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Abstract

This paper summarizes the international evidence on the performance of quantitative easing (QE) as a monetary policy tool when conventional policy rates are constrained by the effective lower bound (ELB). A large body of evidence suggests that expanding the central bank's balance sheet through large-scale asset purchases can provide effective stimulus under the ELB. Transmission channels for QE are broadly similar to those of conventional policy, notwithstanding some important but subtle differences. The effectiveness of QE may be affected by imperfect pass-through to asset prices, possible leakage through global capital reallocation, a reduced impact through the bank lending channel, and diminishing returns to additional rounds of QE. Although the benefits of QE appear, so far, to outweigh the costs, at some point this may be reversed. The exact "effective quantitative bound" where the costs of QE become larger than the benefits is as yet unknown. The summary of the evidence, however, suggests that QE is indeed an "adequate" substitute for monetary policy at the ELB, rather than a "perfect" one.

JEL classification: N10, E52, E58, E61, E65
Bank classification: Central bank research; International topics; Monetary policy framework; Transmission of monetary policy

Résumé

Cet article fait la synthèse des résultats des mesures d'assouplissement quantitatif adoptées à l'échelle internationale alors que l'instrument traditionnel de la politique monétaire, le taux directeur, était contraint par sa valeur plancher effective. Un vaste corpus d'études tend à montrer que le grossissement du bilan des banques centrales par l'achat massif d'actifs peut fournir une impulsion monétaire efficace dans un contexte où les taux sont à leur valeur plancher. Les canaux de transmission de l'assouplissement quantitatif sont globalement analogues à ceux de la politique traditionnelle, en dépit de quelques différences subtiles, mais importantes. Quant à l'efficacité des mesures d'assouplissement quantitatif, elle peut être amoindrie par la répercussion imparfaite de leur action sur les prix des actifs, les « fuites » qui s'opèrent par la redistribution du capital entre les pays, l'atténuation des effets attendus du canal du crédit bancaire et, enfin, par les rendements décroissants des séries supplémentaires de mesures d'assouplissement quantitatif. Il semble pour l'heure que les avantages de l'assouplissement quantitatif en surpassent les coûts, mais un retournement de situation pourrait survenir. Nul ne connaît encore où se situe cette « limite quantitative

effective » au-delà de laquelle les coûts de l'assouplissement quantitatif en excèdent les bienfaits. L'analyse des travaux sur le sujet tend cependant à confirmer qu'à défaut d'être « parfait », l'assouplissement quantitatif est une solution de rechange « adéquate » à la politique monétaire traditionnelle quand les taux d'intérêt atteignent leur plancher effectif.

Classification JEL : N10, E52, E58, E61, E65
Classification de la Banque : Recherches menées par les banques centrales; Questions internationales; Cadre de la politique monétaire; Transmission de la politique monétaire

1. Introduction

The global financial crisis and the ensuing recession required an aggressive and sustained monetary policy response. In the autumn of 2008, central banks around the world quickly lowered policy rates, often reaching what was then thought to be the effective lower bound (ELB) for the conventional policy interest rate. To provide additional monetary easing, major central banks introduced a wide range of asset purchase or "quantitative easing" (QE) programs, many of which are still in place almost seven years later. Consequently, central bank balance sheets remain large, and in some cases continue to increase rapidly.

The experience of the financial crisis suggests that pre-crisis data likely underestimated the frequency and persistence of ELB episodes. At the same time, the medium to long-run neutral rate of interest—the rate of interest that would prevail once all shocks have dissipated and the economy has reached its potential—may be lower on average in the future, both for Canada (Mendes 2014) and abroad (Hamilton et al. 2015, and references therein). Given the current inflation target of 2 per cent for most inflation-targeting countries, a decline in this neutral rate of interest suggests that encounters with ELB episodes might become even more frequent than before. Such concerns have prompted some economists to suggest targeting inflation at a higher rate than 2 per cent to mitigate the risks from ELB episodes (Williams 2009; Blanchard et al. 2010; Ball 2014; Krugman 2014).

However, the ELB constraint is much less of a concern if unconventional monetary policy measures, such as QE, are effective—that is, if they can effectively substitute for conventional policy easing and their potential costs are relatively easily mitigated.[1]

This paper forms part of the research agenda for the renewal of the inflation-targeting agreement outlined in Côté (2014);[2] it reviews the international evidence on the effectiveness of quantitative easing as a policy tool at the effective lower bound. Our main findings are as follows:

- There is a large body of evidence that suggests that expanding the central bank's balance sheet (QE) through large-scale asset purchases can provide effective monetary stimulus when the policy rate reaches the effective lower bound.

[1] QE and forward guidance are both often referred to as unconventional monetary policies (UMPs). However, this paper focuses only on QE, and as such uses the terms UMP, QE and large-scale asset purchases (LSAPs) interchangeably.

[2] Côté (2014) outlines that the Bank of Canada is also in the process of conducting research on the costs and benefits of changing the inflation target in preparation for the renewal of the inflation-control agreement with the Canadian government in 2016.

- The channels through which QE works are largely similar to those identified in conventional policy. In the case of small open economies, the exchange rate channel is particularly important.
- The pass-through of QE to the real economy may be imperfect, but such concerns also apply for conventional policy. In fact, QE could be more effective in some circumstances, since it can target specific sectors/parts of the financial system.
- Globally, the benefits of QE appear to have outweighed any potential costs to date. However, the costs associated with QE could rise with the duration and size of further asset purchases, and at some point these costs may overturn the benefits. Where the "effective quantitative bound" lies is not known and further analysis is warranted.
- Overall, QE can be considered to be an "adequate" substitute for conventional policy, especially during initial rounds of stimulus at the ELB. However, this substitutability is less than perfect.

The remainder of the paper proceeds as follows. Section 2 examines the transmission channels of QE, in comparison to conventional policy. Section 3 summarizes the existing evidence of the effectiveness of QE. Section 4 describes many of the potential risks associated with QE. Section 5 then outlines the limits of the "effective bound" for QE. Section 6 offers some conclusions.

2. Transmission Channels of Quantitative Easing

During normal cyclical downturns, central banks can stimulate aggregate demand, and hence achieve their inflation objective, by lowering the short-term policy interest rate. Lower policy rates are transmitted to the aggregate economy through several major channels:

a) **Interest rate channel:** Lower nominal rates translate into lower real rates when inflation expectations are well-anchored and stable. Lower real rates in turn, encourage investment demand by directly reducing the real cost of capital.

b) **Expectations channel:** Movements in the short-term policy interest rate also influence agents' expectations about the future path of the policy rate, with implications on growth and inflation. The resulting expected future path of these economic variables in turn affects current savings and investment decisions of forward-looking private agents.

c) **Asset price channel:** Lower rates increase asset prices, which stimulate the aggregate economy by (i) directly stimulating consumption spending through increased household wealth (i.e. the wealth channel); (ii) encouraging investment by making equity financing easier for firms; and (iii) improving the balance sheets of firms and consumers, which, in turn, reduce frictions in credit markets and further encourage borrowing (the financial accelerator channel).

d) **Exchange rate channel:** Lower rates also put downward pressure on the exchange rate and encourage an increase in net exports.

e) **Bank lending channel:** Through open market operations, the implementation of lower rates generates excess reserves in commercial banks' balance sheets, which are then transformed into increased deposits and loans to firms, which fosters investment. Lower rates may also increase loan demand by firms and households.[3]

Recent experience has shown that central banks can influence the aggregate economy via the same broad transmission channels through the use of UMPs, even when the short-term rate is at the ELB. In this case, stimulus can be provided by expanding the central bank's balance sheet (QE) through (a) credit facilities that directly encourage lending by banks and other financial institutions by subsidizing their funding costs in certain segments of the market, and (b) large-scale asset purchases (LSAPs) by central banks that increase the price and reduce the yield of a particular asset class (usually long-term government bonds), which then transmits to other types of assets through portfolio rebalancing.

There are, however, important subtleties between the transmission of conventional monetary policy and QE that targets long-term government yields. To appreciate these differences, consider that real long-term rates can be decomposed as follows:

$$\begin{aligned} \text{Real long-term rates} &= \text{Expected path of future short-term rates} \\ &\quad + \text{risk (term + liquidity) premiums} \\ &\quad - \text{expected path of future inflation} \end{aligned} \tag{1}$$

In the conventional case, a temporary reduction in the short-term rate induces a shift in the evolution of future rates in the minds of economic agents, along with a new path for future inflation. The same mechanism is used by QE in the face of the ELB, since it affects long-term rates by lowering or extending the expected future path of the short-term policy rate through signalling and better anchoring expectations for future inflation.[4] However, QE can also affect long-term rates by reducing the term premium through portfolio rebalancing. Since the central bank purchases assets with duration risk, investors might demand less compensation for holding the remaining amount of that risk, and term premiums may fall across many different assets.

[3] The importance of this channel, and the others for that matter, may vary significantly across economies, reflecting differences in their financial systems and economic structure.

[4] Note that, in the presence of the ELB, successful forward guidance also works by suggesting a more accommodative path for expected future short-term rates and the implied path of inflation. However, explicit forward guidance about the future path of the short-term policy rate may suffer from a time-inconsistency problem, whereby as time goes on and the state of the economy changes, the central bank may find it beneficial to deviate from its promised path. LSAPs can mitigate this time-inconsistency problem to a certain degree, since it is harder to change the composition and size of the central bank balance sheet on short notice. As such, some commentators consider the signalling channel of QE to be more effective forward guidance with "skin in the game."

2.1 Risks to the transmission of quantitative easing

The effects of QE may transmit to the real economy broadly through the same mechanisms as conventional policy – such as the asset price, the exchange rate, and bank lending channels. However, some important risks may make the transmission of QE subtly different from the conventional case:

a) **Monetary stimulus through a compression of the term premium may have a relatively smaller effect on investment**

From a corporate finance perspective, firm investment behavior may be different for the same reduction in long-term rates based on whether they are induced by a shift in the path of future short-term rates (conventional policy and signalling), or a compression of the term premium (portfolio rebalancing).

Consider the following stylized example from Stein (2012), whereby a risk-neutral firm faces two options for incremental financing: (i) a 10-year bond rate of 2 per cent, and (ii) a sequence of short-term rates rolled over for 10 years that averages 3 per cent; this example implies a term premium of -1 per cent.[5] In this scenario, it is optimal for the firm to issue cheaper long-term bonds. However, note that one option available to the firm is to use the finances raised by the issuance of long-term bonds to retire/buy back its more expensive outstanding short-term bonds. This guarantees the firm a return of 3 per cent. Consequently, the hurdle rate against which new investment projects are judged remains at 3 per cent—the option consistent with rolling over the sequence of short-term rates. In other words, cheaper long-term rates may induce a change in financing behavior, without affecting investment behavior.[6]

Therefore, stimulus provided through a compression of the term premium may have a relatively smaller effect on investment compared to that provided through a lower expected path of future short-term rates. There is no consensus in the literature, however, on which channel dominates for QE. On the one hand, Krishnamurthy and Vissing-Jorgensen (2011) emphasize the importance of the signalling channel and find no evidence to support the duration risk channel. On the other hand, D'Amico and King (2013), Gagnon et al. (2011) and Joyce et al. (2011a,b) conclude that portfolio rebalancing was the main channel through which QE in the United States and the United Kingdom reduced long-term yields. Christensen and Rudebusch (2012), however, find that Fed LSAPs mainly worked through a signalling channel,

[5] For perspective, consider that the U.S. term premium on 10-year bonds was estimated to be between -0.2 and -0.84 in 2012Q3, based on the Bauer and Diez de los Rios (2012) and Kim and Wright (2005) methodologies, respectively.
[6] Some evidence of this can be seen in the data: a large fraction of the strong non-financial corporate bond issuance in 2012 was devoted to refinancing, and not to new capital spending (Stein 2012).

while the portfolio rebalancing channel was more important in explaining the decline in U.K. yields in response to the Bank of England's QE program.

b) **Asset price pass-through may be less than expected**

The effect of portfolio rebalancing might differ across asset classes. A compression in the term premium might have different implications for pass-through, depending on the degree of substitutability between long-term treasuries and other assets. If long-term Treasury securities are imperfect substitutes for other assets, then removing long-term treasuries from the market may make them scarcer, and hence increase their prices and reduce their yields (scarcity channel). At the same time, imperfect substitutability might imply a smaller pass-through effect on other assets. In contrast, if all assets are substitutable within investor portfolios, then central bank purchases of treasuries with duration risk might make investors demand less compensation for holding the remaining amount of that risk, and term premiums might fall across a broad number of asset classes (duration channel). D'Amico et al. (2012) find strong evidence of the importance of the scarcity channel for U.S. LSAPs. Using sector-specific and micro-level data from insurance company and pension fund investment behavior, Joyce et al. (2014) show that asset purchases by the Bank of England induced investors to shift their portfolios away from government bonds and toward corporate bonds, as expected. However, these portfolio rebalances did not extend to equities.

c) **The transmission of QE in small open economies may be different**

The term premium in a small open economy is heavily influenced by the global term premium. With open capital markets, QE may not exert as much pressure on the term premium as it would in the case of a large and relatively more closed economy (e.g., the United States). On the other hand, the impact may be felt more through the exchange rate, thus boosting the country's economy through increased net trade.[7]

d) **The bank lending channel may be dampened depending on the structure of financial markets**
Consider, for example, the experience in the United Kingdom, which hinges on the particular circumstance that much of the long-term government bonds purchased by the Bank of England were previously held by institutional investors such as insurance companies and pension funds. Butt et al. (2014) suggest that QE operating through a portfolio rebalancing channel gives rise to deposits in the banking system that are short-lived, and thus are not transformed by

[7] Dahlhaus et al. (2014) find that QE in the United States resulted in a depreciation of the U.S. exchange rate vis-à-vis the Canadian dollar, and a decline in net trade from Canada.

commercial banks into long-lived loans.[8] The bank lending channel may be less effective under QE in such circumstances.

e) **QE may have diminishing returns**

Although there is considerable uncertainty associated with existing studies on the effects of QE, there is some evidence suggesting that earlier rounds of QE in the United States and the United Kingdom had larger effects than subsequent rounds. For example, Krishnamurthy and Vissing-Jorgensen (2013) find that the first round of Fed LSAPs were able to reduce 10-year Treasury yields by more than 6 basis points per $100 billion worth of purchases of MBS and Treasury securities. In contrast, they find that the second round of LSAPs reduced 10-year Treasury yields by 3 basis points and the Maturity Extension Program reduced yields by 1.75 basis points per $100 billion worth of purchases. Similarly, Churm et al. (2015) find that the second round of asset purchases by the Bank of England had a smaller per unit effect on long-term gilt yields, and, hence, the real economy.

While these factors may temper the impact of QE, they do not imply that QE will be ineffective. Moreover, it is important to keep in mind that some of these risks, such as imperfect pass-through to asset prices, are also a concern for conventional monetary policy during normal times.

3. Evidence of the Effectiveness of Asset Purchase Programs

Multiple lines of evidence from a large body of literature show that most unconventional monetary policy measures from four major central banks appear to have been successful to date (for a list of these measures, see Appendix A). Early studies on the effects of QE relied on modern event-study methods to determine the financial market impact of announcements related to QE (Krishnamurthy and Vissing-Jorgensen 2011, 2013; D'Amico and King 2013; Gagnon et al. 2011; Joyce et al. 2011a,b). These financial impacts were then used as inputs to generate counterfactual scenarios using structural dynamic stochastic general-equilibrium models (Chung et al. 2012; Chen et al. 2012) and semi-structural or reduced-form econometric models (Baumeister and Benati 2013; Kapetanios et al. 2012) to estimate the impact of QE on the real economy. Since then, a number of more recent studies have used a variety of methods and other information to determine the effect of QE, including the effect of asset purchases on the term structure (Bauer and Rudebusch 2014), and information on the size of central bank balance sheets (Dahlhaus et al. 2014; Gambacorta et al. 2014). It is important to note, however, that identifying and evaluating the

[8] In conventional monetary policy implementation, purchases from the commercial banking system due to open market operations generate long-lasting deposits in commercial banks that get transformed to loans. In contrast, QE in the United Kingdom generated extra cash for institutional investors, which was reflected in commercial bank deposits under these institutional investors' accounts that were "flighty" in nature. Anticipating their short life, commercial banks did not transform these additional deposits into long-term loans.

effects of such policies is challenging, and the associated uncertainty around the effects of QE is larger than that surrounding our understanding of the effects of conventional policy. Therefore, the conclusions from these studies should be viewed with caution.

U.S. Federal Reserve LSAPs

The consensus is that LSAPs positively affected financial markets and provided stimulus to the overall economy. Yields on mortgage bonds in the United States fell in response to purchases of mortgage-backed securities (MBS). Estimates of the cumulative effect of the first three programs in the United States on the yields of 10-year Treasuries range from 65 to 120 basis points (bps). While the impact on the real economy is more difficult to gauge, most studies assert that LSAPs had a material impact on real GDP and inflation (Table 1). For example, Chung et al. (2012) suggest that an approximately 70 bps reduction in the term premium due to QE resulted in real GDP being higher by 3 percentage points by early 2012. Dahlhaus, Hess and Reza (2014) find that Fed asset purchases may have reduced the 10-year Treasury spread by 82 bps, and increased U.S. GDP by more than 2 per cent.

Table 1: Impact of QE in the United States

Impact of LSAP programs	Total size (US$ billions)	Impact	Impact per US$100 billion	Number of studies
Treasury yields		**Basis points**	**Basis points**	
QE1				
Range	1,700	13 to 107	2.9 to 6.3	8[a]
Bernanke (2012)	1,700	40 to 110	2.4 to 6.5	
QE2				
Range	600	15 to 33	2.5 to 5.5	3[b]
Bernanke (2012)	600	15 to 45	2.5 to 7.5	
QE1 + QE2 + Maturity Extension Program				
Range	2,300	65 to 100	2.8 to 4.4	4[c]
Bernanke (2012)	2,300	80 to 120	2.9 to 4.4	
GDP		**Level of GDP**	**Level of GDP**	
QE1		**(per cent)**	**(per cent)**	
Range	1,700	0.9 to 2	0.05 to 0.12	2[d]
QE2				
Range	600	0.1 to 0.78	0.07 to 0.13	5[e]
QE1 + QE2				
Bernanke (2012)	2,300	3.00	0.13	

a. Bauer and Rudebusch (2014), Christensen and Rudebusch (2012), Chung et al. (2012), Gagnon et al. (2011), Hamilton and Wu (2012), Krishnamurthy and Vissing-Jorgensen (2011), Meyer and Bomfim (2010) and Neely (2015)

b. Chung et al. (2012), Krishnamurthy and Vissing-Jorgensen (2011) and Swanson (2011)

c. Meyer and Bomfim (2012), Dahlhaus, Hess and Reza (2014), Ihrig et al. (2012) and Li and Wei (2013)

d. Baumeister and Benati (2013) and Chung et al. (2012)

e. Chen et al. (2012), Chung et al. (2012), Deutsche Bank (2010), Fuhrer and Olivei (2011) and Meyer and Bomfim (2011)

Other major central banks

The Bank of England's gilt purchases are estimated to have lowered yields by 45 to 150 bps, which in turn implies an increase in the level of U.K. GDP by between 0.65 per cent and 1.75 per cent (Table 2).

Table 2: Impact of QE in the United Kingdom

Impact of QE	Total size (£ billions)	Impact	Impact per £100 billion	Number of studies
Gilt yields		**Basis points**	**Basis points**	
APP1	200	48-150	21-75	9[a]
APP2	175	45-56	26-32	2[b]
GDP		**Level of GDP (per cent)**	**Level of GDP (per cent)**	
APP1	200	1.5-1.75	0.75-0.88	2[c]
APP2	175	0.65	0.37	1[d]
APP1+APP2	375	5.50	1.47	1[e]
GDP		**Growth of GDP (per cent)**	**Growth of GDP (per cent)**	
APP1	200	0.8-3.3	0.44-1.65	4[f]

a. Breedon et al. (2012), Caglar et al. (2011) , Bridges and Thomas (2012), Christensen and Rudebusch (2012), Joyce et al. (2011a), Joyce and Tong (2012), Kapetanios et al. (2012), McLaren et al. (2014), and Meier (2009)

b. Churm et al. (2015) and McLaren et al. (2014)

c. Kapetanios et al. (2012) and Joyce et al. (2011a)

d. Churm et al. (2015)

e. Cloyne et al. (2015)

f. Baumeister and Benati (2013), Bridges and Thomas (2012), Caglar et al. (2011) and Pesaran and Smith (2012)

Empirical research finds that the European Central Bank's (ECB's) asset purchase programs have also had important impacts. Eser and Schwaab (2013) find that €1 billion of bond purchases under the Securities Market Program (SMP) decreased 5-year bond yields by 1 to 2 bps in Italy, 3 to 4 bps in Ireland, 4 to 6 bps in Spain, 6 to 9 bps in Portugal and 17 to 21 bps in Greece. Altavilla et al. (2014) find that the Outright Monetary Transactions (OMT) announcements decreased Italian and Spanish 2-year government bond yields by 2 per cent, while leaving German and French bond yields unchanged.[9] This is consistent with an increase in Italian and Spanish GDP by 1.5 to 2 per cent, with spillovers resulting in an increase in German and French GDP by less than 0.5 per cent.

[9] See Appendix A for descriptions of particular programs such as SMP and OMT.

Lastly, Michaelis and Watzka (2014) find that the effect of the recent Japanese QE program on GDP and CPI is stronger and longer lasting than the QE programs implemented prior to the financial crisis.

Can QE substitute for conventional policy?

The evidence suggests that quantitative easing is effective in helping the central bank achieve its inflation objective. A central question, however, is whether QE can act as a "perfect substitute" for conventional monetary policy. For the most part, unconventional monetary policies share many of the same transmission channels as conventional policies. In fact, in certain settings, UMPs could be more effective than conventional measures, since they can specifically target particular markets and/or parts of the financial system.

It is difficult, however, to make a direct comparison of effectiveness per "unit" of stimulus. Yet, if it were the case that QE is less effective than conventional rate cuts, then some would argue that a larger quantity of QE is needed. Thus, assuming that the "effective quantitative bound" has not been reached to date, QE can be considered an "adequate" substitute for conventional policy. Knowing where this bound lies is therefore critical to knowing whether UMPs can effectively substitute for conventional policy. This bound is, to a large extent, dependent on the potential costs that could result from the implementation of QE. In the next section, we consider such costs.

4. Potential Risks Associated with Quantitative Easing

The literature and economic commentary have identified a number of costs or downsides to QE related to its effect on (i) market functioning, (ii) financial stability and (ii) the exit strategy. Some of these costs relate to the particularities of QE. Others, however, are equally applicable for prolonged monetary easing in a conventional sense, or for the "low for long" scenario. In addition to the risks related to the transmission of QE identified in section 2.1, the costs and risks discussed below should be weighed against any benefits of QE when deciding the appropriate level of policy. The effectiveness of QE would reach its upper limit when the cost of additional QE, as discussed below, outweighs any potential benefits. We first discuss the set of costs that are particular to QE.

1) **Excessive QE can impair market functioning by deteriorating liquidity in the market**
   Purchasing too much of an asset's outstanding supply can make price discovery harder and reduce its liquidity, prompting investors to start demanding liquidity premiums for participating in these markets. Referring back to the decomposition of long-term rates in equation (1), we see that increased liquidity premiums can counteract the effects of a term premium compression, and can potentially overturn them when taken to the extreme. QE-implementing

central banks monitor market conditions closely, and currently there has been little evidence that market liquidity is being impaired by the existing QE programs.[10]

2) **QE may generate welfare losses by removing safe assets that provide important services as collateral**

Long-term government bonds are uniquely able to provide a money-like safe-haven service to certain investors, who are in turn willing to pay for the "moneyness" of these securities in terms of forgone returns. The demand for these safe assets is importantly driven by the need of certain institutional investors to hold these high-quality liquid assets for regulatory requirements related to their asset risk profile.[11] Moreover, these assets can be used as collateral multiple times in a chain of financial transactions. Some observers argue that by removing such safe assets from the financial system, QE hinders the functioning of financial markets (Stein 2012; Araujo, Schommer and Woodford 2014), and generates welfare losses (Krishnamurthy and Vissing-Jorgensen 2013).

So far, however, it is not certain whether existing QE programs were the principal factor behind any perceived shortage of safe collateral. Rather, a perceived shortage of safe collateral may have been generated by a shift in the supply of what was considered safe assets, since many assets that were previously considered safe were revealed to be not so during the financial crisis. Multiple headwinds following the financial crisis, as well as new regulatory requirements, kept the demand for safe assets elevated. Moreover, in the absence of QE, a weaker economy would have resulted in more assets being potentially deemed unsafe. The implementation of QE, therefore, may have led to more private sector safe-asset creation, compared to the counterfactual of no QE, which helped rather than hindered market functioning.

If we assume that a negative term premium captures some aspects of market excess demand for safe assets, we can take the following lesson. While initial rounds of QE may be helpful for the functioning of financial markets, at some point indicated by a sufficiently negative term premium, welfare losses from reduced safe assets might outweigh the marginal benefits of additional QE.

[10] To gain some perspective, consider the following information on the percentage of the market share currently held by QE-implementing central banks. The ECB originally limited its purchases under the recently announced QE program to 25 per cent per issue, but later increased the limit to 33 per cent. However, the purpose of this limit is to avoid obtaining a blocking minority in the event of sovereign debt restructuring. Note that even in the absence of QE in Canada, the Bank of Canada holds up to 23 per cent of some issues. As of 2015Q1, the Fed held about 20 per cent of marketable U.S. debt and 29 per cent of government-sponsored enterprise (GSE) securities. Central bank holdings of close to 40 per cent of the government bond market did not cause market impairment in the United Kingdom (Arslanalp and Botman 2015). At the current pace of QE purchases, the Bank of Japan will hold about 40 per cent of the market by the end of 2016, and around 60 per cent by the end of 2018 (ibid).

[11] For instance, under Basel III, banks are required to satisfy the Liquidity Coverage Ratio and the Net Stable Funding Ratio requirement.

Central banks can reduce such welfare losses by purchasing assets other than government securities. In particular, Stein (2012) argues that MBS purchases in the U.S. case may be less problematic in reducing safe assets from the system, while also having a larger impact on the economy by targeting the housing market, which is comparatively more sensitive to financing costs.

3) **QE may make it harder for central banks to raise rates when the time comes**

Purchases of long-term assets by central banks have more than tripled the size of their balance sheets compared to pre-crisis levels. Since most of the assets held are of long-term maturities, it would take many years before central bank balance sheets return to their pre-crisis size and composition in a scenario where central banks decide to no longer reinvest assets that are maturing – that is, allow assets to passively run off. Failure by a central bank to adequately manage its balance sheet could lead to monetary conditions that are not consistent with its policy objectives. The management of balance sheet risk also raises issues of the extent to which, and the means by which, the central bank should be held accountable. These issues underline the importance of ensuring that proper accountability and governance mechanisms are in place when considering the use of unconventional policy measures.

4) **Spillovers from QE can generate excessive volatility for emerging markets**

For example, the expectations of tapering by the Federal Reserve in the summer of 2013 led to sudden movements in capital flows, creating excessive volatility in international currency and asset markets (Dahlhaus and Vasishtha 2014). While central banks should be mindful of such spillovers, this should not be an impediment to taking the actions that are necessary for achieving their price stability mandates. In fact, the outcomes for EMEs would likely have been much worse had the Fed not implemented QE in the first place.

5) **QE may undermine central bank independence and credibility**

An important precondition for interest rate expectations to be well-anchored is the perceived independence and credibility of the central bank in carrying out its mandate of price stability. Large-scale purchases of long-term government bonds may run the risk of being misconstrued as an attempt to monetize large fiscal deficits, which has historically led to high inflation. To keep inflation expectations well-anchored, it is therefore imperative that central banks pursuing large-scale asset purchases clearly communicate that such actions have the sole purpose of achieving their mandated objectives, and explain how their actions would achieve these objectives. None of the respective central banks are suffering from this problem at this time.

Some further risks put forth in the literature against QE pertain to a continuation of accommodative monetary policy in general, and are not specific to the particularities of bond purchases. We discuss some of these risks below:

6) **Sustained low interest rate expectations may pose risks to financial stability**

Long-term asset purchase programs by the Federal Reserve and the Bank of England were successful in reducing interest rates across the entire yield curve. Consequently, markets expected interest rates to remain low for a long time into the future. But "low for long" and the reduction in term premiums may undermine financial stability by encouraging excessive risk taking. Simply, the use of asset purchases could potentially conflict with the central banks' responsibilities for financial stability. These concerns can be mitigated through heightened diligence on the part of financial supervisors and regulatory institutions.[12] Nevertheless, there is an active and still-unresolved debate on the extent to which current QE programs are contributing to asset price overvaluation and financial instability more generally. At this time, the major central banks do not believe that their respective QE programs have led to a material increase in financial vulnerabilities. Nevertheless, any assessment of the costs and benefits of QE, and its ability to substitute for conventional policy, must fully account for financial stability concerns.

7) **Delay of necessary macroeconomic adjustments**

Lower long-term interest rates may have broader unintended macroeconomic consequences (Carney 2010). First, by suppressing debt-service payments, low interest rates may allow sovereigns to delay necessary fiscal consolidation. Second, low rates for an extended period may induce banks to roll over non-viable loans, thereby delaying the necessary restructuring of industry, such as happened in Japan in the 1990s. Finally, low long-term interest rates may provide incentives to households to take on excessive debt or to delay adjustments needed to reduce their indebtedness.

8) **Quantitative easing may have asymmetric effects on different economic agents**

Similar to regular monetary policy actions, asset purchases can have distributional effects—that is, they may benefit one group of economic agents at the expense of another. Recent implementations of quantitative easing raised the price of long-term bonds, equities and other assets, and reduced the returns on these assets. This would make savers who rely on interest income worse off, and borrowers who pay interest expenses better off. At the same time, barring investments in pension funds, a small proportion of households own the majority of investment assets in the economy. Consequently, any benefits from asset price increases would accrue disproportionately to the holders of investment. However, a recent study by the Bank of England (2012) finds that such distributional concerns are minimal for the case of the United Kingdom.

[12] See Yellen (2014) for a discussion on the importance of macroprudential policy for achieving financial stability.

While there are numerous potential costs, it does not appear that such costs are currently limiting the use of QE in the major advanced economies. Simply, the benefits appear to outweigh the costs of these measures.

5. Revisiting the Limits of Conventional and Unconventional Monetary Policy

The conventional wisdom leading up to the implementation of QE suggested that the short-term nominal interest rate available as a policy instrument to the central bank was bound to remain in positive territory. Recent evidence from the euro area, Denmark, Sweden and Switzerland, however, has shown that the effective lower bound for the policy rate is, in fact, below zero.[13] This suggests that although conventional policy rates can go below zero, there is still likely to be a bound on how much stimulus conventional monetary policy can provide.[14]

In a similar way, the effectiveness of UMPs may also have limits. In particular, consider that:

- Insofar as the portfolio rebalancing channel works by reducing the term premium, and tilts the yield curve downwards, the effect of QE through this channel may be limited.
- There are many potential costs that can put a "cap" on the size and duration of QE. Particularly important is the risk that, at a certain point, removing more safe assets from the market would negatively impact liquidity and impair market functioning.
- Finally, a risk remains that, beyond a certain point, central bank purchases of government bonds are misconstrued by private agents as direct monetizing of debt, which has historically given rise to hyperinflation, with no additional effects on the real economy.

Given the potential costs and the potential threats to central bank independence associated with the implementation of quantitative easing, it is clear that QE has an "effective bound." Where this bound lies, however, requires further analysis. That said, it is our view that the major central banks have not reached this bound at this time.

6. Conclusions

The global financial crisis and its aftermath prompted central banks to implement a series of unprecedented policy interventions. On balance, research to date suggests that these measures were—and remain—effective, helping to mitigate the worst aspects of the crisis and sustain the recovery. Without them, economic outcomes would have been much worse. Unconventional monetary policies have thus become part of the tool kit of central banks, permitting them to provide considerable policy stimulus should circumstances require more action.

[13] See Jackson (2015).
[14] Likewise, negative for long could lead to financial innovation that seeks to avoid the impact of negative deposit rates.

Nevertheless, to fully assess their effectiveness, it is necessary to see how well central banks manage the exit from these policies. Moreover, unconventional policies have potential costs. Extended balance sheets imply greater risks for central banks, while highly accommodative monetary policy for an extended period could have adverse consequences for financial stability, as well as for central bank credibility and independence. In our view, QE is not a “perfect substitute” for conventional policy. However, it may be an “adequate” substitute within its effective quantitative bound. Where this bound lies remains an open question.

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Appendix A: Selected Unconventional Monetary Policy Programs

Federal Reserve Board

Program	Date	Summary
LSAP 1	Nov-2008	LSAPs announced: Fed would purchase $100 billion in GSE debt and $500 billion in MBS.
	Mar-2009	LSAPs expanded: Fed would purchase $300 billion in long-term Treasuries and an additional $750 and $100 billion in MBS and GSE debt, respectively.
	Aug-2009	LSAPs slowed: All purchases would finish by the end of October.
	Sep-2009	LSAPs slowed: Agency debt and MBS purchases would finish at the end of 2010Q1.
	Nov-2009	LSAPs downsized: Agency debt purchases would finish at $175 billion.
	Aug-2010	Balance sheet maintained: The Fed would reinvest principal payments from LSAPs in Treasuries.
LSAP 2	Nov-2010	QE2 announced: Fed would purchase $600 billion in Treasuries.
	Jun-2011	QE2 finishes: Treasury purchases would wrap up at the end of month, as scheduled; principal payments would continue to be reinvested.
Operation Twist	Sep-2011	Maturity Extension Program ("Operation Twist") announced: The Fed would purchase $400 billion of Treasuries with remaining maturities of 6 to 30 years and sell an equal amount with remaining maturities of 3 years or less; MBS and agency debt principal payments would no longer be reinvested in Treasuries, but instead in MBS.
	Jun-2012	Maturity Extension Program extended: The Fed would continue to purchase long-term securities and sell short-term securities through the end of 2012. Purchases/sales would continue at the pace of about $45 billion/month.
LSAP 3	Sep-2012	QE3 announced: The Fed would purchase $40 billion of MBS per month as long as "the outlook for the labor market does not improve substantially… in the context of price stability."
	Dec-2012	QE3 expanded: The Fed would continue to purchase $45 billion of long-term Treasuries per month but would no longer sterilize purchases through the sale of short-term Treasuries.
	Dec-2013	QE3 Tapering Begins: Starting January 2014, only $75 billion in assets would be purchased. Purchases of Mortgage Backed Securities would be reduced from $40 billion a month to $35 billion and those of Treasury securities would be reduced from $45 billion to $40 billion.
	Jan-2014	QE3 Tapering continues: Starting February 2014, only $65 billion in assets would be purchased. Purchases of Mortgage Backed Securities would be reduced from $35 billion a month to $30 billion and Treasury securities would be reduced from $40 billion to $35 billion.

	Mar-2014	QE3 Tapering continues: Starting from April 2014, only $55 billion in assets would be purchased. Purchases of Mortgage Backed Securities would be reduced from $30 billion a month to $25 billion and Treasury securities would be reduced from $35 billion to $30 billion.
	Apr-2014	QE3 Tapering continues: Starting May 2014, only $45 billion in assets would be purchased. Purchases of Mortgage Backed Securities would be reduced from $25 billion a month to $20 billion and Treasury securities would be reduced from $30 billion to $25 billion.
	Jun-2014	QE3 Tapering continues: Starting July 2014, only $35 billion in assets would be purchased. Purchases of Mortgage Backed Securities would be reduced from $20 billion a month to $15 billion and Treasury securities would be reduced from $25 billion to $20 billion.
	Jul-2014	QE3 Tapering continues: Starting July 2014, only $25 billion in assets would be purchased. Purchases of Mortgage Backed Securities would be reduced from $15 billion a month to $10 billion and Treasury securities would be reduced from $20 billion to $15 billion.
	Oct-2014	QE3 asset purchases concluded. However, maturing securities in the Fed's balance sheet would continue to be reinvested until after the first hike in short-term rates.

Bank of England

Program	Date	Summary
Asset Purchase Facility	Jan-2009	APF established: The BOE would purchase up to £50 billion of "high quality private sector assets" financed by Treasury issuance.
	Mar-2009	APF announced: The BOE would purchase up to £75 billion in assets, now financed by reserve issuance; medium- and long-term gilts would comprise the "majority" of new purchases.
	May-2009	APF expanded: The BOE would purchase up to £125 billion in assets.
	Aug-2009	APF expanded: The BOE would purchase up to £175 billion in assets; to accommodate the increased size, the BOE would expand purchases into gilts with remaining maturity of 3 years or more.
	Nov-2009	APF expanded: The BOE would purchase up to £200 billion in assets.
	Feb-2010	APF maintained: The BOE maintained the stock of asset purchases financed by the issuance of reserves at £200 billion; new purchases of private assets would be financed by Treasury issuance and DMO cash management operations.
	Oct-2011	APF expanded: The BOE would purchase up to £275 billion in assets financed by reserve issuance; the ceiling on private assets held remained at £50 billion.
	Nov-2011	Maximum private asset purchases reduced: HM Treasury lowered the ceiling on APF private asset holdings from £50 billion to £10 billion.
	Feb-2012	APF expanded: The BOE would purchase up to £325 billion in assets.

	Jul-2012	APF expanded: The BOE would purchase up to £375 billion in assets.
Funding for Lending Scheme	Jul-2012	FLS announced: BoE would subsidize bank funding to increase lending.
	Nov-2013	FLS extended/modified: FLS extended by a year and more incentives for lending to small and medium enterprises provided.
	Dec-2014	FLS extended by one year to end in January 2016.

European Central Bank

Program	Date	Summary
Long Term Refinancing Operations	Mar-2008	LTRO announced: LTRO maturity increased from the usual 3 months to 6 months announced.
	Dec-2011	LTRO expanded: 36-month LTROs announced; eligible collateral expanded.
	May-2013	LTRO expanded: 3 month LTROs till the end of 2014Q2 announced.
	Nov-2013	LTRO extended: 3 month LTROs to be issued until the end of 2015Q2.
	Jun-2014	Additional LTROs allotted.
Covered Bonds Purchase Program	May-2009	CBPP announced: The ECB would purchase €60 billion in euro-denominated covered bonds.
	Jun-2010	CBPP finished: Purchases finish on schedule; bonds purchased would be held through maturity.
	Oct-2011	CBPP2 announced: The ECB would purchase €40 billion in euro-denominated covered bonds.
Securities Market Program	May-2010	SMP announced: The ECB would intervene in the euro area public and private debt securities markets; purchases would be sterilized.
	Jun-2014	SMP sterilization suspended: weekly-fine tuning operation sterilizing the liquidity under SMP suspended.
Outright Monetary Transactions	Sep-2012	OMT announced: Countries that would apply to the European Stabilization Mechanism (ESM) for aid and abide by the ESM's terms and conditions would be eligible to have their debt purchased in unlimited amounts on the secondary market by the ECB.
Targeted Long-Term Refinancing Operations	Jun-2014	TLTROs announced: ECB would allow counterparties to borrow up to 7% of the total amount of their outstanding loans to the euro area non-financial private sector, excluding loans to households for house purchase. Initial entitlement of €400 billion.
	Jul-2014	TLTROs details announced: Initial entitlement was stated as €400 billion. Overall take-up could reach maximum of €1 trillion.
Asset Purchases Program	Sep-2014	ABS/covered bond purchase program announced: ECB would aim to return its balance sheet to 2012 levels - an increase of about €1 trillion.
	Jan-2015	ECB announced asset purchases totalling €1.1 trillion, to be conducted at least through September 2016 at the rate of €60 billion per month, until a sustained adjustment in the path of inflation. Total purchases amounted to around 11% of euro area GDP. Purchases would be composed mostly of

		sovereign debt, but will also include certain agency-backed securities, European supranationals, covered bonds, and asset-backed securities. Purchased assets will have maturities of 2 to 30 years. Purchase of each asset was capped at 33% of outstanding debt of a given issuer, and 25% of each given issue.
	Sep-2015	The cap on issues was raised to 33%.

Bank of Japan

Program	Date	Summary
Outright JGB/CFI purchases	Dec-2008	Outright purchases expanded: The BOJ increased monthly JGB purchases (last increased October 2002) from ¥1.2 trillion to ¥1.4 trillion.
	Jan-2009	Outright purchases announced: The BOJ would purchase up to ¥3 trillion in commercial paper and ABCP and were investigating outright purchases of corporate bonds.
	Feb-2009	Outright purchases expanded: The BOJ would extend commercial paper purchases and the SFSOs through the end of September (previously end of March) and would purchase up to ¥1 trillion in corporate bonds.
	Mar-2009	Outright purchases expanded: The BOJ increased monthly JGB purchases from ¥1.4 trillion to ¥1.8 trillion.
	Jul-2009	Programs extended: The BOJ extended the SFSOs and outright purchases of corporate paper and bonds through the end of the year.
	Oct-2009	Outright purchases of corporate finance instruments would expire at the end of 2009, but the SFSOs would be extended through 2010Q1; ample liquidity provision past 2010Q1 would occur through funds supplying operations against pooled collateral, which would accept a larger range of collateral.
Growth Supporting Funding Facility	May-2010	GSFF announcement: The BOJ would offer ¥3 trillion in 1-year loans to private financial institutions with project proposals for "strengthening the foundations for economic growth."
	Jun-2011	GSFF expanded: The BOJ makes available another ¥0.5 trillion in loans to private financial institutions for the purpose of investing in equity and extending asset-based loans.
	Mar-2012	GSFF expanded: The BOJ makes available another ¥2 trillion in loans to private financial institutions, including ¥1 trillion in U.S.-dollar-denominated loans and ¥0.5 trillion in smaller-sized (¥1 million-¥10 million) loans.
	Feb-2014	GSFF expanded and extended: Rollover time increased to 4 years and scale doubled.

Comprehensive Monetary Easing Program	Oct-2010	An asset purchases program was established as part of CME: The BOJ would purchase ¥5 trillion in assets (¥3.5 trillion in JGBs and Treasury discount bills, ¥1 trillion in commercial paper and corporate bonds, and ¥0.5 trillion in ETFs and J-REITs).
	Mar-2011	APP expanded: The BOJ would purchase an additional ¥5 trillion in assets (¥0.5 trillion in JGBs, ¥1 trillion in Treasury discount bills, ¥1.5 trillion in commercial paper, ¥1.5 trillion in corporate bonds, ¥0.45 trillion in ETFs, and ¥0.05 trillion in J-REITs).
	Aug-2011	APP expanded: The BOJ would purchase an additional ¥5 trillion in assets (¥2 trillion in JGBs, ¥1.5 trillion in Treasury discount bills, ¥0.1 trillion in commercial paper, ¥0.9 trillion in corporate bonds, ¥0.5 trillion in ETFs, and ¥0.01 trillion in J-REITs).
	Oct-2011	APP expanded: The BOJ would purchase an additional ¥5 trillion in JGBs.
	Feb-2012	APP expanded: The BOJ would purchase an additional ¥10 trillion in JGBs.
	Apr-2012	APP expanded: The BOJ would purchase an additional ¥10 trillion in JGBs, ¥0.2 trillion in ETFs, and ¥0.01 in J-REITs.
	Jul-2012	APP expanded: The BOJ would purchase an additional ¥5 trillion in Treasury discount bills.
	Sep-2012	APP expanded: The BOJ would purchase an additional ¥5 trillion in JGBs and ¥5 trillion in Treasury discount bills.
	Oct-2012	APP expanded: The BOJ would purchase an additional ¥5 trillion in JGBs, ¥5 trillion in Treasury discount bills, ¥0.1 trillion in commercial paper, ¥0.3 trillion in corporate bonds, ¥0.5 trillion in ETFs, and ¥0.01 trillion in J-REITs.
	Dec-2012	APP expanded: The BOJ would purchase an additional ¥5 trillion JGBs and ¥5 trillion in Treasury discount bills.
Quantitative and Qualitative Easing	Apr-2013	Monetary Base would be doubled: BOJ would increase its balance sheet by ¥60-70 trillion each year until end of 2014. ETFs and J-REITs would be purchased at a rate of ¥1 trillion and ¥30 billion, respectively. Bank of Japan would continue purchases of CP and corporate bonds until their outstanding amounts reach ¥2.2 trillion and ¥3.2 trillion respectively. CME APP terminated: Bank of Japan would purchase Japanese government bonds at a rate of ¥50 trillion a year under the QQE strategy of increasing the monetary base, and the Japanese government bonds used for conducting money market operations would be absorbed into this program. As such, the asset purchase program under the CME was terminated.
	Oct-2014	The BoJ announced that it would accelerate the annual pace of increase in the monetary base from ¥60-70 trillion to ¥80 trillion, and that it would continue with asset purchases “as long as it is necessary”. The BoJ also announced an increase in the average

		remaining maturity of the purchases from 7 years to 10 years.
Stimulating Bank Lending Facility	Oct-2012	SBLF announced: Through the SBLF the BOJ would fund up to 100% of depository institutions' net increase in lending to the non-financial sector.
	Feb-2014	SBLF expanded and extended: Rollover time increased to 4 years and scale doubled.