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Credit easing versus quantitative easing: evidence from corporate and government bond purchase programs

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Stefania D'Amico[(1)] and Iryna Kaminska[(2)]

Abstract

Using security-level data, we analyse the effects of the Bank of England's multiple rounds of gilt purchases (aka Quantitative Easing, QE) and its Corporate Bond Purchase Scheme (aka Credit Easing, CE) on corporate bond prices and issuance. This allows direct estimation of (i) QE's cross-asset supply effects and (ii) the joint supply effects of QE and CE. We show that in the case of QE alone, the pass-through of the gilt supply shock to corporate bond prices is significant, is larger in the longer-run than at announcement, and is often limited to the default-free component of the corporate yield. In the case of the joint conduct of QE and CE, we find that the CE is more effective than QE in reducing credit spreads, especially for higher-rated bonds, and in stimulating corporate bond issuance, which responds quite rapidly to the corporate bond supply shock.

Key words: Quantitative easing, Corporate Bond Purchase Scheme, monetary transmission mechanism, corporate bonds.

JEL classification: E52, E58, E65, G12.

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1 Introduction

There is mounting evidence that central bank asset purchases of "default-free" securities have reduced their yields by changing their available supply, a policy known as quantitative easing (QE).[1] But the evidence on the amount of pass-through to the yields of riskier assets is less decisive. For instance, earlier event-studies (e.g., Krishnamurthy and Vissing-Jorgenson, 2011; Joyce et al., 2012) show that investment-grade (IG) corporate bond yields fell by a similar amount to government bond yields following QE announcements, suggesting an immediate pass-through to those corporate bonds. However, the persistence and channels of these announcement effects are still not very well understood.[2] In particular, there are no estimates isolating supply effects on assets indirectly targeted by the QE purchases, so-called cross-asset supply effects, and consequently no distinction between their short- and long-run magnitudes. Further, there are no studies of the joint supply effects of QE and credit easing (CE) in private credit markets allowing to quantify the additional contribution of CE in lowering private borrowing costs.

Bernanke (2009) first used the term CE to describe the Federal Reserve's large-scale asset purchases, which focused on changing the size and composition of the asset side of its balance sheet to support private credit markets. In what follows, CE refers exclusively to central bank purchases of defaultable privately-issued securities, to distinguish it from QE, which involves the purchase of default-free government-backed securities. A clear distinction between these two policies is necessary for assessing their relative efficacy. This is key to answering one of the fundamental questions about unconventional monetary policies that has been haunting policy-makers and academics alike: that is, to reduce private borrowing costs, is it more efficient to buy risk-free bonds and rely on the forces of arbitrage to transmit the impact to private yields or to buy riskier privately-issued securities directly? The answer has important implications for the current debate about the future of monetary policy, as CE could prove to be a critical additional tool to fight recessions in the low-interest-rate environment.[3]

In this study, we propose a granular approach based on individual corporate bond prices and government bond quantities purchased by the Bank of England (BoE) during multiple QE programs, to better identify their supply effects on UK

[1]See among many, Gagnon et al., 2011; Hancock and Passmore, 2011; Krishnamurthy and Vissing-Jorgensen, 2011; Joyce and Tong, 2012; D'Amico and King, 2013; Eser and Schwaab, 2016.

[2]For instance, Neely (2016) and Mamaysky (2018) find that the dynamic impact of QE on riskier assets occur over several weeks even months, while Wright (2012) shows that it dies out quite fast.

[3]See for e.g., the panel on "Monetary Policy in 2018 and Beyond" at the 2018 AEA meetings, or Bernanke (2017), "Monetary policy in a new era."

corporate bonds, an indirectly targeted asset class. This allows us to estimate some of QE's cross-asset supply effects. We also consider the individual corporate bond purchases conducted by the BoE during the Corporate Bond Purchase Scheme (CBPS), which was launched at the same time as a new round of QE, following the EU referendum result in 2016. This provides us with the unique opportunity to estimate CE's supply effects and its additional contribution relative to QE. Importantly, in quantifying the impact of either QE alone or QE and CE jointly, we distinguish between their short- and longer-run effects by estimating both, the immediate supply impact on the announcement day and its persistent component over the entire life of each program, which spanned several months. Finally, our analysis goes beyond corporate price effects as it also includes the QE and CE's impacts on corporate bond spreads and issuance, in order to disentangle some of their possible transmission channels.

We favor a security-level approach exploiting cross-sectional variations in quantities and prices for several reasons. First, as in D'Amico and King (2013), it enhances identification of quantity effects by allowing us to build, using individual bond characteristics, instrumental variables that address typical endogeneity issues between quantities and prices, which become more severe during the implementation of QE and CE. Second, it allows us to build, for each corporate bond, buckets of substitute securities, which are crucial to estimate QE's cross-asset supply effects and CE's within-asset substitution effects. Third, controlling simultaneously for government and corporate bond substitute purchases at the bond level allows direct estimation and comparison of the corporate bond price elasticities with respect to government and corporate bond purchases, respectively. This can improve our understanding of the relative efficacy of QE and CE, and hence of whether CE could be employed as a complement or substitute tool in reducing private yields.

Our results indicate that corporate bond price reactions during various QE and the CBPS announcements were in large part driven by the supply channel, as the expected distribution of purchases across bonds explains a significant share of the relative price increases already incorporated at the time of the announcement. In the case of QE alone, this provides evidence of an immediate pass-through via supply effects to an indirectly targeted asset class. Further, in line with the theory of Greenwood, Hanson, and Liao (2018) about cross-asset supply effects in partially-segmented markets, we find that the impact of QE substitute purchases on corporate bond prices is significantly larger in the longer-run than in the short period around the announcement. This suggests that the portfolio rebalancing into riskier assets induced by central bank purchases of government bonds might occur gradually, reaching its peak after several months from the start of those policy interventions.

In the case of the joint conduct of CE and QE, we find that a corporate bond's price sensitivity to its own purchases is substantially higher than its price sensitivity to gilt substitute purchases. And turning to credit spreads, our findings indicate that CE is more effective than QE in reducing this component of corporate yields, especially for higher-rated bonds. Specifically, except for the first QE that was conducted at the height of the financial crisis, QE substitute purchases do not seem to typically affect corporate spreads both in the short- and longer-run. This is because, in more normal market conditions, corporate yields do not respond more than gilt yields to government supply shocks, suggesting QE works primarily by affecting the default-free component of the corporate yield. But, during periods of market distress, QE's cross-asset supply effects significantly lowered credit spreads in the longer-run, indicating that central bank purchases of government bonds might also improve trading conditions and capital mobility in indirectly-targeted riskier markets. This, in turn, might signal that the supply channel interacts, for instance, with the liquidity channel, especially at times of financial market stress.[4] In contrast, CE reduced credit spreads even under relatively normal financial market conditions.

Finally, in the case of corporate debt issuance, we find that, differently from QE, CE seems to stimulate new issuance of corporate bonds quite rapidly. In particular, while across different rounds of QE there is no statistically significant impact of government bond purchases on corporate issuance, in the case of the CBPS, corporate bond purchases have positive and statistically significant effects on sterling denominated corporate bond issuance. This aspect of our findings is consistent with the evidence reported in recent studies of the European Central Bank's (ECB) Corporate Sector Purchase Program (CSPP) (see, Abidi and Miquel-Flores, 2018; Todorov, 2018; Zaghini, 2019).

Taken together, our results show that in the case of QE alone, the pass-through to riskier asset prices is substantial, but generally limited to the default-free component of private yields; unless financial markets are highly disrupted, in which case QE could additionally reduce the risky component. In the case of the joint conduct of QE and CE, we show that CE also reduces the credit spreads of higher-rated bonds, revealing that the price impact of QE is amplified by that of CE purchases, making the total stock effect somewhat larger. This suggests that for those bonds the two policies are complimentary. In contrast, for lower-rated bonds, the evidence in favor of both cross- and within-asset supply effects is weaker. It is possible that, since CE significantly stimulated corporate debt issuance, the negative price impact of new issuance counterbalanced the positive one from the BoE's bond purchases.

Overall, our novel analysis allows us to shed some light on the QE pass-through to private borrowing costs and the additional contribution of CE, relative to QE,

[4] See e.g., Gangnon et al (2011), or Bowdler and Radia (2012).

in lowering those costs. Notably, the direct purchase of defaultable privately-issued securities is found to be more effective in improving credit spreads and new issuance of those securities. This has important implications for the amount of risk a central bank may be willing to add to its balance sheet. Some policy-makers have noted that, even if buying privately-issued securities is not fundamentally different from buying government bonds, it does imply that the central bank steps "into the realm of credit risk."[5] Outright purchases of privately-issued securities affect the risk profile of the central bank's balance sheet and can affect the allocation of credit in the economy, thus policy-makers need to carefully assess the eligibility of those assets and plan to avoid allocative distortions in terms of industries, firms or regions. Although the evaluation of this type of effects is beyond the scope of this paper, some researchers have been focusing on some of those issues.[6]

The literature on QE pass-through to riskier assets is growing rapidly, but there is still considerable uncertainty about the effects of unconventional monetary policy on private borrowing costs. For example, Krishnamurthy and Vissing-Jorgensen (2013) argue that the Fed's QE was relatively ineffective in lowering corporate bond yields, while Gilchrist, Lopez-Salido, and Zakrajšek (2015) provide evidence of a complete pass-through from Treasury yields to real corporate borrowing costs during QE. Further, studies of CE are still few because central banks' corporate bond purchases are a novel tool and thus the data and experiments to study them are becoming available only recently. Much of this research is characterized by two features: the use of an event-study approach focused on short time windows and QE shocks proxied by policy-induced changes in Treasury yields rather than in Treasury quantities. The first feature can lead to mismeasurement of portfolio-rebalancing effects in riskier and less liquid markets where capital might move slower (Greenwood, Hanson, and Liao, 2017; Mamaysky, 2018). The second feature limits the ability to identify the channels of the pass-through, as the QE-induced change in Treasury yields, unlike amounts purchased, can be due to a variety of channels (e.g., signaling, scarcity and duration, D'Amico et al., 2012).

Our work displays some important distinguishing features that set it apart from the existing literature. First, the use of individual quantities purchased of government and corporate bonds allows us to identify the supply channel, also known as the stock effect, separately from other channels; and, the focus beyond the announcement effects helps assessing the more persistent component of this channel. Second, the ability to group those individual quantities in different sets of substitute purchases allows us to determine how localized supply effects are, and therefore the extent of the substitution mechanism, which is key to understand

[5]Bini Smaghi (2009).

[6]For instance, Arce, Gimeno, and Mayordomo (2018) show that the drop in the demand for credit by large bond issuers allowed some of the bank lending to be redirected to smaller non-bond issuing firms, leading them to raise their investment.

the pass-through. Third, the possibility of controlling for both government and corporate bond purchases allows us to disentangle their separate contributions, while still quantifying their joint effects, which have never been studied before. Last but not the least, this is the only paper so far quantifying cross-asset stock effects, as previous studies of this effect have been estimating how supply shocks in one asset class affect prices within the same asset class (i.e., how government bond supply affects government bond yields or agency-MBS supply affects agency-MBS yields). Similarly, recent studies of the ECB's corporate bond purchases, such as Abidi and Miquel-Flores (2018), Todorov (2018), and Zaghini (2019), are also focused only on the impact in the corporate bond market, thus do not isolate cross-market or substitution effects. More importantly, different from us, those authors do not rely on individual quantities purchased of either government or corporate bonds, and thus cannot separately identify the supply channel and the relative efficacy of QE and CE.

The reminder of the paper is organized as follows. Section 2 describes the BoE's asset purchase programmes and data. Section 3 provides a cursory glance at the corporate bond market reaction to QE and CE. Section 4 details our empirical specifications. Section 5 examines the impact of QE alone, whereas Section 6 is focused on the joint effects of QE and CE. Finally, Section 7 offers some concluding remarks.

2 BoE's QE and CE Programmes

During the last financial crisis, the BoE, like many other central banks, conducted multiple rounds of government bond purchases, removing from the market £375 billion of gilts in about four years. In particular, from March 2009 to January 2010, the BoE purchased £200 billion of gilts (QE1); from October 2011 to May 2012 its purchases were extended by £125 billion (QE2); and from July 2012 to November 2012, an additional £50 billion were purchased (QE3). These programs were announced on March 5, 2009, October 6, 2011, and July 5, 2012, respectively. Gilt purchases were implemented through a series of 'reverse auctions' that were held separately for different maturity groups.[7] At the time of the QE1 announcement, intended purchases were split between two auction maturity sectors: (i) 5–10 years and (ii) 10–25 years. By the time of QE2, those purchases were split between three auction maturity sectors: (i) 3–7 years, (ii) 7–15 years, and (iii) 15 years and greater. In the end, the total amount of actual purchases was allocated

[7]Bidders offered to sell gilts to the BoE specifying the amount and price at which they were willing to sell each security.

evenly between the maturity sectors.[8]

On August 4, 2016, as part of a package of monetary policy measures, the BoE announced a fourth round of QE (QE4), consisting of an extra £60 billion of goverment bond purchases, and the CBPS, consisting of direct purchases of up to £10 billion of IG sterling-denominated bonds issued by non-financial corporations "making a material contribution to the UK economy." The stated purpose of the program was to impart monetary stimulus by lowering corporate bond yields, thus reducing the cost of borrowing for companies, by triggering portfolio rebalancing into riskier assets, and by stimulating new issuance. The purchases started in September 2016 and ended in April 2017 with the purchase of exactly £10 billion of bonds, about 7% of eligible securities (£150bn) and 2% of the total UK sterling corporate market (£500bn), which is quite small and not very liquid.

Following the release of the July 2016 minutes, the Monetary Policy Committee (MPC) was reportedly expected to deliver a series of easing measures at the August meeting. Market expectations, however, were diffuse, with little consensus on the composition of the different policy measures. Beyond the rate cut, which was widely expected (only 2 out of 51 economists surveyed by Bloomberg predicted no change to interest rates), market participants were about evenly split on whether additional QE purchases would be announced, with 22 of the 43 economists surveyed by Bloomberg expecting no change to QE at the August meeting but many more expecting QE to be announced later in 2016. Most of the economists forecasting additional QE predicted either £50 or £75 billions of additional purchases. Before the August announcement, the gilt curve flattened mostly in the 5-to-10-year sector rather than in the 10-to-30-year sector, as some investors speculated that the new QE program would try to underweight the longer end of the curve to reduce pressure on pension funds. In addition, a corporate bond purchase program was seen as an unlikely but possible option, as MPC commentaries indicated that corporate bonds could be included in a future asset purchase program, with most MPC members arguing that purchasing corporate bonds would be similar to purchasing gilts.

Overall, the announced package of new easing measures exceeded market expectations. Reportedly, market participants noted that the size of the announced CBPS was not insignificant relative to the estimated eligible universe as BoE was targeting roughly 7%. For comparison, at that time, the ECB was on track to purchase roughly 10% of its eligible corporate debt, which equated to just over 1% of the total euro-denominated, Eurozone-domiciled corporate universe. In response to the CBPS/QE4 announcement, forward OIS rates fell a few basis points, gilt yields fell by up to 16bps at the longer end of the yield curve, and yields on

[8]For more detail on Gilts QE and their announcements see Joyce, McLaren, and Young (2012) and McLaren, Banerjee, and Latto (2014).

corporate bonds potentially eligible for the CBPS fell by 30bps while the Barclays Sterling Aggregate Corporate OAS index tightened by 8bps. UK equity prices increased broadly, with the FTSE 350 1.6% higher, and all sectors gained although bank shares were mixed. The factors cited by investors for the positive price reaction across markets were the asset purchase programs and MPC forward guidance indicating that all its tools had scope for further action.

Regarding the CBPS details, the BoE excluded bonds issued by banks, building societies, insurance companies, and other financial sector entities that regulate, and offered to purchase corporate bonds with the following characteristics:

- Sterling-denominated;
- From companies making a material contribution to economic activity in the UK (which on September 12, 2016 was clarified to mean a series of things: with significant employment in the UK, with their headquarters in the UK, generating significant revenues in the UK, serving a large number of customers in the UK, and having a number of operating sites in the UK);
- Conventional senior unsecured or secured, unsubordinated debt;
- Rated investment grade by at least one major rating agency;
- With minimum amount in issue of £100 million;
- With minimum residual maturity of 12 months, no perpetual debt;
- With at least one month since issuance;
- With no complex structure, such as convertible or containing callable features.

Reportedly, some market participants indicated that the requirement relating to the "material contribution" of companies to the UK economic activity had initially caused some confusion.[9] However, many of the announced criteria could have been in part known based on two previous purchase programs targeting corporate bonds. The first was the Corporate Bond Secondary Market Scheme announced by the BoE in February 2009 to aid secondary market liquidity, which was much smaller in scope and scale than the CBPS, with peak holdings being less than £2bn. The second one was the ECB's CSPP announced in March 2016, which had purposes and characteristics very similar to the CBPS.

[9] See, for example, the summary of the meeting of the ICMA Secondary Market Practices Committee with the Bank of England's Corporate Bond Purchase Scheme on November 2016.

Indeed, when we will look at the results of the event-study regressions used to analyze corporate price changes on the day of the CBPS announcement (Table 1), it will become clear that market participants had already in mind a good approximation of the variables that could have been relevant for the BoE in determining the issues and quantities to purchase. This, in turn, suggests that investors could have been quite successful in forecasting the distribution of those purchases based on the information available at the time of the announcement.

Thus, we can exploit previously known information about the eligibility characteristics to better understand the market reaction and to build instrumental variables (IV), which are necessary to address endogeneity problems typical of any estimated relations between prices and quantities. As suggested by D'Amico and King (2013) in the context of government bond purchases, endogeneity issues likely became more severe during QE implementations, as central banks may have attempted to purchase securities based on their prices, for example, those that they viewed as underpriced relative to the yield curve. This seems to be plausible also during the CBPS, as the BoE indicated that in its auctions it would "seek offers as a spread to a specified reference gilt yield" and that it would "privately set a minimum spread" for each security, that is, a spread below which the BoE would not buy a bond. Such selection criteria could have potentially implied that the BoE would have chosen among the eligible bonds those with larger spreads to gilt yields and thus characterized by relatively lower prices. Further, since one of the CBPS's objectives was to stimulate new issuance, and the BoE also intended "to purchase a portfolio of corporate bonds representative of issuance," it is possible that quantities purchased responded to price changes through this additional mechanism; as it is plausible that issuance increased relatively more for bonds experiencing larger yield declines (price increases). Finally, if market participants tended to offer the central bank those bonds that were expected to underperform, then prices would have affected purchased amounts creating again a reverse causality issue.

Taken together, these endogeneity concerns stress the importance of instrumenting quantities purchased not only for government bonds but also for corporate bonds, in order to better estimate their price impacts. This, in turn, depends on our ability to determine how market participants formed their expectations about CBPS and QE purchases, as the purchase distribution expected before the actual implementation of those programs could not have responded to price changes that took place during the life of the program. To this end, it is crucial to analyze security-level price reactions to the three QE and QE4/CBPS announcements, as those reactions shed light on the expectations formation process as will be shown in Section 3.

2.1 Data

Our data consist of daily observations on corporate and gilt related variables during periods bracketing the first three QE programmes and QE4/CBPS. In particular, for each program, we use data from the day before the announcement, the day of the announcement, and the day of the last purchases. QE1 was announced on March 5, 2009 and completed on January 26, 2010. QE2 was announced on October 6, 2011 and completed on May 3, 2012. QE3 was announced on July 6, 2012 and completed in October 31, 2012. QE4/CBPS were announced on August 4, 2016 and completed by April 27, 2017.

We look only at bonds that have more than one year left to maturity, because Bank of America Merrill Lynch (BoAML)–our main data source for bonds–does not include information on bonds close to expiration. This limitation turns out to be innocuous because the minimum residual maturity for the CBPS eligible bonds was set at 12 months; while for QE the shortest eligible maturity was 3 years, except for the first 5 months of QE1, during which the eligible maturities were restricted between 5 and 25 years. Further, all bonds in our study have a maturity smaller than 50 years. All corporate bonds are identified by a unique International Securities Identification Number (ISIN) and gilts by the CUSIP number, which allows us to easily keep track of security-level data.

Our primary variables of interest are the security-level percentage price changes and yield spread changes measured at end-of-day, as well as the face value of the security-level amounts outstanding and purchased under the QE and CBPS programs. The amounts of each corporate bond and gilt purchased by the BoE are provided by the BoE.[10]

Since we focus only on IG non-financial bonds, we have a total of 297 securities in QE1, 345 securities in QE2, 378 securities in QE3, and 502 in QE4. The part of our empirical analysis focused on securities that were eligible for purchase under the CBPS includes 364 ISINs out of 502. During the time frame of the three QE periods, the number of gilts with more than one year left to maturity and for which we have yield-fitting errors are 30, 37, 36, and 39, respectively.

We also built the following variables. Rating scores take values from 1 to 10 as we have ten rating categories, with 1 being AAA and 10 being BBB-, the worst rating score for IG bonds. UK headquarter is a dummy variable taking the value of one if the company has headquarter in the UK. The credit spread to gilts is the difference between a corporate bond yield and a gilt yield of comparable maturity.

Finally, in some specifications, we also control for some liquidity measures, such as number of trades, or average trade size. Both measures are constructed

[10]QE purchases for all four QEs are available at https://www.bankofengland.co.uk/markets/quantitative-easing-and-the-asset-purchase-facility

from actual transactions and are computed, described and provided by Boneva et al (2019). In particular, as sterling corporate bonds trade relatively infrequently, with around one trade per day on average, these liquidity measures are taken at weekly frequency. These liquidity measures are available only for the most recent period of QE4/CBPS.

3 A cursory look at the corporate market reaction

This section details some characteristics of the overall data and the type of cross-sectional variation that we exploit in our identification procedure. A variety of cursory observations here further motivate our more rigorous search for the supply effects of QE and CE in the following sections.

First, we use the example of QE1, for which information on the individual quantities purchased is publicly available, to illustrate that, on the announcement of the program, yields on corporate securities having a relatively larger amount of gilt substitutes that were subsequently bought by the BoE fell on average by more. Specifically, in Figure 1, across IG corporate bonds sorted by rating category (with 1 being AAA and 10 being BBB-), each blue bar indicates the purchased amount of gilts with nearby maturities, and each red bar marks the decline in yield registered by a specific corporate bond. It is easy to see that, within each rating category, the bonds that display the largest decline in yields are also those with the largest amounts of gilt substitutes bought by the BoE, as the bottom panel is almost a mirror image of the top panel. This clearly indicates that prospective scarcity of gilt substitutes rather than credit risk might be driving a large part of the yield change already on the announcement day. The relative changes in quantities bought by the BoE and associated relative changes in yields, shown in Figure 1, are the type of variation crucial to identifying the supply effects of QE and CE.

Turning to QE4/CBPS, Figure 2 shows the changes in yields on August 4, 2016 for all the available ISINs. Figure 2a orders these by remaining maturity (shown on the top panel). The largest reactions are in the 5- to 20-year maturity range, where the yields declined on average by about 25 basis points, with smaller reductions around the 5-year maturity than around the 20-year maturity; while yields at very short and very long maturities (i.e., between 20 and 50 years) did not fall as much as those in the 5-to-20-year range. This indicates that the impact of the announcement on corporate bond yields, even if quite large, was not significantly driven by the exposure to duration risk. In addition, Figure 2b displays the yield declines for the same bonds shown in Figure 2a but as function of their ratings, where 1 corresponds to the best rating (AAA). By looking at the shaded region, it is evident that the high-yield (HY) bond yields fell on average the least, indicating that market participants expected BoE purchases to be concentrated in IG bonds. Further, by comparing Figure 2a and 2b, it is clear that the HY bonds are also those with the shortest maturities - at those maturities the reduction in yields is around 10 basis points. In contrast, among the IG bonds, those with a higher numeric rating (and thus lower quality) experienced on average a larger decline in yields, about 25 basis points; that is, 5 basis points more than the average yield reduction of higher quality bonds, therefore suggesting that part of the market reaction can be related to credit and/or liquidity risk. Overall, these figures imply that corporate bond characteristics can be very useful in understanding the corporate bond market reaction and investors' expectations.

While a number of studies have previously examined the effects of central banks' asset purchase announcements on a few constant-maturity corporate yields and credit spreads (e.g., Boneva, de Roure, and Morley, 2018), to the best of our knowledge none has employed individual data on hundreds of outstanding IG corporate bonds, during either the QE4/CBPS or previous QEs in the UK.[11] Here, we start analyzing the security-level announcement effects for IG non-financial corporate bonds, by running ISIN-level regressions projecting the announcement day's percentage price changes or credit spread changes on the corporate bond's characteristics as of the day before the announcement. We consider the following bond characteristics: maturity, maturity squared, domicile (UK headquarters), credit rating, issuance size (Face Value), and the level of credit spreads.

Table 1A indicates that the individual characteristics as of the day before the announcement can explain between 40 and 70 percent of the increase in corporate bond prices that occurred on the day of the announcement, with the exception of QE2. Across the announcements of QE1, QE3, and QE4/CBPS there are some common qualitative patterns. The increase in corporate bond prices is larger for securities with longer maturities, but not very long,[12] and with lower credit spreads. During the two most recent programs, bonds with higher (and thus worse) rating scores experienced larger price increases. Finally, the coefficient on the corporate issuance size (a proxy for available supply and liquidity) becomes positive and statistically significant in QE4/CBPS. One possibility is that investors understood that, given the limited size of the sterling corporate bond market, CBPS purchases would have had to reflect the issuance size distribution.

As shown in Table 1B, those same corporate bond characteristics, however, cannot explain much of the changes in credit spreads during earlier QEs and there

[11] Concurrent studies by Abidi and Miquel-Flores (2018) and Todorov (2018) use a discontinuity design approach around the ECB's announcement of the CSPP, exploiting individual bond data, while Boneva et al (2019) look at the impact of the CBPS auctions on the liquidity of individual corporate bonds.

[12] This is similar to the reaction of goverment bond prices during previous QE announcements (see e.g., McLaren et al (2014) for the UK and D'Amico and King (2013) for the US).

are no clear patterns across the different programs, with the exception of the credit spread that is positive and significant for QE1, QE3, and QE4/CBPS, suggesting that corporate bonds with larger initial spreads experienced a relatively smaller decline in yields. Notably, QE4/CBPS seems to be quite different from previous QEs. To start with, all the individual bond characteristics (with the exception of UK headquarters) are strongly significant and can explain a larger share of spread changes. Keeping everything else equal, bonds with worse ratings benefited substantially more (the loading on rating scores is also much higher than that one for QE1-3). Finally, similarly to the price reaction in Table 1A, issuance size also becomes important, while it is insignificant during previous rounds of QEs.

Moreover, since the QE4/CBPS announcement is more specific to corporate bonds, we dig a bit deeper into its impact by studying different cuts of the sample and controlling for more bond characteristics. This is also possible because, for the latest period, we have better data such as liquidity measures. Table 2A focuses only on QE4/CBPS by analyzing different sub-samples of outstanding corporate bonds and including also liquidity as an additional control. In the case of the entire sample, all the explanatory variables are statistically significant and with the expected sign; but, when we restrict the attention to the set of eligible bonds, i.e., IG non-financial bonds, the variable "headquarter in the UK" loses its marginal predictive power. In particular, investors inferred from the announcement that, if the BoE focused on IG bonds, it would not necessarily favor firms domiciled in the UK. However, this last finding is not very robust, as having headquarters in the UK turns out to be significant and flips sign in a specification controlling for liquidity.

The findings of Table 1B are further corroborated when we analyze in more detail the QE4/CBPS's announcement impact on credit spreads, which is described in Table 2B. Overall, it is interesting to note that, when the monetary policy decision contained information and measures specific to corporate bonds, credit spreads seem to be more affected by the announcement (relative to previous QEs) and in a way that is consistent with the price reaction.

To conclude, this cursory glance at the corporate bond market's reaction to QE and CE announcements suggests that, overall, a security-level analysis can be useful for understanding investors' expectations and, therefore, for building the appropriate IVs to capture the expected distribution of future purchases as of the day of the announcement, which will be exogenous to the subsequent policy implementation.

4 Empirical specification

In estimating the short- and long-run effects of QE and CE on corporate bonds, we follow an experiment design very similar to D'Amico and King (2013), but we also extend it to account for contemporaneous purchases of government and corporate bonds. Thus, in what follows, we detail the novel aspects of our approach by mostly focusing on the CBPS, as the methodology for government bonds is already detailed in D'Amico and King (2013).

For each security i in our sample, we partition the outstanding securities into buckets of "substitutes," $S_n(i)$, consisting of other securities with very similar characteristics. The sterling amount of substitutes for each security i purchased under the CBPS or QE programs in the n^{th} bucket is denoted by $Q_{i,n} \equiv \sum_{j \in S_n(i)} Q_{j,0}$, while $Q_{i,0}$ is the amount of security i itself purchased under the CBPS program. We will refer to this as "own purchases," which allow us to analyse the so-called local-supply channel. In our framework, differently from previous QE studies, $S_n(i)$ can consist of securities belonging to an asset class different from that of security i. For example, when we analyze the pass-through of QE to corporate bonds, the set of substitutes will consist of government bonds rather than corporate bonds, and when we analyze the joint impact of QE and CE on corporate bonds, we will consider simultaneously two sets of substitutes, consisting of corporate and government bonds, respectively. This allows direct estimation of the cross-market effects of QE and of the relative efficacy of QE and CE for private borrowing costs.

Because coupon rates and maturities vary considerably across the universe of corporate securities, our main regressions are in price space. In addition, we also analyze credit spreads. In general, our regressions take the following form:

$$\frac{\Delta P_i}{P_i} \text{ or } \Delta CS_i = \beta_0 Q_{i,0} + \boldsymbol{\beta}_{\mathbf{n}} \mathbf{Q}_{\mathbf{i,n}} + \phi(\mathbf{x}_i) + \varepsilon_i,$$

where, for each security i, $\frac{\Delta P_i}{P_i}$ is the percentage price change, ΔCS_i is the corporate spread change, $\mathbf{x}_i$ is a vector of bond characteristics we need to control for, $\phi(\cdot)$ is a smooth function of control variables, and β_0 and $\boldsymbol{\beta}_n$ are the coefficients of interest. For instance, in the case of $\frac{\Delta P_i}{P_i}$, this specification implies that our identification and estimation strategy relies on the cross-sectional variation of individual corporate bond price changes and quantities of all eligible bonds purchased by the BoE. In particular, β_0 measures the own-price elasticity of corporate bonds, while vector $\boldsymbol{\beta}_n$ reflects the cross-price elasticity of corporate securities to other corporate securities and to other government securities. Since this cross-price elasticity depends on the degree of substitutability between the different securities, it measures the substitution effect, and thus can be very important for the aggregate impact of QE and CE. That is, the purchase of a particular security affects that security's price alone through the β_0 term but affects other securities' prices through the applicable $\boldsymbol{\beta}_n$ terms.

Unlike preferred-habitat in government bonds, usually thought of as a function of maturity alone (as, for example, in Vayanos and Vila, 2019), preferred-habitat in corporate securities may be driven by additional factors such as credit risk and/or industry-specific knowledge. Thus, our definition of corporate substitutes can be based on multiple characteristics such as maturity and credit rating. For example, in the CBPS analysis, for each bond i, the most narrow substitute bucket will include all IG corporate bonds having remaining maturity within two years of security i's maturity, as well as within the same or adjacent rating of security i. To analyze how a different degree of substitutability affects the price impact of amounts purchased, we also consider alternative definitions of substitute buckets.

4.1 Addressing endogeneity

So far, we have not addressed the endogeneity concerns described in Section 2. These become particularly relevant when we examine the impact of the BoE's corporate bond purchases on corporate bond prices during CE. However, in evaluating the impact of gilt purchases on a different asset class, such as corporate bonds, endogeneity issues are less obvious, as it seems unlikely that, during QE programs preceding the CBPS, specific gilts were targeted based on their relation to corporate bonds. While this assumption seems reasonable for credit spreads, which by construction are purified from movements in gilt yields, it may be harder to justify for corporate bond prices, whose fluctuations can be closely related to those of gilt prices therefore inheriting their endogeneity issues. Further, since QE4 was conducted simultaneously with the CBPS, it is possible that gilt purchases and corporate purchases were not perceived as independent, making gilt purchases partially endogenous to corporate prices.

To control for these possibilities, we use two-stage least squares. In the first stage, we instrument $Q_{i,0}$ and $Q_{i,n}$ of either corporate bonds, or gilts, or both using information about the security's characteristics available before the program was announced, that is, using pre-CBPS information (or pre-QE information when we analyze QE1, QE2, and QE3). In the second stage, we use instrumented purchases from the first stage as independent variables and changes in either corporate prices or credit spreads as the dependent variables. That is, we estimate the following specification:

$$Q_{i,0,T} \text{ and/or } Q_{i,n,T} = \gamma_0 + \gamma_1 \mathbf{z}_{i,t} + \gamma_2(\mathbf{x}_{i,t}) + u_i \tag{1}$$

$$\frac{\Delta P_{i,t,T}}{P_{i,t}} \text{ or } \Delta CS_{i,t,T} = \beta_0 Q^{IV}_{i,0,T} + \boldsymbol{\beta}_{\mathbf{n}} \mathbf{Q}^{\mathbf{IV}}_{\mathbf{i,n,T}} + \phi_0 + \phi(\mathbf{x}_{i,t}) + \varepsilon_i \tag{2}$$

where t is the day before the announcement of each program, T marks the end of the time interval under consideration, $\mathbf{z}_i$ is the vector of the security-specific instruments. Importantly, while for $Q_{i,0,T}$ and $Q_{i,n,T}$, T always marks the end of each program, for the dependent variables at the second stage, T can indicate different time intervals depending on which effect of the program we are focused on. If the focus is on the immediate impact of expected future purchases, then T will simply equal $(t + 1)$ as, in this case, we will use the daily change around the announcement. If the focus is on the estimation of the stock effect, that is, the permanent impact of the total amount of bonds purchased under QE and/or CBPS, then T is the day after the last purchase, implying that the changes are computed over a period of many months. This is because the stock-effect estimates rely on the cross-sectional variation of cumulative price and spread changes over the entire life of the program and thus measure the longer-run effects of CE and QE. These effects are conceptually and empirically different from the announcement impacts of those policies, as by the end of a program expectations about the purchase distribution are crystallized and a large share of investors should have rebalanced their portfolios.

In the second stage, we also control for individual factors ($\mathbf{x}_{i,t}$) that could have affected corporate prices independently of the BoE purchases. In particular, we control for maturity and maturity squared as these terms not only control for the duration-risk effect of CBPS and QE purchases, but also account for possible secular changes in the slope and curvature of the corporate bond yield curve during those programs, which could have resulted from varying macroeconomic conditions and new corporate issuance. We also include the dummy variable tracking companies with headquarters in the UK, as these companies could have been hit harder in the post-referendum period; credit rating and spreads as of t to control for relative differences in bond riskiness; and the size of issuance as of t, as smaller and arguably less liquid companies could also have suffered more in the EU referendum aftermath. Further, it is possible that, if prices and/or credit spreads are not persistent, the prices of bonds with initial larger (smaller) spreads would tend to rise (fall) relative to those of other securities even in the absence of CBPS and QE purchases, making initial prices or credit spreads correlated with the second-stage error term, which suggests that they should not be omitted as they would bias the purchase coefficients β_0 and β_n.

5 The impact of QE alone

To better understand the relative efficacy of QE and CE, their respective channels, and whether these two monetary policy tools are substitutes or complements, we proceed in steps. First, we analyze the impact of QE on corporate bonds *in the* *absence* of corporate bond purchases by the BoE, which should help isolate the role played by QE for private bonds. Later, we shift our attention to the joint impact of QE and CE by adding to the analysis the corporate bond purchases that took place during the CBPS. Hence, this section is confined to the study of the pass-through of the first three rounds of QE, which implies estimating the price impact of this policy outside the market directly targeted by its purchases. In studying the corporate bond market effect of QE, we begin by estimating the immediate impact of gilt purchases on corporate bond prices and spreads, and then we estimate the longer-run impact of the stock effects. Finally, we also examine the impact of QE on corporate bond issuance, as this could be an additional longer-run effect of this policy.

As for the channels of the QE's transmission mechanism to private yields, a few aspects of our analysis can be informative in this regard. First, the comparison between the estimated impacts on corporate prices and credit spreads should help us understand whether QE affects corporate bond yields through either their default-free component, or their risky component, or both. Second, the magnitude and significance of the cross-price elasticities should inform us on the importance of substitution effects across asset classes and, in particular, on the importance of local-supply effects relative to other channels. Finally, a significant impact on corporate issuance could be suggestive of an additional channel of this policy, the issuance channel.

5.1 The immediate impact of QE

First, using the data on the purchases of gilt substitutes, we analyse QE supply effects on the day of the announcement. Considering that the UK gilt market is quite large relative to the UK corporate bond market, to better capture relative scarcity in the n^{th} maturity sector, as in D'Amico and King (2013), we assume that the potential influence of sterling quantities purchased in a given sector depends inversely on the sterling amounts outstanding, $O_{i,n}$, in that sector, which is not directly influenced by the BoE. Thus, we consider a normalized quantity variable $q_{i,n}$, where the normalization is a function of $O_{i,n}$, in the second stage. The bucket of gilt substitutes is built around each IG corporate bond by considering all gilts with remaining maturity within 2.5 years of corporate bond i's maturity if such maturity is below 10 years, and all gilts with remaining maturity within 5 years of corporate bond i's maturity if such maturity is above 10 years.[13] We increase the bucket's size at the long end of the curve to make sure that each corporate

[13]Since in QE1 the purchases were split between two auction maturity sectors, 5–10 years and 10–25 years, we chose to increase the size of the bucket at the 10-year maturity. If we switch at the 15-year maturity to reflect changes made to the auction maturity sectors in QE2, the results for QE2 and 3 are very similar.

bond in those sectors has more than one gilt as a substitute. Further, for QE1, we restrict the maturity of the corporate bonds to be between 5 and 30 years as the gilt purchases were concentrated in the 5-to-25-year maturity sector.

Our baseline specification for estimating the short-run effect of gilt substitute purchases in each QE program is the following:

$$Q^{QE}_{i,n,T} = \gamma_0 + \gamma_1 \mathbf{z}^{Gilt}_{i,n,t} + \gamma_2(\mathbf{x}_{i,t}) + u_i \tag{3}$$

$$\Delta P_{i,t,t+1}/P_{i,t} = \beta \widehat{q^{QE}_{i,n,T}} + \phi_0 + \phi(\mathbf{x}_{i,t}) + \varepsilon_i, \tag{4}$$

where, for each corporate bond i, $\Delta P_{i,t,t+1}/P_{i,t}$ is the percentage price change on the day of the announcement, and $\mathbf{z}^{Gilt}_{i,n}$ includes IVs built for the entire bucket of gilt substitutes and measured on the day before the announcement: average yield curve fitting errors within the bucket and the percentage of the gilt bucket already held by the BoE in its portfolio (this is zero for QE1). $\mathbf{x}_i$ is a vector of all the corporate bond characteristics included in Table 1, and to control for the mean-reversion issue described in the previous section, in the case of percentage price changes we control for the price level as of the day before the announcement.

Table 3 reports the results of the first-stage regression. First, most of the individual corporate bond characteristics (with the exception of the maturity controls that are also proxying for the average maturity of the gilt bucket) are not statistically significant, confirming our prior that actual gilt purchases were not responding to specific corporate bonds. The coefficients on the maturity variables suggest that purchases depended strongly on remaining maturity in QE1 and QE3. Except for QE1, during which the markets were severely disrupted, the yield-curve fitting errors have a negative sign, suggesting that the BoE tended to purchase in maturity segments that were underpriced (i.e., had higher yields) relative to the yield curve. Importantly, the estimated coefficients on the bucket's amount outstanding in QE1 and on the percentage of the gilt bucket already held by the BoE for QE2 and QE3, indicate that the BoE was less likely to buy gilts that already owned in large amounts relative to the market. The result is consistent with the self-imposed ownership cap on each issue.

The results of the second-stage regressions are presented in Table 4A. Across all three QEs, the gilt substitute purchases have positive and statistically significant effects on corporate bond returns realized on the announcement day. For ease of comparison with Figure 1, we also report the results for the change in yields, which confirm that the expected distribution of future QE purchases drove corporate yields notably lower.[14] For instance, in the case of QE1, the coefficient

[14]It is possible that the notable difference in the R-squared between the specifications in percentage price changes and yield changes confirms that the relations captured by those regressions are much more linear in the price space than yield space.

on $q^{QE}_{i,n,T}$ indicates that the entire average decline of about 30 basis points observed in corporate yields on the day of the announcement (Figure 1) is attributed to QE supply effects. It is quite striking that the instrumented purchases of gilt substitutes can explain on average a large share of the corporate price and yield reactions already on the day of the announcement. This most likely indicates that our first-stage regressions are doing a good job at capturing market expectations about the future distribution of gilt purchases and that the supply channel accounts for most of the announcement impact of QE on corporate bonds, as the substitution effects are large and significant.

Table 4B summarizes the results for the specifications including IG credit spreads as the dependent variable. As detailed in Section 4.1, endogeneity should not be an issue in the estimation of QE cross-asset supply effects for credit spreads, hence those specifications are estimated by simple OLS. Further, since those are spreads relative to gilt yields, and gilt purchases during the first half of QE1 were limited to the 5-to-25-year sector, to avoid anomalous credit spreads, we prefer to restrict our attention to a similar maturity sector. In general, results seem more stable when we exclude shorter maturity IG credit spreads, thus also for the other QEs, Table 4B focused on spreads with at least 5 years left to maturity.

Across all three QE programs, the coefficients on the quantities of gilt substitute purchases are negative but not significant, suggesting that on the day of the announcement QE did not affect credit risk via substitution effects. This, in turn, indicates that within a short time period, corporate yields react at most as much as government yields to a government supply shock. This seems quite reasonable if we think about government and corporate bonds as imperfect substitutes in partially segmented markets. Our results are consistent with those reported in Krishnamurthy and Vissing-Jorgensen (2011) for the Fed's LSAPs; while, they are a bit different from those of Gilchrist and Zakrajsek (2013) who, using credit derivative indexes and an heteroskedasticity-based approach, show a significant decline in credit risk in response to the Fed's asset purchase announcements. However, it is still possible that our results are in line with their findings, if most of the immediate decline in credit risk cannot be attributed to cross-asset supply effects but is due to other channels. This is hard to say as, in those studies, the proxy for QE shocks does not allow the authors to identify the reaction's channels.

5.2 The longer-run impact of QE

The results of the second-stage regressions using as the dependent variable percentage price changes over the entire life of each QE program are presented in Table 5. Again, across all three QEs, the gilt substitute purchases have positive and statistically significant effects on corporate bond returns, and the magnitude of the substitution effects is much larger than in the short-run. This is consistent with the theory of Greenwood, Hanson, and Liao (2018) showing that, in partially-segmented asset markets, prices in a related market not directly targeted by the supply shock (i.e., the corporate bond market in reaction to supply shocks in the government bond market) initially underreact; but, as investors gradually rebalance their portfolios, prices change by more in the long-run. According to our estimates in Table 5, QE cross-asset supply effects increased IG corporate prices by 5.2 percent in QE1, 2 percent in QE2, and 1 percent in QE3, as the BoE bought a smaller percentage of the bucket of gilt substitutes across subsequent programs. This implies a decline of about 55bps, 22bps, and 11bps in the yield of a corporate bond with average duration of 9 years.

Table 6 reports the stock effects for IG credit spread changes. As already mentioned, since in this case we do not think that endogeneity is an issue, we use OLS.[15] It can be noted that, differently from Table 4B, gilt substitute purchases have a negative and statistically significant effect on credit spreads in QE1, especially in the 5-to-30-year maturity sector, where the QE purchases were concentrated. On the other hand, the impact in QE2 and QE3 is not statistically significant. This suggests that substitution effects only depressed credit risk premia during the course of QE1. This finding is consistent with some of the evidence in Joyce, Liu, and Tonks (2017) documenting portfolio reallocation from gilts to corporate bonds by institutional investors during this period. Considering that QE1 was conducted during the height of the financial crisis, our results may indicate that QE is more effective in relatively strained market conditions.

Further, we also run an additional specification for the stock effect, in which we allow the coefficients on the QE substitute purchases to differ across two groups: top- and low-rated IG bonds. This is done by interacting $q^{QE}_{i,n,T}$ with dummy variables that divide the sample into mutually exclusive subsamples, one for the BBB-rated bonds and one for the higher-rating bonds, as those can be viewed as closer substitutes for gilts. We do not find a significant difference in the estimates for the two groups and therefore, for brevity, we do not report these results. This is a bit surprising as we were expecting the QE substitution effect to be larger for the highly-rated bonds; however, it is possible that portfolio rebalancing from gilts to corporate bonds simultaneously improved liquidity and default prospects for lower-quality bonds, increasing the magnitude of their coefficient. This would be consistent with some aspects of the results in Krishnamurthy and Vissing-Jorgensen (2011) and Gilchrist and Zakrajsek (2013), as both studies show that credit derivative indexes declined much more for lower-rated bonds in response to the Fed's QE announcements.

Overall, the difference in the longer-run impact of QE on corporate bond prices

[15] If we use 2SLS we obtain similar results, but in the absence of endogeneity, OLS are more efficient.

(Table 5) and credit spreads (Table 6) seems to indicate that the pass-through of gilt purchases to corporate bonds, identified by our method, works primarily by affecting the default-free component of the private yield. In other words, in response to QE supply shocks, corporate yields tended to decline by at most the same amount as gilt yields. According to theories of limits to arbitrage and partially-segmented markets, changes in the supply of gilts could affect gilt yields more than corporate yields, as corporate bonds are not viewed as perfect substitutes for government bonds. However, during QE1, gilt substitution effects also reduced the credit-risk component of corporate yields, suggesting that supply effects could have an additional impact on credit and liquidity risks, most likely by inducing investors to substitute into relatively riskier assets in periods of elevated risk aversion and market strains.

5.2.1 The impact of QE on corporate bond issuance

We now examine whether the issuance of corporate bonds was impacted by QE purchases. For the first three QE programs, we limit our analysis to non-financial IG bonds. Table 7 shows the results of the second-stage regressions using the amount of corporate bond issuance as the dependent variable. The estimates of the first-stage regression are the same as those reported in Table 3, which implies that we built a bucket of gilt substitutes around each corporate bond existing at the beginning of the program and then assign the instrumented quantities of gilt substitutes, still based on the maturity's proximity, also to corporate bonds that did not exist at the beginning of the program because they were newly issued. The idea being that all the IG corporate bonds in a certain maturity sector share the same gilt substitute purchases independently of the time of their issuance during the program.

We also repeated the same analysis using OLS because, as explained in Section 4.1, issuance in an indirectly targeted market might not be affected by the same endogeneity problems as issuance in the directly targeted market, and we got very similar results. We find that the issuance size is positively related to the amount of gilt substitutes purchased but the estimated coefficients are not statistically significant. This might be due to the issuance being dominated by BBB bonds, driven by other channels in operation which are omitted in our analysis, like a switch from bank to bond financing (see Baranova et al., 2019). However, we do not have enough observations of bonds with ratings A- and higher to check for the gilt substitution channel on the subsample of top-rated bonds.

6 The joint impact of QE and CE

The package of easing measures announced on August 4, 2016 included a new round of quantitative easing (QE4) and the CBPS. This provides us with the unique opportunity to analyse the impacts of both gilt and corporate bond purchases at the same time, which should improve our understanding of the relative efficacy of QE and CE.

Therefore, we enrich our baseline specification of the QE supply effects with the BoE's CBPS purchases by including for each corporate bond: its own purchases, purchases of corporate bonds having similar remaining maturity and credit ratings, and purchases of gilts having similar remaining maturity, as in the analysis of previous QEs.

Thus, our extended specification becomes as follows:

$$Q^{QE}_{i,n,T} = \gamma_0 + \gamma_G \mathbf{z}^{Gilt}_{i,n,t} + \gamma_G(\mathbf{x}_{i,t}) + u_{G,i} \tag{5}$$

$$Q^{CE}_{i,0,T} = \gamma_0 + \gamma_C \mathbf{z}^{Corp}_{i,t} + \gamma_{C,1}(\mathbf{x}_{i,t}) + u_{C,i} \tag{6}$$

$$Q^{CE}_{i,n,T} = \gamma_n + \gamma_B \mathbf{z}^{Corp}_{i,n,t} + \gamma_B(\mathbf{x}_{i,t}) + u_{B,i} \tag{7}$$

$$\frac{\Delta P_{i,t,T}}{P_{i,t}} \text{ or } \Delta CS_{i,t,T} = \beta_0 \widehat{Q^{CE}_{i,0,T}} + \beta_n \widehat{Q^{CE}_{i,n,T}} + \beta_G \widehat{Q^{QE}_{i,n,T}} + \phi_0 + \phi(\mathbf{x}_{i,t}) + \varepsilon_i. \tag{8}$$

Given the significantly smaller size of the corporate bond market, which implies that scarcity can be captured by simple quantities purchased, and to ease comparison of the price elasticities across QE and CE, all quantities are in levels. As detailed in Section 4.1, also in the case of the CBPS, the main idea is to find the expected component of CBPS purchases that is exogenous to price considerations by the BoE and its auction participants.

The corporate-specific instruments, $\mathbf{z^{Corp}_{i,t}}$, include: the amount outstanding of corporate bond substitutes, *Bucket Corporate* AO_t, and the amount outstanding of privately-held gilt substitutes *Bucket Gilt* AO_t, both as of the day before the announcement. The latter is important because, among the small set of market participants that expected corporate bond purchases, most thought they would replace in part purchases of long-term gilts to lessen the QE costs on pension funds, likely induced by the scarcity of long-term gilts. According to this rationale, the BoE would have bought more corporate bonds in the maturity sectors with lower availability of gilts, thereby making CBPS purchases in part dependent on the amount of gilts available in those maturity sectors. Correspondingly, in the presence of corporate bond purchases, we also increase the set of IVs for gilts, $\mathbf{z}_{i,n,t}^{Gilt}$, all measured before the announcement, so they include: the average yield curve fitting errors, the share of the gilt bucket already owned by the BoE, the amount outstanding of corporate bond substitutes and the amount outstanding of privately-held gilt substitutes.

Table 8 summarizes the results for the regressions of cumulative CBPS and QE4 purchases as a function of pre-announcement information. Column 1 shows the results for purchases of individual corporate bonds, $Q_{i,0,T}^{CE}$ (in £mln). As indicated by the strong statistical significance and the positive sign of Face Value, the BoE was expected to buy more corporate bonds with larger issuance size, which is consistent with the BoE's announced intentions to purchase a portfolio of corporate bonds representative of issuance. Similar to the earlier QE programs, during the CBPS, the BoE tended to purchase corporate bonds with longer maturities, although not very long, as indicated by a positive loading on maturity (τ_t) and a negative loading on squared maturity (τ_t^2). The CBPS purchases also leaned toward corporate bonds with inferior credit ratings. Importantly, the estimated coefficient on the bucket's amount of corporate substitutes outstanding is negative and significant, indicating that the BoE was less likely to buy bonds having more substitutes in the market (an ample availability of bonds with similar characteristics would reduce the chance of that specific bond being bought, as the BoE would have more substitutes to choose from). The amount of corporate bonds bought is also negatively and significantly related to the amount of gilt substitutes indicating that this IV plays an important role.

Column 2 shows the results for purchases of corporate bond substitutes, $Q_{i,n,T}^{CE}$. Among the individual bond characteristics only maturity and maturity squared are significant, which should capture the maturity of the bucket itself. The general story here is consistent with what we have already seen for the individual purchases in Column 1. The other two most important explanatory variables are again the amounts of substitutes in the market, confirming that the BoE bought more corporate bonds with larger issuance size and concentrated in maturity buckets characterized by a smaller amount of gilts outstanding.

Next, turning to the purchases of gilts substitutes during QE4 (column 3), we find that the share of gilts already held by the BoE is among the most significant explanatory variables, whose negative coefficient indicates that, also in QE4, the BoE was more likely to buy gilts that it did not already own in large amounts relative to the market. As in the case of previous QEs, the result is consistent with the self-imposed ownership cap on each issue. Also, similar to previous QEs, the yield-curve fitting errors preserve their explanatory power and negative sign. Further, as indicated by the statistical significance and the sign of the amount outstanding of gilt substitutes (*Bucket Gilt* AO_t), the BoE was more likely to buy gilts with larger issuance size. Moreover, most of the individual corporate bond characteristics (with the exception of the squared maturity control that is also proxying for the average maturity of the gilt bucket) are not statistically signficant, implying that actual gilt purchases were not responding to specific corporate bonds.

Finally, it should be noted that when we focus on the universe of corporate bonds actually purchased, as opposed to the many more IG bonds included in the announcement reaction summarized in Table 1, we find that most of the corporate bond characteristics preserve the same sign and statistical significance, except for the credit spread that still exhibits a negative sign but loses its marginal predictive power. This indicates that, overall, investors should have been quite successful in forecasting future CBPS purchases based on those characteristics, which in turn should allow us to capture expected purchases correctly through the first stage.

In parallel to Section 5, in studying the corporate bond market effect of QE and CE together, we begin by estimating the immediate impact of both gilt and corporate bond purchases on corporate bond prices and credit spreads, then we estimate the longer-run impact of those purchases.

6.1 The immediate impact of QE and CE

Earlier studies of the CBPS indicate that the initial announcement impact on eligible bond spreads was to reduce them by around 10−13 basis points (see Boneva et al., 2018; Belsham et al., 2017). However, since the CBPS was announced alongside other policy measures, it is unclear how much of the announcement effect can be attributed to the supply channel specifically. Now that we have derived the expected distribution of future QE4 and CBPS purchases by estimating equations (5)-(7), we can isolate the specific impact of those purchases on corporate bond prices and spreads on the day of the announcement by estimating equation (8). In particular, similar to Section 5.1, we project one-day changes in corporate bond prices and credit spreads on the instrumented amounts purchased (Table 8) and other controls.

Our results are summarised in Table 9. We find that, within the short time-window around the announcement, corporate bond prices react positively and significantly to their own purchases, while credit spreads respond negatively and significantly to those same purchases. This finding stands in some contrast with previous QEs, shown in Table 4B, when there was no significant effects of QE1-QE3 announcements on credit spreads. The estimated coefficient implies that a typical purchase of £30mn would lower the credit spread by about 8-10 bps (i.e., by 0.27*30 and 0.33*30). Remarkably, we find that both corporate bond prices and spreads have not reacted significantly to gilt or corporate substitute purchases over this brief period. The estimates are robust to the definition of the substitutes.

In light of those results, we conclude that most of the 10-13 basis points fall in spreads on August 4, 2016 should be attributed to the local supply effect of the CBPS.

6.2 The longer-run impact of QE and CE

In this subsection, we look at the longer-run effects of the CBPS, in addition to those of QE4, on corporate bond prices and spreads. Table 10 displays the results obtained by regressing corporate percentage price changes and credit spread changes between the day before the announcement (3 August 2016) and the day after the completion of the program (28 April 2017) on the instrumented CBPS and QE purchased amounts. By comparing the first rows of Tables 9 and 10, it can be noted that the initial impact of the CBPS own purchases for both prices and spreads tends to become larger by the end of the programme, but the precise estimates and significance vary across bucket specifications. As in the case of the announcement, corporate price (spread) changes tend to be positively (negatively) related to their own purchases over the entire program, but the statistical significance of the effect tends to be weaker. One potential reason is that firms' active adjusting of their existing bonds' issuance via either buybacks or top-ups during the course of the program interfered with the relative distribution of the purchased bonds and hence also with the effect of the CBPS purchases. Finally, as in the case of the announcement effects, corporate bond prices do not seem to be affected by purchases of their substitutes. That is, there is no evidence of either substitution effects across corporate bonds, or QE4 cross-asset supply effects. This last finding, being quite different from previous QEs, might suggest that the cross-correlation between CBPS and QE4 purchases may be affecting the estimates.

To better understand the implications of the joint long-run effects of QE and CE, we explore an additional specification of the second stage; that is, we allow the coefficients on CBPS and QE purchases to differ across top (A- and up) and low (BBB+, BBB, BBB-) rated eligible corporate bonds. We perform this estimation by interacting the various types of purchases (own, corporate substitutes, and gilt substitutes) with dummy variables that divide the sample into two mutually exclusive subsamples, one for top-rated bonds and one for low-rated bonds. Table 11 presents this additional set of results. In terms of both the price and spread impacts of own purchases, the magnitude of the coefficients for higher- and lower-rated corporate bonds (rows 1-2) is quite similar at the time of the announcement (columns 1-2); but, over the life of the program, the longer-run effect becomes larger and remains significant only for top-rated bonds (columns 3-4).[16]

[16]The heterogeneous effect of large-scale corporate bond purchases on firms' cost of capital can potentially induce so-called misallocation costs and resources, which is outside the scope of this

Interestingly, as shown in the fifth row (column 3) of Table 11, QE substitute purchases increase the prices of top-rated corporate bonds, which are usually viewed by investors as closer substitutes for government bonds. In this case, the QE cross-asset supply effects are significant above and beyond the CE within-asset supply effects, suggesting that for higher-quality corporate bonds these two policies are complementary, so that a typical £30mln CBPS purchase increased the corporate bond price by 2.4 percent and a typical £13bln purchase of its bucket of gilt substitutes during QE4 increased its price by 1 percent (i.e., to get the same effect on the price of a corporate bond via QE4 purchases as via own CBPS purchases, the BoE would have had to buy substantially larger amounts of nearby maturity gilts). This indicates that a corporate bond's price sensitivity to its own purchases is substantially higher than its price sensitivity to gilt substitute purchases. However, the gilt substitute purchases affect credit spreads positively in the longer run, indicating one more time that, although QE affects favorably prices of corporate bonds, their yields do not decline by more than gilt yields in response to gilt purchases. Nonetheless, this QE effect is not large enough to offset the impact of own CBPS purchases on spreads: the combined effect of QE4 and CBPS on credit spreads was still negative, lowering them by around 11 basis points in the longer run. Finally, as in the simpler specification shown in Table 10, there is no evidence of corporate substitution effects in both subsamples of top- and low-rated IG corporate bonds.

One possible rationale for the muted evidence on substitution effects is that, if the CBPS stimulated significant amounts of new issuance during the course of the program (see Figure 4), the negative price impact from new issuance may have offset the positive price impact of CBPS purchases within the same bucket of substitutes. This is quite different from the case of Government bond issuance, which is determined well in advance and does not tend to respond rapidly to changes in government yields. We explore this possible channel more rigorously in the next subsection.

6.3 The issuance channel of CE

Like QE, CE can work through portfolio rebalancing, signalling, liquidity and confidence channels. However, in addition, the CBPS was expected to stimulate issuance in the sterling corporate bond market. Lower credit spreads and improvements in market functioning should induce an endogenous response in the supply of corporate bonds, pushing new issuance up and bond prices down. As a result, the net longer-run impact on corporate bond prices is not clear a priori, which

paper but is analysed, for example, by Kurtzman and Zeke (2017) in a calibrated heterogeneous firm New Keynesian DSGE model.

makes it an empirical question.

Looking more closely into the issuance channel of the CBPS, first, we observe that sterling corporate bond issuance rose sharply following the announcement (Figure 4). The pickup was particularly sharp initially, with the highest recorded monthly issuance of sterling-denominated IG bonds in September 2016, and monthly issuance remained robust until the completion of the scheme. As a result, the share of sterling U.K. private non-financial corporate (PNFC) bonds relative to total UK PNFC bond issuance rose from around 15 percent in early 2016 to almost 40 percent - the highest proportion since 2007 (See Belsham et al., 2017). Next, we identify how much of this increase in issuance might be attributed to the CBPS.

Identifying the impact of CE on issuance during the CBPS is challenging because the purchases were not random and depended on the bond universe, including bonds issued during the program. There is therefore a problem of reverse causality, similar to that discussed in the previous sections.

To address the endogeneity issue, we follow the same extended methodology laid out at the beginning of this section, and derive the instrumented QE and CE purchases of bond substitutes based on the characteristics available at the time of the announcement. Then, we estimate the following specification:

$$Issuance_i = \mu + \beta_1 \widehat{Q^{CE}_{i,n,T}} + \beta_2 \widehat{Q^{QE}_{i,n,T}} + \gamma' x_i + e_i, \tag{9}$$

where $Issuance_i$ is the nominal amount of bond i issued between the end of March 2017 and the CBPS announcement and x_i is a set of bond-level control variables: credit rating, residual maturity and domicile. The coefficients of interest are β_1, which captures the impact of corporate substitute purchases during the CBPS (i.e., within 2 or 2.5 years of remaining maturity and with the same or adjacent credit ratings), and β_2, which estimates the impact of QE substitute purchases of gilts with similar maturities.

The results for equation (9) are summarised in Table 12. We find that the issuance size is positively and significantly related to the CBPS purchases of corporate bonds with similar maturity and credit ratings, confirming that CE can be quite effective in stimulating new corporate issuance. In contrast, there is no evidence of a significant relationship between the issuance of sterling corporate bonds and the QE purchases of gilts with similar maturity, which is in line with findings for previous QEs.

To ensure robustness of our results, we experimented with different measures of substitute corporate bonds and gilts, varying the proximity in terms of maturity and credit rating distance. The results from all of these alternative specifications are similar to our baseline results.

7 Conclusions

Using security-level data on corporate bond prices, spreads, and issuance, as well as individual quantities purchased by the BoE during the course of various QE programs and the CBPS, we analyse QE's cross-asset supply effects and the joint supply effects of QE and CE. In doing so, we distinguish between the short- and longer-run implications of these two policy tools and we try to disentangle some of their channels.

In the case of QE alone, we find strong evidence in favor of significant cross-asset supply effects, as on average a corporate bond's price responded positively and significantly to purchases of gilts with similar maturities. Further, in line with the theory of Greenwood, Hanson and Liao (2018), those cross-asset supply effects grow larger in the longer-run, suggesting that portfolio rebalancing into riskier assets is a gradual process. Further, QE seems to mostly influence the default-free component of the corporate yield, as credit spreads are not significantly affected by this policy, except at the time of financial stress during the first QE.

In the case of the joint implementation of QE and CE, our results show three relevant findings. First, CE is more effective than QE in increasing corporate prices, as a corporate bond's price sensitivity to its own purchases is substantially higher than its price sensitivity to gilt substitute purchases. Second, CE is also more effective in reducing credit spreads, with this effect getting larger and remaining significant in the longer-run only for higher-rated bonds. Third, in contrast to QE, CE can stimulate corporate issuance quite rapidly.

Interestingly, we do not find any evidence of corporate substitution effects, as on average a corporate bond's price reacted positively and significantly to its own purchases but not to the purchases of corporate bonds with similar characteristics. One possibility is that the negative price impact of corporate new issuance in a bucket of substitutes has offset the positive price impact of the CBPS purchases within the same bucket.

Overall, our findings suggest that CE could be an effective monetary policy tool in a low-interest-rate environment. It also emerges that the relative efficacy of CE and QE might depend on the quality/risk of private bonds, which in turn is related to the amount of risk a central bank is willing to add to its balance sheet.

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Tables

Table 1: Individual corporate price and credit spread reactions to the QE and CBPS announcements.

A	Prices, $\Delta P_{t,t+1}/P_t$			
	QE1	QE2	QE3	QE4/CBPS
τ_t	0.41***	-0.01	0.06***	0.25***
τ_t^2	-0.01***	0.001***	-0.001***	-0.004***
$HQ\ in\ UK$	-0.11	0.03	-0.03	-0.10
$Rating_t$	-0.03	0.01	0.03***	0.11***
$Face\ Value_t$	0.45	0.04	-0.001	0.81***
$Credit\ Spread_t$	-0.14***	0.08***	-0.07***	-0.32***
C	-0.43	-0.36***	-0.01	-0.64***
N. obs.	235	333	361	463
Adj. R^2	0.65	0.40	0.67	0.69

B	$\Delta CS_{t,t+1}$			
	QE1	QE2	QE3	QE4/CBPS
τ_t	0.75**	-0.42***	0.004	-0.35***
τ_t^2	-0.02***	0.01***	0.0002	0.01***
$HQ\ in\ UK$	-0.09	-0.02	0.06	0.63
$Rating_t$	-0.03	-0.17	-0.32***	-1.45***
$Face\ Value_t$	-4.28	0.36	-0.45	-5.94***
$Credit\ Spread\ _t$	1.17***	-1.03***	0.84***	2.50***
C	-4.59	3.79**	-1.39*	2.47*
N. obs.	234	333	361	463
Adj. R^2	0.20	0.14	0.11	0.23

Note: t=day before announcement and $t+1$=day of announcement, samples include only IG non-financial bonds with maturities larger than 2 years (for the case of QE1 we only consider bonds with remaining maturities longer than 5 years). Significance codes: *0.1, **0.05, ***0.01 at least.

Table 2: Individual corporate price and credit spread reactions to the QE4/CBPS announcement across different subsample.

A	$\Delta P_{t,t+1}/P_t$			
	(1)	(2)	(3)	(4)
τ_t	0.24***	0.26***	0.26***	0.26***
τ_t^2	- 0.004***	-0.004***	-0.004***	-0.004***
$HQ\ in\ UK$	0.15**	- 0.07	-0.11	-0.13*
$Rating_t$	-0.04***	0.1***	0.1***	0.11***
$Face\ Value_t$	0.74**	0.82***	0.62***	0.62***
$Credit\ Spread_t$	-0.04***	-0.28***	-0.22***	-0.25***
$Liquidity_t$			0.30***	0.29***
C	0.02	-0.7***	-0.87***	-0.86**
N. obs.	870	502	476	440
Adj. R^2	0.55	0.74	0.78	0.75

B	$\Delta CS_{t,t+1}$			
	(1)	(2)	(3)	(4)
τ_t	-0.38**	-0.40***	-0.40***	-0.36***
τ_t^2	0.01**	0.01***	0.01***	0.01***
$HQ\ in\ UK$	-1.43	0.40	0.47	0.66
$Rating_t$	-0.43*	-1.36***	-1.31***	-1.41***
$Face\ Value_t$	-5.73**	-6.23***	-5.1***	-4.87***
$Credit\ Spread_t$	1.81***	2.24***	1.9***	2.11***
$Liquidity_t$			-2.08***	-2.01***
C	-0.83	2.82**	3.87***	3.71**
N. obs.	869	502	476	440
Adj. R^2	0.10	0.23	0.23	0.23

Note:t=August 3, 2016 and t+1=August 4, 2016. The whole sample with sterling denominated corporate bonds with remaining maturity less than one year contains 869 observations, 502 of these include only IG non-financial bonds, 476 include the IG non-financial bonds for which we have the liquidity measure (proxied by the weekly average trade size), and those are reduced to 446 when excluding bonds with less than 2 years left to maturity to control for the signaling channel. Significance codes: *0.1, **0.05, ***0.01 at least.

Table 3: First-stage regression, QEs' cumulative purchases as a function of pre-QE information.

	$Q^{QE}_{i,n,T}(2.5y,5y)$	$Q^{QE}_{i,n,T}(2.5y,5y)$	$Q^{QE}_{i,n,T}(2.5y,5y)$
	QE1($5y<\tau<30y$)	QE2	QE3
$Avg\ yield\ fit\ error_t$	1277***	-5191***	-3114***
$Bucket\ AO_t$	0.39***		
$BoE\ Hold_t/Bucket\ AO_t$		-2086***	-348.7***
$\tau_{i,t}$	3925***	-35.27	-277.3***
$\tau^2_{i,t}$	-145.6***	-2.149	0.03
$HQ\ in\ UK_i$	-351.6	317.3	-439.4
$Rating_{i,t}$	34.6	291.4	85.15
$Face\ Value_{i,t}$	1.571	0.176	-0.611
$Price\ level_{i,t}$	-174.4	245.6	321.5**
C	-13020***	28580***	13860***
$N.\ obs.$	199	325	358
$Adj.R^2$	0.94	0.48	0.74

Note:t=day before announcement and T=end of program; $Q^{QE}_{i,n,T}$ refers to cumulative purchases of gilts in the bucket of substitutes; $Bucket\ AO_t$, is the amount of outstanding gilts in the bucket. For QE1, we restrict the maturity to 5-to-30 years because the gilt purchases were concentrated in the 5-to-30-year maturity sector for the first 5 months of the program. Significance codes: *0.1, **0.05, ***0.01 at least.

Table 4A: Second-stage regressions, Corporate bond price and yield changes on the day of announcement as a function of IV QE purchases.

A	$\frac{\Delta P_{i,t,t+1}}{P_{i,t}}$	$\frac{\Delta P_{i,t,t+1}}{P_{i,t}}$	$\frac{\Delta P_{i,t,t+1}}{P_{i,t}}$	$\Delta Y_{i,t,t+1}$	$\Delta Y_{i,t,t+1}$	$\Delta Y_{i,t,t+1}$
	QE1	QE2	QE3	QE1	QE2	QE3
$\widehat{q_{i,n,T}^{QE}}$	0.22*	0.94**	1.5***	-34.7***	-17.91***	-21.23***
$\tau_{i,t}$	0.45***	-0.0164*	0.059***	-2.82***	-0.197*	-0.0192
$\tau_{i,t}^2$	-0.009***	0.0013***	-0.0008***	0.0574***	-0.0017	7.76e-04
$HQ\ in\ UK_i$	-0.115	0.013	-0.013	-0.1732	0.0496	-0.0101
$Rating_{i,t}$	-0.006	0.017	0.015***	-0.189	-0.211	-0.164*
$Face\ Value_{i,t}$	0.0002	5.71e-05	2.92e-05	8.22e-04	-1.71e-04	-3.68e-04
$Price\ level_{i,t}$	0.003	-0.009***	0.0009	-0.127*	0.106***	-0.0216
C	-1.76**	0.66***	-0.27**	24.29***	-3.70	-1.73
$N.\ obs.$	251	325	358	251	325	358
$Adj.R^2$	0.68	0.41	0.72	0.46	0.26	0.09

Note: Unrestricted maturity for all QEs, $\Delta Y_{i,t,t+1}$ are in basis points, $q_{i,n,T}^{QE}$ refers to cumulative purchases of gilts in the bucket of substitutes relative to total amount outstanding of substitutes in that bucket. Significance codes: *0.1, **0.05, ***0.01.

Table 4B: **OLS regressions, Credit spread changes on the announcement day as a function of QE purchases.**

B	$\Delta CS_{i,t,T}$	$\Delta CS_{i,t,T}$	$\Delta CS_{i,t,T}$	$\Delta CS_{i,t,T}$
	QE1	QE1	QE2	QE3
	$5y \leqslant \tau \leqslant 30y$	$(\tau > 5y)$	$(\tau > 5y)$	$(\tau > 5y)$
$q_{i,n,T}^{QE}$	-15.13	-13.39	-5.80	-14.2
$\tau_{i,t}$	-0.13	-0.072	-0.047	0.002
$\tau_{i,t}^2$	-0.004	-0.006	0.0003	-0.0006
$HQ\ in\ UK_{i,t}$	0.64	0.75	-0.034	0.086
$Rating_{i,t}$	-0.36	-0.46	-0.082	-0.36***
$FaceValue_{i,t}$	-0.006	-0.005	0.0003	-0.0006
$Spread_{i,t}$	0.006	0.006	-0.0128***	0.009***
C	15.24*	13.85	2.95	0.176
$N.\ obs.$	199	205	277	280
$Adj.R^2$	0.0	0.00	0.05	0.07

Note: Significance codes: *0.1, **0.05, ***0.01 at least.

Table 5: Second-stage regressions, Corporate bond percentage price changes over the life of the program as a function of IV QE purchases.

	$\Delta P_{i,t,T}/P_{i,t}$	$\Delta P_{i,t,T}/P_{i,t}$	$\Delta P_{i,t,T}/P_{i,t}$
	QE1 ($5y < \tau < 30y$)	QE2	QE3
$\widehat{q^{QE}_{i,n,T}}$	13.05*	12.04***	13.38***
$\tau_{i,t}$	0.19	0.232***	0.25***
$\tau^2_{i,t}$	0.007	-0.007***	-0.003**
$HQ\ in\ UK_i$	-0.759	-0.103	-0.29
$Rating_{i,t}$	1.729***	0.25***	0.20***
$FaceValue_{i,t}$	-0.0002	0.0013***	0.0017***
$Price\ level_{i,t}$	-4.915	-0.395***	-0.84***
C	37.6***	0.54	6.82***
$N.\ obs.$	199	325	358
$Adj.R^2$	0.62	0.24	0.40

Note:t=day before announcement, T=end of program; $q^{QE}_{i,n,T}$ = cumulative purchases of gilts in the bucket of substitutes relative to total amount outstanding in that bucket. For QE1, we restrict the maturity to 5-to-30 years, where gilt purchases were concentrated for the first 5 months of the program. Significance codes: *0.1, **0.05, ***0.01 at least.

Table 6: OLS regressions, Credit spread changes over the entire life of the program as a function of QE purchases.

	$\Delta CS_{t,T}$	$\Delta CS_{t,T}$	$\Delta CS_{t,T}$	$\Delta CS_{t,T}$
	QE1 ($5y < \tau < 30y$)	QE1 ($5y < \tau$)	QE2	QE3
$q^{QE}_{i,n,T}$	-2.05***	-1.29**	0.31	0.31
$\tau_{i,t}$	0.032	-0.001	-0.001	-0.00
$\tau^2_{i,t}$	-0.002	-0.0003	0.00	0.00
$HQ\ in\ UK_i$	0.007	0.009	0.014	0.025
$Rating_{i,t}$	0.03*	0.03*	-0.03**	0.03***
$\Delta Rating$	0.19***	0.18***	0.14**	0.09*
$Face\ Value_{i,t}$	-0.03***	-0.03***	-0.02***	-0.02***
$Spread\ level_{i,t}$	-0.80***	-0.81***	0.002	-0.23***
C	1.42***	1.25***	0.08	-0.11
$N.\ obs.$	199	205	277	280
$Adj.R^2$	0.92	0.92	0.05	0.52

Note: t=day before announcement, T=end of program; $q^{Gilt}_{i,n,T}$=cumulative purchases of gilts in the bucket of substitutes relative to total amount outstanding in that bucket. For QE1, we also restrict the maturity to 5-to-30 years, where gilt purchases were concentrated for the first 5 months of the program. Significance codes: *0.1, **0.05, ***0.01 at least.

Table 7: Second-stage regressions, Corporate New Issuance as a function of IV QE purchases.

	$\Delta Iss_{i,t,T}$	$\Delta Iss_{i,t,T}$	$\Delta Iss_{i,t,T}$	$\Delta Iss_{i,t,T}$
	QE1	QE2	QE3	QE2&3
$\widehat{q_{i,n,T}^{QE}}$	169.33	246.95	180.01	-763.05
$\tau_{i,t}$	-40.17	23.46	33.96	32.20**
$\tau_{i,t}^2$	1.506	-0.53	-0.60	-0.66*
$HQ\ in\ UK_{i,t}$	-348.96***	-164.91*	-320.61***	-193.27***
$Rating_{i,t}$	28.6*	16.03	32.31	2.60
C	659.9***	203.14	51.86	462.86***
$N.\ obs.$	79	40	22	68
$Adj.R^2$	0.48	0.05	0.40	0.18

Note: Significance codes: *0.1, **0.05, ***0.01 at least.

Table 8: CBPS and QE4 cumulative purchases as a function of pre-CBPS information

	$Q^{CE}_{i,0,T}$	$Q^{CE}_{i,n,T}(2.5y,5y)$	$Q^{QE}_{i,n,T}(2.5y,5y)$
$\tau_{i,t}$	1.46**	106.0***	-205.8
$\tau^2_{i,t}$	-0.04***	-2.16***	-7.81**
$HQ\ in\ UK_i$	-1.81	-37.9	-465.1
$Rating_{i,t}$	3.24***	-1.80	-333.4
$Face\ Value_{i,t}$	0.05***	-7.54	-137.1
$Credit\ spread_{i,t}$	-3.05	-0.65	12.9
$Bucket\ Gilt\ AO_t$	-0.10**	-16.0***	0.04***
$Bucket\ Corporate\ AO_t$	-0.22*	0.04 ***	-0.01
$BoE\ Hold_t/Bucket\ AO_t$			-195.3***
$Avg\ gilt\ yield\ fit\ error_t$			-355.4***
C	-11.7	-874.8***	19729***
$N.\ obs.$	309	309	309
$Adj.R^2$	0.37	0.77	0.70

Note: Bonds and gilts with maturities less than 2 years are excluded. $Q^{CE}_{i,0,T}$ is in Â£mln. Bucket Gilt AO denotes amount outstanding of gilts with similar maturities (i.e. within 2.5 years remaining maturity for bonds maturing in less than 10 years and 5 years for others). Bucket Corporate AO denotes corporate bonds with similar characteristics, i.e., for the case of gilts (column 3) - within 2.5 years of remaining maturity; for the case of corporate bonds (column 2) - within 2.5 years of remaining maturity and with same or adjacent credit ratings. Significance codes: *0.1, **0.05, ***0.01 at least.

Table 9: Corporate bond price and credit spread changes on the day of the QE4/CBPS announcement as a function of IV cumulative QE4 and CBPS purchases.

	$\Delta P_{i,t,t+1}/P_{i,t}$			$\Delta CS_{t,t+1}$		
	(1)	(2)	(3)	(1)	(2)	(3)
$\widehat{Q^{CE}_{i,0,T}}$	0.04***	0.04***	0.04 ***	-0.27***	-0.27**	-0.33***
$\widehat{Q^{CE}_{i,n,T}}$	-0.09	- 0.09	-0.02	1.43	1.80	0.99
$\widehat{Q^{QE}_{i,n,T}}$	-0.02	-0.02	-0.02**	- 0.04	-0.02	-0.01
$FaceValue_{i,t}$	-0.01*	-0.01**	-0.01**	0.07	0.08	0.10*
$\tau_{i,t}$	0.20***	0.21***	0.19***	-0.06	-0.02	0.003
$\tau^2_{i,t}$	-0.002***	-0.002***	-0.002***	0.001	- 0.00	-0.001
$HQ\ in\ UK_i$	-0.02	-0.001	-0.02	0.61	0.57	0.55
$Rating_{i,t}$	0.02	0.01	-0.005	-0.23	-0.67	-0.50
$Credit\ Spread_{i,t}$	0.001	0.001	0.001	-0.04***	-0.03***	-0.03***
C	-0.03	-0.08	0.12	1.63	0.99	0.47
N. obs.	277	277	277	277	277	277
$Adj.R^2$	0.86	0.86	0.86	0.35	0.36	0.36

Note: t=August 3, 2016. Bonds and gilts with maturities less than 2 years are excluded. $Q^{CE}_{i,0,T}$ is in Â£mln, $\widehat{Q^{CE}_{i,n,T}}$ and $\widehat{Q^{QE}_{i,n,T}}$ are in Â£bln. Buckets of substitutes denote bonds and gilts with similar characteristics, i.e., (1) gilts within 2.5 years remaining maturity for bonds maturing in less than 10 years and 5 years for others, and corporate bonds within 2.5 years of remaining maturity and with same or adjacent credit ratings, (2) gilts within 2 years remaining maturity for bonds maturing in less than 10 years and 5 years for others, and corporate bonds - within 2 years of remaining maturity and with same or adjacent credit rating, (3) gilts within 2.5 years remaining maturity, and corporate bonds - within 2.5 years of remaining maturity and with same or adjacent credit ratings. Only corporate bonds with credit ratings unchanged during period are considered. Significance codes: *0.1, **0.05, ***0.01 at least.

Table 10: Longer-run impact of cumulative IV QE4 and CBPS purchases on corporate bond values.

	$\Delta P_{i,t,T}/P_{i,t}$			$\Delta CS_{t,T}$		
	(1)	(2)	(3)	(1)	(2)	(3)
$\widehat{Q^{CE}_{i,0,T}}$	0.07**	0.07**	0.04	-0.33	-0.41	-0.45*
$\widehat{Q^{CE}_{i,n,T}}$	-0.18	-0.03	-0.40	2.02	1.34	1.79
$\widehat{Q^{QE}_{i,n,T}}$	0.05	0.05	0.05**	0.44*	0.60**	0.28
$FaceValue_{i,t}$	-0.05***	-0.05***	-0.04**	0.34**	0.38***	0.39***
$\tau_{i,t}$	0.10**	0.09**	0.14***	1.10***	1.12***	1.09***
$\tau^2_{i,t}$	-0.001	-0.001	-0.002*	-0.01	-0.01	-0.01
$HQ\ in\ UK_i$	0.69***	0.69***	0.65***	-10.5***	- 10.7***	-10.9***
$Rating_{i,t}$	-0.47***	-0.50***	-0.37***	3.50***	3.84***	3.77***
$Credit\ Spread_{i,t}$	0.03***	0.03***	0.03***	-0.38***	-0.38***	-0.37***
C	-3.51***	-3.41***	-3.98***	-17.9**	-19.5**	-14.8*
N. obs.	272	272	272	272	272	272
$Adj.R^2$	0.47	0.47	0.47	0.67	0.67	0.66

Note:t=August 3, 2016 and T=April 28, 2017. Columns (1)-(3) refer to various definitions of buckets of substitutes (bonds and gilts with similar characteristics), i.e., (1) gilts within 2.5 years of remaining maturity for bonds maturing in less than 10 years and 5 years for others, and corporate bonds within 2.5 years of remaining maturity and with same or adjacent credit ratings, (2) gilts within 2 years remaining maturity for bonds maturing in less than 10 years and 5 years for others, and corporate bonds - within 2 years of remaining maturity and with same or adjacent credit ratings, (3) gilts within 2.5 years remaining maturity, and corporate bonds - within 2.5 years of remaining maturity and with same or adjacent credit ratings. $Q^{CE}_{i,0,T}$ is in Â£mln, $\widehat{Q^{CE}_{i,n,T}}$ and $\widehat{Q^{QE}_{i,n,T}}$ are in Â£bln. Only corporate bonds with credit ratings unchanged during period are considered. Significance codes: *0.1, **0.05, ***0.01 at least.

Table 11: Top rated versus lower rated IG bonds

	Announcement impact		*Total impact*	
	$\Delta P_{i,t,t+1}/P_{i,t}$	$\Delta CS_{t,t+1}$	$\Delta P_{i,t,T}/P_{i,t}$	$\Delta CS_{t,T}$
$\widehat{Q^{CE}_{i,T}}$*Top	0.05***	-0.31***	0.08**	-0.71**
$\widehat{Q^{CE}_{i,T}}$*BBB	0.04***	-0.28**	0.05	-0.33
$\widehat{Q^{CE}_{i,n,T}}$*Top	-0.17	0.76	-0.98	-1.67
$\widehat{Q^{CE}_{i,n,T}}$*BBB	-0.00	3.75	1.28*	4.05
$\widehat{Q^{QE}_{i,n,T}}$*Top	-0.02	0.05	0.08**	0.79**
$\widehat{Q^{QE}_{i,n,T}}$*BBB	-0.02	-0.17	-0.02	0.33
$FaceValue_{i,t}$	-0.01**	0.09	-0.05***	0.43***
$\tau_{i,t}$	0.21***	-0.02	0.09*	1.20***
$\tau^2_{i,t}$	-0.002***	0.00	-0.001	- 0.01
$HQ\ in\ UK_i$	-0.03	0.68	0.60***	-9.03***
$Rating_{i,t}$	0.04	-0.46	-0.29**	-3.23***
$Credit\ Spread_{i,t}$	0.001	-0.03***	0.04***	-0.39***
C	-0.29	-0.60	-4.84***	-15.4*
N. obs.	277	277	272	272
Adj.R^2	0.86	0.37	0.50	0.69

Note:t=August 3, 2016, t+1=August 4, 2016, and T=April 28, 2017; Top consists of bonds with ratings from AAA to A-; BBB consists of bonds with ratings BBB+, BBB, and BBB-. Bonds with maturities less than 2 years are excluded. The definitions of buckets of substitutes (bonds and gilts with similar characteristics): gilts - within 2 years remaining maturity for bonds maturing in less than 10 years and 5 years for others; corporate bonds - within 2 years of remaining maturity and with same or adjacent credit ratings. $Q^{CE}_{i,0,T}$ is in Â£mln, $\widehat{Q^{CE}_{i,n,T}}$ and $\widehat{Q^{QE}_{i,n,T}}$ are in Â£bln. Significance codes: *0.1, **0.05, ***0.01 at least.

Table 12a: Effect of QE4 and CBPS purchases of substitutes on sterling corporate bond issuance.

	ALL			IG		
	(1)	(2)	(3)	(1)	(2)	(3)
$\widehat{Q_{i,n,T}^{CBPS}}$	0.12**	0.17***	0.13***	0.24**	0.36***	0.27**
$\widehat{Q_{i,n,T}^{QE}}$	2.83	3.89	-0.10	1.83	2.78	1.63
financial	61.67	62.3	61.6	102.5*	95.6*	102.1*
uk hq	28.86	26.0	24.6	26.4	32.9	31.4
rem maturity	18.25***	18.3***	16.0***	22.7***	22.1***	21.8***
rating	-6.14	-3.62	-5.3	-26.6	-32.5	-31.2
C	217.3	90.9	214.5	95.8	146.3	171.4
nobs	84	84	84	60	60	60
Adj. R^2	0.31	0.33	0.31	0.29	0.30	0.28

Table 12b: Effect of QE4 and CBPS purchases of substitutes on relative sterling corporate bond issuance.

	ALL			IG		
	(1)	(2)	(3)	(1)	(2)	(3)
$\widehat{q_{i,n,T}^{CBPS}}$	6.06***	6.88***	5.51***	10.8***	5.52***	10.45**
$\widehat{q_{i,n,T}^{QE}}$	-338	-577	-549	268	-509.6	117.3
financial	0.02	0.02	0.02	0.02	0.02	0.03
uk hq	-0.04	-0.06	-0.04	0.01	-0.01	0.01
rem maturity	0.00	0.01**	0.001	-0.01***	0.01	-0.01***
rating	0.02***	0.02***	0.02***	-0.03***	-0.02	-0.03***
C	-0.21***	-0.23**	-0.18***	-0.03	-0.02	-0.01
nobs	84	84	84	60	60	60
Adj. R^2	0.70	0.68	0.67	0.89	0.72	0.85

Note:

Dependent variable in Table 12a is the nominal issuance size of £-denominated corporate bonds between August 2016 and end March 2017, while in Table 12b it is the issuance size with respect to the total amount of substitutes available on the CBPS announcement. Maturities shorter than 2 years are excluded. For each bond i, $\widehat{Q_{i,n,T}^{CBPS}}$ denote IV CBPS purchases of corporate bonds with similar characteristics, $\widehat{Q_{i,n,T}^{QE}}$ denote IV QE4 purchases of gilts with similar maturities. Correspondingly, $\widehat{q_{i,n,T}^{CBPS}}$ and $\widehat{q_{i,n,T}^{QE}}$ are normalised by the amounts of substitutes available on the CBPS announcement. Columns (1)-(3) refer to various definitions of substitutes, ie (1) gilts within 2.5 years of remaining maturity for bonds maturing in less than 10 years and 5 years for others, and corporate bonds within 2.5 years and within one credit rating, (2) gilts within 2 years for bonds maturing in less than 10 years and 5 years for others, and corporate bonds - within 2 years and within one rating, (3) gilts within 2.5 years, and corporate bonds within 2.5 years and within one rating. Two samples are considered: IG - investment grade (63 bonds), and ALL (84 bonds). Significance codes: *0.01, **0.05, ***0.01 at least.

Figure 1: Change in sterling corporate bond yields on the QE1 announcements and QE1 purchases of gilts with corresponding nearby maturities.

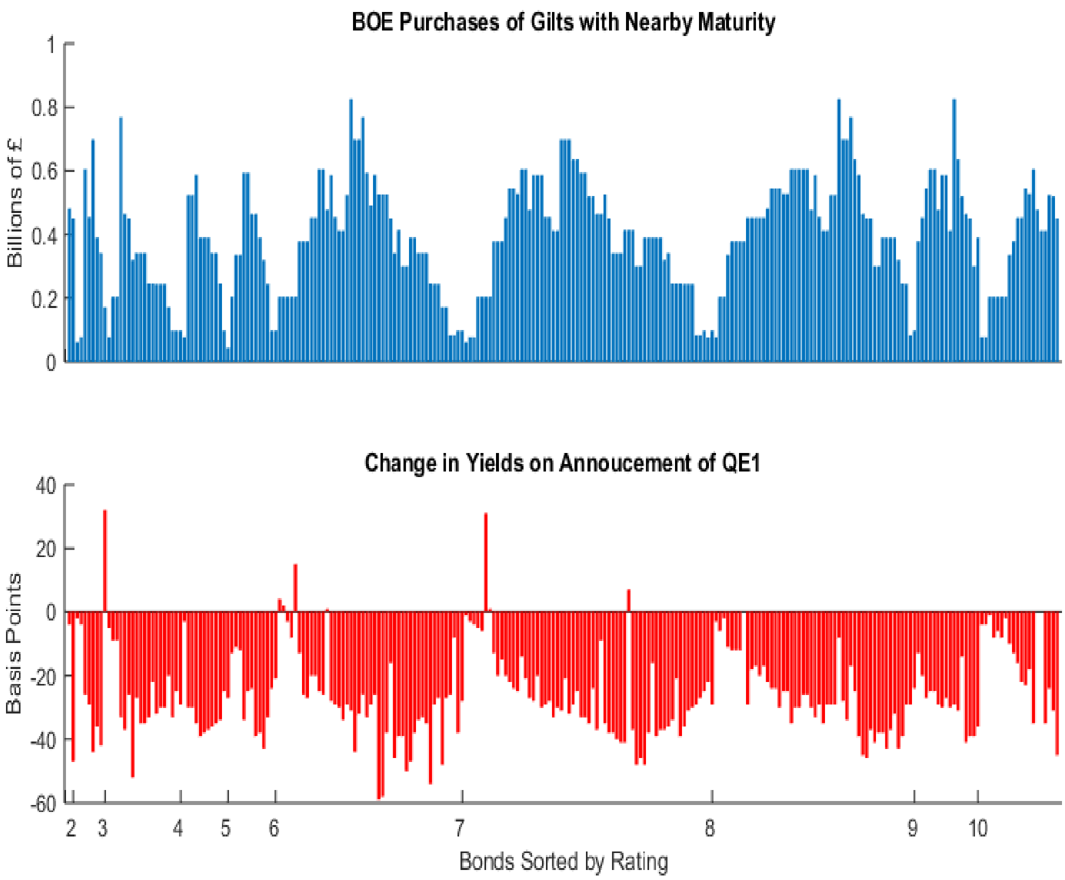
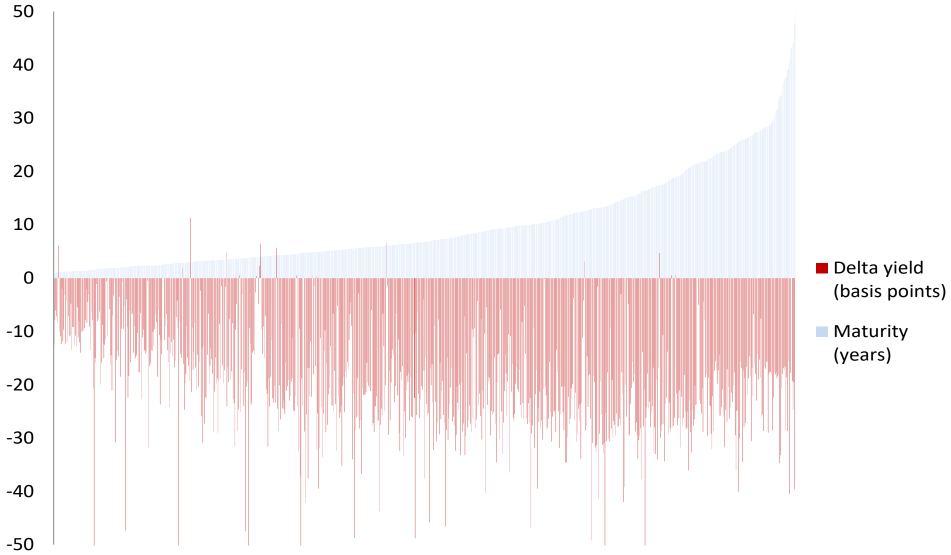


Figure 2: Change in sterling corporate bond yields on the QE4/CBPS announcement.

a) Ordered by maturity



b) Ordered by credit rating

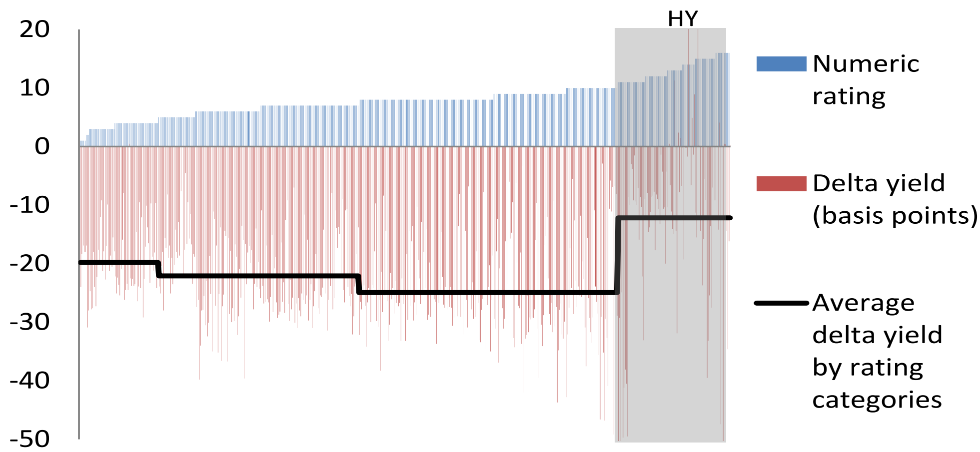


Figure 3: Sterling investment grade bond issuance by private non-financial corporates split by domicile