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Abstract

The operation of the portfolio balance channel has been emphasized by monetary policymakers as a key channel through which quantitative easing (QE) policies work. We assess whether the investment behavior of insurance companies and pension funds in the United Kingdom during the global financial crisis was consistent with such an effect by analyzing both sectoral and institution-level data. Our results suggest QE led to institutional investors shifting their portfolios away from government bonds toward corporate bonds but did not lead to a shift into equities.

JEL classification: C2, C22, G11, E61, E65

Keywords: institutional investors, asset allocation, quantitative easing, portfolio balance channel, global financial crisis

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In response to the 2007–08 global financial crisis and subsequent global economic recession, central banks in the advanced economies adopted a variety of standard and nonstandard measures to ease monetary conditions. The centerpiece of these nonstandard monetary measures has been large-scale asset purchases, commonly referred to as Quantitative Easing (QE). From the end of 2008 to October 2014, the U.S. Federal Reserve's holdings of US Treasury securities and mortgage-backed securities increased from around $500 billion to over $4 trillion as a result of a series of large-scale asset purchase programs; in April 2013, the Bank of Japan announced it would purchase Japanese government bonds worth about 50 trillion yen for 2 years, as part of its qualitative and quantitative easing (QQE) program; and in January 2015, the European Central Bank launched an asset purchase program initially worth €1.1 trillion. In the United Kingdom, which is the focus of this paper, the Bank of England first announced that it would buy £75 billion of financial assets through the creation of central bank reserves in March 2009. This purchase program was subsequently expanded over time, and when the first phase of purchases had been completed in January 2010 (QE1), the Bank had purchased a cumulative total of £200 billion of assets, comprising almost exclusively medium- to long-term UK government bonds (gilts). A further phase of gilt purchases (QE2), from October 2011 to October 2012, resulted in the program being expanded to a cumulative total of £375 billion, an amount equivalent to around 23% of annual nominal GDP.

While the objectives of the QE policy have been clear in terms of helping central banks achieve their mandated price inflation objectives, there has been more debate about how the policy was expected to work, with a number of potential channels being discussed. However, policymakers in both the U.S. (Bernanke 2010, Yellen 2011) and the UK (Bean 2011) have emphasized the portfolio balance channel, which goes back to the work of Tobin and others in the 1960s, as a key element in the expected transmission of asset purchases to the rest of the economy. According to this mechanism, purchases of financial assets financed by central bank money increase liquidity and push up asset prices, as those who have sold assets rebalance their portfolios into riskier assets. This stimulates expenditure by increasing wealth and lowering borrowing costs for households and companies. However, the importance of this channel has been disputed from a modern theoretical perspective (Woodford 2012). Moreover, most empirical research has inferred the importance of this channel indirectly from the behavior of government bond prices/yields and other asset prices (Gagnon et al. 2011, Joyce et al. 2011, Krishnamurthy and Vissing-Jorgensen 2011, D'Amico et al. 2012). There has been less research assessing the direct impact of QE on the investment behavior of financial institutions.

The contribution of this paper is to address this gap in the literature by assessing the effect of asset purchases by the Bank of England on the portfolio allocation decisions of large institutional investors, specifically UK insurance companies and pension funds (ICPFs). ICPFs are major participants in UK financial markets and the group of institutions who the Bank of England specifically targeted through their purchases (Joyce, Tong, and Woods 2011). In terms of related work, Carpenter et al. (2015) model U.S. aggregate flow of funds data over the crisis, but their paper does not address the potential correlation between asset purchases and the other financial control variables included in their analysis, nor do they examine microlevel data on individual institutions. For the UK, Goodhart and Ashworth (2012) examine trends in the national accounts data on net investment behavior by ICPFs, but they do not attempt to model the portfolio behavior of ICPFs to provide a counterfactual.[1]

If QE works through a portfolio balance channel, we would expect ICPFs to have reduced their gilt holdings below what they would otherwise have been, and to have increased their demand for riskier assets. In attempting to answer whether this occurred, we need to model the institutions' investment behavior, in order to generate a plausible counterfactual. In doing so, we follow Pesaran and Smith (2016) and allow only for factors that influence portfolio allocation but at the same time are unaffected by the Bank's QE purchases. The aggregate data allow us to model the effects of QE on the net investment of ICPFs and other investors across different asset classes, enabling us to estimate which sectors sold gilts to the Bank in response to QE and where they reinvested the proceeds. In addition, we also use regulatory data on the asset holdings of the individual institutions themselves to cross check this analysis and to examine the extent to which there may have been heterogeneities across different institutions. Our results suggest QE led to institutional investors shifting their portfolios away from government bonds toward corporate bonds. But portfolio rebalancing seems to have been limited to corporate bonds and did not extend to equities.

The rest of this paper is structured as follows. In Section 1, we discuss some of the previous literature on portfolio balance effects and draw out the possible implications for the behavior of institutional investors. Section 2 describes the main data sources we use and some of their limitations, as well as some summary statistics on ICPF net investment flows and asset holdings. In Section 3, we set out our empirical methodology, which includes estimating models for portfolio investment and asset allocation, as well as constructing counterfactuals. Section 4 goes on to discuss the evidence from the national accounts data on ICPFs. Sections 5 then explores the microevidence on the portfolio behavior of life insurance companies and defined benefit (DB) pension funds. Section 6 sets out our main conclusions.

1. The Portfolio Balance Channel and Institutional Investors

There are a number of channels through which QE might be expected to affect the macroeconomy, including policy signaling, portfolio rebalancing, and liquidity effects, although monetary policymakers have placed particular emphasis on the portfolio balance channel. This channel is particularly associated with the work of Tobin (1963), who demonstrated how changes in asset supplies lead to changes in financial asset prices when there is imperfect substitutability between financial assets, but similar ideas were also developed by others, including Friedman and Schwartz (1963) and Brunner and Meltzer (1973). The portfolio balance channel provides a means for central bank asset purchases to affect the real economy. By purchasing assets from the nonbank private sector in return for central bank reserves, QE increases the sellers' broad money holding. If money is seen as an imperfect substitute for the assets being purchased, the sellers will then seek to rebalance their portfolios by buying other assets, which may be riskier (like corporate bonds rather than gilts). The sellers of these assets will in turn want to rebalance their portfolios. During this process of rebalancing, asset prices will rise until investors are indifferent to the overall supplies of money and financial assets. Higher asset prices, or equivalently lower yields, may in turn be passed on into lower borrowing costs for households and firms and also increase the net wealth of asset holders, both of which should stimulate real activity and inflation.

In modern macroeconomic models, changes in asset quantities do not feed through

[1] The impact on portfolio allocation of more recent QE programs in Japan and the Euro area is examined in Saito and Hogen (2014) and Koijen et al. (2016).

into asset prices, either because assets are assumed to be perfect substitutes for one another or because of other assumptions which result in the private sector effectively consolidating the public sector balance sheet into its own. The consequence is that policies like QE can only work if they change the private sector's expectations of future policy rates through the signaling channel, as transferring assets between the private and public sectors under QE has no effect in itself (Eggertsson and Woodford 2003, Woodford 2012). Under less restrictive assumptions, this QE neutrality result does not always hold, for example, with "preferred-habitat" theories (Culbertson 1957, Modigliani and Sutch 1966), where investors have a preference for a particular segment of the yield curve. Andrés et al. (2004) develop a dynamic stochastic general equilibrium model where two types of agent have different preferences for long-term bonds and show that it generates portfolio balance-type effects. Vayanos and Vila (2009) also develop a model with two types of agent: arbitragers (who are mean-variance optimizers) and preferred-habitat investors. They show that the supply of bonds can affect yields even in the presence of arbitrageurs, provided the latter are risk averse or capital constrained. Central bank asset purchases in this model would affect yields both through a scarcity effect or "local supply effect" concentrated (localized) in the bonds being purchased and through a more broad-based duration risk effect, which reflects the fact that reducing the bonds held by the private sector leads to a fall in the quantity of duration risk held by arbitrageurs, which in turn reduces the market price of duration risk and increases the price of all long-duration assets.

The design of the Bank of England's asset purchase program was targeted toward financial institutions like ICPFs, normally thought of as preferred habitat investors, given the regulatory pressures on them to purchase long-term assets in order to match their long-term liabilities (Fisher 2010).[2] The transactions were conducted through reverse auctions via the gilt-edged market makers (GEMMs), but the ultimate sellers of gilts were unknown (Joyce and Tong 2012).[3]

The aim of this paper is to identify the importance of ICPFs in selling gilts to the Bank of England and to gauge the extent of any portfolio rebalancing by them into riskier assets by analyzing their portfolio allocation behavior during the period that QE purchases took place. More specifically, we attempt to answer the following three questions: (i) Did a significant fraction of the Bank of England's asset purchases come from ICPFs? (ii) Did ICPFs increase their net investment in risky assets more than they would otherwise have done as a result of QE? (iii) Did ICPFs increase their asset allocation toward risky assets more than they would otherwise have done as a result of QE? An affirmative answer to the first question seems a necessary one for a QE portfolio rebalancing effect to have occurred. If the QE policy worked through a portfolio balance channel to any significant degree then a significant fraction of the purchases must have ultimately come from ICPFs.[4] An affirmative answer to the second question also seems a necessary condition for a portfolio balancing channel to have worked. Although it is theoretically possible that any effects could come entirely through prices without any flow effects needing to occur, it seems more plausible that at least some adjustment in quantities would occur in practice and this is typically how portfolio rebalancing is described and for the most part understood. An affirmative answer to the

[2] As Fisher (2010) explains: "[t]he proposition is that, by buying gilts from pension funds and insurance companies (for example), those asset managers would have more cash in their portfolios than they desired, and would be incentivized to use that cash to invest in other, more risky instruments such as corporate bonds and equities."

[3] When the Bank of England buys gilts in the open market it does so from the GEMMs, who act as the counterparties to these trades. But the GEMMs are intermediaries, who would be expected to replenish their supply of gilts with purchases from other counterparties.

[4] It is possible that QE may also have led other agents to rebalance their portfolios, but central banks have emphasized the role of ICPFs, so it seems appropriate to focus on this group of investors. Carpenter et al. (2015) highlight the role of hedge funds in their analysis of portfolio rebalancing in response to the Federal Reserve's large-scale asset purchases.

third question would establish a broader portfolio effect and would seem a natural corollary of the workings of such a channel but would not on its own be necessary or sufficient to establish the existence of a portfolio rebalancing channel. A difficulty of assessing the empirical evidence is that we need to allow for a variety of other factors that may have been influencing portfolio investments over the period: we need to judge the data in terms of a counterfactual of what would otherwise have happened.

2. Data on Portfolio Allocation

Data Sources

Our analysis makes use of a range of data sources, including national accounts data on the flow of funds by sector, and microdata on the portfolio allocations of individual pension funds and life insurance companies. The UK's Office for National Statistics (ONS) publishes financial accounts data with the national accounts that report the net asset acquisition of financial assets (which we also refer to as net investment for brevity) by pension funds and insurance companies combined, as well as other sectors, including overseas investors and other financial institutions. The financial accounts data on ICPFs are available at a quarterly frequency from 1987 to 2012 and are obtained from a combination of sources, including a survey of 1,500 self-administered pension schemes and 300 insurance companies, but also data from other sources, such as central government and the Bank of England, in order to produce a balanced set of National Accounts.

We also make use of two microdata sets on the asset allocations of individual life insurance companies and DB pension schemes. These microdata sets are produced as a product of regulation, which requires that individual life insurance companies and DB pension schemes submit annual financial information to the relevant regulators documenting their asset allocations for risk assessment purposes. In the case of insurance companies, the regulator is the Prudential Regulation Authority (PRA) (formerly the Financial Services Authority [FSA][5]), and for DB pensions (since 2005) it is The Pensions Regulator. The data set for life insurance companies is made publically available via SynThesys, and for DB pensions it is a proprietary data set held by the UK's Pension Protection Fund (PPF).

The SynThesys Life data cover over 350 life insurance companies that were in existence for at least 1 year (and therefore filed returns) from 1985 to 2012. In 1985, there were 229 insurance companies filing returns, but by 2012 this had fallen to just over 100.[6] For each company the data provide annual information on the percentage of total assets[7] held across a number of broad asset categories. In addition, the data provide information on a number of insurance firm-level characteristics, including firm size (measured by total admissible assets), the free asset ratio (the ratio of excess capital resources available to cover long-term business Capital Resource Requirements [CRR] against total assets); the ratio of business premiums to assets; and the proportion of the assets held to match linked liabilities.

The pension fund data relate to the universe of DB pension funds for which the PPF is responsible. In 2012, this consisted of 6,316 DB schemes, covering 11.7 million members.[8] Although the PPF data made available to us were compiled in 2012, the

[5] The FSA was responsible for the regulation of the financial services industry (including insurance companies) in the United Kingdom between 2001 and 2013.

[6] Over the full sample period the regulations governing the completion of these forms has changed, so there may be structural breaks in some series.

[7] We obtain these asset allocation data from the PRA/FSA returns Form 13.

[8] The ONS aggregate data include public sector pension funds and also defined contribution schemes, which are excluded from the PPF universe. However, the PPF data include smaller private pension funds, which are not captured by the ONS data.

underlying asset allocation data were often 1 or 2 years older. For most of the funds, their latest asset breakdown dates are prior to 2011. Moreover, the asset breakdown dates are different for different pension funds, so we adjusted the original data set by interpolating to obtain asset allocations at the same time each year.[9] The adjusted asset allocation data set used in our analysis consists of year-end data from 2005 to 2010. For each pension fund, we have annual data on the percentage of total assets held across a number of broad asset categories. The data also provide information on pension fund size (in terms of either the size of liabilities or number of scheme members); fund maturity (measured by either the percentage of retired members or the average age of scheme members); the amount of the risk-based levy (RBL) paid by the scheme to the PPF, which is mainly determined by sponsor insolvency risk and scheme underfunding risk; and the funding position, measured by the funding ratio (i.e., value of assets as a percentage of liabilities).[10]

Combining these data sets we are therefore able to examine the portfolio behavior of ICPFs at both an aggregate level (net investment flows) and at the level of individual funds/companies (asset shares). Although some of the data sets provide quite a rich breakdown of assets, for most of our analysis we will concentrate on four broad categories: equities, government bonds (split into nominal and index linked where possible), corporate bonds (combining UK and foreign bonds), and cash (including bank deposits and other short-term assets). The amounts allocated to property/land and other assets are relatively small and are therefore excluded from our analysis.

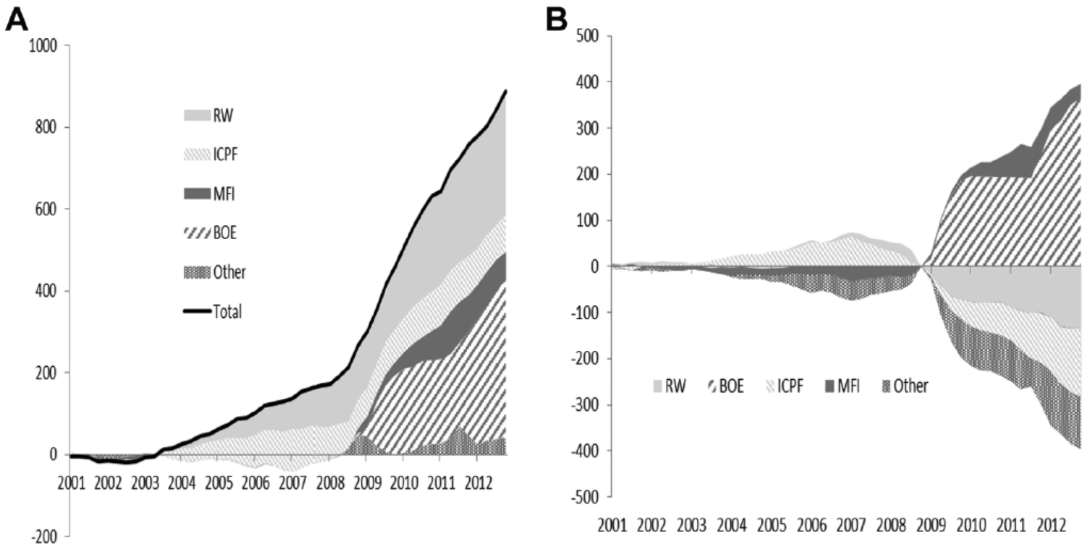

FIG. 1. (A) Cumulative Net Acquisitions of UK Government Bonds by Investor Category Since 2001Q1 (£ billion). (B) Cumulative Net Acquisitions of UK Government Bonds by Investor Category (£ billion) Relative to Amount Implied Assuming Fixed 2001–08 Shares in Net Issuance.

NOTES: Figure 1(B) shows the time profile of the difference between the cumulative net acquisitions of gilts by sector shown in Figure 1(A) and the amount implied if net acquisitions of each sector had grown in line with the sector's share of total net gilt issuance during 2001–08.

[9] Where necessary, we adjusted the original data by interpolating the share of assets in a linear fashion with reference to the asset breakdown dates. We used this method to estimate the share of assets on 31 December of each year to be consistent with the analysis in the PPF's Purple Book.

[10] Assets are valued at market values, and the liabilities are based on the s179 valuation. For the latest s179 valuation guidance, see http://www.pensionprotectionfund.org.uk/DocumentLibrary/Documents/Section_179_Assumptions_Guidance_VA6_Apr11.pdf

Recent Trends

Figure 1(A) derived from ONS financial accounts data shows the quarterly cumulative net acquisition of gilts by different investor categories over the period from 2001. It can be seen that the Bank of England was a significant net purchaser of gilts. Over the same period, Monetary Financial Institutions (other MFIs) also increased their net investment in gilts, as did the overseas sector (rest of the world (RoW)). But, as Figure 1(A) shows, ICPF's net purchases of gilts were relatively small, which could be consistent with them selling gilts to the Bank of England.

The unusual behavior of ICPFs is brought out in Figure 1(B), which shows the difference between the cumulative sectoral net acquisition of gilts in Figure 1(A) and what would have been implied if net acquisitions had grown in line with the share of each sector in total net issuance during 2001–08. Figure 1(B) suggests that there was a significant decline in ICPF's net investment in gilts compared with what might have been expected. This is also true for the overseas sector.

Table 1 reports some summary statistics for quarterly net ICPF investment flows and the annual asset allocations by life companies and pension funds across the main asset classes for each of the data sets we examine.[11] Over the sample as a whole, ICPFs have been disinvesting from equities and increasing their net investment in gilts, corporate bonds, and cash, with corporate bonds being the fastest growing sector. However, the largest asset holdings of life insurers have been in equities and nominal gilts, which have both accounted for about 30% of their total assets on average. For life companies, corporate bonds and cash have made up about 20% of their total assets on average. In the case of pension funds, equities have taken up more than 50% of their total assets on average, with nominal gilts, index-linked gilts, and corporate bonds accounting for 15–20% each and cash a smaller share of less than 10%.[12]

[11] Given that the different data sets often have different ways of grouping assets, it is not possible to work on exactly the same asset classification in each case. Table 1 explains the asset classification for each data set.

[12] Amir, Guan, and Oswald (2010) suggest that UK pension funds moved out of equities into bonds as a response to the new accounting standard FRS17 introduced in transitional form from 2001. Jackson and Tonks (2016) report that UK life insurers shifted their asset allocations from equities to bonds following the FSA Tyner reforms of the risk-based regulatory regime for life insurers from 2005.

TABLE 1

SUMMARY STATISTICS FOR KEY VARIABLES

Variable name	Description of asset class	Statistics for full sample: No. obs	Mean[a]	Std Dev
Net acquisition of assets by ICPFs, quarterly (£ millions), 1987Q1–2012Q4				
$Asset_{ICPF}^{Equities}$	Quoted and unquoted UK shares, shares and other equity issued by the rest of world, and mutual funds' shares.	104	−52.8	5621.6
$Asset_{ICPF}^{Gilts}$	Government bonds of 1+ year maturity (nominal and index linked) issued by UK central government.	104	1429.9	4605.5
$Asset_{ICPF}^{CorpBonds}$	Corporate bonds of 1+ year maturity (local and foreign currencies) issued by UK residents and the rest of world.	104	4613.9	4281.5
$Asset_{ICPF}^{Cash}$	Cash includes currency and deposits.	104	1297.4	3724.4
Asset allocation by life insurance companies (IC), annual (%), 1985–2012	Denominator is total assets of parent IC (excluding assets held to match linked liabilities)			
$Share_{IC}^{Equities}$	Share of equities, and other equity investments.	2,660	31.7	23.0
$Share_{IC}^{NomGilts}$	Share of approved fixed interest securities, typically government nominal bonds, including both UK and other governments (mainly UK government bonds).	3,008	29.6	19.9
$Share_{IC}^{IndexGilts}$	Share of approved variable interest securities, typically government index-linked bonds, including those issued by UK and other governments (mainly UK government bonds).	1,458	3.2	7.2
$Share_{IC}^{CorpBonds}$	Share of fixed and variable interest securities, typically corporate bonds (including UK and overseas corporate bonds).	2,442	19.3	19.6
$Share_{IC}^{Cash}$	Share of cash in hand and deposits.	3,438	20.6	27.3
Asset allocation by pension funds (PF) annual (%), 2005–10	Denominator is total assets of PF.			
$Share_{PF}^{Equities}$	Share of UK and overseas equities, excluding unquoted equities.	21,386	57.4	19.4
$Share_{PF}^{NomGilts}$	Share of UK and other governments' fixed interest bonds.	11,775	16.3	13.8
$Share_{PF}^{IndexGilts}$	Share of variable interest securities, typically UK index-linked bonds.	9,132	15.6	15.1
$Share_{PF}^{CorpBonds}$	Share of fixed interest bonds issued by corporate sector (in both the UK and overseas).	13,149	20.0	15.1
$Share_{PF}^{Cash}$	Share of cash in hand and deposits.	15,125	7.9	14.7

NOTE: [a] The mean portfolio shares of life insurers and pension funds do not sum to 100 because of different sample sizes.

3. Empirical Methodology: Modeling Portfolio Allocation

Institutional investors face the same optimization problem as any other investor of investing a given amount of money to maximize utility subject to some budget constraints, but are subject to a larger array of complicating factors due to the liabilities that the institution must honor (Dinenis and Scott 1993); for example, long-term assets may have to be matched to long-term liabilities. Institutional investor asset allocation decisions may be further complicated by the need to reflect the risk preferences of several groups, including (sometimes multiple) asset managers (Blake et al. 2013), trustees, and pensioners, and so may be nonstandard (McCarthy and Miles 2013). Asset allocation may also be constrained by regulatory requirements (Amir, Guan, and Oswald 2010). Moreover, the dynamic behavior of these investors is complicated by the fact that, while typically shaping their portfolios in line with a strategic asset allocation approach that takes into account the characteristics of the institution and adopts a long-term view of an appropriate asset mix, they may deviate from these allocations in the short term and engage in tactical asset allocation to take advantage of temporary changes in market conditions (Brennan, Schwartz, and Lagnado 1997). For all these reasons, developing a structural model of institutional investor portfolio behavior is particularly challenging. Here we adopt a simpler approach, which is informed by a recent paper by Pesaran and Smith (2016), who argue that it is not always necessary to estimate a fully structural model if the aim is to identify policy effects. What is needed instead, they argue, is a conditional model with parameters that are invariant to the policy change. In constructing such a conditional model of the effects of a policy variable on an outcome variable, they distinguish between control variables that may not be invariant to the policy variable and control variables that affect the outcome variable but are not affected by the policy variable. They argue that only the latter type of control variable is relevant in evaluating the effects of the policy variable, since the former can be substituted out of the model provided there are enough lags of the other variables.

Following Pesaran and Smith (2016), we adopt a reduced-form approach incorporating the variables that we view as independent of the policy variable. We take these variables to include debt issuance by the Debt Management Office (DMO),[13] foreign financial variables, and (where available) the individual characteristics of specific institutions to allow for the nature of their liabilities and the regulatory and other constraints they face. We experimented including domestic macroeconomic controls, but their inclusion induces potential endogeneity and may lead to QE policy effects being underestimated. As a practical matter, when they were included we found that they were typically statistically insignificant. To explain net investment in different asset classes at the sectoral level, we estimate the following regression model:

$$\begin{aligned} Asset_{jt}^{k} &= \alpha_j^k + \pi_j^k QE\ Purchases_t + \gamma_{j1}^k DMO\ Issuance_t \\ &\quad + \gamma_{j2}^k Financial\ Controls_t + \beta_j^k Asset_{jt-1}^k + \epsilon_{jt}^k. \end{aligned} \tag{1}$$

The dependent variable in the regression, $Asset^k$, is the net acquisition (measured in £million) of any asset class k by sector j in quarter t. Regressors include the QE policy variable, $QE\ Purchases_t$, which is measured by the amount of gilt purchases (in £ million)[14], and as controls we include net issuance of gilts, $DMO\ Issuance_t$, and

[13] The UK Government gave an explicit commitment at the start of the QE program not to al- ter its issuance strategy as a result of the asset transactions undertaken by the Bank of England for monetary policy purposes (see the letter from the Chancellor to the Governor of the Bank of England, 3 March 2009, http://www.bankofengland.co.uk/monetarypolicy/Documents/pdf/chancellorletter050309. pdf). Given this, and the fact that debt issuance plans are generally set on an annual cycle, it is not obvious that they would be explained even indirectly within the same quarter or year by plans for QE purchases.

[14] Our regression specifications all use the contemporaneous amount of asset purchases, rather than the expected amount. Unfortunately, we do not have comprehensive data set on expectations of future purchases. We experimented with the inclusion of

foreign financial variables to account for exogenous financial conditions which are independent of the Bank of England's QE policy. The foreign financial controls include the change in the 10-year benchmark U.S. Treasury yield ($\Delta U.S.\ long\ yield$); the change in the U.S. 10-year corporate spread ($\Delta U.S.\ corp\ spread$), which is the difference between the Barclays U.S. high yield index and the 10-year U.S. Treasury yield; the return on the S&P 500 ($U.S.\ S\&P\ returns$); and its realized volatility ($U.S.\ S\&P\ volatility$), a measure of uncertainty.[15][16] In addition, we also include the lagged dependent variable as a regressor to allow for some inertia in the adjustment process.[17]

This equation is similar to the specification used in Carpenter et al. (2015) to examine U.S. flow of funds data but differs in that we use net investment rather than changes in asset stocks, so this regression looks at the determinants of net flows into different assets. As revaluation effects would be expected to represent only a small fraction of each quarter's net flows, these regressions enable us to examine the institutions' active portfolio decision making.

We also investigate the impact of QE purchases on portfolio allocation using data on individual ICPFs. For life companies and pension funds separately, we estimate the following panel regression:

$$Share^k_{i,t} = \alpha^k + \pi^k QE\ Purchases_t + \gamma^k_1 DMO\ Issuance_t + \gamma^k_2 Financial\ controls_t + \gamma^k_3 Firm\ Controls_{i,t} + \beta^k Share^k_{i,t-1} + \epsilon^k_{i,t}, \quad (2)$$

where $Share^k_{i,t}$ is the percentage of any asset class k that a life insurance company/pension fund i holds in period t, and $Firm\ Controls_{it}$ are company or fund i specific characteristics. As in equation (1), $QE\ purchases_t$ is the quantity of QE purchases,[18] $DMO\ Issuance_t$,[19] and *Financial Controls* are as previously defined.

It is important to acknowledge that there are some factors that may also have affected the portfolio allocation of institutional investors, which we do not explicitly consider in our modeling approach. These include expected regulatory and accounting changes at the international level (such as the EU-wide insurance regulations (Solvency II) and changes to International Financial Reporting Standards (IFRS)) and also national level regulations (such as the PRA's regulatory requirements under the Internal Capital Adequacy Assessment Process (ICAAP), Individual Capital Adequacy Standards (ICAS), and the Pension Act 2004). It is extremely difficult to account for the impact of these factors directly due to the fact that changes in regulation and accounting rules often take a long time to implement and institutional investors might change their investment strategies well ahead of implementation. However, the impact of these factors may be captured indirectly by the control variables and lagged dependent variables included in the regressions.

Following Pesaran and Smith (2016), we construct an *ex post* counterfactual comparison of the QE impact. This is calculated as the difference between the realized outcomes which includes the QE policy and a no-QE policy counterfactual scenario,

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the stock of announced purchases but this made very little difference to any of the results, as the Bank of England announced its planned future purchases only 3 or 4 months ahead. These results are available on request from the authors.

[15] The returns and realized volatilities are calculated for either 3 months or 1 year depending on the frequency of the data used.

[16] All the original financial market data used to derive these variables were sourced from Datastream.

[17] When this equation is estimated across each asset class for a given sector, or across all sectors for a given asset class, it becomes possible in principle to impose adding-up constraints for the system as whole. The parameter estimates we report later are freely estimated and do not impose these restrictions, but we find that the data are in any case quite close to satisfying them.

[18] We scale up the QE purchase units from £million in equation (1) to £billion in equation (2) for ease of reporting.

[19] Because of the long time series, we scale DMO debt issuance by nominal GDP for the SynThesys (the microlevel data for life insurance companies) data regressions.

where the counterfactual is based on the net investment model in equation (1) (excluding QE purchases) estimated using a subsample which ends just before the beginning of QE. More formally, this is calculated as:

$$QE\_effect(ex-post)_{T+h} = y_{T+h} - E\left(y_{T+h} | y_T, QE^0_{T+h}, Controls_{T+h}, \Omega_{\text{sub}}\right) \quad (3)$$

where the expectation of the outcome variable $yT+h$ is the linear projection from the model estimated in equation (1), and where $QE^0_{T+h} = 0$ is the policy variable assuming there was no QE, and Qsub is the parameter set based on the subsample estimation up to the end of 2008.[20]

4. Sectoral Results

The OLS regression results from estimating equation (1) for the net acquisition of gilts across investor types are reported in Table 2. The table shows that for ICPFs the coefficient on the Bank of England's net purchases of gilts variable (QE Purchases) is statistically significantly with a negative sign. Its value implies that for every £1 of gilts purchased by the Bank, ICPFs reduced their net inflows into government bonds by about 12 pence (£0.12). Since the coefficient on the lagged dependent variable in the regression is statistically significant and positive, we also report the long-run coefficient on QE purchases, which is estimated to be 0.18 in absolute terms, suggesting that the impact increases over time.

From Table 2 we can see that QE purchases are also negative and statistically significant for three other sectors—OFIs (other financial institutions), MFIs (including banks), and RoW. This is consistent with investors in each of these sectors reducing their net acquisition of gilts in response to the amount of QE purchases. On the whole, the lagged dependent variables for these sectors are either small or statistically insignificant from zero, so the long-run effects reported are only slightly different. Although we do not impose any adding-up constraints, the sum of the coefficients on the QE purchases variable across investor types is close to unity for both the short-run and long-run effects, as we would expect. Finally, the coefficient on the DMO variable, measuring the quarterly issuance of government debt, is positive and statistically significant for each of these same investor sectors, as expected.

The OFI sector includes the GEMMs, and since the mechanics of the QE program involved the Bank of England buying from the GEMMs, we would expect to see a large negative short-run coefficient on the QE purchase variable for this category of investors, which is what we observe. While the long-run effect for this sector is similar to the short-run impact, this should probably not be taken as meaning that OFIs were the ultimate sellers, as the dynamics are likely to be more complicated than our models allow. For example, it seems likely that a lot of the gilts sold by OFIs will have been originally sourced from ICPFs, so the long-run impact probably exaggerates the importance of OFIs as ultimate sellers and understates that of ICPFs.[21] Taking the results at face value, the long-run estimates suggest that, of the £375 billion of total QE, around £68 billion (nearly one fifth) originated from ICPFs. Although probably an underestimate, this still suggests that a significant amount of the Bank's

[20] We also calculated the *ex ante* impact of QE based on the expected difference between the QE policy scenario and a no-QE policy scenario, where both scenarios are based on the estimated model in equation (1) over the full sample. These results are similar to those based on the *ex post* measure and are therefore not reported.

[21] That said, given the greater liquidity in the market as a result of the Bank's presence and the higher balance sheet costs, it is possible that the GEMMs might have been encouraged to hold lower gilt inventories during the QE period, though it is less clear that any effect would have been permanent.

purchases came from institutional investors. The results in Table 2 are based on using the full data sample from 1987Q1 to 2012Q4. To check the results are robust to excluding the earlier part of the sample period from the 1980s and 1990s, the memo item reported in the table shows the QE parameter estimates when the estimation sample is restricted to the period from the beginning of 2000Q1. The main results are essentially unchanged, with the coefficient in the ICPF equation slightly larger.[22]

Table 3 compares regression results for the net investment flows of ICPFs into four broad asset categories: government index-linked and nominal bonds (as before), equities, corporate bonds, and cash. As well as the significant negative coefficient on QE purchases in the gilts equation (repeated from Table 2), there is also a significantly positive coefficient on the QE variable in the corporate bonds equation. This is consistent with a portfolio rebalancing effect, with the coefficient suggesting that £1 of QE leads to ICPFs increasing their long-run flows into corporate bonds by about 30 pence. This would imply that for £375 billion of QE purchases, ICPFs increased their net investment in corporate bonds by £117 billion (= £375 × 0.312). To set this in a broader macrocontext, this is about twice the size of the average amount of annual gross corporate bond issuance in the UK during 2003–08 (according to Dealogic figures), which suggests that the estimated effects from rebalancing are economically significant.

[22] The main results reported in this section are also robust to other specifications, using lags of QE spending, or separating out the first and second waves of QE purchases.

TABLE 2

NET ACQUISITION OF GOVERNMENT BONDS, SECTORAL REGRESSIONS; SAMPLE 1987Q1–2012Q4

	$Asset^{Gilts}_{ICPFs}$	$Asset^{Gilts}_{PNFCs}$	$Asset^{Gilts}_{PCs}$	$Asset^{Gilts}_{OFIs}$	$Asset^{Gilts}_{HHs}$	$Asset^{Gilts}_{RoW}$	$Asset^{Gilts}_{MFIs}$
QE purchases	-0.118^{***}	0.001	−0.001	-0.445^{***}	0.007	-0.174^{**}	-0.250^{***}
	(2.87)	(0.64)	(0.66)	(8.13)	(0.32)	(2.41)	(5.82)
DMO issuance	0.104^{**}	0.002	0.001	0.257^{***}	−0.012	0.332^{***}	0.267^{***}
	(2.51)	(0.81)	(0.39)	(4.77)	(0.74)	(6.47)	(5.88)
ΔU.S. long yield	0.105	−0.002	0.043	−1.380	−0.498	1.406^{*}	0.599
	(0.13)	(0.04)	(1.17)	(1.35)	(0.87)	(1.94)	(0.79)
ΔU.S. corp spread	−0.381	−0.018	0.023^{***}	0.773^{*}	−0.184	0.087	0.109
	(0.94)	(0.86)	(2.83)	(1.73)	(0.70)	(0.22)	(0.37)
U.S. S&P returns	24.550	−1.104	1.097^{*}	−22.280	−6.382	15.832	−6.040
	(1.46)	(0.79)	(1.96)	(1.07)	(0.70)	(0.94)	(0.46)
U.S. S&P volatility	−8.282	−1.489	3.722	54.957	20.925	−85.995	52.510
	(0.15)	(0.49)	(1.47)	(0.73)	(0.57)	(0.93)	(0.98)
Lagged dep. var.	0.347^{***}	0.003	0.194^{***}	−0.026	0.300^{**}	0.130^{*}	0.089
	(3.21)	(0.04)	(2.88)	(0.42)	(2.07)	(1.68)	(0.86)
Constant	393.309	16.963	−66.725	−456.028	−451.452	1,814.521	$-1{,}929.502^{*}$
	(0.32)	(0.26)	(1.06)	(0.35)	(0.62)	(1.00)	(1.95)
Long-run impact	−0.180	0.001	−0.001	−0.434	0.010	−0.199	−0.274
Observations	103	103	103	103	103	103	103
R^2	0.313	0.029	0.067	0.677	0.121	0.491	0.51
Memo item: Parameter estimates over sample 2000Q1–2012Q4:							
QE purchases	-0.132^{***}	0.002	−0.001	-0.410^{***}	−0.015	-0.165^{**}	-0.266^{***}
	(2.78)	(0.72)	(1.02)	(6.96)	(0.45)	(2.14)	(5.67)

NOTE: The table reports regression results for sectoral net investment in government bonds. t-Statistics in absolute values are reported in brackets and are based on Newey–West heteroskedasticity consistent standard errors, where 4 lags were chosen following the Newey and West (1994) plug-in procedure. Significance level: *** 1%; ** 5%; * 10%. The sectors reported are: ICPFs, insurance companies and pension funds; PNFCs, private nonfinancial corporations; PCs, public corporations (excluding the Bank of England); OFIs, other financial institutions and financial auxiliaries, including gilt-edged market makers, mutual funds, and hedge funds; RoW, rest of the world investors; MFIs, monetary financial institutions, such as banks and building societies. Data sources: ONS, Datastream.

To examine the robustness of these findings to the choice of sample, the first memo item in Table 3 shows the results from reestimating the equation over a shorter sample from 2000Q1. Again the results are very similar, showing evidence of portfolio rebalancing from gilts to corporate bonds. The second memo item is from a different specification, which splits QE expenditures between the first phase of purchases from March 2009 to January 2010 (QE1) and from October 2011 to October 2012 (QE2). The coefficients on the two QE policy variables reported for the gilts equation and for the corporate bonds equation are of similar size and significance, with the differences not statistically significant according to a standard *F*-test.

TABLE 3

NET ACQUISITION OF DIFFERENT ASSET CLASSES, ICPFS REGRESSION RESULTS; SAMPLE 1987Q1–2012Q4

	$Asset_{ICPF}^{Equities}$	$Asset_{ICPF}^{Gilts}$	$Asset_{ICPF}^{CorpBonds}$	$Asset_{ICPF}^{Cash}$
QE purchases	−0.089	−0.118***	0.074**	0.040
	(1.37)	(2.87)	(2.53)	(0.81)
DMO issuance	−0.003	0.104**	−0.066***	−0.063*
	(0.08)	(2.51)	(2.63)	(1.65)
ΔU.S. long yield	−1.435	0.105	0.936*	−0.926
	(1.20)	(0.13)	(1.70)	(1.26)
ΔU.S. corp spread	−0.400	−0.381	−0.247	−0.006
	(0.87)	(0.94)	(1.17)	(0.02)
U.S. S&P returns	6.425	24.550	1.555	−26.472**
	(0.360)	(1.46)	(0.17)	(2.39)
U.S. S&P volatility	−56.045	−8.282	1.691	−102.790**
	(−1.10)	(−0.15)	(0.05)	(−2.28)
Lagged dep. var.	0.340***	0.347***	0.762***	0.004
	(2.96)	(3.21)	(8.16)	(0.03)
Constant	1119.586	393.309	1513.481**	3567.726***
	(1.020)	(0.320)	(2.32)	(3.56)
Long-run impact	−0.134	−0.180	0.312	0.040
Observations	103	103	103	103
R^2	0.221	0.313	0.585	0.103
Memo item I: Parameter estimates over sample 2000Q1–2012Q4:				
QE purchases	−0.161**	−0.132***	0.086**	0.055
	(2.49)	(2.78)	(2.32)	(1.02)
Memo item II: Parameter estimates for QE1 and QE2 over full sample 1987Q1–2012Q4:				
QE1 purchases	−0.023	−0.100**	0.081**	0.082
	(0.39)	(2.19)	(2.10)	(1.45)
QE2 purchases	−0.149***	−0.136***	0.068**	0.004
	(3.14)	(3.11)	(2.25)	(0.11)

NOTE: The table reports regression results for ICPF net investment into different asset classes. *t*-Statistics in absolute values are based on Newey–West heteroskedasticity consistent standard errors, where 4 lags were chosen following the Newey and West (1994) plug-in procedure. Significance level: *** 1%; ** 5%; * 10%. Data sources: ONS, Datastream.

In Figure 2, we evaluate the *ex post* impact of QE as described in equation (3). Figure 2 shows the actual and no-QE counterfactuals for ICPF net investment into each asset class, derived by forecasting from a regression estimated up to the period before QE began using the financial accounts sectoral data. We can see that for government bonds, the *ex post* QE effects after the start of the QE program in 2009 are mostly negative, implying that the expected value of investment flows into government bonds would have been higher without QE. This is consistent with our earlier findings that ICPFs were net sellers of government bonds after the introduction of the QE program. In contrast, the net flows into corporate bonds are positive, suggesting that net investment into corporate bonds was higher than would have been expected in the absence of QE. The chart also suggests that in the absence of QE net inflows into equities and cash would have been higher on average, although there is substantial volatility from quarter to quarter.

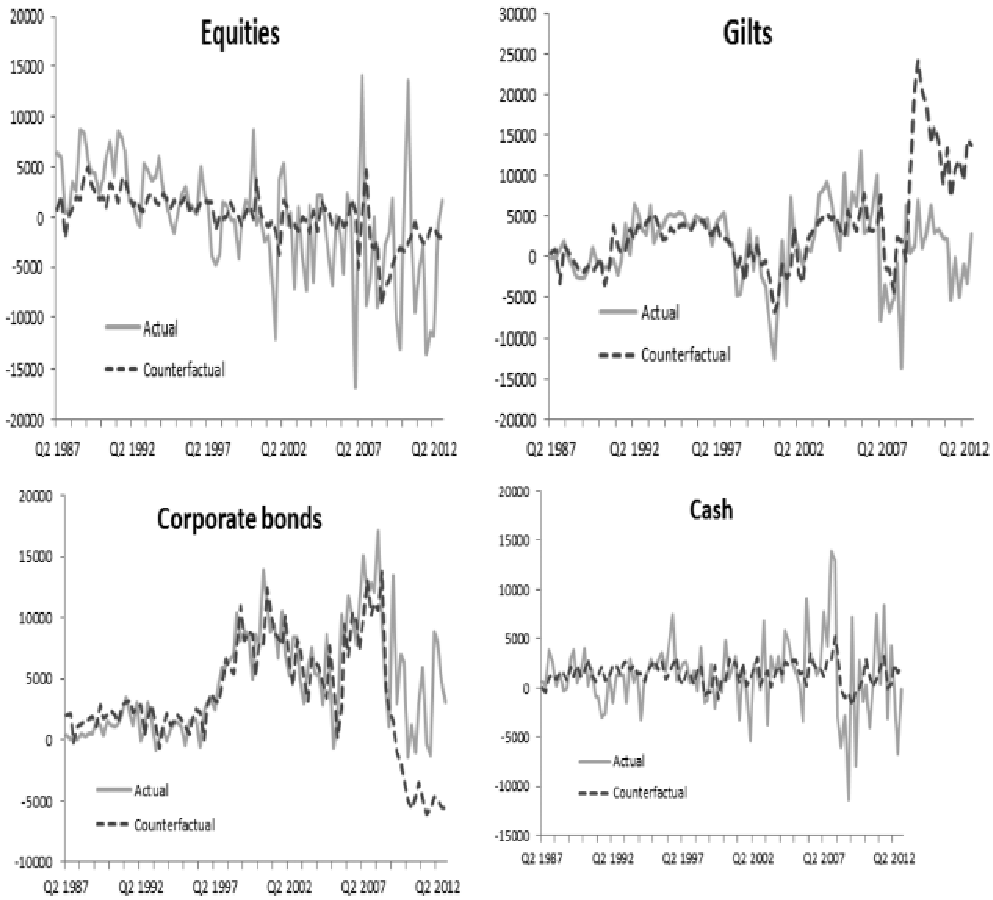

FIG. 2. *Ex Post* Impact of QE on ICPFs: Financial Accounts Data (£ million).

NOTES: The graph shows the *ex post* counterfactuals and outturns for the net acquisition of equities, government bonds, corporate bonds, and cash by ICPFs. The counterfactual was produced by estimating the portfolio balance equations in Table 3 on data up to the end of 2008Q4 and projecting forward on the basis of the control variables.

5. Microlevel Results for Insurers and Pension Funds

In this section, we report estimates for the dynamic panel models described in equation (2) for life insurers (at the parent company level) and for pension funds. Table 4 reports the results for life insurers based on Arellano-Bond estimation, which allows for the presence of a lagged dependent variable, using the annual financial information provided by the SynThesys database from 1985 to 2012. In addition to the financial controls used previously, the regressions also include individual controls relating to the characteristics of the insurance fund, including: firm size, which enters as the log change in total admissible assets; the free asset ratio; the ratio of business premiums to assets; and the fraction of assets linked to liabilities. In interpreting the results, it should be borne in mind that, as described in Table 1, the SynThesys data for nominal and index-linked government bonds include both UK and overseas government bonds, although it seems very likely that UK government bonds dominate. Note also that the data we use for equities and corporate bonds combine UK and overseas securities and that cash includes cash in hand and deposits.

TABLE 4

Asset Allocation by Life Companies; Regressions Results; sample 1985–2012

	$Share_{IC}^{Equities}$	$Share_{IC}^{NomGilts}$	$Share_{IC}^{IndexGilts}$	$Share_{IC}^{CorpBonds}$	$Share_{IC}^{Cash}$
QE purchases	−0.017***	−0.017***	0.001	0.028***	−0.008
	(2.71)	(2.66)	(0.34)	(5.51)	(1.05)
DMO issuance/GDP	20.520***	15.596**	8.007**	−13.318**	−35.863***
	(2.75)	(2.11)	(2.50)	(2.10)	(3.52)
Financial controls	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes	Yes
Lagged dep. var.	0.585***	0.607***	0.408***	0.702***	0.596***
	(20.2)	(24.61)	(12.55)	(27.37)	(24.00)
Constant	17.581***	7.837***	1.605***	6.837***	9.122***
	(11.01)	(5.98)	(3.29)	(6.08)	(6.09)
Observations	2,183	2,506	1,047	1,972	2,873
Memo item I: Parameter estimates over sample 2005–12 (financial controls (1), firm controls (5)–(8))					
QE purchases	0.002	−0.010	0.005*	0.014**	0.002
	(0.24)	(1.48)	(1.75)	(2.37)	(0.28)
Memo item II: Parameter estimates when QE1 and QE2 purchases are separated over full sample 1985–2012					
QE1 purchases	−0.016**	−0.014*	−0.003	0.028***	−0.008
	(2.29)	(1.93)	(0.95)	(4.86)	(0.85)
QE2 purchases	−0.0154	−0.021**	0.008**	0.028***	−0.009
	(1.57)	(2.09)	(2.06)	(3.59)	(0.70)

Note: Dynamic panel model estimated using Arellano–Bond procedure. The DMO control variable is scaled by nominal GDP; the QE purchases variable is in units of £ billion. *t*-Statistics in absolute values are shown in parentheses. Significance level: ***1%; **5%; *10%. Financial controls: (1) First difference of the U.S. long yield; (2) first difference of U.S. corporate spread; (3) U.S. S&P return; (4) U.S. S&P volatility. Firm controls: (5) Firm size (measured by total admissible assets); (6) free asset ratio (the ratio of excess capital resources available to cover long-term business Capital Resource Requirements (CRR) against total assets); (7) ratio of business premiums to assets; and (8) proportion of the assets held to match linked liabilities. Data sources: Synthesys, Datastream.

The coefficient on the QE purchases variable (QE Purchases) in the second column relates to the effect of the QE program on asset allocation to nominal government bonds. The estimated value of this coefficient should be interpreted as −0.01721%. Using the 2012 figure for total life insurer assets, this would imply that £375 billion of QE purchases reduced the value of life insurers' holdings of nominal gilts by around £48 billion.[23] The estimates in Table 4 also suggest that the QE impact on the allocation to index-linked government bonds and equities was negative, but there was a positive impact on the asset allocation toward corporate bonds.

To examine the robustness of these findings to the sample, the first memo item in Table 4 shows the results from reestimating the equation over a much shorter sample from 2005Q1. Since we lose many degrees of freedom from this, the number of financial controls was reduced to just the first difference of the U.S. long yield, but all the firm characteristic controls were retained. Perhaps not surprisingly the statistical significance of the QE variable in these regressions is somewhat reduced, but again the results show evidence of portfolio rebalancing from gilts to corporate bonds, with a negative QE coefficient in the nominal gilts equation and a positive QE coefficient in the corporate bond equation. The second memo item reports the parameter estimates for the QE impact on insurers when we separate out the impact of QE1 and QE2. It can be seen that the impact from QE on the allocation to nominal bonds is slightly larger and more statistically significant for QE2, while the impact on the allocation to corporate

[23] This estimate is derived from 0.01721% * 1,292 * 0.58 * 375 = £48.4 billion, where £1,292 billion is the total assets of all the life insurers who invested in gilts in 2012, according to SynThesys. The asset share percentages are not share percentages against total admissible assets; they are shares against the subtotal, which excludes assets held to match linked liabilities. So, 0.58 is the ratio of the assets not linked to liabilities (i.e., the subtotal) against total admissible assets. The total amount of QE is £375 billion.

bonds has a similar size and statistical significance for both QE1 and QE2.

TABLE 5

ASSET ALLOCATION BY PENSION FUNDS; REGRESSION RESULTS; SAMPLE 2005–10

	$Share_{PF}^{Equities}$	$Share_{PF}^{NomGilts}$	$Share_{PF}^{IndexGilts}$	$Share_{PF}^{CorpBonds}$	$Share_{PF}^{Cash}$
QE purchases	−0.000	-0.006^{***}	0.003^{*}	0.011^{***}	−0.002
	(0.06)	(3.29)	(1.89)	(4.57)	(0.82)
DMO issuance	0.008^{***}	-0.005^{*}	-0.019^{***}	-0.013^{**}	-0.008^{***}
	(2.78)	(1.89)	(4.84)	(2.47)	(2.86)
Financial controls	Yes	Yes	Yes	Yes	Yes
Firm controls	Yes	Yes	Yes	Yes	Yes
Lagged dep. var.	0.774^{***}	1.038^{***}	1.433^{***}	1.144^{***}	0.674^{**}
	(25.01)	(22.00)	(10.17)	(11.61)	(26.10)
Constant	9.227^{**}	2.010	−8.654	-8.842^{*}	−4.990
	(2.44)	(0.50)	(1.63)	(1.71)	(1.28)
Observations	13,891	6,017	4,513	6,694	8,402
Memo item: Parameter estimates from model estimated on changes in asset allocation					
QE purchases	-0.003^{*}	-0.004^{***}	0.001	0.009^{***}	-0.004^{*}
	(2.22)	(2.85)	(0.85)	(6.24)	(1.88)

NOTE: Dynamic panel model estimated using Arellano–Bond procedure. Units for the DMO control variable and for the Bank of England QE variable are £ billions. *t*-Statistics in absolute values are shown in parentheses. Significance level: ***1%; **5%; *10%. Financial controls: First difference of U.S. long yield. Fund controls: (1) Fund size (number of members); (2) maturity of scheme; (3) risk-based levy; and (4) funding ratio. Data sources: PPF, Datastream.

Turning to the panel regression analysis for DB pension schemes, we estimated the dynamic panel model in equation (2) using the annual data provided to us by the PPF for the years 2005–10. The results from this analysis are presented in Table 5. The models estimated include only one financial control variable (the change in U.S. Treasury yields) given the short sample size[24] but various fund-specific controls. These controls include: the size of the pension scheme measured by the log of the number of members; the maturity of the scheme, measured by the ratio of pensioners in payment to the total number of members in the scheme including active and deferred; the size of the RBL, the annual premium that the fund has to pay to the PPF; and the funding ratio, measured by the value of assets as a percentage of liabilities.[25] In interpreting the results, note that, as described in Table 1, the PPF data for nominal and index-linked government bonds include both the UK and overseas government bonds, though the former is likely to dominate. Note also that equities and corporate bonds include both UK and overseas securities and that cash includes cash in hand and deposits.

From the results in Table 5, it can be seen that the allocation to nominal government bonds is estimated to have fallen in response to QE. The change in the portfolio share of pension funds' holdings of nominal government bonds in response to £1 bn of QE is 0.00577%, which would suggest a reduction of around £22 bn over the whole QE period.[26] We also see that QE is associated with an increased allocation to both index-linked and corporate bonds. As with the life companies, these results are broadly consistent with the earlier sectoral data set results. Comparing the results in Tables 4

[24] When this control is excluded the main change is that the QE purchase variable becomes positive and statistically significant in the equity share equation. The full results are available on request.

[25] The funding ratio variable shows the extent to which the scheme is adequately funded; if substan- tially underfunded, the Pensions Regulator may require the scheme sponsor to make additional contribu- tions into the scheme to reduce the deficit (Rauh 2006, Liu and Tonks 2013).

[26] This estimate is derived from 0.00577% * 1,026.80 *375 = £22.2 bn, where £1,026.80 bn is the total assets of all DB pension funds as reported in the PPF's 2012 Purple Book and £375 bn is the total amountofQE.

and 5, pension funds unlike insurers appear to have increased their net investment in index-linked bonds. One reason could be that, following the 1995 Pension Act, DB pension funds have been required to index link pension entitlements and they may therefore have been buying index-linked securities to match their liabilities over the QE period.

One unsatisfactory feature of the estimation results in Table 5 is the coefficient on the lagged dependent variable which exceeds unity for some asset classes, perhaps reflecting the short sample period used for the estimation. To check robustness, we also estimated the same asset share equations in difference form using a fixed effects model. As shown in the memo item in the table, both the responses of nominal gilts and corporate bonds to QE remains similar to the dynamic panel regression estimated in levels.

6. Summary and Conclusions

In this paper we examined a range of data sources, including sectoral net investment data and micro-level data on individual life ICPFs, in order to assess how the Bank of England's QE policy in the aftermath of the global financial crisis affected the investment behavior of ICPFs. More specifically, we looked for evidence of the operation of the so-called "portfolio balance channel" that has been emphasized by UK and U.S. monetary policymakers as a key channel through which QE works.

In answering the questions we posed in Section 2, our results suggest that a substantial fraction of the Bank of England's QE gilt purchases came from institutional investors. Moreover, the balance of evidence from both the analysis of the sectoral data on net investment flows and the analysis of the microlevel data on portfolio shares was consistent with the hypothesis that the Bank of England's QE policy resulted in some portfolio rebalancing behavior by institutional investors, who appear to have reduced their gilt holdings and shifted into riskier corporate bonds relative to the counterfactual.[27] But it appears that portfolio rebalancing was limited to corporate bonds, with most of the evidence suggesting that institutional investors did not shift into equities during the period of QE purchases.

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[27] Additional analysis not reported here (but available on request from the authors) suggests that, although there is some evidence of different behavior according to firm and fund characteristics, this switch was remarkably similar across different insurance companies and pension funds.

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