

# Decomposing leverage in quantitative easing decisions: Evidence from the UK

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## Abstract

The paper analyses the implications arising from the responses of the financial sector in the United Kingdom to the incentives determined by quantitative easing decisions. In a panel vector autoregressive framework, we examine the effects of Bank of England asset purchases on the profitability and disaggregated leverage components for different types of financial institutions, which reflect differences in the sequencing of the quantitative easing strategy. We find that quantitative easing decisions are driven by economic activity, lending rates and financial institutions' leverage. The transmission channel of QE to the boosting of economic growth depends on the degree of financial institutions' leverage and the securities holdings but with a diverging magnitude for the different types of UK financial institutions.

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## 1. Introduction

The global financial crisis that started in 2008 and its aftermath posed significant challenges for monetary authorities. Unconventional monetary policies remain one of the few levers available for policy makers to exercise, with the most common referring to the extension of their balance sheets by large-scale asset purchases (LSAPs), known as quantitative easing (hereafter QE). The QE strategy was initially applied by the Bank of Japan as it tried to handle the Japanese real estate bubble and the deflationary pressures in the early 2000s. The Federal Reserve System (Fed) and the Bank of England (BoE) followed suit in the late 2000s, acting swiftly to evade a meltdown of their financial system.

Traditionally, QE means focusing on buying longer-term government bonds from banks, allowing the sovereign yields to serve as a benchmark for the pricing of riskier privately issued securities (Krishnamurthy and Vissing-Jorgensen, 2011). In this context, the yields on privately issued securities, and consequently the bank lending rates, are expected to decline in parallel with those on government bonds, with the hope that this will stimulate longer-term investments and hence the aggregate demand, thereby supporting price stability (Bowman et al., 2015). Moreover, Joyce et al. (2012) noted that banks may hold onto funds to improve their viability rather than on-lending to the private sector, driving the central banks to intervene with the direct provision of credit to enable its policies to have an impact on the financial intermediation.

The paper analyses the interaction between leverage undertaken by different types of financial institutions and asset purchases by the BoE as part of its QE programme and future QE exit strategies, oriented towards the UK financial institutions, allowing them to enjoy vast financial conditions.<sup>4</sup> Addressing this issue is a challenge, because it is of great interest to

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<sup>4</sup> During the first and second QE programmes spanning from March 2009 to November 2012, the BoE purchased £375 billion of medium- and long-term government bonds (representing approximately 24% of the

disentangle the implications of the effects of QE decisions on the UK financial sector. The setting of monetary policy is performed under several pressures that could force an abrupt change in the policy strategies being promoted within a wide variety of financial and macroeconomic signals. Consequently, a crucial question is raised regarding the extent to which the critical role of the UK financial sector's leverage can ensure the success of quantitative easing. In periods with high deleverage, QE is successful if it reduces the risks of a liquidity shortfall, encouraging the banks to extend credit to higher interest-paying parties through the leverage decisions undertaken and thereby boost economic growth, even though the banks are forced to undertake more risks. Nevertheless, given the level of leverage that the banking sector can experience, banks can stop intermediating loans and may not pass on the additional liquidity to the real economy, thereby making the QE policy ineffective.

Even though there is a considerable amount of empirical literature concerning the broader macroeconomic impact of QE via market rates,<sup>5</sup> few studies, to the best of our knowledge, have examined the impact of QE on the profitability and solidity of financial institutions, focusing mainly on US data (Lambert and Ueda, 2014; Mamatzakis et al., 2015; Mamatzakis and Bermpei, 2016). These studies argue that an unconventional monetary policy reinforces banks' solidity by allowing them to reduce their leverage and extend the maturity of their

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domestic GDP). As a result, the balance sheet of the UK financial institutions was significantly expanded due to the liquidity support.

<sup>5</sup> A strand of the literature has focused on the transmission channels through which asset purchases can affect long-term interest rates by observing the policy signalling channel and portfolio balance channel. The contributors, among others, are the studies by Meier (2009); Joyce et al. (2011a, 2011b); Christensen and Rudebusch (2012); D'Amico et al. (2012); Hamilton and Wu (2012); Joyce and Tong (2012); Gilchrist and Zakrajšek (2013); Neely (2015); and Steeley (2015). Fewer studies have tried to estimate the macroeconomic effects of unconventional monetary policy measures via the linkages between the interest rate spreads and the real economy (Lenza et al., 2010; Chung et al., 2012; Chen et al., 2012).

debt. A handful of recent studies have attempted to highlight the role of financial institutions' leverage decisions but for the case of the conducting of conventional monetary policy, business cycles and real economic activity in the USA (Geanakoplos, 2010; Serletis et al., 2013; Istiak and Serletis, 2016).

In the light of the above discussion, it is important to make further considerations when discussing QE strategic policy interactions. We address these issues from a different angle that innovates and contributes to filling some of the existing gaps in the literature in at least two dimensions.

Firstly, we set up a panel vector autoregressive (panel VAR) framework, characterized by cross-sectional heterogeneity and dynamic interdependencies. We make two assumptions within our modelling framework. In the first assumption, we employ different major types of UK financial institutions and discuss the extent to which QE has exerted different impacts on their performance. This type of identification tries to shed light on a significant gap regarding the vital importance of different types of UK financial institutions in studying the implications of QE decisions, without being oriented narrowly towards a macroeconomic perspective. In the second assumption, we consider a decomposition of leverage into three main components, namely the *gross loans to equity*, *liquid assets to equity* and *securities to equity* components. We then analyse their discrete role in the QE policies implemented and their interactions with real economic activity for the different types of UK financial institutions. These types of identification differentiate our paper from other studies employing similar empirical methodologies or addressing related topics.

Secondly, we draw policy implications based on both directions of impulse and response functions between the QE strategies and the performance of UK financial institutions' balance sheets, assessing the following main research questions. The first question concerns the impulse analysis of QE on the balance sheets and the extent to which the financial

variables of interest can play a key role in the GDP growth. The second question investigates the QE policy response to different shocks of leverage, profitability and real economic activity. Finally, we examine in depth the effects of leverage on profitability and the interactions across the leverage components.

Our findings are of great importance to the existing literature, because they highlight both directions of impulses and responses between the profitability and the leverage of the financial sector and the central bank's QE policies for the real economy. The first finding is that the asset purchases by the BoE are not a determining factor that provides financial institutions with the possibility to improve their profitability, a finding that is in line with the study by Mamatzakis and Bermpel (2016). A significant reduction in profitability is identified for almost all the types of UK financial institutions, with a diverging magnitude between these types, mainly due to the securities that are held and the diversification benefits of other institutions by their involvement in different sectors of activity. Moreover, we observe interdependency between profitability and leverage and an indirect relationship between liquidity and lending, which depends on the type of financial institution. However, our paper recognizes that the significant reduction in profitability for real estate banks presents significant benefits for the economic activity in the UK.

The transmission channels of QE to GDP growth based on financial institutions' leverage have a significantly positive effect through securities holding for commercial banks and bank holding companies. This second finding complements the previous studies about the positive effect of a conventional monetary policy on the GDP via leverage in the USA (see Adrian and Shin, 2010; Geanakoplos, 2010; Serletis et al., 2013; Lambert and Ueda, 2014; Istiak and Serletis, 2016). The contribution of commercial banks in liquidity and leverage responses to the QE shock is of considerable importance and, consequently, the increase in leverage seems to be attributed mainly to risk-taking behaviour by commercial banks. The evidence shows

that a negative shock to the economic activity leads the majority of UK financial institutions to increase their leverage by undertaking significantly high risks, indicating countercyclical effects. This result is in contrast to Adrian and Shin (2009, 2010), who argued for procyclical behaviour of leverage found in the US over periods with a conventional monetary policy.

The third finding is the evidence that QE is also transmitted to the real economy via the significant reduction in the retail banking rates, in comparison with other studies focusing only on the transmission via bond rates (i.e. Joyce et al., 2012; Pesaran and Smith, 2016; Weale and Wieladek, 2016). We argue that the BoE reduces its asset purchases when lending rates are dropped, economic activity is augmented and the leverage of commercial banks is increased. As pointed out by Putnam (2013), exit strategies from QE by central banks could be particularly challenging to implement and have the potential to suspend a return to the normal conduct of monetary policy to the detriment of longer-term economic growth, rational leverage and potential future inflation.

The remainder of the paper is organized as follows. Section 2 provides a detailed description of the data sources and draws some initial insights from a fundamental data analysis. Section 3 discusses the panel VAR framework, including the modelling assumptions. Section 4 illustrates the empirical findings together with a discussion of the results and their policy implications. Finally, Section 5 concludes.

## **2. Data selection**

Part of our sample comes from the Bankscope database<sup>6</sup> and covers the annual accounting data of the financial institutions in the UK for a period spanning from 2005 to 2013.<sup>7</sup>

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<sup>6</sup> We should bear in mind that accounting data derived from Bankscope may suffer from a drawback, observing that when inferences are drawn from the Bankscope database, there can be an implicit selectivity bias (Corvoisier and Gropp, 2001).

However, to ensure potential uniformity, which can be affected by the presence of missing data in Bankscope, in some cases we use the annual reports of the financial institutions for the variables of interest as data sources.

The time span structure was chosen to segregate the impact of QE rounds and diminish the likelihood of other puzzling factors (i.e., purchases of other asset classes during successive QE rounds). Moreover, it can capture transformations observed in the UK financial sector in recent years. In the period preceding the crisis, UK financial institutions increasingly came to depend on wholesale funding rather than their customers' deposits, an element that placed greater pressure on their structure. On the brink of the financial crisis in the UK, financial institutions ended up having less capital and fewer liquid assets than in the past, given the fluctuations in the UK's financial environment. Thus, our time span structure can evaluate the overall impact of QE on the UK financial sector without segregating the impact of different QE rounds.

We draw on two accounting quantities, which are associated with the present research study. The first quantity straightforwardly derived from Bankscope is the *returns on assets* (hereafter *ROA*), used as a key ratio for the evaluation of bank profitability and as a measurement of the overall performance of a financial institution regarding its efficiency in utilizing assets to generate profits, given the structure of liabilities and equity (Athanasoglou et al., 2008; Garcia-Herrero et al., 2009). The second one is the ratio of *leverage*, measuring the risk associated with non-capital funding of overall balance sheets and defined as *total assets to total shareholders' equity* and subordinated debt. This definition is similar to the regulatory leverage ratio used by the Office of the Superintendent of Financial Institutions

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<sup>7</sup> The quarterly frequency could, in principle, give a better insight into the link between the accounting ratios and the QE rounds. However, for most banks quarterly data are not available. On the other hand, the bias in the results obtained using annual data instead of quarterly data appears not to be significant (Gambacorta, 2005).

(OSFI), it is based on total regulatory capital as defined in Basel II, including subordinated debt (Bordeleau et al., 2009), and it is not subject to the model and measurement errors associated with asset risk calculations. High leverage indicates greater vulnerability to adverse shocks that can reduce the overall value of assets. Similarly, it can decrease the long-term availability of funding and increase the reliance on volatile short-term sources of funding (i.e., higher funding liquidity risk).

Moreover, we draw on three quantities derived from Bankscope, namely the *liquid assets*, defined as the sum of cash and cash equivalents, public securities and secured short-term loans, the *gross loans* as the total amount of issued credits and, the sum of *securities*, defined as the sum of investments of banks that include bonds, equity derivatives and any other type of securities. We divide all the three quantities by the total shareholders' equity to derive them as ratios. In this setting leverage, as defined above, is decomposed into three components, denoted as *liquid assets to equity*, *loans to equity* and *securities to equity*, which reflect the extent to which the financial institutions are (de)leveraging within the QE framework effect. This framework of decomposition may expose the financial sector's access to asset liquidation and its resilience to short-term liquidity stress, determine whether it can provide loans to the real economy and withstand adverse non-performing loans' shocks and measure the extent to which a financial institution should leverage in riskier market securities and financing sources and can take on adverse market risks, respectively.

In the standard quantitative easing framework, it is common to assume that the central bank sets its policy interest rate taking into account real-economy variables, for example the real GDP, the output gap, the inflation deviation from the target and so on, when deciding on the amount of QE in which it will engage. In this context we draw on the real GDP derived from the BoE and examine the extent to which it may have an impact on bank performance due to the fact that the demand for lending increases during cyclical upswings (Athanasoglou



et al., 2008). Moreover, we derive the lending rate, as the average long-term rate from the BoE, to examine the extent to which the lending between banks is decreasing.<sup>8</sup> This choice of lending rate relies on the hypothesis that certain bank-specific characteristics (e.g., size, liquidity, short-term funding, cost-to-income proportion and capitalization) only influence the loan supply. Finally, we derive the average annual asset purchases made by the BoE over its total assets as an indicator of QE, which is commonly used in the literature (Hancock and Passmore, 2011; Chen et al., 2012).

Using the Bankscope database, the types of financial institutions are not always mutually exclusive (Bhattacharya, 2003). Consequently, we restrict our sample to five main types of financial institutions in the UK, which are mutually exclusive. Even though the analysis is implemented on a total sample of more than 300 financial institutions, the contribution of each type of financial institution to the QE responses is investigated further, given that each type may reveal significant information. However, due to the data availability and the low relevance of some financial institutions to QE practices, the empirical analysis is focused on five major types. Table 1 presents the types and the number of institutions included over the period studied.

**Table 1: UK financial institutions**

<i>Type of financial institution</i>	<i>Number of financial institutions</i>	<i>Label</i>
<i>Commercial banks</i>	76	<i>ComB</i>
<i>Private banking and asset management companies</i>	32	<i>PrivB</i>
<i>Real estate and mortgage banks</i>	43	<i>RealB</i>
<i>Investment banks</i>	42	<i>InvB</i>
<i>Bank holding companies</i>	20	<i>BkHo</i>
Total	213	

<sup>8</sup> Gambacorta and Iannotti (2007) found that the interest rate adjustment in response to positive and negative shocks is asymmetrical, in that banks adjust their lending rate faster during periods of monetary tightening.

**Note:** The table presents the types and the number of UK financial institutions included over the period studied. Bankscope divides financial institutions by specialization as follows: commercial banks, savings banks, investment banks, real estate and mortgage banks, cooperative banks, credit banks, Islamic banks, non-banking credit institutions, bank holding companies, central banks, specialized governmental credit institutions and multilateral government banks. In terms of the distinctions between the five different types presented in the table, commercial banks are regarded as financial institutions that are owned by stockholders pursuing various lending activities to increase their profits. Real estate and mortgage banks specialize in real estate lending. Investment banks are underwriters that serve as intermediaries between issuers of securities and the investing public. Private banking and asset management companies focus on the management of clients' current investments. Finally, bank holding companies own or control one or more banks.

Next, we rely on some statistical analyses to provide insights that can further motivate our analysis. The findings here are not decisive for the main conclusions of the paper, but they offer a preliminary perspective of on the data. Table 2 illustrates the mean and the standard deviation for the variables of interest by the type of UK financial institution. The idea behind this table is to examine whether the types of UK financial institutions with comparable averages have heterogeneous deviations from the mean.

**Table 2: Summary statistics of accounting ratios for UK financial institutions**

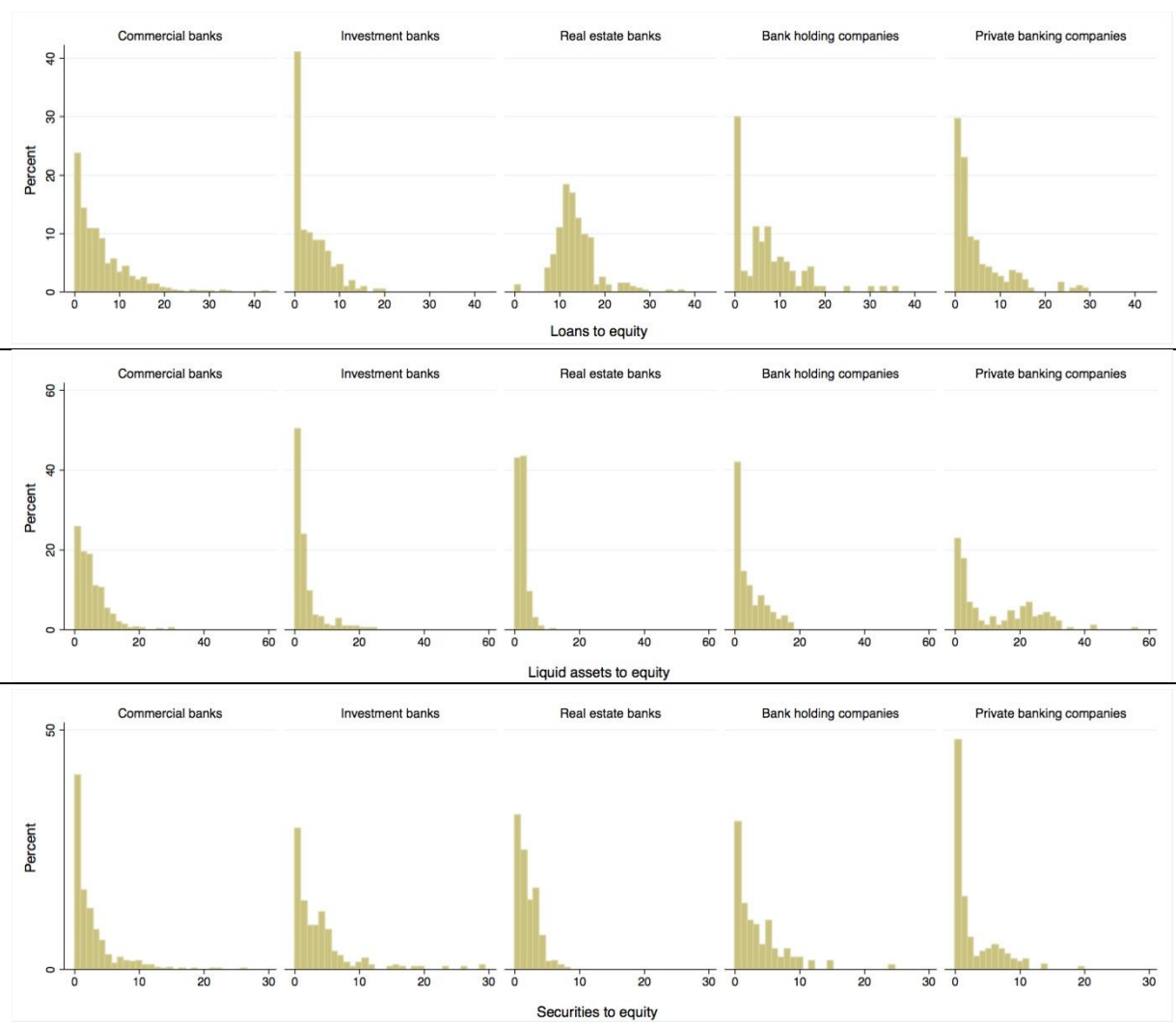
<i>Ratio</i>	<i>Commercial banks</i>		<i>Investment banks</i>		<i>Bank holding companies</i>		<i>Private banking companies</i>		<i>Real estate banks</i>	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
<i>Leverage</i>	13.51	9.27	10.86	8.01	15.03	11.07	19.47	10.49	17.79	5.52
<i>Loans to equity</i>	5.89	6.01	3.72	3.95	6.92	6.91	4.90	5.85	13.56	4.52
<i>Liquid assets to equity</i>	4.99	4.39	3.34	4.58	4.55	4.49	11.87	11.48	2.28	1.58
<i>Securities to equity</i>	2.62	3.41	3.80	4.79	3.56	3.83	2.70	3.38	1.95	1.58
<i>ROA</i>	0.68	1.99	1.13	5.15	1.94	3.66	0.83	2.16	0.39	0.37

**Note:** The table presents the summary statistics of the variables of interest for UK financial institutions, namely the leverage and its components *loans to equity*, *liquid assets to equity* and *securities to equity*, and the ROA. The panel illustrates the mean and the standard deviation of the UK financial institutions by type.

Comparing the results suggested in Table 2, we obtain some interesting findings. Firstly, there is a comparable (or close to) mean value between the types of financial institutions, although their deviations are highly heterogeneous, suggesting that distinguishing financial institutions by type and examining their partial contribution to the QE programme can play a

key role, because they all are quite sensitive to unconventional shocks but differ in their degree of sensitivity. Moreover, the heterogeneity of the leverage's components across the types of financial institutions indicates short-term liquidity stress. To provide further insights into the distribution of the leverage's components that can motivate the distinguishing of financial institutions by type, we derive histograms of the three components of leverage for the five types of UK financial institutions, as shown in Figure 1.

**Figure 1: Histograms of leverage's components by type of financial institution**



**Note:** The figure provides histograms of the three components of leverage, namely *loans to equity*, *liquid assets to equity* and *securities to equity*, for all the types of UK financial institutions.

The findings indicate strong evidence of heterogeneity between the different types of financial institutions across the components, indicating the handling of different processes for each type of financial institution, an element that is robust to our hypothesis not to consider all financial institutions within the same modelling framework. This adjustment is in line with the UK HM Treasury's report (2012), even though these measures are planned to enter into force in 2019 and therefore the effects will only become visible later on. When reviewing the *loans to equity* component, the majority of financial institutions have values below 10%, while there are outliers in all the types with values that exceed 20%. This implies that they promote a very aggressive growth strategy accompanied by a correspondingly increased insolvency risk. In the case of *liquid assets to equity*, there is evidence of a high value crossing the 40% level for a few cases of investment banks, real estate banks and bank holding companies, indicating that they have high-quality liquid assets that can be converted easily and immediately into cash. This fact can be confirmed by the results obtained for the *securities to equity* component; for these institutions, a high value of this component was registered, meaning that they deal with creditworthy securities with short-term maturities.

In 2010 the UK Financial Services Authority (FSA) again addressed the issue of liquidity, adopting a tighter regulation with the purpose of withstanding new stress scenarios and making the financial system more resilient to the major risks that placed pressure on the performance of UK financial institutions, such as the economic downturn, borrower defaults, pressures in funding markets, credit conditions and sovereign risk. At the minimum, the conditions for achieving this objective are higher spreads on lending activities and reduced leverage. Achieving these goals would imply a rebalancing of the financial institutions' funding profiles and a more focused approach on the activities that exploit their comparative advantage. In reality the transition determined a trade-off between deleveraging and revenue generation. Though, as shown in Figure 1, this regulatory framework had an impact,

particularly on commercial banks and bank holding companies, a large number of the institutions ensured a minimal level of liquidity.

### 3. Model setup

The panel VAR framework is a coherent approach to estimating interdependencies by treating all the variables as endogenous and allowing time lags across the variables. Recent relevant studies have used empirical panel VAR modelling frameworks with different structural identification approaches to address a variety of issues, such as the transmission of shocks across units, countries and time.<sup>9</sup> In a panel VAR framework, a cross-sectional dimension is added to the common VAR representation that may reveal additional information about interdependencies. Within the panel VAR approach, we obtain financial institutions' dynamic responses to shocks because of the model's ability to approximate complicated, interdependent adjustment paths with the time-series information. On the other hand, we can control for individual heterogeneity and specify the time-varying relationships between dependent and independent variables.

Without loss of generality, we illustrate the specification of our panel VAR framework, assuming one lag. Let  $y_{i,t}$  be the  $k_i \times 1$  vector of endogenous variables for each unit  $i$ ,  $i = 1, \dots, N$ . The  $k_i \times 1$  vector of endogenous variables takes the form  $Y_{i,t} = [y'_{1,t} \quad \dots \quad y'_{N,t}]'$ . The panel VAR is written as:

$$Y_{i,t} = A_{i,0} + A_i(l)Y_{i,t-1} + u_{i,t} \quad (1)$$

where  $A_{i,0}$  is the vector of all the deterministic common components (e.g., constants, seasonal dummies and deterministic polynomial in time) of the data for all units  $i$ ,  $t$  denotes the time parameter, where  $t = 1, \dots, T$ , coefficients  $A_i(l)$ , and  $u_{i,t}$  is the  $G \times 1$  vector of

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<sup>9</sup> The contributors, among other, are Canova and Ciccarelli (2009), Beetsma and Giuliodori (2011), Canova et al. (2012), Ciccarelli et al. (2013) and De Graeve and Karas (2014).

contemporaneously correlated random disturbances with zero mean and the non-singular variance–covariance matrix  $\Sigma_u$ .

Assuming that the data-generating process features dynamic homogeneity, the pooled estimation approach with fixed effects can be used to estimate the parameters of the model by potentially capturing idiosyncratic but constant heterogeneities across variables and units. However, if different assumptions are imposed in the model specification (e.g., for  $N$  and  $T$ ), the pooled estimation approach is biased. One way to overcome this difficulty is to employ the generalized method of moments (GMM) approach initially proposed by Arellano and Bond (1991). According to them, when the cross-sectional size (number of units, denoted as  $N$ ) is large,  $T$  is fixed and small and, given the fact that lagged regressors are used as instruments, the first assumption is derived by estimating the model parameters with the GMM procedure, which is consistent when  $T$  is small. Nevertheless, the GMM approach also requires differencing model specifications.

In this paper we impose two assumptions to obtain plausible results. The first assumption of the panel VAR framework derived herein is that cross-sectional heterogeneity and dynamic interdependencies are assumed by introducing fixed effects, thus allowing for time-variant individual characteristics.<sup>10</sup> Therefore, the panel VAR is characterized by dynamic interdependencies in which the lags of all endogenous variables of all units enter the model for every unit  $i$ , cross-sectional heterogeneity whereby innovations are correlated contemporaneously and where the intercept, slope and variance of the shocks  $u_{i,t}$  may be unit-specific. In this setting we impose a block structure on the matrix of contemporaneous

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<sup>10</sup> One way to address the implicit selectivity bias in our accounting data is to use fixed effects to ensure robustness in the empirical analysis in relation to non-random selectivity rather than the random-effects estimator.

coefficients (i.e., short-run restrictions) to compute the structural parameters prior to generating impulse response functions, based on the study by Frame et al. (2012).

Under the first assumption and a common set of  $L \geq k + l$  instruments, recall equation (1) in a compact form:

$$Y_t = Z_t A + U_t \quad (2)$$

where  $Y_t$  is the vector of the endogenous variables,  $Z_t = I_{NG} \times (A_0 \ y'_{i,t1})$ , which contains all the remaining deterministic common components of the data for all units  $i$ ,  $A = (A_i(l))' = (a'_i)'$  with  $Gk \times 1$  vectors, and  $U_t$  is the  $GN \times 1$  vector of innovations serially correlated contemporaneously with zero mean and variance–covariance matrix  $\Sigma_u$ . The individual heterogeneity is endorsed in the levels of the variables.<sup>11</sup> Subtracting the means of each variable calculated for each firm-year and introducing fixed effects eliminate any bank-specific time dummies that capture aggregate and global shocks that may affect all firms in the same way and preserve the orthogonality between the transformed variables. Since  $A$  varies with cross-sectional units, it depends on a lower dimension vector that prevents any meaningful unconstrained estimation. For a structural interpretation, we use the following standard linear accounting identity:

$$Y_t = \sum_j Z_t \gamma_j \vartheta_j + U_t + Z_t e_t \quad (3)$$

where  $Z_t \gamma_j$  can capture any potential common, unit-specific, variable-specific and lag-specific information in the regressors,  $\vartheta_j$  are factors that capture the determinants of  $A$  and  $e_t$  is the error term of the linearization. The decomposition allows us to measure the common and unit-specific influences for endogenous  $Y_t$ . Finally, the equation-by-equation GMM estimation yields consistent estimates of panel VAR, in which the joint estimation of the

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<sup>11</sup> Within this context, if the data-generating process features dynamic heterogeneity, both a within and a between estimator will give inconsistent estimates of the parameters, even when  $N$  and  $T$  are large, since the error term is also likely to be correlated with the endogenous regressors.

system of equations makes cross-equation hypothesis testing straightforward (Holtz-Eakin et al., 1988). To check the robustness of the GMM estimator, we test the optimal lag order in both the panel VAR specification and the moment condition using the moment and model selection criteria (MMSC) for GMM models based on the  $J$  statistic of over-identifying restrictions proposed by Andrews and Lu (2001).

The dynamics of the model can be investigated by impulse response analysis (*IRF*). The *IRFs* are informative for the shocks and interactions arising between the endogenous variables of the system. The standard errors of the impulse response functions and confidence intervals are generated using Monte Carlo simulations. The impulse response function is derived to one standard deviation shock to equation  $j$  corresponding to variable  $k$  at time  $t$  on the expected values of  $Y$  at time horizon  $t + h$ .

The second model assumption is identified as a restricted version of the panel VAR framework and examines the dynamic heterogeneity in the responses to shocks that may arise for different consistent formulations of the cross-sectional panel. Suppose that we run the model for one type of financial institution, denoted as  $d$ , from the full-panel sample. Comparing the impulse response functions obtained for the  $d$ -type financial institutions each time allows us to assess roughly the contribution of the  $d$ -type institutions. Therefore, the restricted vector to be estimated in equation (3) is now specified as:

$$Y_t^* = [y'_{1,d,t} \quad \dots \quad y'_{N,d,t}] \quad (4)$$

where  $Y_t^*$  is the  $k_{i,d} \times 1$  vector of endogenous variables for unit  $i$ ,  $i = 1, \dots, N$  and  $d$  denotes the type of financial institutions examined for the restricted model. In addition, suppose that we run the model excluding one of the variables in the full endogenous vector, denoted as  $(k_i - 1) \times 1$ . This form of the restricted model is obtained by the exclusion of the  $k$ -variable, and it can reveal the contribution of the omitted variable to the impulse response functions of the  $d$ -type restricted model. The restricted vector to be estimated in equation (4) is given as:



$$Y_{k,t}^* = [y'_{1,d,t}^{(k_i-1)} \quad \dots \quad y'_{N,d,t}^{(k_i-1)}] \quad (5)$$

where  $Y_{k,t}^*$  is now the  $(k_i - 1) \times 1$  vector of endogenous variables included in the restricted model setup for unit  $i$ ,  $i = 1, \dots, N$  and  $(k_i - 1)$ .

We estimate the panel VAR model repetitively for all the five major categories of financial institutions mentioned in Section 2, under the second model assumption. The cross-sectional interactions within the different types of financial institutions each time can reflect the extent to which the institutions are subject to QE imposed by the central bank. Finally, we expect that central banks pay particular attention to the performance of the components in the endogenous vector compared with all the other types of banks in conducting monetary easing policies, given their size, number and importance as traditional financial intermediaries.

#### **4. Empirical findings under the model setup**

In this section, we present the empirical results from the panel VAR model framework illustrated and discuss the implications associated with the present research questions. We start by selecting the optimal lag length for the panel VAR framework, using MMSC for the GMM models based on the  $J$  statistic of over-identifying restrictions (Andrews and Lu, 2001). The first-order lag specification is chosen to ensure no serial correlation of residuals in the VARX models after estimating the model. Finally, we bear in mind that, when computing the bootstrapped error bands by simulating the model, we use the sample covariance matrix, since the number of endogenous variables in our model is lower than the dimension of the time series included. Under the model assumptions, our panel VAR framework is repetitively estimated for all types and the  $d$ -type of UK financial institutions with the analysis focusing on IRFs (one standard deviation).<sup>12</sup>

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<sup>12</sup>Analysing the response of the financial sector to shocks resulting from the QE policy, it is implicitly assumed that the variables of interest respond within the period to the BoE QE policy. We simulate the model 5,000 times

#### 4.1. Quantitative easing impulses and transmission to GDP growth

We start the empirical analysis by setting the QE effect impulses and the transmission to the UK real GDP growth, as shown in Figure 2. The first important finding is the evidence that, during the period of the positive shock of QE, the profitability (indicated by *ROA*) of commercial banks and real estate banks is reduced significantly, highlighting their role, compared with the others. This finding is in line with Mamatzakis and Bermpei (2016), who identified a reduction in the profitability of US banks during quantitative easing implementation by the Fed.

However, the finding above also contributes to the ongoing debate (i.e., the separate banking system reported in the HM Treasury's report, 2012) by highlighting the significant difference across different types of UK financial institutions. This effect can be beneficial for the real economy when considering the effect of a positive shock of *ROA* on real GDP growth after one period for real estate banks, investment banks and commercial banks. In the case of real estate banks, there is a significant relationship between *ROA* and GDP growth with a one-year time lag. The reduction in their net interest margin may be attributed to the reduction in the lending rate, implying significant benefits for the real economy. Therefore, the above finding adds to the transmission channel of QE to the real economy via *ROA* for commercial banks and real estate banks.

Another significant finding derived from Figure 2 is the evidence that the positive shock of the QE coexists with the significant increase in the *securities to equity* for commercial

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to obtain confidence intervals and median estimates for the impulse responses. In addition, we perform forecast error variance decomposition (FEVD) analysis on the dynamics of the model setup under the model assumptions, derived after 5,000 runs. The FEVD is interpreted as the impact accounted for by innovations in each variable in proportion to the total impact of all the innovations reported over the horizon ahead selected. The results are not reported but are available to the reader on request.

banks and bank holding companies. The real GDP growth responds positively and significantly to a QE positive shock after one period. Therefore, these two types of banks may contribute to the UK real GDP growth because of their significant activity in terms of asset leverage. Moreover, the drop in *liquid assets to equity* for private banking companies and bank holding companies may contribute to the increase in the real GDP growth, given the response of the latter to a positive shock to the *liquid assets to equity* for these types of banks. Finally, the results of Figure 2 provide evidence that the positive shock of QE leads to a significant reduction in the lending rate with beneficial effects on the real GDP growth for all cases of financial institutions, amplifying the investors' mood, in line with the study by Lutz (2015).

### **Figure 2: Impulses of QE and transmission to GDP**

**Note:** The figure presents the responses of all the financial variables of interest to a quantitative easing shock. The thin black line represents the median estimate of the response. The shadow area around the median estimate line of the response represents the 95% confidence bands generated from 5,000 Monte Carlo bootstrap resamplings. To avoid any misunderstanding, we denote the leverage components, namely *securities to equity*, *loans to equity* and *liquid assets to equity*, as “Securities to Equity”, “Loans to Equity” and “Liquid to Equity”, respectively.

QE impulses for Commercial banks

GDP responses in case of Commercial banks

QE impulses for Investment banks

GDP responses in case of Investment banks

QE impulses for Real Estate banks

GDP responses in case of Real Estate banks

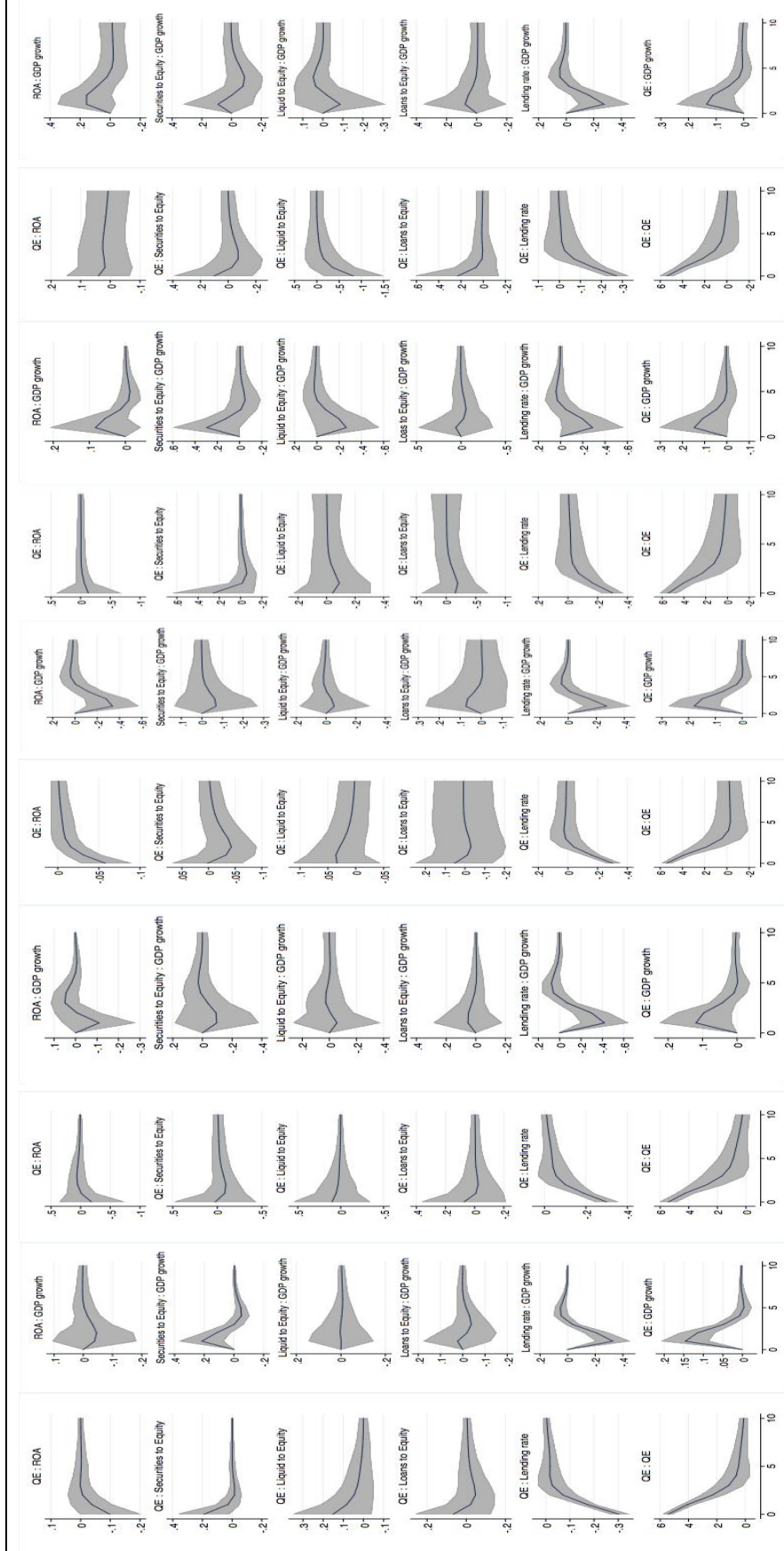
QE impulses for Bank Holding companies

GDP responses in case of Bank Holding companies

QE impulses for Private Banking companies

GDP responses in case of Private Banking companies

QE impulses for Private Banking companies

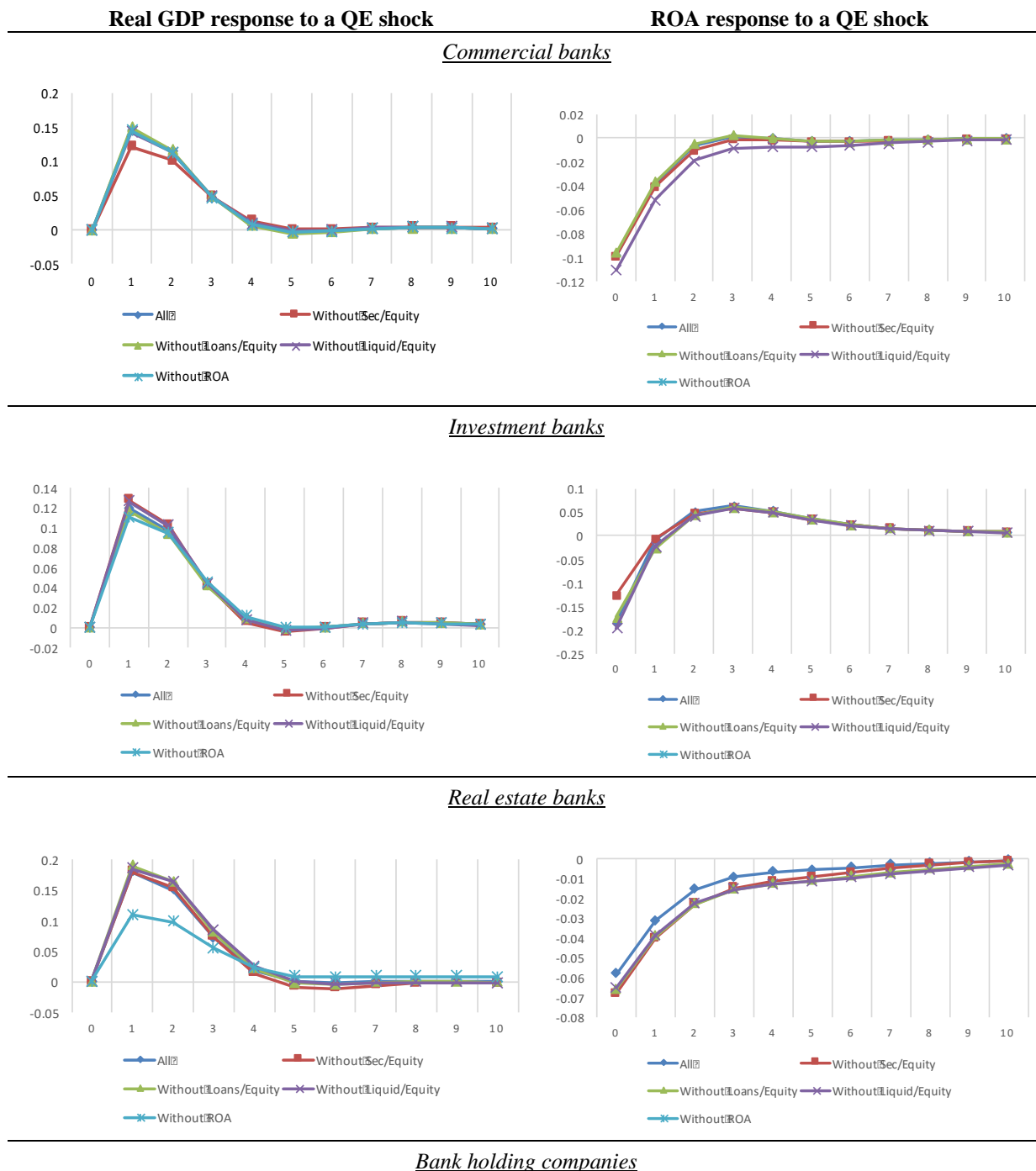


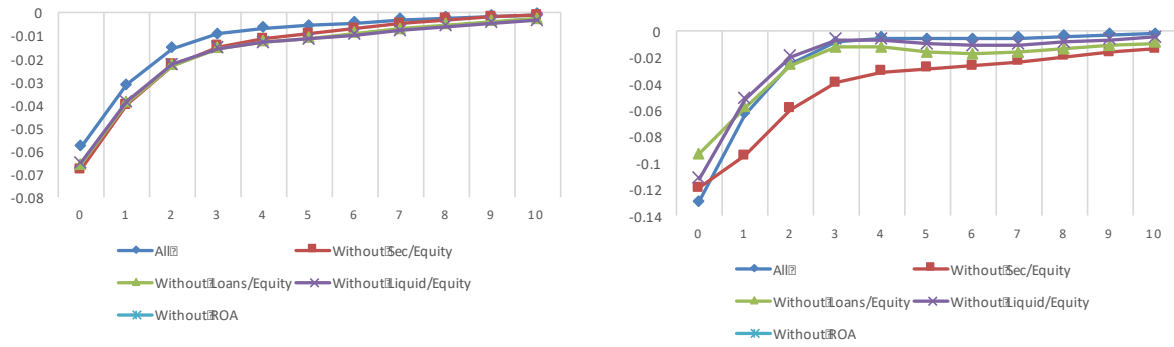
#### 4.2. The role of financial institutions' variables in the GDP growth response and QE shock

We further explore the role of financial institutions' variables in the effects of quantitative easing on the real GDP growth and on profitability. To do so, we repetitively estimate our panel VAR framework, by excluding each time one relevant variable of interest and comparing the responses with the ones from the full baseline framework. Figure 3 presents the results associated with this question. The main finding of our analysis is that the leverage component *securities to equity* amplifies the effect of a QE shock on the real economic activity for bank holding companies and to a less degree for private banking companies and commercial banks. In the case of real estate banks, the effect of a QE shock on GDP growth is much less positive with the exclusion of profitability (*ROA*). Therefore, the transmission of quantitative easing decisions on real activity passes through the effect on *ROA* of real estate banks.

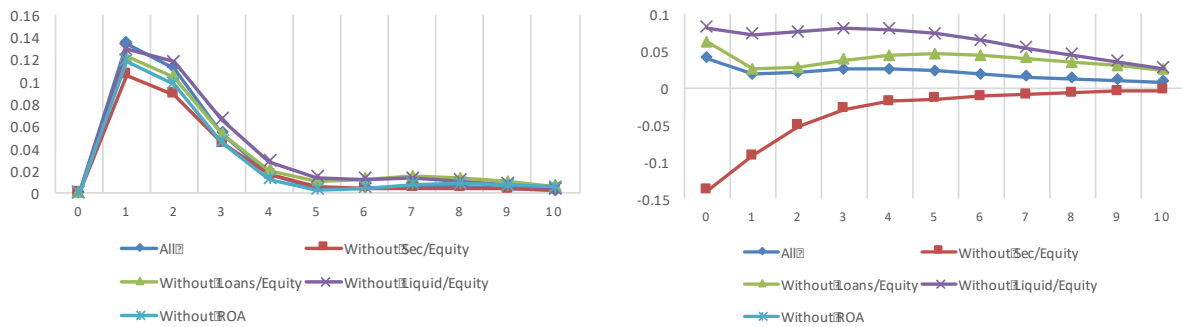
The monetary policy makers keep the net interest margin low for the case of real estate banks, which may add to the efficiency of the transmission of the monetary policy to the real economy. In the majority of the cases, the *ROA* responses to a positive QE shock are negative with the exception of the private banking companies. However, when the *securities to equity* are omitted, the *ROA* also responds in the same manner for this type of financial institution, following the others' *ROA* response to QE. Therefore, the leverage component *securities to equity* is of great importance, providing a tool to the private banking companies to avoid experiencing a significant reduction in their profitability. In the case of the bank holding companies, the same leverage component has a beneficial effect by reducing the negative effect of QE on *ROA*. These results have significant implications for bank managers when facing a significant easing monetary policy. A well-diversified bank strategy to interest and non-interest income activities may reduce the negative effect of a QE strategy on bank profitability.

**Figure 3: Responses of the real GDP and ROA to a positive QE shock – Identifying the role of omitted variables for the types of financial institutions**





Private banking companies



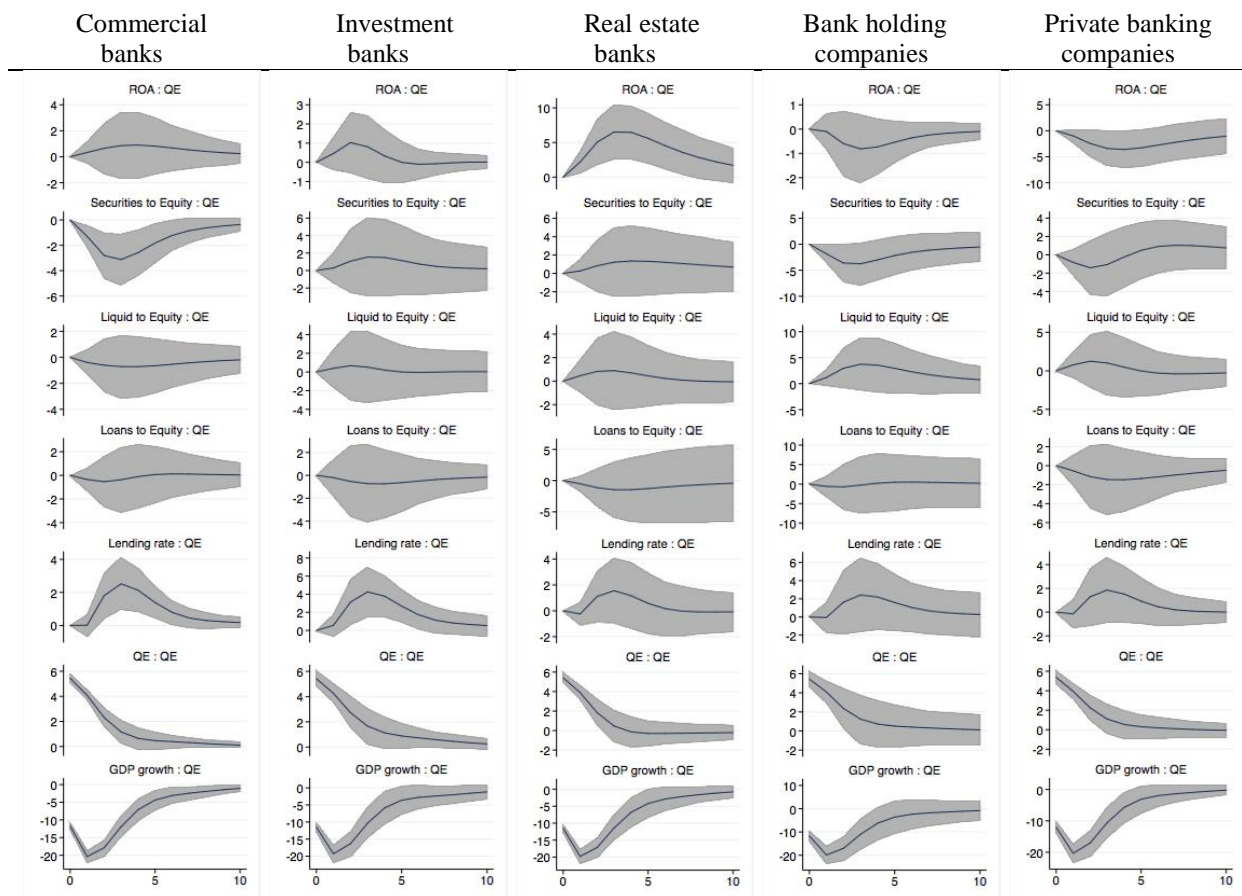
**Note:** The figure presents the responses of the real GDP and ROA to a positive QE shock for 10 period-horizons ahead. The blue line with rhombuses represents the sample containing all financial institutions, the red line with squares represents the sample when *securities to equity* (denoted as Sec/Equity) are excluded, the green line with triangles represents the sample when *loans to equity* (denoted as Loans/Equity) are excluded, the purple line with two-ray asterisks represents the sample when *liquid assets to equity* (denoted as Liquid to Equity) are excluded and the light blue line with three-ray asterisks represents the sample when the *ROA* is excluded. Statistical significance is obtained from 5,000 Monte Carlo bootstrap resamplings.

*4.3. Does the QE policy respond to shocks of leverage and profitability?*

Figure 4 shows the responses of the BoE QE policy to leverage and profitability. The findings illustrate that the BoE reduces asset purchases when a positive growth shock occurs and increases asset purchases when a positive lending rate shock takes place. Looking into the financial institutions' variables, we observe a significant reduction of asset purchases as evidence after a positive shock to the leverage component *securities to equity* for commercial banks. The same finding holds for bank holding and private banking companies but with the absence of the statistical significance. Our findings also provide evidence that the BoE seems to be interested in the increased profitability of real estate banks given their importance to the lending activity and its effect on the real economy. The response of the *QE* variable is

positive after a positive shock to profitability for the real estate banks to reduce the lending rates and to help boost the economy, given the significant role of this type of financial institution in housing lending.

**Figure 4: The BoE QE policy response to leverage and profitability**



**Note:** The figure presents the response functions of QE to all types of macroeconomic and financial shocks. The thin black line represents the median estimate of the response. The shadow area around the median estimate line of the response represents the 95% confidence bands generated from 5,000 Monte Carlo bootstrap resamplings. To avoid any misunderstanding, we denote the leverage components, namely *securities to equity*, *loans to equity* and *liquid assets to equity*, as “Securities to Equity”, “Loans to Equity” and “Liquid to Equity”, respectively.

#### 4.4. Does economic activity affect leverage and profitability?

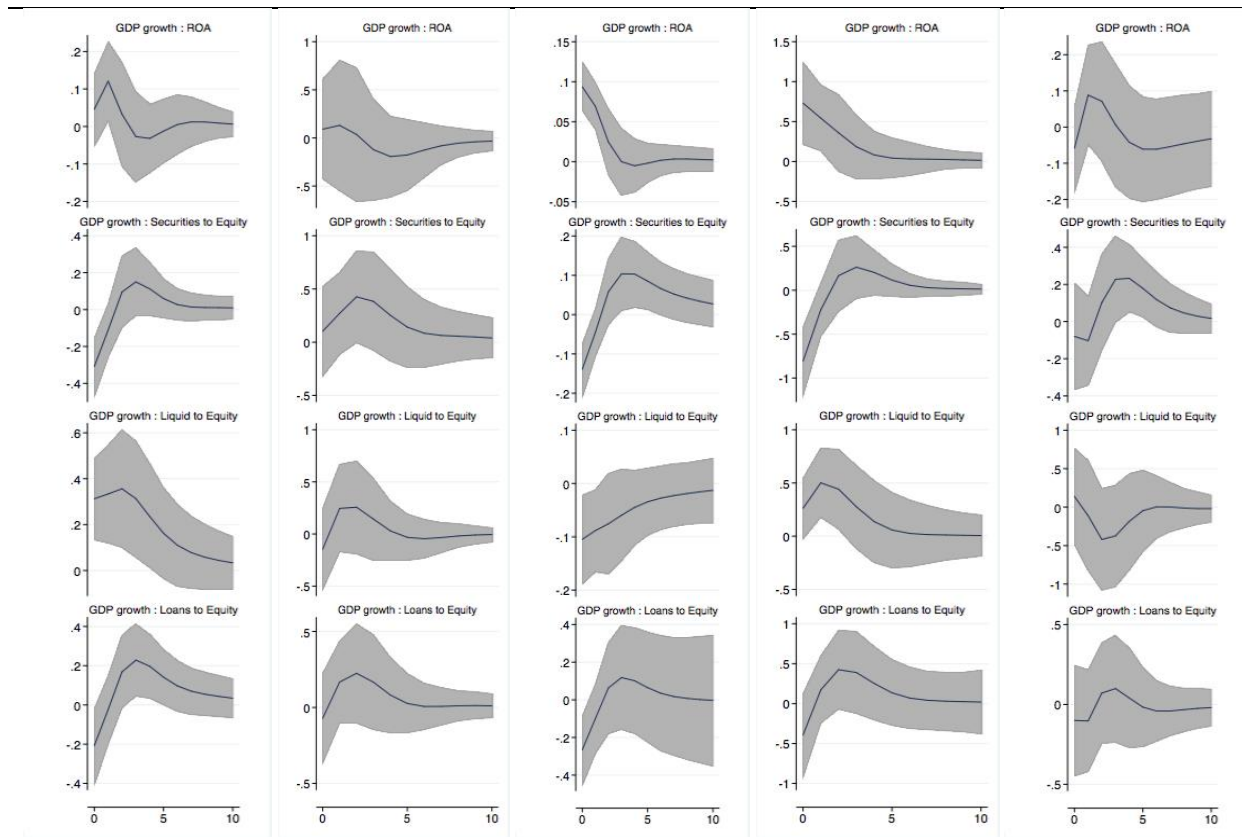
We address this question by testing the impulses of real GDP growth to the financial institutions’ variables of interest. Figure 5 illustrates the results of the IRFs for all the types of financial institutions. The findings are of great interest and indicate a number of aspects. Real GDP growth has a major positive effect on real estate banks’ and bank holding companies’



profitability and to lesser extent on the profitability of commercial banks and private banking companies (first row of Figure 5). The second main finding is that a negative shock to the real GDP growth may increase the *securities to equity* for three out of five types of financial institutions, namely commercial banks, real estate banks and bank holding companies (second row of Figure 5). Moreover, the leverage component *loans to equity* increases after a negative GDP growth shock for the real estate and commercial banks, adding to their leverage. The *liquid assets to equity* are reduced in the case of a negative GDP growth shock for commercial banks and bank holding companies, adding more to their risk profile, while for real estate banks it is increased, lowering their risk profile. Our results imply that risks are undertaken when the economic conditions are worse. This is especially apparent for commercial banks and bank holding companies. By increasing their leverage, these institutions hope to resist a potential reduction in their profitability due to low economic activity. However, this may increase their risk significantly, given that poor conditions in the economic environment lead them to losses. Even though the monetary authorities are afraid of deleverage over weak economic growth, they should take measures for bank capital adequacy due to a possible worsening of the economic conditions.

**Figure 5: Effect of economic activity impulses on leverage and profitability**

Commercial banks	Investment banks	Real estate banks	Bank holding companies	Private banking companies
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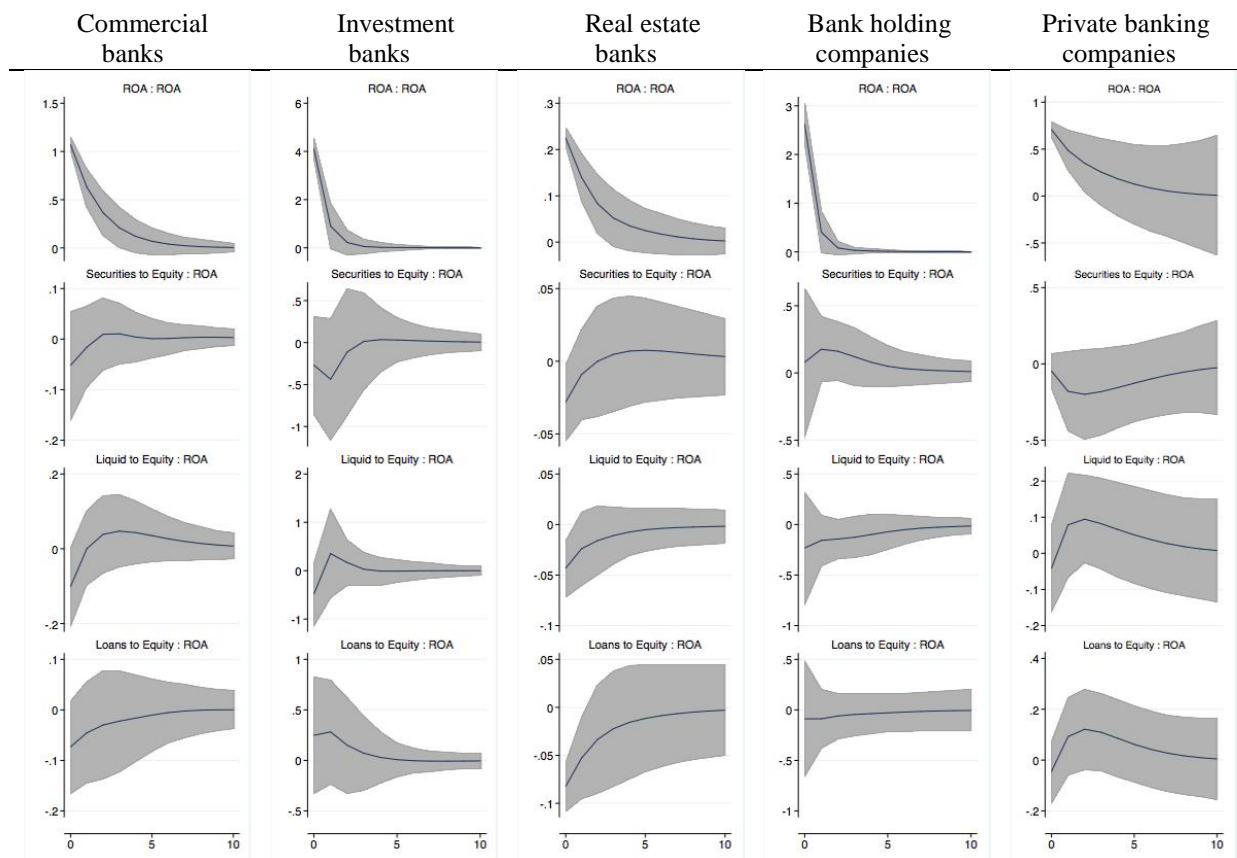
**Note:** The figure presents the profitability (*ROA*) responses to a shock from the three components of leverage, across the different types of UK financial institutions, for 10 period-horizons ahead. The thin black line represents the median estimate of the response. The shadow area around the median estimate line of the response represents the 95% confidence bands generated from 5,000 Monte Carlo bootstrap resamplings. To avoid any misunderstanding, we denote the leverage components, namely *securities to equity*, *loans to equity* and *liquid assets to equity*, as “Securities to Equity”, “Loans to Equity” and “Liquid to Equity”, respectively.

#### 4.5 Does profitability respond significantly to leverage components’ shocks?

Next in our analysis we notice some interesting aspects by comparing the magnitude across the financial institutions’ variables (i.e. profitability and leverage components). We start by examining whether the leverage undertaken increases the profitability. Figure 6 illustrates our findings of *ROA* responses to leverage shocks for the different types of financial institutions. The majority of our results indicate that there is no evidence of increased profitability due to a leverage shock. A positive shock to the leverage components reduces significantly the *ROA* of real estate banks. This finding implies that increased leverage leads to non-profitable risky activity. A positive shock to *loans to equity* has a positive but statistically not significant effect on *ROA* only for the cases of investment banks

and private banking companies. Based on this finding, managers may have additional information regarding the extent to which an increase in loans to equity contributes to bank profitability.

**Figure 6: ROA responses to leverage components' shocks**



**Note:** The figure presents the profitability (*ROA*) responses to a shock from the three components of leverage, across the different types of UK financial institutions, for 10 period-horizons ahead. The thin black line represents the median estimate of the response. The shadow area around the median estimate line of the response represents the 95% confidence bands generated from 5,000 Monte Carlo bootstrap resamplings. To avoid any misunderstanding, we denote the leverage components, namely *securities to equity*, *loans to equity* and *liquid assets to equity*, as “Securities to Equity”, “Loans to Equity” and “Liquid to Equity”, respectively.

In this last in-depth step of our analysis, we examine the interaction of the leverage components and the effect of *ROA* on these components. The findings are presented in Figure 7 (panels A, B and C). The results of panel A in Figure 7 show some interesting aspects. First, the higher the profitability for commercial and real estate banks, the higher their leverage component *securities to equity*. A significant decrease in liquidity leads to higher

*securities to equity* for all the types of financial institution, implying a substitution effect between liquidity and securities. Another interesting finding is the positive significant response of *securities to equity* on *loans to equity* for three out of four types of financial institutions. Among them, the highest response is presented by investment banks, followed by commercial banks, bank holding companies and real estate banks. Consequently, when a significant amount of loans is given over equity, then a significant amount of securities is also bought in terms of equity. Therefore, these two leverage components are complementary for these types of financial institutions. Increased lending to the real economy may be used as a signal of the trend in security markets driven primarily by the main types of financial institutions.

We present the response of *loans to equity* to the rest of the banking variables' shocks in panel B in Figure 7. There is evidence of a unidirectional effect from *loans to equity* to *securities to equity* shocks for all the types of financial institutions. This finding implies that the leverage in *securities* is complementary to the leverage in loans. Considering profitability effects, higher returns on assets lead to higher *loans to equity* with the exception of bank holding companies. A positive shock to liquidity leads to higher loans after three to four periods ahead for real estate banks and lower loans for investment banks. The implications arising from this finding are of great importance, because it indicates the different behaviour of the different types of financial institutions in managing their liquidity usage. Real estate banks, in contrast to investment banks, make a greater contribution to economic growth, leaving space for a discretionary policy by the BoE.

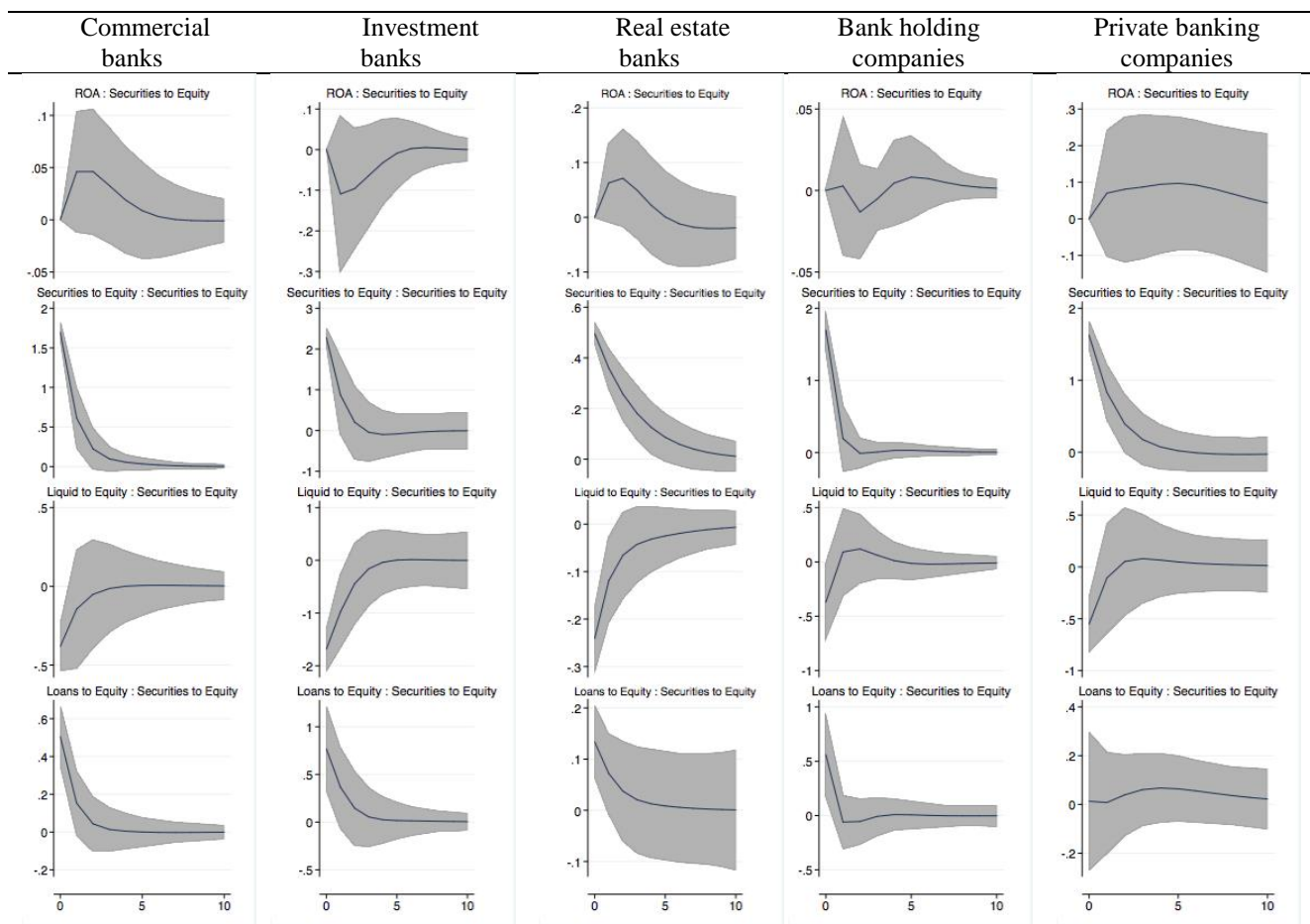
We finally turn our analysis to the liquidity impulses and responses. The results are shown in panel C in Figure 7. Two main findings emerge from this panel. We note that a positive shock to *loans to equity* leads all the types of financial institutions to increase their cash holdings. However, in the case of real estate banks, the response of *liquid assets to equity* to

*loans to equity* fades out smoothly and slowly, without being statistically significant after the third period ahead. The second finding is the positive response of *liquid assets to equity* to a positive shock to *securities to equity* for investment banks. This finding implies a higher level of conservatism than other types of financial institutions, a finding that is also presented to a lower degree for commercial banks. When the leverage component of securities is increased, it is followed by a higher level of cash holdings, while profitability shocks do not statistically affect profitability.

**Figure 7: Leverage impulse responses and profitability shocks**

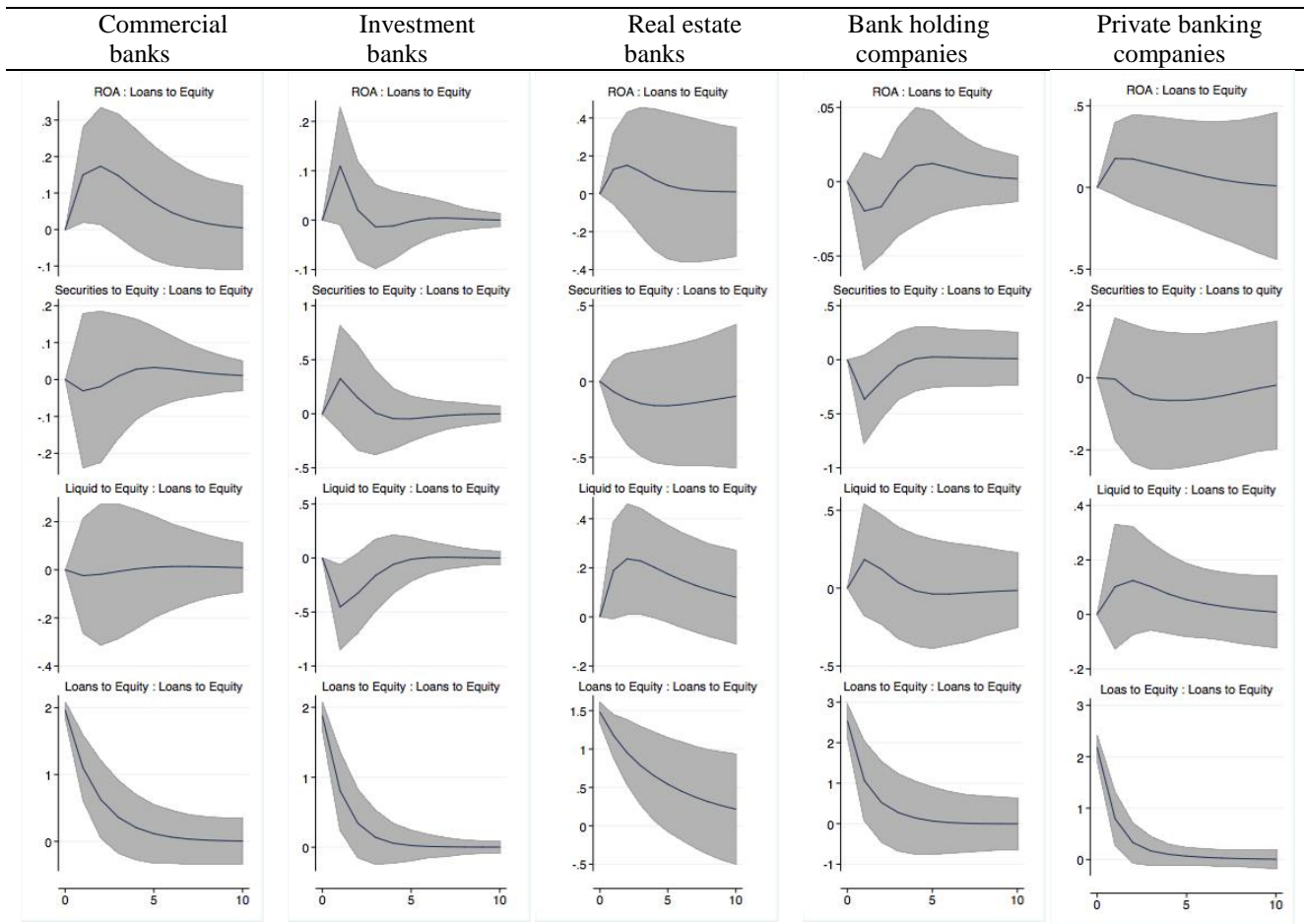
**Panel A**

**Securities to equity responses to leverage components and profitability shocks**



**Panel B**

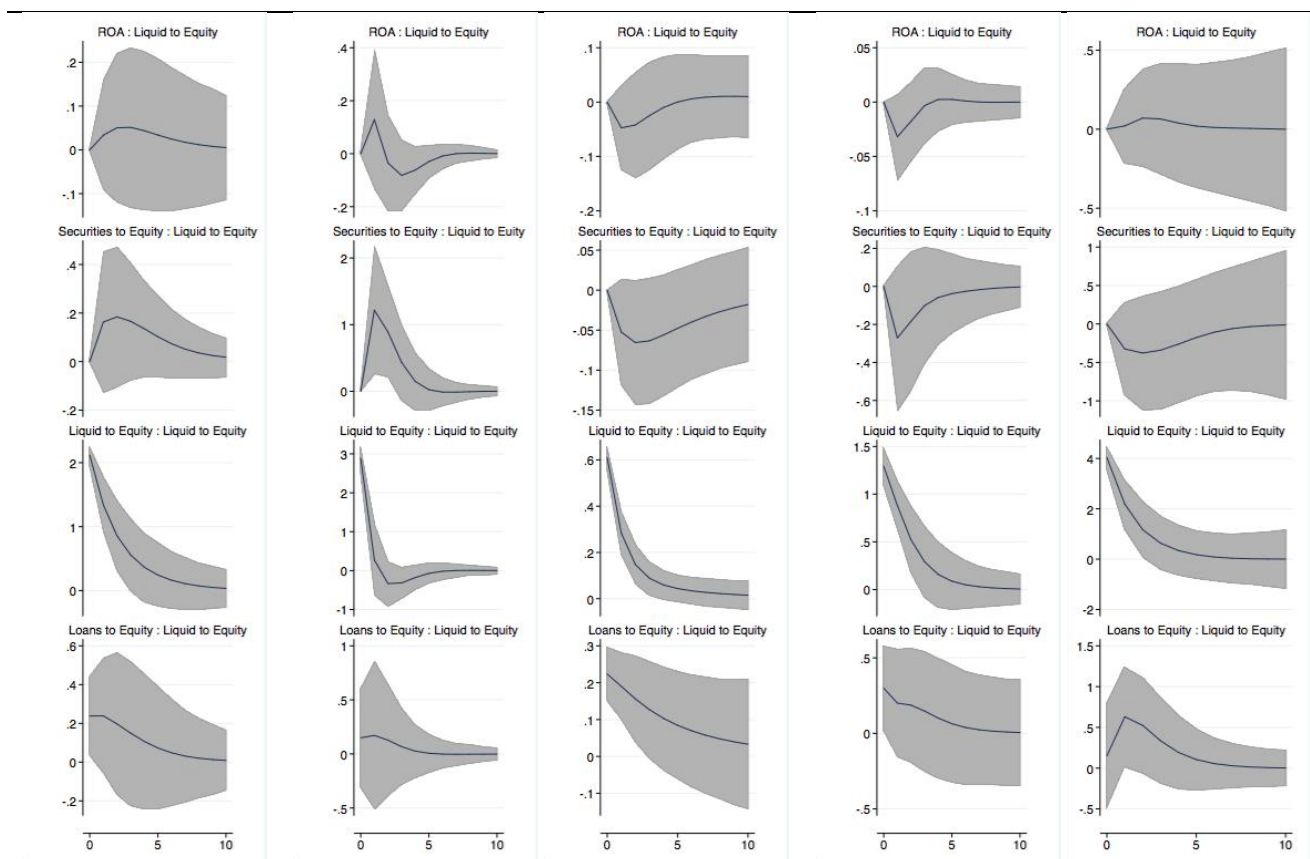
**Loans to equity responses to leverage components and profitability shocks**



**Panel C**

**Liquid assets to equity responses to leverage components and profitability shocks**

Commercial banks	Investment banks	Real estate banks	Bank holding companies	Private banking companies
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**Note:** The figure (panels A, B and C) presents the interaction between the profitability (*ROA*) and the three components of leverage, across the different types of UK financial institutions, for 10 period-horizons ahead. The thin black line represents the median estimate of the response. The shadow area around the median estimate line of the response represents the 95% confidence bands generated from 5,000 Monte Carlo bootstrap resamplings. To avoid any misunderstanding, we denote the leverage components, namely *securities to equity*, *loans to equity* and *liquid assets to equity*, as “Securities to Equity”, “Loans to Equity” and “Liquid to Equity”, respectively.

## 5. Conclusion

Considerable efforts have been made by the central banks in recent years to provide effectively a sufficient monetary stimulus to their economy during the recent global and domestic downturns and ensure the sound functioning of financial sectors. In the UK the financial institutions are the main collectors of funds and suppliers to the non-financial and households’ sectors; therefore, a strong understanding of the UK financial institutions’ role during the implementation of the BoE QE strategy is vital, because it raises a series of concerns regarding the economic spin-off that could be triggered by these monetary policy decisions. The paper gauges how the different types of UK financial institutions’ leverage

responded to the incentives determined by the QE decisions realized in BoE asset purchases, using a panel VAR framework.

We find that QE decisions are driven mainly by real economic activity, lending rates and to a diverging degree the leverage components with different effects on the five main types of UK financial institutions. The findings highlight the crucial role played by commercial banks in explaining these interrelationships. When the BoE proceeds to instigate a positive shock to asset purchases, the financial institutions' profitability is significantly reduced. Turning to the relationship between an unconventional monetary policy and the financial institutions' leverage, we find that QE rounds seem to have a positive effect on the leverage components, implying riskier behaviour during QE rounds for busting the real economy.

The quantitative easing policies aim to increase the money supply by inundating financial institutions with capital in a struggle to encourage lending and implicitly liquidity. Our study shows that, during the implementation of the QE strategy, the leverage of the banking sector is increased. This implies a signal of credit easing conditions that disappeared during the involvement of the financial crisis. The decrease in banks' profitability implied negative signals from the financial sector to the monetary authorities to reduce unconventional easing strategies and assess financial stability, which is the main goal derived from these policies. Moreover, given the high uncertainty and low interest rates, the heightened risk-taking behaviour of financial institutions as a response to a possible restraint on their policy choices can be observed. This pro-risk attitude has high potential to influence the market price of risk in the economic system. Likewise, a higher level of risk affects the financial sector's stability and soundness, particularly if the additional risk is condensed in systemically important financial institutions. As a result, these issues accentuate the policy makers' concerns related to the limitation of financial institutions' risk-taking behaviour.



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