannot further stimulate the economy by cutting interest rates. In theory, the nominal interest rate cannot go below zero because cash pays zero interest. If the federal funds rate were set below zero — that

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is, if banks had to start paying interest on the cash they lend to other banks — banks could get around that cost by simply holding onto the cash, rendering the negative interest rate policy ineffective. In practice, economists and policymakers have recently been surprised to find that even market interest rates can go negative, likely because storing cash can be costly and risky.[1]

By December 2008, the Federal Open Market Committee (FOMC), the Federal Reserve's policymaking arm, had lowered the federal funds rate from 5.25 percent in September 2007 to virtually zero — around 10 basis points. Yet, the economy continued to contract dramatically, the unemployment rate shot up, and the financial crisis was in full force. Policymakers were concerned that the U.S. economy could fall into a *deflation spiral*, in which a contracting economy causes prices to fall, which causes consumers and firms to hold off even more on spending in anticipation of yet-lower prices, which further depresses the economy. But with the federal funds rate already at zero, the Fed faced a conundrum. What could it do in the face of persistent weakness in the economy? Japan's "lost decade" of the 1990s, marked by slow economic growth, stagnant wages, and periods of deflation, convinced U.S. policymakers that quick, unconventional action was needed to counter the crisis. Indeed, in his 2004 article and 2009 remarks, Chairman Bernanke had argued for Japan to adopt an aggressive QE program to combat deflation. In an attempt to get around the zero lower bound, the Federal Reserve started to purchase large quantities of Treasury and mortgage-backed securities (MBS) of longer maturities (Figure 2).

Unlike the conventional monetary tool, which has been studied extensively, quantitative easing triggered a contentious debate on the theory and mechanism through which it should work and, for that matter, whether it would work at all. Indeed, economic theory predicts that in a perfect, *frictionless* market, QE should have very little effect.

WHY SHOULDN'T QE WORK?

With the short-term interest rate at zero, QE is intended to lower rates at the longer end of the *yield curve*. To understand why this approach was theoretically problematic, it will help to first understand the yield curve. U.S. government bills and bonds of various maturities pay different interest rates. This spectrum of rates (or yields) from the shortest (overnight) to the longest (usually 30 years) is known as the *term structure* of interest rates.[2] The yield curve is simply a graphical representation of the term structure of interest rates.

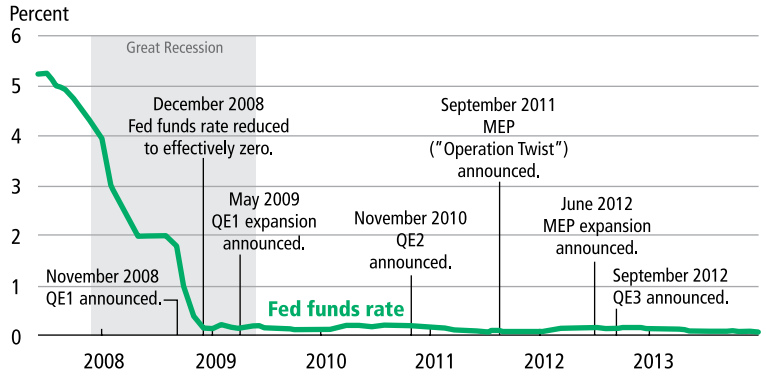
The yield curve can take different shapes. It can slope upward, as on July 21, 2015, with yields for longer-maturity Treasuries being higher than those for shorter-maturity Treasuries (Figure 3). Infrequently, it can also slope downward, as was the case on August 8, 2007, when three-month Treasuries carried higher interest rates than 10-year Treasuries (Figure 4). So what determines the shape of the yield curve?

Investor expectations determine the term structure. Under ideal conditions, the *no-arbitrage condition* stipulates a relationship between short-term and long-term interest rates on securities of comparable credit quality. Think of a world in which investors — whom we will call arbitragers for reasons that will become clear — are risk neutral and are willing and able to buy or sell any security in unlimited quantities as long as they expect the trade to be profitable.[3] Even though real-life investors — think of Wall Street traders — don't have unlimited amounts of money to invest or assets to sell and have limits as to how much credit or inflation risk they care to take on, the no-arbitrage condition provides a useful benchmark for understanding how the shape of the yield curve is determined.

For example, if our arbitrager sees that a three-month Treasury note yield is "too low" compared with the yield on a 10-year Treasury bond, the trader will keep buying 10-year bonds (lowering the yield on the bond) and selling three-month notes (raising the yield on the note) until it is no longer profitable to do this

FIGURE 2

Timeline of the Fed's Quantitative Easing Program

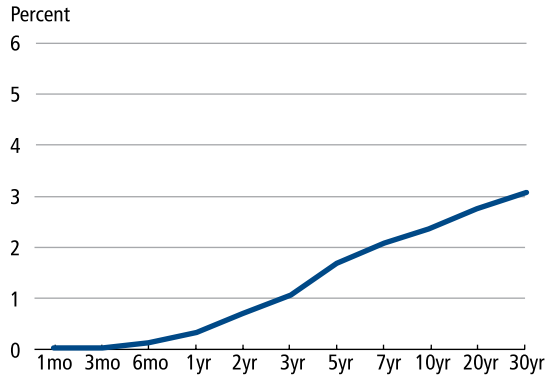


Sources: Congressional Research Service, Federal Reserve.

FIGURE 3

The Yield Curve Typically Slopes Upward

Treasury yields across maturity spectrum on July 21, 2015.

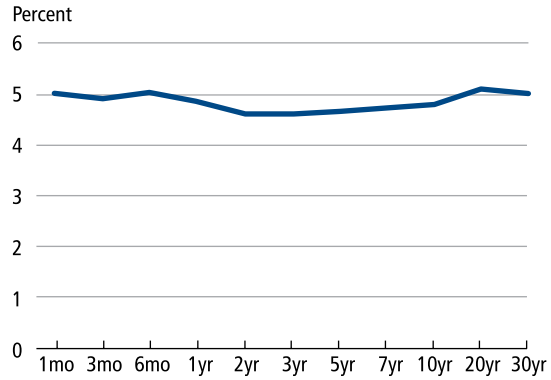


Source: U.S. Treasury.

FIGURE 4

Downward Slope Ahead of Great Recession

Treasury yields across maturity spectrum on August 8, 2007.



Source: U.S. Treasury.

trade. So in theory the two yields equal out, so to speak. After all, why would someone pay more for a 10-year bond than they would to continually roll over three-month notes? As we will see, real-life circumstances might create exceptions to this logic, but only fleetingly.

Thinking about this for a moment, this logic says that the yield on a 10-year Treasury bond will just equal the average of the yields on three-month notes over the next 10 years — that is, the yield on the current three-month note, the yield on a three-month note purchased three months from now, then six months from now, etc., all the way through the next 10 years. So, for this example, the yield curve would be upward sloping if the future interest rate on three-month notes is higher than the current interest rate on three-month notes and downward sloping if the future interest rate on three-month notes is lower than the current three-month rate. Of course, investors don't really know what the rate on a three-month Treasury note is going to be in three months, but they can form expectations of this rate. And these expectations can be measured by forward rates. In the market, investors can obtain these future short rates by buying forward interest rate agreements, which are customized contracts that specify the interest rate to be paid or received on a future date.

For example, an investor can enter into a forward rate agreement with a counterparty in which, in two years, the investor will receive a fixed rate of 5 percent for one year on a principal of $1 million. In other words, at the end of the two years, regardless of the prevailing market interest rate at that time, the investor will lend the $1 million to the counterparty for one year and get the 5 percent interest that was fixed by the forward contract. In these contracts, the fixed rate that investors will receive reflects their expectations about future rates. So, to adjust our previous claim slightly, the yield on the 10-year Treasury bond must equal the average of the *expected* yields on three-month Treasury notes over the 10-year horizon. Going back to our yield curve examples in Figures 3 and 4, the upward sloping yield curve on July 21, 2015, suggests that investors expected short-term rates to increase in the future, while the downward sloping

When No Arbitrage Holds

For the purposes of this article, *arbitrage* is the practice of taking advantage of differences in the market prices of investments to earn risk-free profits. An arbitrage strategy usually involves buying or selling a combination of securities to generate a positive cash flow without risk.

For example, say the same security is listed at the same time on two different stock exchanges in two countries at two different prices. An investor can take advantage of this discrepancy by buying the security at the lower price and then selling it at the higher price to make a riskless profit.

When market prices do not allow for profitable arbitrage, they reach the *no-arbitrage* condition. In practice, profitable arbitrage is rare. For our example, prices of the same security are usually the same across all exchanges, taking into account transaction costs. Investors' risk aversion and capital constraints, as well as market frictions such as transaction costs and market segmentation, make a risk-free arbitrage difficult to pull off.

yield curve on August 8, 2007, suggests that investors expected the economy to weaken and interest rates to therefore fall in the future.

In this theoretical world, long-term rates are *completely* determined by investors' expectations of future short-term rates. This is called the *expectations hypothesis*. So if the Fed hoped to lower long-term rates by buying long-term securities without somehow lowering investors' expectations about future interest rates, arbitragers would simply do the opposite — that is, buy short-term securities and sell long-term securities — and the yield curve would not change.

In addition, investors demand a term premium. Now let's add a touch of realism to the model. Economists have long noticed that the yield curve has a systematic tendency to be more upward sloping than can be explained by investors' expectations about future rates. As we've seen in Figure 4, this doesn't mean that the yield curve always slopes upward, only that it tends to do so even when investors don't expect interest rates to rise.

The most straightforward explanation for this bias is that investors are not risk neutral. Instead, they tend to prefer less risky investment strategies. In particular, they worry: "What will happen if I am forced to sell my 10-year bond before it matures?" Here's the concern: If interest rates rise, the price of a 10-year bond falls, and vice versa if interest rates fall. If the investor needs to sell the bond in, say, year seven, he will take a loss if interest rates have risen in the interim. This means that a risk-averse investor will demand a higher interest rate as compensation for bearing this risk.[4] Longer-maturity bonds suffer larger price swings for the same change in interest rates, so risk-averse investors will demand more compensation for longer-maturity bonds, consistent with the empirical bias toward an upward slope in the yield curve. Economists refer to this compensation as a *term premium*. The size of the term premium reflects the expected volatility of the interest rate — because higher rate volatility increases the likelihood of large bond price swings — and the degree of investors' risk aversion. On the face of it, it is not immediately obvious that the Fed's bond purchases would affect either of these factors.

The expectations model, supplemented by a term premium model, makes up the "theory" that Bernanke was referring to. Traditional theory has held that the shape of the yield curve is determined by investors' expectations about the path and volatility of future interest rates and by investors' degree of risk aversion. According to this theory, buying large quantities of long-term bonds should not affect long-term bond rates except to the extent that these purchases somehow affect either expected future rates or investors' degree of risk aversion.

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WHY MIGHT QE WORK?

QE may affect expectations about future rates. One way for the Fed to affect long-term interest rates is to announce that it will hold the fed funds rate at zero for a long period, an example of *forward guidance*. As long as investors believe that the Fed will do as it says, then long-term rates will fall via the expectations channel. But what does this effect have to do with QE?

Some economists have argued that amassing a large portfolio of securities might help commit the Fed to carrying out its announced policy. According to this argument, investors might worry that the Fed will raise the fed funds rate if the inflation rate rises even slightly above the Fed's 2 percent target, thereby breaking its promise to keep rates low. If investors think this way, the Fed's announcement would not lower long-term rates because investors wouldn't find it credible. According to this view, the Fed might need some way to convince investors that the Fed is willing to keep interest rates low even if inflation moves somewhat above target. They have argued that QE might make the Fed's promise to hold rates low for a long time more credible, making QE a *signaling mechanism*.[5] While this is possible, the precise connection between amassing a large balance sheet and making credible commitments is complicated and hard to pin down.

Markets may be *segmented*. One implication of the no-arbitrage condition is that the supply of securities with particular maturities should not matter for the shape of the yield curve. However, when markets are segmented, bonds of different maturities are no longer perfect substitutes, the

no-arbitrage condition does not hold, and the supply of particular maturities can affect their yields.[6] As an example of market segmentation, life insurance companies like to hold longer-term bonds because their liabilities, such as annuity payouts, are also longer term. When QE reduced the supply of long-term bonds, their price increased and their yield fell.

Why wouldn't arbitragers undo the difference between the yields on long-term and short-term bonds, as dictated by the no-arbitrage logic? The assumption that investors can buy or sell unlimited amounts of securities does not hold in reality; it is a simplification to help economists isolate the factors affecting the yield curve. In reality, a host of factors — especially limited financing — restricts the size of the positions that investors can take. Real-life arbitragers typically rely on investors or the firms that employ them for the funds to finance their position. The sources of finance are not unlimited, and investors are not infinitely patient. So an arbitrager might not have enough financing or time to complete an arbitrage, even it is well founded. For example, the life insurance industry is a large player in the bond market. Arbitragers might not have sufficient capital to complete an arbitrage if long-term rates are lower than expected short-term rates (taking into account the term premium), or their sources of finance may dry up if investors are too impatient to wait until the arbitrage is completed. So when the Fed buys long-term Treasuries, the long-term yield can be lower — and stay lower — than what would be expected by rolling over short-term securities.

Portfolio effects may be important. QE can also affect the term premium by reducing the overall risk tolerance of investors — the *duration risk channel*. QE entered the market by reducing the quantity of riskier long-term assets — Treasury bonds and MBS — held by private investors and increasing the amount of safer assets such as short-term Treasuries. This shift reduced the total amount of risky assets investors held, and their portfolios become safer. As a result, investors may have required less compensation to hold risky bonds and were more willing to tolerate the duration risk of long-term bonds. This effect may have lowered the risk premium on long-term bonds.

EMPIRICAL EVIDENCE OF THE EFFECT OF QE

These three channels — expectations, segmented markets, and lower duration risk — explain why QE can work when we deviate from the no-arbitrage condition. But what does the evidence say? As I will show, the evidence so far suggests that QE did significantly lower long-term rates in the short run, and there is some evidence that QE worked over the longer term, also.

One way to measure the effect of QE is through an event study. That is, we can examine the changes in interest rates of Treasuries of different maturities right after QE announcements. For example, the 10-year Treasury yield dropped 107 basis points two days after the announcement of QE1. Economists have made plausible arguments for using a wider window to examine the announcement effect. Depending on the length of the event window and the methodology used, estimates of the reduction in long-term U.S. rates range from 90 to 200 basis points.[7]

Evidence for the signaling effect. First, QE may have changed investors' expectations about future federal funds rates through the signaling effect. As mentioned before, forward rates reflect investors' expectations of future short rates. Over a two-day window around the announcement of QE1, the expected federal funds rate fell, indicating that QE1 lowered investors' expectations of future short-term interest rates.[8] Assuming the expectation hypothesis holds, Arvind Krishnamurthy and Annette Vissing-Jorgensen estimate the signaling effect through the magnitude of shifts of the forward rate yield two days after the announcement of QE.[9] The estimated signaling effect from lowering investors' expectations accounted for a significant portion of the decrease in 10-year bond rates — about 20 basis points for QE1, which was about 20 percent of the total change in yields over the same time. For QE2, the signaling effect accounted for about 12 basis points, or about 66 percent of the total change in yields. The signaling effect was found to be very small in magnitude for Operation Twist — formally known as the maturity extension program (MEP) — and QE3.[10] The signaling effect was negligible for the MEP and accounted for only a 1 basis point change around QE3.[11] This suggests that those later QE programs did not shift investor expectations as much as the earlier programs had. Michael Bauer and Glenn Rudebusch argue that similar measures of expectations may mismeasure the signaling effect because they ignore the effects of QE on bond risk premiums. They suggest, through a model-based approach, that the signaling effect may account for up to 50 percent of the drop in long-term yields.

Evidence for market segmentation. Michael Cahill and his coauthors found that yields on Treasury bonds of the same maturity as those purchased through QE fell the most around QE events. For example, QE1's purchases focused on two- to 10-year Treasury bonds, whose yields dropped more around the time of the QE1 announcement than yields

for other maturities did. This difference indicates market segmentation and that QE worked by lowering the supply of bonds of particular maturities.[12]

Evidence from abroad. In response to the financial crisis, countries besides the U.S. implemented similar unconventional monetary policies. How effective were those programs? Since 2009, the Bank of England has purchased over 375 billion pounds of assets, mostly British government securities, known as *gilts*. Event study evidence shows that interest rates dropped 75 to 100 basis points around Britain's QE announcements. The Bank of Japan's purchases of almost 187 trillion yen in assets between 2009 and 2012 lowered Japanese interest rates an estimated 50 basis points.[13]

Summing up the evidence, while the evidence for the precise channel through which QE worked is mixed and inconclusive, QE did seem to lower long-term government bond yields around the announcement windows for at least a few days. But remember that the goal of QE was to stimulate the broader economy.[14] Did QE help do that? Was the effect long lasting? And what are the potential costs?

Remember that the goal of QE was to stimulate the broader economy. Did QE help do that? Was the effect long lasting?

QE'S EFFECTS ON THE BROADER ECONOMY

So far, I have focused on the effects of the Fed's QE policy on Treasury yields. However, as noted earlier, the Fed also purchased MBS as part of QE in the hope of stimulating housing demand. What was the effect of QE on mortgage rates? Krishnamurthy and Vissing-Jorgensen showed that QE also lowered mortgage rates significantly on announcement dates. Similarly, Andreas Fuster and Paul Willen showed that QE announcements prompted an immediate reduction in mortgage rates.

Economists have also found evidence that QE affected markets other than those in which the Fed intervened directly. Corporate bonds yields dropped significantly upon the announcement of QE1. For example, top-rated corporate bonds fell 77 basis points for QE1 over a two-day period after the announcement. Krishnamurthy and Vissing-Jorgensen argue that the drop could be due to QE1's effect on reducing the default risk of corporate bonds. QE1 was implemented during the peak of the financial crisis, when the credit market was severely malfunctioning. By purchasing a large amount of securities from the private sector, QE1 increased liquidity in the economy and thus reduced firms' default risk. They also suggest that corporate bond yields dropped modestly for the MEP and very little for QE2 and QE3. Using U.K. data, Michael Joyce and his coauthors suggest that QE led institutional investors to increase the share of corporate bonds in their portfolios, increasing the demand for corporate bonds and hence lowering their yields.

Summing up the event studies: QE1 not only reduced long-term Treasury rates but also reduced borrowing costs for households and firms, at least immediately following its implementation. As for QE2 and QE3, the evidence for similar spillover effects is less conclusive.

Using relatively narrow announcement windows allows researchers to identify the event affecting interest rates with some precision but makes it difficult to establish longer-term effects. Over weeks and months, lots of things happen in the economy, so it becomes increasingly hard to know precisely what is affecting interest rates. Thus, other methods are needed to estimate the longer-term effects of QE.

The longer-term effect of QE. Although event studies show significant immediate effects of QE1 on Treasury yields and on yields of certain types of private sector debt, the reduction would need to persist to affect the real economy. Preliminary estimates of how long lasting QE's effects were on yields have been mixed, ranging from a few months to a few years.[15] But is there evidence of a positive, persistent effect on the real economy?

Through statistical analysis, most studies have found that QE had a positive association with GDP growth and inflation, although the size and persistence of the effects vary widely. Most estimates suggest that the three QE events are associated with a total increase in U.S. GDP of about 2 percentage points, but the range of estimates is very large — between 0.1 and 8.0 percentage points — and the effects were mostly short-lived. Estimates of the correlation of QE and inflation are large but again range widely.[16] Evidence on QE's effect on inflation expectations, house prices, stock prices, consumer confidence, and exchange rates is mixed and thus inconclusive.[17]

My coauthors and I have found some evidence that the MEP affected firm behavior. Firms differ in how much they rely on long-term debt, mainly because they wish to match

the maturity of their real assets and their debts. When we measured a firm's dependence on long-term debt by its historical average of long-term debt over total debt, we found that firms that were more dependent on long-term debt issued more long-term bonds following the MEP to fund more capital investment. Overall, there is some evidence that QE not only affected the yield curve but also had some positive, persistent effects on the economy.

THE RISKS OF QE

Despite the significant uncertainty about the size of the effects of QE and the channels through which it operated, the weight of the evidence says that QE lowered rates on Treasuries and mortgages, and there is some evidence that it also had positive effects on the real economy.

Nonetheless, some economists and policymakers have expressed serious concerns about the potential risk and costs associated with the program. QE is a very new policy tool, and it is difficult to know whether the unprecedented quadrupling of the Fed's balance sheet will lead to too much liquidity and ultimately unacceptably high inflation. That is, when banks begin to lend out the reserves they have built up, the economy might grow so fast that the Fed might find it difficult to raise interest rates in time to avert runaway inflation.[18] In addition, a policy of prolonged monetary accommodation has increased risk-taking behavior among investors. With yields on long-term assets very low, investors may allot a greater share of their portfolios to riskier assets, such as stocks or high-yield corporate "junk" bonds.[19] Such "reaching for yield" leaves investors' portfolios more sensitive to interest rate changes and market volatility.

While there is limited evidence of greater financial instability due to QE, the risk is likely to grow the longer the policy is in place.[20] That might lead to more market volatility as the Fed raises interest rates and when it starts to shrink its balance sheet. A disorderly exit from QE could pose a risk to financial stability. Some Federal Reserve officials have stressed that maintaining financial stability is important for effective monetary policymaking as the Fed raises interest rates.[21] Others have expressed concern that QE has put the Fed in the business of supporting particular sectors — especially housing — at the expense of others.[22] The Fed ended QE3 and stopped expanding its balance sheet in late 2014. By early 2016, high inflation as a result of QE had yet to be seen, but as the economy continues to expand, such potential costs of QE may become reality, and future research would be needed to quantify them. ■

NOTES

[1] For instance, in January 2016, the Bank of Japan lowered its policy interest rate to -0.1 percent. The European Central Bank lowered its interest rate to -0.1 percent in June 2014. Interest rates in Switzerland, Sweden, and Denmark also went below zero. See the 2013 article by Richard Anderson and Yang Liu.

[2] The yield of a bond is its annualized interest rate over its maturity and is usually computed from market prices. Given the market price of the bond P with maturity t, the yield of the bond is P(t)^-(1/t)-1.The yield of a bond is inversely related to its price — the lower the price, the higher the yield. For example, if a 10-year bond is traded at 60 cents in exchange for a $1 payoff in 10 years, its yield is roughly 5.2 percent per year (0.6^(-1/10) -1). The formula here applies to zero coupon bonds. When a bond pays a coupon, it is usually first converted to an equivalent zero coupon bond before applying the computation above.

[3] A risk-neutral investor's investment decision is not affected by the degree of uncertainty in investment outcomes. So, for example, an investment that yielded 100 percent half the time and 0 percent half the time would be equivalent to one that yielded 50 percent with certainty. A risk-averse investor would prefer the certain investment over the riskier investment, even though their expected returns are the same.

[4] Our bond trader might also think about this possibility if his compensation were tied to the success of his trading positions measured on a yearly basis. The market value of his positions changes with market interest rates even if he doesn't actually have to sell any bonds before maturity.

[5] See Brett Fawley and Luciana Juvenal, and Saroji Bhattarai and his coauthors, for example.

[6] Economists often distinguish between segmented markets and the *preferred habitat* theory, which says that investors prefer securities of particular maturities but will also respond to profitable opportunities outside their preferred maturities. For my purposes, *segmented markets* can refer to either view.

[7] See the event studies by Arvind Krishnamurthy and Annette Vissing-Jorgensen. Also see the studies by Tatiana Fic and by Joseph Gagnon and his coauthors and the IMF reports.

[8] Krishnamurthy and Vissing-Jorgensen.

[9] They minimize the risk premium effects by using near-term contracts, which are less affected by bond risk premiums.

[10] A Federal Reserve Board video explains the MEP: www.federalreserve.gov/faqs/money_15070.htm.

[11] The 10-year bond yield dropped only 3 basis points over a two-day window after the QE3 announcement. So in percentage terms, the signaling effect is still significant.

[12] The evidence for a broad-based reduction in duration risk is more mixed. Some studies suggest that up to half the term premium reduction can be attributed to the duration risk channel. Other studies show that the duration risk effect was minimal. Another good reference is the paper by Michael Joyce and his coauthors.

[13] See the IMF reports and the Fic paper for more discussion on the international evidence of the effectiveness of QE.

[14] QE1 was pursued to thaw credit markets during the financial crisis but was also intended to stimulate the real economy by increasing *aggregate demand* — basically, consumer spending and business investment — according to Chairman Bernanke's 2008 speech.

[15] Jonathan Wright, Christopher Neely, and Joyce and his coauthors provide some initial estimates.

[16] See the IMF reports.

[17] See Brett Fawley and Luciana Juvenal's paper and the book by Kjell Hausken and Mthuli Ncube for more details. Andreas Fuster and Paul Willen find that QE substantially boosted mortgage refinancings, though not purchase mortgages.

[18] See the speeches by Charles Plosser and Jeffrey Lacker, for example.

[19] See Joyce and his coauthors and Bo Becker and Victoria Ivashina for more details.

[20] See the IMF's Global Financial Stability Report.

[21] See William Dudley's speeches, for example.

[22] See Plosser and Lacker.

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