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Did the Bank of England's Quantitative Easing Programme Become Fiscally Wasteful?

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Abstract
In the period of central bank independence since 1997, the level of UK nominal interest rates has been driven almost entirely by real rates as reflected in the market for index-linked government bonds. These bonds offered a yield of +4% in the 1980s, falling steadily to below -2% in late 2019, and only recovered somewhat in 2022, with long bond yields closely following short bond yields. The Bank of England doubled its purchases of bonds through its Quantitative Easing (QE) programme in 2020–21 at significantly negative real interest rates, taking up almost all of the increased supply associated with the massively increased budget deficit during the Covid-19 pandemic. Neither the Bank nor the Government bothered about the likely eventual fiscal cost, which rose quite steeply at the margin to the extent that the QE purchases had their intended effect of depressing bond yields. Much, but not all, of the blame for this lies with the Government, since under independence it is the Government that defines what the Bank should take into account in making its decisions about monetary policy. The issue of the eventual fiscal cost of QE is also of concern in the Euro Area and the United States.

Keywords Central bank independence · Interest rates · Quantitative easing

JEL Classification E58

1 Introduction

Quantitative Easing (QE) refers to the purchase of longer-maturity bonds by the central bank in an effort to reduce their yield. It was first introduced in Japan in 1999. After the global financial crisis of 2008–09 it was widely adopted internationally as a standard tool for boosting aggregate demand on the part of central banks that had already reduced the policy interest rate to its lower bound.

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This paper argues that in its later guise the QE programme of the Bank of England (BoE) in particular entailed a substantial risk to the public finances that appears not to have been taken into account in the policy discussions, either inside the Bank's Monetary Policy Committee or between the Bank and the Treasury. I focus on the United Kingdom (a) because the time profile of BoE QE bond purchases makes the issue particularly acute in that country and (b) because I draw extensively on evidence from the market for indexed bonds of different maturities, and this market is more significant and has a longer history in the United Kingdom than elsewhere.

I am far from the first person to suggest that the reversal of QE by bond sales or by not rolling over maturing bonds, collectively known as Quantitative Tightening (QT), has been too long delayed and may entail substantial fiscal risk as a result. My contribution is to present the evidence in a novel fashion. Along the way I show that the market's predictions of future real interest movements as reflected in the yield curve have been spectacularly poor, so that, if the BoE relied on the yield curve to reassure itself that the fiscal risk of QE during the pandemic was small, that belief rested on decidedly shaky foundations. I also discuss the allocation of responsibility between the BoE and the Treasury, who defined what factors should be taken account in deciding monetary policy but left the details of implementation to the Bank, in line with current theories of central bank independence.

The remainder of this article is structured as follows. Section Two summarises the different phases of QE and the macroeconomic conditions at the time. Section Three discusses real and nominal interest rates, and Section Four reviews the theory of the term structure. Section Five discusses potential losses from quantitative easing, and Section Six considers how the blame should be divided between the Bank of England and the Government. Some conclusions are drawn in Section Seven.

2 Quantitative Easing and the Macroeconomy

Although QE was conceived as a cyclical measure that would be reversed once the recession was over, there is general agreement that it has lasted far longer and grown substantially bigger than anyone envisaged at the beginning. Asset purchases began in 2009 with an initial authorisation of £150bn, and continued, albeit with some interruption but with no reversals, until December 2021. The proceeds from bonds that matured before the end of 2021, of which there had been a steady stream of two or three issues per year from 2013 onwards, were entirely rolled over into new bond purchases (at ever higher prices). The Covid-19 epidemic that started in March 2020 gave QE a whole new lease of life: the assets held by the Bank of England's Asset Purchase Facility Fund (APF) increased from £450bn in February 2020 to a maximum figure of £895bn by the end of 2021. This increase of £445bn represented 20.1% of 2019 GDP.[1]

[1] I follow the standard method of quantifying the size of asset purchases (at the nominal purchase price rather than the current market price), with 100% rollovers treated as leaving the nominal purchase price unchanged. The BofE has not revealed what proportion of QE has been subject to this rollover process.

The different phases of QE in the United Kingdom are succinctly summarised in House of Lords (2021). There have been broadly three phases. From 2009 to July 2012 a total of £375bn of government bonds was bought at a time when the economy was still in recession, with low inflation and the unemployment rate averaging about 8% compared with 5% in the years 2002–08. During the global financial crisis Bank rate had been swiftly lowered to 0.5% and stayed there. A significant element of the agreement setting up QE in 2009 that has become particularly relevant in recent years is the commitment of the Treasury to indemnify the Bank against any losses on its asset purchases.

The use of QE in the global financial crisis was widely supported. There is a general consensus that this phase of QE helped to support output at a time when interest rates had effectively reached their lower bound. This consensus is reflected, for example, in the evidence presented to the House of Lords Economic Affairs Committee (House of Lords 2021).

In the second phase (2013 to 2019), although output growth was slow because of the lack of productivity growth, the economy seemed close to macroeconomic equilibrium, with unemployment falling below 5% in 2015 and staying below its pre-2009 level, while inflation averaged 1.4%. Meanwhile, nominal and real bond yields pursued a steady downward course. Having been 1.74% at the end of December 2007, five-year indexed bond yields fell to −1.46% at the end of December 2013 and −2.62% at the end of January 2020; five-year conventional bond yields were 5.39% at the end of 2007, 2.00% at the end of 2013 and 0.38% at the end of January 2020. For 20-year indexed and conventional bonds, the corresponding figures were respectively 0.46% and 4.38% (December 2007), −0.17% and 3.03% (December 2013), and −2.21% and 1.03% (January 2020).

The standard Taylor-type rule of interest-rate setting in an inflation-targeting regime is:

$$i = (\pi * + r) + a(\pi - \pi *) + b(y - y *) \qquad a, b > 0 \tag{1}$$

where i is the policy interest rate, r is the real interest rate, y is output, π is inflation and * denotes an equilibrium or target value. When inflation and output are both at their target values, so that the last two terms in Eq. (1) are zero, the "neutral" interest rate should be equal to the sum of the inflation target and the real interest rate. The downward trend in the real interest rate that was clearly identifiable in the market for indexed bonds implied that the neutral interest rate was steadily declining towards zero as real interest rates slid to −2%, just cancelling out the inflation target of +2%.

There was a marked contrast between this ever-shrinking gap between the neutral and the actual interest rate and the determination of the BoE not to reduce the scale of QE, with the funds from each bond reaching maturity being reinvested in other bonds. The original rationale for QE was as a substitute for pushing the actual interest rate further below the neutral rate, which was problematic once the interest rate hit the "zero lower bound". Almost all observers assumed that, if the neutral rate had stayed at its pre-2009 level, QE would have been steadily unwound either before interest rates began rising or at least in tandem with the rise, and would certainly not remain unchanged as the actual rate converged to the neutral rate. The

BoE has never made clear why it did not at least allow QE to shrink naturally as bonds matured, or exactly how much effect it assumed that each extra £bn of QE had on asset prices and yields and on real output and inflation once financial markets had recovered from the global financial crisis.[2]

Because of this reluctance to begin quantitative tightening together with an extra tranche of QE around the time of the UK's exit from the European Union, QE expanded somewhat further. Up to 2016 a total of £445bn of assets had been acquired, but at this point purchases ceased until early 2020. The outbreak of the Covid-19 pandemic caused the Bank of England in March 2020 to authorise further purchases of £200bn of government bonds, which were soon increased in June and again in November to £430bn, plus £20bn of corporate debt, bringing the total assets held by the APF to £875bn of government debt plus £20bn of corporate debt.

As we have already seen, the prices of gilts of all maturities were extraordinarily high by historical standards at the onset of the pandemic. Although the government's fiscal support measures during the pandemic might have reduced the prices because of the greatly increased supply, this did not happen because the BoE essentially bought up the whole lot. From March 2020 to December 2021 interest rates remained at historically low levels, averaging −3.11% for 5-year and −2.43% for 20-year indexed bonds, and 0.24% for 5-year and 1.00% for 20-year conventional bonds.[3]

This stage of QE lasted until late 2021, and in February 2022 the Bank began a programme of quantitative tightening. Various observers have pointed out that QE was looking likely to incur substantial capital losses for which the taxpayer is ultimately liable (e.g. Allen et al. 2021; Tucker 2022).[4] The losses are a consequence of the volume of bonds acquired together with the unusually high prices paid. This is not exclusively a UK problem (Gros and Shamsfakhr 2022; Levin et al. 2022), but it is significantly more acute in the UK than elsewhere because of the longer average maturity of its stock of government debt (currently the longest maturity is fifty years for both conventional and indexed debt).

[2] It is possible that the Bank felt driven to this "QE paralysis", as it might be termed, by the US "temper tantrum" experience of 2013, when an announcement of not even a halt, let alone a reversal, but a gradual tapering of the rate of expansion of QE towards zero caused a sharp spike in bond yields. It seems inexcusable that the BoE never actually dared to test the reaction to a gradual reduction of QE in the UK bond market.

[3] These and other data on bond yields are taken from end-of-month estimated zero coupon yield curves as given in the data files " glcrealmonthedata" and "glcnominalmonthedata" published on the Bank of England website.

[4] The House of Lords Economic Affairs Committee 202fr1 Report on Quantitative Easing also stated that the Committee agreed with a witness who drew attention to the "potentially enormous" taxpayer liability implied by the commitment of the Government to cover any losses, but they did not discuss the likelihood of such losses materialising.

Table 1 Statistical analysis of the components of nominal interest rates

%	15-year nominal bond yield (N)	15-year indexed bond yield (R)	Inflationary risk (Z)
December 1996 – December 2021			
Mean	3.61	0.52	3.08
Standard Deviation	1.61	1.77	0.44
December 2008 – December 2021			
Mean	2.41	–0.87	3.32
Standard Deviation	1.20	1.25	0.29

The data are based on estimates of end-of-month zero-coupon real and nominal yield curves as reported in the statistics section of the Bank of England website. The inflationary risk (Z) is calculated as $(1+Z/100)=(1+N/100)\div(1+R/100)$

3 Real and Nomimal Interest Rates

I focus on real interest rates not just because they are one of the two components of nominal interest rates, the other being what I shall call "inflationary risk", which consists of expectations of inflation plus a risk premium. Real interest rates have been the critical component of nominal interest rates in the QE period (2009 onwards) and also during the whole period of central bank independence in the UK before QE began (1997 onwards). Table 1 shows this using the standard deviation of the two components up to 2021. The 15-year inflationary risk component has been remarkably stable at just over 3%, which seems to imply a good deal of confidence that inflation will not move far from the 2% target. The significant point is that the standard deviation of the yield on a 15-year indexed bond was four times as large as the standard deviation of inflationary risk.[5]

Focusing on the market for index-linked bonds enables the analyst to penetrate the fog of inflation uncertainty. It is true that under QE the Bank of England decided not to buy any index-linked bonds, which are largely held by buy-and-hold investors such as pension funds and are therefore less liquid than conventional bonds, in the sense of lower trade volumes and also a lower price elasticity of demand. That does not undermine the case for paying close attention to the market for index-linked bonds in analysing the possible fiscal costs of QE because, as Table 1 implies, this is the key to understanding nominal interest rates also. In other words, the fact that throughout the QE period nominal bond yields have stayed very close to real yields

[5] It needs to be borne in mind that the BoE's inflation target is forward-looking. i.e. it is intended to prevent any price shock from being magnified through a wage-price spiral, and not to reverse the shock or to return prices to their pre-shock growth path. Thus, even under the assumption of 100% success for inflation targeting, any shocks in the future will be expected to shift the price growth path while preserving its slope. Since historical experience suggests that the distribution of the first-round price effect of shocks is skewed in a positive direction, there will be an expectation of price growth somewhat above 2% per annum in the long run.

plus a constant offers us a way of evaluating the likely fiscal cost of QE by analysing the market for index-linked bonds.

I point out that the market's apparent belief in 2020–21 that ultra-low (and indeed negative) short-term real interest rates were likely to persist for the next 50 years, as evidenced by the flatness of the yield curve for index-linked bonds, should have been of little comfort because, throughout the (albeit limited) history of these bonds, the market has underestimated future movements in real interest rates. If real interest rates were to return reasonably swiftly to anything like their historical average, then the cost of QE purchases of conventional bonds at such high prices would turn out to be substantial.

4 Economic Theory and the Term Structure of Interest Rates

Before we analyse the potential fiscal cost of the 2020–21 QE asset purchases in more detail, it is useful to remind ourselves about the theory of interest rates.

The standard approach to explaining the yield curve (the relationship between short-term and long-term bond yields at any given time) is the expectations theory. An investor buying a conventional fixed-rate bond at time t and intending to sell at time $t+2\ m$ may buy a bond of maturity $2\ m$; alternatively (s)he may buy a succession of bonds of maturity $<2\ m$, such as a bond of maturity m, followed by a second bond of maturity m at time $t+m$. The yield on this second bond is unknown at time t. The expectations theory says that these two strategies should be expected to produce identical returns, so that the spread between longer- and shorter-maturity bonds will reflect expected future interest rates. The only caveat to this is the likelihood that there is a risk premium attached to longer-maturity bonds, in case unexpected inflation undermines their real value, since the yield to maturity is fixed for those who bought longer-maturity bonds at time t.

The expectations theory is incomplete for empirical purposes. This is because there is only one piece of information – the long/short yield spread – and two unknowns that cannot be observed (the expectations of future yields, and the risk premium). So the expectations theory has to be supplemented by additional hypotheses about the determination of the risk premium and of interest rate expectations before it can be taken to the data. In the absence of anything better, it is standard to assume that the risk premium is a constant, so that it can be absorbed by an intercept term in any regression.[6] As for expectations, the modern approach is to assume that they are formed rationally, and are therefore based on a correct interpretation of all information available at time t (otherwise agents have ignored opportunities for improving the forecast despite having strong financial incentives not to do so). In empirical work this is taken to imply that any forecast errors in future short rates should be random and uncorrelated with any variables known at time t, such as the

[6] Since the rate of inflation is more volatile when it is higher, one might consider that the risk premium is more likely to be a function of recent inflation than absolutely constant over time, but I shall not pursue that issue here.

term spread (e.g. Campbell and Shiller 1991; Pflueger and Viceira 2011). This joint hypothesis of expectations theory plus rational expectations can be tested by regressing the error in forecasting future interest rates on suitable controls and seeing if all the candidate explanatory variables are statistically insignificant as expected. Note that in order not to fail this test the forecasts do not have to be accurate in the sense that the errors are small in absolute value, but just orthogonal to any available information. In other words, rational expectations can be seriously wrong, not necessarily because they ignored or misinterpreted the information available at the time, but because the information required for an accurate forecast only becomes available in the future, if at all, so that the random element in the regression equation has a high variance.

Expectations theory can be applied to the market for index-linked bonds in similar fashion (Pflueger and Viceira 2011). In this case the slope of the yield curve reflects a combination of expected movements in short-term real rates and a real risk premium. The risk premium in index-linked bonds is almost certainly smaller than in nominal bonds, since there is virtually no inflation risk. There remains a risk of fluctuations in real interest rates in the future, but some financial institutions, such as pension funds with defined-benefit liabilities for decades ahead, may actually be more interested in the longer-term real value of the fund than its short-term value; for them the risk premium would be of the opposite sign to that usually assumed. With stable monetary conditions, interest rates should be stationary, which implies that the mean of the difference between present and future interest rates should be zero. In that case the mean of the term spread would give us an estimate of the risk premium. As an illustration, from January 2000 to December 2018 the mean difference between 20-year and 5-year rates on conventional bonds was 0.78% compared with 0.25% for indexed bonds, using the BoE's estimated zero-coupon yield curves. I now show that, if the yield curve for indexed bonds is judged as a forecast of future movements in real interest rates, it has been persistently far too flat, by a margin that is too large to be realistically attributed to the risk premium.

The expectations theory is just about the triangular relationship between current short-term interest rates, future short-term rates and the current yield on longer-maturity bonds; it says nothing about why interest rates are at the level that we observe. The equilibrium real interest rate is usually conceived as the rate that equalises planned saving and investment at full employment. Sources of medium-run changes in savings over decades may arise from fiscal policy or from demographic factors such as the ratio of retirees to employees in the population, because the former tend to be dissavers and the latter to be savers (e.g. Rachel and Summers 2019). Investment intentions reflect the profit opportunities offered by technical progress and also macroeconomic conditions and the wider policy environment.

Over the 40-year history of indexed bond markets, real interest rates have changed considerably and in ways that the financial markets have consistently failed to predict; throughout the period the yield curve for UK indexed debt has been persistently but erroneously flat, and markedly so if we assume that the real risk premium is less than 0.5% per annum. The expectations theory of long-term indexed bond yields interprets this flatness to mean that whatever short-term rate we observe today will persist with little change into the indefinite future. That has just not happened. The

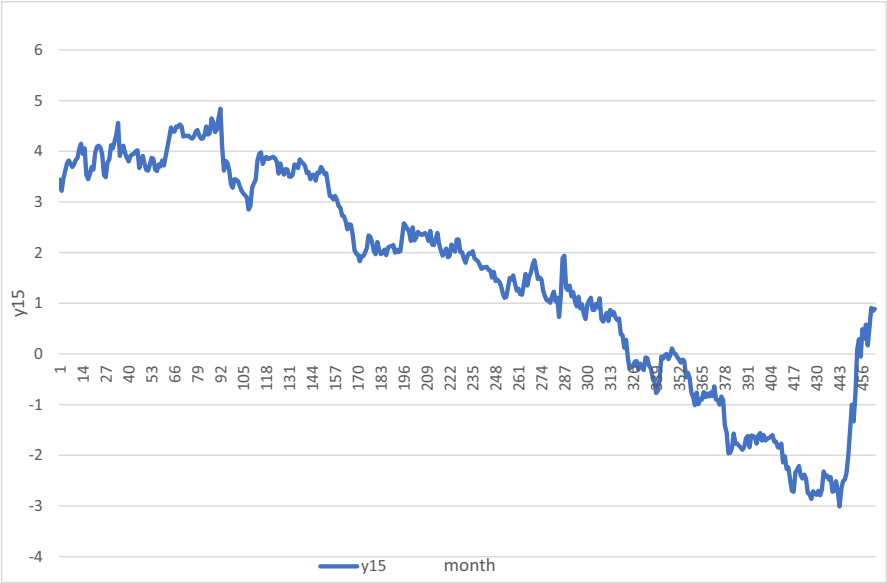

Fig. 1 Yields on15-year UK indexed bonds 1985–2023 (% p.a.). Source of data: end-month zero-coupon yield curves from the file glcrealmonthedata on the Bank of England Website. Month 1 = January 1985. January 2020 = Month 421; December 2021 = Month 444

analysis below is based on the indexed bond market in the United Kingdom, because the UK was the first advanced country to issue such bonds, and they cover the full range of maturities up to fifty years, which makes estimates of the yield curve more reliable. The indexation against inflation is not quite 100%, but it is close enough to it that we can ignore this limitation.[7]

Figure 1 reproduces a graph of estimated fifteen-year zero-coupon real bond yields from the UK indexed debt market since 1985.[8] The pronounced downward trend is similar to that for world real interest rates derived from index-linked bonds (an average of G-7 countries other than Italy) in Rachel and Summers (2019, Fig. 1). If the market had correctly predicted this, the yield curve should have had a significant negative slope, with long-term rates below their short-term rates.

Table 2 gives some data about estimated zero-coupon yields on UK index-linked bonds. The rows refer to yields observed at 31 December 1987, 1992, 1997,… at five-year intervals up to 2022. Column A shows the yield on five-year bonds, and Column B shows the yield on 20-year bonds at the same date. In both cases the yield was solidly positive with no obvious trend until about 1997, after which it fell persistently until

[7] There has always been a lag in the indexation, which was eight months initially and three months on bonds issued after 2005–6. This means that holders are not compensated for differences between inflation in the three months before the bond matures and inflation in the three months prior to issue.

[8] I concentrate on 15-year and 20-year bond yields because they are close to the average maturity of index-linked bonds in issue, which is 18.8 years.

Table 2 Yields on UK index-linked bonds (% p.a.): comparing 5-year and 20-year maturities

At 31 Dec	5-year	20-year	B – A	Four successive 5-year	B – D
	A	B	C	D	E
1987	2.95	4.16	1.21	2.84	1.32
1992	3.15	3.85	0.70	2.53	1.32
1997	3.21	3.05	−0.16	1.37	1.68
2002	2.05	2.16	0.11	0.14	2.02
2007	1.74	0.96	−0.78	−0.39	1.35
2012	−1.46	−0.03	1.43*	−1.09*	1.06*
2017	−2.12	−1.71	0.41**	−0.90**	−0.81**
2022	0.34	0.56	0.22		

*Three successive five-year bonds compared with a 15-year bond

**Two successive five-year bonds compared with a 10-year bond. The data are from the file glcrealmonthedata.xls on the Bank of England website for the date given in the left-hand column. The numbers refer to the estimated zero-coupon yield curve for index-linked bonds at 31 December of the year shown in the first column. A – the five-year bond yield; B – the 20-year bond yield; C – the 20-year/5-year yield spread (B – A); D – the average yield on four successive five-year bonds starting at the same date; E – the realised yield difference between a 20-year bond and four successive 5-year bonds (B – D)

2020; in 2022 it began to increase again. Column C shows the difference between them (the term spread), which is positive in six out of the eight cases but fairly small (the average is 0.39). Column D shows the yield on a strategy of investing in four successive 5-year bonds starting at the date that is indicated as an alternative to a 20-year bond (for 2012 and 2017, the comparison is for a 15-year and a 10-year bond respectively because the return on four successive five-year bonds is not yet known) and Column E shows how much that differs from the yield on a 20-year bond. What stands out from Column E is that for the whole period from 1987 to 2012, the realised return on a succession of 5-year bonds is more than one percentage point p.a. less than the yield on a 20-year bond. The downward trend is far greater than suggested by the initial term spread, which indicates that the market was far too optimistic about future yields on indexed bonds and did not anticipate the decline that actually occurred.

It is difficult to glean information about *ex ante* real interest rates in earlier periods because we cannot observe inflationary expectations, but I make a brief attempt to do so, and also to judge the likelihood of negative real interest rates in the coming decades, in the Appendix.

5 Possible Losses on Quantitative Easing

The scale of Quantitative Easing in 2020–21 was huge. In the financial years 2020–21 and 2021–22, QE government bond purchases amounted to £430bn. This represented 19.25% of 2019 GDP and 63% of total gilt sales of £680bn over the

Table 3 Potential real losses on an indexed bond with negative yield

15-year indexed bond (% p.a.)	Loss of real value at maturity (%)
−2.50	31.6
−2.25	28.9
−2.00	26.1
−1.75	23.3
−1.50	20.3
−1.25	17.2
−1.00	14.0
−0.75	10.9
−0.50	7.3
−0.25	3.7

The table assumes that the bonds pay no coupon

same period.[9] Haldane et al. (2016, pp. 11–12) plot the estimated impact of each major QE announcement up to 2016 on bond yields, using data from four jurisdictions: the UK, the USA, Japan and the Euro Area, and scaling the size of each announcement by GDP.[10] The authors note that, up to 2016 at least, the yield effect of each unit of QE seemed to have diminished. They speculate that this may be because later episodes were less of a surprise to the bond market, although it seems more likely that the effect of QE fell as financial markets regained stability. Certainly in 2020–21 indexed bond yields in the UK did not react much either to the resumption of QE in March 2020 or to the announcement in late 2021 that it was going to be replaced shortly by Quantitative Tightening, which actually began in March 2022. The zero-coupon yield curve on 15-year indexed bonds showed a yield that was down to −2.47% by August 2019 and that stayed in the range −2.30 to −3.00 until early 2022, only rising (i.e. becoming less negative) after the start of the Ukrainian war in March 2022. This was probably because the extra demand for bonds created by QE was matched by the massive expansion in the supply resulting from the huge budget deficits of the pandemic period.

Four factors determine the eventual fiscal loss from each unit of QE. The loss per unit of QE needs to be multiplied by the size of the APF, which was of course magnified by the absence of any tightening measures in the preceding years.

(1) One is how negative is the real rate of return on the bonds if held to maturity. For example a 20-year indexed bond issued at time t with a real rate of return of −2.5% p.a. will have lost 39.7% of its real value upon maturity at time $t+20$.

[9] The figure of £680bn of gilt sales comes from the Debt Management Office's Annual Reports.

[10] It is not clear that the size of the announcement is the only relevant aspect for the impact on bond yields; the number of months over which it is spread, and therefore the monthly purchase rate, may also be relevant. Indeed comments in the August 2023 Monetary Report indicate that the Bank of England believes that the modest pace of asset disposals from the APF has kept the impact on yields relatively low.

In this case, it is clear that bonds were bought at heavily negative real yields. Throughout the QE period from March 2020 to November 2021, the real yield on 15-year index-linked bonds averaged about −2.5% p.a., while the yield on 15-year conventional bonds averaged 0.6% p.a. up to January 2021, and then rose in February 2021, averaging 1.1% p.a. between the end of February 2021 and the end of January 2022, just before the start of Quantitative Tightening. The Bank justified its policy by reference to both inflation and output being below target, and no mention was ever made in the Monetary Policy Reports of the possible cost of buying bonds with guaranteed negative real returns of such a magnitude if held to maturity. Table 3 shows the loss in real value over 15 years of different levels of negative annual return. The numbers are based on zero-coupon indexed bonds, but they would be similar for conventional bonds, assuming that inflation turned out much as expected. The yield on 15-year indexed bonds averaged about −2.5%, implying an eventual loss of 31.5% according to Table 3. Since 2020–21 QE was 19.25% of 2019 GDP, the prospective fiscal loss amounts to 6.06% of one year's GDP, which one would have thought was too substantial to be ignored.

(2) The second factor is the likelihood of that cost being reduced because the assets bought under QE are sold before their maturity date, say within ten years, and for a better return than if they had been held to maturity. This requires real interest rates to stay negative for at least ten years, because if the real return at time $t+j$ of a bond maturing at time $t+20$ reaches zero, the capital loss from selling it at time $t+j$ will be the same as if the bond were held to maturity. This is where the future path of real interest rates enters into the equation. In fact the yield on 20-year indexed bonds returned above zero in October 2022, and reached + 1% by May 2023. If the authorities had been luckier, the recovery of bond yields might not have occurred so early in the QT process, and more of the bonds might have been sold for a smaller capital loss than Table 3 suggests. Alternatively, as Tucker (2022, pp.23–4) suggests, the QE purchases of 2020–21 might have been regarded as temporary measures to stabilise the gilts market in the context of a massive expansion of supply and unwound very quickly.

(3) The third factor is whether inflation turns out in fact to be significantly different from the rate implied by the spread between indexed and conventional bonds.

(4) Finally, the fourth factor is that, if QE had the desired effect of pushing up bond prices, then the likely fiscal cost of further QE purchases was steadily increasing as QE was expanded. This last is an important but widely overlooked point, which is illustrated below. For simplicity a linear relationship is assumed between the size of QE and the yield on the bonds bought although, as a referee points out, the relationship may well be non-linear, for reasons that are discussed below.

Point (4) is critical, because it suggests that much more thought should have been given to the advantages of limiting the size of the QE programme. If QE purchases had been smaller, then the price of bonds might have fallen somewhat, which would have reduced the possible fiscal loss from QE at the margin. Some evidence of the

Table 4 A numerical example of the marginal fiscal cost of different levels of QE

(1)	(2)	(3)	(4)
Size of QE increase 2020/21	Average real yield for 15-year indexed bonds (%)	Expected real loss (%) if held to maturity	Extra loss compared to QE smaller by 0.1X (% of X)
X	−2.50	31.60	5.03
0.9X	−2.30	29.46	4.69
0.8X	−2.10	24.93	4.32
0.7X	−1.90	19.81	3.89
0.6X	−1.70	15.29	3.47
0.5X	−1.50	11.12	3.00

In column (1), X = actual QE purchases of government bonds in 2020–21 (£430bn). Column (2) assumes that the total QE purchases were equivalent to buying 15-year index-linked bonds at the stated real yield. Column (3) is the expected real % loss calculated as in Table 3. Column (4) is the increment to Column (3) relative to the row below

effect of QE on bond prices is offered in the Bank of England's May 2020 Monetary Policy Report. On page 18 there is a graph that shows yields on conventional 10-year bonds falling from 0.6% in mid-February to 0.2% by the end of the first week in March, then rising sharply to 0.8% by 19 March, which was the day on which QE was announced. Yields immediately began to fall back after 19 March, stabilising at 0.3% by mid-April. The Bank of England attributes the rise to the effect of Covid-19 on the budget deficit, and the reversal to the announcement of the rapid implementation of £200bn of QE. The Monetary Policy Committee decided to increase bond purchases by a further £100bn at the meeting of 19 June 2020, and by yet another £150bn at the 4 November meeting.[11]

The issue of the rising marginal cost as QE was expanded is perhaps best illustrated with the aid of a numerical example. Denote the size of the actual 2020–21 QE programme as X, and suppose (1) that it is all spent on 15-year index-linked bonds with a real yield of −2.50%. and (2) that for every reduction in purchases by 1 percentage point, the yield on indexed bonds would have been increased by k percentage points. Note that for QE to have any purpose, k cannot be too close to zero. Suppose $k = 0.02$, which means QE of 0.5X would have a yield one percentage point less negative than QE of X, or –1.50%. With X = 19.25% of 2019 GDP and a likely fiscal loss as shown in Table 3, the loss on QE of size 0.5X is $0.5 \times 19.25 \times 20.3 = 1.95\%$ of 2019 GDP. Subtracting this from the fiscal loss figure for QE of size X of 6.06% of 2019 GDP tells us that the addition of a second 0.5X had a prospective additional fiscal loss of 4.11% of 2019 GDP, which is over twice the size of the first 0.5X. In other words the prospective marginal fiscal cost of additional QE was increasing quite steeply with the size of the QE programme.

[11] Two members of the Monetary Policy Committee had argued for a £300bn QE package already at the March meeting.

This is further illustrated in Table 4, which shows the additional loss of increasing QE by a further 10% of X. The last 10% increment that takes QE from 90 to 100% of X risks an extra fiscal loss of 5.03% of X, or 50.3% of the increment to QE, which would be a startlingly high wastage rate. On top of that, some of the bonds from earlier QE purchases matured and they were all rolled over. The real yield on index-linked bonds in 2019 was similar to that in 2020 and 2021, implying similar fiscal losses on these rollovers to those on new QE. Unfortunately the APF annual reports only state the number of bonds rolled over and not the value. Altogether nine issues were rolled over in the years 2019–21; this compares with about 60 conventional issues in the market, so maybe 15% of the £445 bn of pre-2020 APF assets were rolled over into new bonds paying solidly negative real yields.

As things have turned out, real and nominal interest rates have not followed the path expected by the bond market, but by 2024 had risen by about three percentage points to + 1% and + 4% respectively. The APF's 2023/24 Annual Report (p. 36) calculates the indemnity due from the Treasury if all the assets were sold at the market price prevailing at the end of March 2023 as £191.1bn, which amounts to 8.0% of 2023 GDP. With public debt close to 100% of GDP, this represents an 8% increase in the burden of public debt.

As a referee has pointed out, there might have been good reasons for risking such a loss, because the alternative might have been perceived as worse. For example, the BoE has made it clear that it wished to ease the liquidity problems of firms and households with floating-rate debt by keeping nominal interest rates as low as possible, and the Bank cites the behaviour of the gilts market in mid-March 2020 as evidence for this. As we have seen, the gilts market bounced back almost as soon as the extra QE was announced. Yields and spreads had moved a long way back towards their pre-Covid values by the end of March, but we do not know how much of the £200bn promised had been spent by then. Consequently it is impossible to judge whether the QE effect claimed by the BoE derived from the rapid dispersal of the funds or just the knowledge that the funds were there. With a smaller QE, there might have been a crisis in the debt market in response to the greatly increased monthly supply of gilts. Sudden falls in asset prices caused by a shock can easily overshoot the new equilibrium, because even those who believe that the asset has become good value and would be potential buyers cannot be sure that enough other investors agree with them. They therefore hesitate to act on their beliefs in case the asset is even cheaper tomorrow. Even if this argument is valid, we have little idea of the point at which it might occur, so to pre-empt it entirely by buying large quantities of bonds at unusually high prices seems premature. A more flexible alternative would have been to have announced a very large programme but to spend it gradually and to have kept most of the funds in reserve to respond to any signs of a price collapse.

At any rate it is clear that the BoE did not regard it as its responsibility to allow the decisions of the Monetary Policy Committee (MPC) to be influenced by the eventual fiscal cost. To quote from page 13 of the May 2020 Monetary Report:

> "The MPC has clear operational independence for how the inflation target is achieved and is accountable to Parliament for its actions in meeting that tar-

get. Alongside that institutional framework, the UK Government has provided explicit indemnities for monetary policy operations such as quantitative easing that could otherwise create risks to the Bank's balance sheet. These arrangements ensure that the MPC can take the actions it needs to meet its objective of price stability."

This comment implies that MPC decisions were not going to be influenced in any way by fiscal considerations. It is true that this was the intention behind the indemnity clause, but it conveniently ignores the point that the AFP's assets had grown to nearly six times as much as was originally authorised in 2009, and that (taking rollovers into account) significantly more than 50% of these assets had been bought at prices that were very high by historical standards.

6 Allocating Responsibility

Over the 24 months from January 2020 to December 2021, during which period the Bank of England acquired £430 bn of UK government bonds through its programme of Quantitative Easing, the end-of-month yield on 20-year conventional bonds averaged 1.00% p.a. and the yield on 20-year indexed bonds averaged −2.41% p.a. As discussed above, purchasing long-maturity bonds at these prices would incur a substantial fiscal cost if real interest rates were to return to near their historical average. The potential benefits of QE needed to be weighed against this possible cost in judging the optimal extent of QE purchases. Was the omission of this the fault of the Bank of England or the Government?

The Bank of England Act 1998 defines the objectives of the Bank to be: to maintain price stability and, subject to that, to support the economic policy of the Government, including its objectives for growth and employment. The exact definitions of "price stability" and "the economic policy" are specified in an annual letter from the Chancellor of the Exchequer to the Bank entitled "Remit for the Monetary Policy Committee". In the 2018 edition of this letter one element of economic policy is stated to be "a credible fiscal policy, returning the public finances to health, while providing the flexibility to support the economy." This is modified slightly by 2021 to "a credible fiscal policy, maintaining sustainable public finances, while providing the flexibility to support the economy." These letters also authorise the resort to unconventional measures (i.e. QE) in the event of an exceptional shock when conventional measures by themselves are insufficient, but make no mention of the possible fiscal cost of QE at the prices prevailing in 2020–21.

These letters certainly did not oblige the Bank to consider the possible losses on QE during the COVID-19 pandemic, but by mentioning "sustainable public finances" they gave it licence to do so, or at least to enter into a dialogue with the Treasury about it. It may be that the Bank did raise the question of the possible large size of the indemnity with the Treasury, but it has never suggested that this was the case. Rather than take that approach, in its public statements at least the Bank appears to have relied on the indemnity clause to absolve it from any need to think about possible fiscal losses, concentrating instead on doing the maximum possible

to support output during the crisis. This may have suited its institutional goals, but for a central bank to ignore the possible impact of its decisions on the burden of public debt suggests a lack of social responsibility, particularly when the Bank had contributed to the problem by its reluctance to initiate quantitative tightening.

In short, between them the Government and the Bank ignored the issue. Since it was the Government that wrote the rules by which an independent central bank should conduct monetary policy, it should bear most but not all of the responsibility.

7 Conclusions

The Quantitative Easing programme of the Bank of England eventually exposed the public finances to the possibility of substantial losses, a possibility which has recently become an actuality as interest rates have risen across the whole spectrum of maturities. This happened as a consequence of a combination of factors.

(1) The Bank of England is required to set monetary policy in order to achieve an inflation target of 2% p.a. and also to pay attention to output and growth. Like the output target, the inflation target is symmetric, which means that the Bank should seek to correct excessively low as much as excessively high inflation. When QE was introduced in 2009, there was an explicit agreement that, in order to allow the BoE to set monetary policy without consideration of any fiscal consequences, the Bank should be indemnified by the Treasury for any losses that arose. This agreement was not altered in any way as the Bank's balance sheet expanded and the assets bought became increasingly expensive.

(2) The spread between nominal and real interest rates as revealed by the estimated zero-coupon yield curves on conventional and indexed bonds has been consistent with a high degree of credibility of the inflation-targeting regime, and as a result fluctuations in nominal interest rates have been largely driven by the sizeable movements in real interest rates.

(3) The real interest rate spread between short- and long-term indexed bonds has been consistently too small in absolute value as a predictor of future short-term real interest rate movements. In this respect the theory of rational expectations has been a spectacular failure in the UK indexed bond market. The excessive flatness of the real yield curve has meant that, as real interest rates have fallen into negative territory, long- and medium-term yields on both indexed and conventional bonds have followed them down, causing the prices of such bonds to be exceptionally high when QE purchases were expanded during the pandemic. The flatness of the yield curve suggests that the financial markets expected negative real interest rates that were at the extreme end of historical experience to persist for a long time, even though this belief seemed to imply that in equilibrium 21st-century households, unlike their predecessors, had a negative discount rate.

(4) The BoE failed to develop a strategy for reversing QE in the period 2014–19 when the economy was close to equilibrium, or to explore the effect on gilt yields of a degree of tightening. In particular it has never explained why, between bouts of QE, it rolled over all maturing bonds into new issues rather than just

Table 5 UK interest rates 1825–1914 (%)

Interest rate	Data	Years	Mean	St. dev	Minimum	Maximum
Bank rate	31 December	91	4.19	1.30	2.00	8.00
Bank rate	Year average	90	3.77	1.04	2.00	7.35
Consols yield	Year average	90	3.10	0.33	2.26	3.81

Calculated from the Bank of England data file "a millenium of macroeconomic data"

allowing its gilt holdings to shrink naturally. It has also never discussed why the expansion of QE in 2020 went as far as to absorb all the additional bond issuance by the government, rather than just some fraction of it, without exploring the counterfactual (i.e. the effect of a smaller expansion of QE on bond prices and gilt market dynamics) and keeping a large proportion of it in reserve in case of market instability. As a result, both the quantity of bonds held in the Asset Purchase Facility and the price at which they were bought were significantly higher than they might have been.

(5) During the pandemic, it would have been sensible for the Treasury to have adjusted the rules of central bank independence to reduce the fiscal risk attached to very large bond purchases by the BoE at exceptionally high prices. It did not do so, perhaps because it prioritised rapid large-scale fiscal support to businesses and households over the long-term fiscal consequences, in the same way that it sacrificed some fraud controls for quick disbursement in the Bounce Back Loans Scheme (National Audit Office 2021).

To summarise: the Bank of England and the Treasury should share the blame for the large fiscal cost of quantitative easing that had reached 8% of annual GDP by 2024. The Bank failed to develop a medium-term strategy for quantitative tightening after the global financial crisis had passed and was too hasty with large-scale gilt purchases during the pandemic, and the Treasury failed to act to limit the risk to the public finances entailed by the Bank's decisions. It is true that events such as the war in Ukraine have played a part in the rapid return of real interest rates to positive levels, and in that sense the Bank and the Treasury were unlucky; but the risk should have been considered much more carefully.

Appendix 1 – Real Interest Rates Before 1983 and Future Prospects

Most of the twentieth century was a period of major disruption by wars and the Great.Depression, followed by a transition to a world of persistent peacetime inflation. Jordà et al. (2017) estimate real returns on bonds in sixteen countries between 1870 and 2015 to have averaged 2.5% p.a., but that is *ex post* rather than *ex ante*.

Going further back in history, we can however appeal to the fact that, once the inflation and post-war deflation associated with the Napoleonic wars were over, the price level in Britain remained more or less constant right up to 1914 (if anything

the trend was slightly downwards). If we assume that the financial markets recognised this and anticipated stable prices with a high degree of probability, then we can interpret the evidence from long-term nominal interest rates in this period as largely reflecting beliefs about the real interest rate.

Table 5 gives some statistics relating to UK interest rates from the end of 1824 to the end of 1914. Bank Rate (the short-term policy rate) varied between 2.00 and 8.00 per cent per annum. For longer-maturity bonds, the Bank of England data file "a millenium of macroeconomic data for the UK" gives only the yearly average and not an end-of-year value. Both the year average and the end-year series are, however, available for the Bank Rate; Table 5 shows that the year-average smooths the underlying data, cutting the standard deviation by 20%, from 1.30 to 1.04 percentage points. Long-term interest rates are represented in Table 5 by the perpetual bonds known as Consolidated Annuities, which were first issued in 1752. These bonds pay a coupon twice yearly, but with no promise ever to return the principal. Their effective maturity is the inverse of the population's discount rate. The average yield on them from 1825 to 1914 was 3.10%, with relatively little variation (the standard deviation of the year average is 0.33%, and if we add 25% to allow for the smoothing effect, it is still only 0.41%). It is unlikely that, even at its minimum of 2.26%, the yield was entirely accounted for by inflation risk and the risk premium, which means that the long-term real interest rate was always positive over this 90-year period, and much less variable than it has been over the last 40 years.

In short, all this suggests that the negative long-term real interest rates of 2020–21 were historically extremely unusual. Nevertheless the potential fiscal cost of large QE bond purchases need not have been a significant issue if there were good reason to believe that real interest rates would stay close to zero for decades, as the expectations theory would conclude from the absence of a strong upward slope in the real yield curve. Persistently negative real interest rates are not likely to happen unless the incentives to invest were to weaken dramatically, for instance if technical progress were to come virtually to a halt. What insights can we glean from history about that?

The idea that there were cycles in investment and the rate of technical progress was suggested by Kondratieff in 1925 in an article originally published in Russian.[12] He posited a cycle of between 45 and 60 years in length since the Industrial Revolution. The cycle consisted of alternating periods of faster and lower growth. This idea has been picked up by various authors since (see Bieshaar and Kleinknecht 1984 for a literature review). Bieshaar and Kleinknecht (1984) test for significant differences in trend rates of growth of real output in a variety of countries between periods corresponding to the upswings and downswings of Kondratieff and later authors. They find that the change in trend between upswings and downswings was not statistically significant before 1890, but it was in the twentieth century, essentially because of slow growth between 1913 and 1938. Solomou (1986) carries out a similar exercise for the rate of innovation,

[12] For an English translation, see N.D. Kondratieff (1936), The long wave in economic life, *Review of Economics and Statistics* 17, no. 6.22.

based on the identification of innovations by Mensch (1979). The assumption is that if innovations cluster together, the grounds for a new acceleration of investment and growth will be provided. The test is for the non-randomness of technical innovations according to Mensch's data, and Solomou's conclusion is that randomness in the rate of technical innovation cannot be ruled out. Thus the steadiness of real interest rates in the nineteenth century seems to be consistent with the smoothness of technical progress at the time.

Robert Gordon has made an intensive study of US productivity growth since 1920. He estimates that output per hour grew fast between 1920 and 1970, at an average annual rate of 2.82%, slowing to 1.50% between 1970 and 1996 before reaccelerating to 2.38% from 1996 to 2006, and finally slowing to 0.93% from 2006 to 2016 (Gordon 2018, Tables 1 & 5). The rate of issue of new patents in the US actually grew faster in the decade 2006–16 (by 27% between the two end-years) than in the average per decade between 1956 and 1996 (by 17.4%); nevertheless Gordon and others have identified several factors that foreshadow a slower rate of productivity growth in the 21st than in the twentieth century, such as slower labour force growth, the decreasing effectiveness of research effort as the easy discoveries lie largely in the past, and the deglobalisation of supply chains because of security and other concerns (Adler et al. 2017). Gordon's estimate of future trend productivity growth is 1.2% p.a.

In later work Gordon and Sayed (2022) focus on the cyclical behaviour of US output per labour hour. This measure of labour productivity was markedly pro-cyclical in 1950–85, but this pro-cyclicality faded considerably in 1986–2006. They argue that the pro-cyclical pattern was dramatically reversed in 2008–09, when businesses reacted in panic to the global financial crisis by severe cuts in labour hours, with gradual rehiring over the period 2010–16. Their point is that, because of this, estimates starting in 2010 considerably underestimate the recent trend rate of productivity growth, and this may have stoked interest in the idea that we have entered a period of stagnation.

To sum up: the rate of technical progress as embodied in labour productivity has fluctuated, but not in regular cycles, and may well be somewhat slower in the twenty-first century than it was in the 20th. This will probably be reflected in a lower rate of investment and therefore some reduction in the real rate of interest, but anecdotal evidence and the boom in the share prices of companies perceived to be at the forefront of technical innovation suggest that technical progress still continues at a reasonable pace. As a long-run trend, negative real interest rates therefore seem somewhat unlikely.

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Data Availability The data used in this study were obtained from the following Excel files on the Bank of England website:

1. zero-coupon yield curves: glcnominalmonthedata (conventional), glcrealmonthedata (indexed);
2. pre-1914: a millenium of macroeconomic data for the UK.

Declarations

Competing Interests The author has no relevant financial or non-financial interest to declare, and has no affiliation with any entity or organization with any financial or non-financial interest in the subject matter of this manuscript.

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