2897G

PART IIA PAPER 3 PROJECT

Question 3

Theory and policy interest has focused recently on the relationships between central banks' large-scale financial assets purchases (QE) and movements in financial asset prices and yields and in prices and wages in the wider economy.

Using the data provided and/or any other that you wish to introduce:

a) For the period 4 January 2010 to 21 January 2020, examine and analyse the short-period (5 to 10 days) effects of QE announcements by the Bank of England's Monetary Policy Committee on:

- Overnight interest rates as shown by the Sterling Overnight Index Average (SONIA).
- UK Treasury Bill yields.
- UK medium- and long-term government bond (or gilt) yields.
- Corporate bond yields.
- Movements in equities' indices: FTSE 100 and FTSE 250.
- The (narrow) Sterling Exchange Rate Index (ERI).

b) Interpret your results with respect to the effect of news announcements about QE on:

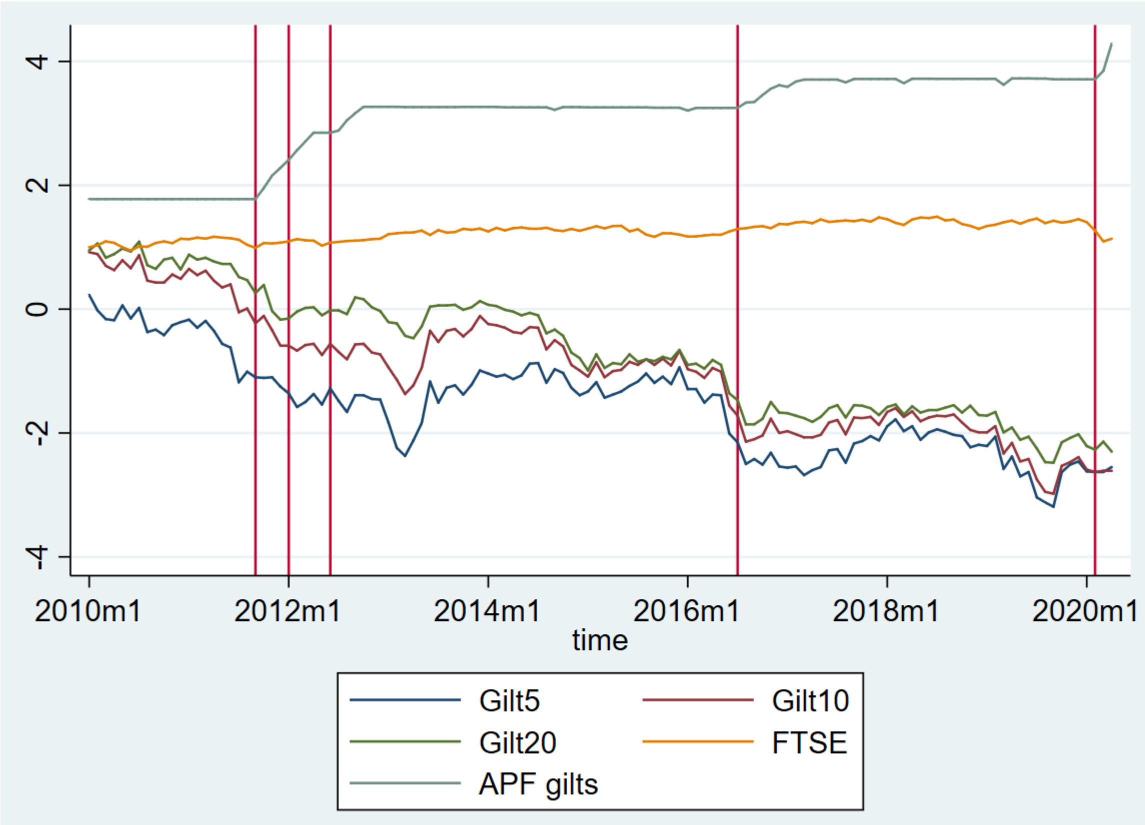
- Financial asset values.
- The Sterling ERI.
- Consumer prices.
- Cost of investment.

c) In the light of your findings, consider critically the macroeconomic effectiveness of QE in stimulating economic activity and in reducing income and wealth inequalities.

Word count: 1998, excluding 1 figure, 7 tables and the bibliography.

1 Introduction

In response to the global financial crisis, the Bank of England (BoE) loosened monetary conditions by conventional and unconventional means, including the quantitative easing (QE) programme introduced in 2009. Since then, QE has been used on multiple occasions.



Gilt5, Gilt10, Gilt20: real yields on 5, 10 and 20-year maturity gilts. Source: BoE.
FTSE: the FTSE100 stock index, normalised to 1 at 2010m1. Source: Reuters Eikon.
APF gilts: value of gilts on the APF' balance sheet in £100bn. Source: ONS.
Vertical lines: QE extension announcement dates.

In 2011-12, the Monetary Policy Committee (MPC) cited sluggish recovery and the ongoing Eurozone debt crisis as the main reasons to extend the Asset Purchase Facility's (APF) balance sheet. In 2016 and 2020 the economic effects of the Brexit referendum and the coronavirus pandemic led to additional gilt (and corporate bond) purchases.

FIGURE 1

The repeated use of QE in the UK and elsewhere warrants interest in evaluating its effectiveness. I estimate asset price movements attributable to QE. Its effect on yields and stock prices is statistically significant but small in magnitude.

2 Data

I decided to extend the studied time period until April 2020, in order to incorporate the coronavirus QE announcement. This has a twofold benefit: firstly, I should get a more accurate estimate of the effects of the 2011-2016 rounds, as anecdotal evidence suggested that the March 2020 announcement was mostly unexpected (the data confirms this). Secondly, the effects of this round are interesting in and of themselves.

Table 1 explains the series I use, mentioning any data issues.

Description	**Source**	**Issues**
SONIA rates	BoE series IUDSOIA	None.
3-month Treasury bill rates	Thomson Reuters Eikon query GB3MT=RR, historical daily rates	The BoE provides only monthly data and discontinued in 2017. The date index did not match normal trading days, so I imputed about 20 days with the previous trading day's value.
Gilts yields (real and nominal for 2.5, 5, 10 and 20-year maturities)	BoE UK yield curve data	The BoE does not calculate real yield data if reliable prices are not available. This results in missing data on 2.5-year real yields in some event windows.
S&P U.K. Investment Grade Corporate Bond Index	Provided with the project	Ends on 24 Mar 2020, so I have no data for the 26 Mar 2020 announcement. I located the series as request .SPUKICG on Eikon but the Judge Business School's subscription, which I used through the Marshall Library's account, had no access to the series.
FTSE100 and FTSE250 stock indices	Thomson Reuters Eikon queries .FTSE and .FTMC	The provided series for FTSE100 was wrong with a day missing and earlier data shifted by one day; in addition 22 days' entries were incorrect. The Financial Times was cited as the source; in fact Reuters supplies the FT's data, which matched mine when accessed in early May but not the provided data.
Effective Pound exchange rate	BoE series XUDLBK67	None.
MPC announcements	Provided with the project, BoE monetary policy summary and minutes	The Bank Rate was erroneously given as 0.35% for the Aug 2017 meeting in the provided data; I corrected it to 0.25%.
QE, Bank Rate and credit easing (CE) expectations	Thomson Reuters Eikon query POLLS ->Economics and CBs -> CB Polls ->UK -> BOE BANK RATE, GB BOE QE QILTS, GB BOE QE CORPORATE BOND PURCHASES	The poll was not taken for some MPC meetings in the sample. None of these MPC meetings announced QE or changed the BR, so I assumed that expectations matched this. For days without MPC meetings, I filled in the expectations with the actual values.

Based on the above, I calculated daily changes in SONIA, Tbill rates and gilt yields, daily returns on the bond and stock indices and the exchange rate and surprise amounts of BR, QE and CE. These are the inputs in my econometric specification. Each series is daily frequency and is available 05/01/2010–30/04/2020, except for the corporate bond index, which is only available 05/01/2010 - 24/03/2020.
To facilitate reproducibility, I created a GitHub repository containing all the data. The repository is accessible here: `https://github.com/2897G/Metrics-project`

TABLE 1

3 Methodology

I employ event study methodology to examine the announcement effects of QE decisions. Financial asset values are assumed to follow a random walk (with drift) and unusually small or large daily returns after announcements are taken as evidence of QE news' influence. These "abnormal returns" must be weighted by the magnitude (and sign) of the surprise in the announcements to arrive at an overall estimate to QE's influence.

3.1 Estimation of Abnormal Returns

The cumulative abnormal return for asset i in event window $[T_0, T]$ is

$$CAR_i = \sum_{t=T_0}^{T} AR_{it} = \sum_{t=T_0}^{T} R_{it} - \mathbb{E}(R_{it})$$

where R_{it} is the actual return on asset i on day t and $\mathbb{E}(R_{it})$ represents "normal returns", estimated by the sample average of daily returns in the estimation window. My estimation windows run from the first datapoint to the previous MPC meeting date, leaving a sample size of over 400 even for the first event. Hence sampling error is negligible.

3.2 Event Windows

I used 4 event windows, with "day" referring to trading day: 1, 2 and 5-day windows starting on the MPC announcement's day and a 5-day window starting 5 days after the announcement.

It is common practice to specify an event window for a period before the event, in order to pick up information leakage. However, in this case results for such a window would be uninterpretable due to confounding events (especially because the MPC's decision might depend on asset price movements in this window).

I estimated the two 5-day windows as the prompt specified the 5-10 days timeframe. Virtually nothing is significant in the last window, which is not surprising under efficient markets. Movements on the 5-day horizon are often significant, but it is clear from the results that this comes from movements on the first 2 days.

The longer the event window, the more likely that the estimates pick up all movements even if markets don't adjust instantaneously, but also the more likely that the estimates will be inaccurate due to confounding events. Hence I use the short event windows for news-based calibration. Joyce et al. (2010) suggest that the 2-day window is the most appropriate for gilt markets (indeed the results show large negative movements on the first day after the announcement). For stocks and the ERI I prefer the 1-day window because (1) more events, especially in times of turmoil, affect these asset classes and (2) stocks and currencies are electronically traded (often by computers) while gilts are OTC, which might cause gilt prices to adjust more slowly.

3.3 Statistical Inference

Once the point estimates have been calculated, it is crucial to test for their statistical significance (that is, I perform a test of H_0 that the given day's return is the historical mean return plus random noise against the alternative that a special event was driving returns). For example, Mackinlay (1997) shows how this can be done under the assumption of normally distributed returns. Normality, however, is an unsatisfactory assumption for asset returns (especially in high-frequency data, see e.g. Brown and Warner, 1985). The Jarque-Bera, Shapiro-Wilk and Shapiro-Francia tests overwhelmingly reject normality for each series. Furthermore, volatility clustering is a well-known phenomenon in financial econometrics, so I tested for heteroscedasticity. Having rejected normality, I used a modified version of the Breusch-Pagan test that does not assume normality (STATA Manual Regress Postestimation, p.16). The test overwhelmingly rejected homoscedasticity for each of the series.

Therefore I computed p-values that do not rely on normality or homoscedasticity. The p-values reported are based on the nonparametric GRANK test of Kolari and Pynnonen (2011), which is robust to non-normality, event-induced volatility and serial correlation in abnormal returns. However, issues can arise when using nonparametric tests for multiple-day windows (Cowan, 1992), so I also produced p-values using Patell's (1976) test. The results were consistent, with every significant coefficient from the first test remaining significant.

3.4 Surprise-based Calibration

It is common in the literature (for example Gagnon et al., 2011 or Wright, 2012) to characterise QE announcements as "buy" (expected to decrease yields) or "sell" (expected to increase yields). I do the same, in order to know which way yields and prices should move if the announcements in fact have an effect.

To specify the expected sign of financial asset value movements at news announcements, one has to take account of the expectations investors had formed before the announcement. Given efficient markets (in the semi-strong sense of Fama, 1970), we should expect that any price change caused by the announcement is due to the deviation of the announcement from expectations (which I call surprise). I was able to proxy for these expectations using the mean value from the "GB BOE QE Gilts" poll of City economists, conducted by Reuters before each MPC meeting.

Table 2 shows the 5 announcements of QE extensions that happened between January 2010 and April 2020. There were some MPC meetings that did not introduce additional QE purchases when financial markets expected they would; these constitute negative surprises. My analysis incorporates the three largest negative surprises, as the others were at most £4bn. This approach allows for a quantitative measurement of the "strength" of news, in contrast to the aforementioned papers.

Date	**MPC announcement**	**QE surprise**
06/10/2011	QE increased by £75bn	+£56bn
09/02/2012	QE increased by £50bn	-£1bn
05/07/2012	QE increased by £50bn	£0bn
08/11/2012	No change	-£14bn
07/03/2013	No change	-£7bn
14/07/2016	No change	-£7bn
04/08/2016	QE increased by £60bn, CE of £10bn announced, BR cut by 0.25%	+£25bn
26/03/2020	QE increased by £210bn, CE increased by £10bn BR cut by 0.65%	+£201bn

TABLE 2

Finally, I regress the estimated abnormal returns (or, in the case of yields, differences) on the surprise for each of the 8 announcements, using OLS. Given that no surprise should lead to 0 abnormal returns, $(0, 0)$ can be taken as a sure datapoint, so I use regression through the origin. When included, the constants were not significant.

4 Results

Tables 3 and 4 show the abnormal return (and difference) estimates for each event.

Event date: **06oct2011**, with **4** event windows specified, using the Generalised Rank test by Kolari and Pynnonen

SECURITY	CAAR[0,0]	CAAR[0,1]	CAAR[0,4]	CAAR[5,9]
sonia_diff	-0.28%	-0.30%	0.80%	-0.99%
	(0.8573)	(0.8912)	(0.8199)	(0.7788)
tbill_diff	-0.01%	0.08%	-0.36%	-0.06%
	(0.9811)	(0.9152)	(0.7512)	(0.9580)
gilt2,5_r_diff	-16.74%***	-31.52%***	-27.35%**	19.25%
	(0.0027)	(0.0001)	(0.0294)	(0.1252)
gilt2,5_n_diff	4.31%	4.95%	11.34%	-5.49%
	(0.3131)	(0.4124)	(0.2370)	(0.5671)
gilt5_r_diff	-8.33%*	-16.02%**	-2.85%	6.65%
	(0.0890)	(0.0209)	(0.7954)	(0.5452)
gilt5_n_diff	3.60%	8.09%	22.79%**	-9.11%
	(0.4740)	(0.2554)	(0.0436)	(0.4198)
gilt10_r_diff	-2.52%	-5.99%	15.93%	2.31%
	(0.5759)	(0.3479)	(0.1158)	(0.8194)
gilt10_n_diff	4.86%	13.06%*	32.87%***	-14.04%
	(0.3425)	(0.0717)	(0.0043)	(0.2225)
gilt20_r_diff	-0.34%	-3.41%	18.40%**	1.63%
	(0.9277)	(0.5229)	(0.0300)	(0.8479)
gilt20_n_diff	0.26%	1.48%	19.40%*	-16.46%*
	(0.9539)	(0.8136)	(0.0519)	(0.0990)
bond_return	0.48%	-0.00%	-1.13%	1.50%**
	(0.1215)	(0.9972)	(0.1069)	(0.0315)
ftse100_return	3.65%***	3.90%**	6.52%**	0.23%
	(0.0016)	(0.0172)	(0.0120)	(0.9290)
ftse250_return	3.29%***	3.97%**	7.51%***	-0.92%
	(0.0035)	(0.0127)	(0.0030)	(0.7165)
eri_return	-0.73%	0.27%	-0.24%	0.41%
	(0.1093)	(0.6798)	(0.8176)	(0.6894)

Event date: **09feb2012**, with **4** event windows specified, using the Generalised Rank test by Kolari and Pynnonen

SECURITY	CAAR[0,0]	CAAR[0,1]	CAAR[0,4]	CAAR[5,9]
sonia_diff	0.55%	-0.16%	1.16%	-1.54%
	(0.7342)	(0.9451)	(0.7476)	(0.6704)
tbill_diff	-0.10%	0.00%	-0.29%	0.31%
	(0.8360)	(0.9963)	(0.7843)	(0.7731)
gilt2,5_r_diff	-4.10%	-6.26%	-37.55%***	0.98%
	(0.4570)	(0.4228)	(0.0024)	(0.9369)
gilt2,5_n_diff	0.60%	-4.94%	-4.87%	4.44%
	(0.8840)	(0.3946)	(0.5965)	(0.6298)
gilt5_r_diff	-4.03%	-10.49%	-19.09%*	2.43%
	(0.4019)	(0.1233)	(0.0769)	(0.8217)
gilt5_n_diff	-0.95%	-11.71%	-14.20%	8.19%
	(0.8503)	(0.1017)	(0.2109)	(0.4703)
gilt10_r_diff	0.05%	-5.48%	-9.81%	1.41%
	(0.9907)	(0.3968)	(0.3387)	(0.8907)
gilt10_n_diff	5.81%	-4.21%	-9.27%	8.61%
	(0.2898)	(0.5880)	(0.4518)	(0.4845)
gilt20_r_diff	7.27%*	6.55%	4.50%	1.46%
	(0.0674)	(0.2445)	(0.6139)	(0.8703)
gilt20_n_diff	15.86%***	11.92%*	5.90%	7.21%
	(0.0011)	(0.0824)	(0.5876)	(0.5076)
bond_return	-0.28%	0.01%	0.46%	-0.26%
	(0.3837)	(0.9852)	(0.5260)	(0.7208)
ftse100_return	0.33%	-0.41%	0.24%	0.38%
	(0.7899)	(0.8102)	(0.9296)	(0.8899)
ftse250_return	0.63%	0.01%	1.03%	1.31%
	(0.5964)	(0.9955)	(0.6998)	(0.6240)
eri_return	-0.02%	0.04%	0.20%	-0.87%
	(0.9729)	(0.9503)	(0.8436)	(0.3857)

Event date: **05jul2012**, with **4** event windows specified, using the Generalised Rank test by Kolari and Pynnonen

SECURITY	CAAR[0,0]	CAAR[0,1]	CAAR[0,4]	CAAR[5,9]
sonia_diff	-0.10%	-0.46%	-0.12%	-0.95%
	(0.9440)	(0.8278)	(0.9704)	(0.7758)
tbill_diff	0.00%	0.01%	-0.18%	-1.78%*
	(0.9927)	(0.9897)	(0.8571)	(0.0744)
gilt2,5_r_diff	0.00%	0.00%	0.00%	0.00%
	(.)	(.)	(.)	(.)
gilt2,5_n_diff	-8.27%**	-11.45%**	-9.24%	-7.55%
	(0.0339)	(0.0379)	(0.2907)	(0.3880)
gilt5_r_diff	-6.18%	-7.17%	-1.80%	-15.89%
	(0.1920)	(0.2846)	(0.8653)	(0.1346)
gilt5_n_diff	-9.15%*	-14.65%**	-14.56%	-9.51%
	(0.0647)	(0.0366)	(0.1902)	(0.3922)
gilt10_r_diff	-5.47%	-7.01%	-0.44%	-11.57%
	(0.2262)	(0.2729)	(0.9653)	(0.2539)
gilt10_n_diff	-5.64%	-11.66%	-13.76%	-6.63%
	(0.3070)	(0.1360)	(0.2670)	(0.5925)
gilt20_r_diff	-2.22%	-3.16%	2.96%	-7.27%
	(0.5683)	(0.5670)	(0.7351)	(0.4059)
gilt20_n_diff	-1.84%	-6.22%	-8.43%	-10.65%
	(0.7065)	(0.3677)	(0.4414)	(0.3304)
bond_return	-0.01%	0.68%	1.57%**	1.40%*
	(0.9761)	(0.1399)	(0.0307)	(0.0542)
ftse100_return	0.14%	-0.38%	-0.35%	0.38%
	(0.9033)	(0.8195)	(0.8959)	(0.8868)
ftse250_return	-0.29%	-0.85%	-1.83%	0.98%
	(0.8055)	(0.6097)	(0.4866)	(0.7089)
eri_return	0.26%	0.63%	1.15%	0.16%
	(0.5431)	(0.2996)	(0.2322)	(0.8698)

Event date: **08nov2012**, with **4** event windows specified, using the Generalised Rank test by Kolari and Pynnonen

SECURITY	CAAR[0,0]	CAAR[0,1]	CAAR[0,4]	CAAR[5,9]
sonia_diff	-0.19%	0.35%	-3.47%	1.57%
	(0.8957)	(0.8617)	(0.2809)	(0.6258)
tbill_diff	-0.19%	0.02%	-0.35%	0.45%
	(0.6662)	(0.9763)	(0.7215)	(0.6524)
gilt2,5_r_diff	0.00%	0.00%	0.00%	0.00%
	(.)	(.)	(.)	(.)
gilt2,5_n_diff	0.96%	1.92%	4.44%	9.49%
	(0.8005)	(0.7222)	(0.6037)	(0.2673)
gilt5_r_diff	2.15%	0.95%	4.85%	0.84%
	(0.6402)	(0.8845)	(0.6387)	(0.9355)
gilt5_n_diff	1.87%	0.59%	3.91%	12.93%
	(0.7024)	(0.9320)	(0.7210)	(0.2383)
gilt10_r_diff	0.63%	-2.59%	-2.66%	6.62%
	(0.8866)	(0.6779)	(0.7883)	(0.5038)
gilt10_n_diff	1.77%	-1.89%	1.35%	12.45%
	(0.7473)	(0.8083)	(0.9124)	(0.3119)
gilt20_r_diff	-2.60%	-6.48%	-8.77%	5.26%
	(0.4949)	(0.2300)	(0.3056)	(0.5389)
gilt20_n_diff	-0.91%	-3.09%	1.66%	7.84%
	(0.8509)	(0.6527)	(0.8789)	(0.4716)
bond_return	-0.11%	0.15%	-0.06%	-0.81%
	(0.7299)	(0.7377)	(0.9372)	(0.2675)
ftse100_return	-0.28%	-0.40%	-1.25%	0.48%
	(0.8096)	(0.8081)	(0.6284)	(0.8512)
ftse250_return	-0.58%	-1.06%	-2.21%	0.39%
	(0.6108)	(0.5117)	(0.3892)	(0.8796)
eri_return	0.05%	-0.25%	-0.68%	0.20%
	(0.9117)	(0.6736)	(0.4674)	(0.8305)

1 star, 2 stars and 3 stars denote significance at the 10%, 5% and 1% level, respectively.
'r' stands for the real yield, 'n' for nominal. The estimates for 'diff' variables have a basis point interpretation, as the data was in percentage terms.

TABLE 3

Event date: **07mar2013**, with **4** event windows specified, using the Generalised Rank test by Kolari and Pynnonen

SECURITY	CAAR[0,0]	CAAR[0,1]	CAAR[0,4]	CAAR[5,9]
sonia_diff	-0.56%	-0.32%	1.35%	-0.95%
	(0.6850)	(0.8675)	(0.6602)	(0.7587)
tbill_diff	0.02%	-0.56%	-0.81%	1.99%
	(0.9757)	(0.4921)	(0.5331)	(0.1266)
gilt2,5_r_diff	0.00%	0.00%	0.00%	0.00%
	(.)	(.)	(.)	(.)
gilt2,5_n_diff	3.17%	5.91%	2.39%	-3.14%
	(0.3922)	(0.2601)	(0.7739)	(0.7058)
gilt5_r_diff	0.94%	0.62%	-15.84%	16.98%
	(0.8427)	(0.9258)	(0.1348)	(0.1090)
gilt5_n_diff	4.71%	8.15%	1.14%	-7.58%
	(0.3225)	(0.2267)	(0.9147)	(0.4781)
gilt10_r_diff	2.48%	4.32%	-9.43%	4.18%
	(0.5801)	(0.4955)	(0.3479)	(0.6775)
gilt10_n_diff	6.37%	11.38%	2.93%	-9.37%
	(0.2361)	(0.1349)	(0.8077)	(0.4373)
gilt20_r_diff	2.19%	3.92%	-1.52%	-2.57%
	(0.5689)	(0.4710)	(0.8599)	(0.7653)
gilt20_n_diff	5.96%	9.73%	5.53%	-11.13%
	(0.2101)	(0.1485)	(0.6044)	(0.2968)
bond_return	-0.44%	-0.36%	0.03%	0.60%
	(0.1768)	(0.4377)	(0.9686)	(0.4122)
ftse100_return	0.16%	0.83%	0.74%	-0.85%
	(0.8846)	(0.5967)	(0.7647)	(0.7336)
ftse250_return	0.17%	0.59%	0.12%	0.20%
	(0.8759)	(0.7017)	(0.9595)	(0.9353)
eri_return	-0.36%	-0.68%	-0.55%	1.38%
	(0.3702)	(0.2367)	(0.5494)	(0.1299)

Event date: **04aug2016**, with **4** event windows specified, using the Generalised Rank test by Kolari and Pynnonen

SECURITY	CAAR[0,0]	CAAR[0,1]	CAAR[0,4]	CAAR[5,9]
sonia_diff	-21.05%***	-24.26%***	-24.44%***	-0.25%
	(0.0000)	(0.0000)	(0.0000)	(0.9372)
tbill_diff	-0.09%	-2.79%**	-3.86%*	-0.26%
	(0.9195)	(0.0317)	(0.0597)	(0.8980)
gilt2,5_r_diff	0.00%	0.00%	0.00%	0.00%
	(.)	(.)	(.)	(.)
gilt2,5_n_diff	-10.15%***	-8.32%	-10.72%	6.22%
	(0.0050)	(0.1040)	(0.1856)	(0.4426)
gilt5_r_diff	-16.67%***	-20.00%***	-31.80%***	-4.27%
	(0.0002)	(0.0013)	(0.0013)	(0.6654)
gilt5_n_diff	-15.66%***	-14.20%**	-20.06%*	6.48%
	(0.0007)	(0.0305)	(0.0534)	(0.5329)
gilt10_r_diff	-16.84%***	-19.98%***	-35.28%***	-0.82%
	(0.0000)	(0.0007)	(0.0001)	(0.9301)
gilt10_n_diff	-16.58%***	-14.36%**	-26.02%**	5.72%
	(0.0013)	(0.0489)	(0.0241)	(0.6202)
gilt20_r_diff	-10.97%***	-13.04%***	-29.59%***	-1.05%
	(0.0015)	(0.0077)	(0.0001)	(0.8918)
gilt20_n_diff	-16.12%***	-16.75%***	-36.80%***	8.71%
	(0.0003)	(0.0080)	(0.0002)	(0.3835)
bond_return	2.04%***	2.57%***	4.24%***	-1.10%
	(0.0000)	(0.0000)	(0.0000)	(0.1310)
ftse100_return	1.57%	2.35%	3.38%	-0.16%
	(0.1279)	(0.1078)	(0.1433)	(0.9433)
ftse250_return	1.41%	2.65%*	3.88%*	0.16%
	(0.1631)	(0.0639)	(0.0865)	(0.9430)
eri_return	-1.35%***	-1.47%**	-2.44%**	-0.63%
	(0.0031)	(0.0233)	(0.0172)	(0.5423)

Event date: **14jul2016**, with **4** event windows specified, using the Generalised Rank test by Kolari and Pynnonen

SECURITY	CAAR[0,0]	CAAR[0,1]	CAAR[0,4]	CAAR[5,9]
sonia_diff	-6.39%***	0.73%	0.22%	-0.26%
	(0.0000)	(0.7089)	(0.9444)	(0.9317)
tbill_diff	-0.90%	10.11%***	8.72%***	-4.98%***
	(0.2648)	(0.0000)	(0.0000)	(0.0056)
gilt2,5_r_diff	1.98%	5.60%	-1.15%	-1.06%
	(0.6743)	(0.4007)	(0.9133)	(0.8217)
gilt2,5_n_diff	3.47%	5.80%	5.73%	-7.47%
	(0.3281)	(0.2478)	(0.4705)	(0.3469)
gilt5_r_diff	2.47%	5.80%	5.09%	-10.94%
	(0.5647)	(0.3397)	(0.5960)	(0.2548)
gilt5_n_diff	4.24%	7.36%	7.88%	-9.49%
	(0.3546)	(0.2559)	(0.4420)	(0.3545)
gilt10_r_diff	2.92%	7.18%	8.24%	-9.46%
	(0.4731)	(0.2130)	(0.3660)	(0.2998)
gilt10_n_diff	5.35%	10.17%	10.40%	-9.75%
	(0.2956)	(0.1594)	(0.3634)	(0.3939)
gilt20_r_diff	2.68%	8.74%*	10.89%	-5.13%
	(0.4331)	(0.0703)	(0.1544)	(0.5024)
gilt20_n_diff	4.19%	11.53%*	13.55%	-10.91%
	(0.3420)	(0.0644)	(0.1697)	(0.2689)
bond_return	-0.06%	-0.19%	-0.11%	0.82%
	(0.8584)	(0.6826)	(0.8765)	(0.2579)
ftse100_return	-0.24%	-0.03%	0.85%	0.29%
	(0.8109)	(0.9850)	(0.7095)	(0.8975)
ftse250_return	0.19%	-0.21%	1.43%	1.28%
	(0.8444)	(0.8796)	(0.5076)	(0.5518)
eri_return	0.75%*	0.29%	0.30%	-0.32%
	(0.0651)	(0.6145)	(0.7441)	(0.7279)

Event date: **26mar2020**, with **4** event windows specified, using the Generalised Rank test by Kolari and Pynnonen

SECURITY	CAAR[0,0]	CAAR[0,1]	CAAR[0,4]	CAAR[5,9]
sonia_diff	-0.22%	-0.42%	-0.43%	-0.76%
	(0.8734)	(0.8297)	(0.8891)	(0.8056)
tbill_diff	0.69%	0.18%	-6.15%*	15.55%***
	(0.6230)	(0.9275)	(0.0505)	(0.0000)
gilt2,5_r_diff	0.11%	-6.33%	-4.08%	-4.51%
	(0.9815)	(0.3471)	(0.7020)	(0.6721)
gilt2,5_n_diff	1.11%	1.73%	1.07%	0.62%
	(0.7415)	(0.7156)	(0.8866)	(0.9338)
gilt5_r_diff	-5.09%	-11.90%*	-11.68%	1.33%
	(0.2497)	(0.0574)	(0.2385)	(0.8929)
gilt5_n_diff	-1.51%	-1.86%	-3.26%	3.46%
	(0.7228)	(0.7576)	(0.7318)	(0.7166)
gilt10_r_diff	-9.68%**	-16.61%***	-14.61%	3.05%
	(0.0198)	(0.0047)	(0.1159)	(0.7424)
gilt10_n_diff	-6.30%	-8.55%	-10.78%	7.50%
	(0.1871)	(0.2056)	(0.3133)	(0.4827)
gilt20_r_diff	-11.02%***	-17.88%***	-9.01%	-4.19%
	(0.0019)	(0.0004)	(0.2571)	(0.5986)
gilt20_n_diff	-5.87%	-11.77%*	-11.07%	1.02%
	(0.1689)	(0.0509)	(0.2458)	(0.9146)
bond_return	0.00%	0.00%	0.00%	0.00%
	(.)	(.)	(.)	(.)
ftse100_return	2.21%**	-3.20%**	-4.25%**	3.95%*
	(0.0176)	(0.0149)	(0.0408)	(0.0575)
ftse250_return	3.68%***	-0.40%	-2.02%	8.50%***
	(0.0000)	(0.7537)	(0.3202)	(0.0000)
eri_return	1.80%***	3.45%***	4.78%***	-0.15%
	(0.0001)	(0.0000)	(0.0000)	(0.8872)

1 star, 2 stars and 3 stars denote significance at the 10%, 5% and 1% level, respectively.

'r' stands for the real yield, 'n' for nominal. The estimates for 'diff' variables have a basis point interpretation, as the data was in percentage terms.

TABLE 4

4.1 Individual Events

A positive QE surprise is expected to increase Treasury bill yields (since the APF's purchases are financed by the creation of central bank reserves, a substitute for Treasury bills), decrease real gilt yields (especially for medium-long maturities) and corporate bond yields (i.e. the bond index should increase due to the capital gain on bonds), increase stock prices and depreciate the Sterling exchange rate. Vice versa for negative surprises. The SONIA is pinned down by the BoE's interest rate corridor, so QE should not have much of an effect.

Overall, most movements were of the expected sign and statistical significance suggests that QE announcements have had an identifiable impact on asset prices.

Few movements are significant for the events on 09/02/2012, 05/07/2012, 08/11/2012, 07/03/2013 and 14/07/2016, which is in line the proxy for expectations.

There are a few unexpected results. Shorter-term yields dropped more than longer-term yields on 06/10/2011. The surprise on 04/08/2016 was smaller than on 04/08/2016 and 26/03/2020 but the yield movements were larger. The ERI appreciated a lot on 26/03/2020. See the Evaluation section.

4.2 Surprise-based Calibration

Table 5 shows the estimated average effect of £1bn surprise QE. Results for 1, 2 and 5-day windows are included, as well as estimates dropping the 2020 event for sensitivity analysis.

VARIABLES	(1) sonia_diff	(2) tbill_diff	(3) gilt25_r_diff	(4) gilt25_n_diff	(5) gilt5_r_diff	(6) gilt5_n_diff	(7) gilt10_r_diff	(8) gilt10_n_diff	(9) gilt20_r_diff	(10) gilt20_n_diff	(11) bond_return	(12) ftse100_return	(13) ftse250_return	(14) eri_return
1-DAY														
surprise	-0.000120	3.26e-05***	-0.000212	3.36e-05	-0.000440*	-0.000131	-0.000575***	-0.000342**	-0.000565***	-0.000369**	0.000205	0.000155**	0.000217***	6.39e-05*
	(0.000164)	(3.66e-06)	(0.000328)	(8.59e-05)	(0.000219)	(0.000122)	(0.000130)	(0.000135)	(7.20e-05)	(0.000123)	(0.000143)	(5.86e-05)	(4.33e-05)	(3.05e-05)
2-DAY														
surprise	-0.000161	-2.16e-05	-0.000704	7.05e-05	-0.000863**	-8.55e-05	-0.000948***	-0.000330	-0.000926***	-0.000634***	0.000162	-8.24e-05	4.95e-05	0.000152***
	(0.000198)	(3.81e-05)	(0.000584)	(8.28e-05)	(0.000322)	(0.000144)	(0.000160)	(0.000237)	(8.29e-05)	(0.000126)	(0.000198)	(9.62e-05)	(8.53e-05)	(2.31e-05)
5-DAY														
surprise	-0.000152	-0.000311***	-0.000393	1.67e-05	-0.000806**	-0.000238	-0.000878***	-0.000595**	-0.000566**	-0.000741**	0.000330	-0.000126	-2.37e-05	0.000196***
	(0.000193)	(3.36e-05)	(0.000297)	(9.49e-05)	(0.000289)	(0.000155)	(0.000251)	(0.000194)	(0.000211)	(0.000287)	(0.000306)	(0.000104)	(9.10e-05)	(5.10e-05)
2-DAY, DROP 2020														
surprise	-0.00156	-0.000327	-0.00564***	-8.51e-05	-0.00356***	-1.68e-05	-0.00215	0.000622	-0.00129	-0.00112	0.000162	0.000683***	0.000742***	-3.84e-05
	(0.00185)	(0.000364)	(5.46e-05)	(0.000988)	(0.000958)	(0.00156)	(0.00135)	(0.00180)	(0.000931)	(0.00151)	(0.000198)	(5.49e-05)	(6.32e-05)	(0.000118)
Observations	8	8	4	8	8	8	8	8	8	8	7	8	8	8
R-squared	0.013	0.353	0.196	0.007	0.333	0.004	0.460	0.058	0.554	0.213	0.147	0.513	0.768	0.284

Robust standard errors in parentheses.

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

The estimates from the preferred event windows are highlighted.

The R-squared is that of the regression for the preferred event window.

The estimates are generally sensitive to the event window length. Gilt yield change estimates are not sensitive to using a 2 vs 5-day window.

The results for the ERI are driven my the 2020 event, as shown by the sign change and loss of significance when the 2020 event is exlcuded. As expected, standard errors increase significantly.

The results were not sensitive to using the median (instead of mean) surprise or the raw announcement values. However, the explanatory power (as measured by R-squared) decreases when raw announcement values are used. These results are not reported but available on https://github.com/2897G/Metrics-project.

TABLE 5

The results confirm that yields decreased and stock indices rose due to QE. The results are statistically significant, except for the 2.5-year gilts, where a lot of data is missing.

Table 6 shows the effect on real yields, inflation expectations and the stock indices, scaled up for the whole magnitude of the QE rounds between 2010-2016 and 2010-2020.

	gilt5	exp_inf5*	gilt10	exp_inf10*	gilt20	exp_in20*	bond**	ftse100	ftse250
2010-2016	-20bp	18bp	-22bp	14bp	-22bp	7bp	-21bp	3.6%	5.1%
2010-2020	-38bp	35bp	-42bp	27bp	-41bp	13bp	-37bp	6.7%	9.4%

* Change in expected yearly inflation at the given time horizon, calculated as the difference between nominal and real yields.
** The corporate bond yield change was calculated by finding the average yearly yield (5.6%) for the the bond index and translating the calibrated event window appreciations of the index into yield changes at the average yield.

TABLE 6

The inflation expectations estimates show that markets believed that the inflationary impacts of QE would extend beyond the 5-year horizon (with 10bp increase in inflation over the 5-10 year horizon and no effect afterwards).

Smaller companies' stocks appreciated more, suggesting that QE decreased risk factors.

5 Evaluation

Table 7 summarises the issues plaguing my estimates. The confounding events issue may be severe; for the US, Thornton (2017, p.69) even states that "event-study announcement effects cannot and should not be cited as evidence of QE's effectiveness" because of this. Overall, the estimates are subject to considerable uncertainty.

Issue	Consequences
Small number of observations (only 5 QE announcements).	Low confidence in the estimates. Cannot test the model fit or distribution assumptions.
Expectations measured by survey data.	Possibly a noisy proxy. Expectations may have changed between the time when the survey was taken and the actual announcement. Only a negligible fraction of market participants can be surveyed, possibly not the ones that have the most influence on asset prices.
Confounding events.	Potentially inaccurate estimates. I tried to discover any important confounding events by searching for financial news articles on the announcement dates. E.g. the ECB announced CBPP2 on 06/10/2011 and the Chancellor of the Exchequer announced the CBILS on 26/03/2020, which can affect UK yields. However, there doesn't seem to be any good way to control for these one-off events.
More news than QE.	The MPC meeting minutes contain more information than simply the QE announcement, e.g. the BoE's general economic outlook. If market participants revise their outlook based on the meeting minutes, a confounding event is introduced. Since the MPC decides to introduce additional QE only when they forecast economic conditions to deteriorate, the confounding event is systematic so estimates of QE's impact will be biased.
Possibility of structural break.	If some parameters of the economy that determine the effect of QE change over time, it is hard to interpret the "average effect". There are not enough datapoints to check for such a break.
Endogeneity of debt issuance.	If market participants expect that the DMO (or corporations) will issue more debt when yields are lower, the decrease in yields will be smaller than what it would be under exogenous debt issuance. Hence, the estimates will be biased towards 0.
Influential observations.	The event on 26/03/2020 was associated with the largest surprise by far, and may drive the estimates by itself. Table 5 shows that this is the case for shorter-term gilts but not for other asset classes. Hence, the confidence in the estimates diminishes, as any random shock on this date will lead to a large error in the overall estimates.
Persistence of effects.	It has been suggested (e.g. Wright, 2012, for the US) that gilt yield reductions due to QE are only temporary, which reduces the effectiveness of QE policies. For the UK, Daines et al. (2012) find that the movements have been persistent.

TABLE 7

My estimates of the impact of a unit QE are smaller than the literature's estimates for QE1 in 2009. Meier (2009) estimated a 40-100bp and Joyce et al. (2010) estimated a 100bp reduction in 10-year yields due to a £200bn programme; my estimates are one-fifth this size. Reasons for this might include, firstly, that the policy signalling channel was active for the QE1 round but not afterwards. Secondly, nominal yields were already much lower in the ZLB environment of 2016 and 2020 than at QE1. Thirdly, QE may not be equally efficient in responding to all kinds of crisis; e.g. its effect may be larger when the issue is bank illiquidity (2009) versus a real productivity shock.

Since the justification for undertaking QE is that the BoE predicts inflation to undershoot its 2% target and economic stimulus is needed, the effectiveness of QE should not be evaluated based on asset price movements per se.

In terms of the macroeconomic effect, my analysis shows that QE was successful in reducing the cost of investment (as measured by real yields) which should have a positive effect on GDP through increased investment. The wealth effect from increased asset prices can also operate but is likely to be weak as most of it accrues to the wealthy. Inflation expectations rose, which also suggests a positive impact on economic activity.

Measuring QE's effect on inflation and GDP quantitatively requires a completely different approach due to the complexity of economic interrelationships, infrequent data on macro variables and long lags in the transmission. Most papers use highly complex versions of VARs to construct a counterfactual scenario. Unfortunately, the literature has such a wide range of estimates so as to render the results uninterpretable, sometimes even within a single paper. For the UK, Kapetanios et al. (2012, Table F) find that the peak effect on GDP growth from a 100bp reduction in yields is 0.28%-5.36% depending on the model specification. Baumeister and Benati

(2010) estimate that GDP growth would have reached -12% without QE. Scaling the preferred estimates of 1.5% GDP growth and 1.25% inflation increase of Kapetanios et al. to my estimates for the 2010-2016 rounds, the impact on GDP is only 0.33% and on inflation only 0.28%. This is broadly consistent with Churm et al. (2015), who estimated peak boosts of 0.5%-0.8% for GDP and 0.6% for inflation for a 45bp reduction in 10-year gilts.

Policymakers should also consider the redistributive effects of QE. On the one hand, as well-off households hold more of their wealth in financial assets, QE increases wealth inequality. On the other, QE has equalising effect to the extent that it reduces unemployment, increases house prices and decreases mortgage payments (Montecino and Epstein, 2015). The debate is still open, a survey of results is Colciago et al. (2019). ECB research claims that QE has been equalising overall (Lenza and Slacalek, 2018) while a dis-equalising effect is found by Montecino and Epstein, (2015) and Daniel Wales (forthcoming) for the US and by Mumtaz and Theophilopoulou (2017) for the UK. Pension funds have frequently opposed ultra-low interest rates (Financial Times, 2019).

The effects on inequality in likely to depend on policy design choices, such as whether obstacles are removed for lower-income households to refinance their loans. Another suggestion is the reliance on the Treasury's and BoE's lending facilities (such as the PWLB or CCFF) to lend directly to local governments and corporations instead of relying on asset prices to generate employment.

6 Conclusion

QE news announcements after 2010 had significant but quantitatively small effects on yields and stock prices, while an impact on the Sterling exchange rate is not identified. By calibrating the event study estimates with the surprise components of each announcement, I estimate that 10-year real gilt yields fell 22 basis points, corporate bond yields fell 21bp and the FTSE100 index increased by 3.6% in reaction to the 2011-2016 QE rounds. Inflation expectations on the 5-year horizon increased by 18bp per year. The movements are almost doubled when the March 2020 round is included.

These estimates are subject to considerable uncertainty, because of the small sample size and the possibility of confounding events. While a positive but small macroeconomic impact is suggested, the effectiveness of quantitative easing remains an open question.

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