POST 2007 CRISIS UNCONVENTIONAL MONETARY POLICY IN THE UK

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Abstract

The main focus of this PhD thesis is to investigate the unconventional monetary policy tools introduced by the Bank of England (BoE) in its response to the recent financial crisis and to analyse its impact on the UK economy and especially the banking sector. The thesis consists of four chapters; an introductory chapter and three self-contained chapters.

The **first chapter** mainly inspects the types and the sizes of the *unconventional* interventions of the monetary authorities in the UK, the US, and the EU after the collapse of Lehman Brothers in 2008. It also describes the transmission channels through which the impact of the unconventional monetary policies is delivered into the wide economy, and includes a survey of the literature of quantitative easing.

The **second chapter** employs a flow of funds (FOFs) analysis based on Godley and Lavoie (2007) balance sheet framework using ONS sectoral data for the period between 2007 and 2011. It focuses on two distinct sub-periods (2007-2008 and 2009-2011) to assess the initial effects of mid-2007 financial crisis on the UK economy and examine the influence of BoE's asset purchase program (APP) on the sectoral financial positions in the main financial asset categories. The analysis implicates five main results. First, APP was unsuccessful in expanding bank lending which dropped by about £208 billion in the 2009-2011 period. Second, APP might have positive effects on debt securities and equity prices and hence consumer wealth. Third, through reducing the cost of borrowing, it appears that APP induced the majority of sectors to issue more debt securities. Fourth, after the introduction of APP early in 2009, several sectors relied more on equity rather than debt capital. Finally, domestic productive sectors (NFCs, MFIs, OFIs, and INSs) showed some *abroad* bias and sent massive amounts of money out of the country.

The **third chapter** explains the drop in total bank lending after the introduction of APP from an agent-based computational economics (ACE) point of view. The baseline model contains four types of agents -households (HHs), big firms (BFs), small and medium enterprises (SMEs), and banks-. These agents interact monthly for a period of 50 months in an environment that simulates bank lending markets in the UK after

APP was introduced in 2009. The ACE model is anchored to the actual values of several variables -such as homeownership statistics and nonfinancial firms leverage ratio- around the time of the program initiation. The lower bond yields caused by APP encourage BFs to substitute bank borrowing with security debt (bonds). In addition, the risk weight regime of Basel capital adequacy requirements induces banks to favour mortgages over business loans to SMEs. My analysis contrasts the implications on bank behaviour of Basel III capital adequacy requirements (scenario 3) with Basel I (simple capital adequacy requirements with no risk weights) and the case of no capital requirements (scenarios 1 and 2 respectively). The scenario analysis shows that in the absence of risk weighting (i.e. scenarios 1 and 2), both lending to SMEs and total lending would have been higher. The combination of lower bond yields and Basel III capital adequacy requirements on banks appears to play a role in the drop in the amount of bank loans to businesses. Similar to the actual data, simulation results indicate that the rise in the amount of mortgages was not enough to counter the decrease in business loans which represents the main cause of the shrinkage in total bank lending.

The **fourth chapter** tries to analyse the same issue of falling bank lending after APP introduction using a three-sector DSGE model. The main results show that a negative shock in gilts yield -initiated by massive asset purchases under the program- induces big unrestricted firms to shift from bank borrowing to security debt (bonds). The fall in BFs bank borrowing decreases the share of the loans to BFs in banks asset compositions and hence increases the amount of risk weighted assets. Induced by Basel III capital requirements, banks start to adjust their portfolios to accommodate more mortgages and less loans to small and medium enterprises (SMEs). The analysis of the role of capital adequacy requirements points out that while the introduction of strong enough capital requirements decreases the risks in the banking system, it may deprive the bank financing from SMEs.

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Chapter 1

Post Crisis Unconventional Monetary Policy in the UK, the US, and the EA

Abstract

This chapter inspects the types and the sizes of the *unconventional* interventions of monetary authorities in the UK, the US, and the EU after the collapse of Lehman Brothers in 2008. It also describes the transmission channels through which the impact of the unconventional monetary policies is delivered into the wide economy, and it includes a survey of the literature of quantitative easing.

The main findings can be summarized in three key points. First, the central banks of the UK, US and the Euro Area have employed asset purchase programs of different flavours and bought substantial amounts of different financial assets; mainly debt securities. Second, these asset purchases have led to a vast growth in the total assets of the Bank of England, the Federal Reserve and the Euro System which, in turn, reflected mainly on the size of commercial banks reserves with these central banks. Third, if the bank lending channel were to work, there should be a wide expansion in the size of the bank lending. However, the data suggests that there have been slight increases in commercial banks' credit relatively to the rises in amounts of reserves with the central banks. Accordingly, the bank lending channel seems to be blocked or not working for some reason or another.

1.1 Introduction

The recent global economic crisis, which originated in the US, was the outcome of several serious problems in the global economic and financial systems such as the absence of proper supervision over the financial system, massive amounts of credit created, and the build-up of bubbles in different asset markets. These problems produced a number of essential points about crisis management and prevention approaches and opened a door for policy makers and market members to absorb important lessons. The deeper investigation of the causes of the crisis raises interesting questions concerning the role public entities (central banks, governments, and supervision bodies) play to sustain financial stability, the effectiveness of the available policy measures, the operational framework of the financial markets, and the participation of different financial institutions in the spread of the crisis.

Due to its major impact on the different parts of the economy, the monetary policy is considered to be a crucial component of any effective response to any crisis. This policy can, through numerous channels, influence both economic growth and short-term stabilization. However, "the experience in developing countries shows that the traditional monetary policy, with its primary focus on price stability and static market efficiency, has inherent contradictions with realities for sustaining pro-growth policies needed for achieving the objectives of macroeconomic stability, rapid growth, and poverty reduction" (Mujeri (2009)). The mid-2007 financial crisis forced the central banks of different developed countries to loosen the monetary policy by decreasing interest rates to record levels. In the UK, for example, the Monetary Policy Committee (MPC) of the Bank of England (BoE) decreased the short-term policy rate to 0.5% in March 2009. However, this massive easing in monetary policy was not enough to strengthen aggregate spending. Consequently, central banks started to use the unconventional monetary policy tools to stimulate the economy. In order to pump further liquidity into the market, the central banks began to expand their holdings of longer term assets especially governmental and higher rank companies' bonds and mortgages. This measure, which is so-called quantitative easing (QE), aimed to inject more money into the economy and stimulate nominal spending by increasing asset prices (and consumers' wealth in effect) on the one hand and decreasing the cost of borrowing on the other.

After the collapse of Lehman Brothers in fall 2008, the central banks of the UK, The US, and the Euro Area (EA hereafter) lunched enormous longer term asset purchase programs which have had very important implications on the size and the composition of central banks' balance sheets, money aggregate measures, and the consolidated balance sheet of the commercial banking system. Since its introduction early in 2009 and until November 2012, the BoE's asset purchase program (APP) had been expanded many times to reach the current level of £375 billion. Meanwhile, the Federal Reserve (Fed) had employed three Large Scale Asset Purchase (LSAPs) programs (QE1, QE2 and QE3) with more than $2.2 trillion in value since late November 2008. Until the last quarter of 2014, the asset purchase programs of the European Central Bank (ECB) launched in mid-2009 have been relatively narrower because of the ECB major dependence on its Long Term Refinancing Operation (LTRO) programs to provide liquidity to banks. ECB initially used two types of asset purchase programs (with total value of about €284.9 billion): two Covered Bonds Purchase Programs (CBPPs: CBPP1 and CBPP2) which covers credit institutions' securities, and Securities Markets Program (SMP) which includes purchasing securities of other debt securities issuers (mainly the central governments of the EA Member States). All the three programs were terminated by the end of October 2012. However, between October 2014 and March 2015, the ECB introduced a new and larger set of asset purchase programs. This included the third wave of CBPPs programs (CBPP3), the asset-backed securities purchase program (ABSPP), and the public sector purchase program (PSPP). The data of the three central banks' balance sheets reveals vast expansions in the size of the total assets due to the large asset purchase programs mentioned above. However, the figures on the liabilities side of these balance sheets indicate to an interesting conclusion: a significant portion of the money, which is supposed to be pumped out using asset purchase programs, returned to the central bank balance sheets in the shape of excessive commercial banks reserves. Table 1.1 shows the amounts of money pumped out using asset purchases in the UK, US and EA, whereas Table 1.2 displays increases in banks reserves after the introduction of these programs (between late-2008 and mid-2009) by the end of November 2012.

Table 1.1: The Amounts of Asset Purchases under Quantitative Easing and in the UK, US and EA

UK Asset Purchase Program		US LSAPs[1]		ECB Asset Purchase Programs			
Program	**Amount**	**Program**	**Amount**	**Program**	**Amount**	**Program**	**Amount[6]**
		QE1	$1550 Billion	CBPP1[2]	€60 Billion	CBPP3[2]	€143.9 Billion
APP	£375 Billion	QE2	$600 Billion	CBPP2[2]	€16.4 Billion	ABSPP[4]	€15.4 Billion
		QE3	$80 Billion	SMP[3]	€208.5 Billion	PSPP[5]	€499.9 Billion
Total	£375 Billion	**Total**	$2,230 Billion	**Total**	€284.9 Billion	**Total**	€659.2 Billion

[1] LSAPs: The Federal Reserve's Large Scale Asset purchase programs.
[2] CBPP1, CBPP2, and CBPP3: the ECB's Covered Bonds Purchase Programs 1, 2, and 3.
[3] SMP: the ECB's Securities Markets Program.
[4] ABSPP: the ECB's Asset-Backed Securities Purchase Program.
[5] PSPP: the ECB's public sector purchase program.
[6] The total amounts of asset purchased under CBPP3, ABSPP, and PSPP as of 08/Jan/2016.

Table 1.2: Expansions in Banks Reserves with Bank of England, Federal Reserve, and the Euro System after the Introduction of QE

	Bank of England[1]	Federal Reserve[2]	Euro System[3]
Extra Bank Reserves Added after the Introduction of Asset Purchase Programs	**£250.309 Billion**	**$932.922 Billion**	**€466.546**

[1] the change in the size of reserve balances with the Bank of England between 04/03/2009 and 21/11/2012.
[2] the change in the size of reserve balances with the Federal Reserve between 26/11/2008 and 28/11/2012.
[3] the change in the size of reserve balances with the Euro System between 01/07/2009 and 27/11/2012. As we can see here, the increase in the size of bank reserves with the Euro System is bigger than the total value of the longer term assets purchased under CBPP1, CBPP2, and SMP. This because the European Central Bank launched Long Term Refinancing Operation (LTRO) programs that aim to provide liquidity to the credit institutions through direct loans. Afterward, bank reserves witnessed a steady decrease until the end of January 2015 (they were €243.754 billion), then started to expand quickly by about €530 billion in less than a year (€773.697 billion) because of the launch of the new asset purchase program repeating the trend after the launch of the first wave of asset purchase programs.

The remaining of this chapter is organised as follows. Section 1.2 describes the transmission channels through which the impact of the unconventional monetary policies is deliver into the wide economy, whereas section 1.3 includes of a survey of the literature of QE. Section 1.4 investigates the types and the sizes unconventional monetary interventions in the UK, the US, and the EU after the fall of Lehman Brothers in 2008. Lastly, section 1.5 concludes.

1.2 Transmission Channels for Unconventional Monetary Policy Tools

Generally, monetary policy exerts its influence on the economy through affecting financial assets prices and returns. At times where short-term policy rate is virtually zero, conventional monetary policy tools become ineffective, but this does not mean that monetary authorities can do nothing to motivate the economy. According to Bernanke and Reinhart (2004), there are three strategies to stimulate the economy in situations similar to post-financial crisis settings: (i) committing to keep future short-term interest rates lower than they are currently expected, (ii) changing the structure of central bank balance sheet to affect the relative supply of different financial assets in the market, and (iii) expanding the monetary base beyond the size required to maintain zero short-term policy rate (or QE).

i. Influencing Future Interest Rates Expectation:

The current yields of longer maturities financial assets (such as shares and gilts) depend partly on investors' expectations of the path of short term-interest rates in the future. For example, if the yields of one-year and two-year gilts are 5% and 10% respectively, this means that investors expect the yield of one-year gilts to be 15.5% one year from now. As a result, we can affect assets yields and prices by influencing investors' expectations of short-term interest rates in the future. The central bank might do this by promising to keep short-term policy rate at or near zero for some time, and hence affect expected short-term interest rates in the future.

In our example, if the central bank promise to keep short-term policy rate at its current level for two years, the expected yield of one year gilts next year becomes 5% (instead of 15.5%). Consequently, the current yield of two-year gilts decreases from 10% to 5%. Bernanke and Reinhart (2004) point out that the commitment of the central bank to low short-term policy rate can be unconditional (for some period of time) or conditional in the sense that it is linked to some economic conditions. An example of conditional commitment can be found in the Japanese experience of unconventional monetary policy tools when the Bank of Japan (BOJ) promised to maintain low short-term interest rates until "core" CPI growth rate became stably zero or positive (Ugai (2006)).

ii. Changing the Composition of Central Bank's Balance Sheet:

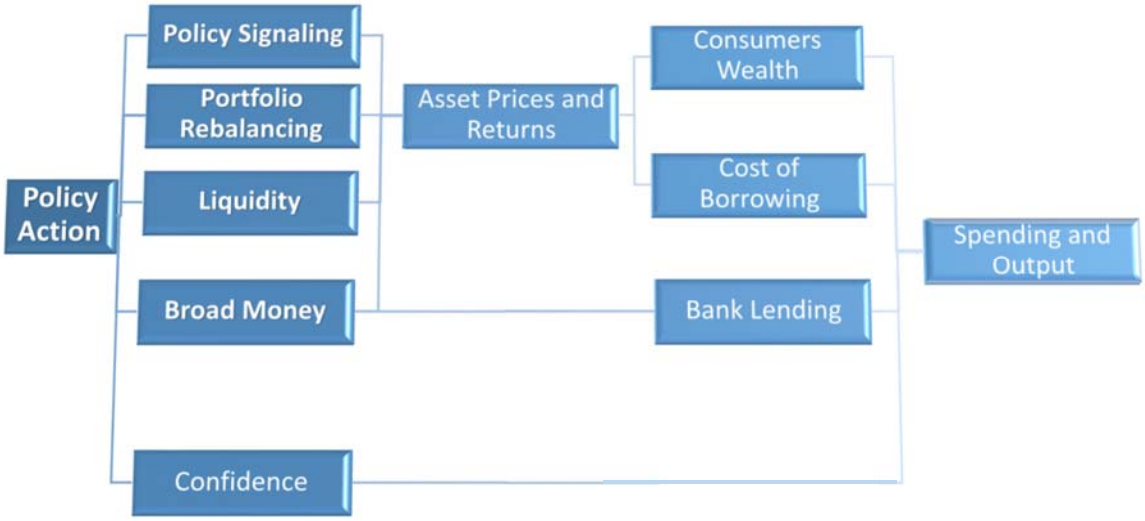
Due to open market operations, central bank typically holds a mix of different assets in its balance sheet. Subsequently, the central bank can affect the term structure of interest rates and yield curve by changing the component of assets mix which it holds. For example, if the central bank shifts form short-term securities into longer term assets, this will push the yields of the last down by decreasing liquidity premiums that investors require on these assets.

iii. Expanding the Monetary Base (Quantitative Easing):

Instead of changing its composition, the central bank can modify the size of its balance sheet to achieve desired results. When short-term policy rate is almost zero, central bank may enter the market to buy longer term assets using newly created (electronic) money. The central bank credits the price of the purchased assets to the account of the seller's bank, which in turn credits amount into the seller's account. By doing so, the central bank can increase the broad money in the economy. QE policy has been the subject matter of the recent monetary policy research. Writers have been trying to analyse the effects of this policy tool on inflation, interest rates, and different financial markets.

Unconventional means of monetary policy have many channels to achieve desired results in the economy. All channels, shown in Figure 1.1, exert their effects on the economy through asset prices and returns, except bank lending which appears only under QE and consumer confidence which directly influence spending and output. (Joyce, Tong, and Woods (2011))

Figure 1.1: Unconventional Monetary Policy Tools Transmission Channels



1.2.1 Signalling Effect

By using any policy tool, the central bank may affect market participant expectations about the future. For instance, when central bank changes the composition of its balance sheet, this may lead investors to think that the short-term policy rate will stay low for longer period.

1.2.2 Portfolio Rebalancing Effects

When the central bank actions affect relative asset prices, they induce investors to change their holdings. For example, if the central bank buys a large amount of gilts, this will push their prices up, and consequently their yields down. Investors respond to these changes by altering the composition of their portfolios toward other assets driven by relatively higher yields. In turn, investors' response leads to higher prices and lower yields for the other assets.

These changes affect the economy in two different directions. On one hand, higher asset prices increase the consumers' wealth, and this leads to higher consumption spending. On the other hand, lower yields mean lower borrowing costs for firms and higher investment spending consequently.

1.2.3 Liquidity Premiums

When the central bank enters the market, it increases the liquidity of different assets by encouraging trading. This means a decrease in liquidity premiums and consequently higher asset prices.

1.2.4 Confidence Effect

By improving the economic outlook, unconventional central bank strategies may boost consumer spending, and then directly affect aggregate demand and output.

1.2.5 Increasing Bank Lending

As mentioned before, when the central bank buys assets from outside the banking system, it credits the amount into reserve account of the seller's bank which, in turn, deposits the same amount into the seller's account. This means higher liquidity within the banking system as a whole which may encourage banks to expand their lending to households and businesses.

1.3 Quantitative Easing Literature

Since it was first introduced by the BOJ in 2001, QE has been the topic of many researches. Before exploring the research works on the current experience of QE policy in the UK, the US, and the EA, it is worth having a look on the past literature of Japanese QE experience between 2001 and 2006 to get some useful inferences about the effects of QE policy through different transmission channels.

In his survey on the effects of the BOJ's quantitative easing policy (QEP), Ugai (2006) divides the empirical works according to three different transmission mechanism: (i) the effects of BOJ's commitment to keep short-term interest rates low until CPI growth turns positive (i.e. the effects on future path of interest rates), (ii) the effects of expanding the size of BOJ's balance sheet (mainly, portfolio rebalancing effects), and (iii) Effects of altering the BOJ's asset composition (effects on risk premiums on financial assets). Many researchers tried to investigate the effects of BOJ commitment on the yield curve of Japanese government bonds (JGBs). Generally, they found that JGBs yield curves became flatter because of QEP. For example, Baba *et al.* (2005) use a macro-finance model to measure the difference between the estimated future path if there was no such commitment and the actual future path of interest rates on JGBs under the commitment and discover that the differential yields had increased noticeably after 2003 and reached a maximum of 0.5% on medium-term bonds (3 years to 5 years) and 0.2% on 10-year bonds. The authors attribute the lower differential yields on 10-year bonds to the higher inflation expectations generated by lower yield curve. Furthermore, they find out that maturity risk premiums (or term premiums) had decreased under the commitment starting from the second quarter of 2003.

The evidence with regard to the portfolio rebalancing effects of BOJ's QEP was mixed. For instance, Kimura and Small (2004) verify the portfolio rebalancing effects using Capital Asset Pricing Model (CAPM) with market portfolio that consists of the monetary base, Nikkei stock average, long-term JGBs, high- and low-grade corporate bonds, and foreign government bonds (the yen-dollar exchange rate). Their results show statistically significant decrease in credit spread on higher grade corporate bonds. Since these changes in risk premiums, according to Kimura and Small, reflect changes in the supply and demand of the different financial assets, they conclude that portfolio rebalancing effect may exist. On the other hand, Oda and Ueda (2005) indicate a contrast result. They empirically inspect the outcomes of BOJ zero interest rate and QEP and point out that portfolio rebalancing effects of both policies are not statistically significant. The researches that analysed Ugai's third channel generally produced consistent results. According to Kimura and Small (2004), changing the composition of BOJ's balance sheet results in lower

risk premiums on assets with counter-cyclical returns (government and high-grade corporate bonds) but lower risk premiums on assets that have pro-cyclical returns (equities and low-grade corporate bonds).

Instead of concentrating on the effects of different transmission channels of BOJ's QEP, other studies examined the overall effects of this policy on the Japanese economy. Generally, these studies tried to detect QEP consequences on aggregate demand, prices, and financial markets stability. Some studies claimed that although BOJ's QEP had lowered the yield curves, its effects on economy and prices were insignificant. For instance, Okina and Shiratsuka (2004) point out that BOJ's QEP was "effective in stabilizing market expectations for the path of short-term interest rates; thereby reducing longer-term interest rates and flattening the yield curve". However, the policy failed to inverse market expectations about deflation persistence. Using vector autoregressive method, Honda, Kuroki, and Tachibana (2007) have a different opinion. They indicate that QEP was effective in increasing aggregate output through asset prices channel. Their result was confirmed by Harada and Masujima (2009) who conclude that aggregate output had been affected by QEP through both asset prices and the size of bank reserves at the BOJ. Furthermore, Schenkelberg and Watzka (2011) demonstrate that Japanese QEP led to significant temporary effects on the real economy, but it did not have major effects on inflation.

After having a look at Japanese QEP literature, it is now the time to explore the more recent literature that investigates the current unconventional monetary policy experiences in the UK, the US, and the EU. During the recent few years, most researches have concentrated on QE channels that work through asset prices and returns. QE has been found to flatten the yield curve of different fixed return assets especially government bonds and other long-term safe assets. D'Amico and King (2011) discover that the first wave of treasury bonds purchased by the Fed under LSAPs programs moved the yield curve of treasury securities by up to 50 basis points. Their results also support the presence of portfolio-rebalancing effects on other asset yields. Similar results are found by Gagnon, Raskin, Remache, and Sack (2010) who anticipate that LSAPs programs produced a reduction of 30 to 100 basis points in maturity risk (or term)

premium on 10-year treasury securities and bigger reductions in interest rates on longer term agency mortgage-backed securities. Krishnamurthy and Vissing-Jorgensen (2011) approve these findings. They point out that LSAPs programs led to significant decreases in the yields of treasury and mortgage-backed securities, but did not have much effect on lower quality bonds yields. Confirming the results of Kimura and Small (2004), Gilchrist et al. (2014) indicate a similar impact of QE on treasury bonds yields but disagree on the impact on corporate bonds yields. Their results show that a fall of 10 basis point in the 2-year Treasury yield caused by an unconventional monetary intervention would lower the corporate bonds yield by 10 to 14 basis points. McLaren et al (2014) support this view. According to them, asset purchases under APP not only decreased gilts yield through the local supply effects (asset purchases by BoE lessen the supply of gilts remaining for the private sector), but also the yields of corporate bonds. They also argue that the anticipated asset purchases had significant effects on yields after each announcement in March 2009, August 2009, and February 2012. Daines, Joyce and Tong (2012) inspect the impact of the first round BoE gilts purchases. Their results indicate a fall of 100 basis points in gilts yields. Finally, in their investigation of QE of the BoE on the financial markets, Joyce, Lasaosa, Stevens, and Tong (2011) show that the policy had a significant influence on the financial markets. However, while asset purchases mainly decreased gilts yields, their effects on equity returns were not certain. Similarly, Eser and Schwaab (2015) examine the influence of ECB's SMP program on the government bond yields in the five countries the program covered. They specify that the purchases of 0.1% of the amount of debt outstanding cause reduction of about 3 basis points in the yields of 5-year bonds. However, Pattipeilohy et al. (2013) stipulate that while the LTRO interventions had generally lowered the short-term government bond yields, SMP program had not have a clear impact until Summer 2011 when it was extended to include Italy and Spain. Even then, the impact of SMP disappeared in few weeks. Furthermore, Christensen and Rudebusch (2012) investigate the drivers of the QE-triggered falls in the yields of government bonds in the US and the UK by decomposing the changes in the interest rates on these bonds into changes in the expectations about the

monetary policy and changes in the term premiums. They show that while the falls in the US Treasury yields were driven by lower policy expectations, the drops in the UK gilt yields reflected lower term premiums.

Several authors have considered an international channel of QE by studying the impact of QE in the developed economies (mainly the US) on the financial markets of the emerging economies. For example Fratzscher et al. (2013) analyse the impact of the Fed's QE programs on the sovereign debt yields and equity markets in 65 countries. Their results indicate that despite the Fed's QE programs led to lower sovereign debt yields and boosted the equity market across the 65 countries, this impact was only confined to the early stages of the programs (namely QE1). Chen et al. (2014) support the presence of spill-overs of the US QE to other countries. Then specify that the influence of US QE on capital flows and asset prices and returns in the emerging markets was significant except for the economies with better fundamentals. Bauer and Neely (2014) employ dynamic structure models to check the role of portfolio rebalancing and signalling channels in the falls in bond yields internationally caused by the Fed's LSAPs programs. They designate that the degree of substitutability between US and other countries bonds (measured by the covariance between the yields of the two type of bonds) is the main determinant of cross-broader portfolio rebalancing effects. Meanwhile, signalling effects tend to be stronger for countries with large yield response to US conventional monetary policy shocks.

Generally, the number of researches that analyse the effects of recent QE policies on the wider economy is relatively small. Giannone *et al.* (2012) applied "vector autoregressive (VAR) specification with 13 lags for the (log-) level variables" (P8) on the data of aggregate monetary and financial institution balance sheet and 17 other macroeconomic variables in the EA to estimate the outcomes of the ECB's unconventional monetary policy means. They conclude that ECB actions reinforced "market functioning and the transmission of monetary policy to the real economy, thereby bolstering macroeconomic activity and employment in a modest but significant way", (P12). Starting from the output of empirical studies

which spotted a drop of about 100 basis points in gilts yields, Kapetanios *et al.* (2012) evaluate the probable macroeconomic effects of BoE QE using three different time series models. Their results show that the program prevented further drops in both real GDP and inflation and, consequently, lend support to the effectiveness of quantitative easing. Chen, Cúrdia, and Ferrero (2011) come up with identical inference. Using simulation, they find out that the second round of the Fed's LSAPs has a very small (about 0.5%) but persistent positive influence over the real GDP on one hand and very small marginal impact on inflation on the other. These results are reinforced by Engen et al. (2015). Their analysis indicates favourable influence of the Fed's QE on output, inflation and unemployment. Yet, the influence was gradual and took a long time to be visible.

Lastly, the response of bank lending to QE program has had relatively lower attention. For example, Bowman *et al* (2011) identify a positive but small impact of BOJ QE on bank lending. Joyce and Spaltro (2014) show similar outcomes for the BoE APP program. They claim that the effects were more important for smaller banks. However, using an agent-based model, Fatouh (2015) shows that the combination of APP-caused lower bond yields and the risk weighted capital adequacy requirements played was a key contributor to the drops in bank lending (especially business lending) after the introduction of APP.

1.4 Quantitative Easing in the UK, the US, and Euro Area

As mentioned earlier, subsequent to Lehman Brothers failure in Fall 2008, the central banks of the UK, The US, and the EA lunched massive longer term asset purchase programs to address the severe economic slowdown and to support economic recovery after the financial crisis. These programs had very important implications on the size and the composition of central banks' balance sheets, money aggregate measures, and the consolidated balance sheet of the commercial banking system. The following sections explore the progress of asset purchase programs and the developments in the banking system few years after of the introduction of QE in the three countries/regions.

1.4.1 Quantitative Easing Timeline

In this section, the key stages throughout the progress of the asset purchase programs in the UK, US, and EA are presented. This includes specifying the dates and briefly explaining the content of the most important QE-related decisions such as the introduction of new programs and the expansion or termination of the current programs.

1.4.1.1 Quantitative Easing Timeline in the UK

The BoE launched its asset purchase program early in March 2009. This program is open-ended in that the Monetary Policy Committee of the Bank decides regularly either to continue with the current amount of asset purchases or to increase it to some new level. Figure 1.2 presents the evolution of the Bank England's QE policy.

Figure 1.2: QE Timeline in the UK

QE Introduction	QE Expansion	QE Further Expansion	QE Further Expansion	QE Further Expansion	QE Further Expansion	QE Further Expansion	QE Further Expansion
5-Mar-2009	7-May-2009	6-Aug-2009	5-Nov-2009	6-Oct-2011	9-Feb-2012	5-Jul-2012	
Bank of England Announces £75 Billion Asset Purchase Programme	MPC Increases Size of Asset Purchase Programme by £50 Billion to £125 Billion	MPC Increases Size of Asset Purchase Programme by £50 Billion to £175 Billion	MPC Increases Size of Asset Purchase Programme by £25 Billion to £200 Billion	MPC Increases Size of Asset Purchase Programme by £75 Billion to £275 Billion	MPC Increases Size of Asset Purchase Programme by £50 Billion to £325 Billion	MPC Increases Size of Asset Purchase Programme by £50 Billion to £375 Billion	

Source: Bank of England (http://www.bankofengland.co.uk**)**

1.4.1.2 Quantitative Easing Timeline in the US

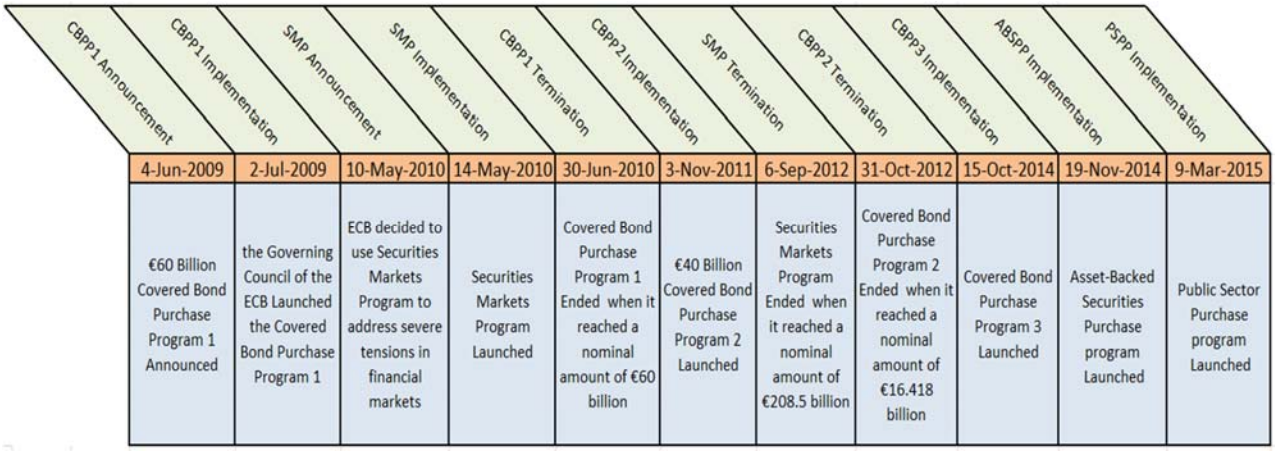
The Fed had introduced the first stage of its LSAPs programs (Large Scale Asset Purchase Programs) around the end of November 2008 and completed the first two stages of these programs (QE1 and QE2) by the end of June 2011. On September 13, 2012, the Fed started an open-ended third stage of LSAPs programs (QE3) under which the Fed will buy $40 billion of mortgage-backed security per month along with keeping the policy rate very low until the end of 2015 at least. Figure 1.3 displays the progress of Fed's LSAPs programs since their introduction in late 2008.

Figure 1.3: QE Timeline in the US

QE1 Introduction	QE1 Evaluation	QE1 Expansion	QE1 Closure	QE2 Announcement	QE2 Launch	QE2 Closure	Operational Twist	QE3 Announcement	QE3 Started	QE3 Clouser
25-Nov-2008	16-Dec-2008	18-Mar-2009	31-Mar-2010	27-Aug-2010	3-Nov-2010	30-Jun-2011	21-Sep-2011	31-Aug-2012	13-Sep-2012	29-Oct-2014
$100 Billion GSE direct obligations, $500 billion in MBS	Evaluating benefits of purchasing longer term Treasury Securities	Expand MBS program to $1.25 trillion, buy up to $300 billion of longer-term Treasury securities	QE1 purchases were completed at the end of Q1 2010	Fed Chairman Ben Bernanke hints at QE2	$600 Billion QE2 announced	QE2 purchases were completed at the end of Q2 2011	The Committee intends to replace $400 billion of Treasury securities with maturities of 3 years or less with Treasury securities with maturities of 6-30 years by the end of June 2012	Fed Chairman Ben Bernanke hints at QE3	FOMC decided to launch a new $40 billion a month, open-ended, bond purchasing program of agency mortgage-backed securities	FOMC directed the Open Market Trading Desk at the Federal Reserve Bank of New York to conclude the current asset purchase program by the end of October.

Source: The Federal Reserve (http://www.federalreserve.gov**)**

Figure 1.4: QE Timeline in the Euro Area



CBPP1 Announcement	CBPP1 Implementation	SMP Announcement	SMP Implementation	CBPP1 Termination	CBPP2 Implementation	SMP Termination	CBPP2 Termination	CBPP3 Implementation	ABSPP Implementation	PSPP Implementation
4-Jun-2009	2-Jul-2009	10-May-2010	14-May-2010	30-Jun-2010	3-Nov-2011	6-Sep-2012	31-Oct-2012	15-Oct-2014	19-Nov-2014	9-Mar-2015
€60 Billion Covered Bond Purchase Program 1 Announced	the Governing Council of the ECB Launched the Covered Bond Purchase Program 1	ECB decided to use Securities Markets Program to address severe tensions in financial markets	Securities Markets Program Launched	Covered Bond Purchase Program 1 Ended when it reached a nominal amount of €60 billion	€40 Billion Covered Bond Purchase Program 2 Launched	Securities Markets Program Ended when it reached a nominal amount of €208.5 billion	Covered Bond Purchase Program 2 Ended when it reached a nominal amount of €16.418 billion	Covered Bond Purchase Program 3 Launched	Asset-Backed Securities Purchase program Launched	Public Sector Purchase program Launched

Source: The European Central Bank (http://www.ecb.europa.eu/home/html/index.en.html**)**

1.4.1.3 Quantitative Easing Timeline in the Euro Area

As mentioned earlier, the asset purchase programs in the EA have come in two separate segments. The first segment (operated between July 2009 and October 2012) included programs of two types SMP program (Securities Markets Program) and Covered Bond Purchase Programs (CBPPs). The CBPPs programs (there had been two until November 2012) were mainly designed to purchase bonds issued by EA credit institutions with given minimum credit ratings ('AA' or equivalent in CBPP1 and 'BBB' or equivalent in CBPP2), but they may cover the secured bonds of other entities under certain conditions. The ECB terminated CBPP1 by the end of June 2010 when it reached the planned nominal value of bond

purchases of €60 billion. Under CBPP2, the ECB intended to purchase €40 billion of the eligible bonds. However, when the program was ended in October 2012, the nominal value of bond purchases was only €16.418 billion. The SMP program, launched in mid-2010, was designed to purchase marketable euro-denominated debt instruments issued by either Member States' central governments or public entities or any other entities incorporated in the EA meeting certain criteria. Under this program, the accumulated asset purchases by the ECB exceeded €208.5 billion by the end of September 2012. Although it was ended in September 2012, the ECB decided to hold the assets purchased under the program to maturity.

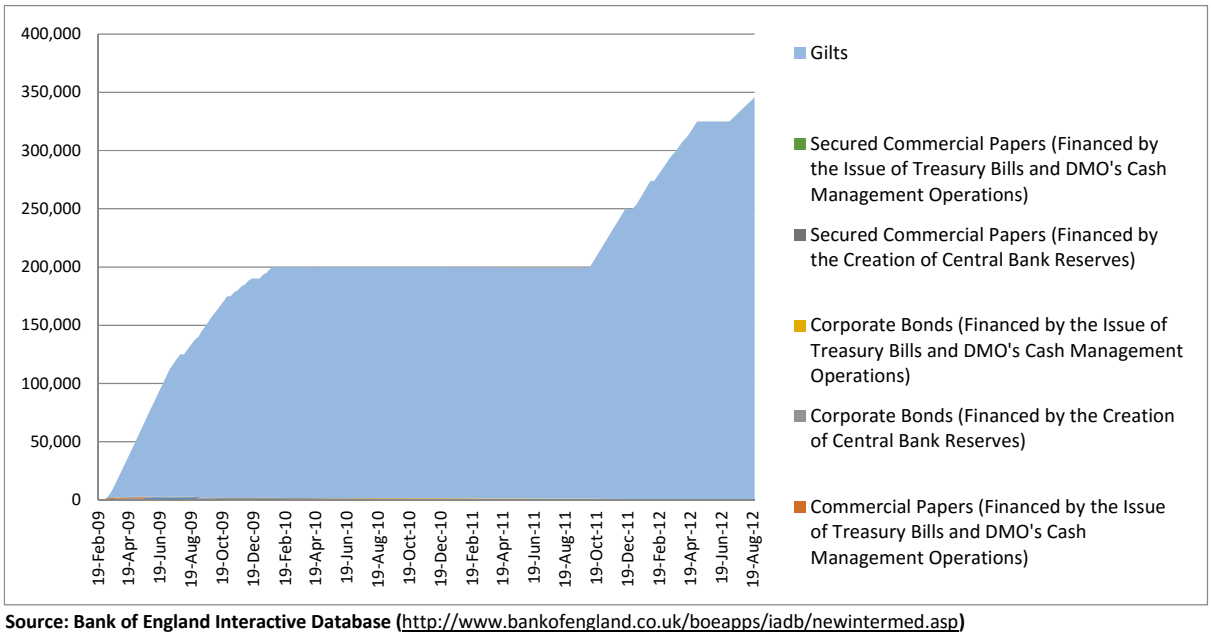
Two years after the closure of the first segment programs, the ECB introduced a second segment of asset purchase programs between October 2014 and March 2015. This segment included a third wave of CBPPs (CBPP3), ABSPP (the asset-backed securities program), and PSPP (the public sector purchase program). When launched in October 2014, CBPP3 was planned to last for at least two years. Relative to the previous two waves of CBPPs programs, CBPP3 is the largest in size and expected to have significant impact on the balance sheet of the Euro System. Until mid-January 2016, the ECB have purchased a total of €143.931 billion of eligible assets under CBPP3; this is almost twice the amount purchased under the first two waves (CBPP1 and CBPP2). The ABSPP program was initiated in November 2014 and was also planned to last for at least two years. The aim of this program is to assist bank in diversifying their funding sources and expanding lending, and to encourage the issuance of new securities. The purchases under this program are still limited in size relative to the other two programs run by the ECB; the total value of asset purchases under this program until the beginning of 2016 was about €15.35 billion. The PSPP was introduced in March 2015 to buy the securities issued by the public sector in the EA. This program covers two types of securities including the sovereign bonds issued by the member states (88% of the total purchases is allocated to these securities), and EA-based international organizations and multilateral development banks. The PSPP is the largest asset purchase program introduced by the ECB to date. By

the end of 2015, asset purchases under this program reached almost €500 billion (€499.902 billion). Figure 1.4 demonstrates the key dates in ECB asset purchase programs progression.

1.4.2 What Types of Asset Were Purchased?

The central bank choice of the type of assets to purchase under QE programs is very important since it defines the shape of the transmission mechanism to the real economy for two reasons. First, since some types of assets are held by certain investor groups, the central bank can affect the behaviour of these groups to achieve the desired results. For example, the central bank may target the assets held mainly by the pension funds -which concentrate on highly cash bearing assets- to cause a decrease in their returns and induce these funds to alter assets mixture in their portfolios toward other assets in order to spread the effects of QE to the other assets. Second, when the central bank aims at some asset types, it gives an incentive to different types of investors to move to the other assets and consequently decreases the cost of borrowing for the issuers of these assets through decreasing liquidity premiums. In this section, the breakdown of central bank QE-related asset purchases on the different types of assets in the UK, the US, and the EA is investigated.

Figure 1.5: Bank of England Asset Holdings Breakdown (£Million, Weekly)



Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp**)**

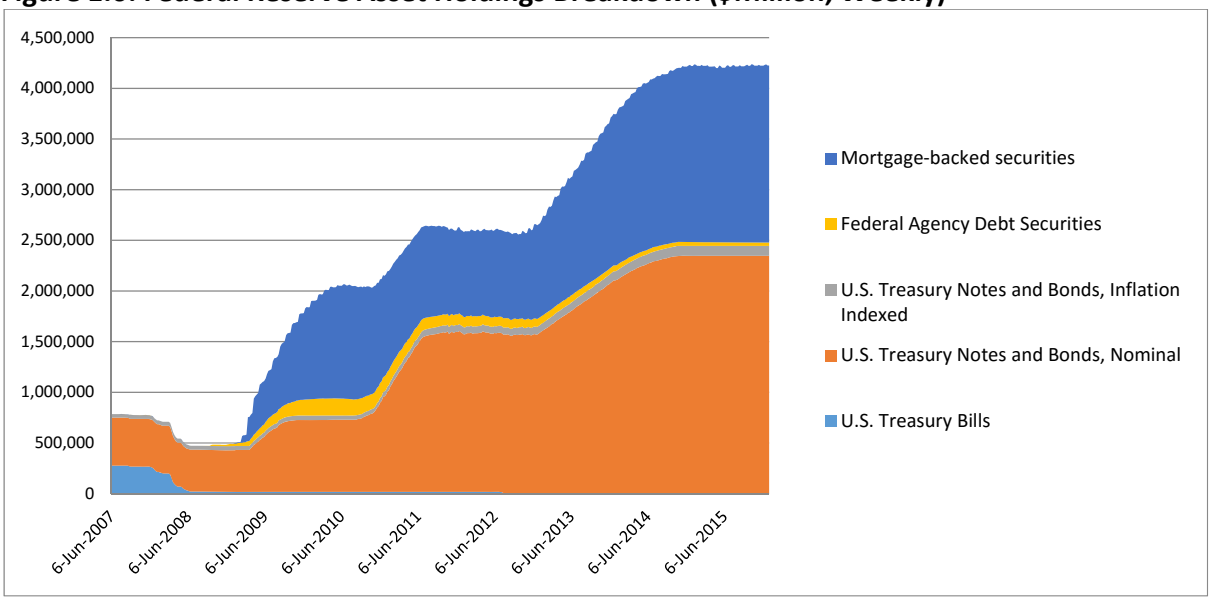
1.4.2.1 Bank of England Asset Purchases Breakdown

Figure 1.5 displays the structure of asset purchases done by the BoE's Asset Purchase Facility Fund after the introduction of QE in March 2009 until June 2012. In this Figure, it is clear that the BoE asset purchases are almost entirely concentrated on government gilts, while the purchases of corporate bonds and secured commercial papers hardly represent 1% of the total value of the purchases.

1.4.2.2 Federal Reserve Asset Purchases Breakdown

Instead of presenting the mix of the assets purchase by the Fed under LSAPs programs, Figure 1.6 illustrates the developments in the Fed's asset holdings breakdown since June 2007. The Figure shows that the holdings of treasury bills by the Fed had almost vanished after the launch of LSAPs programs by the end of 2008. After that there were vast expansions in the holdings of the longer term assets. Unlike the Bank of England, the Fed had not focused on government bonds; rather, its asset purchase programs included massive amounts of mortgage-backed securities.

Figure 1.6: Federal Reserve Asset Holdings Breakdown ($Million, Weekly)



Source: The Federal Reserve Data Download Program (DPD) (http://www.federalreserve.gov/datadownload/**)**

1.4.2.3 Euro System Asset Purchases Breakdown

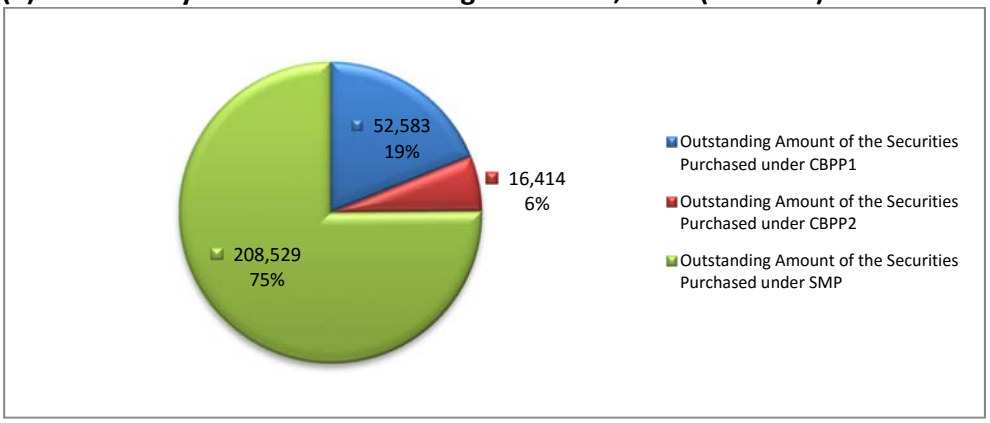
Since the asset purchase programs of the ECB have come in two separated segments (with almost two years between the end of the first segment and the start of the second one), it would be better to analyse

the break-down of asset holdings at two points of time. Asset holdings due the first segment of programs were built through the first two CBPPs programs and the SMP program. Figure 1.7.a shows the breakdown of the securities held by the Euro System across the different asset purchase programs at the time of the closure of the first segment of programs in October 2012.

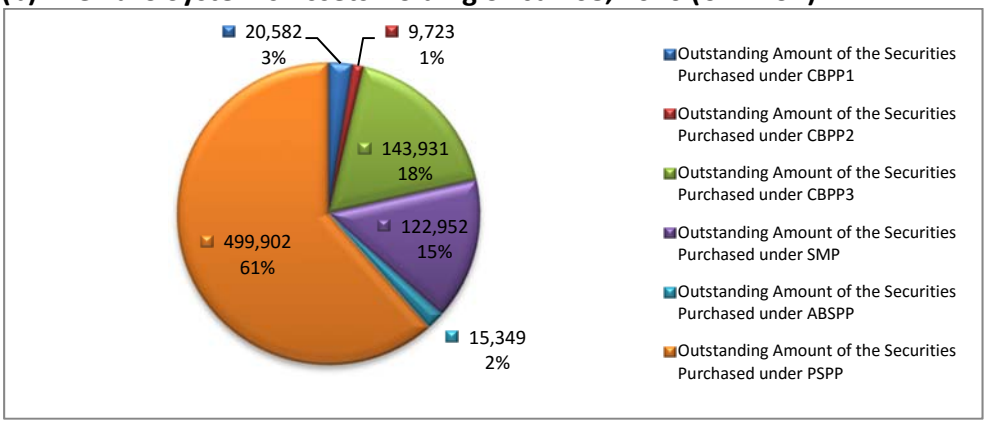
The ECB started the second segment of its asset purchase programs in October 2014. As mentioned earlier, this segment includes a third CBPPs program (CBPP3), ABSPP, and PSPP. The assets purchased under these programs have added to the remaining assets held from the first segment of the programs making the cross-program breakdown of asset holdings of the Euro System by the end of 2015 as Figure 1.7.b shows.

Figure 1.7: The Euro System's Asset Holdings Breakdown

(a) The Euro System's Assets Holding on Nov 24, 2012 (€Million)



(b) The Euro System's Assets Holding on Jan 08, 2016 (€Million)



Source: The European Central Bank Statistics (http://www.ecb.europa.eu/stats/intro/html/index.en.html**)**

1.4.3 Central Banks Balance Sheets

The longer term assets purchase programs (or QE) lunched by the BoE, the Fed, and the ECB had a very interesting impact on the balance sheets of these central banks in terms of size and composition.[1] To finance its purchases of the longer term assets, each central bank creates new virtual or electronic money and deposits this amount into the reserve account of the seller's bank. Consequently, these programs produce two main effects on the central bank balance sheet. First, since it includes an increase in bank reserves size, asset purchase programs raise the amount of total assets/liabilities and therefore the size of the central bank balance sheet. Second, asset purchase programs contain longer term assets so they change the composition of the assets side of the central bank balance sheet toward increasing the share of longer term assets in the central bank asset holdings. In the following section, the impact of asset purchase programs in the UK, US and EU on the balance sheets of the central banks of these three countries/regions will be explored in details.

1.4.3.1 The Bank of England Balance Sheet

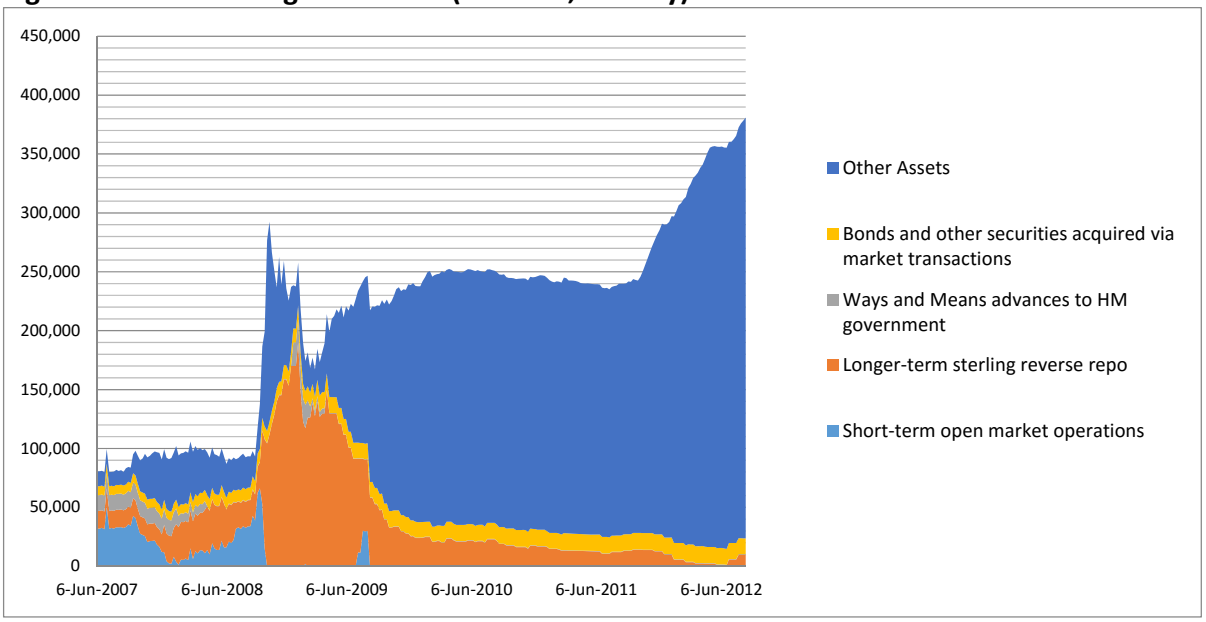
As mention earlier, the BoE introduced it quantitative easing (QE) policy in March 2009. The asset purchases concentrated mainly on government gilts and paid lower attention to the other long term assets. "Whilst the accounts of the Fund are not consolidated with those of the Bank, the Fund is financed by loans from the Bank and those loans are included in other assets. The loans account for the majority of the increase in 'other assets' since March 2009".[2] Figure 1.8 presents the developments in the asset side of the BoE's balance sheet between June 2007 and June 2012 on a weekly basis. As the Figure shows, the "Other Assets" category had been dramatically increasing in both absolute value and the share to the total assets over the time especially following to the introduction of QE policy in March 2009 with some exceptions. As a result of this wide QE-related growth in "Other Assets", the balance sheet of the BoE was more than tripled. Meanwhile, the liabilities side of the BoE's balance sheet witnessed radical changes in size and structure shown in Figure 1.9. In this Figure, it is easy to realize that the increases in asset holdings

[1] The analysis here will cover the consolidated balance sheet of the Euro System and not only the balance sheet of the European Central Bank which represents the head institution in the Euro System.

[2] http://www.bankofengland.co.uk/statistics/Pages/iadb/notesiadb/central_bank_bs.aspx

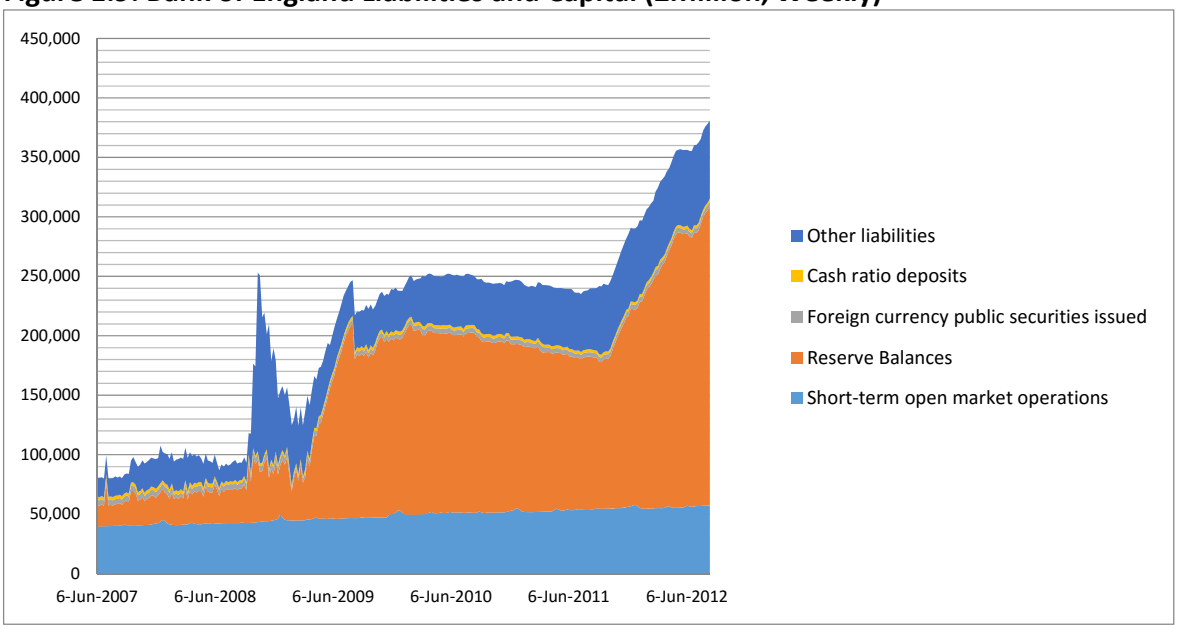
on the assets side reflected almost entirely on bank reserve balances on the liabilities side. The main result of these developments on the liabilities side is to expand the monetary base and to increase the share of bank reserve in it.

Figure 1.8: Bank of England Assets (£Million, Weekly)



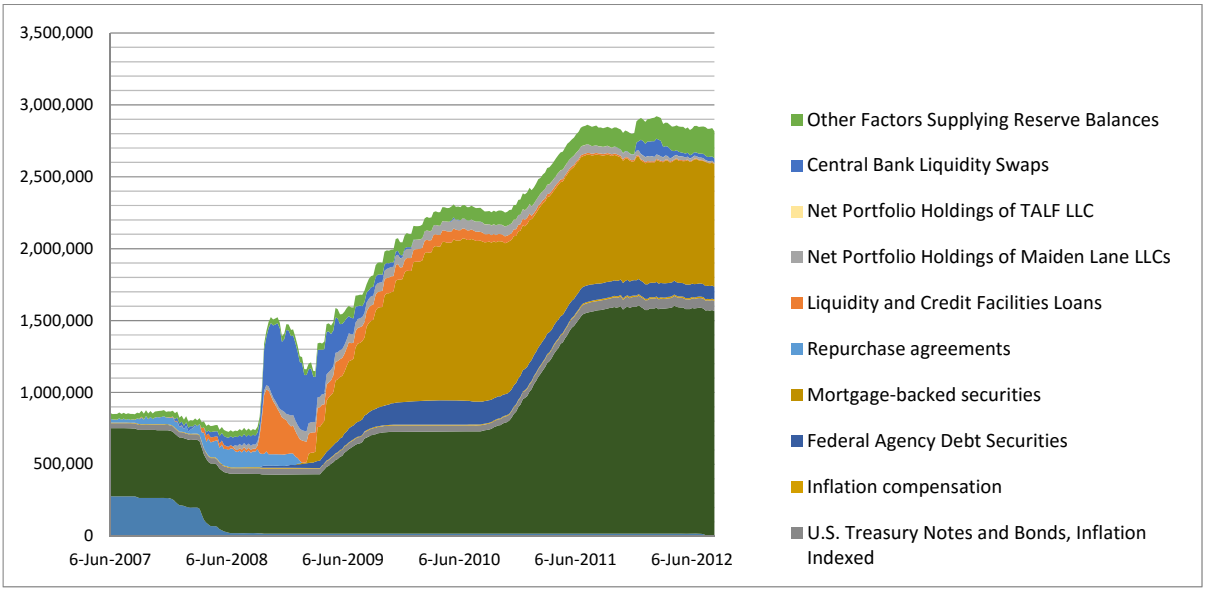
Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp**)**

Figure 1.9: Bank of England Liabilities and Capital (£Million, Weekly)



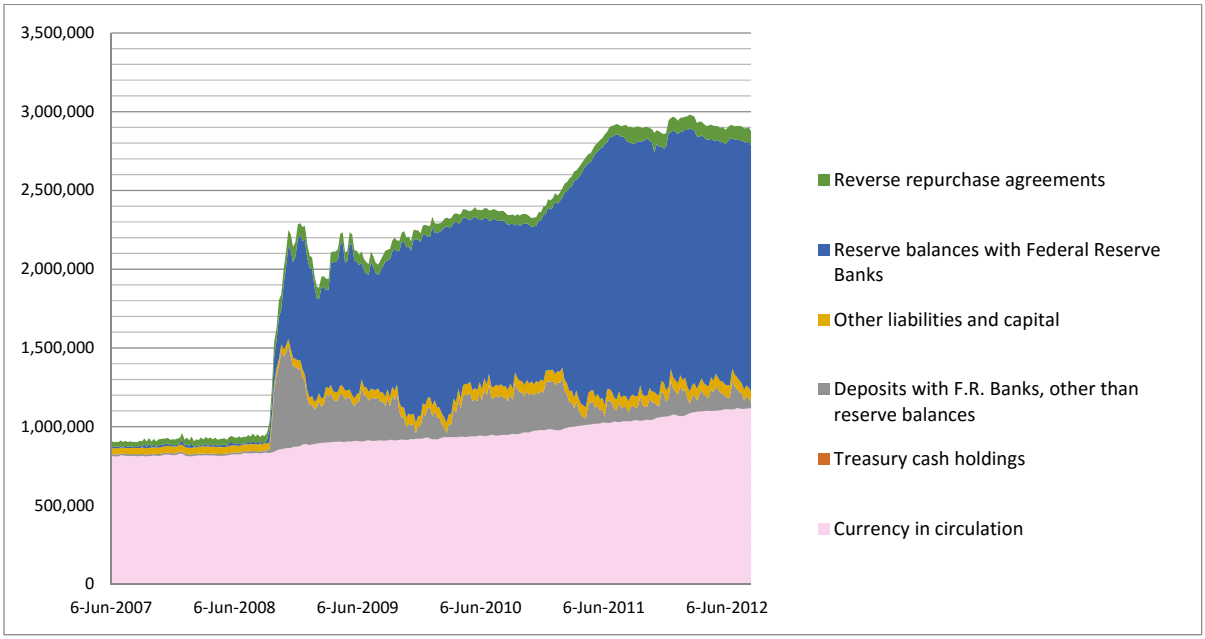
Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp**)**

Figure 1.10: Federal Reserve Assets ($Million, Weekly)



Source: The Federal Reserve Data Download Program (DPD) (http://www.federalreserve.gov/datadownload/**)**

Figure 1.11: Federal Reserve Liabilities and Capital ($Million, Weekly)



Source: The Federal Reserve Data Download Program (DPD) (http://www.federalreserve.gov/datadownload/**)**

1.4.3.2 The Federal Reserve Balance Sheet

The Fed lunched its LSAPs programs around the end of November 2008. While the BoE's APP concentrated on government gilts, LASPs programs covered a wide range of risky mortgage-backed securities in addition to treasury longer term securities. These programs had an impact on the Fed balance

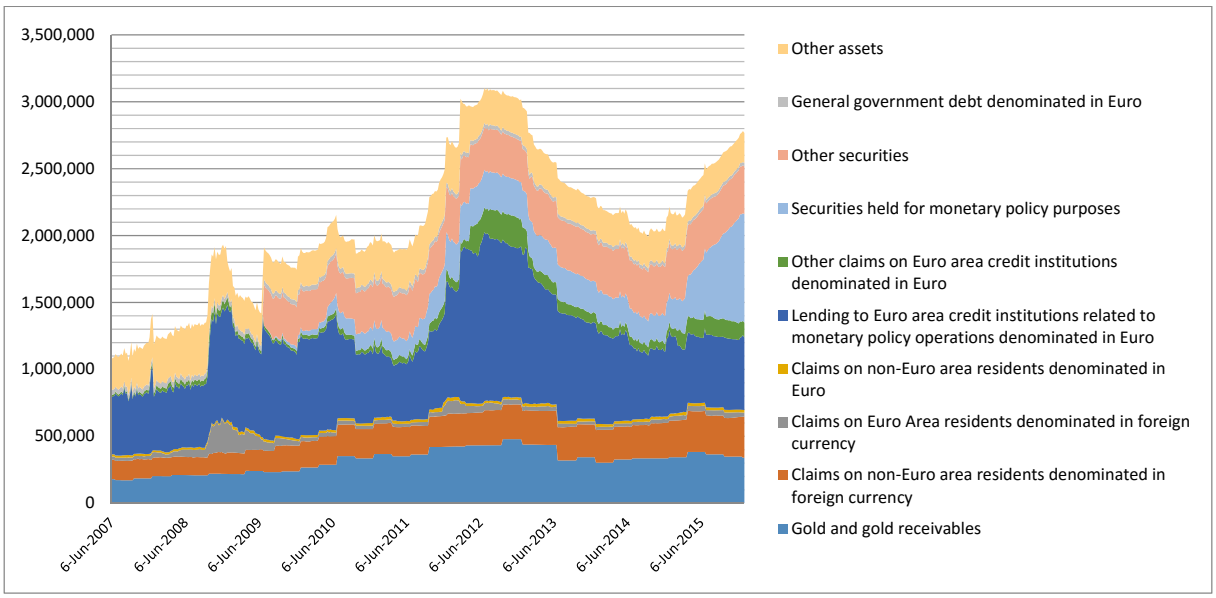
sheet similar to that of APP on the BoE's balance sheet in terms of the size of the total assets, but their effects on asset composition had been different somehow, as Figure 1.10 shows. The extensive expansion in the total assets in this Figure is mainly due to the increases in holdings of treasury and mortgage-backed securities. Similar to the BoE case, the inflation of the total assets related to LSAPs programs has produced a big growth in bank reserves with the Fed. This growth in bank reserves accompanied with a steady increase in currency in circulation balanced the increase in the total asset on the one hand and broadly expanded the monetary base in US on the other (Figure 1.11).

1.4.3.3 The Euro System Balance Sheet

After the first wave of asset purchase programs of the ECB, the balance sheet of the Euro System had witnessed patterns similar to those in the case of the BoE and the Fed. As Figure 1.12 shows, the increases in the amount of loans provided to commercial banks under the ECB's LTROs programs had played a main role in the significant expansion of the total assets of the Euro system between 2009 and 2012. Meanwhile, the presence of "Securities held for monetary policy purposes" category -relate to the asset purchase programs employed by the ECB since July 2009- helped to some extent in the aggregate increase of the total assets. After the closure of the first wave of programs late in 2012, the size of the balance sheet of the Euro System decreased significantly (by more than 30%) back to the pre-QE level. However, after the introduction of the second wave of programs late in 2014, the balance sheet started to expand again. The main difference between the two expansions (after the first and the second waves) is that, unlike the first expansion where LTROs programs played the main role, the second expansion has been driven primarily by the increases in the amounts of the securities purchased under the second wave of asset purchase programs. On the liabilities side of the Euro System's balance sheet, similar but less dramatic trends in can be spotted after the first wave of asset purchase programs. Similar to the US case, the amount of banknotes in circulation displays steady increases during the past years, and this is reasonable since US dollar and Euro represent "international reserves" these days. In addition, bank reserves did not show clear trends until mid-2011 as Figure 1.13 shows. In this Figure, the balance of these reserves was fluctuating up and down before June 2011, and then it had shown notable expansion. These

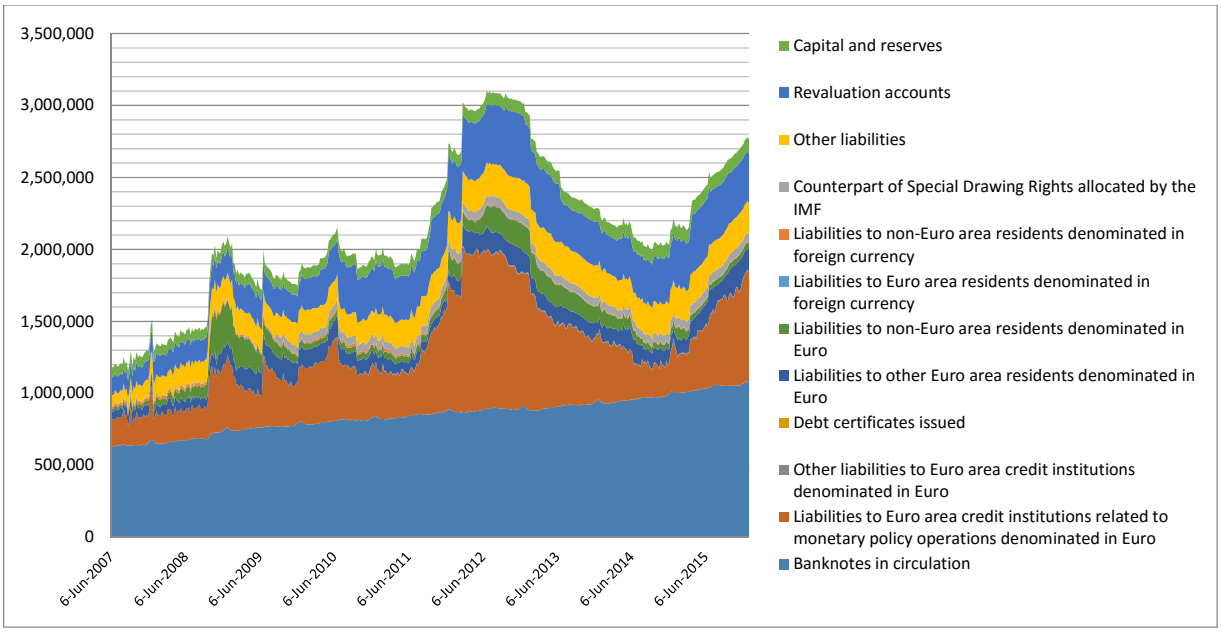
increases in bank reserves and currency in circulation represent a big share of the growth in total liabilities needed to finance the inflation of the Euro System's total assets after the introduction of its asset purchase programs in mid-2009. Similarly, the growing currency in circulation and bank reserves account for a big chunk of the expansion of the liabilities after the second wave of asset purchase programs.

Figure 1.12: Euro System Assets (€Million, Weekly)



Source: The European Central Bank Statistics (http://www.ecb.europa.eu/stats/intro/html/index.en.html**)**

Figure 1.13: Euro System Liabilities and Capital (€Million, Weekly)



Source: The European Central Bank Statistics (http://www.ecb.europa.eu/stats/intro/html/index.en.html**)**

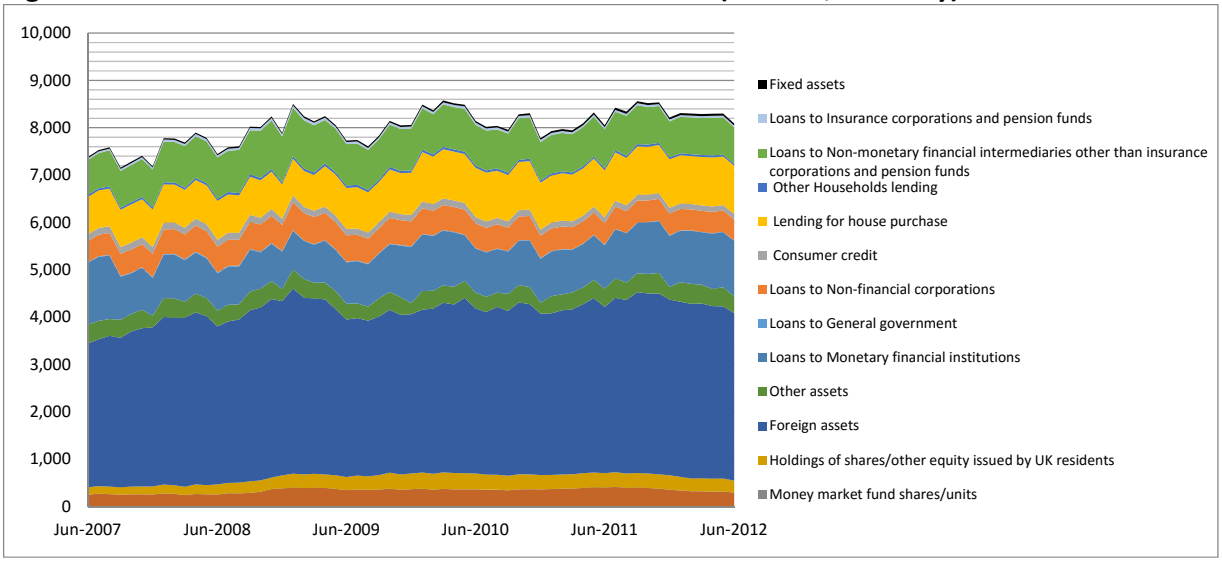
1.4.4 Commercial Banks Consolidate Balance Sheets

Amongst various QE transmission channels, bank lending can be considered one of the most important ones for two main reasons. First, the size of commercial banks' credit depends on their reserves base with the central bank which expands as a result of asset purchases under QE. Second, commercial banks can provide credit facilities to producers and consumers, and therefore, affect the real economy from different directions. This section inspects the developments in the commercial banking sector in UK, US and EU after the introduction of QE through analysing the trends in the consolidated balance sheet of this sector.

1.4.4.1 Commercial Banks Consolidated Balance Sheet in the UK

Figure 1.14 displays the developments on the asset side of the commercial banks consolidated balance sheet in the UK. In this Figure, slight growth in the total assets can be detected during the period between June 2007 and June 2012. The interesting here is that the expansion in the total assets comes mainly from the growing foreign asset holdings. Inversely, the amounts of loans provided to different resident sectors do not show any increase which means that their relative share in commercial banks portfolios had been decreasing over the time.

Figure 1.14: Consolidated UK Commercial Banks Assets (£Billion, Monthly)

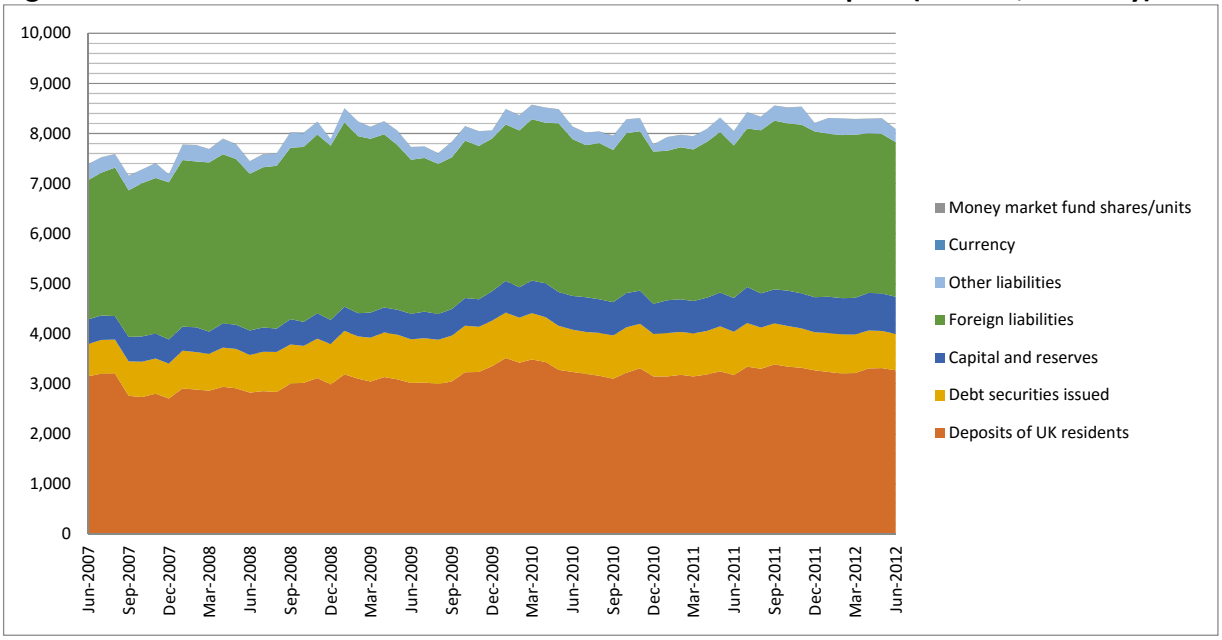


Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp**)**

This suggests that the huge amounts of cheap money pumped into the economy through bank reserves had not been able to expand the size of bank lending, but on the contrary, they had decreased the dependence of the commercial banks on these loans as a source of income because of the lower interest rates in the domestic market.

On the liabilities side, while the growth of the total assets had been financed by relatively slight and equal increases in almost all liabilities, a major part of the finance come from the expansion of foreign liabilities and residents' deposits. Figure 1.15 displays these developments graphically.

Figure 1.15: Consolidated UK Commercial Banks Liabilities and Capital (£Billion, Monthly)



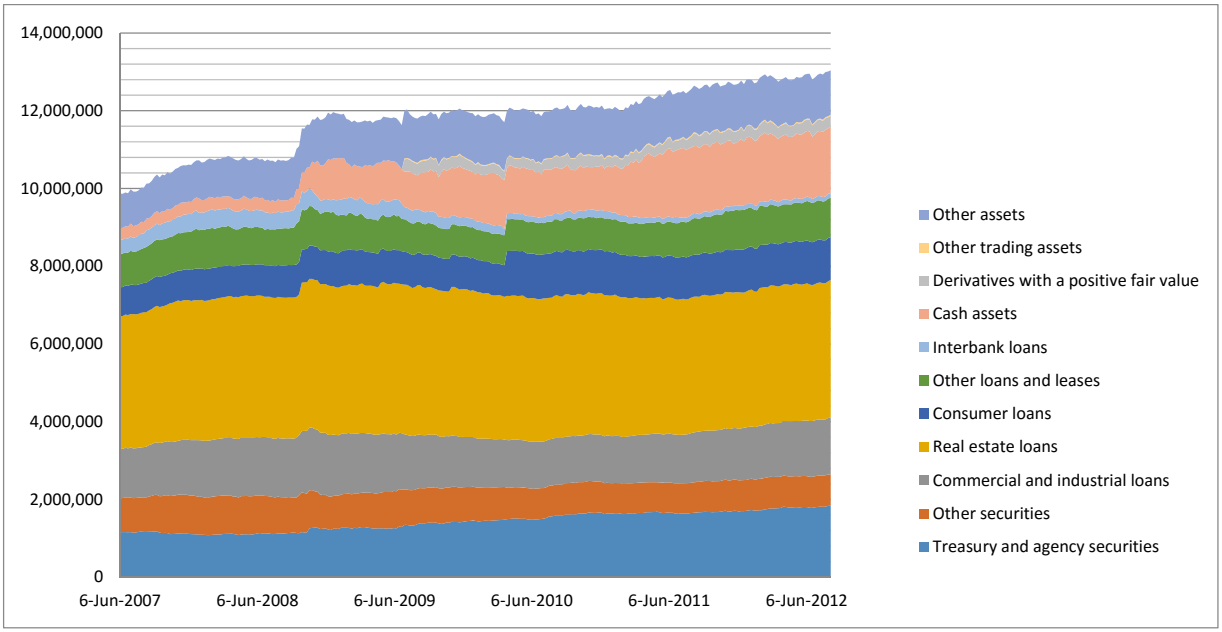
Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp**)**

1.4.4.2 Commercial Banks Consolidated Balance Sheet in the US

The banking sector in the US had witnessed wider expansion in the total assets as shown in Figure 1.16. Significant increase is noticed in the amount of cash assets and holdings of treasury and agency securities, whereas the size of bank loans of different types demonstrates slighter rises. Thus, compared to the UK case, asset purchase programs in the US resulted in some growth in the size of bank lending; this growth, however, was not enough to reflect the huge expansion in the reserves with the Fed presented earlier.

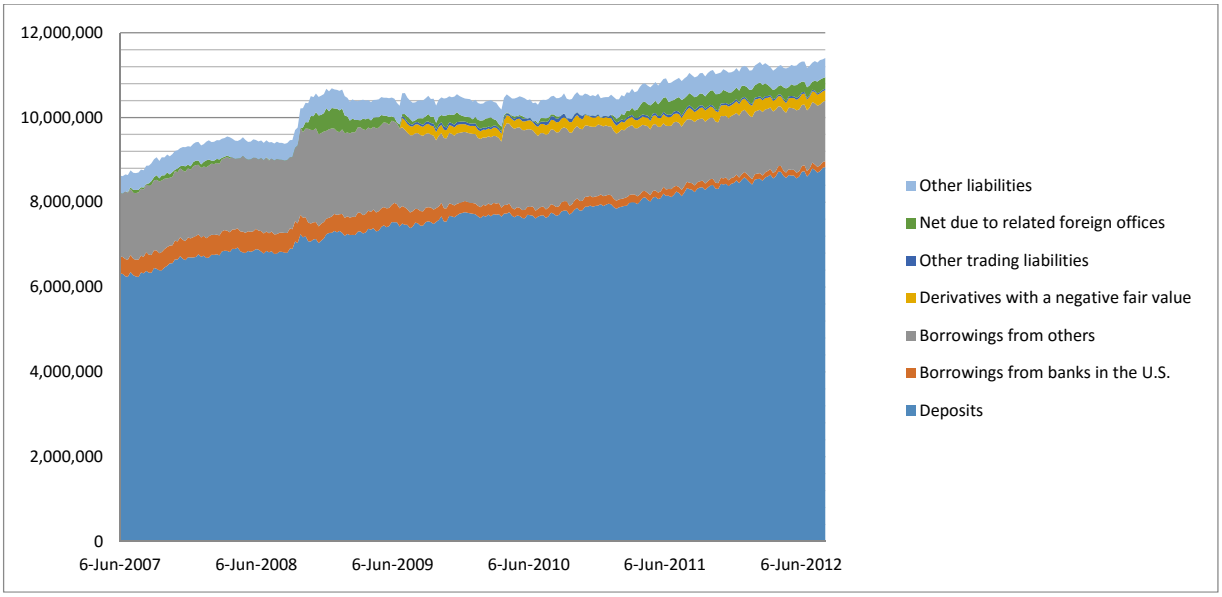
Figure 1.17 infers that the expansion of total assets of US banks had reflected primarily on the size of deposits with the banks. Moreover, this growth in deposits had led to a decrease in the inter-bank borrowing and banks' borrowing from the others.

Figure 1.16: Consolidated US Commercial Banks Assets ($Million, Weekly)



Source: The Federal Reserve Data Download Program (DPD) (http://www.federalreserve.gov/datadownload/**)**

Figure 1.17: Consolidated US Commercial Banks Liabilities and Capital ($Million, Weekly)

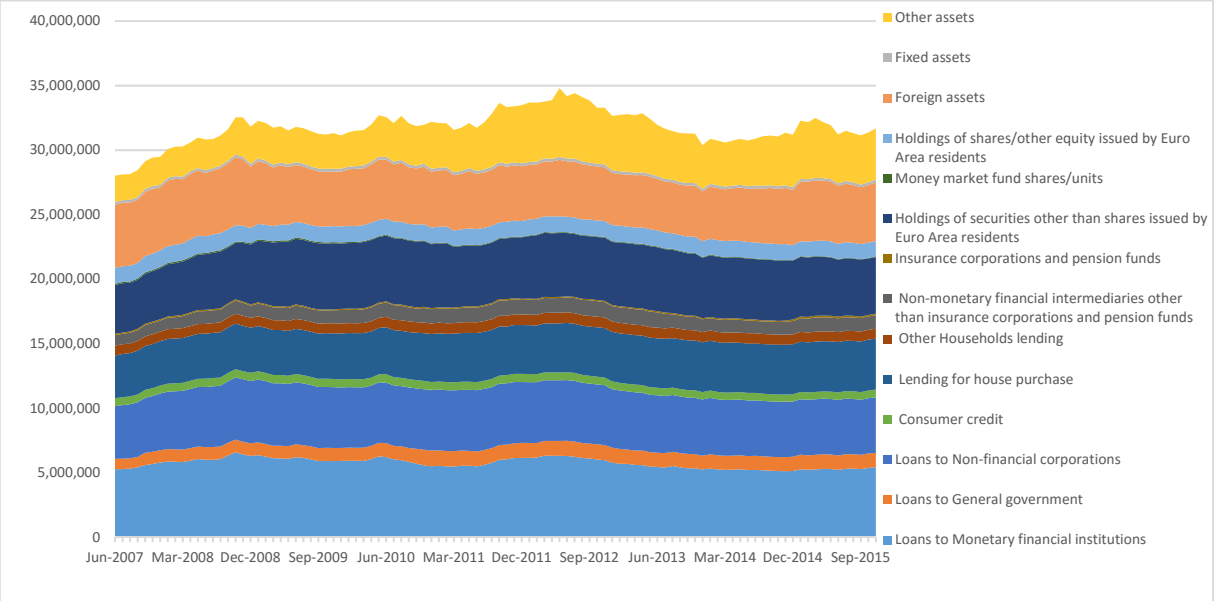


Source: The Federal Reserve Data Download Program (DPD) (http://www.federalreserve.gov/datadownload/**)**

1.4.4.3 Commercial Banks Consolidated Balance Sheet in the Euro Area

The assets side of the consolidate balance sheet of the commercial banking sector in the EA exhibits patterns similar to those in the US. By exploring the developments of the European commercial banks assets shown in Figure 1.18, a steady expansion in the total assets of the banks can be noticed after the introduction of the first wave of asset purchase programs by the ECB in 2009. This expansion is due to the increasing balances of all assets except foreign assets. The major drivers of the expansion of total assets were the growth in the holdings of financial assets and some components of the banks' loan portfolios. However, as pointed out in the US case, the rises in bank lending were not enough to reflect the expansion in reserves base of the European banks with the Euro System. Later, the total assets of the EA banks witnessed a slight fall between the conclusion of the first wave and the introduction of the second wave of the asset purchase programs. Similar to the trend after the launch of the first wave, banks' total assets have been slightly expanding since the second wave was introduced late in 2014.

Figure 1.18: Euro Area Consolidated Commercial Banks Assets (€Million, Monthly)

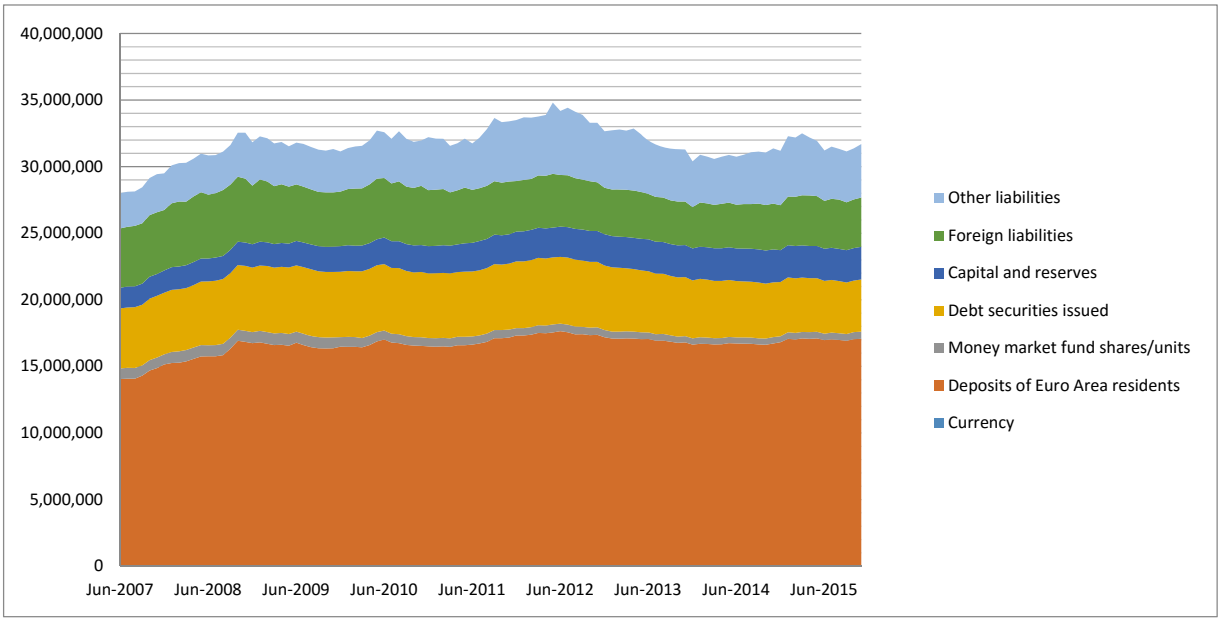


Source: The European Central Bank Statistics (http://www.ecb.europa.eu/stats/intro/html/index.en.html**)**

Turning to liabilities side of the balance sheet, it is possible to say that the expansion of the total assets after the two waves of the asset purchase programs had mainly reflected on the deposits base with the

banks, the balance of "Other Liabilities" category, and banks' capital and reserves. These developments are illustrated in Figure 1.19 which presents the liabilities of the commercial banks in the EA.

Figure 1.19: Euro Area Consolidated Commercial Banks Liabilities and Capital (€Million, Monthly)



Source: The European Central Bank Statistics (http://www.ecb.europa.eu/stats/intro/html/index.en.html**)**

1.4.5 Asset Purchase Programs in the UK, the US, and the EA Compared

The asset purchase programs introduced in the UK, the US, and the EA aimed to boost the slowing economy through various transmission channels. Yet, there were significant differences between the three QE experiences with regard to the design and the performance of the asset purchase programs. From the perspective of policy design, the programs can be differentiated in terms of diversity, the types of the assets purchased, the way the programs are managed, and the timing of asset purchases. First, unlike the BoE, which introduced only one asset purchase program, the Fed and the ECB launched several programs. Second, in terms of the asset purchased, the APP of the BoE concentrated mainly on government gilts, whereas the Fed and the ECB programs covered asset-backed securities and corporate bonds as well as government securities. Third, while the Fed and the ECB operate a rate of change policy the BoE operates a levels policy. As mentioned earlier, the MPC of the BoE decides regularly whether to

change the level of asset holdings or to maintain its current level. Conversely, instead of changing the level of asset holdings, the Fed and the ECB alter the rate of purchases (i.e. the amount of monthly asset purchases). Lastly, in contrast to the BoE and the Fed whose asset purchases were executed in the few years after the financial crisis, the ECB had not started the major chunk of its asset purchases until late 2014.

The perspective impact on asset yields and the role of the banks in the economy differentiate the asset purchase programs in the EA from those in the UK and the US. First, Contrary to the UK and the US where asset purchase programs which involved the element of "surprise", the second wave of ECB's asset purchase programs is not expected to have a significant impact on asset yields since markets had been expecting this wave to be launched. In several sovereign bond markets, the expectation of the probable asset purchases by the ECB induced investors to buy sovereign bonds bidding their prices up and hence lowering their yields. For instance, the yield of ten-year Portuguese government fell by 3.5% (from 6.2% to 2.7%) in the months leading to the introduction of the second wave of programs in October 2014. Consequently, the impact of the second wave on yields would be probably limited. Moreover, unlike the firms in the US, borrowing from banks (rather than using debt securities) represents the main source of debt financing of the firms in the EA. As a result, the later would benefit less from the potential lower cost of borrowing in the capital markets (i.e. lower bond yields).

1.5 Conclusions

This chapter reviewed the historical development of the unconventional monetary policy tools that were first used by the BOJ in early 2000s. These measures are design to be used when the economic conditions generate very low (virtually zero) short term policy rate, and include three main tools: influencing future interest rates expectation, changing the composition of central bank's balance sheet, and expanding the monetary base (or quantitative easing). Theoretically, these policy tools may use various transmission channels -analysed in the first part of the chapter- to deliver their impact into the

wider economy, all of these channels work through asset prices and returns except for two channels which operate over bank lending and confidence level in the economy.

The next section tried to survey the past literature related to the third unconventional monetary policy tool: quantitative easing (QE). This included an inspection of the literature that addresses the Japanese QE experience at the beginning of the century, followed by a review of the recent research works associated with the current QE practice in the UK, the US, and the EA.

After that, the data collected from different sources on the QE progress in the three countries/regions was examined and analysed. This incorporated an exploration to the chronology of the most important events of the current asset purchase programs, inspecting the amounts and types of the asset purchased, and graphically observing the effects of these programs on the balance sheets of the central banks and the consolidated balance sheet of the commercial banking sector in the three countries/regions.

The main findings of this chapter can be summarized in three key points. First, the central banks of the UK, US and the EA had employed asset purchase programs of different flavours and bought substantial amount of different financial assets, mainly debt securities. Second, these asset purchases had led to a vast growth in the total assets of the BoE, the Fed and the Euro System which, in turn, reflected mainly of the size of commercial banks reserves with these central banks.

Third, if the transmission mechanism that uses bank lending channel were to work, there should be a wide expansion in the size of the bank lending. However, the data suggests that there had been slight increases in commercial banks' credit relative to the raises in amounts of reserves with the central banks. Accordingly, the bank lending channel seems to be blocked or not working for some reason or another.

The remainder of this thesis will be based on the conclusions presented above. Chapter 2 employs a flow of funds (FOFs) analysis based on Godley and Lavoie (2007) balance sheet framework using ONS sectoral data for the period between 2007 and 2011 to assess the initial effects of mid-2007 financial crisis on UK economy and examine the influence of BoE's asset purchase program (APP) on the sectoral financial

positions in the main asset categories. The remaining two chapters will investigate the same issue of dropping total bank lending after the introduction of APP in 2009 despite of the noticeable expansion in the total amount of mortgages. While Chapter 4 attempts to explain this drop in total bank lending using a three-sector DSGE model, Chapter 3 tries to approach the problem from an agent-based computational economics (ACE) point of view.

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Chapter 2

Implications of Quantitative Easing Policy

Flow of Funds Analysis of the UK

Economy Post 2007

Abstract

This chapter employs a flow of funds (FOFs) analysis based on Godley and Lavoie (2007) balance sheet framework using ONS sectoral data for the period between 2007 and 2011. It focuses on two distinct sub-periods (2007-2008 and 2009-2011) to assess the initial effects of mid-2007 financial crisis on UK economy and examine the influence of the Bank of England's (BoE) asset purchase program (APP) on the sectoral financial positions of the main seven sectors (households (HHs), nonfinancial corporations (NFCs), monetary financial institutions (MFIs), other financial intermediaries (OFIs), insurance companies and pension funds (INSs), rest of world (ROW), and government (GOV)) in the main financial asset categories. The analysis implicates five main results. First, APP was unsuccessful in expanding bank lending which dropped by about £208 billion in the 2009-2011 period. Second, APP might have positive effects on debt securities and equity prices and hence consumer wealth. Third, through reducing the cost of borrowing, it appears that APP induced the majority of sectors to issue more debt securities. Fourth, after the introduction of APP early in 2009, several sectors relied more on equity rather than debt capital. Finally, domestic productive sectors (NFCs, MFIs, OFIs, and INSs) showed some *abroad* bias and sent massive amounts of money out of the country. The impact of BoE APP found its way into various asset markets where higher asset prices and lower asset returns can be noticed especially for longer-term assets. This fall in asset yields decreased the cost of both debt and equity capital and hence induced different sectors to raise further longer-term funds from these two sources. However, the fall in the cost of capital might cause a trade-off between bank loans and longer-term capital as most sectors used big shares of the funds raised to repay significant amounts of bank loans which dramatically dropped after APP was introduced. The relatively lower asset yields in the UK motivated productive private sectors (NFCs, MFIs, OFIs, and INSs) to move substantial amounts of domestically raised funds outside the country to benefit from higher returns overseas.[3]

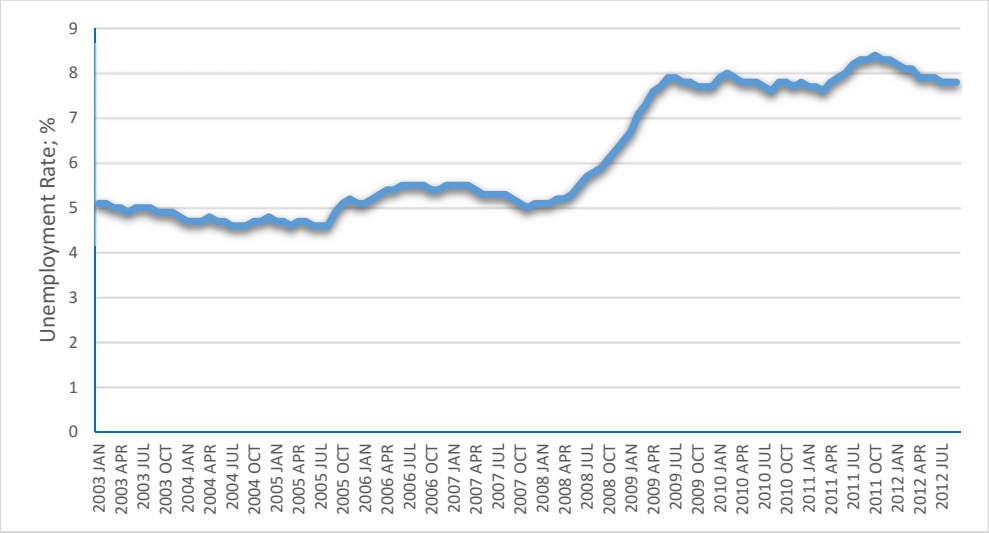
[3] Thanks for Prof Joao Santos Silva for his valuable comments which helped enhancing the quality of this chapter.

2.1 Introduction

The mid-2007 financial and economic crisis ended a period of notable stability in the global economy during which world's major economies enjoyed sustainable growth and low and stable inflation (Barwell and Burrows (2011)). The crisis triggered severe recessions in different countries and raised the threat of total collapse in the global financial system. It also played a key role in the failure of major businesses (such as Lehman Brothers) and the sovereign-debt crisis in Europe, and contributed in the huge evaporation of more than £416 billion in UK households' wealth.

Like other economies worldwide, UK economy witnessed a large drop in retail sales especially in furniture and DIY stores, along with remarkable increase in unemployment particularly between 18-24 age group people. The UK economy officially entered a recession period when GDP fell down by 1.5% in 2008 Q4; Figures 2.1 and 2.2 demonstrate these developments. As shown in Figure 2.1, unemployment rate in the UK had been relatively stable between 4-6% until September 2008 when it started gradually rising to exceed 8% in mid-2011.

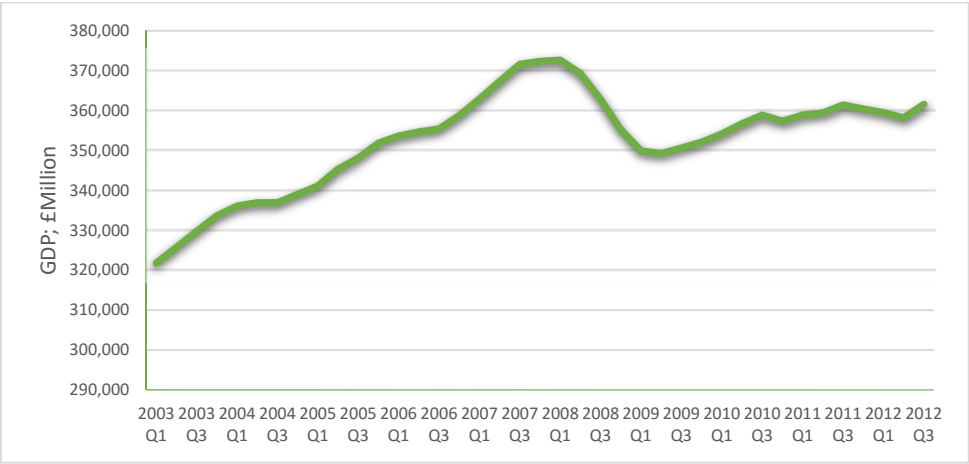
Figure 2.1: UK Unemployment Rate (%; Seasonally Adjusted)



Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

Falling retail sales and increasing unemployment reflected on the GDP which displayed negative growth rates starting between 2008 Q2 and 2009 Q2 as Figure 2.2 illustrates.

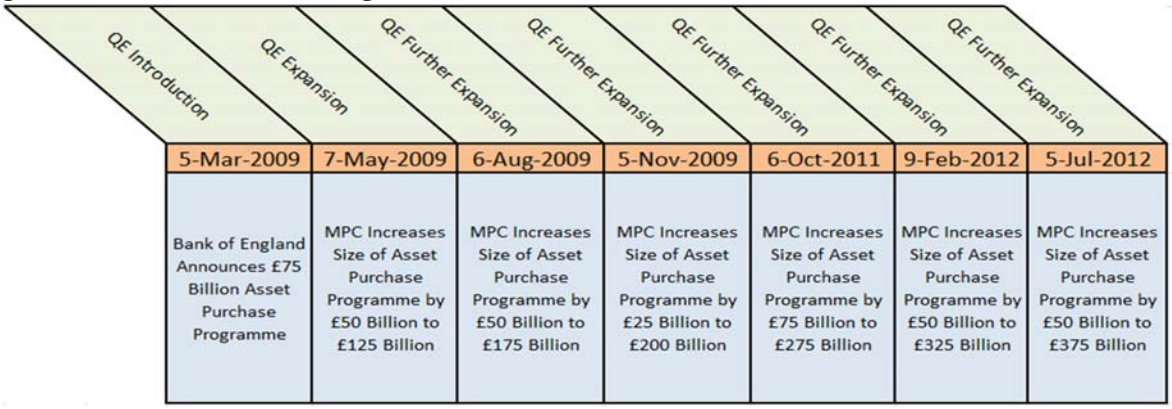
Figure 2.2: UK Quarterly Gross Domestic Product (£ Million; Seasonally Adjusted)



Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

To fight economic slowdown, the monetary authorities of the developed economies decreased their policy rates to some unprecedented record levels. The Monetary Policy Committee (MPC) of Bank of England (BoE hereafter), for example, decreased the short-term policy rate many times down to 0.5% in March 2009. However, because wide monetary loosening was not sufficient to boost aggregate expenditure and help the economy to recover, central banks considered the usage of the unconventional monetary policy measures and mainly quantitative easing (QE). After the fall of Lehman Brothers late in 2008, and in order to pump out more liquidity into the economy, the BoE initiated its £75 billion longer term asset purchase program (APP henceforth) early in March 2009. The program was meant to be open-ended in the sense that MPC chooses regularly either to continue with the current size of asset holdings or to increase it to some new level. Just less than four years after the introduction of the program, the MPC increased the size of longer term asset holdings several times up to £375 billion in July 2012. Figure 2.3 presents the key stages of the BoE's APP until late November 2012. These enormous amounts of asset purchased reflected gradually on the size of BoE's balance sheet. A quick inspection of the assets side of BoE's balance sheet data detects wide expansions in the balance of "Other Assets" category under which the purchases of Asset Purchase Facility Fund (APFF) are recorded. The investigation of the liabilities side of the balance sheet indicates that a substantial share of the purchased assets was financed by expanding the amount of bank reserves with BoE.

Figure 2.3: Quantitative Easing Timeline in the UK



Source: Bank of England (http://www.bankofengland.co.uk**)**

As mentioned earlier, QE is an unconventional monetary policy tool used to stimulate the economy when policy interest rate reaches its zero lower bound at which the traditional transmission mechanisms of policy rate are out of order. Various transmission channels have been suggested in the previous QE literature. For instance, Joyce, Tong, and Woods (2011) indicate five transmission channels for unconventional monetary policy tools; this includes policy signaling, portfolio rebalancing, liquidity, broad money, and confidence. The impact of QE passes directly to the wider economy through the confidence influence on aggregate spending. Meanwhile, QE effects transmit over the first three channels through asset prices and returns, whereas it utilizes also bank lending when it works through broad money channel.

In this chapter, a flow of funds (FOFs) model is used to document and evaluate the impact of QE in the UK on the balance sheets of different sectors through analyzing the linkages between real economy developments on the one hand and balance sheet changes on the other. Flow of funds accounts, first developed in the US in 1951, represent a useful tool to investigate the relationships between different components of the economy through tracking the financial flows across different sectors in the economy, and exploring the implications of real economy developments on the sectoral balance sheets and asset prices. Thus, they are critical in detecting the main trends in an economy over the time -such as the growth in each sector indebtedness and/or the changes in its structure- and understanding the macroeconomic behaviour. Bê Duc and Le Breton (2009) point out that flow of funds data can support two types of analysis; monetary analysis and economic analysis. While it provides valuable information about the

allocation of different sectors' financial resources between money and other financial assets, "they provide insight into developments in the balance sheet of the nonfinancial sectors (e.g. wealth and debt) which have implications for these sectors' income, spending, and saving decisions, and thus potentially affect aggregate demand and, ultimately, price developments" (Bê Duc and Le Breton (2009)).

Flow of funds analysis allows for tracking the flow of money between different parts of the economy which reflects directly on the financial positions of different sectors and the size and types of asset/liability relationships between these sectors. It hence has important inferences about the past and future behavior of different economic units. This helps researchers and policy makers to understand the effects of past development, and to increase the accuracy in estimating the influence of proposed policy interventions in the future. The flow of funds model presented later utilizes an approach similar to that in Barwell and Burrows ((2011)) who employed a balance sheet framework to trace the evolution of sectoral balance sheet over the Great Moderation period between 1994 and 2007.

The rest of the chapter is organized as follows. Part 2.2 outlines the flow of funds model employed in the chapter. In part 2.3, the model is applied to the UK data over the period between 2007 and 2011 which is divided into two sub periods. The last part includes concluding remarks of the chapter.

2.2 The Balance Sheet Model

In their book of monetary economics, Godley and Lavoie (2007) utilize a framework based on national accounts to build a series of complete accounting systems of equations that relate between different stocks and flows in the national accounts. This system is complete in that the sum of each row or column in the transaction matrix is zero (Godley and Lavoie (2007)). Generally, their accounting-based framework is similar somehow to the financial statements included in the annual reports of corporations (the balance sheet, the income statement, and the statement of cash flows), and can then be represented using three matrices: overall (or sectoral) balance sheet matrix, transaction flow matrix, and full-integration matrix. The balance sheet matrix (shown in Table 2.1) combines the balance sheets of different economic sectors in one outfit which displays the physical assets and financial assets/liabilities of each sector at some point of time. In a balance sheet, total assets must be equal to total liabilities plus the net worth, and consequently for any column/sector in Table 2.1 the sum of tangible capital and financial assets on the

one hand must be equal to the sum of financial liabilities and net worth on the other. For example, the balance sheet of households in the second column of the Table must satisfy the following condition (where K_h: households owned tangible capital, B_h: bills held by households, H_h: cash held by households, M_h: households' deposits with banks, E_f and E_b: households' equity in production firms and banks respectively, L_h: households' bank borrowing, and NW_h: households' net worth):

$$K_h + B_h + H_h + M_h + E_f + E_b = L_h + NW_h$$

$$\Rightarrow K_h + B_h + H_h + M_h + E_f + E_b - L_h - NW_h = 0$$

Moreover, the fact that financial assets of different parties represent financial liabilities to the other parties requires each row in Table 2.1 that corresponds with some financial asset to sum up to zero. For instance, households, banks, and the central bank hold all the bills issued by the government:

$$B_h + B_b + B_{cb} = B$$

$$\Rightarrow B_h + B_b + B_{cb} - B = 0$$

Table 2.1: Godley and Lavoie Simplified Sectoral Balance Sheet Matrix

	Households	Production Firms	Banks	Government	Central Bank	∑
Tangible Capital	$+K_h$	$+K_f$				$+K$
Bills	$+B_h$		$+B_b$	$-B$	$+B_{cb}$	0
Cash	$+H_h$		$+H_b$		$-H$	0
Deposits	$+M_h$		$-M$			0
Loans	$-L_h$	$-L_f$	$+L$			0
Equities	$+E_f + E_b$	$-E_f$	$-E_b$			0
Net worth	$-NW_h$	$-NW_f$	$-NW_b$	$-NW_g$	0	$-K$
∑	0	0	0	0	0	0

Source: Godley and Lavoie (2007; P32)

* K_i: tangible capital owned by sector i; $i \in \{h, f, b, g, cb\}$; $\sum K_i = K$
* B_i: government bills held by sector i; B: total amount of government bills; $\sum B_i = B$
* H_i: cash held by sector i; H: total cash issued by the central bank; $\sum H_i = H$
* M_i: deposits of sector i with banks; M: total deposits with banks; $\sum M_i = M$
* L_i: bank loans owed by sector i; L: total loans provided by banks; $\sum L_i = L$
* E_i: equity issued by sector i
* NW_i: net worth of sector i; $\sum NW_i = -K$

The transactions flow matrix (presented in Table 2.2) includes a list of flows related to the transactions between different parts of the economy such as consumption, wages, taxes, etc. When an entity (person or organization) receives inflows from various sources, it uses them either to finance its current or capital activities or to expand its existing wealth of different forms. Thus, the sum of sources (+) in any columns

of Table 2.2 must be equal to the sum of uses (-). For instance, production firms use their current inflows from selling consumption and investment products to households ($C + I_h$), other production firms (I_f), and government (G) to pay their expenses such as wages (WB), interest on bank loans (interest rate on loans at the beginning of period $r_{l(-1)}$ times the size of loans at the beginning of period $L_{f(-1)}$), and taxes (T_f) and make the net profit (F_f) available to owners or households:

$$C + I + G = WB + F_f + r_{l(-1)}.L_{f(-1)} + T_f$$

$$\Rightarrow C + I + G - WB - F_f - r_{l(-1)}.L_{f(-1)} - T_f = 0$$

By using available sources to finance current or capital expenditure or to accumulate additional wealth, economic units create sources for the other units. Accordingly, the sum of each row in Table 2.2 must equal to zero. For example, the funds spent by government to purchases goods and services represent a source that can be used by production firms to finance their current spending.

Table 2.2: Godley and Lavoie Transaction Flow Matrix

	Households	Production Firms		Banks		Government	Central Bank		∑
		Current	Capital	Current	Capital		Current	Capital	
Consumption	$-C$	$+C$							0
Investment	$-I_h$	$+I$	$-I_f$						0
Gov. Exp.		$+G$				$-G$			0
Wages	$+WB$	$-WB$							0
Profits	$+FD_f + FD_b$	$-F_f$	$+FU_f$	$-F_b$	$+FU_b$	$+F_{cb}$	$-F_{cb}$		0
Loan Interest	$-r_{l(-1)}.L_{h(-1)}$	$-r_{l(-1)}.L_{f(-1)}$		$+r_{l(-1)}.L_{(-1)}$					0
Deposit Interest	$+r_{m(-1)}.M_{h(-1)}$			$-r_{m(-1)}.M_{(-1)}$					0
Bill Interest	$+r_{b(-1)}.B_{h(-1)}$			$+r_{b(-1)}.B_{b(-1)}$		$+r_{b(-1)}.B_{(-1)}$	$+r_{b(-1)}.B_{cb(-1)}$		0
Taxes – Transfers	$-T_h$	$-T_f$		T_b		$+T$			0
Change in Loans	$+\Delta L_h$		$+\Delta L_f$		$-\Delta L$				0
Change in Cash	$-\Delta H_h$				$-\Delta H_b$			$+\Delta H$	0
Change in deposits	$-\Delta M_h$				$+\Delta M$				0
Change in Bills	$-\Delta B_h$				$-\Delta B_h$	$+\Delta B$		$-\Delta B_{cb}$	0
Change in Equity	$-(\Delta E_f.p_{ef} + \Delta E_b.p_{eb})$		$+\Delta E_f.p_{ef}$		$+\Delta E_b.p_{eb}$				0
∑	0	0	0	0	0	0	0	0	0

Source: Godley and Lavoie (2007; P39)

* C: consumption expenditure
* I_i: investment expenditure by sector i; $i \in \{h, f, b, g, cb\}$; I: total investment expenditure; $\sum I_i = I$
* G: government expenditure
* WB: wages paid by production firms
* F_i: profits made by sector i; F_i either distributed to owners (FD_i) or retained (FU_i), so $F_i = FD_i + FU_i$
* F_{cb}: central bank profits
* r_j: interest rate on instrument j; $j \in \{l = loans, m = deposits, b = bills\}$; the subscript (-1) refers to the previous period
* T_i: net taxes (taxes – transfers) paid by sector i; T: net tax revenues to the government; $\sum T_i = T$
* p_{ef}: price of production firms equity
* p_{eb}: price of banks equity
* B_i: government bills held by sector i; B: total amount of government bills; $\sum B_i = B$
* H_i: cash held by sector i; H: total cash issued by the central bank; $\sum H_i = H$
* M_i: deposits of sector i with banks; M: total deposits with banks; $\sum M_i = M$
* L_i: bank loans owed by sector i; L: total loans provided by banks; $\sum L_i = L$
* E_i: equity issued by sector i

The full-integration matrix is the most important one for flow-of-funds analysis purposes since it demonstrates the developments in different asset/liability categories and consequently the changes in the economic positions of different sectors between two points of time as illustrated in Table 2.3. The changes in the balance sheet of some entity come from modifications to the size of different assets and liabilities on the one hand and revaluation effect on the other. As a result, Table 2.3 consists of four sections: initial balance sheet, changes in assets/liabilities, revaluation, and closing balance sheet. In each of Table 2.3 columns, the closing net worth is equal to the sum of initial net worth, changes in assets/liabilities, and the revaluation effects. For instance, the closing net worth of households (NW_h) can be given by the following equation (where p_{ef}: the price of production firms' equity, p_{eb}: the price of banks' equity, p_k: the price of tangible capital, NW_{h-1}: households initial net worth):

$$NW_h = NW_{h-1} - \Delta L_H + \Delta H_H + \Delta M_H + \Delta B_H + \left(\Delta E_f . p_{ef} + \Delta E_b . p_{eb}\right) + \Delta K_h . p_k$$

$$+ \left(\Delta p_{ef} . E_{f(-1)} + \Delta p_{eb} . E_{b(-1)}\right) + \Delta p_K . K_{h(-1)}$$

Table 2.3: Godley and Lavoie Full-Integration Matrix

		Households	P. Firms	Banks	Government	C. Bank	∑
Net Worth, end of previous period		$NW_{h(-1)}$	$NW_{f(-1)}$	$NW_{b(-1)}$	$NW_{g(-1)}$	0	$K_{(-1)}$
Changes in NW due to Transactions	ΔLoans	$-\Delta L_h$	$-\Delta L_f$	$+\Delta L$			0
	ΔCash	$+\Delta H_h$		$+\Delta H_b$		$-\Delta H$	0
	ΔDeposits	$+\Delta M_h$		$-\Delta M$			0
	ΔBills	$+\Delta B_h$		$+\Delta B_b$	$-\Delta B$	$+\Delta B_{cb}$	0
	ΔEquities	$+(\Delta E_f . p_{ef} + \Delta E_b . p_{eb})$	$-\Delta E_f . p_{ef}$	$-\Delta E_b . p_{eb}$			0
	ΔTangible Capital	$+\Delta K_h . p_k$	$+\Delta K_f . p_k$				$+\Delta K . p_k$
Changes in NW due to Revaluations	Capital gains in equity	$+\Delta p_{ef} . E_{f(-1)}$ $+\Delta p_{eb} . E_{b(-1)}$	$-\Delta p_{ef} . E_{f(-1)}$	$-\Delta p_{eb} . E_{b(-1)}$			0
	Capital gains in tangible capital	$+\Delta p_k . K_{h-1}$	$+\Delta p_k . K_{f(-1)}$				$+\Delta p_k (K_{h(-1)} + K_{f-(1)})$
Net Worth, end of current period		NW_h	NW_f	NW_b	NW_g	0	K

Source: Godley and Lavoie (2007; P44)

* K_i: tangible capital owned by sector i; $i \in \{h, f, b, g, cb\}$; $\sum K_i = K$; the subscript (-1) refers to the previous period
* B_i: government bills held by sector i; B: total amount of government bills; $\sum B_i = B$
* H_i: cash held by sector i; H: total cash issued by the central bank; $\sum H_i = H$
* M_i: deposits of sector i with banks; M: total deposits with banks; $\sum M_i = M$
* L_i: bank loans owed by sector i; L: total loans provided by banks; $\sum L_i = L$
* E_i: equity issued by sector i; the subscript (-1) refers to the previous period
* NW_i: net worth of sector i; $\sum NW_i = -K$; the subscript (-1) refers to the previous period
* p_{ef}: price of production firms' equity
* p_{eb}: price of banks equity
* p_k: price of physical capital

The implementation of the full-integration framework, shown in Table 2.3, requires data on the sectoral balance sheets and financial flows and the changes in net worth due to revaluations. While the first part of the data needed can easily be found in the sectoral financial and nonfinancial balance sheets and sectoral financial accounts data published by the Office for National Statistics (ONS) in the UK, the calculation of revaluation effects on net worth is not straight forward as it involves tracking the changes in prices of all physical and financial assets held by all sectors between two points of time. Accordingly, the residual method suggested by Barwell and Burrows (2011) is utilized to estimate revaluations-related changes in net worth. This method estimates the revaluation in the sector s holdings of asset i from period t–1 to period t through the following equation:

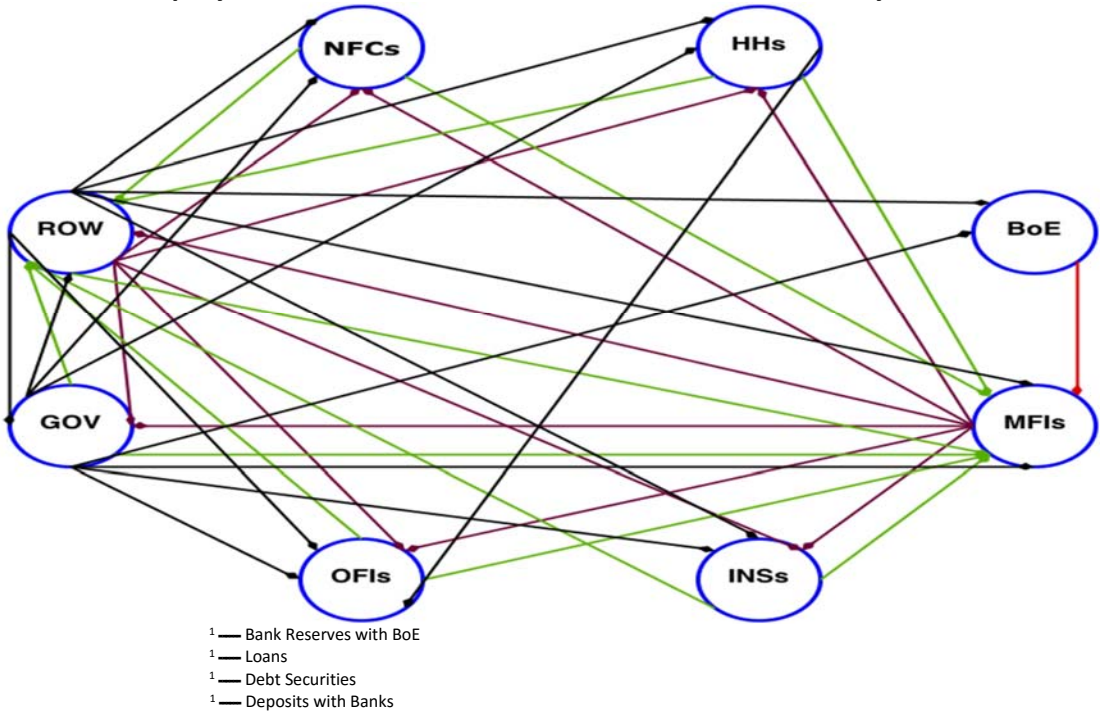
$$Revaluation_{i,s,t} = Stock_{i,s,t} - (Stock_{i,s,t-1} + Flow_{i,s,t})$$

Finally, following Barwell and Burrows (2011) on the one hand, and Castrén and Kavonius (2009) and Castrén and Rancan (2012) on the other, the flow of funds analysis in this chapter aggregates across main asset classes (deposits, loans, debt securities, equity, pension, and other assets) ONS data of seven separate sectors: households and non-profit institutions serving households (HHs), nonfinancial corporations (NFCs), banks or monetary financial institutions (MFIs), other financial intermediaries (OFIs), insurance companies and pension funds (INSs), rest of world (ROW), and government (GOV). The creditor-debtor linkages arisen from different financial assets between these sectors represent a network of relationships in which the components of economy interact with each other. This macro-network of the economy can be represented graphically in a chart similar to that displayed in Figure 2.4 which includes a network of non-equity indebtedness (i.e. deposits, loans, bank reserves, and debt securities) in the UK.[4]

In the next part of this chapter, the framework described here will be applied to the ONS data between 2007 and 2011 to document stylized facts and compare them to the actual observations during that period which will be divided into two sub period: post crisis-pre QE period (2007-2008) and QE period (2009-2001).

[4] Since this paper aims at analysing the effect of QE on the UK economy, it may be better to include the Bank of England as a separate sector. However, because of the lack of detailed data, this separation is not possible.

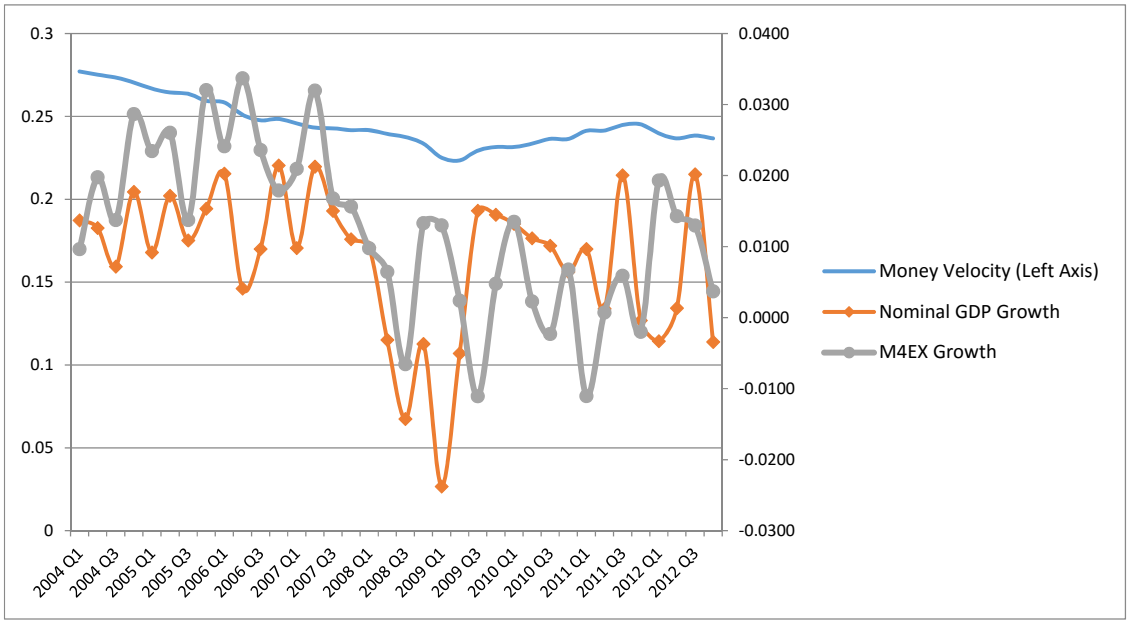
Figure 2.4: Non-Equity Indebtedness Macro-Network for the UK Economy[1]



2.3 The Analysis

Prior to the application of the balance sheet model explained above to the UK data, it is worth tracking the monetary developments over the 2007-2008 and 2009-2011 periods to investigate the implications of the crisis and BoE APP for the broad money. Figure 2.5 illustrates the quarterly growth rates of nominal GDP and M4 excluding intermediate other financial corporations (M4ex), and money velocity defined as the ratio between nominal GDP and M4ex between 2004 Q1 and 2012 Q4. In the Figure, the influence of the crisis is noticeable on nominal GDP and M4ex growth rates which presented significant deterioration between 2007 Q2 and 2009 Q2. Since the fall in nominal GDP is deeper than that in M4ex, money velocity showed a clear drop during that period. However, after the introduction of APP in March 2009, the growth rate of nominal GDP displayed a complex pattern. It noticeably increased between March and September 2009 (from -2.38% and +1.51%), then it slightly decreased until December 2010. After that it returned to its pre-crisis fluctuating pattern but with a wider range. Meanwhile, M4ex growth rate returned to the pre-crisis fluctuating pattern but at significantly lower levels. These developments in nominal GDP and M4ex growth rates explain the increase in money velocity between 2009 Q3 and 2012 Q1.

Figure 2.5: Nominal GDP Growth, Broad Money Growth, and Money Velocity (2004-2012)



Source: Bank of England (http://www.bankofengland.co.uk**) and ONS (**http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

As stated earlier, the accounting-based framework is implemented using the UK data between 2007 and 2011. This period is divided into two sub periods: 2007-2008 and 2009-2011. The rationale behind this division is to investigate the initial impact of the financial crisis on the sectoral balance sheets before the introduction of APP in 2009 on the one hand, and the implications of QE on the UK economy on the other.

2.3.1 Post Crisis-Pre QE Period

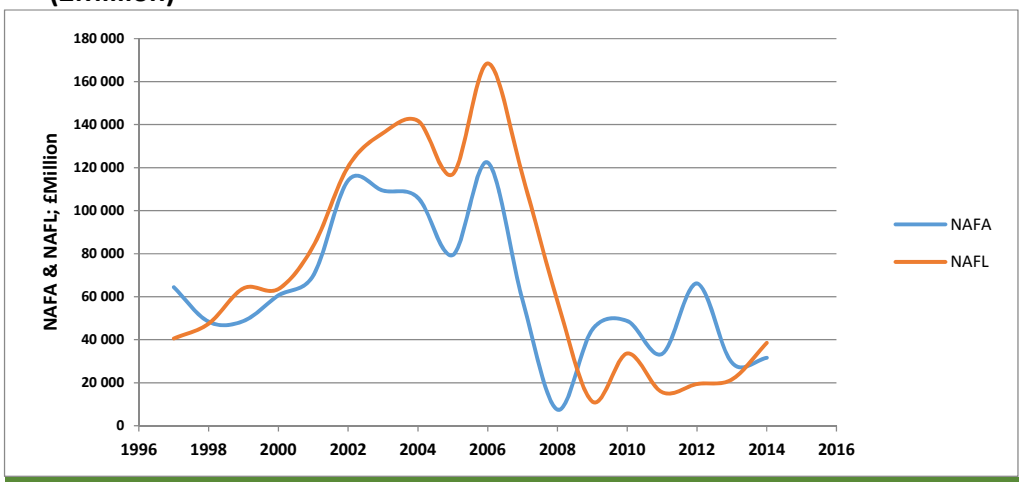
The developments in the sectoral balance sheets in the UK over the period between January 2007 and December 2008 are displayed in the full integration matrix in Table 2.4. During this period, UK economy entered a slowdown period as a result of the mid-2007 global financial crisis which had very important implications on the economic positions of different sectors. In the next sections, Table 2.4 figures will be explored sector-by-sector to investigate financial crisis impact on the sectoral economic positions.

2.3.1.1 Households and Non-Profit Institutions (HHs)

A quick look on Table 2.4 suggests that the financial position of HHs sector as a net lender had deteriorated by almost £400 billion -accounts for more than 10% of sector's financial assets at the time- in only two years mainly as a result of expansion in financial liabilities and to less extent the drop in financial

assets. A deeper inspection of the data shows that assets and liabilities revaluations played a key role in the depreciation in HHs' financial position. Despite the fact that HHs sector accumulated financial liabilities more than financial assets by about £110 billion in 2007 and 2008, a decrease of around £350 billion in the value of sector's financial assets was the main cause of the drop in the net lending of HHs. For instance, pension assets lost more than 17.5% of its value in 2008 according to OECD data.[5] The drop in HHs net lending was not a new trend but it worsened at the time of the crisis as displayed in Figure 2.6 which shows the developments in HHs sector net acquisition of financial assets and liabilities (NAFA and NAFL) over the period between the beginning of 1997 and the end of 2014. Between 1999 and 2008, HHs sector was accumulating more financial liabilities than financial assets every year with the biggest difference of about £50 billion in 2008.

Figure 2.6: UK HHs' Net Acquisition of Financial Assets (NAFA) and Liabilities (NAFL) 1997-2014 (£Million)



	1997	1998	1999	2000	2001	2002	2003	2004	2005
NAFA	64 409	48 350	48 692	60 646	69 868	114 089	109 304	106 025	79 381
NAFL	40 563	47 457	63 940	63 583	83 521	120 575	136 095	141 739	116 983
	2006	2007	2008	2009	2010	2011	2012	2013	2014
NAFA	122 347	58 209	7 492	44 818	48 713	33 432	66 168	29 324	31 609
NAFL	168 435	116 240	57 786	11 218	33 597	15 544	19 381	21 508	38 536

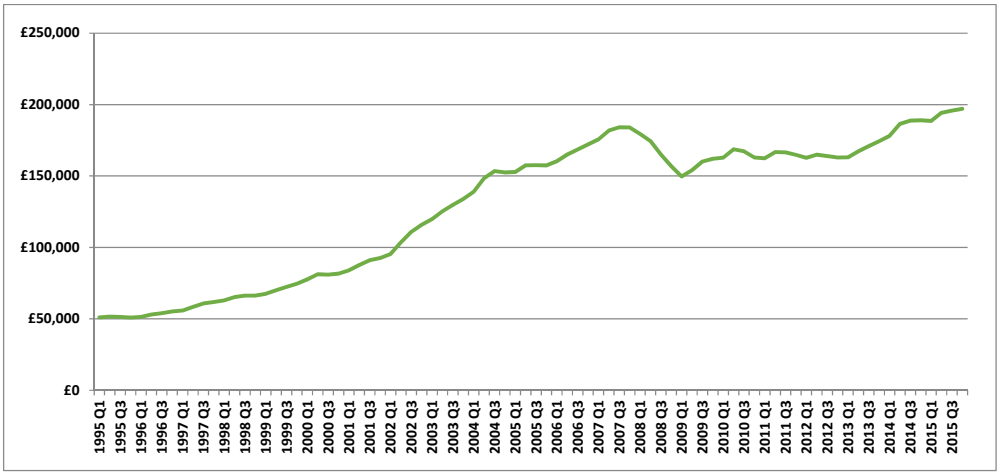
Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

Another interesting development in Table 2.4 is the large devaluation of HHs sector physical assets by more than £173 billion during 2007 and 2008. This drop in the value of physical assets was driven mainly

[5] See http://www.oecd-ilibrary.org/docserver/download/0110071ec005.pdf?expires=1458431325&id=id&accname=guest&checksum=C8C6C177DE528033B2C6B4699D3BA9BA.

by the noticeable fall in UK house prices between 2007 Q4 and 2009 Q1 as illustrated in Figure 2.7. This fall in house prices appears to be demand-led. In other words, the fall of house prices after the crisis was more a result of lower mortgage availability and reasonably pessimistic expectations about the future trends in the housing market rather than fire sales of houses during the crisis. The data from National Association of Estate Agents (ANEA) shows that while the number of properties available per estate agent branch expanded from 70 to 91 in the 2007-2008 period, the average number of house buyers on book per branch almost halved during the same period (it fell from 398 by the end of 2006 to only 207 by the end of 2008).

Figure 2.7: Average House Price in the UK (£; not seasonally adjusted)



Source: Nationwide (http://www.nationwide.co.uk/**)**

2.3.1.2 Nonfinancial Corporations (NFCs)

Figures in Table 2.4 show a decrease in NFCs' net borrowing by about £640 billion (from £1.967 to £1.329 trillion) during 2007 and 2008. Two factors contributed to the reduction of NFCs sector's indebtedness: relatively higher financial assets acquisition and revaluation effects. NFCs acquired more financial assets -mainly in ROW equity and outgoing foreign direct investment- than financial liabilities by about £70 billion. However, revaluation effects, especially in equity, account for around 90% of the drop in the net borrowing. This decline in equity indebtedness was a direct result of share prices fall between November 2007 and March 2009 as Figure 2.8 presents. Furthermore, similar to HHs sector, a

very big devaluation in the value of NFCs' physical assets can be spotted in the revaluation effects part of Table 2.4. The main cause of this wear in physical assets value was the depreciation of commercial real estate prices which lost about 30% of its value during 2008 according to FTSE UK commercial property index.[6]

Figure 2.8: FTSE Index 1995-2016 (Monthly)

Source: Yahoo! Finance (http://finance.yahoo.com**)**

2.3.1.3 Monetary Financial Institutions (MFIs)

MFIs sector net lending position shows slight fall in 2007 and 2008 (about £66 billion) as can be inferred from Table 2.4. This development was the net result of the interaction of many factors on both assets and liabilities sides of MFIs sector balance sheet. First, banks increased the amount of loans they provide by £531 billion, yet most of these loans went to OFIs, NFCs, and ROW sectors. Second, a shift from foreign to domestic debt securities and equity can be spotted in Table 2.4. MFIs sector decreased its foreign holdings of debt securities and equity by £123 billion and £40 billion respectively. However, it increased domestic holdings by £131 billion and £57 billion respectively. On the liabilities side, two main

[6] http://www.bpf.org.uk/en/reita/performance/ftse_uk_commercial_property_index.php

developments can be detected. While banks accepted £671 billion in new deposits mainly from OFIs, ROW, and HHs sectors, they raised about £163 billion in new debt securities.

Figure 2.9: FTSE A350 Banks 2000-2016 (Monthly)

Source: Yahoo! Finance (http://finance.yahoo.com**)**

Table 2.4-A: UK Transactions Matrix (2007-2008; £Million)

	HHs		NFCs		MFIs		OFIs		INSs		ROW		GOV	
	Sources	Uses	Sources	Uses	Sources	Uses	Sources	Uses	Sources	Uses	Sources	Uses	Sources	Uses
Income-Expenditure Flows														
Gross Income	2 220 085		768 384											
Taxes - Transfers		- 9 869		416 160									555 846	
Consumption		2 184 274												
Investment		154 005		282 101										
Government Expenditure														666 603
Net Lending		- 108 325		70 123										- 110 757
Financing Flows														
Change in Cash		5 307		237	3 375	- 1 951					- 47	20	285	
Change in Deposits		128 026		67 894	721 306	279 183		- 236		29 330	29 239	221 954		24 394
Change in Loans	154 264		202 742	170 754	- 143	531 694	96 287	160 511	- 6 851	791	278 835	- 125 570	14 759	1 713
Change in Debt Securities	2 405	- 8 267	28 204	3 992	162 606	9 364	293 003	179 581	1 270	70 192	- 828	373 027	147 004	5 775
Change in Equity		- 149 009	91 212	220 112	528	17 059	155 653	147 465	2 121	- 33 851	169 757	215 471		2 024
Change in Pensions		71 857		- 3 253				- 193	60 140	- 198		- 8 176		103
Change in OFLs/OFAs	17 357	17 787	44 710	- 22 745	20 881	112 500	- 17 791	91 129	- 15 686	- 17 679	148 716	- 87	26 971	44 253
NAFL/NAFA	174 026	65 701	366 868	436 991	908 553	947 849	527 152	578 257	40 994	48 585	625 672	676 639	189 019	78 262

Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

* OFLs and OFAs refer other financial liabilities and other financial assets respectively
* NAFL and NAFA refer to net acquisition of financial liabilities and net acquisition of financial assets respectively
* NAFA = NAFL + Net Lending

Table 2.4-B: UK Full-Integration Matrix (2007-2008; £Million)

Opening Balance Sheet														
	HHs		NFCs		MFIs		OFIs		INSs		ROW		GOV	
	A	L	A	L	A	L	A	L	A	L	A	L	A	L
Total Financial	3 873 579	1 412 880	1 725 891	3 692 988	8 007 721	7 703 311	2 522 537	3 195 678	2 213 059	2 357 170	6 712 399	6 325 149	339 673	704 247
Total Non-Financial	4 471 400		1 547 000											
Net Worth		6 932 099		- 420 097		304 410		- 673 141		- 144 111		387 250		- 364 574
Flow of Funds														
	NAFA	NAFL	NAFA	NAFL	NAFA	NAFL	NAFA	NAFL	NAFA	NAFL	NAFA	NAFL	NAFA	NAFL
Deposits (With)														
MFIs	115 478		- 2 135			671 016	300 456		13 203		221 954		22 060	
UK Interbank deposits					50 290	50 290								
ROW's MFIs	12 548		70 029		228 893		- 300 692		16 127			29 239	2 334	
Loans (Provided By)														
MFIs		- 946		131 010	531 694			288 751		- 5 316		103 869		14 326
Non-Banks (secured on dwellings)		156 315		2 488			156 315		775				1 713	
ROW's MFIs/Non-Banks		- 1 105		- 15 739				- 203 863		- 740	- 221 014			433
FDI Loans into the UK				84 983		- 143		11 399		- 795	95 444			
FDI Loans out of the UK			170 754				4 196		16			174 966		
Debt Securities (Issued By)														
GOV	- 9 895		1 741		23 633		80 690		- 21 028		71 972		- 109	147 004
ROW	176		- 10 244		- 122 864		76 467		53 471			- 828	2 166	
Domestic Private Sector	1 452	2 405	12 495	28 204	108 595	162 606	22 424	293 003	37 749	1 270	301 055		3 718	
Equity (Issued By)														
ROW	5 050		140 365		- 40 024		59 425		3 299			169 757	1 642	
Mutual Funds	- 23 492		10		32		77	- 6 811	16 530		32			
Domestic Private Sector	- 130 567		79 737	91 212	57 051	528	87 963	162 464	- 53 680	2 121	215 439		382	
Pensions														
	71 857		- 3 253				- 193		- 198	60 140	- 8 176		103	
Other														
Gold & SDRs											74		- 74	
Currency	5 307		237		- 1 951	3 375					20	- 47		285
Other Deposits	17 673		- 204		- 11		10 038	15 660			- 581		17 501	28 756
Other Loans by UK Residents	- 3 271	14 418	- 18 689	45 258	- 126		44 943	- 32 528	- 21 317	- 17 860		- 782	11 391	4 425
Other Accounts Receivables/Payables	4 188	2 939	- 3 298	- 1 402	- 48	20 684	1 276	- 1 066	- 152	2 174	420	1 038	15 275	- 6 706
Finance Leasing			586	854	- 30	197	1 134	143						496
Financial Derivatives	- 803	0	- 1 140		112 715		33 738		3 790			148 460	160	
Total NAFA/NAFL	65 701	174 026	436 991	366 868	947 849	908 553	578 257	527 152	48 585	40 994	676 639	625 672	78 262	189 019
Change in Physical Capital														
	154 005		282 101											
Revaluation Effects														
Debt Securities	5 085	- 1 733	- 16 658	- 32 693	147 937	100 968	- 8 753	307 523	- 30 165	- 63	80 639	275 192	8 650	32 030
Equities	- 64 209		- 42 955	- 472 378	- 112 886	10 263	- 228 506	- 375 148	- 191 467	- 36 418	- 278 172	- 36 497	14 828	
Financial Derivatives	2 718	2 731	28 378	28 608	6 040 620	6 018 372	1 548 739	1 552 402	119 734	120 426	3 024 800	3 038 059	- 4 391	
Pensions	- 289 355		0				0		0	- 289 316	39		0	
Physical Assets	- 173 705		- 296 801											
Other Assets/Liabilities	20 914	- 37 778	123 695	775	660 407	711 468	216 804	- 45 797	6 965	22 590	1 208 663	1 107 356	2 970	- 8 714
Close Balance Sheet														
	HH		NFC		MFI		OFI		INS		ROW		GOV	
	A	L	A	L	A	L	A	L	A	L	A	L	A	L
Total Financial	3 614 433	1 550 126	2 255 342	3 584 168	15 691 648	15 452 935	4 629 078	5 161 810	2 166 711	2 215 383	11 425 007	11 334 931	439 992	916 582
Total Non-Financial	4 451 700		1 532 300											
Net Worth		6 516 007		203 474		238 713		- 532 732		- 48 672		90 076		- 476 590

Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

Finally, some interesting points can be made on revaluation effects part in Table 2.4. First of all, there is an increase in the valuation of debt securities both held and issued by MFIs which can be explained by the several decreases in BoE short-term policy rate in 2007 and 2008. Furthermore, while the general fall in share prices shown in Figure 2.8 justifies the devaluation of equity held by banks, it is not easy to explain the increase of £10 billion in banks equity as bank share prices were decreasing at the time according to FTSE A350 Banks index in Figure 2.9. However, a deeper analysis of ONS dataset suggests that this increase in bank equity value was the net effect of a decrease in quoted equity value by £16 billion and an increase of £26 billion in unquoted equity value. A very important development spotted in this section on both assets and liabilities sides is the huge positive revaluation of financial derivatives which represents more than 400% of the financial derivative balance in the initial balance sheet at the beginning of 2007. Despite the fact that financial derivatives are highly volatile, it is not easy to find a sound economic explanation for this massive revaluation, especially at the time of the crisis. Indeed, the enormous inflation in financial derivatives balances had underseen accounting causes. Reporting institutions and the British Bankers' Association (BBA) decided that the credit derivatives definition captured by Form DQ (Quarterly Derivatives Return) should be expanded to meet the criteria specified in international standards with effect from 2007 Q4 (O'Connor (2008)). This definitional shift accounts for most of the increase in financial derivatives gross positions for all sectors in Table 2.4 with the major effects be on MFIs, ROW, and OFIs sectors balance sheets.

2.3.1.4 Other Financial Intermediaries (OFIs)

OFIs sector witnessed a decrease in its net borrowing position by about £140 billion from £673 billion to £533 billion during 2007 and 2008 due to many factors on both balance sheet sides. First, OFIs shifted some £300 billion of their deposits with foreign banks (about 58% of the balance at the beginning of 2007) to domestic banks, but also decreased the size of loans from ROW lending institutions by £203 billion.

Second, a quick look on the debt securities and equity sections suggests that OFIs raised extra £294 billion and £155 billion in debt securities and equity respectively. However, a deeper analysis of the ONS dataset shows that while the rise in debt securities balance was the net effect of a £2 billion decrease in short-term securities and a £295 billion increase in longer term securities, the growth of equity capital was the net of a £7 billion decrease in mutual funds equity and a £162 billion increase in other OFIs equity. The additional capital was mainly used to provide more loans: £156 billion in secured loans to HHs, £45 billion to other UK residents, and £4 billion in outgoing foreign direct investment on the one hand, and to acquire further debt securities and equity issued by domestic and foreign entities on the other. In revaluation section of Table 2.4, the devaluation of equity held and issued by OFIs sector can be easily justified given the general trend in share market, whereas explaining the opposite revaluation trends in debt securities held and issued by the sector is a trickier task. A more comprehensive examination of ONS data points out that this depreciation in the value of OFIs debt securities holdings was mainly generated by a fall in the value of domestic short-term securities and the longer term bonds issued by domestic private sector except those issued by MFIs.

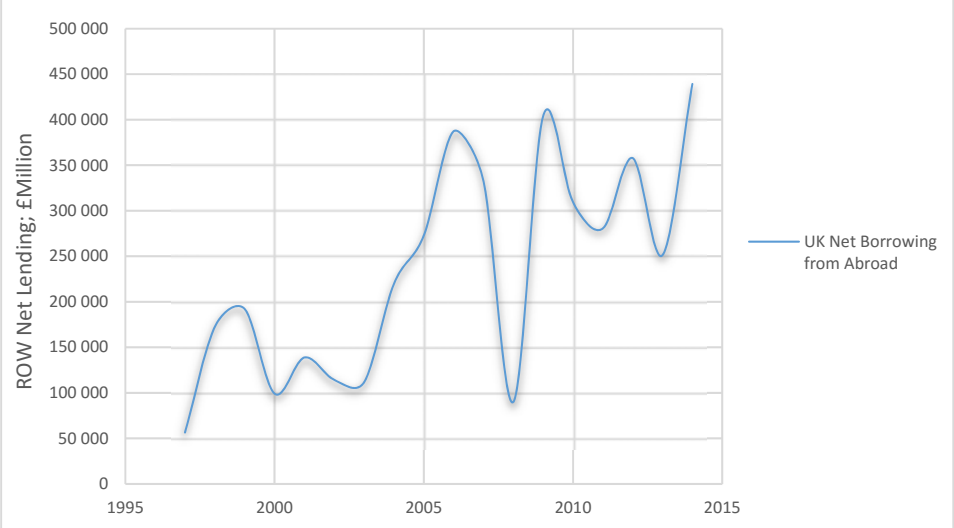
2.3.1.5 Insurance Companies and Pension Funds (INSs)

Similar to other net borrowing sectors, the net borrowing position of INSs sector fell by about £95 billion from £144 billion to £49 billion during 2007 and 2008. As Table 2.4 shows, INSs accumulated about £8 billion financial assets more than financial liabilities over 2007-2008 period, and consequently the main drivers of the drop in net borrowing of INSs sector can be marked in revaluation effects part of the Table. In this part, there are devaluations in all securities issued and held by INSs sector except financial derivatives which shows an increase in value because of the change in the accounting treatment of these instruments mentioned above. Nonetheless, the key role was played by the significant decrease in the value of INSs sector pension indebtedness toward HHs by around £290 billion.

2.3.1.6 Rest of World (ROW)

In Table 2.4, ROW sector witnessed a noticeable deterioration in its net lending position which reached its lowest size in more than ten years by the end of 2008 as Figure 2.10 reveals. During 2007 and 2008, ROW sector expanded deposits with domestic MFIs by about £222 billion and expanded holdings of domestic debt securities and equity by £373 billion and £215 billion respectively. These increases in deposits and debt and equity holdings were not enough to attain the original level of net lending into the UK because of four main factors (two in loans section and other two in revaluation section): the drop in the size of loans supplied by ROW credit providers to domestic private sectors, relatively higher outgoing compared to incoming foreign direct investment, the appreciation of ROW debt securities held by UK residents, and the devaluation of ROW holdings of domestic equity.

Figure 2.10: Rest of World Net Lending into the UK (£ Million)



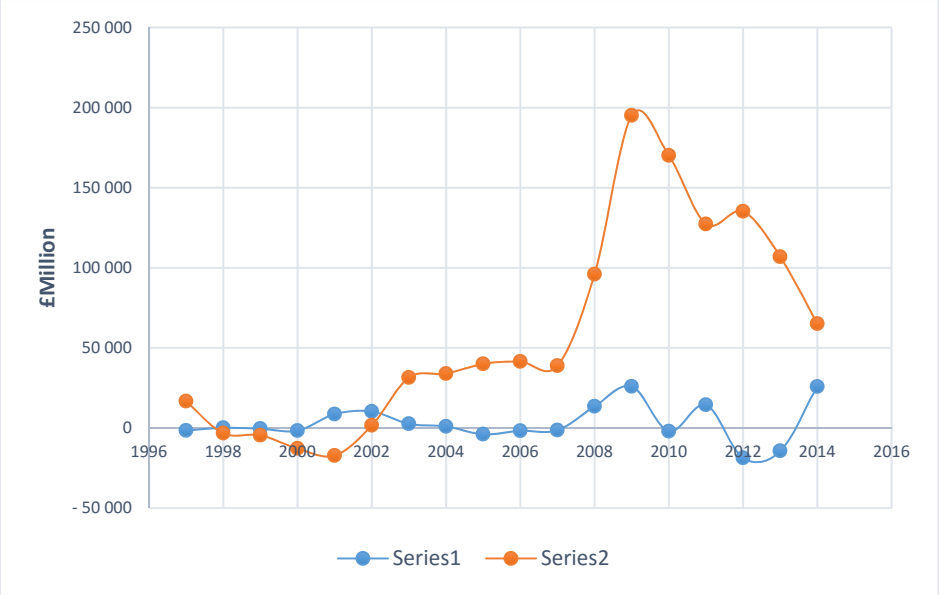
Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

2.3.1.7 Government (GOV)

As can be inferred from Table 2.4, the net borrowing position of government expanded by some £112 billion during the 2007-2008 period. The major change in government balance sheet happened on the liabilities side where additional £147 billion of debt securities (mainly longer term) issued by UK government in 2007-2008 period, which, consequently, increased UK government outstanding debt

securities to £651 billion by the end of 2008. The growth in the size of government debt securities was not a new trend at the time as Figure 2.11 shows. In this Figure, after the period between 1998 and 2001 when the government had retired more securities than the new issues, government security indebtedness was steadily growing until 2006 then witnessed a very quick expansion between 2007 and 2009.

Figure 2.11: The Growth of Outstanding UK Government Debt Securities 1997-2014 (£Million)



Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

2.3.1.8 Period Summary

The 2007-2008 period witnessed a reduction in the gaps between the financial positions of net lending sectors (HHs, MFIs, and ROW) and the net borrowing sectors (NFCs, OFIs, INSs, and GOV) except government whose net borrowing expanded by more than £100 billion during that period. The developments in financial and physical assets markets had important implications on the balance sheets of different sectors, and consequently played a key role in the changes in the net worth of these sectors with the major effect be on HHs sector's net worth which fell by about £400 billion in less than two years. First, the drop in share market between late 2007 and early 2009 affected equity values on both the liabilities side of the issuing sectors balance sheets and the assets side of the holding sectors balance sheets. While this devaluation in equity decreased equity indebtedness of issuing sectors (mainly NFCs

and OFIs) by about £910 billion during 2007-2008 period, its major effect on the holding sectors was on OFIs which lost £229 billion of the value of their equity holdings. Second, the obvious drop in real estate prices between 2007 Q4 and 2009 Q1 reflected on value of the nonfinancial assets of HHs and NFCs sectors which decreased by £20 billion and £15 billion respectively during that period.

Finally, the expansion in the definition of credit derivatives which came into effect late in 2007 to meet international standards resulted in a huge growth in the gross balances of these financial instruments at both sides of different sectors balance sheets with a major impact on MFIs, OFIs, and ROW sectors balance sheets. For instance, this definitional change explains a big part of the increase in the total assets of MFIs sector; it also accounts for 79% of assets growth and 78% of the liabilities growth.

2.3.2 QE Period

The full integration matrix in Table 2.5 presents the changes in the UK sectoral balance sheets over the period between January 2009 and December 2011. Early in 2009, the BoE realized that the decreases in the short-term policy rate, which reached its lower bound at the time, were not enough to stimulate the economy and to support economic recovery. To increase the level of liquidity in economy, MPC launched APP in March 2009 with an initial level of a £75 billion. Since its introduction, APP has had important influence on the economic and financial positions of different parts of the UK economy. In the following sections, the figures in Table 2.5 will be inspected sector-by-sector to explore the impact of QE on sectoral balance sheets over the 2009-2011 period.

2.3.2.1 Households and Non-Profit Institutions (HHs)

The figures in Table 2.5 indicate dramatic developments in HHs sector balance sheet. First of all, the sector net lending position witnessed an increase by more than £712 billion over the 2009-2011 period as a result of a significant expansion in financial assets and a slight decrease in financial liabilities. In this context, it is interesting to point out that in 2009 HHs sector ended a period of ten years at which it accumulated annually more financial liabilities than financial assets as Figure 2.6 shows. Furthermore, on

the assets side of the balance sheet, patterns similar to but weaker than those in the 2007-2008 period can be spotted with some exceptions. HHs sector decreased holdings of all domestic financial instruments except equity in mutual funds and increased deposits with banks but to a lower extent. On the liabilities side, the expansion in HHs sector loans was much slower in the 2009-2011 period; they increased by only about £7.5 billion compared to more than £154 billion in the 2007-2008 period. The same applies to funds raised through debt securities which grew by less than 10% of its growth in the 2007-2008. The main difference between the two periods appears in revaluation effects part, HHs witnessed significant revaluations in its holdings of different financial assets, especially pensions and equity. These developments can be mainly explained by the recovery of equity market (Figure 2.8) and the fall in debt securities yields (see, for example, Daines, Joyce and Tong (2012) and Joyce, Lasaosa, Stevens, and Tong (2011)).

Table 2.5-A: UK Transactions Matrix (2009-2011; £Million)

	HHs		NFCs		MFIs		OFIs		INSs		ROW		GOV	
	Sources	Uses	Sources	Uses	Sources	Uses	Sources	Uses	Sources	Uses	Sources	Uses	Sources	Uses
Income-Expenditure Flows														
Gross Income	3 642 998		1 050 973											
Taxes - Transfers		- 28 956		513 054									680 266	
Consumption		3 444 342												
Investment		161 008		362 087										
Government Expenditure														1 099 801
Net Lending		66 604		175 832										- 419 535
Financing Flows														
Change in Cash		7 973		983	11 538	2 726					- 284	- 65		
Change in Deposits		67 970		50 881	431 768	603 627		- 33 923		- 884	66 034	- 187 110		- 2 759
Change in Loans	7 486		- 157 092	- 73 187	- 256	- 207 774	164 317	- 49 316	- 12 906	2 331	- 166 342	135 672	- 25 238	2 243
Change in Debt Securities	203	- 4 946	3 434	6 129	- 40 533	212 007	6 581	304 820	3 298	47 400	274 903	196 633	530 936	16 779
Change in Equity		18 091	76 940	128 575	1 316	31 797	263 123	143 468	2 032	- 42 389	120 057	144 165		39 761
Change in Pensions		25 361		- 2 780				- 138	19 809	- 154		- 2 295		- 185
Change in OFLs/OFAs	52 670	12 514	- 14 487	- 25 974	159 868	- 89 525	- 9 034	- 2 738	- 12 884	20 028	- 67 723	2 068	13 987	44 311
NAFL/NAFA	60 359	126 963	- 91 205	84 627	563 701	552 858	424 987	362 173	- 651	26 332	226 645	289 068	519 685	100 150

Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

* OFLs and OFAs refer other financial liabilities and other financial assets respectively
* NAFL and NAFA refer to net acquisition of financial liabilities and net acquisition of financial assets respectively
* NAFA = NAFL + Net Lending

Table 2.5-B: UK Full-Integration Matrix (2009-2011; £Million)

Opening Balance Sheet														
	HHs		**NFCs**		**MFIs**		**OFIs**		**INSs**		**ROW**		**GOV**	
	A	**L**	**A**	**L**	**A**	**L**	**A**	**L**	**A**	**L**	**A**	**L**	**A**	**L**
Total Financial	3 614 433	1 550 126	2 255 342	3 584 168	15 691 648	15 452 935	4 629 078	5 161 810	2 166 711	2 215 383	11 425 007	11 334 931	439 992	916 582
Total Non-Financial	4 451 700		1 532 300											
Net Worth		6 516 007		203 474		238 713		- 532 732		- 48 672		90 076		- 476 590
Flow of Funds														
	NAFA	**NAFL**	**NAFA**	**NAFL**	**NAFA**	**NAFL**	**NAFA**	**NAFL**	**NAFA**	**NAFL**	**NAFA**	**NAFL**	**NAFA**	**NAFL**
Deposits (With)														
MFIs	74 215		34 242			- 161 350	- 65 867		- 12 968		- 187 110		- 3 862	
UK Interbank deposits					593 118	593 118								
ROW's MFIs	- 6 245		16 639		10 509		31 944		12 084			66 034	1 103	
Loans (Provided By)														
MFIs		52 578		- 82 861	- 207 774			- 65 202		- 1 994		- 86 256		- 24 039
Non-Banks (secured on dwellings)		- 40 973		3 130			- 40 973		887				2 243	
ROW's MFIs/Non-Banks		- 4 119		- 36 697				243 312		- 8 508	192 789			- 1 199
FDI Loans into the UK				- 40 664		- 256		- 13 793		- 2 404	- 57 117			
FDI Loans out of the UK			- 73 187				- 8 343		1 444			- 80 086		
Debt Securities (Issued By)														
GOV	- 1 157		1 396		338 569		11 746		24 395		155 283		704	530 936
ROW	264		7 608		- 56 804		272 085		32 095			274 903	19 655	
Domestic Private Sector	- 4 053	203	- 2 875	3 434	- 69 758	- 40 533	20 989	6 581	- 9 090	3 298	41 350		- 3 580	
Equity (Issued By)														
ROW	5 053		95 946		17 504		4 884		- 7 258			120 057	3 928	
Mutual Funds	45 314		28		88		241	88 945	43 186		88			
Domestic Private Sector	- 32 276		32 601	76 940	14 205	1 316	138 343	174 178	- 78 317	2 032	144 077		35 833	
Pensions														
	25 361		- 2 780				- 138		- 154	19 809	- 2 295		- 185	
Other														
Gold & SDRs											- 219		219	
Currency	7 973		983		2 726	11 538					- 65	- 284		363
Other Deposits	8 988		- 2 543				3 608	16 322			1 060		16 509	11 300
Other Loans by UK Residents	7 743	50 396	- 7 623	- 20 292	290		- 37 380	- 25 323	14 851	- 10 750		377	18 196	1 669
Other Accounts Receivables/Payables	- 4 000	2 274	- 2 628	4 930	- 21	- 1 731	1 932	- 213	405	- 2 134	1 227	1 214	7 885	460
Finance Leasing			71	875	- 42	249	1 470	180						195
Financial Derivatives	- 217	0	- 13 251		- 89 752		27 632		4 772			- 69 314	1 502	
Total NAFA/NAFL	126 963	60 359	84 627	- 91 205	552 858	563 701	362 173	424 987	26 332	- 651	289 068	226 645	100 150	519 685
Change in Physical Capital														
	161 008		362 087											
Revaluation Effects														
Debt Securities	18 397	- 1 762	7 595	93 434	77 612	- 66 162	-63 549	120 305	200 672	- 4 368	88 467	38 390	- 11 775	139 737
Equities	146 609		- 123 127	319 154	23 973	18 875	206 559	157 583	158 359	- 3 436	154 453	75 049	399	
Financial Derivatives	2 058	2 067	- 2 616	- 2 266	-2 132 232	-2 130 125	720 102	711 592	- 13 416	- 12 787	- 383 957	- 353 033	4 066	
Pensions	411 029		0				0		0	411 112	83		0	
Physical Assets	268 592		- 112 587											
Other Assets/Liabilities	- 278 504	- 82 106	50 827	26 977	- 623 253	- 663 831	- 38 683	- 145 455	34 201	12 304	- 124 601	- 154 040	25 414	9 635
Close Balance Sheet														
	HH		**NFC**		**MFI**		**OFI**		**INS**		**ROW**		**GOV**	
	A	**L**	**A**	**L**	**A**	**L**	**A**	**L**	**A**	**L**	**A**	**L**	**A**	**L**
Total Financial	4 309 577	1 528 684	2 160 061	3 930 262	13 590 606	13 175 393	5 815 680	6 430 822	2 572 859	2 617 557	11 448 520	11 167 942	558 246	1 585 639
Total Non-Financial	4 881 300		1 781 800											
Net Worth		7 662 193		11 599		415 213		- 615 142		- 44 698		280 578		-1 027 393

Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html**)**

2.3.2.2 Nonfinancial Corporations (NFCs)

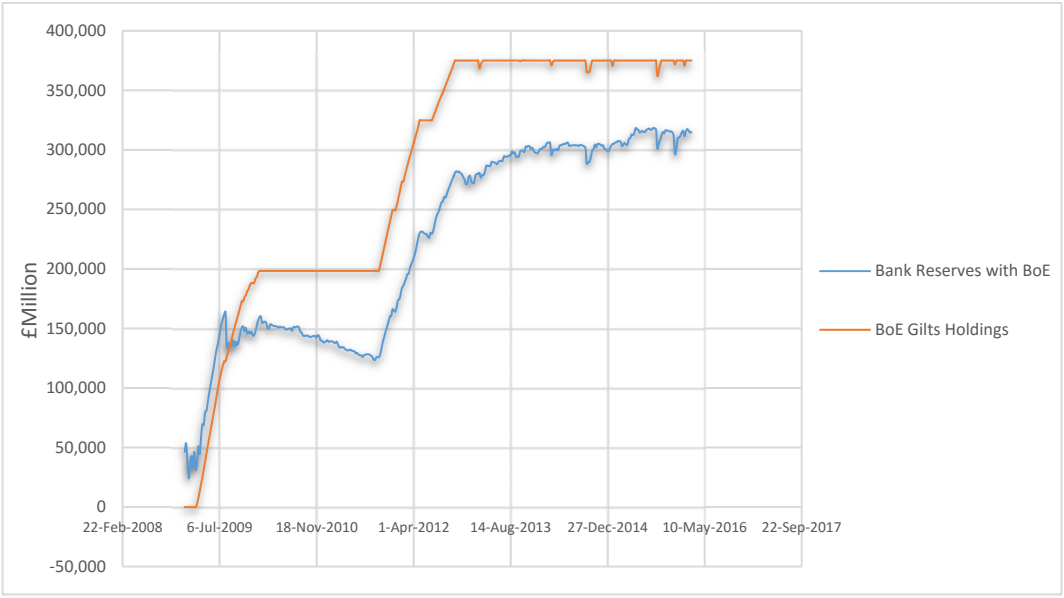
The first examination of NFCs sector figures in Table 2.5 indicates that while the sector accumulated extra £85 billion in financial assets and depreciated £91 billion of its financial liabilities, its net borrowing position expanded by more than £441 billion in the 2009-2011 period. A deeper analysis of the assets side shows increases in deposits with domestic and foreign banks and holdings of all securities except debt securities issued by domestic private sector and financial derivatives along with a decrease in outgoing foreign direct investment by more than £73 billion. In comparison to the 2007-2008 period, NFCs displayed more interest in financial rather than direct investment outside the UK, preferred foreign to domestic debt securities, and continued to increase their holdings of foreign and domestic equity. The major developments on liabilities side of NFCs sector balance sheet were the repayment of about £119 billion of bank loans, the fall in incoming foreign direct investment, and - similar to the 2007-2008 period- the reliance on equity rather than debt issuance to raise new long term capital (£77 billion versus £3.5 billion). In revaluation effects section of Table 2.5, while the appreciation in the values of debt securities on both balance sheet sides and in NFCs equity on liabilities side can be explained give the fall in debt securities yields and the general rise in share market, the devaluation of equity holdings on the assets side requires further investigation. ONS data analysis points out that this depreciation was generated by a drop of £98 billion in the value of NFCs foreign equity holdings compared to some £25 billion fall in the value of domestic equity investments.

2.3.2.3 Monetary Financial Institutions (MFIs)

Although MFIs sector accumulated more financial liabilities than financial assets, net lending position of MFIs sector improved by £176.5 billion in three years from £238.7 billion in January 2009 to £415.2 billion in December 2011. Four major developments in MFIs sector balance sheet require attention in Table 2.5: a shrinkage in the deposits with banks, a substantial growth in MFIs holdings of government debt securities, a massive expansion in the interbank deposits, and a significant fall in bank loans. First, the increase in HHs and NFCs deposits was not enough to prevent the decrease in deposits with domestic

banks which was mainly driven by a drop in the foreign and the domestic financial sectors deposits. Furthermore, Figure 2.12 shows expansions in government securities holdings and interbank deposits; these increases were a direct result of BoE APP which raised BoE gilts holdings on the one hand, and bank reserves where BoE credits the price of the purchased assets on the other. Moreover, bank lending represents one of transmission channels through which the impact of QE is delivered into the real economy (Joyce, Tong, and Woods; 2011). However, contrary to 2007-2008 period, the amount of loans banks provided declined by about £208 billion during 2009-2011 period. This may suggest that BoE QE failed to stimulate bank lending but rather bank lending diminished after QE introduced early in 2009.

Figure 2.12: Bank of England Gilts Holdings and Bank Reserve with BoE (£ Million; Weekly)



Source: Bank of England (http://www.bankofengland.co.uk**)**

Finally, the developments in revaluation effects section explain a big part of the expansion in net lending position of MFIs sector. The major contribution comes from the increase in the value of holdings of debt securities and equity on the one hand and the devaluation of debt securities issued by MFIs especially medium term securities (about £34 billion) on the other.

2.3.2.4 Other Financial Intermediaries (OFIs)

OFIs sector witnessed a growth of more than £82 billion in its net borrowing position in 2009-2011 period. Unlike the first three sectors, the expansion in OFIs sector net borrowing position was mainly

generated from the difference between NAFA and NAFL rather than revaluation effects. Three main developments in OFIs sector balance sheet can be figured out from Table 2.5. First, OFIs decreased their transactions with domestic banks on both side of the balance sheet through decreasing deposits with banks and repaying part of their bank loans. Second, OFIs became somewhat *abroad biased*; they invested relatively higher amounts in foreign rather domestic debt instruments (i.e. loans and debt securities) and raised the majority of its new debt capital from foreign sources. In net, OFIs moved more than £71 billion out of the UK. Lastly, equity issuance was the main source of OFIs new longer term capital.

2.3.2.5 Insurance Companies and Pension Funds (INSs)

Although INSs invested more than £26 billion in new financial assets and repaid £651 million of their financial liabilities, the revaluations of different assets and liabilities worked in the opposite direction. As a result, INSs sector figures in Table 2.5 indicate a slight decline by about £4 billion or 8.2% in the net borrowing of the sector between January 2009 and December 2011. Similar to OFIs sector case, INSs sector became relatively *abroad biased* in non-equity instruments except loans received from all (domestic and foreign) sources, and sent about £50 billion, in net, overseas. While INSs shifted part of bank deposits from domestic to foreign banks and invested more in foreign rather domestic debt instruments (loans and debt securities), they redeemed noticeable share of their loan indebtedness to different creditors and issued about £3.3 billion of new debt securities. In equity market, INSs sold a part of their equity holdings except mutual funds equity where they invested additional £43 billion and raised further £2 billion in equity during the 2009-2011 period. In revaluation effects section of Table 2.5, INSs sector witnessed an increase in the value of its holdings of debt securities and equity. It also witnessed a drop in the value of its debt securities and equity indebtedness which would have converted the sector from a net borrower to a net lender had not the value of its pension related liabilities expanded by more than £411 billion.

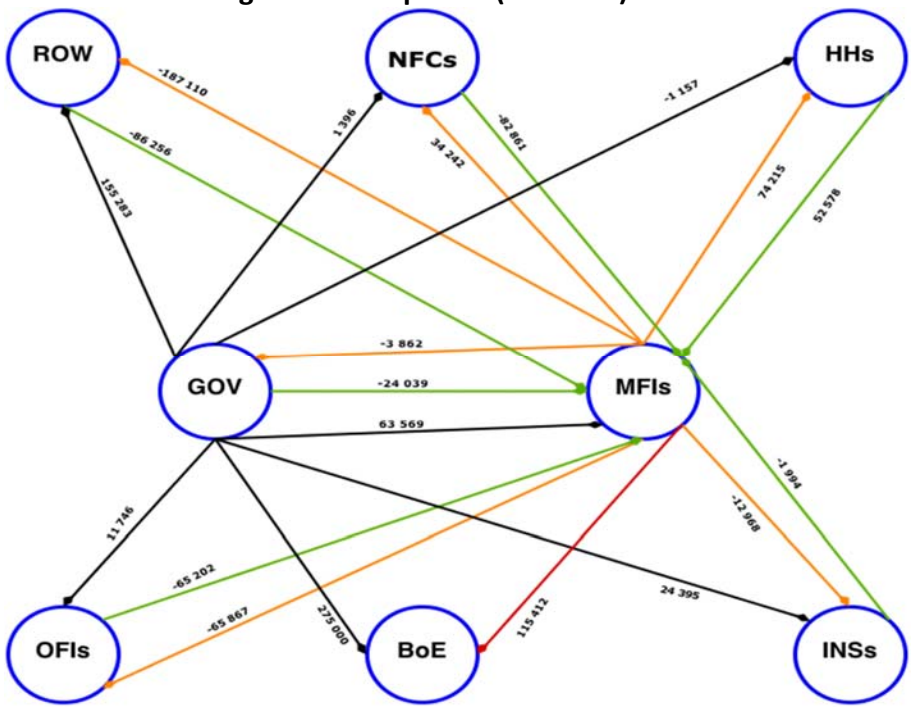
2.3.2.6 Rest of World (ROW)

The net lending position of ROW sector more than tripled from roughly £90 billion to about £281 billion during the 2009-2011 period. Non UK residents accumulated more UK assets than UK-based

liabilities by more than £62 billion; yet, 70% of the expansion in UK net borrowing from abroad was due to revaluation. On the assets side, while ROW sector withdrew part of deposits with domestic banks and decreased its direct investment in domestic ventures, it invested more funds in domestic debt instruments especially loans (£193 billion), government debt (£155 Billion), and private sector equity (£144 billion). On the liabilities side, ROW sector raised more capital in the UK from security-based sources (debt securities and equity) and decreased its reliance on domestic banks loans.

2.3.2.7 Government (GOV)

Figure 2.13: Changes in Deposits with Banks, Bank Loans, Reserves with BoE, and Government Debt Securities during 2009-2011 period (£ Million)[1]



[1] — Deposits with Banks — Bank Loans — Bank Reserves with BoE — Government Debt Securities

During the 2009-2011 period, the net borrowing of GOV sector more than doubled from about £477 billion in January 2009 to more than £1.027 trillion by the end of 2011 as a direct result of the issuance of huge amounts of government debt securities and the noticeable increase in the value of these securities. The major developments in GOV sector balance sheet in this period are very similar to but more significant than those which occurred over the 2007-2008 period except the drop in government deposits with

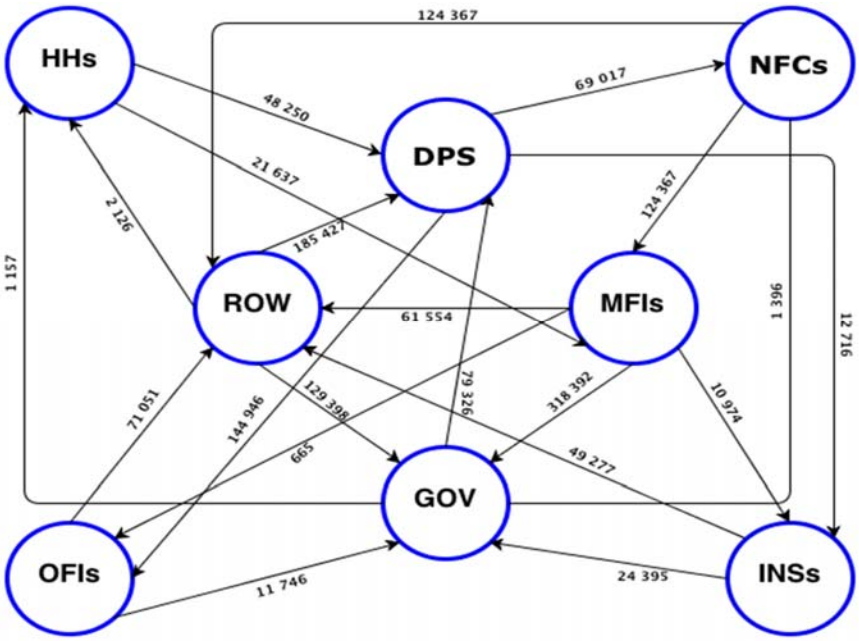
domestic banks and holdings of private sector debt securities. As Table 2.5 figures show, government raised its holdings of foreign securities and domestic equity and provided more £18 billion in the form of loans to HHs sector on the assets side, decreased its reliance on domestic and foreign banks loans, and issued £531 billion of extra debt securities on liabilities side. Lastly, the major change in revaluation effects section of Table 2.5 was the noticeable growth in valuation of government debt securities which accounts for roughly the quarter of the expansion in GOV sector net borrowing position in the 2009-2011 period.

2.3.2.8 Period Summary

Contrary to the 2007-2008 period, the gaps between financial positions of the net lending sectors (HHs, MFIs, and ROW) and the net borrowing sectors (NFCs, OFIs, INSs, and GOV) -except INSs sector whose net borrowing fell slightly- expanded over the three years after the introduction of APP in 2009. Figure 2.13 demonstrates the main financial flows during the 2009-2011 period. Five major developments characterize the 2009-2011 period: substantial fall in domestic bank deposits and loans and expansion in interbank deposits, noticeable growth in the issuance of debt securities especially government gilts, obvious reliance of domestic productive private sectors (NFCs, MFIs, OFIs, and INSs) on equity capital rather than debt capital, higher level of domestic sectors interaction with ROW sector and increasing amounts of money sent overseas, and significant positive revaluations of equity and debt securities. First, although domestic banks accepted over £108 billion of further deposits from HHs and NFCs, and provided about £53 billion in additional loans to HHs sector, total deposits and total bank lending fell by approximately £161 billion (2.4%) and £208 billion (5.5%) respectively during the 2009-2011 period. This drop in deposits and bank loans was accompanied by a wide expansion in interbank deposits by more than £593 billion. Second, the issuance of new debt securities by all sectors except MFIs notably increased during the 2009-2011 period, with the major expansion be in government gilts and -to lower extent- foreign debt securities, as Table 2.5 illustrates. This growth in debt securities is reasonable given the fall in debt securities yields due to BoE asset purchase activities (see, for example, Daines, Joyce and Tong

(2012)). Third, although they issued big sums of new debt securities, all domestic productive private sectors except INSs relied on equity rather than debt securities issuance to raise massive amounts of long term capital. Yet, determining the causes of this tendency is not an easy duty. Fourth, the size of financial transactions with ROW sector significantly grew on both balance sheet sides for all sectors except MFIs.

Figure 2.14: Net Flows between Different Sectors during 2009-2011 Period (£ Million)[1]



[1] DPS denotes for domestic private sector included to overcome the inability to allocate some of the financial flows especially flows related to debt securities and equity) over different sectors. The incoming and outgoing arrows to this node reflects the net financial flows -that cannot be specifically allocated- between domestic private sector as a whole and the seven sectors included in the analysis.

Figures in Table 2.5 show that whereas domestic sectors increased their deposits with foreign banks, they received a lot of foreign funds in form of direct loans on the one hand and investment in debt securities and equity on the other. Nevertheless, domestic productive private sectors (NFCs, MFIs, OFIs, and INSs) sent in net massive amounts of money out of the country as Figure 2.14 shows. Again, it is not easy to explain this kind of abroad bias. Finally, the clear increase in the valuations of debt securities and equity played the major role in the evolution of the financial positions of most sectors. While BoE asset purchase activities in debt securities market may represent a valid justification for the growth in the value of these securities (especially gilts), the effect of BoE APP on equity prices is less obvious.

2.3.3 Cross-Period Comparison and QE Implications

According to Joyce, Tong, and Woods (2011), the impact of QE is delivered to the real economy through several transmission channels: policy signalling, portfolio rebalancing, liquidity premiums, bank lending, and consumer confidence. While most of these channels pass over asset prices and returns to influence consumer wealth and the cost of borrowing, bank lending and consumer confidence channels directly affect spending and output in the economy.

The comparison between the figures of the post-crisis pre-QE period on the one hand and the QE period on other in Tables 2.4 and 2.5 indicates very important implications about the impact of APP on the UK economy over about three years after its introduction in March 2009. First, the new electronic money created by BoE to finance its asset purchases is credited into reserve account of the seller's bank (which, in turn, deposits the same amount into the seller's account) to increase liquidity within the banking system and then encourage banks to expand lending to households and businesses. However, Table 2.5 shows that BoE APP failed to increase the size of bank lending except loans provided to the HHs sector. On the contrary, total bank lending (which increased by about £532 billion in the 2007-2008 period) fell down by roughly less than £208 billion over the 2009-2011 period. Second, the significant positive revaluations of debt securities and equity may suggest that APP succeeded in raising the prices of debt securities and equity and consequently positively affect consumer wealth. Nonetheless, while the influence of APP on debt securities prices is sensible and easy to understand, its impact on equity prices as well as the reflection of the increases in consumer wealth on the real economy require additional investigation. Third, since many studies indicate a possible drop in the yields of longer-term debt securities, it appears that APP did well in inducing different sectors to issue more debt securities. Yet, whether the expansion in debt capital really reflected on spending and output represents an open question that needs further exploration. Finally, two new trends in the sectoral balance sheets can be spotted by comparing between Tables 2.4 and 2.5: the relative greater dependency on equity rather than

debt issuance to raise new longer-term capital, and the higher level of interaction with nonresidents and the increasing amounts of money sent abroad. Accordingly, additional examination is required to specify the role of APP in these new tendencies.

Overall, the fact that revaluations effects explain relatively big part of the developments in the balance sheets of most sectors may point out that APP during its first three years was more successful in affecting asset prices and returns rather than influencing the decision making of different sectors of the UK economy.

2.4 Conclusion

This chapter employed a flow of funds model built on Godley and Lavoie (2007) framework to inspect the influence of BoE APP on the UK economy through exploring the developments in the sectoral balance sheets before and after the introduction of APP in March 2009. Following Barwell and Burrows (2011) on the one hand, and Castrén and Kavonius (2009) and Castrén and Rancan (2012) on the other, the model aggregated ONS data of seven different sectors between 2007 and 2011 across six main asset classes (deposits, loans, debt securities, equity, pension, and other assets). In order to document the initial effects of global financial crisis and evaluate the impact of QE on the UK economy, the five-year period covered in the chapter was divided into two sub-periods around APP introduction: post crisis-pre QE period (2007-2008) and QE period (2009-2011). The main results of the analysis show that the 2007-2008 period witnessed a shrinkage in the gaps between the financial positions of net lending sectors (HHs, MFIs, and ROW) and net borrowing sectors except the government sector -whose net borrowing expanded by more than £110 billion- due to changes in financial assets/liabilities accumulation and developments in assets markets. Moreover, QE period was characterized by five major developments: considerable reduction in domestic bank deposits and loans and growth in interbank deposits, obvious increase in debt securities issuance especially government gilts and foreign bonds, clear dependence of domestic productive private sectors (NFCs, MFIs, OFIs, and INSs) on equity rather than debt capital, higher level of interaction with

nonresidents and increasing amounts of money sent abroad, and significant positive revaluations of equity and debt securities. The comparison between the figures of the two periods produced very important results concerning the influence of BoE APP on UK economy. First, APP was unsuccessful in expanding bank lending which dropped by about £208 billion in the 2009-2011 period. Second, APP might have positive effects on debt securities and equity prices and hence consumer wealth. Third, through reducing the cost of borrowing, it appears that APP induced the majority of sectors to issue more debt securities. Fourth, after the introduction of APP early in 2009, several sectors relied more on equity than debt capital. Finally, domestic productive private sectors (NFCs, MFIs, OFIs, and INSs) showed some *abroad bias* and sent massive amounts of money out of the country on the other.

Overall, the impact of BoE APP found its way into various asset markets where higher asset prices and lower asset returns can be noticed especially for longer-term assets. This fall in asset yields decreased the cost of both debt and equity capital and hence induced different sectors to raise further longer-term funds from these two sources. However, the fall in the cost of capital might cause a trade-off between bank loans and longer-term capital in the sense that funds raised through new capital issuance replaced bank loans as most sectors used big shares of the funds raised to repay significant amounts of bank loans which dramatically dropped after APP was introduced. Moreover, the relatively lower asset yields in the UK motivated productive private sectors (NFCs, MFIs, OFIs, and INSs) to move substantial amounts of domestically raised funds outside the country to benefit from higher returns elsewhere.

Finally, the results shed the light on some interesting points that require more investigation and represent rich areas for further research. This includes the impact of APP on equity prices, the reflection of increases in consumer wealth (due to positive asset revaluations) and debt capital (resulted from the decreases in the cost of borrowing) on the real economy, and the causes of the higher levels of reliance on equity rather than debt capital and interaction with ROW sector and the increasing amounts of money sent abroad.

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Chapter 3

The Impact of Quantitative Easing on Bank Lending in the UK

Evidence from an Agent-Based Model

Abstract

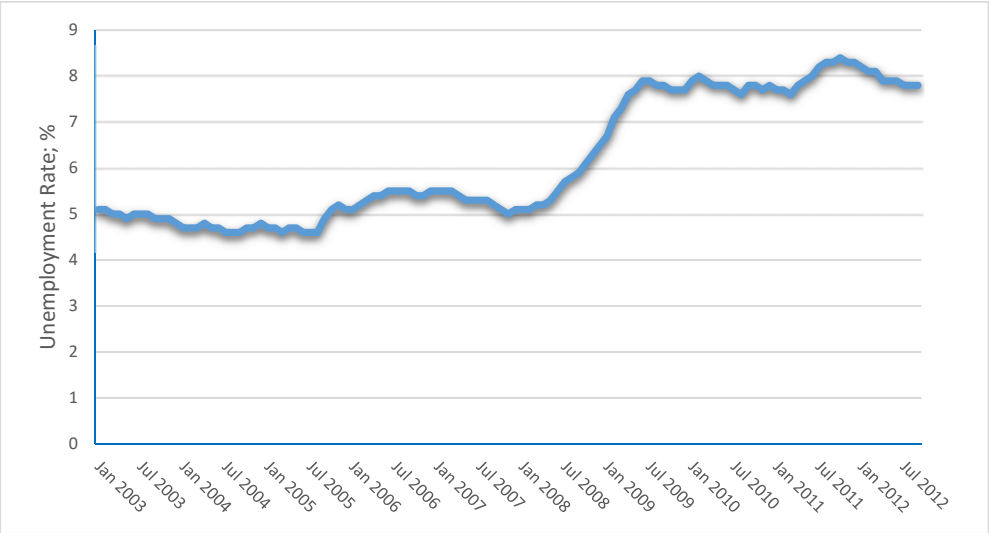
Against the backgrounds of unprecedented expansion of bank reserves at the central banks, the model proposed in this chapter combines the main factors in the environment of quantitative easing (QE) milieu and that of Basel regulatory framework. The lower bond yields caused by QE encourage big firms to substitute away from bank borrowing to security debt (bonds). In addition, the risk weight regime of Basel capital adequacy requirements induces banks to favour mortgages over business loans to small and medium enterprises (SMEs). This chapter explains the drop in bank lending to nonfinancial sector using an agent-based computational economics (ACE) approach. The baseline model contains four types of agents -households (HHs), big firms (BFs), small and medium enterprises (SMEs), and banks- which are empirically calibrated with the actual UK data for these agents. The model agents interact monthly for a period of 50 months in an environment that simulates bank lending markets in the UK after APP was introduced in 2009. In a scenario analysis, we contrast the implications on bank behaviour of Basel III capital adequacy requirements (scenario 3) with Basel I (simple capital adequacy requirements with no risk weights) and the case of no capital requirements (scenarios 1 and 2 respectively). The scenario analysis shows that in the absence of risk weighting (i.e. scenarios 1 and 2), both lending to SMEs and total lending would have been higher. The combination of lower bond yields and Basel III capital adequacy requirements on banks appears to play a role in the drop in the amount of bank loans to businesses. Similar to the actual data, simulation results indicate that the rise in the amount of mortgages was not enough to counter the decrease in business loans which represents the main cause of the shrinkage in total bank lending.[7]

[7] I am grateful for Dr. Marco Rabrto of the University of Genoa whose lectures at Essex provided much help in build-up of the MatLab® code used in the simulation in this chapter.

3.1 Introduction

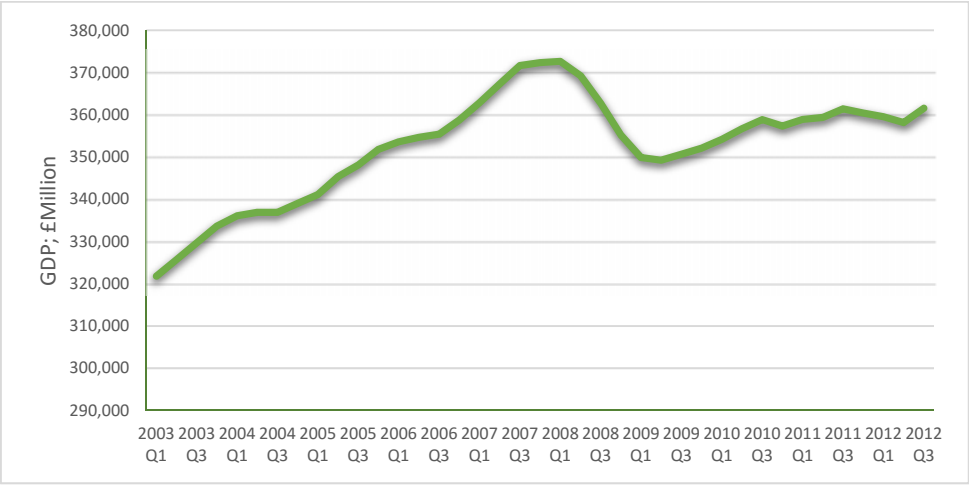
The financial crisis of mid 2007 produced severe recessions in major economies and raised the threat of a total collapse of the global financial system. The crisis had major repressions for the UK economy which witnessed a clear rise in unemployment (Figure 3.1) and severe contractions in GDP which fell by about 4.7% in the last 3 quarters of 2008 as Figure 3.2 shows.

Figure 3.1: The UK Monthly Unemployment Rate (%; Seasonally Adjusted)



Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html)

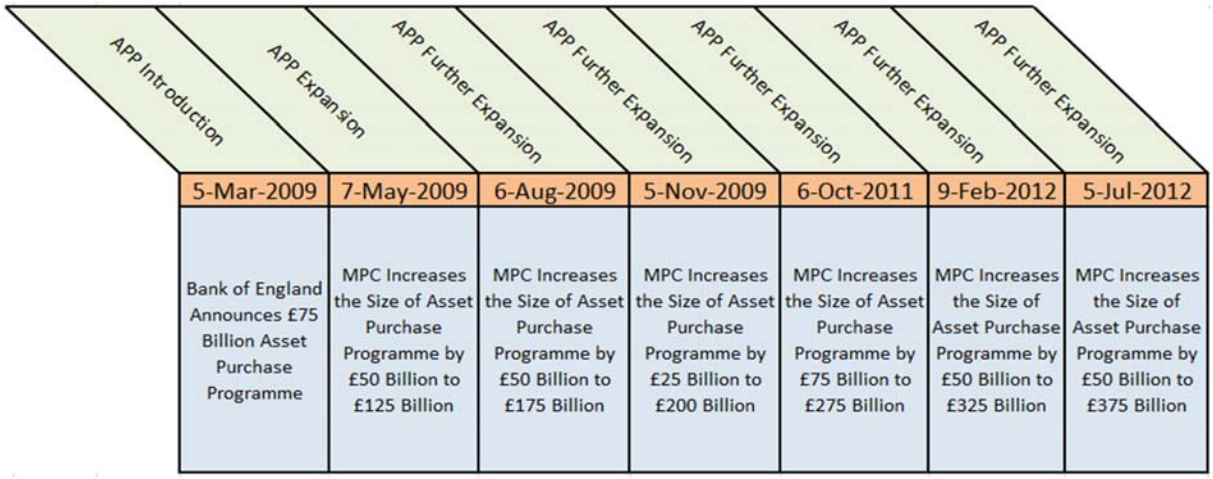
Figure 3.2: The UK Quarterly Gross Domestic Product (£ Million; Seasonally Adjusted)



Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html)

Similar to the monetary authorities of other countries, the Bank of England (BoE henceforth) reduced its short-term policy rate to exceptionally low levels. The Monetary Policy Committee (MPC hereafter) of the Bank decreased many times the policy rate which reached 0.5% -effectively its lower bound- early in 2009. Nevertheless, the substantial monetary loosening proved not to be sufficient to support aggregate demand and hence help the economy to recover. Consequently, in order to inject more liquidity into the economy and boost aggregate expenditure, MPC launched an open-ended asset purchase program (APP hereafter) to buy longer term securities in March 2009. The program started with £75 billion of asset purchases then expanded in several tranches up to £375 billion in July 2012. Figure 3.3 presents the key stages of APP between March 2009 and July 2012.

Figure 3.3: The Bank of England's Asset Purchase Program (APP) Timeline



Source: Bank of England (http://www.bankofengland.co.uk)

According to Joyce, Tong, and Woods (2011) quantitative easing (QE) policy influences the real economy through five transmission channels which include policy signalling, portfolio rebalancing, liquidity, broad money, and confidence. As Figure 3.4 illustrates, while the effects of QE can spread directly into the wider economy through the confidence factor leading to larger aggregate expenditure, asset prices and returns represent the path of transmission for the other four channels. The broad money channel utilizes the bank lending transmission mechanism which is central to this chapter. For instance, when a central bank buys

debt securities from outside the banking system,[8] it produces new electronic money which it deposits into the reserve account of the seller's bank which, in turn, credits the same amount into the seller's account. This increases liquidity within the banking system and may induce banks to expand their lending to households and businesses. Lastly, by affecting asset yields, QE might boost aggregate spending through decreasing the cost of borrowing for firms and consumers (Joyce, Tong, and Woods (2011)).

Figure 3.4: The Transmission Channels of Quantitative Easing (QE)

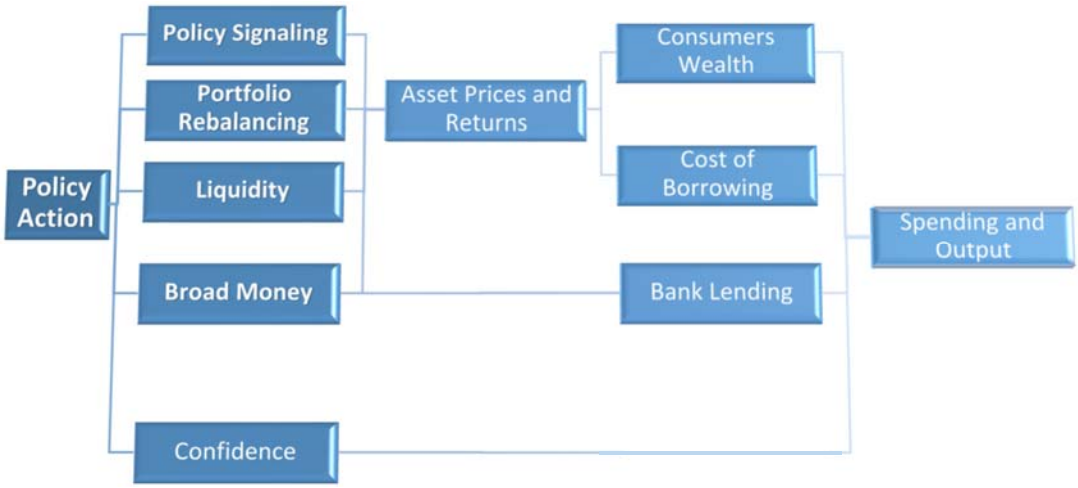
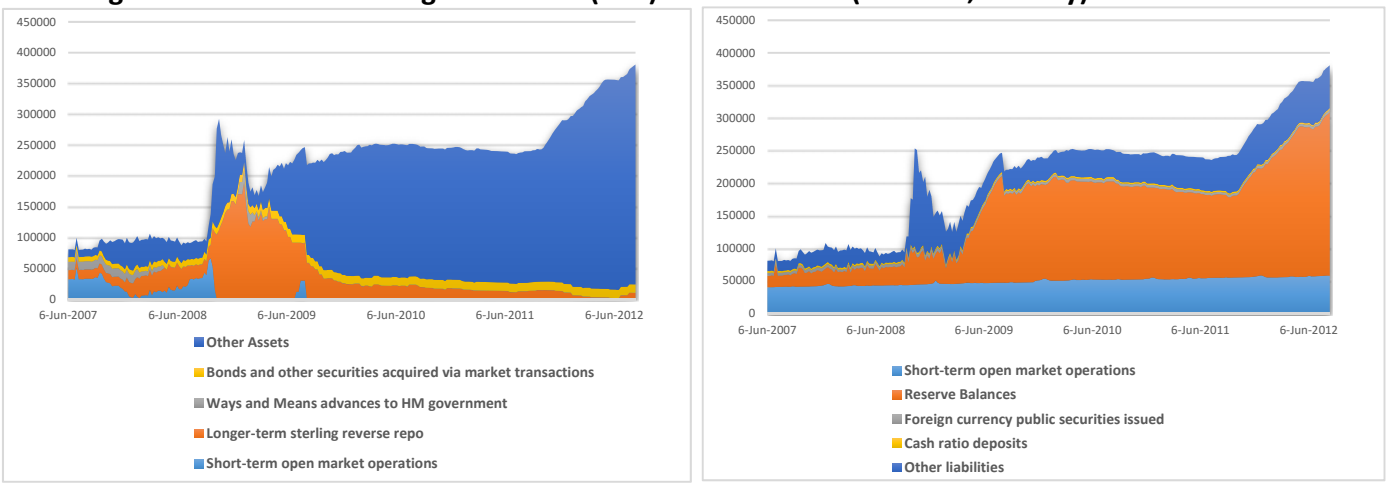


Figure 3.5: The Bank of England Assets (Left) and Liabilities (£Million, Weekly)



Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp)

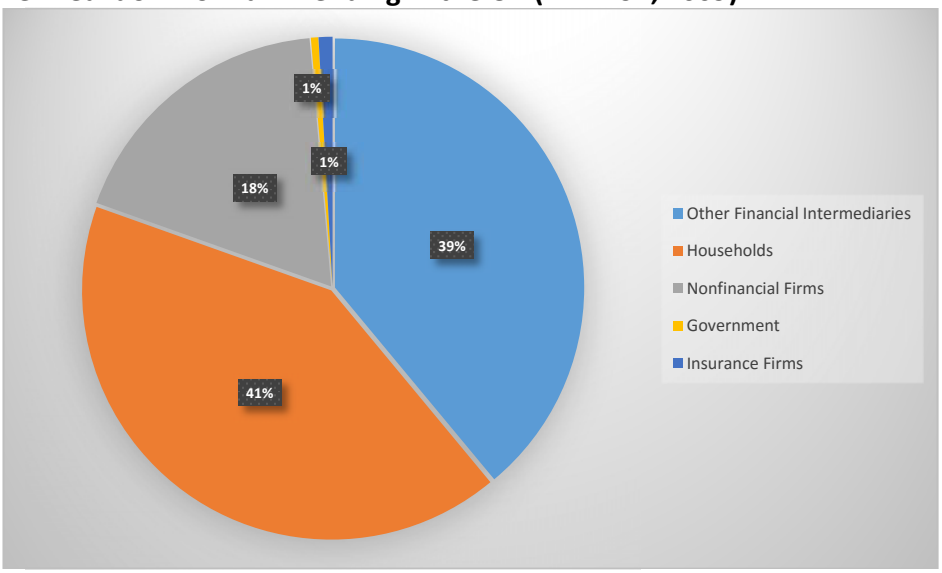
[8] See point number 42 in the minutes of the Monetary Policy Committee meeting for the 4 and 5 March 2009 available at: http://www.bankofengland.co.uk/publications/minutes/Documents/mpc/pdf/2009/mpc0903.pdf

The asset purchases under APP had significant implications for the balance sheet of BoE (Figure 3.5). The size of "Other Assets" category -which includes the value of the assets purchased by Asset Purchase Facility Fund under APP- witnessed a massive increase after March 2009. More importantly, on the liabilities side of the balance sheet there is a substantial expansion in bank reserves balances in the same period. More specifically, after each of APP expansions shown in Figure 3.3, the balance of bank reserves increased by almost the same amount of the expansion (or even more). For instance, after the first wave of asset purchases (£75 billion) and just before the first expansion (7 May 2009), bank reserves balance increased by about £56 billion (£31.5 billion to £87.5 billion). The same trend can be noticed after the second wave of purchases (£50 billion); the balance of reserves rose by about £76.5 billion between May and August 2009. Between March 2009 and August 2012, the total amount of bank reserves increased from about £31.5 billion to £251.9 billion. Thus, a considerable proportion of the liquidity pumped out through APP returned back to BoE in the form of excess bank reserves.[9]

Meanwhile, Office for National Statistics (ONS) data shows that bank lending in the UK fell by more than £218.6 billion in four years after APP was introduced early in 2009. The sectoral balance sheets and financial accounts available from ONS indicate that banks in the UK provide loans to households (mostly in the form of mortgages) nonfinancial businesses, and other financial intermediaries (Figure 3.6). Figure 3.7 presents the amounts of bank lending to the two nonfinancial sectors between 1997 and 2012. As the Figure demonstrates, bank lending to households and nonfinancial businesses witnessed a period of stable growth before the financial crisis. However, while household borrowing from banks fell by 3.8% fall in 2008 then started to grow afterwards, nonfinancial firms borrowing showed a steady fall in the same period. Accordingly, the shrinkage in the amount of loans to nonfinancial businesses has been one of the main causes of the decrease in total bank lending mentioned above.

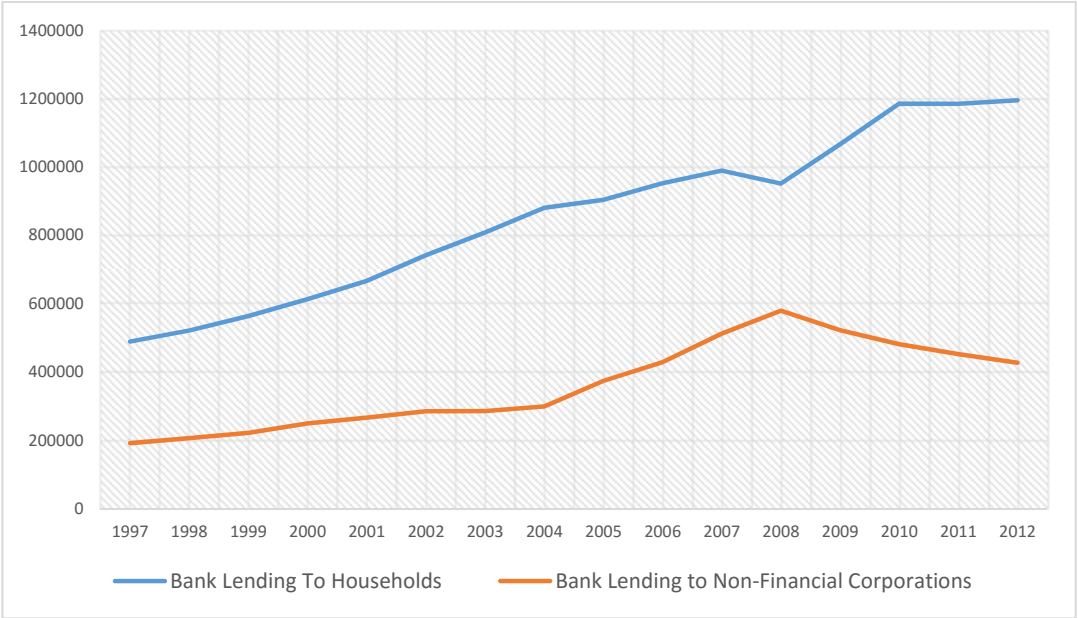
[9] The same phenomena of increasing bank reserves at the central bank appears in the US where the reserve balances with Federal Reserve expanded massively after the launch of large scale asset purchase (LSAP) programs in 2008.

Figure 3.6: The Breakdown of Bank Lending in the UK (£Million, 2009)



Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html)

Figure 3.7: Bank Lending to Households and Nonfinancial Corporations (£Million)

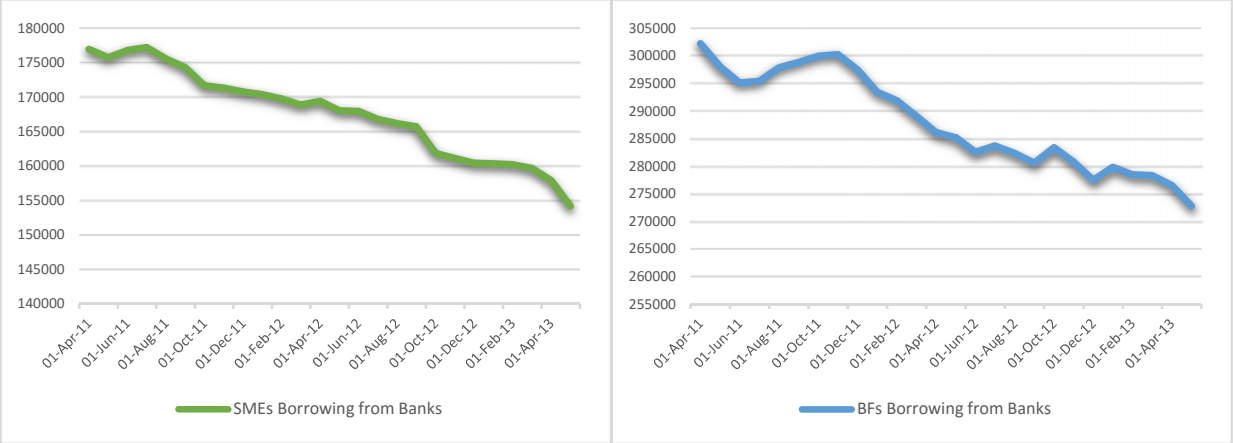


Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html)

Indeed, this is part of a bigger problem of "why banks don't lend" being discussed by several authors (for example, Blundell-Wignall and Roulet (2013) and Partnoy and Eisinger (2013)). The focus of this chapter is not so much on the cash hoarding (in the form of reserves with the central bank) by banks, but more on the role played by both the lower demand for bank loans by bigger nonfinancial firms and the higher relative

cost of bank lending to smaller firms in the developments in bank lending markets after March 2009. The distinction between big firms (BFs) and small and medium enterprises (SMEs) in the category of nonfinancial firms is important in the context of this chapter because the accessibility to debt financing is different between the two types of firms. BFs have access to security debt (bond) market, whereas borrowing from banks represents the sole source of debt financing for SMEs. As Figure 3.8 indicates, the monthly amounts outstanding of UK bank loans to both BFs and SMEs according to BoE dataset have shown clear drop especially after November 2011.[10]

Figure 3.8: Bank Lending to Big Firms and Small and Medium Enterprises (£Million)[11]



Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp)

While the fall in bank lending during recessions has a long legacy, including the theories on liquidity trap where there is reduced borrowing from banks (see for example Krugman et al. (1998) and Krugman (2000)), a relatively new strand of literature on the impact on bank lending due to capital adequacy requirements has evolved since the 1990s. The diverse justifications for the decreases in bank lending during recessions in the presence of capital adequacy requirements have been based either on the lower supply of credit by banks or the lack of demand for loans. The supply-side explanations can be grouped into

[10] According to BoE dataset, BFs and SMEs bank borrowing fell by 12.25% and 13.49% respectively between April 2011 and November 2013.

[11] The charts use the data on sterling monthly amounts outstanding of banks loans to SMEs and to all nonfinancial businesses from BoE's Statistical Interactive Database.

two main categories. Authors in the first category (such as Thakor (1996), and Borio and Zhu (2012)) attribute the decrease in bank lending to the changes in the risk perception of the banks. The other category of explanations (for example, Repullo and Suarez (2013) and Repullo (2013)) refers to the shortage of bank capital (the *capital crunch* hypothesis) as the main driver of credit rationing in the downturn especially in the presence of *pro-cyclical* capital regulations (see Brunnermeier et al. (2009)).[12]

From the prospective of the fall in the demand for loans, the focus has been mainly on the issue that nonfinancial firms tend to cut back their investment spending during recessions. For instance, Bikker and Hu (2012) argue that the lack of demand for bank loans rather than supply is the key factor of the fall bank borrowing in slumps.[13] However, in this context, little consideration has been given to the impact of lower bond yields (and hence the wider use of security debt) which is caused by QE, on the demand for bank loans by big nonfinancial firms which represents a vital element in our explanation of the fall of bank lending to nonfinancial businesses. Similar to Ivashina and Scharfstein (2010) inferences, this chapter reconciles the two sides. In other words, the fall in bank lending is driven by a mixture of demand and supply factors. In order to explain the fall in bank lending, it is important to examine the drivers of the shrinkage in the size of business loans especially with respect to the interaction between different credit markets taking into account the impact of BoE's APP on the relative costs of alternative debt instruments. The influence of APP on gilts and corporate bonds yields represents the starting point here. Asset purchases by BoE reduce the supply of gilts remaining for the private sector (local supply effects) leading to lower yields on gilts and corporate bonds (McLaren et al (2014)). The lower bond yields induce BFs to substitute parts of their bank borrowing with security debt (bonds). Influenced by the capital requirements, that assign different risk weights for different types of loans, banks respond to the drop in big firms borrowing, by expanding mortgages and decreasing the amount of loans granted to SMEs (which carry a higher risk weight).

[12] The reliance of capital regulations on the mark-to-market valuations of assets and the market-based measures of risk make these regulations *pro-cyclical* and increase the volatility in asset markets. That is, the rises in market value of equity during booms accompanied with fixed costs of bank regulations induce banks to expand their lending. In contrast, during busts equity prices become low decreasing the ability of banks to provide loans. For a further discussion of the *pro-cyclicality* of bank regulations see Brunnermeier et al. (2009).

[13] See also, Berger and Udell (1994).

This chapter utilizes macro agent-based computational economics (ACE henceforth) methodology to model the developments in the UK bank lending markets since APP was introduced. The ACE model of the chapter follows the data driven approach recommended by Markose (2013) in the sense that the distributional assumptions about the financial characteristics of different economic sectors such as households, nonfinancial businesses and banks are based on empirical foundations.

Analogous to the actual data, simulation results point out that the growth of mortgages was not sufficient to counter the decline in business loans which represents the main cause of the shrinkage in total bank lending. A combination of lower bond yields and Basel III capital adequacy requirements on banks appears to play a role in the drop in the amount of bank loans to businesses. The lower bond yields induce big firms to substitute parts of bank borrowing by security debt (bonds). Influenced by the capital requirements, which assign different weights for different types of loans, banks respond to the drop in big firms borrowing, by expanding mortgages and decreasing the amount of loans granted to SMEs. This conclusion is consistent with the previous studies (for example, Heid, Porath and Stolz (2004)) in the sense that a fall in capital buffers induces banks to rebuild them by raising capital and lowering risk-weighted assets by investing more in the safer asset (mortgages) and less of the riskier asset (loans to SMEs).

The reminder of the chapter is structured as follows. Section 3.2 surveys the relevant literature in some details. The approach used in the chapter is outlined in Section 3.3, whereas the empirical facts used in the construction of the model are presented in Section 3.4. Section 3.5 characterise the ACE model and provides a full description of the model agents and their behaviours. Simulation outcomes are presented in details in section 3.6. The last section contains concluding remarks of the chapter.

3.2 The Related Literature

This section of the chapter is divided into three subsections. The first includes a brief survey of the QE literature including that related to the Japanese QE introduced in 2001. The second section examines some of the main papers in the field of the impact of capital adequacy requirements on bank lending in recessions. In the last section, the literature of agent-based computational economics (ACE) is reviewed in details.

3.2.1 The Impact of Quantitative Easing on Bank Lending

Quantitative easing (QE) has been studied by several authors since its introduction by the Bank of Japan (BOJ) in 2001 especially recently after the monetary authorities of the US, UK and EU launched their own editions of QE. However, most of QE literature has been concentrated on the influence of the massive asset purchases on asset yields on the one hand and the aggregate economy on the other. Less attention has been paid for the effects on bank lending. First, while authors agree that asset purchases under QE have decreased the yields of government bonds (Kimura and Small (2004) for Japan, D'Amico and King (2011) for the US, and Daines, Joyce and Tong (2012) for the UK), the evidence on the impact on other assets yields has been mixed. Kimura and Small (2004) point out that BOJ asset purchases led to lower premiums on higher grade corporate bonds. This conclusion is supported by McLaren et al (2014) who argue that asset purchases under APP reduced gilts yield and, through local supply effects (asset purchases by BoE reduce the supply of gilts remaining for the private sector), the yields of corporate bonds. They claim that the expected asset purchases had a significant impact on yields after each announcement in March 2009, August 2009, and February 2012. Conversely, Oda and Ueda (2005) show that the portfolio rebalancing effects of BOJ QE are not significant. The majority of the papers that analyse the effects on the wider economy specify positive influence of QE on the real economy. For instance, Honda, Kuroki, and Tachibana (2007) and Harada and Masujima (2009) indicate that BOJ QE increased aggregate output through asset prices and bank reserves. This conclusion is supported by the results for US QE (Chen, Cúrdia, and Ferrero (2011) and Baumeister and Benati (2010)) and UK QE (Kapetanios *et al.* (2012)). Lastly, the response of bank lending to QE program has had relatively lower attention. For example, Bowman *et al* (2011) identify a positive but small impact of BOJ QE on bank lending. Joyce and Spaltro (2014) show similar outcomes for the BoE APP program. They claim that the effects were more important for smaller banks.

3.2.2 Bank Lending and Capital Adequacy Requirements

The influence of capital requirements on bank lending and bank behaviour has been investigated by several authors since the introduction of Basel rules in the late 1980s. Thakor (1996) inspects the role

played by Basel capital rules in the developments in the US banking system in the early 1990s including the fall in aggregate bank lending and the increase in the share of government debt securities holding in the portfolios of US banks. He indicates that an expansionary monetary policy in the presence of capital requirements may either increase or decrease bank lending depending on the impact of the increasing money supply on the term structure of the interest rates. Hans et al. (1999) survey the literature related to the impact of capital requirements on the behaviour of the banks. They point out that weakly capitalized banks tend to substitute away from assets with higher risk weights and to cut their total lending to enhance their capital ratios. These findings are supported by several authors[14] including Gambacorta and Marques-Ibanez (2011) who specify that banks with weaker capital ratios and greater dependence on market funding and non-interest income sources strongly decreased their lending during the crisis. Moreover, Heid, Porath and Stolz (2004) results show that a fall in capital buffers induces banks to rebuild them by raising capital and lowering risk-weighted assets by investing more in the safer assets and less of the riskier assets.

However, although most of the literature focus on the role of the supply of credit, some authors attribute the decreases in bank lending in recessions to demand factors. Berger and Udell (1994) investigate the causes of the reallocation of credit by U.S. commercial banks from loans to securities in the early 1990s. Their results indicate that while risk-related credit crunch hypotheses are not salient reasons of the fall in bank lending, demand-side impact on lending tend to be strong. More recently, Bikker and Hu (2012) argue that credit rationing in a cyclical downturn is barely driven by a shortage in bank capital as the *capital crunch* hypothesis (for example Repullo and Suarez (2013)). They show that while the demand factors dominate the market, the preeminent loans supply variables (bank capital and reserves) tend to be insignificant determinants of bank lending.

3.2.3 Macro Agent-Based Computational Economics

The study of the economy by means of ACE and network analysis is a relatively new field. It also represents a suitable approach to respond to the criticisms raised on the methodological foundations of

[14] For example, Gambacorta and Mistrulli (2004), Rime (2001), and Furfine (2000).

the macroeconomic theory. Because of the failure of the existing macroeconomic models in predicting the great recession of 2008-09 and evaluating the consequences of such a recession, these models and their usage in policy analysis have received severe criticism (Wieland, V. (2010)). Macroeconomists have been accused of a heavy dependence on dynamic stochastic general equilibrium (DSGE) models that are built around special cases where market inefficiencies are not possible (Stiglitz (2011)) and institutional details and financial interconnections in the provision of liquidity, capital adequacy and solvency are ignored (Markose (2013)). Buiter (2009) points out that "… the typical graduate macroeconomics and monetary economics training received at Anglo-American universities during the past 30 years or so, may have set back by decades of serious investigations of aggregate economic behaviour and economic policy-relevant understanding". This view is supported by Nobel Prize Winner Paul Krugman -in the Economist, June 2010- who indicates that "most work in macro-economics in the past 30 years has been useless at best and harmful at worst". In particular, critics of the standard macro models have used the aggregation of individual economic units, the perfect rationality of these units, and the assumption of equilibrium as a ground to attack these models (Lengnick (2011)). First of all, the majority of macro models link the macro movements directly to the individual units' behaviours -either through equating the aggregates to the representative units or by adding up the individual decisions to find the aggregates- to provide a proper microfoundation. However, several experiments have indicated that the aggregate behaviour of big groups usually differs considerably from the behaviours of the individual units. For instance, Schelling's (1969) analysis of racial segregation models points out that interaction between individuals may create significant segregation in big cities even if individual preferences for residing in areas dominated by people of the same race are slight. More recently, in the context of the 2007 financial crisis, many authors have noted the pitfall of the macroeconomic models where extrapolation of the behaviour of the representative optimizing agents can result in fallacy of composition. Specifically, with microprudential policies where the risk is specified at the level of individual units and the implications of their interaction with each other are ignored, systemic-wide risks and instabilities are not modelled or managed (For example, Markose (2013)

and Goodhart et al (2009)). Moreover, the assumption of perfect rational utility-maximizing agents has proven to be very unrealistic. Rather than complex utility optimization approach which requires everyone to have perfect information, individuals tend to use relatively *simple* behavioural rules to make decisions (Akerlof (2002)). Lastly, most of macro models are built around the assumption of a stable state once reached there will be no incentive for any further changes (i.e. equilibrium), and if the economy for some reason deviates for that state, it returns to it through quick adjustment processes. Yet, it has been frequently proven that such adjustment processes barely exist (Gaffeo et al. (2008), Kirman (2006), Ackerman (2002)) and that real markets are often characterized by multiple equilibria, volatility, and coordination problems (Arthur (2006)).

Generally, existing macro ACE models can be classified into four main categories. The models in the first category combine conventional economic theory with computational techniques. For instance, Arifovic (1994), specifies that rational expectations equilibrium can be attained if the agents employ genetic algorithm to make production decisions. Additionally, Chen (2003) indicates that overlapping generations (OLG) models -in which agents use learning algorithms to maximize utility- are employed in several studies about inflation and price stability. The second category of ACE models consists of massive real economy models. Models such as EURACE and ASPEN projects which try to mimic the entire EU and US economies respectively, include substantial simulations of the agents in real world economies (Chan and Stiglitz (2008)). These models have been used by some authors to investigate the impact of policy interventions in the US and the Euro Area. For example, Teglio, Raberto and Cincotti (2013) use the EURACE environment to assess the impact of capital adequacy requirements on the wider economy. They perform simulations over a 40-year period and examine the short, medium and long run implications of different levels of capital adequacy ratios. Their results show a non-trivial impact of capital adequacy ratios on GDP, the unemployment rate and the aggregate capital stock on banks. They also point out that this influence of the capital adequacy ratios arises from the credit channel, and varies significantly depending on the time span of the evaluation period. In contrast, the third group of ACE models contain a basic *picture* of the real

economy and attempt to explain macroeconomic developments by simulating the agents in the basic economies they address. For instance, Stiglitz et al. (1996) introduce a gold-food economy with zero-intelligence agents.[15] Their results point out that existence of arbitrage opportunities is enough to stabilize market prices in the long run. Bruun (2008) implements an agent-based Keynesian model and confirms Keynes argument that the self-organizing properties of an economy can operate without depending on price changes as an equilibrating factor. Using a simple baseline model, Lengnick (2011) indicates that simulation results are able to imitate several empirical facts like the presence of reasonable levels of involuntary unemployment, empirical laws like Philips curve, the dynamic correlation between inflation and output, and money neutrality. Lastly, the models in the fourth and most recent category -including the model of this chapter- follow the data driven approach recommended by Markose (2013) in the sense that the distributional assumptions about agents are based on empirical foundations.

3.3 Methodology

This chapter tries to explain the developments in bank lending markets in the UK after the introduction of APP in 2009 using an ACE model with four types of agents (households, big firms, small and medium enterprises and banks) interacting monthly for a period of 50 months in an environment that imitates these markets. In this section, I outline the different steps of my approach. Anchored to the relevant empirical distributional facts, the model works through five stages. First, the size of agent populations is set in a way that mimics the actual populations of the agents. More specifically, the actual agent populations are scaled down proportionally to calculate the hypothetical size of the populations. Second, each agent is given a balance sheet which represents its initial condition. The value assigned to each item in an agent's balance sheet is drawn from a distribution that replicates the empirical distribution. For example, the values of household housing wealth are set to reflect the home ownership data. In the third stage, the behavioural

[15] Agents in this model have to obtain an essential good (food) either by producing it or by purchasing it using another good (gold) that can be produced.

rules of the agents are defined. These rules describe the responses of the agents to different developments. For instance, a big firm would respond to a fall in the cost of security debt (bonds) by replacing part of its bank loans with bonds. Then, in fourth stage of the process, the simulation is run under three different scenarios of bank behaviour to investigate the role played by capital requirement rules. At the end of this stage, the values of bank lending aggregates to the other agents are calculated for each of the 50 months. Finally, the simulated bank lending aggregates are rescaled up then compared to the actual bank lending aggregates to validate the model.

3.4 Empirical Details on the UK Economy

Before describing the model agents and their behaviours, the following section presents some facts about the UK economy around the launch of APP in 2009. These facts represent the empirical base to which the model is anchored. This section surveys the empirical facts about the nonfinancial sectors (including households and nonfinancial businesses) and banks in the UK around the time of APP introduction. It aims to provide empirical foundations for the model.

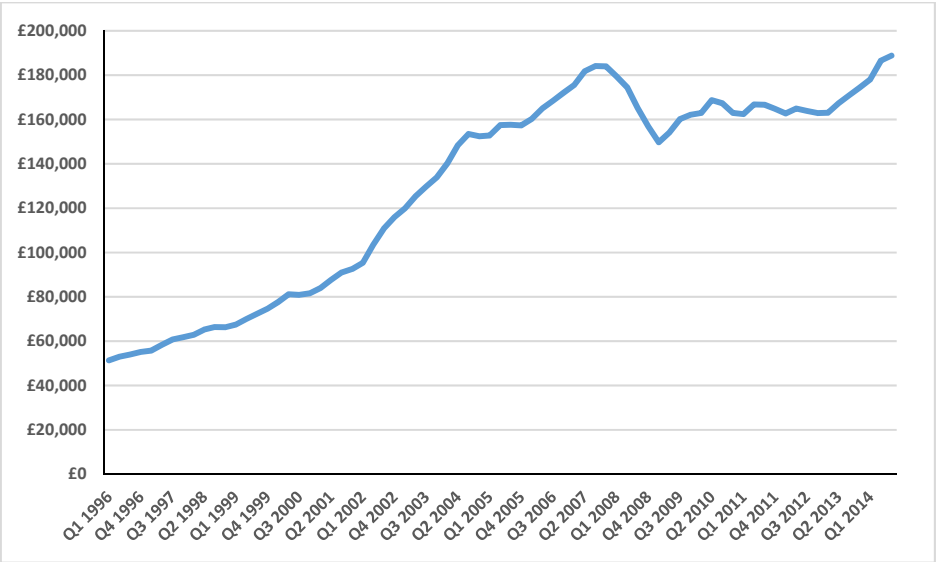
3.4.1 Housing and Mortgages Markets

As Figure 3.9 illustrates, after having a long period of persistent growth between 1996 and 2007, UK house prices witnessed a noticeable drop in the years following the financial crisis. In particular, the average house price in the UK, according to Nationwide's dataset[16], increased by more than 258% in 12 years from £51,367 in 1996 Q1 to £183,959 in 2007 Q4, then fell by more than 18.6% down to £149,709 in 2009 Q1. Moreover, ONS home ownership and renting data[17] indicates that 64% of homes in the UK are owner-occupied (the remaining 36% of homes are rented), and that about 52% of the home owners have mortgage obligations.

[16] http://www.nationwide.co.uk/about/house-price-index/download-data#xtab:uk-series.

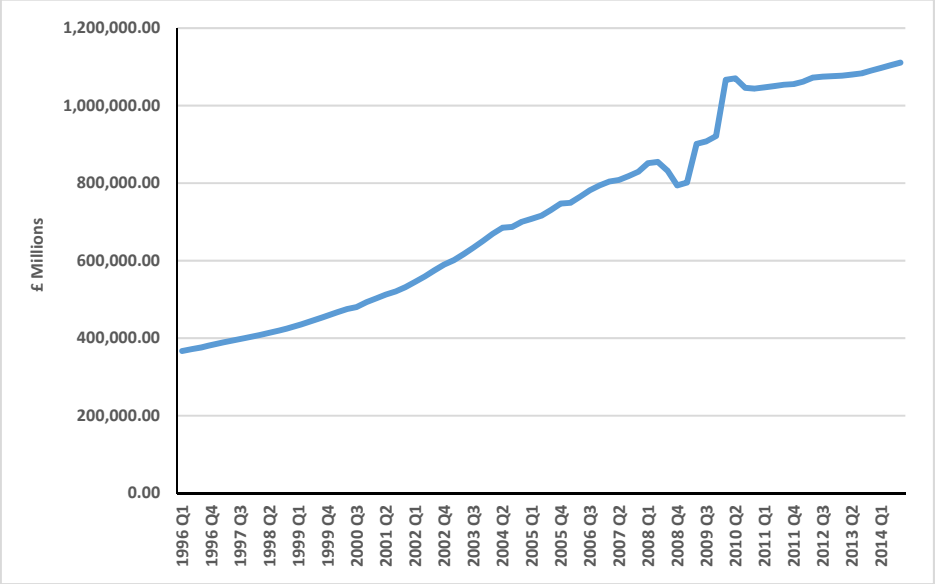
[17] http://www.ons.gov.uk/ons/rel/census/2011-census/detailed-characteristics-on-housing-for-local-authorities-in-england-and-wales/short-story-on-detailed-characteristics.html.

Figure 3.9: Average House Price in the UK (1996-2014)



Source: Nationwide House Price Index **(http://www.nationwide.co.uk/about/house-price-index/download-data#xtab:uk-series)**

Figure 3.10: Quarterly Amounts Outstanding of Mortgages in the UK (1996-2014)

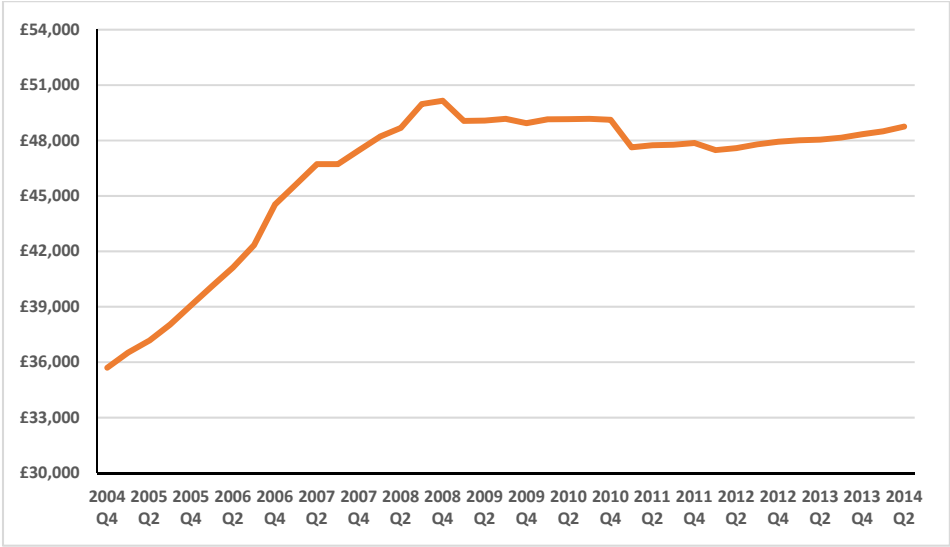


Source: Quarterly amounts outstanding of monetary financial institutions' sterling net secured lending to individuals and housing associations (in sterling millions) seasonally adjusted available at the Bank of England's Statistical Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/NewInterMed.asp?Travel=NIxSSx)

Figure 3.10 demonstrates that the mortgages market has showed a significant expansion in volume during the past two decades. More specifically, the gross amount outstanding of mortgages has continuously grown from £366.764 billion in 1996 Q1 to about £1.111 trillion in 2014 Q4 with an exception

of the second half of 2008 where it fell by 7.1%. Likewise, the average household mortgage indebtedness (Figure 3.11) had displayed a clear increase until 2009 Q1 where it fell by more than £1,000 from £50,150 to £49,070. However, while the fall in gross mortgages was temporary and lasted for a short period of time, the average household mortgage debt needed more than four years to start recovering properly from its post crisis drop. Indeed, the average household mortgage debt fell by about 5.1% between 2008 Q4 and 2012 Q1 then started to increase again.

Figure 3.11: Quarterly Average Household Mortgage Indebtedness in the UK (1996-2014)



Source: The Money Statistics of the Money Charity (http://themoneycharity.org.uk/money-statistics-archive/)

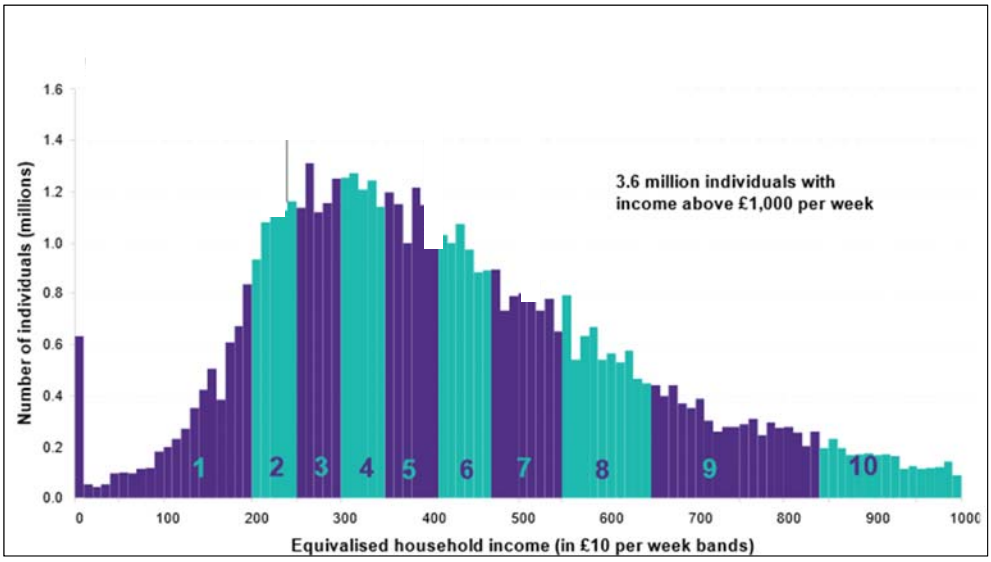
3.4.2 Households Income Distribution

As shown in Figure 3.12, the household income in the UK follows a lognormal distribution. According to Institute for Fiscal Studies (IFS)[18], the average weekly income of a household in the 2008-09 financial year was £560.64 (an equivalent of £2,429.43 per month[19]) with 50% of the households making £450.52 or less a week (or £1,951.84 a month).

[18] Institute for Fiscal Studies: Inequality and Poverty Spreadsheet which "provides data on British living standards, inequality and poverty" available at: http://www.ifs.org.uk/tools_and_resources/incomes_in_uk.

[19] Monthly income = Weekly Income x 52 (weeks a year) / 12 (months a year).

Figure 3.12: The Probability Distribution of Household Weekly Income (2008-09)



Source: Households below average income (HBAI): 1994/95 to 2008/09; P15**;** Department for Work and Pensions; Available at: https://www.gov.uk/government/statistics/households-below-average-income-hbai-199495-to-200809

3.4.3 Nonfinancial Businesses Financing Structure

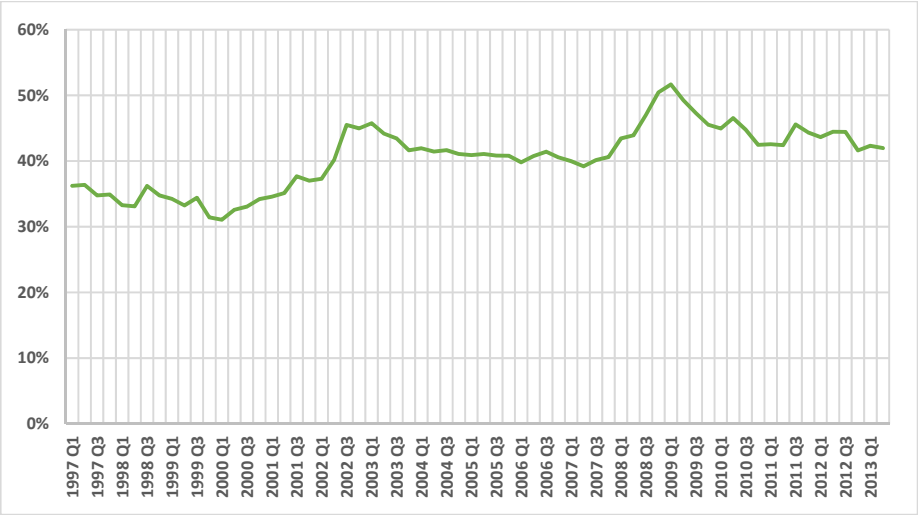
During the past two decades, the share of debt financing in the balance sheets of nonfinancial has shown a stable trend. Particularly, after a relatively long period of rather small fluctuations around some level, the leverage ratio of the nonfinancial rapidly rose to some peak after which it fell a bit to become stable around some higher level compared to the previous stability period. For instance, the leverage ratio of nonfinancial businesses in Figure 3.13 was stable around its mid-30% level for five years between 1997 Q1 and 2001 Q4, then increased quickly to reach about 45% by 2002 Q4. Half a year later, the ratio fell and stayed stable around 40% for more than four years. In 2009 Q1, the leverage ratio was 51.66%[20] which represents its highest level in a few decades. Lastly, BoE data on business bank lending (presented in Figure 3.7) indicates that the monthly growth in big firms borrowing from banks was ranging between –1.46% and 0.99% during the period between April 2011 and April 2013.

The composition of nonfinancial firms' debt financing has changed towards more security debt (bonds) and less bank lending since 1997 especially after the launch of APP in 2009 Q1 as Figure 3.14 reveals. More precisely, nonfinancial firms increased the share of security debt in their debt mix from about 30.5% at the

[20] Calculated by dividing the total debt of nonfinancial firms (£1,709,646 million) on their total liabilities (£3,309,550 million) in 2009 Q1.

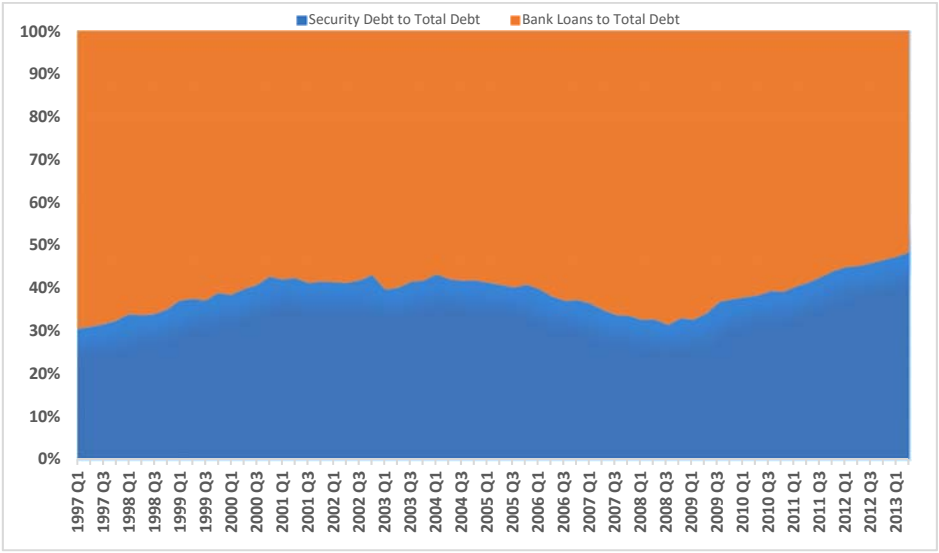
beginning of 1997 to 43.3% in the first quarter of 2004. However, this share witnessed a continuous fall until 2009 Q1 (about 32.7%[21]) where it started to increase clearly. Lastly, the financial balance sheets data of nonfinancial corporations sector issued by ONS indicates that cash holdings of nonfinancial businesses in 2009 Q1 represented about 12.83% of their total assets.[22]

Figure 3.13: Nonfinancial Firms Leverage Ratio



Source: Constructed using ONS sectoral financial balance sheets.

Figure 3.14: The Shares of Bonds and Bank Loans in Nonfinancial Firms Total Debt



Source: Constructed using ONS sectoral financial balance sheets.

[21] This is equal to the ratio of nonfinancial corporation security debt in 2009 Q1 (£333,907 million) to the sum of total security debt and total bank lending in the same quarter (£1,021,517 million).

[22] Calculated by dividing the total amount of cash and deposits of the nonfinancial firms (£424,763 million) on their total liabilities (£3,309,550 million) in 2009 Q1.

3.4.4 Funding for Lending Scheme

In July 2012, BoE and HM treasure introduced the Funding for Lending Scheme (FLS) to motivate banks to increase their lending to real economy through providing medium-term finances whose value and price rely on the lending performance of the borrowing bank (Churm et al. (2014)). The FLS was extended in April 2013 to allow banks to borrow from the scheme until January 2015 and to provide some incentives to expand lending to SMEs. Baddeley-Chappell (2013) indicates that FLS has had a substantial impact on the mortgage market through lowering mortgage rates, which went down by about 1%. He believes that "this reduction has been achieved not through the use of the scheme, but rather through the potential funding capacity that the scheme introduced. This has reduced demand for, and hence the price of, other funding routes (such as consumer savings)". Moreover, Al-Eyd and Berkmen (2013) point out that in spite of the lower funding cost, aggregate bank lending to the private sector has not expanded. They specify several factors that might have limited the influence of FLS including the absence of big cost advantages, the weak demand for credit, the financial health of the UK banks, and the design of capital charges on FLS financing.

3.5 The Model

The model of this chapter contains four types of agents: 1,000 households (HHs), 3 big firms (BFs), 229 small and medium enterprises (SMEs) and 10 banks which interact monthly for a period of 50 months in an environment that simulates bank lending markets in the UK after APP was introduced in 2009. While the number of households with at least one adult working in 2009 was 21.464730 million[23], there were 4.923320 million businesses 99.9% (i.e. 4.918915 million) of which were SMEs.[24] This indicates a proportion of 0.229 between the number of SMEs and the number of HHs. Hence, if HHs population size in the model

[23] In 2009, there were 25.83 million households 16.9% of them were workless (i.e. with no adult working). Yet the model assumes that only non-workless households would be interested in obtaining mortgages to buy houses.

[24] Small and Medium Enterprise Statistics for the UK and Regions; Enterprise Directorate; The Department for Business, Innovation and Skills (BIS); Available at: http://webarchive.nationalarchives.gov.uk/20110920151722/http:/stats.bis.gov.uk/ed/sme/index.htm

is set to 1,000, the number of SMEs would be 229. Moreover, the number of BFs is set to 3 to account for the very big firms that are not captured by the distribution of BFs total assets described later. Lastly, each of the HHs, BFs, and SMEs would choose only one preferred bank to do business with. This implicates that the assets and liabilities in the balance sheet of any bank are the horizontal sums of the corresponding assets and liabilities in the balance sheets of the agents who choose this bank. For example, the amount of deposits on the liabilities side of a bank balance sheet is the sum of the cash holdings of all HHs, BFs, and SMEs who favour this bank. The 10 banks in the model are built to represent the biggest 10 banks in the UK using the actual equity to total assets ratios of these banks around the introduction of APP.

Each household earns an income and accumulates its wealth at each period only in the form of housing and cash (deposited with the preferred bank). To expand housing wealth, a household needs to have sufficient cash to cover the down payment (the deposit) and to obtain a mortgage from the bank with which it does business (the preferred bank). Nonfinancial firms (BFs and SMEs) employ physical capital and cash to operate and finance their operations using a mixture of debt financing and equity. The amount of physical capital (and total assets) defines the firm's size which, in turn, determines its accessibility to different debt markets. While SMEs are restricted to bank borrowing, BFs can also issue debt securities to raise debt financing. Banks hold cash (accept deposits) of HHs, BFs and SMEs, and provide loans in the form of mortgages to households and business loans to BFs and SMEs. The differences in debt markets accessibility for HHs, BFs, and SMEs reflect on the market power of banks which enjoy relatively stronger market position in mortgages and loans to SMEs markets rather than loans to BFs market. A further description of the starting conditions of the agents and the behaviour of these agents over the simulation period will be presented in the next sections.

3.5.1 Agents Description and Initial Conditions

As mentioned earlier, the four types of agents (HHs, BFs, SMEs, and banks) have linkages in several credit markets including mortgages market and business loans markets. The presence and the size of a linkage between two agents of two types (similar to these in Figure 3.15) in a given period relies on the initial (financial) circumstances of the two agents at the beginning of the period and their behaviours during

that period. The initial financial positions of the different types of agents (Figure 3.16) at the start of the simulation period were estimated using the actual data from ONS, Nationwide, and The Money Charity around the launch of APP in March 2009.

Figure 3.15: A Simplified Representation of the Model

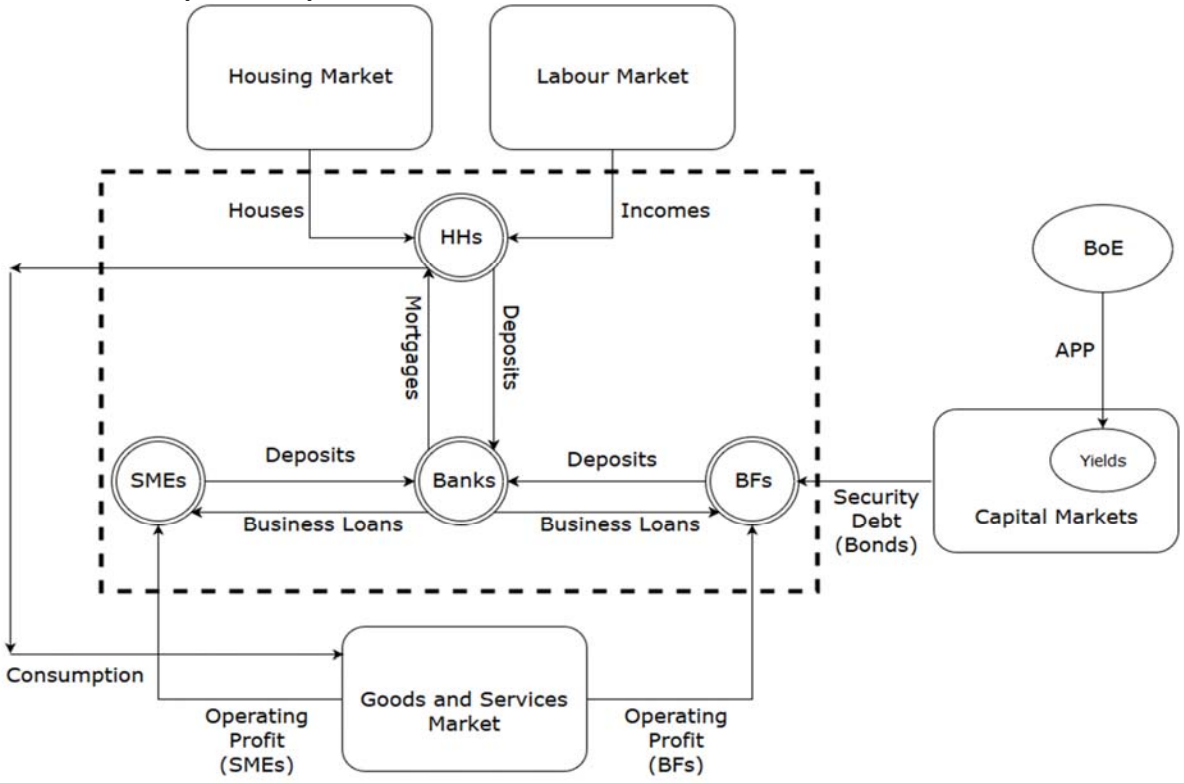


Figure 3.16: The Balance Sheets of the Model Agents

Household Balance Sheet

- Housing	No. of houses x house price	**- Mortgages**	£0 to £70,965 if Housing > 0
		- Equity (net worth)	
- Cash (deposits with banks)	housing > 0; [£5,000; £50,000].		

Big Firm Balance Sheet

- Physical Capital	£5 million to £300 million	**- Bank loans**	31.87% of total assets
- Cash (deposits with banks)	12.83% of total assets	**- Bonds (Security debt)**	19.79% of total assets
		- Equity	

SME Balance Sheet

- Physical Capital	£50,000 to £1 million	**- Bank loans**	40% of total assets
- Cash (deposits with banks)	12.83% of total assets	**- Equity**	

Bank Balance Sheet

- Cash	**- Deposits**
- Mortgages	**- Other liabilities**
- Business loans	**- Equity**
*** to BFs**	
*** to SMEs**	

3.5.1.1 Households

As Figure 3.16 shows, each household finances its holding of housing and cash using a mixture of its own resources and mortgages obtained from the preferred bank it does business with. The model assumes that all the properties (houses) are identical and traded at the same price of £149,400[25] and that HHs deposit all their cash holdings with banks. As mentioned earlier, only 64% of UK households own at least one property according to ONS data. To calibrate this fact, the model introduces a random *number of houses* variable (whose probability distribution is shown in Figure 3.17) which is multiplied by the average house price to obtain the initial housing wealth for each household. The initial amount of cash held by HHs is assumed to be uniformly distributed between £5,000 and £50,000. Moreover, since only 52% of the home owners have mortgages with an average mortgage debt of £49,070 (in 2009 Q1), the model assumes that the amount of mortgage liability of HHs at period 1 is uniformly distributed between £0 and £70,965[26]. A household's equity (net worth) is the difference between its total assets and mortgage liability. Lastly, based on the actual income distribution *Households below average income (HBAI)* described before, HHs initial income follows a lognormal distribution which is estimated using the monthly equivalents of IFS's parameters of the weekly income distribution (in 2009 Q1).[27]

Figure 3.17: The Probability Distribution of the Number of Houses per Household in Period 1

Number of Houses	0	1	2	3	4
Probability	0.36	0.16	0.16	0.16	0.16

3.5.1.2 Firms (BFs and SMEs)

BFs and SMEs in the model use physical assets and cash to run their operations. The model assumes that the physical capital of BFs is uniformly distributed between £5 million and £300 million to differentiate

[25] Although the average house price in the UK in 2009 Q1 was £149,709 according to Nationwide data, the model sets house price to £149,400 to avoid fractions when calculating mortgage payments.

[26] This is half the amount of a new mortgage which is equal to (1 – the down payment or deposit ratio of 0.05) x average house price. The uniform distribution is used here because of the lack of data on the actual mortgages distribution. The upper limit of the distribution is set relatively not very far from the average mortgage indebtedness to account for the big mass at zero (48% of HHs have no mortgages).

[27] Data is available at: http://www.ifs.org.uk/tools_and_resources/incomes_in_uk.

BFs from SMEs whose physical capital follows a uniform distribution between £50,000 and £1 million. Since, as mentioned before, the ratio of nonfinancial businesses liquid assets holdings to their total financial liabilities in 2009 Q1 was 0.1283, the amount of cash held by each firm in period 1 (the beginning of simulation) represents 12.83% of the total assets of that firm.

Both BFs and SMEs finance their assets by a mixture of equity and debt financing. However, there are two main differences between the two firm types on the liabilities side of the balance sheet. First, because of their stronger financial positions, BFs enjoy more flexibility in debt markets where they can obtain bank loans or issue debt securities (bonds) to the public to raise debt finances. In addition, the strong financial position enables BFs not only to build flexible debt structure, but also to have higher leverage in their balance sheets. Consequently, while the leverage (debt to total liabilities or assets) ratio of BFs in period 1 is set 51.66% (the leverage ratio of nonfinancial businesses in 2009 Q1), SMEs finance only 40% of their total assets by borrowing from banks. Finally, since the security debt of nonfinancial corporations in 2009 Q1 represented 32.7% of their total debt, the model assumes that the balances of bank loans and bonds in the initial balance sheet of each big firm represent 31.87% and 19.79% respectively the firm's total assets.

3.5.1.3 Banks

Banks represent the heart of the model since they have links with all other agents in the model. Each non-bank agent selects randomly a preferred bank to deposit cash and to obtain debt financing. Therefore, the balances of debt assets (mortgages and loans) and liabilities (deposits) of a bank is the horizontal sum of the corresponding liabilities and assets of the non-bank agents who prefer to do business with that bank. Banks in this model are allowed to obtain costless liquidity (through the FLS scheme and/or by using the substantial amounts of excess reserves they keep with the BoE) to provide credit; however, they have to adhere to capital adequacy requirements (to attain equity to risk weighted assets or loans above a certain level), and are restricted to their internal resources (retained earnings) to expand the stock of equity capital. As stated earlier, the banks in the model are set to simulate the biggest 10 banks in the UK. This is done using the actual equity to total assets ratios for these banks at the beginning of 2009.[28]

[28] The actual equity to total assets ratios for the UK biggest 10 banks are reported in the appendices.

3.5.1.4 Initial Conditions

The fluctuations in the yields on different debt instruments play a key role in the model of this chapter. Changes in interest rates have clear implications for different debt markets by affecting the debt structure of BFs in particular. The model includes 6 different interest rates whose initial values are presented in Figure 3.17. The initial levels of these rates are chosen in a way that reflects the actual values (were possible), the relative riskiness of debt instruments, and the possible portfolio rebalancing. First, the risk free rate (r_{RF}) and gilts rate are set to the actual levels of BoE policy rate (0.5%) and 10-year gilts rate (4%) just before the launch of APP. Second, risk premiums on different types of bank loans are arbitrarily selected given that loans to SMEs are riskier than mortgages which, in turn, are riskier than loans to BFs. Moreover, since corporate bonds represent a good substitute of gilts, it is reasonable to assume the rate on bonds follows gilts rate fluctuations whether they are resulted from the changes in risk-free rate or gilts risk premium. Lastly, the fact that the corporate bonds represented 32.7% of nonfinancial corporations' total debt of in 2009 Q1 indicates that the cost of these bonds was higher than the cost of bank loans. Hence, the risk premium on BFs bonds (above gilts rate) is set to 2% to make interest rate on these bonds higher than interest rate on BFs loans.

Figure 3.17: Initial Values of Interest Rates

Interest Rate	Initial Value
risk free rate (r_{RF})[1]	0.5%
government gilts rate (r_G)[2]	4%
interest rate on mortgages (r_{HH})	7% (r_{RF} + 6.5%)
interest rate on BFs loans (r_{BF})	5.5% (r_{RF} + 5%)
interest rate on BFs security debt (r_S)	6% (r_G + 2%)
interest rate on SMEs loans (r_{SME})	8.5% (r_{RF} + 8%)

[1] **BoE's policy rate. (Source: Bank of England (http://www.bankofengland.co.uk))**
[2] **Median yield on 10-year gilts in 2008 Q4 (Source: DataStream®)**

3.5.2 Agents Behaviours

This section demonstrates the responses of the model agents to the developments in the surrounding environment on the one hand and the actions of each other on the other. According to Daines, Joyce and Tong (2012), the first round BoE purchases caused a 100 basis points fall in gilts yields. Hence, the impact of BoE's APP is introduced into the model by allowing gilts rate to decrease by 2.5 basis points each period.

This fall in gilts yield accompanied with fixed risk free rate (imitating the fixed policy rate) results in changes in the relative cost of corporate bonds and consequently has significant implications for BFs.

3.5.2.1 Households Behaviour

The model assumes that HHs incomes grow at 0.275% each month in line with inflation between March 2009 and March 2013 where average annual inflation rate in the UK was 3.3% during that period. It also assumes that HHs keep their expenditure habits of spending 70% of income on consumption unchanged. The remaining 30% of income adds to household cash which is used to pay the mortgage obligations (mortgage principal and interest) and to cover the deposit if a new mortgage is obtained. In every period, each household chooses whether it wants to buy a new house and comes with a positive outcome with a probability that depends on its current home ownership status; that is, when a household is a first time buyer (or has no housing wealth), the urgency to buy a home is greater. To accommodate this, the model assume that a household decides that it wants to buy a house with probability of 20% if it has at least one house and 30% if it has none. Once the household elects to buy a house, it applies for a mortgage to finance the purchase from its preferred bank. The household application will be successful if it meets the *minimum requirements* employed by the banks in the model. To obtain a new mortgage, banks require the applying household to have at least twice the down payment or the deposit (5% of house price which is growing at a random rate ranging between -1.75% and 4.09% per month), no more than 3 mortgages, and sufficient income to meet mortgage obligations including those related to the new mortgage. Household income would be sufficient if mortgage payment in the coming month (including the amount related to the new mortgage) represents no more than 40% of that income. Altogether, the components of a household balance sheet in any period t are given by the following set of equations:

$$Income_t = Income_{t-1} \times \left(1 + \frac{0.033}{12}\right) \quad (1)$$

$$Housing_t = Housing_{t-1} + \frac{1}{0.95} \times New\ Mortgage_t \quad (2)$$

$$Liquidity_t = Liquidity_{t-1} + 0.3\ Income_t - \frac{0.05}{0.95} \times New\ Mortgage_t - Mortgage\ Payment_t \quad (3)$$

$$Mortgage\ Payment_t = Principal\ Payment_t + Interest_t \quad (4)$$

$$Principal\ Payment_t = Principal\ Payment_{t-1} + \frac{1}{360} \times New\ Mortgage_{t-1} \quad (5)$$

$$Interest_t = \frac{r_{HH(t-1)}}{12} \times Mortgages_{t-1} \quad (6)$$

$$Mortgage\ Availalbe_t = \begin{cases} 1 & if\ Liquidity_{t-1} \geq 2 \times 7{,}470\ and\ Mortgage\ Payment_{t+1} \leq 0.4 \times Income_t \\ 0 & Otherwise \end{cases} \quad (7)$$

$$New\ Mortgage_t = \begin{cases} HousePrice_t \times (1 - 0.05) & if\ Household\ Wants\ to\ buy = 1, Mortgage\ Available_t = 1 \\ 0 & Otherwise \end{cases} \quad (8)$$

$$Mortgages_t = Mortgages_{t-1} - Principal\ Payment_t + New\ Mortgage_t \quad (9)$$

$$Equity_t = Housing_t + Liquidity_t - Mortgages_t \quad (10)$$

3.5.2.2 Big Firms Behaviour

As stated earlier, BoE's APP decreases the cost of corporate bonds through the portfolio rebalancing effect. This induces BFs to replace part of their bank loans with security debt. The model assumes that BFs keep the size of physical capital and total debt unchanged, issue no new equity, and maintain a constant annual operating profit (i.e. profit before interest) to total assets ratio of 10%. In each period, a big firm chooses the debt financing mixture to maximize its net profit which is the difference between its operating profit and the cost of debt financing:

$$\pi_{BF,t} = Operating\ Profit_t - r_{S,t}.Bonds_t - r_{BF,t}.Loans_t \quad (11)$$

The comparisons between bank borrowing and security debt here are based on the interest costs of the two sources and a relative *desirability* factor that makes one source preferred to the other under certain economic conditions. Generally, bank loans are shorter in maturity than corporate bonds and tend to carry more flexible interest rates. Therefore, it is reasonable to say that firms would prefer bank borrowing to security debt in booms when interest rates are relatively high and vice versa in recessions when the rates are low. When interest rates are relatively high, firms prefer bank loans since they represent shorter commitments whose interest cost would decrease faster than the interest cost of security debt. Inversely, lower interest rates make security debt more attractive to firms since they can enjoy fixed but

low interest rates for longer periods of time compared to bank borrowing. Thus, since interest rates when APP launched were relatively low, BFs will respond to decreases in bonds interest rate (r_S) when it becomes equal to the interest rate on bank borrowing (r_{BF}) by issuing more bonds and using the proceeding to pay back part of their bank loans. In other words, the debt mixture of BFs is restructured towards more security debt and less bank loans on average. Hence, the components of a big firm balance sheet in any period t can be given as follows:

$$Physical\ Capital_t = Physical\ Capital_{t-1} \tag{12}$$

$$Operating\ Profit_t = 0.10 \times (Physical\ Capital_{t-1} + Liquidity_{t-1}) \tag{13}$$

$$Liquidity_t = Liquidity_{t-1} + Operating\ Profit_t - r_{S(t)}.Bonds_{t-1} - r_{BF(t)}.Loans_{t-1} \tag{14}$$

$$Loans_t = \begin{cases} Loans_{t-1} & if\ r_S \geq r_{BF} \\ Loans_{t-1} + \Delta loans_t & if\ r_S < r_{BF} \end{cases} \tag{15}$$

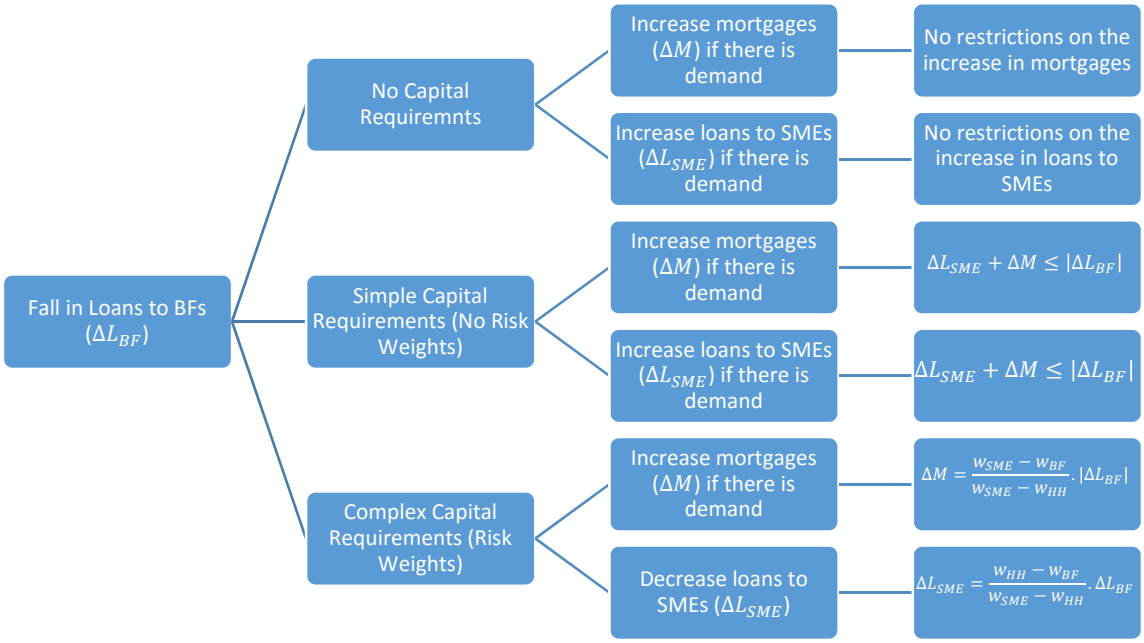
$$Bonds_t = \begin{cases} Bonds_{t-1} & if\ r_S \geq r_{BF} \\ Bonds_{t-1} - \Delta loans_t & if\ r_S < r_{BF} \end{cases} \tag{16}$$

$$Equity_t = Physical\ Capital_t + Liquidity_t - Loans_t - Bonds_t \tag{17}$$

3.5.2.3 Banks Behaviour

Since the BFs respond to the lower bond yields resulted from the considerable assets purchases under APP by substituting part of their bank borrowing with security debt, the behaviour of the banks in this model is derived conditional on the changes in BFs debt structures. As mentioned earlier, banks in the model grant loans, and have to commit to capital adequacy rules that require them to finance a certain proportion of their risk weighted assets (loans) using equity capital. To investigate the impact of capital adequacy requirements, the model operates through three different scenarios: no capital requirements, simple fractional capital requirements (a fraction of total lending has to be financed using equity capital), and complex fractional capital requirements where different assets have different weights to reflect their relative riskiness. Figure 3.19 illustrates the response of a bank to a fall in the bank borrowing of its BFs customers under each scenario.

Figure 3.19: Banks Behaviour under Different Scenarios



3.5.2.3.1 Case I: No Capital Requirements

Under this scenario, banks are not required to finance any fraction of their assets using equity capital. In the absence of capital restrictions, banks will grant loans "at will". More specifically, each bank chooses the amount of total lending and anticipates BFs demand on loans, then grants mortgages and loans to SMEs to maximize its profit is given by the following equation:

$$\pi_B = r_{BF}.L_{BF} + r_{HH}.L_{HH} + r_{SME}.L_{SME} - s_{BF}.(L_{BF}).L_{BF} - s_{HH}.(L_{HH}).L_{HH} - s_{SME}.(L_{SME}).L_{SME} \quad (18)$$

$$\text{s.t.} \qquad L_T = L_{BF} + L_{HH} + L_{SME} = \overline{L_T}$$

Where L_T: total bank lending; i = {*BF*, *HH*, *SME*}: the agent type, *Li*: bank lending to agents of type *i*; r_i: interest rate on loans to type *i* agents; S_i (L_i): default risk cost (i.e. the probability that an agent of type *i* defaults) which increases in the amount of lending to type *i* agents. The optimal amounts of mortgages and loans to SMEs in this case rely on the difference between the yields of the two types of loans (r_{HH} and r_{SME}), and the amount available for investment in the two types (i.e. the amount of total lending minus BFs loans):

$$L_{HH} = \frac{(r_{HH} - r_{SME}) + 2s_{SME}(L_T - L_{BF})}{2(s_{HH} + s_{SME})} \quad (19)$$

$$L_{SME} = \frac{\left(r_{SME} - r_{HH}\right) + 2s_{HH}\left(L_T - L_{BF}\right)}{2\left(s_{HH} + s_{SME}\right)} \tag{20}$$

Hence, a fall in L_{BF}, driven by the lower bond yields, will lead to an increase in L_{HH} and L_{SME}:

$$\frac{\partial L_{HH}}{\partial L_{BF}} = \frac{-2s_{SME}}{2\left(s_{HH} + s_{SME}\right)} < 0 \tag{21}$$

$$\frac{\partial L_{SME}}{\partial L_{BF}} = \frac{-2s_{HH}}{2\left(s_{HH} + s_{SME}\right)} < 0 \tag{22}$$

Therefore, the response of banks to a fall in BFs loans will be to expand the supply of mortgages and SMEs loans. This means that the demand side in mortgages and loans to SMEs markets will have the control as long as banks have unused lending capacities. In other words, in every period, each bank checks if it has a spare lending capacity, and decides the amount of loans granted (or renewed). Accordingly, the non-cash items on the assets side of the balance sheets of banks (loans) evolve as follows:

$$Mortgages_t = Mortgages_{t-1} + new\ mortgages_t - mortgage\ paybacks_t \tag{23}$$

$$Loans\ to\ BFs_t = Loans\ to\ BFs_{t-1} + new\ loans\ to\ BFs_t - BFs\ paybacks_t \tag{24}$$

$$Loans\ to\ SMEs_t = Loans\ to\ SMEs_{t-1} + new\ loans\ to\ SMEs_t - SMEs\ paybacks_t \tag{25}$$

3.5.2.3.2 Case II: Simple Fractional Capital Requirements with No Risk Weights

Banks in this case are required to finance some proportion of their loans using equity capital. Compared to Case I, the amount of loans will be lower for any level of equity capital. Each bank here ranks different investment opportunities and picks the ones it can "afford" given its current stock of equity. Thus, Case II is similar to Case I but with a lower total lending capacity. To introduce the capital adequacy requirements -that states that at least a fraction γ_{Req} of bank assets must be financed by equity- into the model, I follow Aliaga-Díaz, Olivero, and Powell (2011) who state that if a bank has insufficient capital, it is subject to a cost that increases with the distance between the required capital to asset ratio and the actual one. Hence, the profit function in this case becomes:

$$\pi_B = \sum (r_i - \delta).L_i - \sum s_i.(L_i).L_i - \left(\mu.\log\left(\frac{1}{\gamma} - \frac{1}{\gamma_{req}} \right) \right).L_T \quad (26)$$

$$\text{s.t. } L_{BF} + L_{HH} + L_{SME} = \overline{L_T}$$

$$\frac{1}{\gamma} = \frac{1}{\frac{E}{L_{BF} + L_{HH} + L_{SME}}} = \frac{L_T}{E}$$

Where *E*: bank equity capital, $\delta = \sigma.\left(E / L_T \right)$: the cost of equity capital per £1 of total lending; σ : the cost of equity capital estimated by using the Capital Asset Pricing Model (CAPM)[29]; γ_{Req}: the required equity to assets ratio; and γ: the actual equity to assets ratio. In accordance with Basel I, the capital to assets ratio (γ_{Req}) is set to 8% with an optional buffer of 2% above the required level. Since the amount of total lending is already set, the profit function of the bank can be written as follows:

$$\begin{aligned} \pi_B &= \sum r_i.L_i - \sum s_i.(L_i).L_i - \beta.(L_{BF} + L_{HH} + L_{SME}) \\ &= \sum (r_i - \alpha).L_i - \sum s_i.(L_i).L_i \end{aligned} \quad (27)$$

Where $\beta = \left(\mu.\log\left(\frac{1}{\gamma} - \frac{1}{\gamma_{req}} \right) \right)$: the cost of having insufficient equity or the cost of noncompliance with the capital rules, and $\alpha = \delta + \beta$: the total equity cost. Similar to the first scenario, the optimal amounts of mortgages and loans to SMEs in this case rely on the difference between the yields of the two types of loans (r_{HH} and r_{SME}), and the amount available for investment in the two types (i.e. the amount of total lending minus BFs loans):

$$L_{HH} = \frac{\left((r_{HH} - \alpha) - (r_{SME} - \alpha) \right) + 2s_{SME}(L_T - L_{BF})}{2(s_{HH} + s_{SME})} = \frac{(r_{HH} - r_{SME}) + 2s_{SME}(L_T - L_{BF})}{2(s_{HH} + s_{SME})} \quad (28)$$

$$L_{SME} = \frac{\left((r_{SME} - \alpha) - (r_{HH} - \alpha) \right) + 2s_{HH}(L_T - L_{BF})}{2(s_{HH} + s_{SME})} = \frac{(r_{SME} - r_{HH}) + 2s_{HH}(L_T - L_{BF})}{2(s_{HH} + s_{SME})} \quad (29)$$

In equations 28 & 29, a fall in L_{BF} induces banks to grant more mortgages and loans to SMEs:

[29] For example, Rizzi (2013).

$$\frac{\partial L_{HH}}{\partial L_{BF}} = \frac{-2s_{SME}}{2\left(s_{HH} + s_{SME}\right)} < 0 \tag{30}$$

$$\frac{\partial L_{SME}}{\partial L_{BF}} = \frac{-2s_{HH}}{2\left(s_{HH} + s_{SME}\right)} < 0 \tag{31}$$

Moreover, the cost of noncompliance with the capital rules is assumed to be very high and can lead to bank failure. To avoid this high cost, banks try to keep capital to assets ratio very close to 10%. Hence, the behaviour of a bank in any period relies on the value of its capital to assets ratio (γ). Following Repullo and Suarez (2013), if $\gamma_t < 8\%$, failure probability becomes very high and the bank needs to decrease total lending rapidly to prevent total failure, whereas if $\gamma_t > 10\%$, the bank has excess lending capacity that it can use to grant more loans. Lastly, if $8\% \leq \gamma_t \leq 10\%$, the bank has insufficient lending capacity and starts to ration part of its current loans. As a result, the response of banks to a fall in BFs bank borrowing depends on the value of the capital to assets ratio at the end of previous period (month) γ_{t-1}. More specifically, if $\gamma_{t-1} < 10\%$, the bank will maintain (or decrease if the drop in BFs loans is not sufficient) its mortgage and SMEs loans. However, if $\gamma_{t-1} \geq 10\%$, the response of banks will be analogous to that in Case I in the sense that they try to expand mortgage and SMEs loans if possible to compensate for the fall in BFs loans. Hence, the developments on the assets side of each bank's balance sheet can be described as follows:

$$Mortgages_t = \begin{cases} Mortgages_{t-1} - mortgage\ paybacks_t & if\ \gamma_{t-1} < 8\% \\ Mortgages_{t-1} & if\ 8\% \leq \gamma_{t-1} < 10\% \\ Mortgages_{t-1} + new\ mortgages_t - mortgage\ paybacks_t & if\ \gamma_{t-1} \geq 10\% \end{cases} \tag{32}$$

$$Loans\ to\ BFs_t = Loans\ to\ BFs_{t-1} + new\ loans\ to\ BFs_t - BFs\ paybacks_t \tag{33}$$

$$Loans\ to\ SMEs_t = \begin{cases} Loans\ to\ SMEs_{t-1} - SMEs\ paybacks_t & if\ \gamma_{t-1} < 8\% \\ Loans\ to\ SMEs_{t-1} & if\ 8\% \leq \gamma_{t-1} < 10\% \\ Loans\ to\ SMEs_{t-1} + new\ loans\ to\ SMEs_t - SMEs\ paybacks_t & if\ \gamma_{t-1} \geq 10\% \end{cases} \tag{34}$$

3.5.2.3.3 Case III: Complex Fractional Capital Requirements with Risk Weights

Similar to the previous case, banks are required to finance a fraction of their asset using equity capital. However, the fraction in this case becomes a *capital to risk weighted asset* ratio since it addresses the relative riskiness of assets by assigning risk weights to different types of assets. In terms of riskiness, business loans to BFs represent the safest asset in bank balance sheet and loans to SMEs are the riskiest,

whereas mortgages include average risks. Therefore, some risk weights (w_{BF}, w_{HH}, w_{SME}) need to be used to reflect the relative riskiness of the three types of loans, and capital requirements take the form of capital to risk weighted assets ratio (rather than capital to total assets as in Case II). The profit function of a bank in this case take the following formula:

$$\pi_B = \sum(r_i - \delta_i).L_i - \sum s_i.(L_i).L_i - \left(\mu.\log\left(\frac{1}{\gamma} - \frac{1}{\gamma_{req}}\right)\right).L_T \quad (35)$$

$$\text{s.t.} \quad L_{BF} + L_{HH} + L_{SME} = \overline{L_T}$$

$$\frac{1}{\gamma} = \frac{1}{\frac{E}{w_{BF}L_{BF} + w_{HH}L_{HH} + w_{SME}L_{SME}}} = \frac{w_{BF}L_{BF} + w_{HH}L_{HH} + w_{SME}L_{SME}}{E}$$

Where $w_{BF} < w_{HH} < w_{SME}$: risk weights for loans to BFs, mortgages, and loans to SMEs respectively; E: bank equity capital; $\delta_i = \sigma.w_i.\left(E/L_T\right)$: the cost of equity capital per £1 of lending to type i agents; σ : the cost of equity capital estimated by using the Capital Asset Pricing Model (CAPM); γ_{Req}: the required equity to risk weighted assets ratio; γ: the actual equity to risk weighted assets ratio. The model uses following risk weights borrowed from Allen & Overy Client Briefing Paper 3 on Capital Requirements Directive IV Framework (2014).

w_{BF}	w_{HH}	w_{SME}
20%	*50%*	*100%*

As equations 36 and 37 show, in addition to the relative yields and the amount available for investment in mortgages and loans to SMEs, the risk weights and bank equity have a significant impact on the optimal allocation between the two types of loans:

$$L_{HH} = \frac{\left(E.\left(\frac{1}{\gamma_{Req}} - \left(\frac{w_{BF}.L_{BF} + w_{SME}.(L_T - L_{BF})}{E}\right) + \left(\frac{L_T.\mu.(w_{HH} - w_{SME})}{E.((r_{HH} - \delta_{HH} - s_{HH}) - (r_{SME} - \delta_{SME} - s_{SME}))}\right)\right)\right)}{w_{HH} - w_{SME}} \quad (36)$$

$$L_{SME} = \frac{\left(E.\left(\frac{1}{\gamma_{Req}} - \left(\frac{w_{BF}.L_{BF} + w_{HH}.(L_T - L_{BF})}{E}\right) + \left(\frac{L_T.\mu.(w_{SME} - w_{HH})}{E.((r_{SME} - \delta_{SME} - s_{SME}) - (r_{HH} - \delta_{HH} - s_{HH}))}\right)\right)\right)}{w_{SME} - w_{HH}} \quad (37)$$

In equations 35 & 36, while a drop in loans to BFs (L_{BF}) results in -similar to the first two cases- a rise in mortgages, it causes a decrease in loans to SMEs:

$$\frac{\partial L_{HH}}{\partial L_{BF}} = -\frac{\left(w_{BF} - w_{SME}\right)}{w_{HH} - w_{SME}} < 0 \tag{38}$$

$$\frac{\partial L_{SME}}{\partial L_{BF}} = -\frac{\left(w_{BF} - w_{HH}\right)}{w_{SME} - w_{HH}} > 0 \tag{39}$$

It is sensible in Cases II and III to assume that capital adequacy requirements will not affect banks' lending capacity when economic climate is good because of the relatively lower risks associated with different loans and the higher ability to raise equity capital from internal and external resources. However, when the economy is unwell, the riskiness of most loans increases especially business loans provided to financially fragile customers like SMEs, and the possibility of raising external equity capital becomes limited. Hence, banks tend to be very reluctant to provide financing to risky customers when the economic climate is poor. Consequently, when the economic conditions are not good, a drop in BFs bank borrowing -as a result of the drop the cost of corporate bonds mentioned earlier- motivates banks which want to maintain the original amount of total lending -through the riskier asset pools- to *restructure* their asset portfolios towards less loans to SMEs and more mortgages. This result holds as long as the capital to risk weighted assets ratio is not well above 10% (the required minimum capital coverage of 8% plus the optional buffer of 2%). The idea here is that substituting the amount of the fall in BFs loans with extra loans to riskier borrowers increases the size of risk weighted assets and as a result decreases the capital to risk weighted assets ratio. Hence, a bank facing a similar situation will choose not only to allocate the whole extra lending capacity (resulted from the fall in business loans to BFs) to the asset with the lower risk weight (mortgages), but also to replace part of SMEs loans with mortgages.

The change in business loans to SMEs relies mainly on the relative risk weights and the size of the change in BFs loans in the balance sheet of the bank. More specifically, the bigger the change in BFs loans

and/or the smaller the difference between the risk weights of mortgages and SMEs loans, the bigger will be the change the amount of loans to SMEs. Under the assumption that each bank starts with the optimal asset mix -given the risk weights and the returns of different assets-, and tries to maintain its total lending (L_T) the same and to commit to the capital adequacy requirements, the of banks' assets movements in Case III can be described by the following equations:[30]

$$Loans\ to\ BFs_t = Loans\ to\ BFs_{t-1} + new\ loans\ to\ BFs_t - BFs\ paybacks_t \tag{40}$$

$$Mortgages_t = Mortgages_{t-1} + new\ mortgages_t - mortgage\ paybacks_t \tag{41}$$

$$\text{s.t.} \quad Max(Mortgages_t - Mortgages_{t-1}) \leq \frac{w_{SME} - w_{BF}}{w_{SME} - w_{HH}} . |\Delta Loans\ to\ BFs_t| \qquad if\ \Delta Loans\ to\ BFs_t < 0$$

$$Loans\ to\ SMEs_t = \begin{cases} Loans\ to\ SMEs_{t-1} \times \left(1 + \frac{w_{HH} - w_{BF}}{w_{SME} - w_{HH}} \times \Delta Loans\ to\ BFs_t\right) & if\ \Delta Loans\ to\ BFs_t < 0 \\ Loans\ to\ SMEs_{t-1} & otherwise \end{cases} \tag{42}$$

3.5.2.4 SMEs Behaviour

Similar to BFs, SMEs have a constant but lower annual operating profit to total assets ratio of 5%, and keep the size of physical capital fixed over the simulation period. Yet, SMEs can't -to large extent- control their debt financing -like BFs- since the single source of this financing is bank loans whose size depends solely on banks' will to grant loans or extend/renew current credit facilities to these firms. Additionally, the model assumes that SMEs have unlimited demand for debt financing and that they can't raise further external equity financing during the simulation period. As shown above, while in Cases I and II SMEs might be able to obtain more bank loans after a fall in BFs bank borrowing, they face declining amounts of credit facilities from their banks, and the bigger the reduction in BFs bank borrowing, the stronger will be the drop in loans to SMEs. In particular, under the third scenario, once BFs start to replace bank loans with bonds, the amount of loans granted to each SME drops by $\frac{w_{HH} - w_{BF}}{w_{SME} - w_{HH}} \times Mean(BF\ Loans\ Growth_t)$. Consequently, the components of a SME balance sheet in a given period t are as follows:

$$Physical\ Capital_t = Physical\ Capital_{t-1} \tag{43}$$

[30] The mathematical derivation of the formulas in equations 41 and 42 is shown in Appendix A1.

$$Operating\ Profit_t = 0.05 \times (Physical\ Capital_{t-1} + Liquidity_{t-1}) \quad (44)$$

$$Liquidity_t = Liquidity_{t-1} + Operating\ Profit_t - r_{SME(t)}.Loans_{t-1} - Loans_{t-1} + Loans_t \quad (45)$$

$$Loans_t = Loans_{t-1} + new\ loans_t - Loan\ paybacks_t \quad (46)$$

$$Equity_t = Physical\ Capital_t + Liquidity_t - Loans_t \quad (47)$$

3.6 Simulation Results

As stated earlier, the model in this chapter covers a period of 50 months and mimics the interaction between different agents and the responses of these agents to the developments in debt markets. At the beginning of simulation period (*t = 1*), the model parameters, the initial values of interest rates, house prices and HHs incomes, and the starting financial positions (balance sheets) of all agents are set to reflect the empirical assumptions described earlier. Additionally, at that stage, HHs, BFs and SMEs select (randomly) their preferred banks with which they will do business (i.e. deposit cash holdings and obtain loans). Figure 3.20 summarises the initial values (distributions) of different variables in the model. In the following periods, the financial positions of different agents evolve reflecting the developments in credit markets. At any given month *t*, the asset purchase under APP lead to a fall in gilts yield which reflects on the yield of corporate bonds through the portfolio rebalancing effect. BFs anticipate the fall in bonds yield and start to change the structure of its debt financing when the cost of bonds becomes lower than the cost of bank loans.

Meanwhile, each household receives it income, finances it consumption, pay its mortgage instalment, and accumulates the rest into its cash holdings. As mentioned earlier, a household chooses whether it wants to buy a new house with a probability that reflects its ownership status (20% if it has at least one house and 30% if it has none). If the household decides to buy a new house, it applies for a mortgage from its preferred bank and gets one if it meets the minimum requirements in terms of income (the mortgage payment can't exceed 40% of the household income), cash (the household has to have at least twice the amount of the down payment or deposit in cash), and the number of current mortgages (a household can't have more than three mortgages at a time) given that the bank has a spare lending capacity.

Figure 3.20: The Initial Values/Distributions of the Model's Variables

Variable	Value/Distribution						Assumptions/Empirical facts
Households							
Number of households	1,000						Scaled down from 21,464,730
Number of houses per household	Number	0	1	2	3	4	Only 64% of UK households own at least one property
	Probability	0.36	0.16	0.16	0.16	0.16	
House price	£149,400						Average house price in 2009 Q1.
Household housing wealth	Number of Houses x House price						
Household cash	Uniformly distributed between £5,000 and £50,000						
Household mortgage liability	Uniformly distributed between £0 and £70,965						- 52% of the homeowners have mortgages - HHs average mortgage liability in 2009 Q1 was £49,070
Household equity	Household housing wealth + household cash - household mortgage liability						
Household income	Log-normally distributed						The distribution is estimated using the monthly equivalents of IFS's parameters of the weekly income distribution (in 2009 Q1)
Household preferred bank	Randomly selected						
Big Firms							
Number of big firms	3						Scaled down from 4,405
Big firm Physical capital	Uniformly distributed between £5 million and £300 million						
Big firm cash	(0.1283/0.8717) x physical capital						cash represented 12.83% of nonfinancial firms total assets in 2009 Q1
Big firm leverage ratio	51.66%						NFCs leverage ratio in 2009 Q1 was 51.66%
Big firm loans	34.77% x (physical capital + cash)						Loans represented 67.3% of NFCs total debt in 2009 Q1. (67.3% x 51.66% = 34.77%)
Big firm bonds	16.89% x (physical capital + cash)						Bonds represented 32.7% of NFCs total debt in 2009 Q1. (32.7% x 51.66% = 16.89%)
Big firm equity	Big firm physical capital + big firm cash - big firm loans - big firms bond						
Big firm preferred bank	Randomly selected						
Small and medium enterprises							
Number of SMEs	229						Scaled down from 4,918,915
SME Physical capital	Uniformly distributed between £50,000 and £1 million						
SME cash	(0.1283/0.8717) x physical capital						cash represented 12.83% of nonfinancial firms total assets in 2009 Q1
SME leverage ratio	40%						SMEs are less able to use debt financing compared to BFs
SME loans	40% x (physical capital + cash)						
SME equity	SME physical capital + SME cash - SME loans						
SME preferred bank	Randomly selected						
Banks							
Number of banks	10						
Bank total mortgages	Sum of mortgages of HHs that deal with the bank						
Bank loans to big firms	Sum of loans to big firms that deal with the bank						
Bank loans to SMEs	Sum of loans to SMEs that deal with the bank						
Bank deposits	Sum of cash of households, big firms and SMEs that deal with the bank						
Bank equity	Mortgages + loans to big firms + loans to SMEs – deposits						
Interest rates							
Risk-free rate (r_{RF})	0.5%						BoE policy rate
Government gilts rate (r_G)	4%						Median yield on 10-year gilts in 2008 Q4
Interest rate on BFs bonds	6%						r_G + 2%
Interest rate on BFs loans	5.5%						r_{RF} + 5%
Interest rate on mortgages	7%						r_{RF} + 6.5%
Interest rate on SMEs loans	8.5%						r_{RF} + 8%
Risk Weights							
BFs loans risk weight	0.2						
Mortgages risk weight	0.5						
SMEs loans risk weight	1.0						

Figure 3.21: The proportion of Successful Mortgage Applications

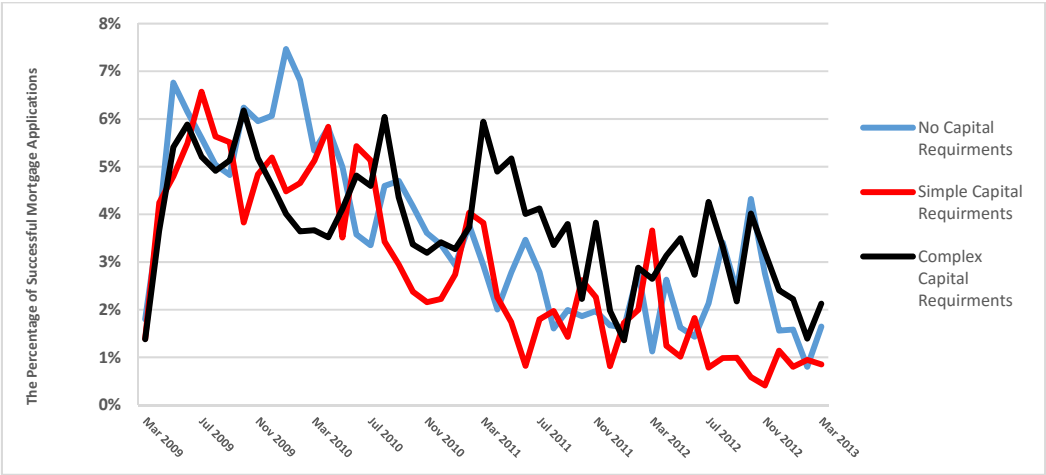
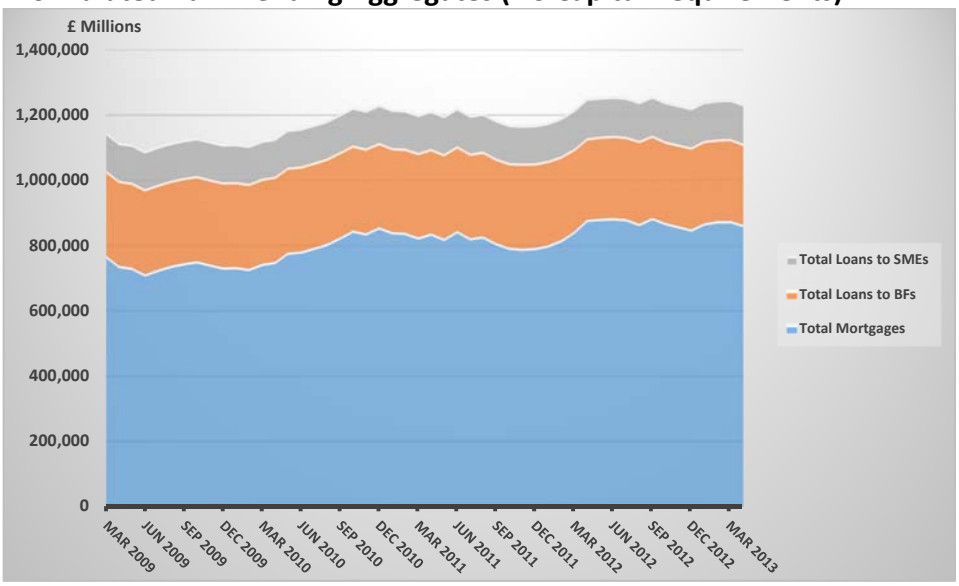


Figure 3.21 presents the proportion of successful mortgage applications in every month under each of the three capital requirements regimes. The value of the new mortgage (on the liabilities side of the household balance sheet) depends on the house price at month t and the size of the deposit (5% of the house price). On the assets side, the housing wealth of the household increases by the value of the new house, whereas cash holdings fall by the amount of the down payment (deposit). The simulation is run under each of the three scenarios described in the banks behaviour section. Sections 3.6.1 to 3.6.3 present the outcomes of the simulation. In order to make them comparable to actual data, the amounts of mortgages, loans to BFs, and loans to SMEs in the following sections are rescaled up using the proportions between the actual and the hypothetical numbers of the agents. In section 3.6.4, the model is validated using the history-friendly approach suggested by Windrum, Fagiolo and Moneta (2007). Lastly, section 3.6.5 discusses the impact of altering the capital adequacy requirements regime.

3.6.1 Case I: No Capital Requirements

Figure 3.22 displays the simulation results under the assumption that banks don't have to commit to any capital requirements. As this Figure illustrates, BFs don't change their debt structure during the first 20 periods since the falling cost of security debt is still bigger than the cost of bank borrowing. However, once the first becomes smaller than the last, BFs begin to issue new security debt to replace a fraction of their bank loans. In response to a fall in BFs bank borrowing, banks tend to grant more mortgages and to expand loans to SMEs. Led by the increasing mortgages, total bank lending witnesses an expansion during the first 20 months, then stays stable around some higher level.

Figure 3.22: Simulated Bank Lending Aggregates (No Capital Requirements)



3.6.2 Case II: Simple Fractional Capital Requirements with No Risk Weights

Simulation results under the simple fractional capital requirements are displayed in Figure 3.23. The simulation under this scenario produces similar trends to those under no capital requirements case. When BFs bank borrowing starts to fall, banks do provide more mortgages. They also increase loans to SMEs, but in lower amounts compared to the previous scenario. Subsequently, similar to Case I, total bank lending rises for the first 20 periods, then remains stable afterwards.

Figure 3.23: Simulated Bank Lending Aggregates (Simple Capital Requirements; No Risk Weights)

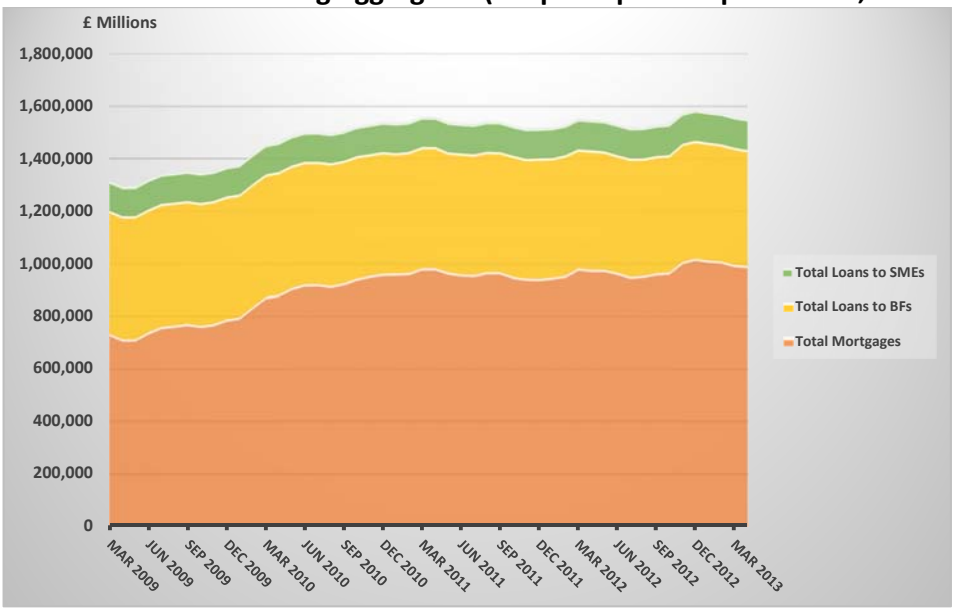
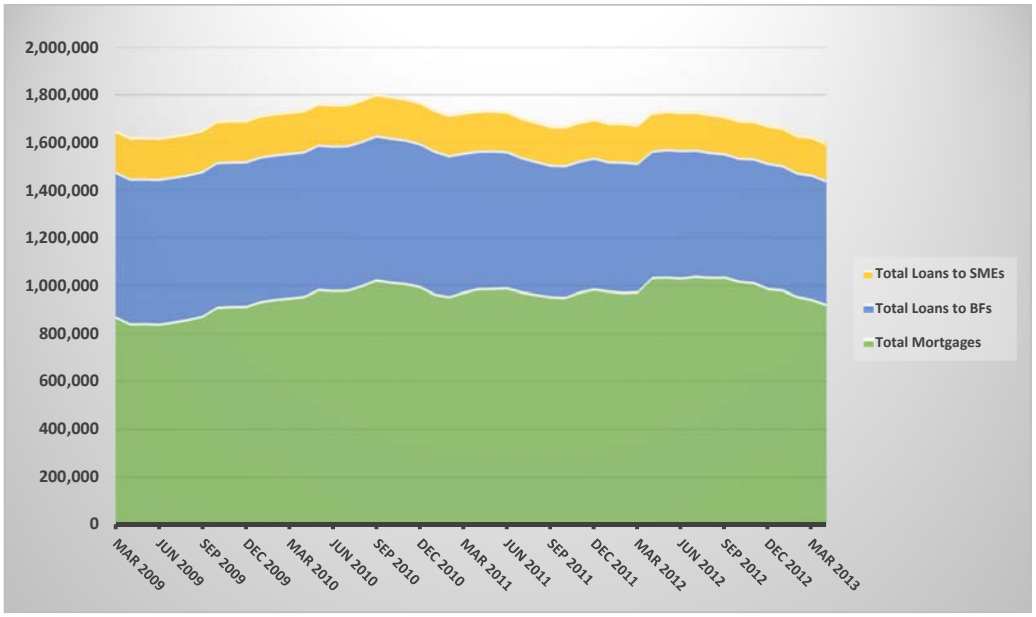
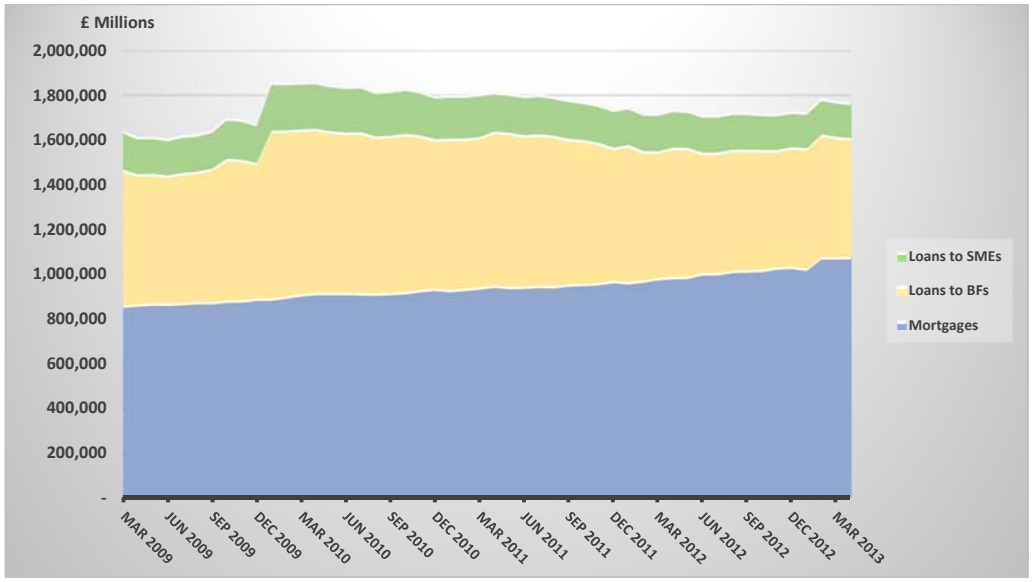


Figure 3.24: Simulated vs. Actual Bank Lending Aggregates (Complex Capital Requirements; Risk Weights)

a. Simulated Lending Aggregates



b. Actual Lending Aggregates



Source: Bank of England's Bankstats (http://www.bankofengland.co.uk/statistics/Pages/bankstats/default.aspx)

3.6.3 Case III: Complex Fractional Capital Requirements with Risk Weights

The simulation under the third scenario has produced the results displayed in the Figure 3.24. These results present similar trends to the actual data. This especially true for the data on mortgages and total bank lending which shows a significant drop in the second half of the simulation period once the fall in gilts

(and hence bonds) yields starts affecting the debt structure of BFs towards less bank loans and more security debt. The lower BFs bank borrowing increases the riskiness of banks assets and hence causes a decreases in their capital buffers. Consistent with Thakor (1996), Hans et al. (1999), and Heid, Porath and Stolz (2004) results, this fall in capital buffers induces banks to rebuild them by raising capital and lowering risk-weighted assets by investing more in the safer asset (mortgages) and less of the riskier asset (loans to SMEs).

3.6.4 Model Validation

Several validation methods have been used to validate simulated models in engineering in computer sciences. For instance, Sargent (2013) outlines 17 techniques that can be used to validate models. These techniques use logical reasoning, quantitative methods, or visual representation to verify the soundness of simulated models. One of these techniques, *historical data (or empirical) validation*, is recommended by Windrum, Fagiolo and Moneta (2007) to assess models in the context of ACE. In their *history-friendly approach*, a good model is one that is able to generate several stylized facts observed in the actual data. To validate the model of this chapter, this section examines the degree to which simulated lending aggregates represent actual lending aggregates. To do that, two sets of regressions are run. In the first set, each of the time series of simulated and actual lending aggregates is regressed on time (t), then the outcomes of regressions are compared between each simulated series and the corresponding actual series. The regressions in the second group investigate the correlation between simulated and actual data by regressing each actual time series on the corresponding simulated one. The summary of the regressions is presented in Figures 3.25 and 3.26.[31]

Figure 3.25: Summary of the Simulated and Actual Bank Lending Aggregates Regressions on Time

Variable	Coefficient on time	Standard Error	p value	R^2
Simulated BFs Loans	1.64×10^{10}	1.51×10^{9}	0.00	0.7059
Actual BFs Loans	1.80×10^{10}	1.68×10^{9}	0.00	0.7008
Simulated SMEs Loans	4.87×10^{9}	4.26×10^{8}	0.00	0.7269
Actual SMEs Loans	5.18×10^{9}	4.71×10^{8}	0.00	0.7122
Simulated Mortgages	2.93×10^{10}	2.17×10^{9}	0.00	0.7879
Actual Mortgages	2.91×10^{10}	2.04×10^{9}	0.00	0.8063
Simulated Total lending	5.06×10^{10}	4.11×10^{9}	0.00	0.7557
Actual Total lending	5.23×10^{10}	4.17×10^{9}	0.00	0.7574

[31] The detailed regression results are reported in the appendices.

Figure 3.26: Summary of the Regression of Actual on Simulated Bank Lending Aggregates

Variable	Coefficient on the Simulated Variable	Standard Error	p value	R^2
Actual BFs Loans	1.100397	0.125398	0.00	0.9937
Actual SMEs Loans	1.073266	0.0112729	0.00	0.9946
Actual Mortgages	0.9807749	0.0074565	0.00	0.9972
Actual Total lending	1.03002	0.0043908	0.00	0.9991

The coefficients on the simulated variables and R^2 values in Figure 3.26 reveal very strong (almost perfect) correlations between the actual and simulated bank lending aggregates. Similarly, the comparison between the results of the regressions of each of the actual bank lending aggregates with the corresponding results for simulated aggregates indicate that the simulated data is a very good representation of the actual data.

3.6.5 Changing the Capital Requirements System

These sections explore the influence of changing the capital requirements regime on simulation results presented in the preceding sections. It starts by examining the effects of moving from no capital requirements to simple capital requirements, then turns to investigate the impact of replacing a simple capital adequacy regime with a complex one.

3.6.5.1 No Capital Requirements to Simple Capital Requirements

Simulation outcomes indicate that a drop in BFs bank borrowing produces similar consequences under both regimes. However, since total bank lending tends to be higher under no requirements regime, requiring banks to finance a certain fraction of their loans with equity capital will probably lead to a fall in total bank lending. As a result, each bank compares the drop in its lending to BFs (ΔL_{BF}) and the needed decrease in total lending (ΔL_T) to commit to the new capital rules. If $\Delta L_{BF} > \Delta L_T$, the bank acts as if it were already working under the simple capital requirements by allocating the difference ($\Delta L_{BF} - \Delta L_T$) to provide more mortgages and loans to SMEs. If $\Delta L_{BF} \leq \Delta L_T$, the bank will have to maintain or cut lending in mortgages and loans to SMEs markets. Nevertheless, if a bank wants to grant further mortgages, it will have to raise more equity capital and/or reduce SMEs lending.

3.6.5.2 Simple Capital Requirements to Complex Capital Requirements

Simply, moving from a simple capital requirements regime to a complex one by introducing risk weights, would give banks extra lending capacity since they have to hold less equity to provide the current level of mortgages and loans to BFs. Therefore, an expansion in BFs loans and mortgages -and to a lower extent SMEs loans- would be expected in this case. If the regime shift is accompanied with a fall in BFs bank borrowing, banks might respond in the same way if there was no shift (i.e. noticeably increasing mortgages and narrowly expanding SMEs loans). Yet, once the spare lending capacity is almost fully exhausted, any further drop in BFs loans would generate the outcomes presented in Case III shown in Figure 3.23.

3.7 Conclusion

Increasing bank lending is one of the main goals of BoE's APP launched early in 2009. Yet, ONS sectoral financial accounts data shows that although bank lending to households has been expanding since 2009, total bank lending witnessed a noticeable drop driven by the falling lending to businesses. To explain this decrease in bank lending, this chapter introduces a baseline ACE model which contains four types of agents -1,000 households (HHs), 3 big firms (BFs), 229 small and medium enterprises (SMEs) and 10 banks- and mimics the interaction between these agents in different credit markets. HHs in the model own houses and hold cash with banks, and finance these assets using a mixture of mortgages and equity (net worth). A household can expand asset holdings by saving a part of its income and/or obtain a mortgage from its preferred bank. Moreover, both firm types (BFs and SMEs) utilize a combination of physical capital and cash -financed by equity and debt capital- to make profit. Yet, while SMEs are restricted to bank borrowing as the sole source of debt financing, BFs can choose between bank loans and issuing bonds to raise debt capital. Lastly, banks hold the cash of the other agents and provide debt financing to these agents in the form of mortgages (granted to HHs) and business loans (to BFs and SMEs).

The baseline model was anchored to the actual values of several variables, such as homeownership statistics and nonfinancial firms leverage ratio, around the time of APP launch, then simulated for 50 periods (months) under three different scenarios. Banks do not have to commit to any capital rules under the first scenario, whereas they are required to finance a fraction of their asset with equity capital under the other two scenarios. The difference between the second and the third scenarios appears in the way different types of bank assets are treated. In other words, while under the second case all loan types have the same impact on the actual equity to (risk weighted) assets ratio, they carry different weights that reflect the relative riskiness of each type under the third case. Banks respond to falls in BFs bank borrowing in the same way under the first two scenarios by expanding their lending to the other two types of agents (HHs and SMEs). Under the third scenario, however, they tend to replace part of SMEs loans with mortgages in response to the riskier assets due the drop in the safest asset (BFs loans).

Simulation results under the third scenario present similar trends to the actual data. In the early periods, the growing mortgages expand total bank lending. However, once BFs start to exchange part of their bank borrowing with security debt (bonds) as a result of the lower gilts (because of APP) and hence -through portfolio rebalancing effect- corporate bonds yields, the size of total bank lending starts to fall. A possible explanation of these trends is that the fall in gilts yield and hence corporate bonds yield encourages BFs to adjust their debt financing towards less bank borrowing and more security debt. The decrease in BFs loans -which represents the safest asset in bank loan portfolios- increases the riskiness of banks asset pools and hence lower the capital buffers. Finally, a comparison between simulation outcomes under the third scenario and those in the first two indicates that the combination of lower asset yields and complex capital adequacy requirements (with risk weights) appears to cause the drop in total bank lending after the introduction of APP in 2009. This conclusion is consistent with the results of Heid, Porath and Stolz

(2004) who point out that a fall in capital buffers induces banks to rebuild these buffers by raising capital and lowering risk-weighted assets by investing more in the safer asset (mortgages) and less of the riskier asset (loans to SMEs).

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Appendices:

A3.1 Derivation of the formulas in Equations 41 and 42

❋ First, define the following:

⊙ L_{BF} = bank loans to big firms.

⊙ L_{HH} = total mortgages.

⊙ L_{SME} = bank loans to SMEs.

⊙ L_T = total bank lending.

$$L_T = L_{BF} + L_{HH} + L_{SME}$$

⊙ R = risk weighted assets:

$$R = w_{BF}.L_{BF} + w_{HH}.L_{HH} + w_{SME}.L_{SME}$$

❋ Second, assume that each bank keeps its total lending and risk weighted assets fixed over the time, and that there is a fall in loans to BFs (i.e. $\Delta L_{BF} < 0$), hence:

$$\Delta L_T = \Delta L_{BF} + \Delta L_{HH} + \Delta L_{SME} = 0 \quad \text{(i)}$$

$$\Delta R = w_{BF}.\Delta L_{BF} + w_{HH}.\Delta L_{HH} + w_{SME}.\Delta L_{SME} = 0 \quad \text{(ii)}$$

❋ From equation (*i*) we can write:

$$\Delta L_{HH} = -(\Delta L_{BF} + \Delta L_{SME}) \quad \text{(iii)}$$

❋ Substitute equation (*iii*) into equation (*ii*)

$$w_{BF}.\Delta L_{BF} + w_{HH}.(-\Delta L_{BF} - \Delta L_{SME}) + w_{SME}.\Delta L_{SME} = 0 \Rightarrow$$

$$(w_{BF} - w_{HH}).\Delta L_{BF} + (w_{SME} - w_{HH}).\Delta L_{SME} = 0 \Rightarrow$$

$$(w_{SME} - w_{HH}).\Delta L_{SME} = -(w_{BF} - w_{HH}).\Delta L_{BF} \Rightarrow$$

$$(w_{SME} - w_{HH}).\Delta L_{SME} = (w_{HH} - w_{BF}).\Delta L_{BF} \Rightarrow$$

$$\Delta L_{SME} = \frac{w_{HH} - w_{BF}}{w_{SME} - w_{HH}}.\Delta L_{BF}$$

❋ Substitute the change in loans to SMEs into equation *iii*:

$$\Delta L_{HH} = -\left(\Delta L_{BF} + \frac{w_{HH} - w_{BF}}{w_{SME} - w_{HH}}.\Delta L_{BF}\right) \Rightarrow$$

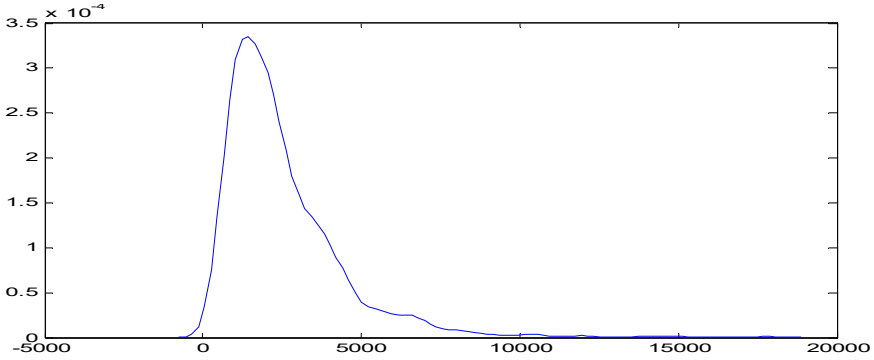
$$\Delta L_{HH} = -\Delta L_{BF}.\left(1 + \frac{w_{HH} - w_{BF}}{w_{SME} - w_{HH}}\right) \Rightarrow$$

$$\Delta L_{HH} = -\Delta L_{BF}.\frac{w_{SME} - w_{HH} + w_{HH} - w_{BF}}{w_{SME} - w_{HH}} \Rightarrow$$

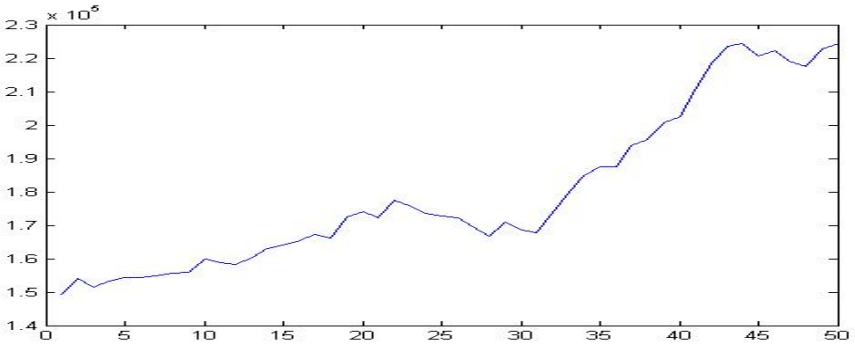
$$\Delta L_{HH} = -\Delta L_{BF}.\frac{w_{SME} - w_{BF}}{w_{SME} - w_{HH}} \Rightarrow$$

$$\Delta L_{HH} = \frac{w_{SME} - w_{BF}}{w_{SME} - w_{HH}}.|\Delta L_{BF}|$$

A3.2 Simulated Distribution (Monthly Income of HHs)



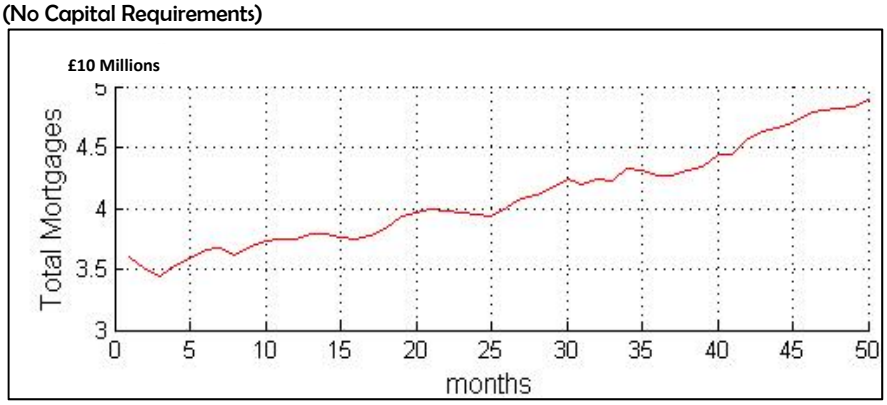
A3.3 Simulated Average House Price



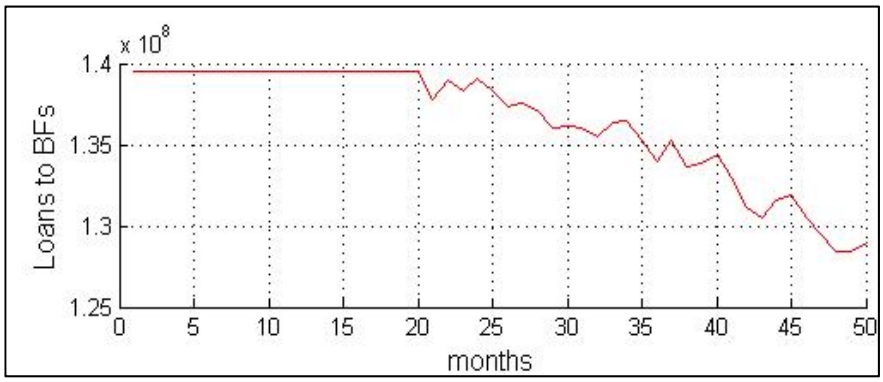
A3.4 Non-Scaled Simulated Bank Lending Aggregates

1. Case I: No Capital Requirements

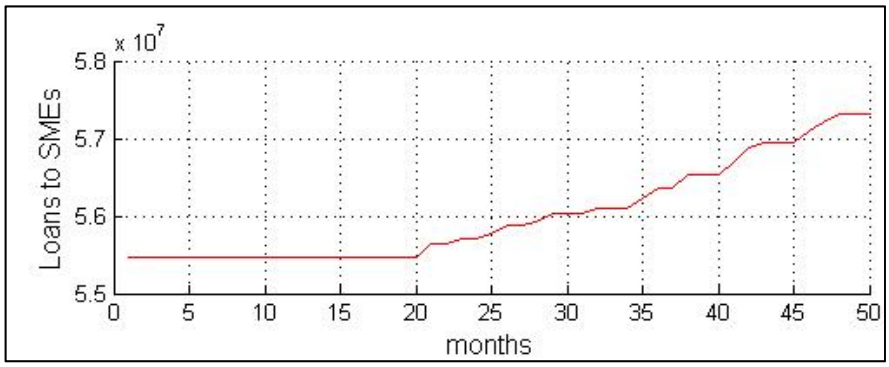
Total Mortgages (No Capital Requirements)



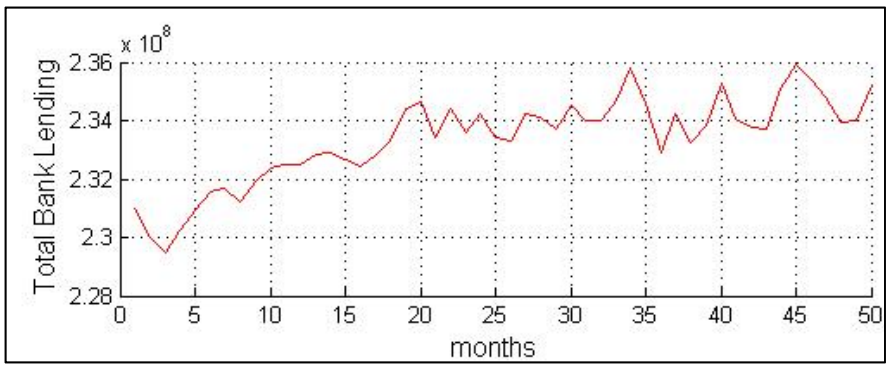
Big Firms Total Bank Loans (No Capital Requirements)



SMEs Total Bank Loans (No Capital Requirements)

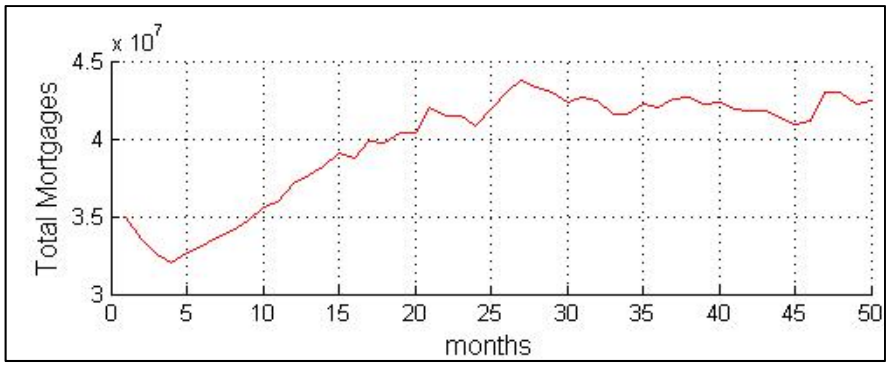


Total Bank Lending (No Capital Requirements)

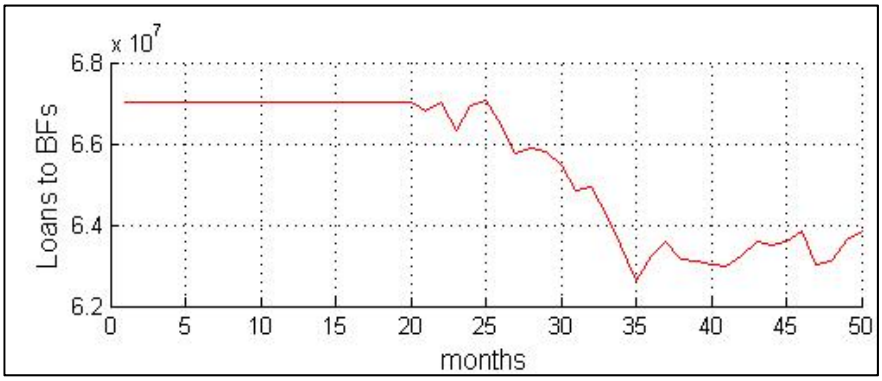


2. Case II: No Simple Capital Requirements; No Risk Weights

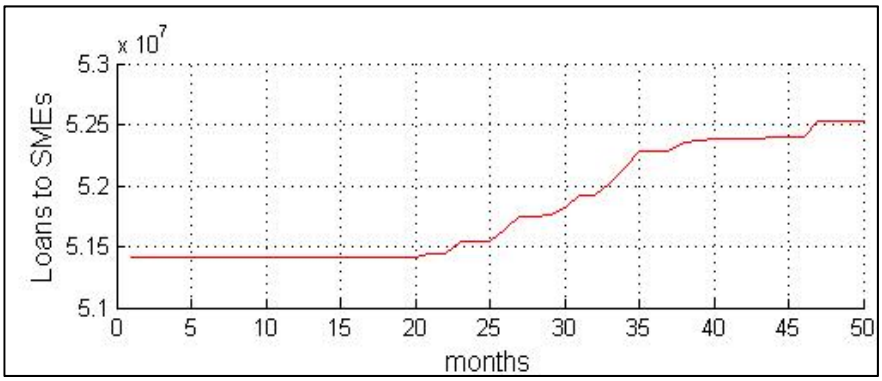
Total Mortgages (Simple Capital Requirements; No Risk Weights)



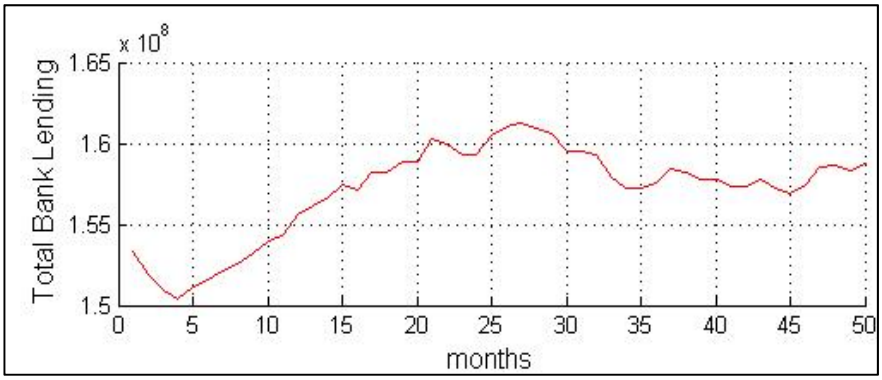
Big Firms Total Bank Loans (Simple Capital Requirements; No Risk Weights)



SMEs Total Bank Loans (Simple Capital Requirements; No Risk Weights)



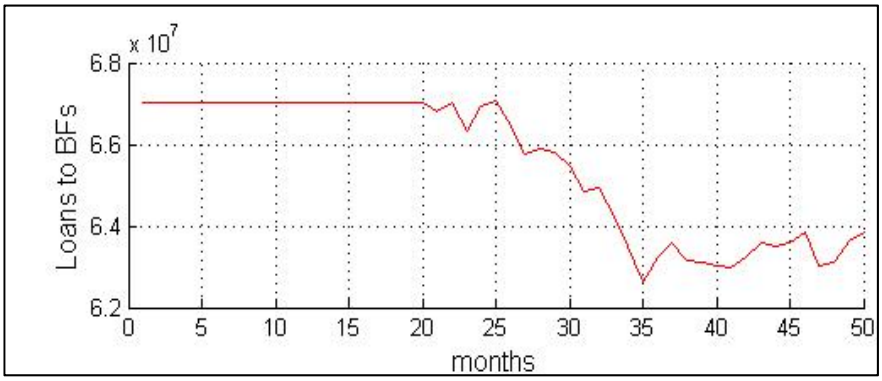
Total Bank Loans (Simple Capital Requirements; No Risk Weights)



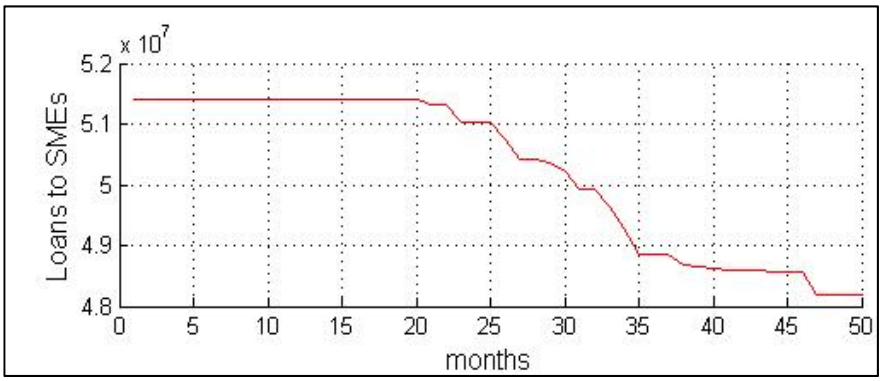
3. Case III: Complex Capital Requirements with Risk Weights

Total Mortgages (Complex Capital Requirements; Risk Weights)

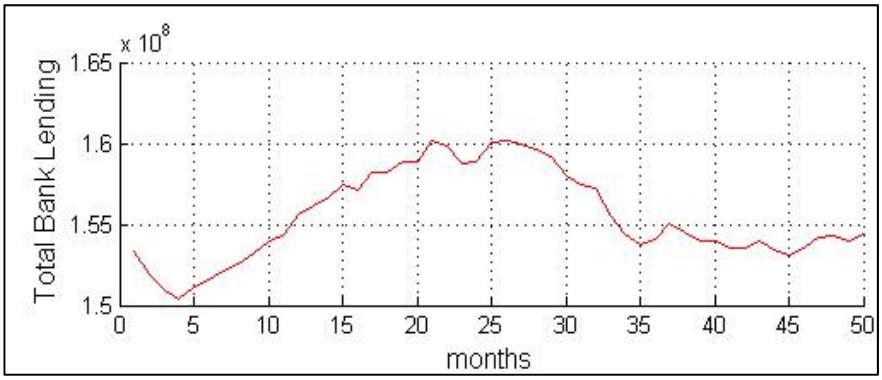
Big Firms Total Bank Loans (Complex Capital Requirements)



SMEs Total Bank Loans (Complex Capital Requirements)



Total Bank Lending (Complex Capital Requirements)



A3.5 The Outcomes of Regressions Used in Model Validation

1. Regressions of Simulated and Actual Bank Lending Aggregates on Time

Simulated BFs Loans

Source	SS	df	MS
Model	1.1503e+25	1	1.1503e+25
Residual	4.7927e+24	49	9.7810e+22
Total	1.6295e+25	50	3.2591e+23

Number of obs = 50
F(1, 49) = 117.60
Prob > F = 0.0000
R-squared = 0.7059
Adj R-squared = 0.6999
Root MSE = 3.1e+1

BFs_SIM	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	1.64e+10	1.51e+09	10.84	0.000	1.33e+10	1.94e+10

Actual BFs Loans

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	114.78
Model	1.3916e+25	1	1.3916e+25	Prob > F =	0.0000
Residual	5.9409e+24	49	1.2124e+23	R-squared =	0.7008
				Adj R-squared =	0.6947
Total	1.9857e+25	50	3.9714e+23	Root MSE =	3.5e+1

BFs_ACT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	1.80e+10	1.68e+09	10.71	0.000	1.46e+10	2.14e+10

Simulated SMEs Loans

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	130.39
Model	1.0168e+24	1	1.0168e+24	Prob > F =	0.0000
Residual	3.8211e+23	49	7.7982e+21	R-squared =	0.7269
				Adj R-squared =	0.7213
Total	1.3989e+24	50	2.7979e+22	Root MSE =	8.8e+10

SMEs_SIM	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	4.87e+09	4.26e+08	11.42	0.000	4.01e+09	5.72e+09

Actual SMEs Loans

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	121.25
Model	1.1538e+24	1	1.1538e+24	Prob > F =	0.0000
Residual	4.6631e+23	49	9.5164e+21	R-squared =	0.7122
				Adj R-squared =	0.7063
Total	1.6201e+24	50	3.2403e+22	Root MSE =	9.8e+10

SMEs_ACT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	5.18e+09	4.71e+08	11.01	0.000	4.24e+09	6.13e+09

Simulated Mortgages

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	181.99
Model	3.6892e+25	1	3.6892e+25	Prob > F =	0.0000
Residual	9.9329e+24	49	2.0271e+23	R-squared =	0.7879
				Adj R-squared =	0.7835
Total	4.6825e+25	50	9.3651e+23	Root MSE =	4.5e+11

Mortgages_~M	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	2.93e+10	2.17e+09	13.49	0.000	2.49e+10	3.37e+10

Actual Mortgages

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	203.92
Model	3.6419e+25	1	3.6419e+25	Prob > F =	0.0000
Residual	8.7511e+24	49	1.7859e+23	R-squared =	0.8063
				Adj R-squared =	0.8023
Total	4.5170e+25	50	9.0340e+23	Root MSE =	4.2e+11

Mortgages_~T	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	2.91e+10	2.04e+09	14.28	0.000	2.50e+10	3.32e+10

Simulated Total Lending

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	151.60
Model	1.0970e+26	1	1.0970e+26	Prob > F =	0.0000
Residual	3.5458e+25	49	7.2363e+23	R-squared =	0.7557
				Adj R-squared =	0.7507
Total	1.4516e+26	50	2.9032e+24	Root MSE =	8.5e+11

TLending_SIM	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	5.06e+10	4.11e+09	12.31	0.000	4.23e+10	5.88e+10

Actual Total Lending

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	157.09
Model	1.1749e+26	1	1.1749e+26	Prob > F =	0.0000
Residual	3.6650e+25	49	7.4796e+23	R-squared =	0.7622
				Adj R-squared =	0.7574
Total	1.5414e+26	50	3.0829e+24	Root MSE =	8.6e+11

TLending_ACT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
t	5.23e+10	4.17e+09	12.53	0.000	4.39e+10	6.07e+10

2. Regressions of Actual Bank Lending Aggregates on Simulated Bank Lending Aggregates

Actual BFs Loans on Simulated BFs Loans

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	7700.49
Model	1.9732e+25	1	1.9732e+25	Prob > F =	0.0000
Residual	1.2556e+23	49	2.5624e+21	R-squared =	0.9937
				Adj R-squared =	0.9935
Total	1.9857e+25	50	3.9714e+23	Root MSE =	5.1e+10

BFs_ACT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
BFs_SIM	1.100397	.0125398	87.75	0.000	1.075197	1.125597

Actual SMEs Loans on Simulated SMEs Loans

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	9064.56
Model	1.6114e+24	1	1.6114e+24	Prob > F =	0.0000
Residual	8.7109e+21	49	1.7777e+20	R-squared =	0.9946
				Adj R-squared =	0.9945
Total	1.6201e+24	50	3.2403e+22	Root MSE =	1.3e+10

SMEs_ACT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
SMEs_SIM	1.073266	.0112729	95.21	0.000	1.050613	1.09592

Actual Mortgages on Simulated Mortgages

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	17300.90
Model	4.5042e+25	1	4.5042e+25	Prob > F =	0.0000
Residual	1.2757e+23	49	2.6035e+21	R-squared =	0.9972
				Adj R-squared =	0.9971
Total	4.5170e+25	50	9.0340e+23	Root MSE =	5.1e+10

Mortgages_ACT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Mortgages_SIM	.9807749	.0074565	131.53	0.000	.9657905	.9957593

Actual Total Bank Lending on Simulated Total Bank Lending

Source	SS	df	MS	Number of obs =	50
				F(1, 49) =	55029.38
Model	1.5401e+26	1	1.5401e+26	Prob > F =	0.0000
Residual	1.3713e+23	49	2.7986e+21	R-squared =	0.9991
				Adj R-squared =	0.9991
Total	1.5414e+26	50	3.0829e+24	Root MSE =	5.3e+10

TLending_ACT	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
TLending_SIM	1.03002	.0043908	234.58	0.000	1.021196	1.038844

A3.6 Top 10 UK Banks Equity to Total Assets Ratios

This appendix presents the actual equity to total assets ratios of the biggest 10 UK banks. These ratios were used to set the values of the equity items in the initial balance sheets of the banks in the model.

Bank	Date	Equity to Total Assets Ratio
HSBC	31/12/2008	2.05%
Barclays	31/12/2008	2.12%
Royal Bank of Scotland	31/12/2008	2.65%
Lloyds	31/12/2008	2.22%
Standard Chartered	31/12/2008	4.84%
NatWest	31/12/2008	4.19%
Santander UK	31/12/2013	4.66%
Nationwide	31/12/2008	3.36%
The Co-operative Bank	31/12/2008	5.27%
Clydesdale and Yorkshire Bank	31/12/2008	4.85%

Source: Bankscope Database available at (http://www.bvdinfo.com)

A3.7 MatLab Code

```
clc
clear all
close all

colour = 'r';

%% Capital Adequecy Requirements Regime
% 1 = No capital adequecy requirements
% 2 = Simple capital adequecy requirements with no risk weights
% 3 = Complex capital adequecy requirements with no risk weights

Case = 3;                                                                    %
set the capital adequecy regime

%% Parameters
T = 50;                                                                      %
simulation period in months.
DTV = 0.05;                                                                  %
the proportion of the house value a household has to put as a down payment
(deposit in the UK).
```

```
if Case == 1
   w1 = 0;                                                              %
risk weight for high quality loans to big firms.
   w2 = 0;                                                              %
risk weight for mortgages.
   w3 = 0;                                                              %
risk weight for risky SME loans.
else
   if Case == 2
      w1 = 1;
      w2 = 1;
      w3 = 1;
    else
       if Case == 3
          w1 = 0.2;
          w2 = 0.5;
          w3 = 1.0;
       end
   end
end


%% The Size of Agent Populations
NrHHs = 1000;                                                           %
the number of households.
NrBFs = 3;                                                              %
the number of big firms.
NrSMEs = 229;                                                           %
the number of small and medium enterprises.
NrBanks = 10;                                                           %
the number of banks.

%% Initial Values
rG(1) = 0.04;                                                           %
interest rate on government gilts.
rH(1) = 0.07;                                                           %
interest rate on mortgages.
rRF(1) = 0.005;                                                         %
risk-free inerest rate.
rBF(1) = rRF(1) + 0.05;                                                 %
interest rate on big firms bank loans.
rS(1) = rG(1) + 0.02;                                                   %
interest rate on big firm bonds.
rSME(1) = rRF(1) + 0.08;                                                %
interest rate on small and medium enterprises bank loans.
HousePrice(1) = 149400;                                                 %
average house price in the UK in 2009 Q1.

%% House ownership status                                               %
only 64% of UK households live in owned homes calibrated using ONS data.
Household.NrHouses(1,:) = round(rand(1,NrHHs)*4)
for hh=1:NrHHs
    if Household.NrHouses(1,hh)==0
        per = 36/100
    else
        per = 16/100
```

```
    end
end

%% Household Balance Sheets
% Assets Side
Household.Housing(1,:)= Household.NrHouses(1,:) * HousePrice(1);
Household.Liquidity(1,:) = randi([5000 50000],1,NrHHs);

% Liabilities Side
if Household.Housing(1,:) == 0
   Household.Mortgages(1,:) = 0
else
   Household.Mortgages(1,:) = randi([0 70965],1,NrHHs)
end
Household.Equity(1,:) = Household.Housing(1,:) + Household.Liquidity(1,:) -
Household.Mortgages(1,:);

%% Household Income                                                    %
Household income in the UK follows a lognormal distribution according to IFS.
pd = makedist('Lognormal','mu',7.47515025423602,'sigma',0.662869245249149);
Household.Income(1,:) = random(pd,NrHHs,1);

%% Household Willingness to Buy a Property
Household.WantToBuy(1,:) = round(rand(1,NrHHs)*1)
for hh=1:NrHHs
    if Household.Housing(1,:) == 0
       if Household.WantToBuy(1,hh)==0
            per = 70/100
       else
            per = 30/100
       end
    else
       if Household.WantToBuy(1,hh)==0
            per = 80/100
       else
            per = 20/100
       end
    end
end

%% Household preferred bank
Household.IdxBank(1,:) = randi(NrBanks,1,NrHHs);

%% Big Firm Balance Sheet
% Assets Side
BF.PhysicalCapital(1,:) = randi([5000000 300000000],1,NrBFs);
BF.Liquidity(1,:) = (0.1283/0.8717) * (BF.PhysicalCapital(1,:));          %
liquid assets represented 12.83% of nonfinancial firms total assets in 2009
Q1

% Liabilities Side
BF.Loans (1,:) = 0.3477*(BF.PhysicalCapital(1,:)+BF.Liquidity(1,:));      %
BFs leverage ratio in 2009 Q1 was 51.66% and loans represented 67.3% of total
debt
```

```
BF.Bonds (1,:) = 0.1689*(BF.PhysicalCapital(1,:)+BF.Liquidity(1,:));       %
BFs leverage ratio in 2009 Q1 was 51.66% and security debt represented 32.7%
of total debt
BF.Equity (1,:) = BF.PhysicalCapital(1,:) + BF.Liquidity(1,:)- BF.Loans (1,:)
- BF.Bonds (1,:);

%% Big firm preferred bank
BF.IdxBank(1,:) = randi(NrBanks,1,NrBFs);

%% Small/Medium Firm Balance Sheet
% Assets Side
SME.PhysicalCapital(1,:) = randi([50000 1000000],1,NrSMEs);
SME.Liquidity(1,:) = (0.1283/0.8717) * (SME.PhysicalCapital(1,:));         %
liquid assets rpresented 12.83% of nonfinancial firms total assets in 2009 Q1

% Liabilities Side
SME.Loans (1,:) = 0.40*(SME.PhysicalCapital(1,:)+SME.Liquidity(1,:));      %
SMEs are less able to use debt financing, hence the levearge ratio is assumed
to be 40%
SME.Equity (1,:) = SME.PhysicalCapital(1,:) + SME.Liquidity(1,:) - SME.Loans
(1,:);

%% Small/Medium firm preferred bank
SME.IdxBank(1,:) = randi(NrBanks,1,NrSMEs);



%% Bank balance sheets
% Assets Side
for b=1:NrBanks
    Bank.TotalMortgages(1,b) =
sum(Household.Mortgages(1,find(Household.IdxBank==b)));
% consistency with households mortgages
end
for b=1:NrBanks
    Bank.BFLoans(1,b) = sum(BF.Loans(1,find(BF.IdxBank==b)));
end
for b=1:NrBanks
    Bank.SMELoans(1,b) = sum(SME.Loans(1,find(SME.IdxBank==b)));
end
% Total Bank Lending:
for b=1:NrBanks
    Bank.TotalLending(1,b) = Bank.TotalMortgages(1,b) + Bank.BFLoans(1,b) +
Bank.SMELoans(1,b)
end
    Bank.Liquidity(1,:) = (Bank.TotalMortgages(1,:)+ Bank.BFLoans(1,:) +
Bank.SMELoans(1,:)) * (1/9);                                    % hyp:
Liquidity represents 10% of the total assets of a bank

% Liabilities Side
for b=1:NrBanks
    Bank.Deposits(1,b) =
sum(Household.Liquidity(1,find(Household.IdxBank==b))) +
sum(BF.Liquidity(1,find(BF.IdxBank==b))) +
sum(SME.Liquidity(1,find(SME.IdxBank==b)));
end
```

```
Bank.Equity(1,1) = (2.05/100) * (Bank.Liquidity(1,1) +
Bank.TotalLending(1,1));           % HSBC equity to total assets on
31/12/2008 was 2.05%
Bank.Equity(1,2) = (2.12/100) * (Bank.Liquidity(1,2) +
Bank.TotalLending(1,2));           % Barclays equity to total assets on
31/12/2008 was 2.12%
Bank.Equity(1,3) = (2.65/100) * (Bank.Liquidity(1,3) +
Bank.TotalLending(1,3));           % RBS equity to total assets on
31/12/2008 was 2.65%
Bank.Equity(1,4) = (2.22/100) * (Bank.Liquidity(1,4) +
Bank.TotalLending(1,4));           % Lloyds equity to total assets on
31/12/2008 was 2.22%
Bank.Equity(1,5) = (4.84/100) * (Bank.Liquidity(1,5) +
Bank.TotalLending(1,5));           % Standard Chartered equity to total
assets on 31/12/2008 was 4.84%
Bank.Equity(1,6) = (4.19/100) * (Bank.Liquidity(1,6) +
Bank.TotalLending(1,6));           % NatWest equity to total assets on
31/12/2008 was 4.19%
Bank.Equity(1,7) = (4.66/100) * (Bank.Liquidity(1,7) +
Bank.TotalLending(1,7));           % Santander UK equity to total assets on
31/12/2013 was 4.66%
Bank.Equity(1,8) = (3.36/100) * (Bank.Liquidity(1,8) +
Bank.TotalLending(1,8));           % Nationwide equity to total assets on
31/12/2008 was 3.36%
Bank.Equity(1,9) = (5.27/100) * (Bank.Liquidity(1,9) +
Bank.TotalLending(1,9));           % Co-Operative equity to total assets on
31/12/2008 was 5.27%
Bank.Equity(1,10) = (4.85/100) * (Bank.Liquidity(1,10) +
Bank.TotalLending(1,10));          % Clydesdale equity to total assets on
31/12/2008 was 4.85%

for b=1:NrBanks
Bank.OtherLiabilities(1,:)= Bank.Liquidity(1,:)+ Bank.TotalLending(1,:) -
Bank.Deposits(1,:) - Bank.Equity(1,:);
end

% Capital to Risk Weighted Assets Ratio
if Case == 1
   Bank.EquitytoRiskWeightedAssets(1,:) = 0;
else
   Bank.EquitytoRiskWeightedAssets(1,:) = ((Bank.Equity(1,:))/((w1 *
Bank.BFLoans(1,:) + w2 * Bank.TotalMortgages(1,:) + w3 *
Bank.SMELoans(1,:))));
end

%% Interest Rates Dynamics:
for t=2:T
rG(t) = rG(t-1) - 0.00025;
rH(t) = rH(t-1);
rRF(t) = rRF(t-1);
rBF(t) = rRF(t) + 0.05;
rS(t) = rG(t) + 0.02;
rSME(t) = rRF(t) + 0.08;
end
```

```
%% Balance Sheet Developments:
for t = 2:T
%% 1- Big Firms Balance Sheets:
% Big Firm Physical Capital:
    BF.PhysicalCapital(t,:) = BF.PhysicalCapital(t-1,:);
% Big Firm Debt Financing:
  % Growth in BFs Bank Borrowing
    g = -0.0145978105135334;
    h = 0.00990437767077834;
    BF_BBG(t,:) = (h-g) * rand(1,1) + g;
  % Changes in Debt Financing
    if  rS(t)<rS(t-1) && rS(t)<rBF(t)
        BF.Bonds(t,:) = BF.Bonds(t-1,:) +  (-(BF_BBG(t,:))) * BF.Loans(t-
1,:);
        BF.Loans(t,:) = (1 + (BF_BBG(t,:))) * BF.Loans(t-1,:);
    else
        BF.Bonds(t,:) = BF.Bonds(t-1,:);
        BF.Loans(t,:) = BF.Loans(t-1,:);
    end
% Big Firm Profits
    BF.Profit(t,:) = (0.10/12) * (BF.PhysicalCapital(t-1,:) + BF.Liquidity(t-
1,:));                                                                  % hyp:
the return on total assets is 10% for the big firms
% Big Firm Liquidity:
    BF.Liquidity(t,:) = BF.Liquidity(t-1,:) + BF.Profit(t,:) - rS(t) *
BF.Bonds(t-1,:) - rBF(t) * BF.Loans(t-1,:);
% Big Firm Equity:
    BF.Equity (t,:) = BF.PhysicalCapital(t,:) + BF.Liquidity(t,:) - BF.Loans
(t,:) - BF.Bonds (t,:);

%% 2- Small & Medium Enterprises Balance Sheets:
% SME Physical Capital:
    SME.PhysicalCapital(t,:) = SME.PhysicalCapital(t-1,:);
% SME Banks Borrowing:
    % Availability of Loans to SMEs:
    for b = 1:NrBanks
        if Case == 1
           Bank.EquitytoRiskWeightedAssets(t,b) = 0;
        else
           Bank.EquitytoRiskWeightedAssets(t,b) = ((Bank.Equity(t-1,b))/((w1
* Bank.BFLoans(t-1,b) + w2 * Bank.TotalMortgages(t-1,b) + w3 *
Bank.SMELoans(t-1,b))));
        end
    end
    for b = 1:NrBanks
        if Case == 1
           Bank.SMELonasAvailable(t,b) = 1
        else
            if Case == 2 && Bank.EquitytoRiskWeightedAssets(t,b) >= 0.10
% an optional capital buffer of 2% is employed by banks
               Bank.SMELonasAvailable(t,b) = 1
            else
                if Case == 2 && Bank.EquitytoRiskWeightedAssets(t,b) >= 0.08
                   Bank.SMELonasAvailable(t,b) = 0
                else
                   Bank.SMELonasAvailable(t,b) = -1
                end
```

```
            end
        end
    end
    % The size of SME Bank Borrowing
    for i = 1:NrSMEs
        if Bank.SMELonasAvailable(t,SME.IdxBank(1,i)) == 1 && rS(t)<rBF(t)
           SME.Loans(t,i) = SME.Loans(t-1,i) * (1 - mean(BF_BBG(t,:)));
        else
           if Bank.SMELonasAvailable(t,SME.IdxBank(1,i)) == -1 &&
rS(t)<rBF(t)
              SME.Loans(t,i) = SME.Loans(t-1,i) * (1 + ((w2-w1)/(w3-w2)) *
mean(BF_BBG(t,:)));
           else
              SME.Loans(t,i) = SME.Loans(t-1,i);
           end
        end
    end

% SME Profit:
    SME.Profit(t,:) = (0.05/12) * (SME.PhysicalCapital(t-1,:) +
SME.Liquidity(t-1,:));
% hyp: the return on total assets is 5% for the small and medium enterprises
% SME Liquidity:
    SME.Liquidity(t,:) = SME.Liquidity(t-1,:) + SME.Profit(t,:) - rSME(t) *
SME.Loans(t-1,:) - (SME.Loans(t-1,:) - SME.Loans(t,:));
% SME Equity:
    SME.Equity (t,:) = SME.PhysicalCapital(t,:) + SME.Liquidity(t,:) -
SME.Loans (t,:);

%% 3- Households Balance Sheets:
% House Prices
a = -0.0175050826107479;
b = 0.0409166317965757;
HPG(t) = (b-a)* rand(1,1) + a;
HousePrice(t) = HousePrice(t-1)*(1+HPG(t));
% The Average house price monthly growth rate between 1953 Q1 and 2014 Q3 has
been between -1.75050826107479% and 4.09166317965757%
% Household Income:
Household.Income(t,:) = Household.Income(t-1,:) * (1 + 0.033/12);
% Household Mortgage Payments, New Mortgages, and Total Mortgages:
    % Principal Payback:
     for hh=1:NrHHs
       if Household.Mortgages(t-1,hh) <= 0
          Household.PrincipalPayment(t,hh) = 0
       else
          if Household.Mortgages(t-1,hh) <= (1-DTV)* HousePrice(t)/360
             Household.PrincipalPayment(t,hh) = (1-DTV)* HousePrice(t)/360
          else
             if Household.Mortgages(t-1,hh) <= 2 * (1-DTV)* HousePrice(t)/360
                Household.PrincipalPayment(t,hh) = 2 * (1-DTV)*
HousePrice(t)/360
             else
                if Household.Mortgages(t-1,hh) <= 3 * (1-DTV)*
HousePrice(t)/360
                   Household.PrincipalPayment(t,hh) = 3 * (1-DTV)*
HousePrice(t)/360
```

```
                else
                   Household.PrincipalPayment(t,hh) = 4 * (1-DTV)*
HousePrice(t)/360
                end
             end
          end
       end
     end
     % Total Mortgage Payments (Interest & Principal):
       for hh=1:NrHHs
           if Household.Mortgages(t-1,hh) > 0
              Household.MortgagePayment(t,hh) =
Household.PrincipalPayment(t,hh) + (rH(t-1)/12)* Household.Mortgages(t-1,hh)
           else
          Household.MortgagePayment(t,hh) = 0
           end
       end
    % Household Balance Sheets continue Below...

%% 4- Bank Balance Sheets:
% Loans to Big Firms:
    for b=1:NrBanks
        Bank.BFLoans(t,b) = sum(BF.Loans(t,find(BF.IdxBank==b)));
    end
% The Change in Loans to Big Firms and the Resulting Change in Loans to SMEs:
    for b=1:NrBanks
        Bank.BFLoansChange(t,b) = Bank.BFLoans(t,b) - Bank.BFLoans(t-1,b);
        Bank.SMELoansChange(t,b) = ((w2-w1)/(w3-w2)) *
Bank.BFLoansChange(t,b);
    end
% Loans to SMEs:
    for b=1:NrBanks
        Bank.SMELoans(t,b) = sum(SME.Loans(t,find(SME.IdxBank==b)));
    end
% Bank Balance Sheets Continue Below...

%% 3- Households Balance Sheets Continued
% New Mortgages Availabilty for a Household:
for hh=1:NrHHs
    if Household.Mortgages(t-1,hh) <= 3 * (1-DTV)* HousePrice(t)/360 &
(Household.MortgagePayment(t,hh) + (1 + rH(t)) * (1-DTV)* HousePrice(t)/360)
<= 0.40 * Household.Income(t,hh) ...
           & Household.Liquidity(t-1,hh) >= 2 * 0.05 * (1-DTV)*
HousePrice(t)
       Household.MortgageAvailable(t,hh) = 1
    else
       Household.MortgageAvailable(t,hh) = 0
    end
end
% Household Willingness to Buy a Property
Household.WantToBuy(t,:) = round(rand(1,NrHHs)*1)
for hh=1:NrHHs
    if Household.Housing(t-1,:) == 0
       if Household.WantToBuy(t,hh)==0
            per = 70/100
       else
```

```
            per = 30/100
        end
    else
        if Household.WantToBuy(t,hh)==0
            per = 80/100
        else
            per = 20/100
        end
    end
end
% New Mortgages:
for hh=1:NrHHs
    if  Household.WantToBuy(t,hh) == 1 & Household.MortgageAvailable(t,hh) ==
1
        Household.NewMortgage(t,hh) = HousePrice(t) * (1-DTV)
    else
        Household.NewMortgage(t,hh) = 0
    end
end
%Total Mortgages:
        Household.Mortgages(t,:) = Household.Mortgages(t-1,:) -
Household.PrincipalPayment(t,:) + Household.NewMortgage(t,:);
% Household Housing Wealth:
    Household.Housing(t,:) = Household.Housing(t-1,:) + (1/(1-DTV)) *
Household.NewMortgage(t,:);
% Household Liquidity:
    Household.Liquidity(t,:) = Household.Liquidity(t-1,:) - (rH(t-1)/12)*
Household.Mortgages(t-1,:) - Household.PrincipalPayment(t,:) - (DTV/(1-DTV))
* Household.NewMortgage(t,:) + 0.30 * Household.Income(t,:);
% Household Equity:
    Household.Equity(t,:) = Household.Housing(t,:) + Household.Liquidity(t,:)
- Household.Mortgages(t,:);

%% 4- Bank Balance Sheets Continued

% Total Mortgages:
    for b=1:NrBanks
        Bank.TotalMortgages(t,b) =
sum(Household.Mortgages(t,find(Household.IdxBank==b)));
    end
% Total Bank Lending:
for b=1:NrBanks
        Bank.TotalLending(t,b) = Bank.TotalMortgages(t,b) + Bank.BFLoans(t,b)
+ Bank.SMELoans(t,b)
end
% Bank Profit:
    for b=1:NrBanks
        Bank.Profit(t,b) = sum((rH(t-1)/12)*Household.Mortgages(t-
1,find(Household.IdxBank==b))) + sum((rBF(t-1)/12)* BF.Loans(t-
1,find(BF.IdxBank==b))) + sum((rSME(t-1)/12)* SME.Loans(t-
1,find(SME.IdxBank==b)));
    end
% Bank Liquidity:
    for b=1:NrBanks
```

```
        Bank.Liquidity(t,b) = Bank.Liquidity(t-1,b) +
sum(Household.MortgagePayment(t,find(Household.IdxBank==b))) + sum((rBF(t-
1)/12)* BF.Loans(t-1,find(BF.IdxBank==b))) + ...
            sum((rSME(t-1)/12)* SME.Loans(t-1,find(SME.IdxBank==b))) +
sum(BF.Loans(t-1,find(BF.IdxBank==b))- BF.Loans(t,find(BF.IdxBank==b))) + ...
            sum(SME.Loans(t-1,find(SME.IdxBank==b))-
SME.Loans(t,find(SME.IdxBank==b)));
    end
% Bank Deposits:
    for b=1:NrBanks
        Bank.Deposits(t,b) =
sum(Household.Liquidity(t,find(Household.IdxBank==b))) +
sum(BF.Liquidity(t,find(BF.IdxBank==b))) +
sum(SME.Liquidity(t,find(SME.IdxBank==b)));
    end
% Bank Equity:
    Bank.Equity(t,:) = Bank.Liquidity(t,:)+ Bank.TotalLending(t,:) -
Bank.Deposits(t,:);


end

%% 5- Banking System Aggregates
for t = 1:T
% Total Mortgages
BankingSYS.Mortgages(t) = (21464730/1000) * sum(Bank.TotalMortgages(t,:),2);

% Loans to Big Firms:
BankingSYS.BFLoans(t) = (4918915/229) * sum(Bank.BFLoans(t,:),2);

% Loans to SMEs:
BankingSYS.SMELoans(t) = (4918915/229) * sum(Bank.SMELoans(t,:),2);

% Total Lending:
BankingSYS.TotalLending(t) = BankingSYS.Mortgages(t) + BankingSYS.BFLoans(t)
+ BankingSYS.SMELoans(t);
end

%% Simulations and Results:

font_sz = 12;

figure(21);
subplot(2,1,1); hold on; grid on
plot((BankingSYS.TotalLending),colour)
ylabel('Total Bank Lending','fontsize',font_sz)
xlabel('months','fontsize',font_sz)

figure(22);
subplot(2,1,1); hold on; grid on
plot((BankingSYS.Mortgages),colour)
ylabel('Total Mortgages','fontsize',font_sz)
xlabel('months','fontsize',font_sz)

figure(23);
```

```
subplot(2,1,1); hold on; grid on
plot((BankingSYS.BFLoans),colour)
ylabel('Loans to BFs','fontsize',font_sz)
xlabel('months','fontsize',font_sz)

figure(24);
subplot(2,1,1); hold on; grid on
plot((BankingSYS.SMELoans),colour)
ylabel('Loans to SMEs','fontsize',font_sz)
xlabel('months','fontsize',font_sz)
```

Chapter 4

The Impact of Quantitative Easing on Bank Lending in the UK

Evidence from a DSGE Model

Abstract

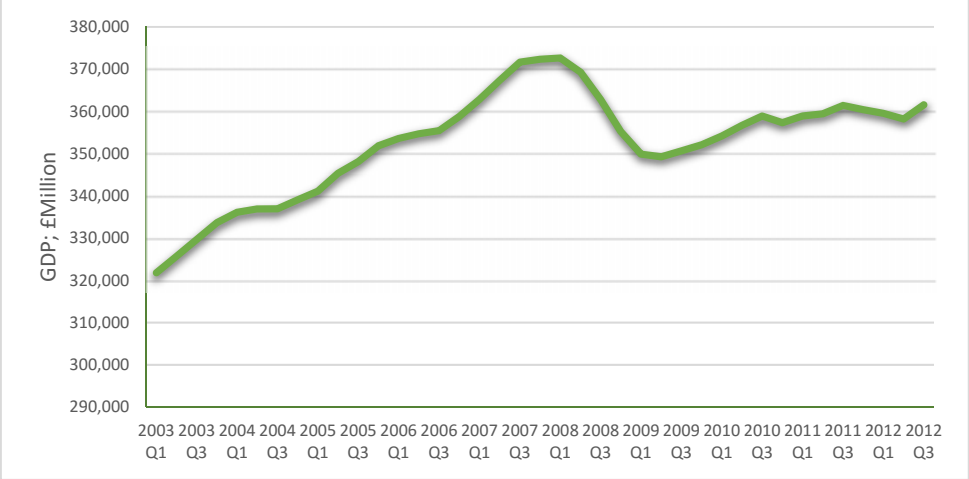
Increasing bank lending by expanding liquidity in the banking system is one of the main objectives of the Bank of England asset purchase program. However, data from the Office for National Statistics indicates that despite of the rise in bank lending to households, total bank lending has been declining since 2009. To explain this drop in total bank lending, this chapter employs a three-sector DSGE model. The main results show that a negative shock in gilts yield, initiated by massive asset purchases under the program, encourages big unrestricted firms to shift from bank borrowing to security debt (bonds). The fall in BFs bank borrowing reduces the share of loans to BFs vis-à-vis bank's total assets and hence increases the amount of risk weighted assets. Induced by the Basel III capital requirements, banks start to adjust their portfolios to accommodate more mortgages and less loans to small and medium enterprises (SMEs). The analysis of the role of capital adequacy requirements points out that while the introduction of strong enough capital requirements decreases the risks in the banking system, it may at the same time deprive banks from financing SMEs.[32]

[32] I am thankful for Dr. Stefan Niemann whose priceless comments significantly improved the model of this chapter.

4.1 Introduction

The recent financial crisis generated severe recessions in developed economies and raised the threat of collapse for the whole global financial system. Similar to several economies around the world, the UK economy witnessed a noticeable fall in retail sales and an increase in unemployment especially amongst people in 18-24 age group. As a result, the economy officially entered a recession period in 2008 Q4, when the GDP dropped by about 1.5%, as illustrated in Figure 4.1.

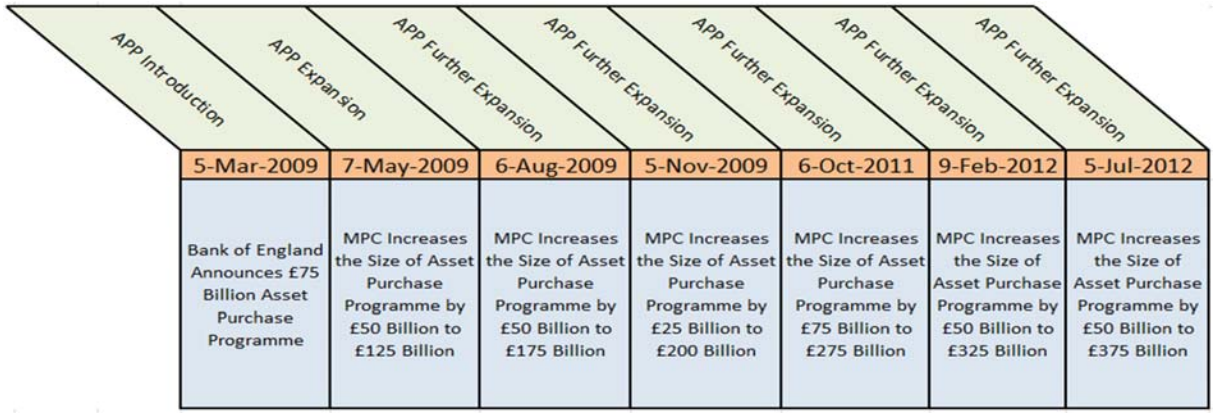
Figure 4.1: The UK Quarterly Gross Domestic Product (£ Million; Seasonally Adjusted)



Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html)

The first response of the monetary authorities in developed countries was to decrease their policy rates, which in turn, reached unprecedented low levels. The Monetary Policy Committee (MPC) of the Bank of England (BoE hereafter), for instance, reduced the short-term policy rate several times down to 0.5% early in 2009. Yet, the massive monetary loosening was not enough to improve aggregate expenditure and to support economic recovery. This induced the central banks to consider the usage of unconventional monetary policy tools, mainly quantitative easing (QE hereafter). In March 2009, the MPC introduced its open-ended £75 billion longer term asset purchase program (APP hereafter) to increase liquidity in the economy and to boost aggregate demand. As shown in Figure 4.2, the program was expanded many times, but since July 2012, it has been fixed at £375 billion.

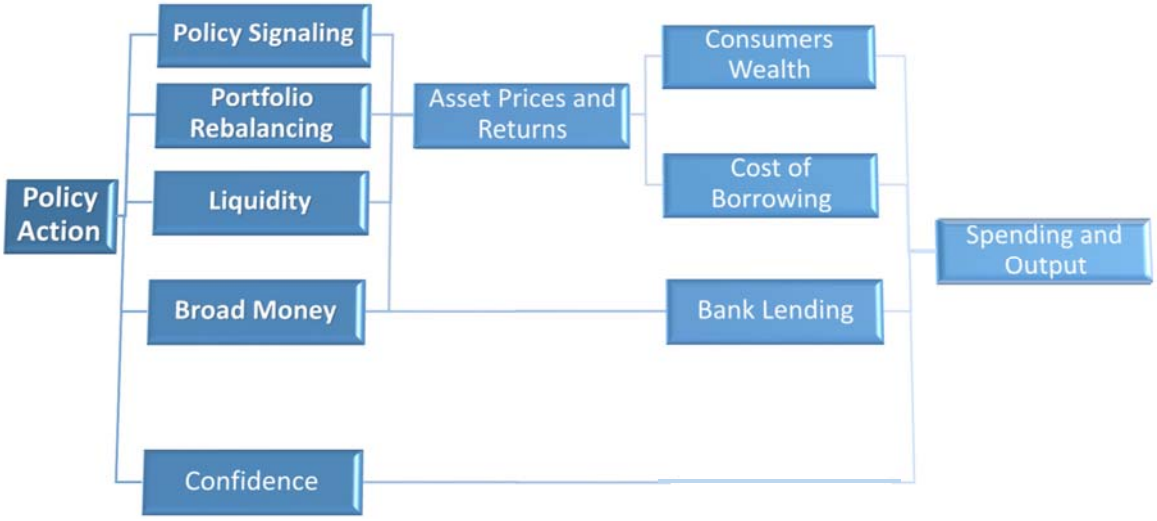
Figure 4.2: Bank of England's Asset Purchase Program (APP) Timeline



Source: Bank of England (http://www.bankofengland.co.uk)

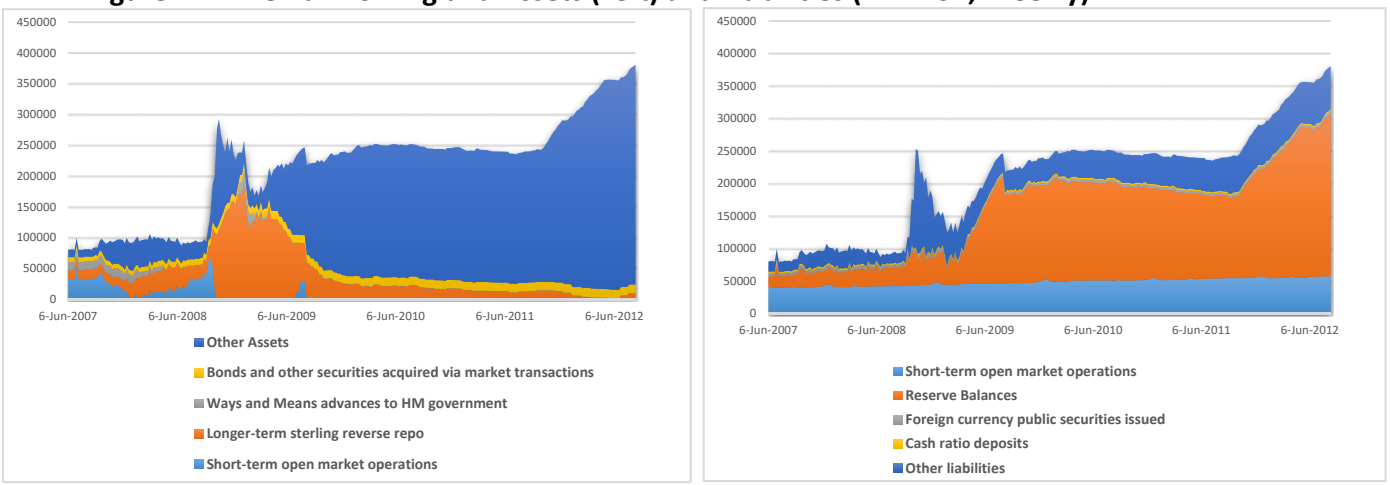
Joyce, Tong, and Woods (2011) indicate five transmission channels for QE (Figure 4.3): policy signalling; portfolio rebalancing; liquidity; broad money; and confidence. The effects of QE transmit directly to the wider economy using confidence impact on aggregate spending. Meanwhile, the influence of QE passes the first three channels through asset prices and returns, and additionally utilizes bank lending channel when it operates through the broad money channel. When a central bank purchases securities from outside the banking system,[33] it creates new electronic money and deposits it into the reserve account of the seller's bank, which in turn, credits the same amount into the seller's account. This expands liquidity within the banking system and may encourage banks to expand their lending to households and firms.

Figure 4.3: The Transmission Channels of Quantitative Easing (QE)



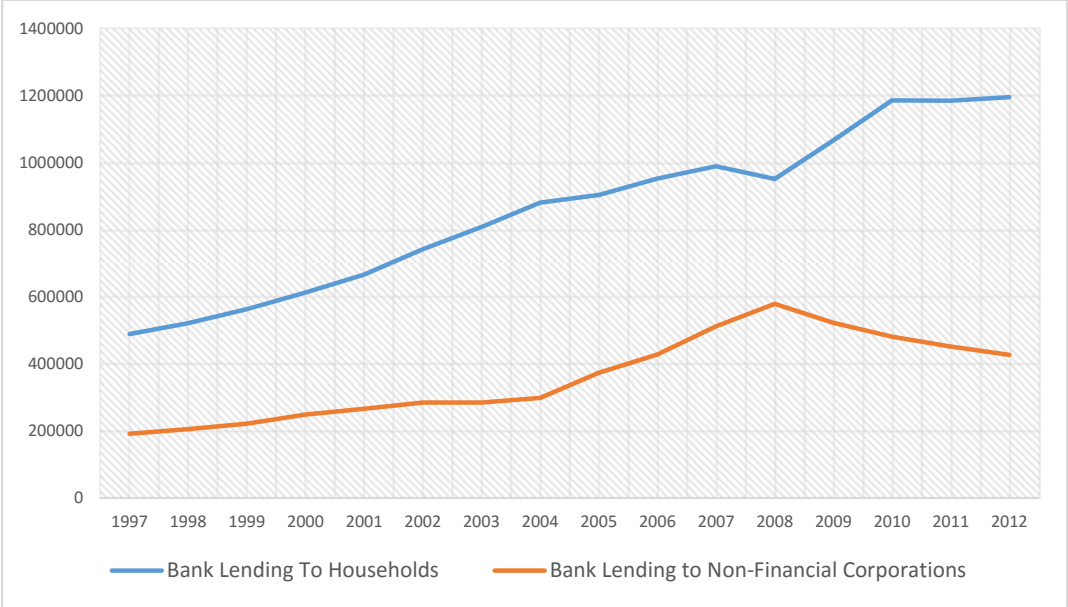
[33] See point number 42 in the minutes of the Monetary Policy Committee meeting for the 4 and 5 March 2009 available at: http://www.bankofengland.co.uk/publications/minutes/Documents/mpc/pdf/2009/mpc0903.pdf

Figure 4.4: The Bank of England Assets (Left) and Liabilities (£Million, Weekly)



Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp)

Figure 4.5: Bank Lending to Households and Nonfinancial Corporations (£Million)



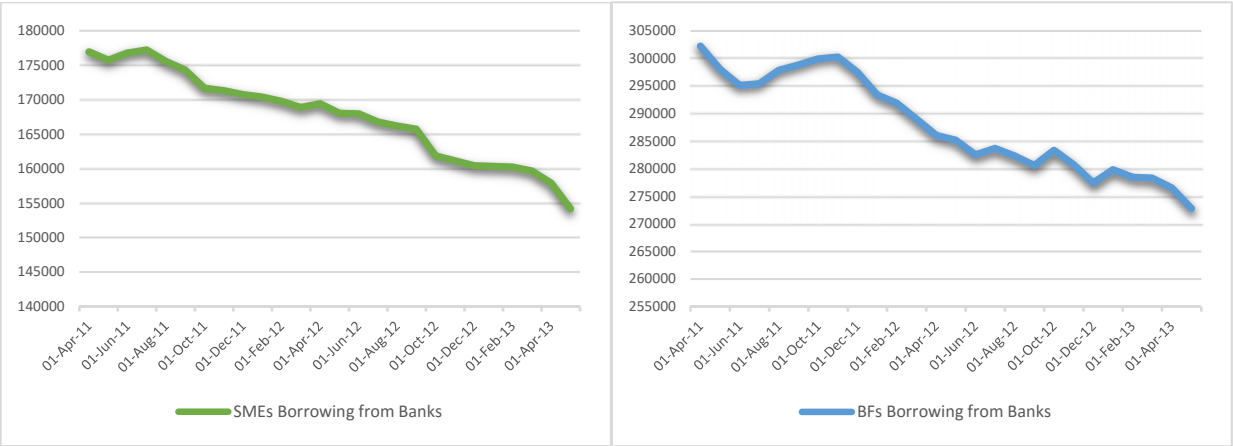
Source: ONS (http://www.ons.gov.uk/ons/datasets-and-tables/index.html)

The asset purchases under APP had major consequences on the balance sheet of the BoE (Figure 4.4). The size of the "Other Assets" category, which includes the assets purchased by the Asset Purchase Facility Fund under the APP, increased enormously after March 2009. The more important development can be spotted on the liabilities side of the balance sheet, where the bank reserves balances grew noticeably during the same period. More precisely, after every expansion of APP in Figure 4.2, the size of the bank

reserves expanded by almost the same amount of the expansion (or even more). For example, after the first stage of asset purchases (£75 billion) and just before the first expansion (7th May, 2009), the bank reserves balance expanded by about £56 billion (from £31.5 billion to £87.5 billion). The same trend can be observed after the second wave of purchases (£50 billion), where the balance of reserves increased by about £76.5 billion between May and August 2009. The data from the UK Office for National Statistics (ONS hereafter) shows that bank lending in the UK dropped by more than £218.6 billion, during the first four years after the introduction of APP early in 2009. Furthermore, according to the sectoral balance sheets and the financial accounts published by ONS, banks in the UK provide loans primarily to households (mostly in the form of mortgages), nonfinancial firms, and other financial intermediaries. As Figure 4.5 displays, bank lending to households has been noticeably increasing over the time (from roughly more than £489 billion in 1997 to about £1,195.5 billion by the end of 2012). Moreover, nonfinancial firms borrowing from banks did grow between 1997 and 2008, but then started falling afterwards. Consequently, the drop in loans to nonfinancial businesses represents one of the main reasons in the fall in aggregate bank lending mentioned above. Certainly, this constitutes part of a bigger problem of "why banks don't lend", which is currently being debated by several writers (for instance, Blundell-Wignall and Roulet (2013)). The emphasis of this chapter is not on the cash hoarding behaviour of banks, but more on the role of the lower demand for bank loans by bigger nonfinancial firms and the higher relative cost of lending to smaller firms in the changes in bank lending markets after March 2009. The differentiation between big firms (BFs) and small and medium enterprises (SMEs) in the category of nonfinancial firms is essential in this chapter, since the accessibility to different types of debt financing is different between the two types of firms. BFs can access security debt (bond) market, whereas SMEs can borrow only from banks. As Figure 4.6 indicates, the monthly amounts outstanding of UK bank loans to both BFs and SMEs according to BoE dataset have shown a clear drop, especially after November 2011.[34]

[34] According to the BoE dataset, BFs and SMEs bank borrowing fell by 12.25% and 13.49%, respectively between April 2011 and November 2013.

Figure 4.6: Bank Lending to Big Firms and Small and Medium Enterprises (£Million)[35]



Source: Bank of England Interactive Database (http://www.bankofengland.co.uk/boeapps/iadb/newintermed.asp)

The reasons for the falls in bank lending in economic downturns in the existence of capital adequacy requirements have been an area for large debate. Nevertheless, despite the diversity of explanations, authors have based their justifications for this falls on either the lower demand for loans or the decreased banks supply of credit. Supply-based explanations can be allocated into two categories. Researchers in the first category (like Thakor (1996)) attribute the drop in bank lending to the changes in the banks' perception of risk. The other group of explanations (for instance, Repullo and Suarez (2013)) refers to the lack of bank capital (i.e. the capital crunch hypothesis) as the key cause of loan rationing in slumps. Conversely, some authors (such as Bikker and Hu (2012)) claim that it is the shortage in demand for bank loans and not the supply of loans, which is the main factor for the fall of bank loans in recessions. This chapter reconciles the two views. The drop in bank lending is produced by a combination of demand and supply factors in the bank lending markets. To explain the shrinkage in bank lending, it is essential to inspect the drivers of the fall in the size of business loans, especially the interaction between different credit markets, taking into consideration the influence of BoE's APP on the relative costs of alternative debt instruments. The impact of APP on the yields of gilts and corporate bonds constitutes the starting point. The BoE asset purchases

[35] The charts use the data on the sterling monthly amounts outstanding of banks loans to SMEs and to all nonfinancial businesses from the BoE's Statistical Interactive Database.

decrease the remaining supply of gilts for the private sector (i.e. local supply effects), causing lower yields on gilts and corporate bonds (for example, McLaren et al (2014)). The lower yields on bonds encourage BFs to replace parts of their bank borrowing by security debt. Influenced by capital requirements, which assign different weights for different loan types, banks react by increasing mortgages and cutting the size of SMEs loans. This chapter employs a DSGE model with a banking sector to build a sound explanation of the shrinkage in bank lending. The rest of the chapter is organized as follows: Section 4.2 explores the previous literature of DSGE models with financial intimidation. The baseline model is outlined in section 4.3. In section 4.4, the roles of the lower gilts yield after the introduction of APP (indicated by many authors, e.g. Daines, Joyce and Tong (2012), and Joyce, Lasaosa, Stevens, and Tong (2011)) and the Basel III capital adequacy requirements in the decline of bank lending, are examined. The last section includes concluding remarks of the chapter.

4.2 The Related Literature

Thanks to Bernanke et al. (1999), who introduced credit and collateral requirements into general equilibrium models, recent models began to account for the interaction between financial and credit markets and the other parts of the economy. During the past few years, many researchers have introduced some sort of banks to their dynamic general equilibrium models for different purposes. To examine the role of monetary policy and banking, Goodfriend and McCallum (2007) build a two-sector model: goods producing firms which employ labour and capital to produce goods; and banks which combine the monitoring effort and collateral to *produce* loans. They indicate that the presence of the banking sector provides an endogenous explanation for significant part of the differences between the short-term interbank rate on the one hand and the yields of the assets included in the model on the other. Moreover, Cúrdia and Woodford (2009) expand the New Keynesian monetary transmission mechanism model to include a spread between the interest rates offered to savers and borrowers. They point out that while the existence of a positive spread has slight implications for the predicted influence of certain policies,

the changes in this spread are of greater significance for the relations between the policy rate and the aggregate expenditure and between real activity and inflation. Christiano, Motto, and Rostagno (2007) use a DSGE model with a banking sector and financial markets to examine the nature of the shocks initiated in the financial markets (also analysed by Gertler and Kiyotaki (2010), who inspect the spread of crises that resulted from financial intermediation disruptions into real economy), and the significance of these markets in the propagation of non-financial shocks (also investigated by Brunnermeier and Sannikov (2012), who specify that the nonlinear magnification related to financial frictions increases the possibility of economic instability), and to make recommendations about the best policy responses to financial market shocks. They show that shocks arising from financial frictions play an important role in explaining the evolution of US and EA data in the 1990s and early 2000s. In their model which assigns explicit roles for equity and debt financing, Jermann and Quadrini (2009) reveal a similar result. They indicate that the addition of financial shocks enhances the model explanatory capacity and bring it considerably closer to the data. However, Gerali et al. (2010) argue that the majority of the models exploring the role of financial intermediation assume that banks operate under perfect competition, and consequently emphasize the demand side of the credit market. They also claim that supply side factors, including competition in the banking sector, rate setting strategies and the financial soundness of banks have the same importance in shaping the dynamics of the business cycle. Their results show that the inclusion of banking sector in the model partially weakens the impact of demand shocks but supports the propagation of supply shocks.

More recently some authors expanded their models to accommodate for the unconventional monetary policy measures. For instance, Cúrdia and Woodford (2009) and (2010), and Gertler and Karadi (2011) extend the New Keynesian model to evaluate the unconventional monetary means utilized after the recent crisis using a framework that assigns a role for the size of the central bank's balance sheet in equilibrium determination. One main conclusion can be spotted in the three papers: the credit policy (or asset purchase programs) of the central bank is of high significance when the functionality of financial markets is imperfect.

4.3 The Model Economy

The economy in this model consists of three sectors: households; nonfinancial firms; and banks. Households (HHs) consume, supply labour, and accumulate financial assets including money, government gilts and corporate bonds. The nonfinancial productive sector hires labour to produce final goods and services. The model employs the typical working capital constraint that requires the firms to pay the wages in advance (see for example Corugedo et al. (2011)). The gap between the outgoing and incoming cash flows is covered using debt financing that is available from different sources. This sector contains two firm types: big firms (BFs) and small and medium enterprises (SMEs). The two types differ in their accessibility to debt markets; that is, while BFs have access to all debt markets, SMEs are restricted to bank lending as a sole source of debt financing. Banks accept HHs' deposits and provide loans to the other three agents in the economy, i.e. mortgages to households, business loans to BFs, and business loans to SMEs. The market power of banks varies between these three credit markets; that is, banks enjoy strong positions in mortgages and SMEs loans markets, whereas the BFs loans market has a rather competitive supply side and a monopolistic demand side. The following sections describe the model of this chapter in detail. Lastly, to keep the analysis simple, the model does not include a government budget constraint and hence abstracts from the constraints on the implementation of monetary of fiscal policies. The model tries to evaluate the impact of QE policy on bank lending rather than building a comprehensive picture of its influence on different economic variables and sectors it is intended to affect.

4.3.1 Households

The economy includes *N* utility maximizing households. The representative household is maximizing lifetime utility by choosing consumption (C_t) and labour supply (h_t) in each period, and holds money (deposits with banks), corporate (BFs) bonds, and government gilts:

$$\boldsymbol{max}\ \boldsymbol{E}\left(\sum \boldsymbol{\beta^t}\left(\boldsymbol{ln}(\boldsymbol{C_t}) + \boldsymbol{ln}(\boldsymbol{1}-\boldsymbol{h_t})\right)\right) \tag{1}$$

The budget constraint that the representative household faces is the following:

$$\boldsymbol{C_t + q_{B,t}.B_t + q_{G,t}.G_t + X_t \leq W.h_t + Y_{BF,t} + Y_{SM,t} + B_{t-1} + G_{t-1} + (1 + r_{RF}).X_{t-1}} \quad (2)$$

Where, β: the household discount factor, C_t: consumption at time *t*, h_t: the amount of labour supplied (to BFs and SMEs) at time *t*, *W*: the competitive wage rate, $Y_{BF,t}$: the profit of BFs at time *t*, $Y_{SM,t}$: the profit of SMEs at time *t*, $q_{B,t}$: the discounted price at time *t* of a £1 corporate bond with one year to maturity, B_t, B_{t-1}: the amounts held of BFs bonds (or corporate bonds) at times *t* and *t-1*, $q_{G,t}$: the discounted price at time *t* of a £1 government gilt with one year to maturity, G_t, G_{t-1}: the amounts held of government gilts at times *t* and *t-1*, X_t, X_{t-1}: the amount of deposits with banks at times *t* and *t-1*, and r_{RF}: the risk-free rate.

4.3.2 Firms

Firms in the model employ HHs' labour to produce output at the competitive wage rate (*W*). As mentioned earlier, the model assumes that the wages are paid one period before the firms can get the value of the output. The gap between outgoing cash flows and incoming cash flows is solved by obtaining credit. There are two types of firms: big unrestricted firms which can borrow from banks or external investors (BFs), and SMEs which have no access to the bond market. Hence, debt finance includes bank loans and security debt for big firms, and only bank loans for SMEs. The profit maximization problem of the both types is as follows:

Profit = Output – effective cost of labour

4.3.2.1 Big Firms

Each of these firms decides the amount of labour to hire and the composition of debt financing used to pay the wages. Consequently, the profit maximization problem of these firms is given by:

$$\boldsymbol{Y_{BF} = A_{BF}h_{BF} - (1 + r_{BF})L_{BF} - (1 + r_D).B} \quad (3)$$

Where: Y_{BF}: the profit of the big firm, A_{BF}: total-factor productivity for the BFs, h_{BF}: the amount of labour employed by the firm, r_{BF}: the interest rate on bank loans to BFs, L_{BF}: the amount of bank loans obtained by the firm, r_D: the interest rate on corporate debt securities, *B*: corporate bonds. The interest rate on bonds can be decomposed into the yield of government gilts (which is equal to the risk-free rate plus a

term premium) and a risk premium that depends on BFs leverage level and the amount of total debt. Since high quality corporate bonds represent a good substitute for government gilts, it is reasonable to assume that fluctuations in gilts yield reflect on corporate bonds yield through portfolio rebalancing channel. Similarly, the interest rate on bank lending to big firms is equal to the risk-free (policy) rate plus a risk premium that is a function in BFs leverage level and the amount of total debt. Lastly, since the wage bill is financed using a mixture of debt financing, the demand of the big firm for labour can be written as a function of the total amount of debt financing and the wage rate:

$$\boldsymbol{W.h_{BF} = L_{BF} + B \Rightarrow h_{BF} = \frac{1}{W}(L_{BF} + B)} \quad (4)$$

Accordingly, the profit maximization problem of the representative BF can be written as follows:

$$\boldsymbol{Y_{BF} = \frac{A_{BF}}{W}(L_{BF} + B) - \big(1 + r_{RF} + a\varphi(L_{BF} + B)\big).L_{BF} - \big(1 + r_G + b\varphi(L_{BF} + B)\big).B} \quad (5)$$

Where: r_{RF}: the risk free rate, φ: the leverage ratio, defined as the ratio of total debt to the total assets, r_G: gilts yield (which is equal to the risk free rate plus a term premium that reflects the interest rate risk not the government default risk), a, $b > 0$. To ensure portfolio rebalancing, the model assumes that $2a < b$. Despite of the difference in the structure of the interest rate on loans to BFs and the interest rate on corporate bonds doesn't mean that the model assumes a strong market segmentation to prevent arbitrage. The different structures are used to isolate the impact of changes in the gilts yields that are not resulted from changes in the risk free rate but from the changes in the term premium on gilts. In other words, a change in the risk-free rate would not affect the debt structure of the BFs as its influence on both debt sources would be the same.

4.3.2.2 Small and Medium Enterprises

Because these firms can only borrow from banks, their debt financing is mainly affected by the supply of loans provided by banks to them. The profit function of the representative SME is as follows:

$$\boldsymbol{Y_{SM} = A_{SM}h_{SM} - (1 + r_{SM})L_{SM}} \quad (6)$$

Where Y_{SM}: the profit of the SME, A_{SM}: total-factor productivity for the SMEs, h_{SM}: the amount of labour employed by the SME, r_{SM}: interest rate on bank loans to SMEs, L_{SM}: the amount of bank loans obtained by the SME. Since the wage bill is financed with bank loans, the demand of the SME for labour can be written as a function of the total amount of loans and the wage rate:

$$\boldsymbol{W.h_{SM} = L_{SM} \Rightarrow h_{BF} = \frac{1}{W}.L_{SM}} \quad (7)$$

Accordingly, the profit function of the representative SME can be written as follows:

$$\boldsymbol{Y_{SM} = \frac{A_{SM}}{W} L_{SM} - (1 + r_{SM}) L_{SM}} \quad (8)$$

4.3.3 Banks

As stated previously, banks in this model accept deposits, provide three types of loans, and enjoy a market power that differs from one credit market to another. Banks are monopolistic in mortgages and loans to SMEs markets. They are, however, rather competitive in loans to BFs market. Therefore, each bank chooses the size of mortgages and loans to SMEs to maximize its profits. Moreover, to maintain the equality between the assets and the liabilities sides of the balance sheet, the total lending of the representative bank in any period ($L_{T,\,t}$) cannot exceed the amount of deposits (X_t) plus the bank total equity (E_t) in that period. Thus, the balance sheet identity equation at time t+1 is as follows (where RE_t: retained earnings in period t):

$$\boldsymbol{L_{T,t+1} = X_{t+1} + E_{t+1} = X_{t+1} + E_t + RE_t} \quad (9)$$

To introduce the capital adequacy requirements -that states that at least a fraction γ_{Req} of bank assets must be financed by equity- into the model, I follow Aliaga-Díaz, Olivero, and Powell (2011) who state that if a bank has insufficient capital, it is subject to a cost that increases with the distance between the required capital to asset ratio and the actual one. Assuming that there are no taxes and that banks fully retain their profits, the profit function of the representative bank takes the following formula:

$$\begin{cases} \boldsymbol{\pi = (r_H - r_{RF})L_H + (r_{BF} - r_{RF})L_{BF} + (r_{SM} - r_{RF})L_{SM} - \left[\mu_0 + \mu_1 \ln\left(\frac{1}{\gamma} - \frac{1}{\gamma_{req}}\right)\right]L_T = RE} & \boldsymbol{if\ \gamma < \gamma_r} \\ \boldsymbol{\pi = (r_H - r_{RF})L_H + (r_{BF} - r_{RF})L_{BF} + (r_{SM} - r_{RF})L_{SM} - \mu_0 L_T = RE} & \boldsymbol{if\ \gamma \geq \gamma_r} \end{cases} \quad (10)$$

s.t:

$$\boldsymbol{L_T = L_H + L_{BF} + L_{SM}} \quad \textbf{(11)}$$

$$\boldsymbol{\frac{1}{\gamma} = \frac{1}{\frac{E}{w_{BF}.L_{BF} + w_{SM}.L_{SM} + w_H.L_H}} = \frac{w_{BF}.L_{BF} + w_{SM}.L_{SM} + w_H.L_H}{E}} \quad \textbf{(12)}$$

Where: r_H: the interest rate on mortgages, r_{SM}: the interest rate on bank loans to SMEs, γ: is the actual capital to asset ratio, L_{SM}: total lending to SMEs, L_H: the amount of mortgages, L_T: total bank lending, w_{BF}, w_{SM} and w_H are the risk weights for loans to BFs, loans to SMEs, and mortgages respectively.

4.3.4 Solving the Macroeconomic Model

While the clearance of the goods market in the model outlined above requires the consumption expenditure to be equal to the sum of the labour income and the total profits of the two types of firms (i.e. $Y_{BF} + Y_{SM}$), the quantities in the financial markets are solely decided by the side of the market that has the strongest position in that market. For example, BFs control the amount of their borrowing in the market of bank lending to BFs since they have a relatively stronger position than banks in this market. Similarly, banks rule the other two markets at which they operate because of their better market position, when compared to HHs (in mortgages market) and SMEs (in the market of bank lending to SMEs). Accordingly, the macroeconomic system can be written as follows:

$$\boldsymbol{\frac{1}{C_t} = \beta E\left(\frac{1}{C_{t+1}}\right)} \quad \textbf{(13)}$$

$$\boldsymbol{\frac{1}{1 - h_t} = \beta E\left(\frac{1}{1 - h_{t+1}}\right)} \quad \textbf{(14)}$$

$$\boldsymbol{C_t + q_{B,t}.B_t + q_{G,t}.G_t + X_t \leq W.h_t + Y_{BF,t} + Y_{SM,t} + B_{t-1} + G_{t-1} + (1 + r_{RF}).X_{t-1}} \quad \textbf{(15)}$$

$$\boldsymbol{C_t = Y_{BF,t} + Y_{SM,t}} \quad \textbf{(16)}$$

$$\boldsymbol{h_{BF} = \frac{B + L_{BF}}{w}} \quad \textbf{(17)}$$

$$h_{SM} = \frac{L_{SM}}{w} \tag{18}$$

$$Y_{BF} = \frac{A_{BF}}{w}(L_{BF} + B) - \left(1 + r_{RF} + a\varphi(L_{BF} + B)\right).L_{BF} - \left(1 + r_G + b\varphi(L_{BF} + B)\right).B_{BF} \tag{19}$$

$$Y_{SM} = \frac{A_{SM}}{w}L_{SM} - (1 + r_{SM})L_{SM} \tag{20}$$

$$B = \frac{\frac{A_{BF}}{w} - (1 + r_G) - \frac{b}{b - 2a}(r_G - r_{RF})}{a.\varphi} \tag{21}$$

$$L_{BF} = \frac{\frac{A_{BF}}{w} - (1 + r_{RF}) - \frac{a}{a - 2b}(r_G - r_{RF})}{b.\varphi} \tag{22}$$

$$r_{BF} = r_{RF} + a.\varphi.(L_{BF} + B) \tag{23}$$

$$L_H = \frac{\left(E.\left(\frac{1}{\gamma_{Req}} - \left(\frac{w_{BF}.L_{BF} + w_{SM}.(L_T - L_{BF})}{E}\right) + \left(\frac{L_T.\mu_1.(w_H - w_{SM})}{E.(r_H - r_{SM})}\right)\right)\right)}{w_H - w_{SM}} \tag{24}$$

$$L_T = L_H + L_{BF} + L_{SM} \tag{25}$$

$$\begin{cases} \pi = (r_H - r_{RF})L_H + (r_{BF} - r_{RF})L_{BF} + (r_{SM} - r_{RF})L_{SM} - \left[\mu_0 + \mu_1 \ln\left(\frac{1}{\gamma} - \frac{1}{\gamma_{req}}\right)\right]L_T = RE & if\ \gamma < \gamma_r \\ \pi = (r_H - r_{RF})L_H + (r_{BF} - r_{RF})L_{BF} + (r_{SM} - r_{RF})L_{SM} - \mu_0 L_T = RE & if\ \gamma \geq \gamma_r \end{cases} \tag{26}$$

$$\frac{1}{\gamma} = \frac{w_{BF}.L_{BF} + w_{SM}.L_{SM} + w_H.L_H}{E} \tag{27}$$

$$L_{T,t} = X_t + E_{t-1} + RE_{t-1} \tag{28}$$

4.4 Calibrated Model and Experiments

Using DYNARE[36], the model has been log-linearized around the non-stochastic steady state and an artificial time series has been generated by simulating 10,000 observations and dropping the first 1,000 simulations. The following sections present the calibration of the model parameters and report the results

[36] Available at Dynare website: http://www.dynare.org.

of impulse response experiments with respect to a negative one standard deviation shock in gilts yield (r_G). The shocks in gilts yield (and the term premium) follow stationary autoregressive processes of order one:

$$\boldsymbol{r_{G,t} = r_{G,t-1} + u_{G,t}} \qquad \boldsymbol{u_{G,t} \sim N(0, \sigma_G = 0.00945)} \tag{29}$$

4.4.1 Calibration

The 10 parameters of the baseline model are presented in Table 4.1 are calibrated using two types of sources: previous papers and time series data from the databases of ONS, BoE, and Data Stream®. First, the quarterly households discount factor β is standard in the literature and has been set to 0.9999. Moreover, while the values of the cost parameters in the profit function of the representative bank (μ_0, μ_1) have been borrowed from Aliaga-Díaz, Olivero, and Powell (2011), the values of the risk weights (w_{BF}, w_{SM}, and w_H) and the value of required capital to assets ratio (γ_{Req}) in that function come from a Allen & Overy customer briefing on Capital Requirements Directive IV Framework (January 2014) and the Basel III regulatory framework available from the Bank for International Settlements (BIS) respectively. The values of the remaining parameters (a, b and φ) have been calculated using the quarterly data of bank lending and policy rate (BoE), the nonfinancial firms balance sheet (ONS), and the interest rates on gilts and corporate bonds in the UK (Data Stream®).

Table 4.1: Baseline Model Parameter Values

β	*0.9999*	γ_{Req}[2]	*0.07*
μ_0	*0.001*	a	*0.0025*
μ_1	*0.275 x 10^{-5}*	b	*0.0052*
w_{BF}[1]	*0.2*	φ	*0.4323*
w_{SM}[1]	*1.0*		
w_H[1]	*0.5*		

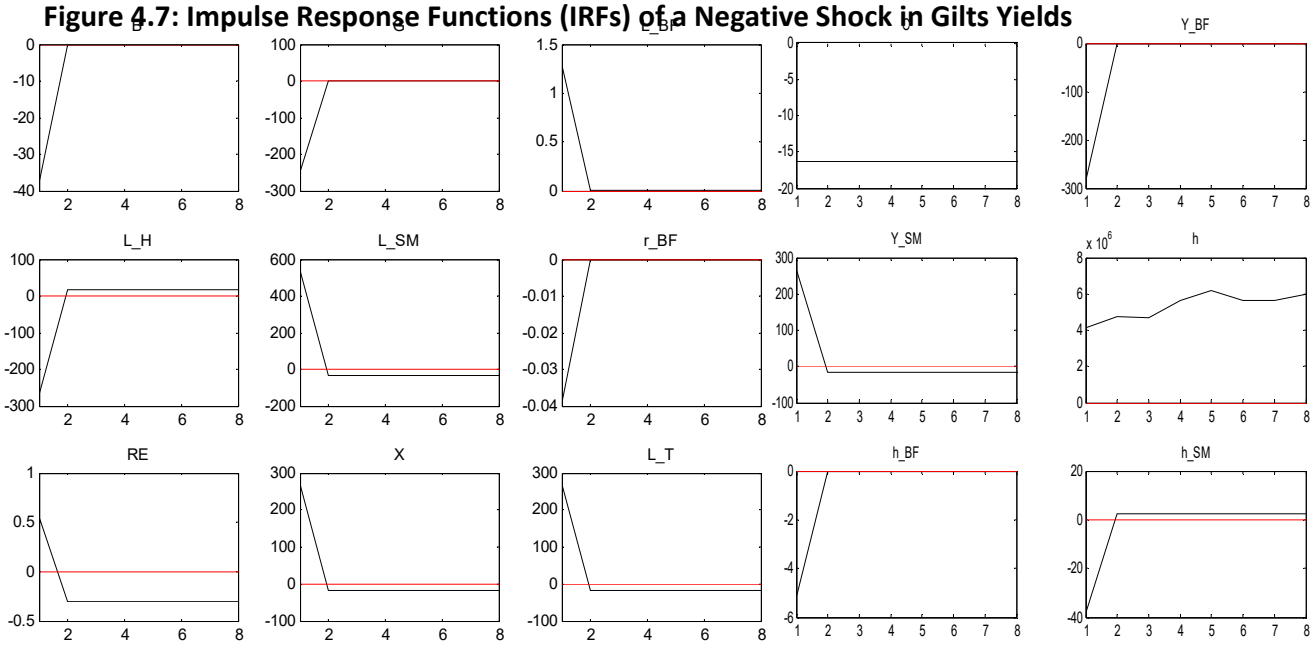
Source: 1. Capital Requirements Directive IV Framework: Standardised Approach to Credit Risk in the Banking Book, Allen & Overy Client Briefing Paper 3, January 2014, P12 (http://www.allenovery.com)
2. Bank for International Settlements (http://www.bis.org)

4.4.2 Impulse Response Functions

The impulse response functions (IRF functions hereafter) with respect to a negative one standard deviation shock in gilts yield (r_G) are presented in Figure 4.7. As the Figure shows, a negative shock in gilts yield that resulted from a decrease in the risk premiums caused by the BoE's APP program, and not from a

drop in policy (or *risk-free*) rate, leads to a decline in the relative cost of BFs security debt (r_{BF}), and consequently induces the representative BF to adjust its debt structure towards more security debt and less bank borrowing. In turn, the fall in BFs bank borrowing reduces the share of the loans to BFs in banks asset compositions and hence increases the amount of risk weighted assets. To maintain profitability and to ensure compliance to the capital adequacy requirements on the one hand and to respond to the decreasing ability to lend (because of the lower profits and thus retained earnings and the shrink in deposits) on the other, banks start to restructure their loan portfolios to include more mortgages and less loans to SMEs.

Figure 4.7: Impulse Response Functions (IRFs) of a Negative Shock in Gilts Yields



4.4.3 The Role of the Capital Adequacy Requirement

This section investigates the role of the required capital to assets ratio in shaping the impact of a negative shock in gilts yield that resulted from the BoE's APP. To do this, the IRF functions have been estimated under different scenarios presented in Figures 4.8-4.10. The first scenario assumes that banks have no capital requirements to obey; that is, the cost of having insufficient capital is zero (i.e. $\mu_1 = 0$). Figure 4.8 displays the IRF functions under this scenario. The fall in bank lending to BFs, as a result of

cheaper security debt, induces banks to increase investment in the other two markets. However, the riskier asset pools affect the profitability of the banks and hence their ability to lend over time. As a result, banks start to speculate on higher returns by concentrating on the (riskier) market of loans to SMEs.

Figure 4.8: IRF Functions of a Negative Shock in Gilts Yields - Zero Capital Requirements ($\mu_1 = 0$)

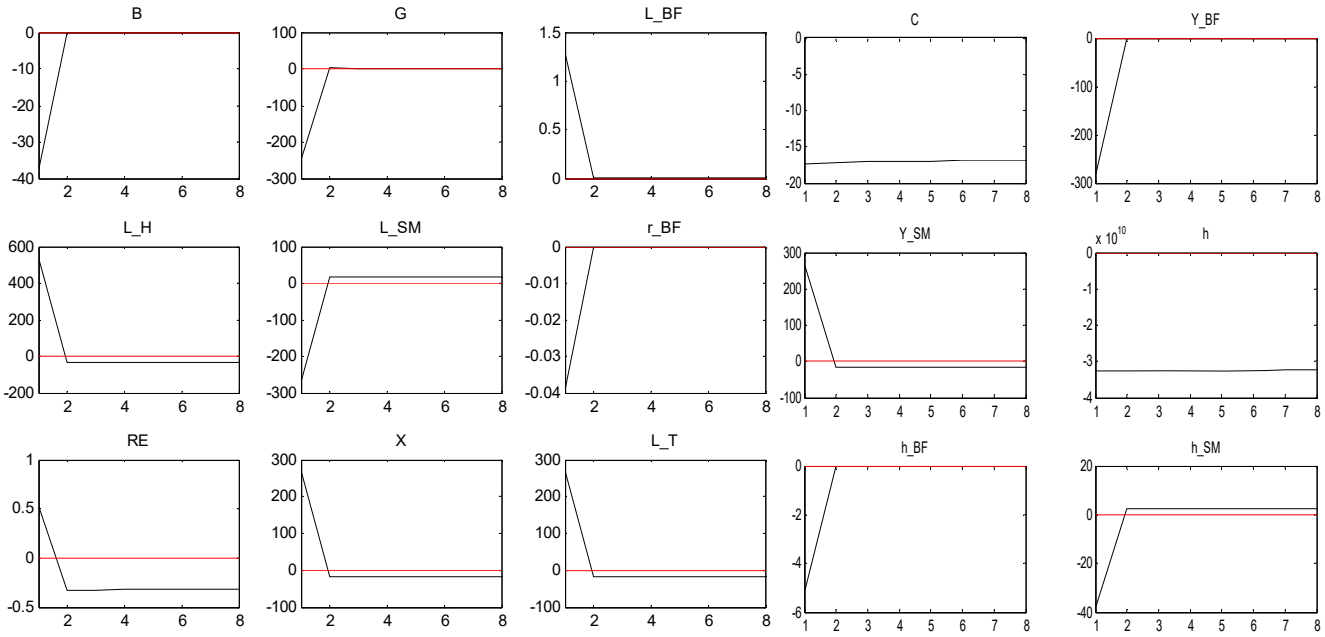
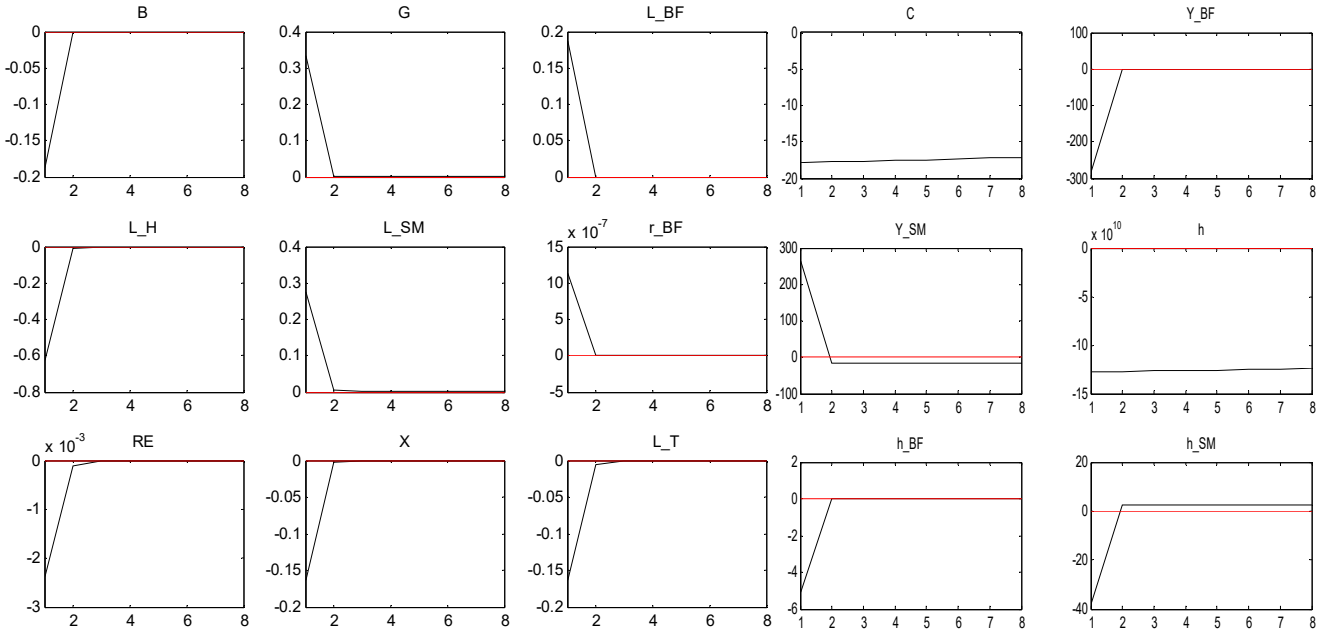
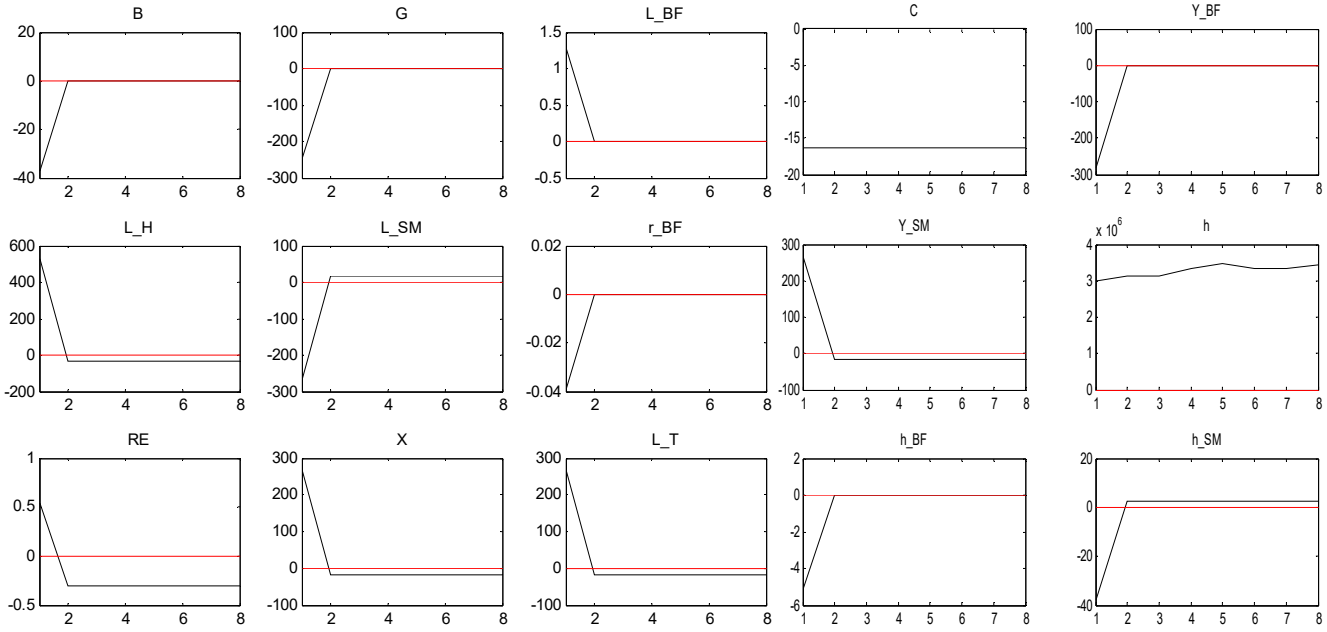


Figure 4.9: IRF Functions of a Negative Shock in Gilts Yields - Full Capital Coverage ($\gamma_{Req} = 1$)



The IRF functions of the second scenario which requires a full capital coverage of the risk weighted assets (i.e. γ_{Req} = 1) are shown in Figure 4.9. In this case, the fall in gilts yield produces outcomes similar to the original case (when γ_{Req} = 0.07) except the fact that total bank lending is not decreasing but rather increasing after the shock. The drop in BFs bank borrowing induces banks to invest more in mortgages and less in SMEs loans, since these loans require twice the amount of capital needed to support the same amount of mortgages (since w_H = 0.5 and w_{SM} = 1). Although the profitability of banks shrinks after the shock, the healthier (less risky) financial position enhances profitability two periods after the shock, and hence enables them to expand total lending.

Figure 4.10: IRF Functions of a Negative Shock in Gilts Yields – Partial Capital Coverage (γ_{Req} = 0.05)



Finally, in order to check whether the presence of the capital requirements, regardless of their level, is enough to decrease banks' incentives to take on excessive risks (compared to no capital requirements case discussed above), the last scenario adopts a 5% required capital to risk weighted assets ratio. As Figure 4.10 illustrates, a negative shock in gilts yield in this instance, leads to outcomes that are very similar to consequences of the same shock under zero capital requirements. Thus, the imposed capital requirements

should be high enough to persuade banks not to take on excessive risks. In fact, the required capital to risk weighted ratio (γ_{Req}) in this model, should be at least 6.255%, to have patterns similar to those in Figure 4.7. To sum up, while the introduction of strong enough capital requirements decreases the risks in the banking system, it may deprive banks from financing SMEs.

4.5 Conclusion

While one of the BoE's APP aims is to increase bank lending through expanding the liquidity in the banking system, ONS data shows that although bank lending to households has been increasing after the launch of APP, the size of total bank lending has been shrinking. To explain the fall in total bank lending, this chapter used a three-sector DSGE model. Households in the model maximize lifetime utility, choosing consumption and hold gilts, corporate bonds and money. Firms in the model employ HHs' labour to produce output at the competitive wage rate. The model assumes that the wages are paid one period before the firms can get the value of the output. BFs could choose between borrowing from banks and issuing security debt to minimize the cost of debt financing, whereas SMEs are restricted to bank loans as the sole source of debt financing. Banks provide three types of loans to the other agents in the economy, including mortgages to households and business loans to BFs and SMEs, and enjoy market power that differs from one market to the other. They are rather competitive in the market of loans to BFs, but have stronger positions in the other two markets (mortgages and loans to SMEs). The profit function of the representative bank accounts for the Basel III capital adequacy requirements, by introducing a penalty (cost) of insufficient capital that increases in the gap between the required and the actual capital to assets ratios.

Several studies point out that a fall in gilts yield resulted from lower risk premiums. Depending on this, the impact of APP entered the model as a negative shock in the gilts yield. The IRF functions of a one standard deviation negative shock in gilts yield indicated results that are close to the data; that is, an increase in corporate debt security and mortgages, and a shrink in business loans and total bank lending.

A plausible explanation of these trends may be that the drop in the gilts yield, and then corporate bonds yield, through portfolio rebalancing channel, motivates BFs to restructure their debt financing towards more security debt and less bank borrowing. This fall in BFs' bank borrowing decreases the share of the loans to BFs in banks asset compositions, and hence increases the amount of risk weighted assets. In response to that, banks start to adjust their portfolios to accommodate for more mortgages and less loans to SMEs. The last part of the chapter included an analysis of the role of capital adequacy requirements. It indicated that while the introduction of *strong enough* capital requirements decreases the risks in the banking system, it may deprive banks from financing SMEs, at times when they need. Finally, the model of the chapter may represent a basis for a future model that, for example, consider the impact of a variable policy rate in order to make the model more general.

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Appendices

A4.1 Calibrating the Leverage Ratio (φ)

✳ The financial balance sheets for nonfinancial corporations from ONS is the source of the data used here.

✳ The leverage ratios were calculated on a quarterly basis between 2004 Q1 and 2013 Q2 by dividing the sum of non-equity (debt) items on the total financial liabilities. The results are shown in the table below. The average leverage ratio during that period is used as an estimate of φ.

Period	Leverage ratio	Period	Leverage ratio	Period	Leverage ratio	Period	Leverage ratio
2004 Q1	0.4732	2006 Q3	0.4061	2009 Q1	0.3468	2011 Q3	0.4226
2004 Q2	0.4648	2006 Q4	0.3992	2009 Q2	0.3633	2011 Q4	0.4364
2004 Q3	0.4582	2007 Q1	0.3913	2009 Q3	0.3810	2012 Q1	0.4482
2004 Q4	0.4551	2007 Q2	0.3793	2009 Q4	0.3981	2012 Q2	0.4496
2005 Q1	0.4543	2007 Q3	0.3664	2010 Q1	0.3889	2012 Q3	0.4579
2005 Q2	0.4506	2007 Q4	0.3656	2010 Q2	0.3977	2012 Q4	0.4655
2005 Q3	0.4357	2008 Q1	0.3576	2010 Q3	0.4042	2010 Q1	0.4699
2005 Q4	0.4389	2008 Q2	0.3541	2010 Q4	0.4046	2010 Q2	0.4829
2006 Q1	0.4286	2008 Q3	0.3414	2011 Q1	0.4169		
2006 Q2	0.4158	2008 Q4	0.3497	2011 Q2	0.4225	**Average**	**0.4323**

A4.2 Calibrating Parameter a

✳ If the following equation, which defines the interest rate on BFs bank borrowing, is solved for a:

$$r_{BF} = r_{RF} + a.\varphi.(L_{BF} + B)$$

✳ Parameter a can be calculated using the following formula:

$$a = \frac{r_{BF} - r_{RF}}{\varphi.(L_{BF} + B)}$$

✳ Then, the data on interest rates from the BoE and Data Stream®, and the financial balance sheets from the ONS dataset to calculate the values of parameter a between 2004 Q1 and 2013 Q2, on a quarterly basis. The results are shown in the table below. The average of these values is used as an estimate parameter a in the model.

Period	Parameter a	Period	Parameter a	Period	Parameter a	Period	Parameter a
2004 Q1	0.002197	2006 Q3	0.002204	2009 Q1	0.004676	2011 Q3	0.002601
2004 Q2	0.004364	2006 Q4	0.000739	2009 Q2	0.004124	2011 Q4	0.002692
2004 Q3	0.003321	2007 Q1	0.000173	2009 Q3	0.002768	2012 Q1	0.003289
2004 Q4	0.001559	2007 Q2	0.000321	2009 Q4	0.002392	2012 Q2	0.002911
2005 Q1	0.003182	2007 Q3	0.000277	2010 Q1	0.002359	2012 Q3	0.002361
2005 Q2	0.001477	2007 Q4	0.001346	2010 Q2	0.002384	2012 Q4	0.002506
2005 Q3	0.002783	2008 Q1	0.001343	2010 Q3	0.002346	2013 Q1	0.003553
2005 Q4	0.002657	2008 Q2	0.001181	2010 Q4	0.001956	2013 Q2	0.004832
2006 Q1	0.003229	2008 Q3	0.001463	2011 Q1	0.003051		
2006 Q2	0.003427	2008 Q4	0.003708	2011 Q2	0.002860	**Average**	**0.0025**

A4.3 Calibrating Parameter b

✻ If the following equation, which defines the interest rate on BFs security debt, is solved for *b*:

$$r_D = r_G + b.\varphi.(L_{BF} + B)$$

✻Parameter *b* can be calculated using the following formula:

$$b = \frac{r_D - r_G}{\varphi.(L_{BF} + B)}$$

✻ Then, the data on interest rates from the BoE and Data Stream®, and the financial balance sheets from the ONS dataset to calculate the values of parameter *b* between 2004 Q1 and 2013 Q2, on a quarterly basis. The results are shown in the table below. The average of these values is used as an estimate parameter *b* in the model.

Period	Parameter b	Period	Parameter b	Period	Parameter b	Period	Parameter b
2004 Q1	0.003610	2006 Q3	0.003555	2009 Q1	0.014421	2011 Q3	0.003614
2004 Q2	0.003649	2006 Q4	0.003847	2009 Q2	0.012937	2011 Q4	0.003769
2004 Q3	0.003313	2007 Q1	0.003613	2009 Q3	0.008348	2012 Q1	0.003837
2004 Q4	0.003001	2007 Q2	0.003725	2009 Q4	0.006993	2012 Q2	0.003705
2005 Q1	0.002540	2007 Q3	0.004749	2010 Q1	0.005560	2012 Q3	0.003673
2005 Q2	0.003312	2007 Q4	0.005821	2010 Q2	0.006230	2012 Q4	0.003942
2005 Q3	0.003725	2008 Q1	0.008018	2010 Q3	0.006702	2013 Q1	0.003740
2005 Q4	0.003468	2008 Q2	0.008525	2010 Q4	0.003216	2013 Q2	0.003758
2006 Q1	0.003833	2008 Q3	0.008939	2011 Q1	0.002505		
2006 Q2	0.001954	2008 Q4	0.013758	2011 Q2	0.003631	**Average**	**0.0052**