Policy Brief

Quantitative Easing: An Underappreciated Success

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After short-term interest rates in many advanced economies fell below 1 percent, central banks turned to quantitative easing (QE) to support economic growth. They purchased massive and unprecedented amounts of long-term bonds in an effort to reduce long-term borrowing costs. Nevertheless, recovery from the Great Recession proved disappointingly slow. Recently, some central banks have pushed short-term interest rates slightly below zero to provide an additional boost to growth. The slow recovery and the turn to negative rates have raised questions about the benefits of QE bond purchases and whether their effectiveness has reached a limit.

Meanwhile, there has been an explosion of research on QE and its effects. By and large, this research has attracted little attention from the public or even the financial press. Studies overwhelmingly agree that QE does ease financial conditions and there is no reason to doubt that it supports economic growth. QE can be especially powerful during times of financial stress, but it has a significant effect in normal times with no observed diminishing returns. Rarely, if ever, have economists studying a specific question reached such a widely held consensus so quickly. But this consensus has yet to spread more broadly within the economics profession or the wider world.

HOW DOES QE WORK?

Conventional monetary policy works by reducing the short-term interest rate, which encourages consumption and investment. QE works by reducing the long-term interest rate, which also encourages consumption and investment.[1] Central banks are still assessing whether and how to make QE a standard part of their policy toolkit, but policymakers have little doubt that QE does operate in many ways like conventional monetary policy.

In advanced economies during and after the Great Recession, QE operated through three channels: (1) reducing risk spreads associated with market panics, (2) reducing expectations of the future short-term policy interest rate, and (3) reducing the term

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premium in bond yields by reducing the supply of long-term bonds in the market.[2] At this stage, with reasonably well-functioning markets and market expectations of future policy rates in line with—or even lower than—rates suggested by central bank announcements, only the third channel remains potent, giving rise to the perception that QE has a diminishing effect. But the

1. QE also can operate through direct or subsidized lending and purchases of other assets such as equities and real estate. Such programs are less common and less studied. The Bank of England and the European Central Bank operate subsidized lending programs. The Bank of Japan purchases equity and real estate investment trusts. Gagnon and Hinterschweiger (2013) present a comprehensive review of the crisis responses of the central banks of the four main advanced economies as of December 2012 as well as a survey of studies on the effects of the various programs.

2. The yield on a long-term bond is commonly divided into two components: the average expected value of future short-term interest rates over the life of the bond and the term premium. Neither component can be directly observed, but there are techniques for estimating the expected value of future short rates, including through surveys of bond market participants. The term premium equals the bond yield minus the average expected future short rates.

evidence suggests that there is no tendency for the third channel, known as the portfolio balance effect, to diminish.[3] Indeed, there are grounds to believe that the portfolio balance effect may be increasing, as additional QE bond purchases remove bonds from investors who are more reluctant to sell them and thus who demand ever higher prices (and lower yields). No central bank has pursued QE to an extent that would allow for a test of the "increasing potency" hypothesis.

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However, as with short-term interest rates, there remains the issue of a lower bound on long-term interest rates. Ten-year government bond yields are slightly below zero in Japan and Switzerland. Additional QE purchases of 10-year bonds in these countries might not drive yields much further below zero because investors have the option of holding paper currency with a fixed yield of zero.

STUDIES OF QE EFFECTS ON BOND YIELDS

Since 2010, an outpouring of research has focused on the financial market effects of QE (table 1). To date, the vast majority of QE purchases have been limited to government bonds, or government-guaranteed bonds in the United States. Table 1 displays estimated effects on the 10-year government bond yield of a QE bond purchase equivalent to 10 percent of GDP. These studies unanimously conclude that QE lowers bond yields significantly, even when focus is limited to the portfolio balance effect and not the other channels.

As shown in table 1, the two most common types of QE studies are event studies and time series studies. The simplest event studies add up movements in bond yields around central bank announcements concerning QE programs. Studies use different sizes of event "windows," from 30 minutes to 3 days bracketing the announcements. Shorter windows risk missing some of the market reaction; longer windows risk including the effects of other news that is unrelated to QE. By and large,

the results are not particularly sensitive to the size of the event window.

When QE programs catch markets by surprise, simply adding up the yield movements in the windows is a reasonable way to estimate the total effects of QE on yields, as long as the study includes all events in which news about the QE program was released. Arguably, these conditions existed around the time of the first QE programs in the United Kingdom and the United States in 2008–09. For later QE programs, this approach does not work well because markets began to anticipate the possibility of additional QE based on economic data before central banks announced it. For later event studies, researchers typically try to include other news events besides central bank announcements, such as data releases, that might have conveyed information about future QE or they use survey information on market expectations about future QE purchases before any central bank announcement.[4] Churm, Joyce, Kapetanios, and Theodoridis (2015) use daily deviations between UK bond yields and foreign bond yields to estimate changes in market expectations about UK QE.

The simplest event studies report the entire effect of QE announcements on bond yields. Some studies delve further and attempt to parse out the channels, focusing mainly on guidance about future short-term rates and the term premium.[5] A considerable element of judgment enters into these estimates, which rely on comovements of Treasury bonds at different maturities. As shown in table 1, the two studies by Christensen and Rudebusch find relatively small effects of QE on the term premium. But it is important to note that their studies do not imply small overall effects of QE. Rather, they find that QE reduces expectations of future short-term interest rates much more, and at longer horizons, than most other studies find.

The other broad category of studies is time series regressions of bond yields or term premiums on the supply of long-term bonds. Most of these studies use samples that end before the launch of QE programs, in part because they were done near the beginning of QE and in part because of the concern that QE announcements would change the timing of the response of yields to bond supply.[6] Because these studies generally focused on normal market conditions and central banks were not using QE to guide expectations of future short-term interest rates,

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3. Some observers have argued that QE cannot push the term premium below zero. However, the term premium has been significantly below zero at times, and there is no theoretical lower bound. For some classes of investors (life insurance companies, pension funds) long-term bonds may be less risky than short-term bonds and thus can have a lower expected rate of return.

4. A later event study that does not control for market anticipation of QE is that of Fukunaga, Kato, and Koeda (2015), which may partially explain the low estimated effect.

5. These studies focus on the most liquid (on the run) Treasury bonds in order to minimize any influence from market-calming effects.

6. The concern is that QE announcements would bring forward the normal response of yields to supply as markets come to anticipate supply shifts. An exception is the study of Fukunaga, Kato, and Koeda (2015), which includes more than a year after the launch of QE in Japan.

Table 1   Estimates of effects of QE bond purchases on 10-year yields (purchases normalized to 10 percent of GDP)

Study	Sample	Method	Yield reduction (basis points)
United States			
Greenwood and Vayanos (2008)[a]	1952–2005	Time series	82
Gagnon, Raskin, Remache, and Sack (2011)	2008–09	Event study	78
	1985–2007	Time series TP only	44
Krishnamurthy and Vissing-Jorgensen (2011)	2008–09	Event study	91
	2010–11	Event study	47
Hamilton and Wu (2012)	1990–2007	Affine model	47
Swanson (2011)	1961	Event study	88
D'Amico and King (2013)	2009–10	Micro event study	240
D'Amico, English, López-Salido, and Nelson (2012)	2002–08	Weekly time series	165
Li and Wei (2012)	1994–2007	Affine model of TP	57
Rosa (2012)	2008–10	Event study	42
Neely (2012)	2008–09	Event study	84
Bauer and Neely (2012)	2008–09	Event study	80
Bauer and Rudebusch (2011)[b]	2008–09	Event study TP only	44
Christensen and Rudebusch (2012)[b]	2008–09	Event study TP only	26
Chadha, Turner, and Zampolli (2013)	1990–2008	Time series TP only	117*
Swanson (2015)[b]	2009–15	Yield curve TP only	40
Christensen and Rudebusch (2016)[b]	2008–09	Event study TP only	15
United Kingdom			
Joyce, Lasaosa, Stevens, and Tong (2011)	2009	Event study	78
	1991–2007	Time series	51
Christensen and Rudebusch (2012)[b]	2009–11	Event study TP only	34
Churm, Joyce, Kapetanios, and Theodoris (2015)	2011–12	International comparison	42
Japan			
Fukunaga, Kato, and Koeda (2015)	1992–2014	Time series TP only	24
	2013–14	Event study	17
Euro area			
Middeldorp (2015)[c]	2013–15	Event study	45–132
Altavilla, Carboni, and Motto (2015)[d]	2014–15	Event study	44
Middeldorp and Wood (2016)[c]	2015	Event study	41–104
Sweden			
De Rezende, Kjellberg, and Tysklind (2015)	2015	Event study	68

* This yield reduction corrects an earlier version of this Policy Brief, which erroneously listed 56.

a. Greenwood and Vayanos scaled the effect relative to the size of the Treasury market. The estimate here is based on the ratio of Treasury debt to GDP in 2015.
b. These studies further differentiate between signaling effects and portfolio effects. The reported estimate is for the portfolio effect only.
c. The smaller estimate is for German bonds and the larger one is for Italian bonds.
d. The estimate is for an average of euro area bonds.

Note: There are 100 basis points in 1 percentage point. Most studies present a range of estimates. This table displays the study's preferred estimate if one exists; if not, it presents the midpoint of the range. For event studies, we normalize by purchases of all long-term bonds, not only government bonds. Some of the nonevent studies include nongovernment bond purchases and others do not. "TP only" denotes studies that attempt to estimate the term premium component of movements in bond yields. For event studies, the normalization is based on GDP in the final year of the event.

these studies mainly capture the portfolio effects of QE on the term premium.

Some event studies and some time series studies focus only on 10-year bond yields or measures of the 10-year term premium derived from outside sources. Others use information on yields of government bonds across a range of maturities in the context of models of the yield curve to provide decompositions of yield movements into expected future short rates and term premiums.

In terms of magnitudes of effects, the early simple event studies tended to obtain large estimates, probably because they included all three components of QE effects: market calming, forward guidance, and portfolio balance. Later event studies and time series studies found smaller effects. The median effect in table 1 is about 50 basis points for a purchase equal to 10 percent of GDP. The medians for the United States, United Kingdom, and euro area are all in a range from about 45 to 55 basis points. The only estimate for Sweden is higher and the median for Japan is lower. Japan has a much larger government bond market relative to GDP than the other countries studied, which may suggest that QE effects operate in proportion to the size of the targeted bond market rather than the size of the economy.

A few studies in table 1 do not fit into the broad categories of event studies and time series studies. Based on the first QE program in the United States, D'Amico and King (2013) look at changes in the yields of bonds purchased by the Fed and changes in the yields of bonds with similar maturities that were not purchased by the Fed. Because the Fed focused on buying less liquid, off-the-run securities, it had a relatively large effect on their yields, particularly in 2009 when the market had not fully calmed down. Scaling up these effects by the amounts purchased leads to a very large estimate of the effect of QE on yields.

D'Amico, English, López-Salido, and Nelson (2012) combine elements of the D'Amico-King approach (local scarcity) with a time series approach that includes a measure of bond duration and is estimated over a sample prior to QE. Applying their coefficients to the first two rounds of US QE yields a fairly large estimated effect.

Swanson (2011) applies a simple event study technique to the Fed's Operation Twist of 1961. He finds a rather large effect when scaled by GDP, especially considering there were likely no market calming or forward guidance effects at that time. However, the bond market was considerably smaller as a share of GDP in 1961 than in 2010, which may explain the moderately large estimated effect.

A few other studies do not fit into the template of table 1. Meaning and Zhu (2012) estimate independent effects of Treasury issuance, Fed purchases, and average maturity of bonds outstanding. They find a substantial effect of QE on bond yields. Wright (2012) finds significant effects of Fed QE announce-

ments on bond yields but does not relate these effects to the size of purchases. He finds effects that diminish considerably over time. Neely (2015) argues that Wright's specification probably underestimates the persistence of QE effects.

Two studies are skeptical about QE effects. Stroebel and Taylor (2012) find little effect on bond yields on the days the Fed actually purchased bonds. However, most researchers have concluded that the market responds to QE at the time of announcements rather than at the time of purchases (and Stroebel and Taylor do find a significant reduction in bond yields on the main announcement date of the first round of US QE). Thornton (2015), citing his previous research, argues that the effects in event studies may reflect other news besides QE, and he points out that these effects often seem short-lived. However, he does not present a competing hypothesis to explain the results of event studies, and the robustness of event studies to window size and to country studied suggests that QE is the relevant news. The persistence issue was addressed by Neely (2015), who finds that effects are persistent.[7] Thornton also finds that the time series results in Gagnon, Raskin, Remache, and Sack (2011) are sensitive to the inclusion of a time trend, but he acknowledges that results in some other studies are not sensitive to a time trend.

Cumulative purchases of long-term bonds under the various QE programs in the United States totaled about 23 percent of GDP as of the conclusion of the programs in 2014. Based on the median of the estimates in table 1, the QE programs reduced the 10-year yield in the United States about 1.2 percentage points. Many other factors are influencing bond yields at present, but an effect from QE of this magnitude appears plausible. In the fourth quarter of 2014, the 10-year Treasury yield was 2.3 percent, 2.6 percentage points below its average value of 4.9 percent over the ten years ending in 2007, just prior to the Great Recession.[8]

MACROECONOMIC EFFECTS OF QE

There are strong reasons to believe that reductions in bond yields caused by QE do boost economic growth. Many of the studies listed in table 1, as well as other studies, find that QE reductions in government bond yields spill over into lower private bond yields, higher equity prices, weaker exchange rates, and lower foreign bond yields (Neely 2012; Glick and Leduc 2012; Rogers, Scotti, and Wright 2014). These correlations have long been observed with respect to conventional monetary policy. Economic models (both theoretical and empirical) imply that all of these effects boost economic growth.

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7. The large effects of announcements about QE purchases that are many months or even years into the future suggest that markets believe that QE has a long-lasting impact.

8. Data are from Haver Analytics.

Federal Reserve economists estimate that the Fed's QE purchases in 2009 had a stimulative effect on the US economy similar to that of a 1 percentage point cut in the federal funds rate (Engen, Laubach, and Reifschneider 2015).[9] Over time, cumulative rounds of Fed QE had the equivalent effect of a

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2.5 percentage point cut in the federal funds rate. According to this analysis, the Fed's cumulative QE programs reduced the unemployment rate by more than 1 percentage point as of early 2015 while also boosting the inflation rate by nearly half a percentage point.

An alternative way to estimate the macroeconomic effects of QE is to compute a "shadow" short-term rate based on the entire term structure of interest rates and its historical influence on macroeconomic variables. The shadow rate is constructed to be close to the short-term rate in normal times but can go below zero when the short-term interest rate is stuck at zero. When QE reduces longer-term interest rates, the shadow rate declines, reflecting both the portfolio and signaling channels of QE. It is an attempt to translate unusual pressures on longer-term interest rates into a hypothetical short-term rate that would deliver the same amount of macroeconomic stimulus.

Estimates show a shadow short-term interest rate around –2 percent in late 2013, falling to –3 percent in mid-2014, and returning to around –2 percent in early 2015 (Wu and Xia 2015).[10] The shadow rate estimates return to the effective federal funds rate by construction when the funds rate exceeds 0.25 percentage points, as it has since mid-December 2015.[11] This reflects a shortcoming of the shadow rate concept and does not imply that the effect of Fed purchases vanishes when the policy rate rises significantly above zero.[12]

Churm, Joyce, Kapetanios, and Theodoridis (2015) estimate that QE bond purchases in the United Kingdom had a cumulative macroeconomic effect equivalent to a cut in the short-term interest rate of 1.5 to 3 percentage points. In addition, they estimate that the subsidized lending program had an independent effect equivalent to around 1 percentage point.

There are no published studies yet of the macroeconomic effects of QE in countries that launched them later than the United States and the United Kingdom. However, in a speech last November, European Central Bank president Mario Draghi estimated that the decline in lending rates following the launch of QE in the euro area was comparable to what would be expected from a 1 percentage point cut in the policy interest rate.[13]

The Bank of Japan launched a major QE program in 2013. Prior to 2013, core inflation in Japan languished around –0.5 to –1 percent for several years.[14] Since the start of the QE program, core inflation has jumped around 2 percentage points to just over 1 percent, about two-thirds of the way to its target of 2 percent. Given the weak global economy and the large consumption tax increase in 2014, the only plausible explanation for this remarkable rise in inflation is the QE program.

CONCLUSION

There is overwhelming evidence that QE bond purchases ease financial conditions. The channels are similar to those of conventional monetary policy. Standard macroeconomic models suggest that QE has a meaningful positive effect on economic growth and inflation. This effect is not limited to periods of financial stress.

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9. This result is based on the estimated term premium effect of Li and Wei (2012), which is close to the median of the estimates for the United States.

10. Updated data are available at https://www.frbatlanta.org/cqer/research/shadow_rate.aspx?panel=1.

11. Indeed, the shadow rates begin to move toward zero in mid-2015, probably reflecting the influence of 6-month and 12-month bond yields in the model as markets came to expect the Fed's first rate hike in late 2015.

12. Other studies have used the concept of shadow rates to help in modeling the term structure of interest rates near the zero bound but without a direct linkage to macroeconomic effects (Krippner 2013, Christensen and Rudebusch 2016).

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13. Mario Draghi, Monetary Policy: Past, Present, and Future, speech at the Frankfurt European Banking Congress, November 20, 2015, www.ecb.europa.eu/press.

14. Data refer to the Bank of Japan's preferred measure of consumer prices excluding energy and fresh food. See *Outlook for Economic Activity and Prices* at www.boj.or.jp/en/mopo/outlook/gor1510b.pdf.

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